Measuring the Digital Transformation

A ROADMAP FOR THE FUTURE

OECD

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BETTER POLICIES FOR BETTER LIVES

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Foreword

Sound measurement is crucial for evidence-based policy making; it helps to identify the need for policy intervention, enhances accountability, and improves the evaluation of the efficiency and effectiveness of policy actions. The demand for useful data and measurement tools relating to the ongoing and accelerating digital transformation is particularly acute due to the wide-ranging role that digitalisation and digital technologies play in economies and everyday lives.

The aim of *Measuring the Digital Transformation: A Roadmap for the Future* is not to "rank" countries or develop composite indicators. Instead, its objective is to provide policy makers and analysts with key indicators for each of the dimensions of the Going Digital integrated policy framework but also additional indicators providing detail and nuance, and link to relevant policy levers, to give analysts, stakeholders and policy makers deeper insights into how their economies are performing along those dimensions. The publication draws upon the wealth of data available at the OECD, as well as other international organisations and private data providers.

A forward-looking measurement roadmap develops nine actions that, if prioritised and implemented, would substantially advance the capacity of countries to monitor the digital transformation and its impacts. The first four overarching actions are directed towards building the next generation of data and indicators capable of dealing with the challenges of the digital transformation: make the digital economy visible in economic statistics, understand the economic impacts of the digital transformation, measure well-being in the digital age, and design new and interdisciplinary approaches to data collection. Five further actions target specific areas identified as requiring attention: transformative technologies, data and data flows, skills in the digital era, trust in online environments, and governments' digital strengths. The actions build on 19 roadmap pages, spread throughout the publication, that identify policy needs for measurement, discuss the challenges and propose options for international action.

Trends in the digital era (Chapter 1). This opening chapter sets the stage and develops a narrative around technology trends and digital transformations. It highlights trends rather than country comparisons and makes use of less-traditional data sources. The target audience is any person interested in understanding the broad picture and emerging developments. It highlights elements such as the rise of Big data analytics and artificial intelligence, the increased demand for cloud computing services, the nature of the global data infrastructure, the increasing digital transformation of all sectors, the impact of digitalisation on the workplace and on younger generations and scientists, and the evolution of "digital divides". It also offers examples of the use of text-mining techniques, Internet-based statistics and online job vacancies to develop new indicators of interest.

Growth and well-being (Chapter 2). This chapter illustrates the contribution of information industries and economic activities undergoing digital transformations to growth, productivity, global production networks, the composition of demand, trade and jobs in global value added chains. It also looks at how digital technologies are used by citizens and provides examples of impacts on their well-being. The chapter includes three roadmap pages that examine how to measure digital intensity in sectors, explore indicators of well-being in the digital age and address the challenges of developing a digital "satellite account".

Seven thematic chapters (Chapters 3 to 9) align with the seven policy dimensions of the Going Digital integrated policy framework, as shown in the figure below. The narrative reflects priorities for government monitoring and action, from enhancing the availability and quality of the infrastructure (Chapter 3) to encouraging the effective use of digital technologies by individuals and businesses (Chapter 4); enabling the digitalisation of science, innovation, markets and governments (Chapter 5); ensuring good jobs and outcomes in the workplace (Chapter 6); monitoring societal impacts (Chapter 7); strengthening digital security, privacy and trust in online environments (Chapter 8); and fostering market openness (Chapter 9).

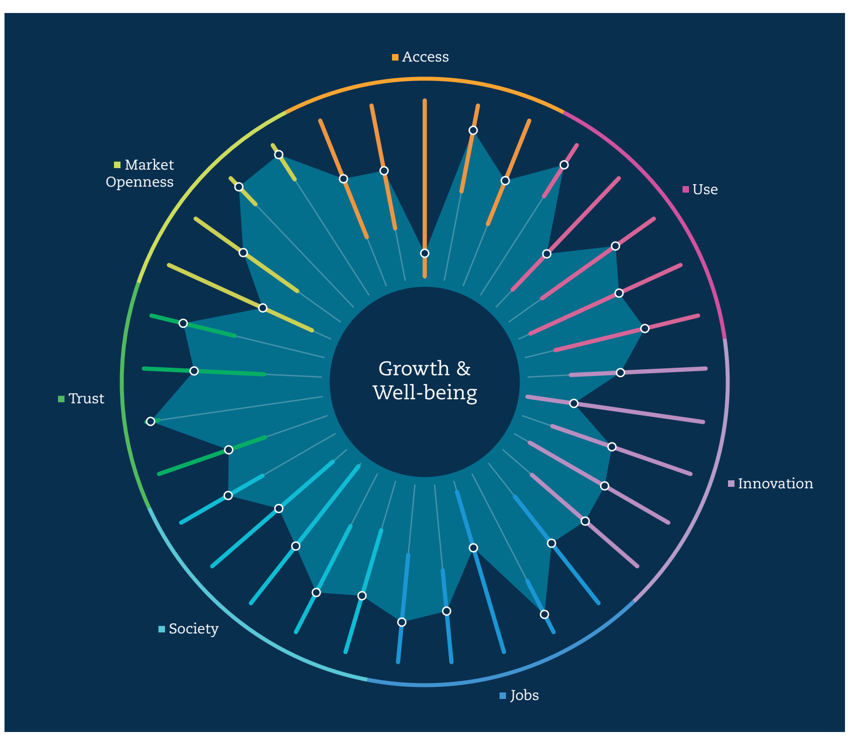
Issues related to education and skills are not singled out as separate dimensions in the policy framework; rather, they are explored as enabling factors for other dimensions. Likewise, indicators related to skills are proposed throughout the publication: Chapter 4 examines skills for the effective use of technologies; Chapter 5 on innovation looks at tertiary education in science, engineering and ICT; Chapter 6 on jobs highlights skills in the workplace and key skills for adaptability and resilience, education and training; Chapter 7 on social prosperity explores digital skills capabilities; and Chapter 8 on trust looks at digital security skills.

The target audience for the thematic chapters includes policy analysts with a certain level of sophistication in the use of indicators. Roadmap pages feature challenges and actions surrounding the Internet of Things, cloud computing services, open source software, online platforms, platform-mediated workers, e-skills, e-commerce, digital trade, and data and data flows, among others.

A smaller set of indicators for each of the seven dimensions of the policy framework have been selected for visualisation and international comparisons in the Going Digital Toolkit. The Toolkit also provides easy access to additional indicators from the publication, and the underlying data and databases, as well as related publications, policy guidance and more: *www.oecd.org/going-digital-toolkit*.

Visualisation of 33 key indicators in the Going Digital Toolkit

Across 7 policy dimensions of the Going Digital integrated policy framework



Note: In the Going Digital Toolkit countries are benchmarked across 7 policy dimensions and 33 indicators. The black dot represents the sample average and the coloured lines represent the spread of OECD countries with respect to the top-performing OECD country within each indicator.

Source: OECD Going Digital Toolkit, *www.oecd.org/going-digital-toolkit*.

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This publication is a key outcome of the Measurement module of the OECD-wide project: Going Digital: Making the Transformation Work for Growth and Well-being. The module was jointly led by the OECD Directorate for Science, Technology and Innovation (DSTI), the Statistics and Data Directorate (SDD) and the Directorate for Trade and Agriculture (TAD).

Measuring the Digital Transformation: A Roadmap for the Future is the result of a collaborative effort among several parts of the OECD Secretariat, national statistical offices, researchers and private sector data providers. Lead authors are Alessandra Colecchia, Daniel Ker and Elif Köksal-Oudot from the Economic Analysis and Statistics Division of DSTI, together with Andrea de Panizza of the Italian National Statistical Institute (Istituto Nazionale di Statistica, Istat).

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The report also features the results of an exploratory analysis of business ICT usage survey micro-data undertaken by Pauline Beck and colleagues at the UK Office for National Statistics, Irene Ek and colleagues at the Swedish Agency for Growth Policy Analysis, and Mateusz Gumiński and colleagues at Statistics Poland. Special thanks go to Andrea de Panizza and Stefano de Santis of Istat who developed the code, provided advice, analysed the data and interpreted the results.

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The measurement roadmap pages on cloud computing services, online platforms, and data and data flows benefitted from two dedicated measurement workshops. The OECD wishes to thank all participants in the "Workshop on measuring online platforms and cloud services in National Accounts", which was jointly organised by DSTI and SDD in September 2018. The UK Economic Statistics Centre of Excellence (ESCoE), co-organised, with the OECD, an expert workshop on "data on data and data flows" held in London in November 2018. For this workshop, David Nguyen and Marta Paczos produced discussion papers under the supervision of Rebecca Riley (Director of ESCoE). Special thanks go to all those who presented their work at these workshops.

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This collaborative effort would not have been possible without the help and dedication of all. By further building the evidence, based on this report and its forward-looking measurement roadmap, as well as other initiatives undertaken by the international community, countries will be able to prepare the ground for more robust policies to promote growth and well-being in the digital era.

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Reader's Guide

Acronyms

ADE	Automated data exchange
AI	Artificial intelligence
ANA	Annual National Accounts
API	Application Programming Interface
ASJC	All Science Journals Classification
ATUS	American Time Use Survey
B2B	Business to business
B2C	Business to consumer
BEA	United States Bureau of Economic Analysis
BERD	Business expenditure on research and development
BHPS	British Household Panel Survey
ccTLD	Country code top-level domain
CIPO	Canadian Intellectual Property Office
CO_2	Carbon dioxide
CPC	Central Product Classification
CPI	Consumer price index
CPU	Central processing unit
CRM	Customer-relationship management
CSIRT	Computer Security Incidents Response Team
DOCSIS	Data Over Cable Service Interface Specification
DSL	Domain-specific language
DSTRI	Digital Services Trade Restrictiveness Index
EB	Exabyte
EBOPS	Extended Balance of Payments Services Classification
EDT	Enquête Emploi du Temps
EEA	European Economic Area
EPO	European Patent Office
ERP	Enterprise resource planning
ESS	European Social Survey
ETCB	Estonian Tax and Customs Board
EU	European Union
EUIPO	European Union Intellectual Property Office
EWCS	European Working Conditions Survey
FDI	Foreign Direct Investment
FDI RRI	Foreign Direct Investment Regulatory Restrictiveness Index
FERMA	Federation of European of Risk Management Associations
FTTB	Fibre-to-the-building
FTTH	Fibre-to-the-home
GB	Gigabyte
Gbps	Gigabits per second
GCI	Global Cybersecurity Index
GDP	Gross domestic product
GDPR	General Data Protection Regulation
GFCF	Gross fixed capital formation

GODI	Global Open Data Index
gTLD	Generic top-level domain
GVC	Global value chain
HBSC	Health Behaviour in School-Aged Children Study
HTM	High-tech manufacturing
IaSD	Internet as a statistical data source
ICIO	Inter-Country Input-Output
ICT	Information and communication technology
IFR	International Federation of Robotics
ILO	International Labour Organization
ILPO	Israel Patent Office
IMF	International Monetary Fund
INAPI	National Institute for Industrial Property of Chile
IoT	Internet of Things
IP	Internet Protocol
IP5	Five largest intellectual property offices worldwide (EPO, JPO, KIPO, NIPA, USPTO)
IPC	International Patent Classification
ISCED	International Standard Classification of Education
IPv6	Internet Protocol version 6
ISCO	International Standard Classification of Occupations
ISIC	International Standard Industrial Classification
ISO	International Organization for Standardization
ISSA	International Survey of Scientific Authors
Istat	Italian Statistical Institute
IT	Information technology
ITU	International Telecommunication Union
JPO	Japan Patent Office
kbps	Kilobits per second
kg	Kilogramme
KIPO	Korean Intellectual Property Office
KIS	Knowledge-intensive service
M2M	Machine to machine
Mb	Megabyte
Mbps	Megabits per second
ML	Machine learning
MNE	Multinational enterprise
MOOC	Massive Online Open Course
MPI	Max Planck Institute
MSA	Metropolitan statistical area
NAICS	North American Industry Classification System
NFC	Near field communication
NGA	Next Generation Access
NIA	National Information Society Agency
NIPA	National Intellectual Property Administration of People's Republic of China
nm	Nanometre
NPL	Non-patent literature
NSE	Natural sciences and engineering
NSO	National statistical office
NTI	National Treatment Instrument
O*NET	US Occupational Information Network

OER	Open Educational Resources
OGD	Open government data
OLI	Online Labour Index
OSS	Open source software
PIAAC	OECD Programme for the International Assessment of Adult Competencies
PISA	OECD Programme for International Student Assessment
PPM	Peer platform market
PPP	Purchasing power parity
R&D	Research and development
RFID	Radio-frequency identification
SaaS	Software as a service
SAT	Statistics Canada Survey of Advanced Technology
SCM	Supply chain management
SEEA	UN System of Environmental-Economic Accounting
SIM	Subscriber identity module
SME	Small and medium-sized enterprise
SOC	Standard Occupational Classification
SQL	Structured Query Language
STRI	Services Trade Restrictiveness Index
Tbps	Terabytes per second
TFI	Trade Facilitation Indicators
TiM	Trade in Employment
TiVA	Trade in Value Added
TLD	Top-level domain
TRAINS	Trade Analysis Information System
UIBM	Italian Patent and Trademark Office
UK IPO	United Kingdom Intellectual Property Office
UNCTAD	United Nations Conference on Trade and Development
UNSD	United Nations Statistics Division
UNU	United Nations University
USD	United States dollar
USPTO	United States Patent and Trademark Office
VC	Venture capital
VDSL	Very-high-bit-rate digital subscriber line
VR	Virtual reality
WBG	World Bank Group
WEEE	Waste Electrical and Electronic Equipment
WIPO	World Intellectual Property Organization
WTO	World Trade Organization
ZB	Zettabyte

Abbreviations

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

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

Country groupings

BRIICS	Brazil, the Russian Federation, India, Indonesia, China and South Africa.
Euro area	Austria, Belgium, Cyprus, Estonia, Finland, France, Germany, Greece, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, the Netherlands, Portugal, Slovak Republic, Slovenia and Spain.
EU28	European Union
G7	Canada, France, Germany, Italy, Japan, the United Kingdom and the United States.
G20	Argentina, Australia, Brazil, Canada, China, France, Germany, India, Indonesia, Italy, Japan, Mexico, the Russian Federation, Saudi Arabia, South Africa, Korea, Turkey, the United Kingdom, the United States and the European Union.
OECD	Total OECD
ROW	Rest of the world
WLD	World

Executive Summary

Measuring the Digital Transformation: A Roadmap for the Future provides new insights into the state of the digital transformation by mapping indicators across a range of areas – from education and innovation to trade and economic and social outcomes – against current digital policy issues, as presented in *Going Digital: Shaping Policies, Improving Lives*. In so doing, it also identifies measurement gaps and sets out a forward-looking measurement Roadmap.

Digital technologies can democratise innovation, but strong potential remains for wider diffusion

Mobility, cloud computing, the Internet of Things (IoT), artificial intelligence (AI) and Big data analytics are among the most important drivers of the digital transformation. Over 2013-16, five economies – China, Chinese Taipei, Japan, Korea and the United States – were responsible for developing between 70% and 100% of the top 25 cutting-edge digital technologies. Declining data storage and processing costs have facilitated the collection of large volumes of data and the adoption of Big data analytics which are now performed by 12% of businesses overall and one-third of large businesses. Data centres are becoming a critical infrastructure, and cloud computing – which provides users with on-demand access to the ICTs they need at any given time (rather than purchasing them outright) – enables companies, especially small, young and credit-constrained firms, to reduce the cost of experimenting with new technologies, scaling up and adapting technology use to the business cycle. Almost 26% of small businesses in the OECD reported purchasing cloud services in 2018.

More people are connected than ever before, but other gaps may emerge

In OECD countries, the share of people who use the Internet grew by 30 percentage points over the last ten years and more than doubled in Greece, Mexico and Turkey. Over half of individuals in Brazil, China and South Africa now use the Internet, narrowing the gap with OECD countries. In 2018, over three-quarters of individuals in the OECD area used the Internet every day. However, even in economies with almost universal Internet uptake, there is a divide in terms of the sophistication of Internet use, with many people carrying out relatively basic and limited activities online. Only in a number of Nordic countries does the share of Internet users carrying out the whole spectrum of activities measured reach as high as 45-60%. There are also generational differences in Internet use. In the majority of OECD countries nearly all 16-24 year-olds use the Internet on a daily basis – the median value was 96% in 2018 – while for individuals in the 55-74 age bracket the median stood at 55%, with very wide differences (about 50 percentage points) between leading and lagging countries.

As younger generations adopt an "always-on" lifestyle, attention should be paid to impacts on well-being

In the OECD area, 17% of students first accessed the Internet at or before the age of 6. In 2015, 43% of 15 year-olds spent between two and six hours per day online outside of school, up significantly from 30% in 2012. In Europe, the average individual allocated more than three hours per day to Internet usage in 2016, while on average people aged 14-24 spent a further 1.5 hours each day online. Across OECD countries, 90% of students enjoy using digital devices, with 61% reporting in 2015 that they forget the time when using them, and 55% indicating that they feel bad when no Internet connection is available. The latter figure reached 80% in countries such as France, Greece, Portugal and Sweden. Younger people are also more likely to provide personal information on the Internet than older individuals.

All firms and markets are affected by the digital transformation, although the pace of change differs

The scope and speed of the digital transformation varies across countries, sectors, organisations and places. Although almost no business today is run without digital technologies, they are often not used to their full potential. While broadband access has almost reached saturation in business, on average, only 20% of enterprises in OECD countries benefited from high-speed broadband (100 Mbps or greater) in 2018. A new OECD taxonomy reveals that highly digital-intensive sectors are often more dynamic and scale-up faster than other sectors of the economy, but have also experienced more significant declines in business dynamism and increases in market concentration over time. Firms in highly digital-intensive sectors enjoy 55% higher mark-ups – the wedge between the price a firm charges for its output and the cost the firm incurs to produce one extra unit of output – than firms in the rest of the economy, on average, and the gap has been increasing.

Firms in highly digital-intensive sectors are adding jobs, placing the spotlight on skills

A new OECD taxonomy reveals that highly digital-intensive sectors were responsible for the creation of around 40% of the 38 million jobs added in the OECD area between 2006 and 2016. Jobs differ in their ICT task intensity – the frequency with which ICT tasks are undertaken – ranging from around 40% in the Russian Federation and Turkey to nearly 60% in Scandinavian countries. While approximately 25% to 50% of employees in the information industries are ICT specialists, other industries employ around four people in other ICT task-intensive occupations for every one ICT specialist, on average. For every ten additional jobs created in Europe between 2011 and 2017, four were in ICT task-intensive occupations. In most OECD countries, women tend to work in jobs that are more ICT task intensive, on average, than men. Even so, in 2017, the majority of 16-24 year-old programmers in Europe were still men.

Broad skillsets are in demand and training is key

Navigating the digital transformation requires a combination of solid cognitive skills (mathematics and literacy) coupled with problem-solving skills, as well as non-cognitive and social skills (e.g. communication and creativity). However, 13% of 16-65 year-olds in the OECD area lack basic cognitive skills and less than 30% have a “well-rounded” cognitive skill set combining high levels of literacy, numeracy and problem-solving skills. The younger generation is doing better, with the share of young workers with good skills for problem solving in technology-rich environments almost five times that of the oldest workers. Training and upskilling are a must for thriving in the digital transformation. In 2018, 40% of workers in the European Union had to learn to use new software or ICT tools, and about 10% needed specific training to be able to cope with those changes. Low-skilled workers are most in need of training to adapt to a digitalising workplace but only 40% receive training on average, compared to almost 75% of high-skilled workers. OECD governments currently spend 0.13% of GDP on training for unemployed people and workers at-risk of involuntary unemployment; however, the digital transformation may require a significant increase.

As existing metrics and measurement tools struggle to keep up, it is imperative to act now

The international statistical community has made progress and further advances are in the pipeline, however more must be done to strengthen the evidence base needed to monitor and shape the digital transformation. The measurement work undertaken in the OECD Going Digital project has led to a set of nine proposed actions that, if prioritised and implemented, would substantially advance the capacity of countries to monitor the digital transformation and its impacts.

The first four overarching actions are directed towards building the next generation of data and indicators capable of dealing with the challenges of the digital transformation:

1. Make the digital transformation visible in economic statistics.
2. Understand the economic impacts of digital transformation.
3. Measure well-being in the digital age.
4. Design new approaches to data collection.

Five further actions are targeted to specific areas identified as requiring attention:

5. Monitor transformative technologies (notably the Internet of Things, AI and Blockchain).
6. Make sense of data and data flows.
7. Define and measure the skills needed in the digital era.
8. Measure trust in online environments.
9. Assess governments' digital strengths.

By further building the evidence base, countries can prepare the ground for more robust policies to promote growth and well-being in the digital era. Action now will reap rewards in the future.

A MEASUREMENT ROADMAP FOR THE FUTURE

Measuring the Digital Transformation maps existing indicators drawn from a wide range of areas including education, innovation, trade, economic and social outcomes against current digital policy issues, as presented in *Going Digital: Shaping Policies, Improving Lives* (OECD, 2019). By so doing, it identifies gaps in the current measurement framework and assesses progress made by several initiatives towards filling these gaps, as documented in the 19 roadmap sections of the publication. The overarching objective of *Measuring the Digital Transformation* is to advance the measurement agenda by building on these roadmaps and a wide body of ongoing work in national and other international organisations, as well as areas already identified in *Measuring the Digital Economy: A New Perspective* (OECD, 2014) and in the *G20 Toolkit for Measuring the Digital Economy* (G20, 2018).[1]

This is a challenge. Existing metrics and measurement tools struggle to keep up with the rapid pace of the digital transformation. The range of questions that can be asked about its impacts is daunting. How can digital transformations be measured and tracked in all sectors of the economy, including the public sector? How to measure the disruption of existing business models and the emergence of new ones, the reorganisation of work or the size of the sharing economy? How can the value of data, both private and public, be captured in standardised statistics? How can international transactions of digitised goods and services be traced? How should the impact of policies on the digital economy be monitored and assessed? What are the economic activities and jobs of the future? What are the impacts of digital transformations on the well-being of citizens and society at large?

Much of the information required to respond to these questions already exists or is being developed, but not all. There is a recognition that statistical information systems need to adapt, and in some cases expand, to capitalise on their ability to provide more granular insights. There is also a need for new, complementary, data infrastructures capable of tracking the emergence of new activities and monitoring their substitution for traditional ones, on a timely basis wherever these occur. Such information systems must also adapt to newly emerging digital footprints (i.e. the enormous flows of information generated by digital technologies and digitally enabled activities, such as e-commerce, cloud services and the Internet of Things) that are now being generated.

In the shorter term, the challenge is to improve the international comparability of current indicators and make statistical systems more flexible and responsive to the introduction of new and rapidly evolving concepts driven by the digital transformation.

"Even in areas where international standards to guide statistical collection exist, countries may lack the capabilities and resources to implement them systematically, disseminate the resulting information openly or make efforts to ensure that data are comparable. There is a clear lack of coverage in developing countries compared to developed countries due to differences in statistical capacity among countries, or user needs and priorities for statistical collection" (G20, 2018).

Even among OECD countries, ensuring the international comparability of indicators used to monitor the digital transformation can present challenges. Only a limited number of indicators can be compiled for monitoring across countries, and these are usually fairly standard and not sufficiently granular to capture the changing dynamics of the digital transformation. Efforts to exploit official statistics at the micro level (e.g. enterprise/establishment/organisation, worker or household/individual) in an internationally co-ordinated fashion, including the use of administrative data and the exchange of micro-data among national statistical offices (NSOs), should be supported, especially with respect to data-linking opportunities. This will mean continuing to encourage the development of tools and mechanisms to access micro-data while ensuring data confidentiality.

A number of options exist and have begun to be explored and developed to increase the flexibility of current statistical frameworks. These include developing and populating satellite accounts, exploiting the potential of existing micro-data, adding questions to existing surveys, periodically augmenting existing surveys with topic-specific modules and developing high-frequency surveys to meet specific needs. Remaining gaps could be addressed through new and experimental approaches developed to meet the specific priorities and resources of countries (OECD, 2014).

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1. The 2018 Argentine G20 Presidency, in collaboration with a steering committee of international organisations (IOs) led by the Organisation for Economic Co-operation and Development (OECD) and comprising the International Telecommunication Union (ITU), the United Nations Conference on Trade and Development (UNCTAD), the European Union, the World Bank Group (WBG), the International Monetary Fund (IMF), and the International Labour Organization (ILO), has produced a *G20 Toolkit for Measuring the Digital Economy*. The toolkit highlights methodological approaches and indicators used to monitor the digital economy, and key gaps and challenges regarding digital economy measurement for further study. See Annex 3 of the G20 Digital Economy Ministerial Declaration, 24 August 2018, Salta, Argentina.

Several international organisations are contributing to the measurement of the digital transformation through initiatives, some of which are described in the G20 Toolkit for Measuring the Digital Economy. These include, but are not limited to, work on key ICT indicators within the Partnership on Measuring ICT for Development led by the ITU, UNCTAD and the United Nations Educational, Scientific and Cultural Organization (UNESCO) Institute for Statistics (UIS). The OECD works closely with several of these organisations, including the World Trade Organisation (WTO) on the issue of measuring digital trade, and the IMF on measuring the implications of the digital economy for macroeconomic statistics.

In the longer term, the challenge for the statistical community will be to design new and interdisciplinary approaches to data collection and to leverage the information captured by digital systems.

As the digital transformation spreads across every sector and affects every aspect of society, measuring its distinct features and dynamics will become increasingly challenging. New approaches will be needed – and the digital tools and footprints created by digital activities can form part of the solution. The digital transformation is also being felt across all dimensions of data production and use. For example, qualitative information is increasingly becoming a source of quantitative evidence. Text-mining tools (e.g. natural language processing) underscore the potential to alleviate some of the common challenges facing statistical collection (e.g. survey fatigue and classification systems that are applied differently by human coders) and offer opportunities for generating adaptable indicators. In this context, policies promoting (open) access to data collected for administrative purposes by the public and private sectors represent an important means to facilitate new forms of analysis.

The next generation of data infrastructure for policy making in the digital era needs to build partnerships with the private sector and engage with stakeholders to bring publicly available, reliable data into the policy-making process.

The proposed measurement roadmap will have to be discussed and implemented gradually through close co-operation between the statistical community and other stakeholders. Policy makers will need to define user needs, while researchers contribute insights essential for the development of appropriate metrics and data infrastructures. Engagement with organisations, businesses, universities and the public sector will be indispensable, as the statistical system can only collect data that can feasibly be measured inside such organisations. In particular, private source data can open new opportunities for monitoring the digital transformation and its impacts. They can help track data flows and uses on a continuous basis across actors, sectors and locations. For example, these data can provide insights into job vacancies and the emergence of new jobs profiles or the new services and business models enabled by online platforms. However, the use of private source data for measurement and analysis raises new challenges that need to be overcome by working together both on statistical quality frameworks and viable economic models of data sharing.

The OECD and the other international organisations actively contributing to the digital measurement agenda will need to continue to improve co-ordination, in order to avoid fragmented efforts and initiatives and ensure that the international community takes up the challenge to further build the evidence base for more robust policies for growth and well-being in the digital era.

Nine actions – if prioritised and implemented – would substantially advance the capacity of countries to monitor the digital transformation and its impacts. The first four overarching actions (1 to 4) are directed towards building the next generation of data and indicators capable of dealing with the challenges of the digital transformation. An additional five actions (5 to 9) target specific areas identified as requiring priority attention.

Action 1
Make the digital economy visible in economic statistics

Measuring the digital transformation and its impacts requires the development of indicators that complement the views provided by traditional measurement frameworks, such as those used to measure GDP and trade flows. But even within these current frameworks the way that firms, products and indeed transactions are classified and identified requires adaptation. In addition, it is essential to accelerate efforts to capture relevant phenomena outside the current production boundary of national accounts, for example, those concerning the consumption (and value) of online services provided to consumers free of charge, such as online search, social networking sites and so on. At the same time, work on tackling the challenges of globalisation and the measurement of services not physically fixed to a single location (e.g. cloud services and services provided by online platforms) should be further encouraged. Platforms in particular raise new policy challenges, but little is yet known about the actors operating on them, their characteristics, the types of activities in which they engage, the services they provide, the value they create and the locations from which they operate. In addition, by providing easy access to customers for transport services, accommodation, food delivery and many others, online platforms are increasing the importance of household production, blurring the lines between different institutional sectors within the economy and changing the nature of work.

NSOs, research communities and international organisations are encouraged to continue to work together to:

- Populate the OECD digital supply-use tables (Mitchell, 2018) and measure transactions in line with the Handbook on Measuring Digital Trade (forthcoming), in particular for those areas that supplement national accounts and trade statistics, in order to obtain new details and perspectives.

- Within the framework of the digital supply-use tables and the Handbook on Measuring Digital Trade:
  - Identify transactions based on their "digital nature" (i.e. digitally ordered, digitally delivered and/or digital intermediary platform enabled) and new actors relevant for the digital economy (e.g. digital intermediary platforms, e-sellers and firms dependent on intermediary platforms).
  - Develop new aggregations of firms, products and transactions that provide more granular insights into the actors, including households and the products involved.
  - Better capture digitally enabled production by households and continue to develop estimates of unpaid household activities in economic statistics and tackle the challenge of understanding and estimating the value generated by services provided to users free of charge (though often involving an implicit transaction related to personal data).
- Improve the quality and breadth of information on e-commerce transactions through enhancements to surveys on ICT use by businesses and individuals, the incorporation of e-commerce questions into other appropriate surveys (particularly e-commerce revenues in structural business surveys and online spending in household expenditure surveys), and the use of alternative data (e.g. anonymised information on transactions from banks and credit card companies).
- Support the development of common definitions and taxonomies of different types of platforms, formulate standard questions on platform work for inclusion in relevant surveys (e.g. labour force, ICT usage and time-use surveys) in order to derive robust estimates of the numbers of platform workers, and explore the role of administrative data and alternative data sources (e.g. web-scraped data) to gain insights into platform-intermediated transactions.

Action 2
Understand the economic impacts of digital transformation

Digital technologies are implemented as a part of business processes, together with labour, capital and knowledge capital assets, in order to drive performance. The initial and strongest evidence of their economic impact will likely surface in micro-data (data about firms, workers or consumers) before showing up in macro-data. To this end, it is important to be able to link together existing datasets, exploit the potential of administrative records, and develop measures of digital maturity in business that can then be used to analyse the impacts of digital technologies on firm performance. Robust measures of changes in prices and quality are also crucial to analysing the contribution of digital technologies to economic performance. For example, measures of the actual performance of broadband connections (i.e. broadband quality) are critical for consumers to make informed choices, and for policy makers and regulators alike to ensure that the services provided are of optimal quality. However, they are also key to measuring productivity and assessing the contribution of ICTs to economic growth. Digitalisation may also further complicate the measurement of prices and volumes more generally, as it increases the pace of quality change, leads to changes in the outlets through which products are sold and may involve new price differentiation practices, among others.

Quality of service provision should also be considered in the context of "divides", such as between businesses of different sizes, or households with different compositions, incomes or locations. To this end, business and household surveys on the adoption of digital technologies should continue to be reviewed regularly to fully account for emerging phenomena, such as high-speed broadband, cloud computing services, data assets and other technologies, both as enablers of innovation and as contributors to business performance and consumer welfare. At the same time, opportunities to further capitalise on administrative data through linking existing datasets should continue to be exploited. In addition, surveys of technology adoption and administrative data need to be aligned with aggregate economic measures.

The broader statistical community is encouraged to:

- Improve the measurement of ICT investment to arrive at internationally comparable deflators for hardware, software and communication infrastructure, including the pricing of broadband services bundles, and analyse the impacts and opportunities digitalisation creates in relation to the measurement of prices and volumes more generally.
- Improve the measurement of broadband quality (performance), including experienced speeds, latency, reliability and robustness of broadband services in both rural and urban areas.
- Regularly review the framework for measuring ICT usage to identify and prioritise areas in which surveys can improve and evolve in line with ongoing developments and policy priorities; this includes delivering sufficiently granular detail for the differentiated analysis of impacts of the digital transformation on individuals, firms and places.
- Exploit the statistical potential of administrative data sources and review existing data collections to maximise data-linking opportunities for research.
- Improve access to these datasets while ensuring data confidentiality.

Action 3
Encourage measurement of the digital transformation's impacts on social goals and people's well-being

The digital transformation is impacting many aspects of people's lives. Accordingly, measurement frameworks are required to capture these aspects including emerging impacts. In this respect, frameworks play a key role in measuring the extent to which digital technologies and new business models can help address societal goals, including those associated with health, ageing populations and climate change. At present, evidence of the impacts of the digital transformation on well-being is scarce in many areas. For example, relevant data on how the use of digital technologies affects people's experiences of mental health or their social lives are not collected frequently or in a harmonised manner. Survey vehicles are an important source of self-reported objective and subjective data. They can be used to collect data on people's life experiences in the context of the digital transformation, as well as to attempt to establish causal relationships (e.g. between the diffusion of digital technologies and various well-being outcomes).

The broader statistical community is encouraged to:

- Promote wider implementation of the OECD Model Survey on ICT Access and Usage by Households and Individuals (OECD, 2015) to develop subjective well-being and mental health questions for inclusion.
- Include detailed ICT-use variables in household surveys (e.g. general social surveys and labour force surveys), and especially in longitudinal surveys, in order to better understand the causal relationships between Internet use and well-being outcomes over time.
- Develop new statistical tools including surveys to monitor the impact of ICT use on adults and children, such as exposure to disinformation or hate speech.
- Improve measurement of the impact of the digital transformation on the environment, by enhancing statistical linkages among ICT-use surveys, consumer expenditure surveys, supply-use tables and industry-level data.

Action 4
Design new and interdisciplinary approaches to data collection

Given the pace of technological change, it is understandable that current frameworks are not yet able to reveal the full magnitude and scope of the digital transformation. However, digital technologies can be part of the solution as they generate enormous flows of information. Numerous online actions leave digital "footprints" that can be observed using tools that scan, interpret, filter, gather and organise information from across the Internet. While they offer great opportunities for statistics, Internet-based data also raise a number of issues regarding statistical quality, security and privacy that must be addressed. The Internet also enables the creation of non-physical organisations and the flexible outsourcing of business activities, within sectors of activity and across locations, thus blurring the boundaries between firms and markets and between work and social life. This creates challenges for current methods of collecting statistics. New interdisciplinary methods of analysis are therefore necessary to understand innovative behaviour, its determinants and its impacts at the level of the individual and the organisation.

NSOs, regulators, Internet Service Providers (ISPs), the research community, the Internet community and international organisations are invited to work together to:

- Further develop international statistical standards for the collection of Internet-based data and their compilation into statistical indicators (e.g. treatment of web search results).
- Assess alternative models of co-operation among businesses, Internet intermediaries and NSOs for the collection and treatment of Internet-based data; and promote the development of an associated regulatory framework, including technical and regulatory solutions, to preserve user security and privacy.
- Develop interdisciplinary approaches to data collection and new units of data collection.
- Improve the measurement of digital activities in complex business structures, organisations and networks.

Action 5
Monitor technologies underpinning the digital transformation, notably the Internet of Things, AI and Blockchain

A range of rapidly developing technologies are set to drive the next phase of the digital transformation. The Internet of Things (IoT), an ecosystem in which applications and services are driven by data collected from devices that act as sensors and interface with the physical world, is expected to grow exponentially, connecting many billions of devices within a relatively short time. IoT applications span economic sectors including: health, education, agriculture, transportation, manufacturing, electric grids and many more. Meanwhile, artificial intelligence (AI) has the potential to revolutionise production as well as contribute to tackling global challenges related to health, transport and the environment. Blockchain likewise has the potential to transform the functioning of a wide range of industries and applications such as finance, health, transportation, agriculture, environment and supply chain management. The general purpose and interdisciplinary nature of these digital technologies underscores the need for a consistent framework to define them, identify their emergence, monitor their development and diffusion, and quantify their economic and social impacts.

Policy makers, regulatory authorities, business, statistical and research communities are encouraged to:

- Develop internationally harmonised definitions and taxonomies for AI and Blockchain, fit for the purpose of monitoring the development of these technologies and their applications, including defining the key policy needs for measurement.
- Build on the OECD definition of IoT (OECD, 2018) and related taxonomies for its application domains (e.g. massive machine communications such as sensors for smart cities, critical IoT requiring ultra-fast and highly reliable connections such as automated vehicles); and provide clear prioritisation for the measurement of those IoT elements and indicators of most relevance to policy makers, beyond simple counts of machine-to-machine connected devices, in order to measure the potential demands IoT might create for communication infrastructures due to the flow of large amounts of data generated.
- Engage with stakeholders within the IoT ecosystem (e.g. different connectivity providers, IoT platform providers, etc.) for the benefit of data collection and policy and regulatory analysis.
- Develop tools to monitor the adoption of IoT, AI and Blockchain technologies by businesses and the impact of their diffusion on performance and productivity.

Action 6
Improve the measurement of data and data flows

In recent years, both the scale of data usage and its importance for many business models and processes has increased exponentially. However, there are significant challenges involved in evaluating data as an input to production and their "asset-like qualities". Data flows between organisations in particular can take place quickly and at low cost. Moreover, different organisations can derive value from the same data, at the same time, without diminishing what others can do with them. Finally, the value of data is heavily context-dependent (e.g. on the information contained and how it is used). The combination of these factors results in many conceptual and practical measurement challenges. These are further amplified by the fact – linked in part to the proliferation of cloud computing services – that these flows and interactions commonly occur across national boundaries.

The statistical, business and research communities, and international organisations are encouraged to work together to:

- Develop pertinent taxonomies and classifications of data for statistical measurement purposes.
- Further study the role and nature of data in business models and processes.
- Explore methods for measuring data flows and stocks.
- Improve the measurement of knowledge-based assets including data and their role for production, productivity and competitiveness.

Action 7
Define and measure skills needs for the digital transformation

The development of the digital economy and its applications, such as "Big data" analytics, cloud computing and mobile applications, increases the demand for certain skills that are often in short supply. At work, a shortage of ICT specialists may be compounded by managerial obstacles to the development of new business models, new organisational structures and new working methods. At the same time, demand is rising for complementary skills, such as the capability to compile and analyse information, communicate on social networks, brand products on e-commerce platforms and so on. This trend also heightens the need for users to learn how to search and choose among a myriad of mobile applications and to know how to protect themselves against digital security risks ("digital hygiene").

Traditionally, official statistics have used educational attainment, vocational training with standardised content, or occupational categories with codified and predictable tasks as a proxy for skills. New insights could be gained by exploiting and harmonising detailed national surveys on tasks and skills and by working with the business community to define new metrics of skill shortages.

The statistical, business and research communities, and international organisations are encouraged to work together to:

- Exploit the potential of existing public and private statistics on skills, and occupation and industry classifications, and to promote the harmonisation of national job tasks surveys.
- Better exploit existing cross-country surveys (e.g. the European Survey of Working Conditions and the OECD Programme for the International Assessment of Adult Competencies), and promote the linking of employer-employee datasets containing information on skills, jobs and activities at the individual level.
- Improve access to and the use of online vacancy datasets to measure vacancies in digital-related jobs, their duration and rate of filling.
- Encourage the systematic use of expert assessment to identify emerging skills needs at a detailed level of tasks and occupations, and across different countries.

Action 8
Measure trust in online environments

Management of security, privacy and consumer protection risk online, as well as the general level of trust of the population in online environments, have become key policy issues as individuals, businesses and governments shift large parts of their daily activities to the Internet. While efforts have been made to improve the measurement of trust, such as the harmonisation of statistics from Computer Security Incidents Response Teams (CSIRTs) and a consumer survey of attitudes to trust in peer platform markets, other avenues should be explored further. For instance, the OECD has developed an analytical framework for measuring digital security risk management practices in businesses, based on the Principles contained in its 2015 Council Recommendation on Digital Security Risk Management for Economic and Social Prosperity. This framework has led to the identification of a set of potential core indicators. Work is also ongoing to improve the international comparability of personal data breach notification statistics, which are produced by Privacy Enforcement Authorities (PEAs). Despite the broadly acknowledged importance of trust between partners in online exchanges, measurement of these aspects of trust is not a longstanding practice, especially within official statistics. Alternative approaches currently underway utilise behavioural insights from experiments, for example, to ascertain how disclosures impact consumer trust in the context of personalised pricing in e-commerce. Internet-based data (e.g. malware activities recorded by a firewall, use of sentiment analysis on social media to measure people's trust, cookie statistics, browser settings or statistics on downloads of security/privacy-related software) could also be used to measure various aspects of trust.

The statistical community, regulators and other stakeholders, such as Internet intermediaries, business and consumer associations, and international organisations are invited to work together to:

- Develop guidance for PEAs to produce and report internationally comparable statistics on data breach notification.
- Develop a more reliable and comprehensive dataset on digital security incidents and digital risk management practice, key elements of which include reaching a consensus on typology and taxonomy, the creation of a trusted public-private digital security incident repository, and incentives to promote the reporting of incidents and data sharing by organisations.
- Test and improve the quality and rate of response of digital security-related surveys.
- Further study consumer attitudes and behaviour to highlight contexts where trust in online interactions increases or decreases, with a view to improving survey methodology in this area.
- Develop a framework for measuring individuals' trust in online environments, and explore survey-based and experimental approaches to test the feasibility of measuring this trust.
- Explore the use of Internet-based statistics to measure trust-related aspects and promote a statistical quality framework for Internet-based data.

Action 9
Establish an impact assessment framework for digital governments

Governments are progressively adopting digital technologies to encourage innovation in service design, operation and delivery. The move from using digital technologies to improve efficiency (e-government) to using them to influence and shape public governance outcomes (digital government) should enable governments to better respond to broader policy imperatives such as public trust, social well-being and civic engagement. To address the challenges and seize the opportunities of the digital age, governments should prioritise the establishment of an impact assessment framework to measure the concrete contribution of digital government to broader policy outcomes.

Policy makers, the statistical and research communities, and international organisations are encouraged to work together to:

Develop new statistical tools to assess the effects of digital technologies on the relationship between governments and citizens and businesses, taking into special consideration the extent to which key groups are impacted (e.g. seniors, low-income households, single parents, those with disabilities or mental health issues and so on), and providing evidence on the overall level of public trust in government.

- Define metrics to assess the effect of digital technologies on driving more efficient, inclusive and tailored public service delivery.
- Develop metrics to measure the impacts of existing practices and policies to promote public sector data sharing, access and re-use, including with regard to citizens' trust in the ability of governments to handle personal data.
- Establish guidelines for public sector organisations to measure the scope and impact of data re-use in public administrations and on public policy-making processes.
- Measure the diffusion of emerging technologies such as AI and Blockchain within government processes and services.
- Evaluate potential barriers to the full integration of digital technologies within government.

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Chapter 1

TRENDS IN THE DIGITAL ERA

1.1 Technology trends

- At the digital frontier
- Digital technology waves
- AI technologies
- AI-related applications
- Mapping AI companies
- AI companies in key sectors
- The science behind AI
- Scientific excellence in AI
- Faster and cheaper
- Network and content
- The global data infrastructure
- Data at the centre
- Cloud and software

The digital revolution continues apace. Text-mining techniques are enabling fast-accelerating digital technologies to be identified. Measuring the development of artificial intelligence (AI) is challenging as the boundaries between AI and other innovations are blurred and change over time, but experimental work leveraging the expert community is leading to definitions of AI-related science and technologies. Patent databases are being used to identify the main fields in which AI is being applied, and web footprints are being leveraged to identify companies developing and using AI, as well as to examine their applications throughout the economy. In addition, bibliometric analysis is being used to reveal who precisely is leading in AI-related science. Thanks to sustained technological progress, growth in network capacity and decreasing costs of ICT products, more content can be accommodated on Internet infrastructure. Moreover, as bandwidth for data transmission increases, flows of information generated by digital technologies and digitally enabled activities are growing at an unprecedented pace and data centres are becoming a critical infrastructure underpinning the digital transformation.

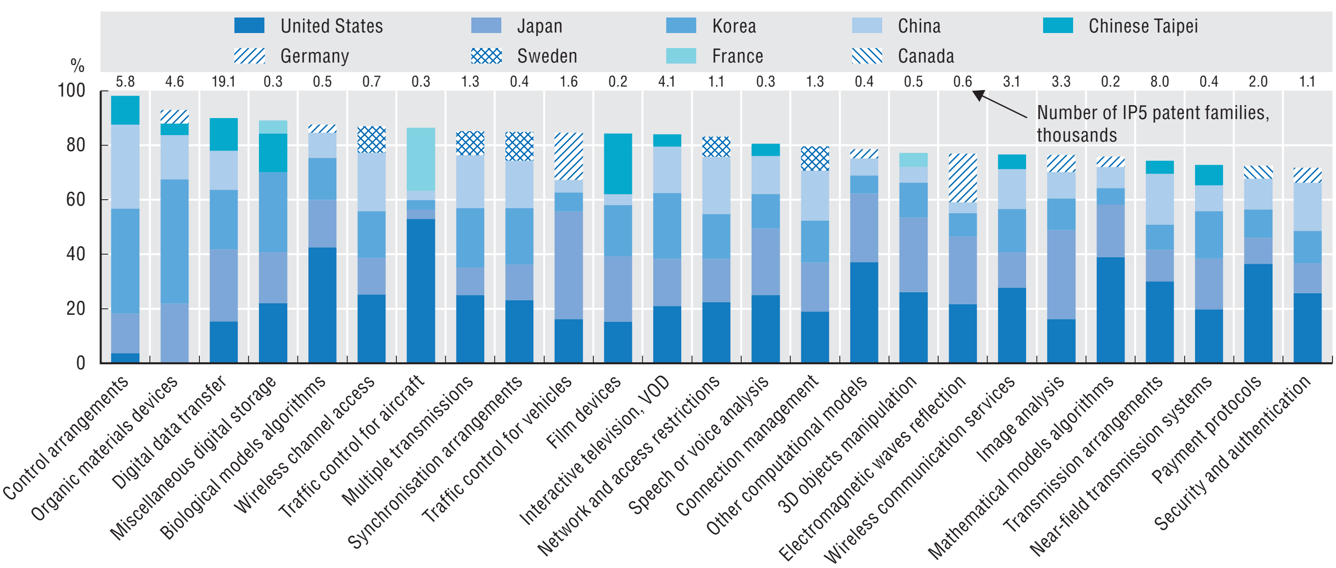
At the digital frontier

Five economies account for most developments at the digital technology frontier. 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. Digital technologies are an example of fast-accelerating 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 (OECD, 2017). The OECD used a data-mining approach to monitor the extent to which different ICT fields emerge and develop, and to identify fast-accelerating technologies. Over 2013-16, five economies accounted for 72% to 98% of the top 25 fast-accelerating digital technologies. Japan and Korea contributed to the development of all ICT fields in which development accelerated during this period, together accounting for 7% to about 68% of all patenting activities in these ICT fields. The United States led the development of digital technologies related to aircraft traffic control (53%) and to algorithms based on biological models (43%) and mathematical models (39%). The People's Republic of China (hereafter "China") was among the top-five economies developing technologies in most fast-accelerating ICT fields, and was particularly active in control arrangements (31%) and wireless channel access, as well as in network and access restriction techniques (21%). A few European economies, namely Sweden, Germany and France, also featured among the top five players in emerging digital technologies.

1. Top players in emerging digital technologies, 2013-16

Share of top five economies' patents in top 25 technologies fast accelerating from 2010 onwards



Source: OECD, STI Micro-data Lab: Intellectual Property Database, http://oe.cd/ipstats, January 2019. See chapter notes. StatLink contains more data.

StatLink https://doi.org/10.1787/888933928293

Identifying acceleration in technological development

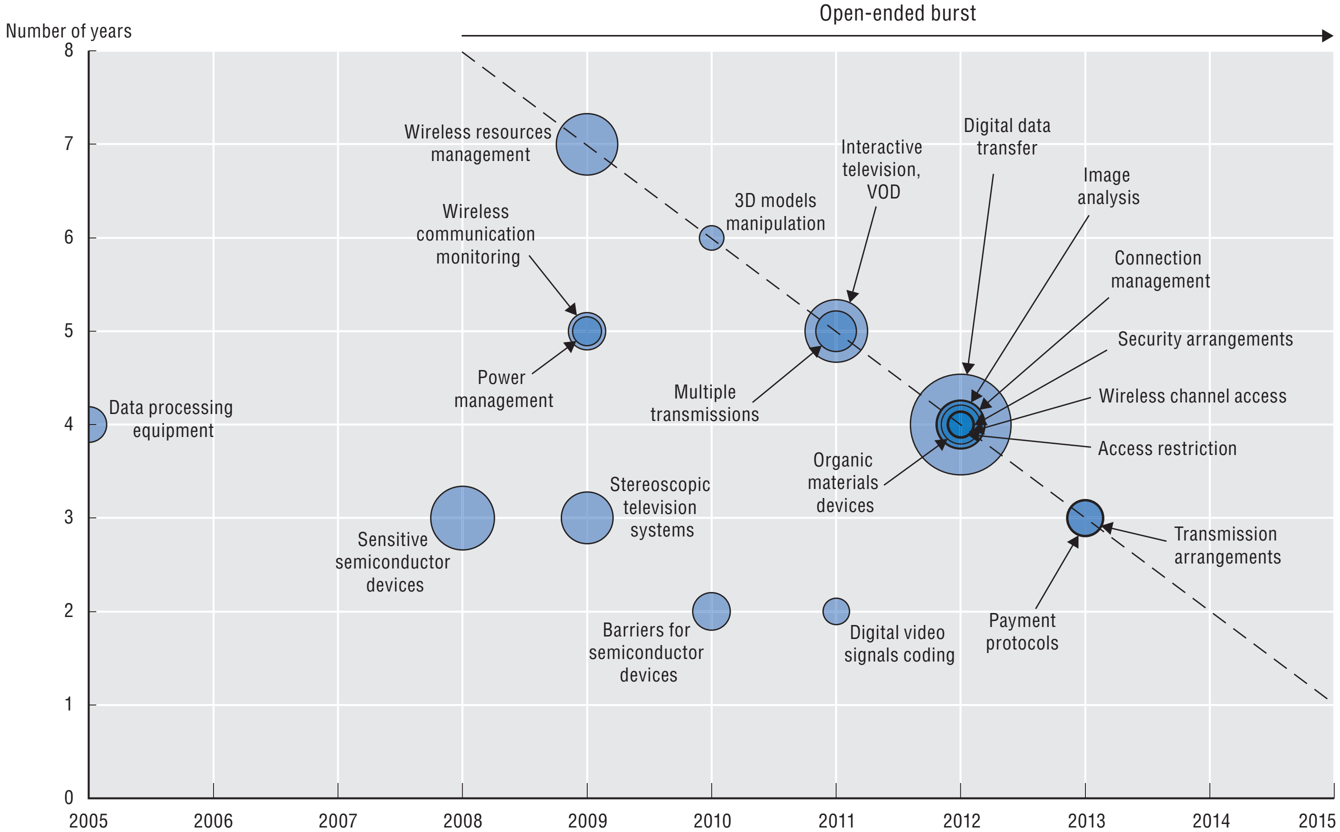
Patents protect novel technological inventions. Patent data can thus help investigate a number of policy-relevant issues related to innovation and technological development. A data-mining approach called "DETECTS" (see Dernis et al., 2016) exploits information contained in patents to identify technologies in which development increases sharply 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 accelerate when a substantial increase in the number of patents filed in that field is observed. Monitoring fields in which accelerations of technological developments occur is important 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 technological trajectories arising from the cross-fertilisation of different technologies (e.g. ICT and environmental technologies).

Digital technology waves

The general-purpose nature of digital technologies increases their development speed and sustains their acceleration over time as they find new areas of application. Analysis focusing on ICT-related fields over the period 2005-15 reveals the sequence of technological developments occurring during that decade, the extent to which some ICT fields saw development accelerate and the length of the period during which such accelerations were sustained. In the mid-2000s, activities burgeoned in the field of data-processing equipment, whereas the late 2000s saw accelerations in semi-conductor and wireless communications. Since 2012, inventions patented in the top-five Intellectual Property offices worldwide (IP5) and related to digital data transfer experienced a persistent acceleration of unprecedented intensity, at an average growth rate of 19% a year. During the last part of the period considered, domains linked to organic materials devices, image analysis, connection, transmission, or security management experienced accelerated development. Compared to those observed at the beginning of the period, recent accelerations in the pace of development seem to last longer and consist of a higher number of inventions.

2. Intensity and development speed in ICT-related technologies, 2005-15

Intensity of accelerations (bubble size) and duration over time



Source: OECD, STI Micro-data Lab: Intellectual Property Database, http://oe.cd/ipstats, January 2019. See chapter notes. StatLink contains more data.

StatLink https://doi.org/10.1787/888933928312

How to read this figure

A larger bubble indicates a greater intensity of acceleration (i.e. the pace at which the technology accelerates), and the different shades indicate different technologies that start to accelerate at the same time. The X axis indicates the year in which technologies start to accelerate, and the Y axis displays the number of years during which technologies continued to burst. For example, acceleration in the development of patented technologies related to data-processing equipment (on the left) was first observed in 2005 (X axis), and lasted for four years (Y axis), until the end of 2009. Bubbles located along the diagonal line on the right-hand side of the figure represent technologies that were still developing at an accelerated pace at the end of the sample period. Among ICT technologies that began to accelerate in 2012 are those related to digital data transfer, organic materials devices, image analysis and connection management. 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 2015.

AI technologies

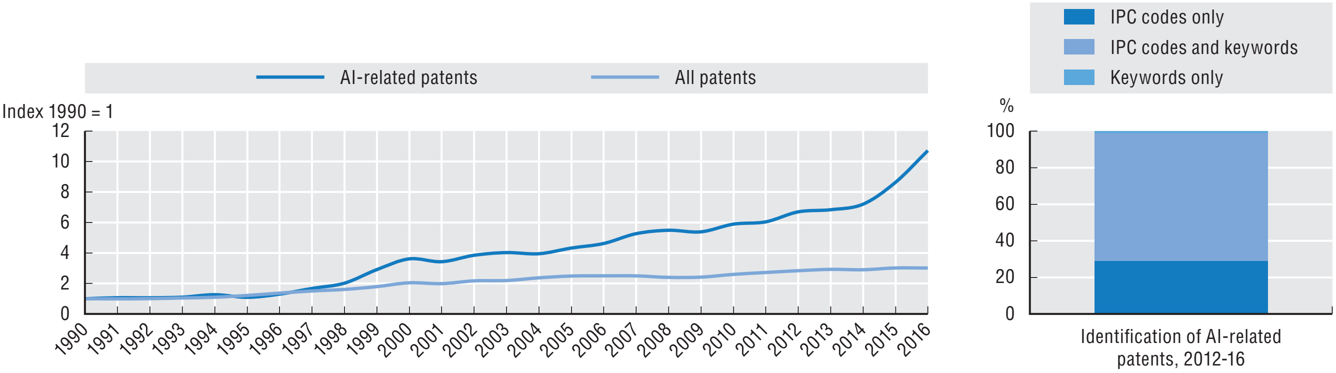
AI-related inventions have accelerated since 2010 and continue to grow at a much faster pace than is observed on average across all patent domains. Artificial intelligence (AI) is a term used to describe machines performing human-like cognitive functions (e.g. learning, understanding, reasoning, or interacting). It has the potential to revolutionise production as well as to contribute to tackling global challenges related to health, transport, and the environment (OECD, 2017). AI developments began in the 1950s, when pioneers in computing, mathematics, psychology, and statistics set out to solve some concrete problems in order to make machines that can "think" (Turing, 1950). These included playing games, classifying images, and understanding natural language. Technologies developed by AI researchers became extremely valuable in themselves, as well as for many other purposes. One such technology is machine learning (ML), a relatively recent development in the history of AI technologies that uses a statistical approach to identify patterns in large datasets. ML and other AI-related developments, coupled with technologies such as Big data analytics and cloud computing, are strengthening the potential impact of AI (OECD, 2019a).

The multifaceted nature of AI and its rapid evolution over time make it challenging to clearly identify and measure AI-related technological developments. An experimental three-pronged approach is pursued here, whereby patent classification codes, key words obtained from an analysis of AI-related scientific publications, and a combination of the two, have been used to search patent documents to identify AI-related inventions protected through patents. About one-third of AI patents were identified using patent classification codes only, whereas the bulk of such inventions was detected through the joint use of codes and keywords.

Data on inventions protected in the top-five Intellectual Property offices (IP5) worldwide show that the development of AI-related technologies continued at a sustained pace over the period 1990-2016. The number of AI-related patents grew more than tenfold during the period considered, a much faster pace than that observed on average across all patent domains. As measured by the patent data, technological developments in AI have accelerated since 2010.

3. Technology developments in artificial intelligence, 1990-2016

Index 1990 = 1 based on the number of IP5 patent families



Source: OECD, STI Micro-data Lab: Intellectual Property Database, http://oe.cd/ipstats January 2019. See chapter notes.

StatLink https://doi.org/10.1787/888933928331

How can AI-related developments in science and technology be tracked?

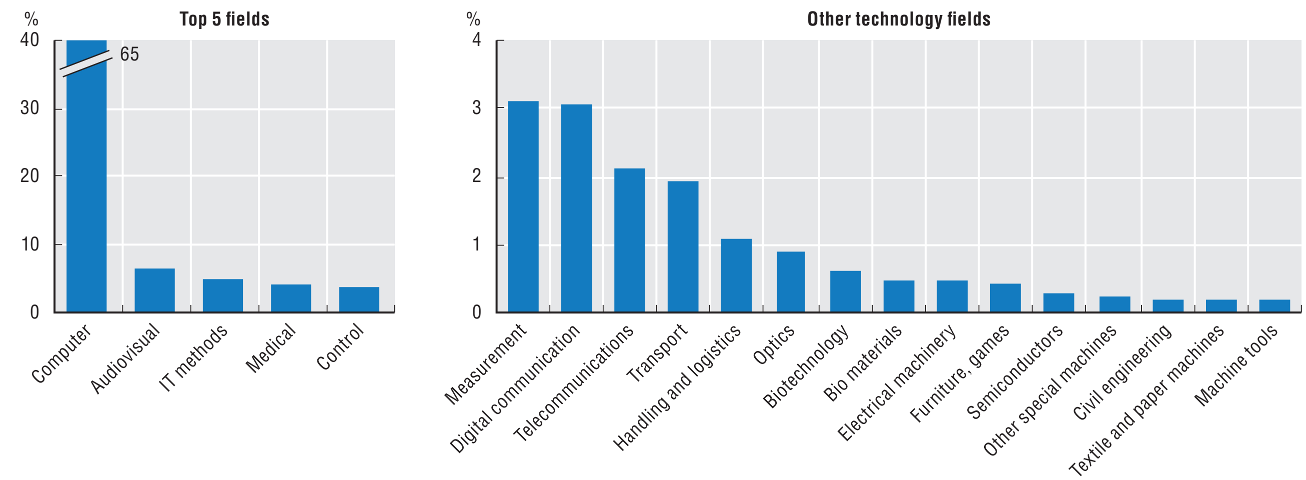
Artificial Intelligence refers to a machine-based system that is capable of influencing the environment by making recommendations, predictions or decisions for a given set of objectives. It does so by utilising machine and/or human-based inputs to: i) perceive real and/or virtual environments; ii) abstract such perceptions into models manually or automatically; and iii) use model interpretations to formulate options for outcomes (OECD, 2019b). Measuring the development of AI is challenging as the boundaries between AI and other innovations are blurred and change over time. Experimental work by the OECD and the Max Planck Institute for Innovation and Competition (MPI) relies on a three-pronged approach aimed at measuring AI developments in: science, as captured in scientific publications; technological developments, as proxied by patents; and software, in particular open source software. The approach entails identifying documents (publications, patents and software) which are unambiguously AI-related, using expert advice and assessing the similarity of other documents to those unambiguously considered as AI-related. The patent-based approach initially developed by the OECD and MPI has been further refined through work carried out under the aegis of the OECD-led Intellectual Property (IP) Statistics Task Force, and benefitting in particular from the advice of experts and patent examiners from IP Australia, the Canadian Intellectual Property Office (CIPO), the European Patent Office (EPO), the Israel Patent Office (ILPO), the Italian Patent and Trademark Office (UIBM), the National Institute for Industrial Property of Chile (INAPI), the United Kingdom Intellectual Property Office (UK IPO), and the United States Patent and Trademark Office (USPTO).

AI-related applications

AI-related innovations are being applied to a wide range of fields. An examination of the technology fields on which AI-related patents rely shows that AI technologies are naturally rooted in computer technologies, and are frequently associated with developments in audiovisual technologies, IT methods, and medical technologies. Among the variety of technological areas most often combined with AI are pattern recognition, image analysis, and speech recognition. Specific types of algorithm (e.g. for biological models, knowledge-based systems, and machine learning) accounted for about one-fifth of AI-related developments during the period 2012-16. Image analysis, biological model algorithms and other computational models are among the areas showing an increasing reliance on AI-related components.

4. Top fields of application of AI-related technologies, 2012-16

Share of application fields in AI-related patents, IP5 patent families

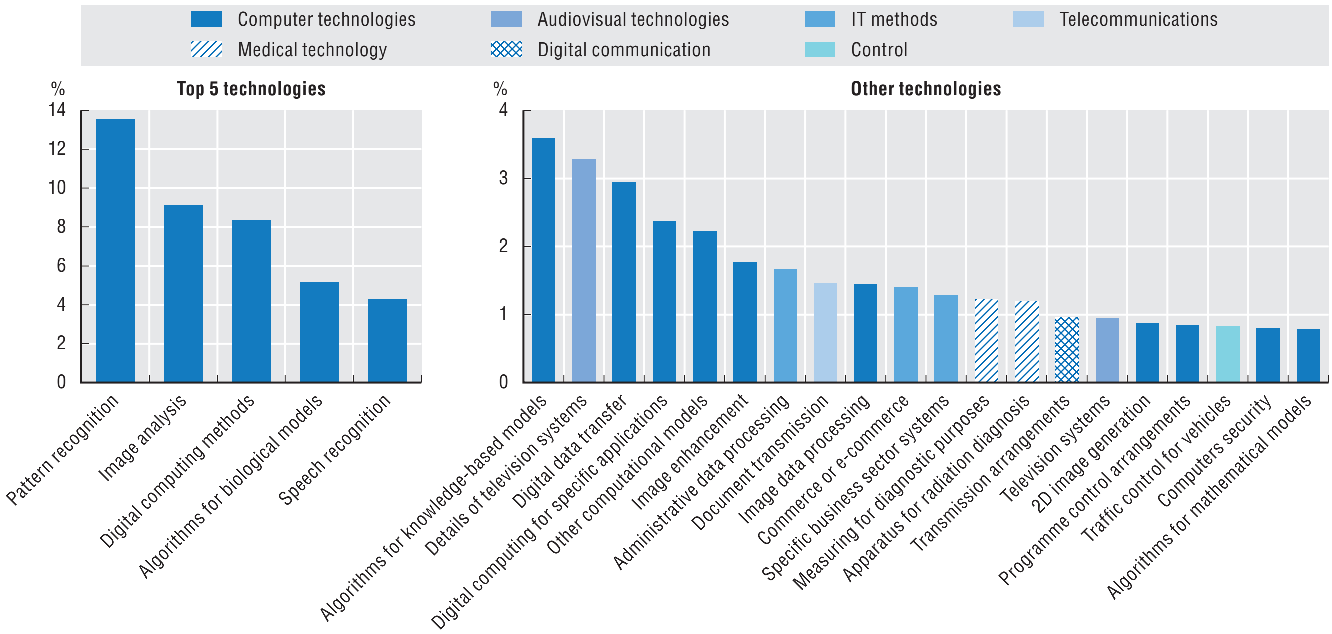


Source: OECD, STI Micro-data Lab: Intellectual Property Database, http://oe.cd/ipstats January 2019. See chapter notes. StatLink contains more data.

StatLink https://doi.org/10.1787/888933928350

5. Top technologies combined with artificial intelligence, by field of application, 2012-16

Share of technology (IPC) classes in AI-related patents, IP5 patent families



Source: OECD, STI Micro-data Lab: Intellectual Property Database, http://oe.cd/ipstats January 2019. See chapter notes. StatLink contains more data.

StatLink https://doi.org/10.1787/888933928369

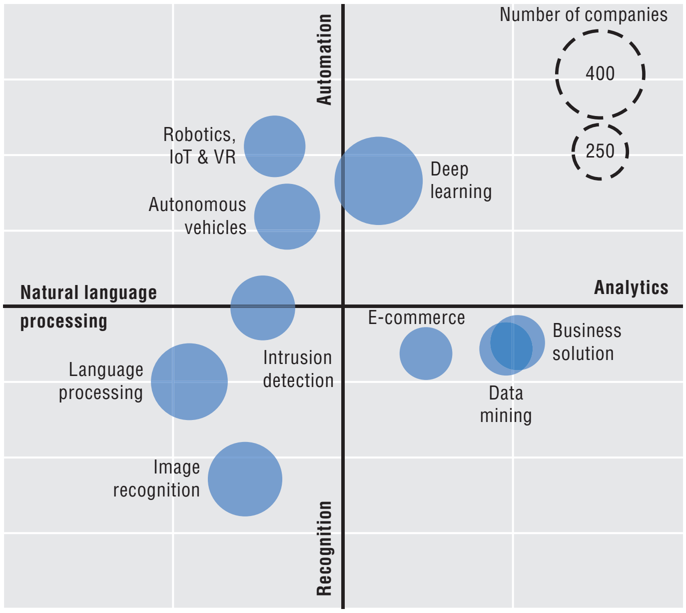
Mapping AI companies

AI companies in different industries are developing and applying a variety of AI-related technologies. Artificial intelligence (AI) is permeating all sectors of the economy. However, little is known about the specific types of AI technologies and approaches being used in each sector, or the purposes for which they are being developed.

In 2018, there were about 6 000 AI-related companies in the United Kingdom alone, according to data from Glass AI, a company that interprets open web text (i.e. sentences and paragraphs) at scale. About 2 800 of these companies make explicit mention of AI activities on their website. These companies appear to combine different AI-related technologies and approaches, depending on their field of application or area of activity. For instance, about 400 companies focus on deep learning, and rely on automation-related technologies and, to a lesser extent, data analytics. About 300 companies currently advancing the use of AI in robotics, the Internet of Things (IoT) and virtual reality (VR) are concentrating on automation and, to a lesser extent, natural language processing. About 250 AI companies are directing their attention to analytics coupled with recognition-related technologies with a view to developing e-commerce-related AI technologies. A similar number of companies rely on different combinations of the same technologies for data mining and business solution-related developments.

6. AI-related companies in the United Kingdom, by focus of activity, 2018

Principal components projection of UK AI-related companies



Source: OECD calculations based on Glass.ai data, January 2019. See chapter notes. StatLink contains more data.

StatLink https://doi.org/10.1787/888933928388

Mapping AI technologies and applications through topic modelling

Glass AI identifies AI companies by searching for AI-related keywords across an organisation's website, including in sections such as "News", "About us" and so on. The bubbles in the chart and the names on the axis are the outcome of a topic modelling exercise. This was performed on the business descriptions of 2 800 companies in the Glass sample that explicitly state on their website that they are active in AI. Based on the Latent Dirichlet Allocation algorithm and Gibbs sampling, the topic modelling exercise grouped companies into nine broad themes ("Topics"). Topics were identified on the basis of the frequency and combination of words contained in the business description of the companies, and their probability of belonging to one or more of the topics (with the sum of probabilities equal to 1). The topics represented on the axis were labelled on the basis of principal component analysis and the frequency with which words featured together in a given topic. The size of the bubbles mirrors the number of companies active in any of the topics identified.

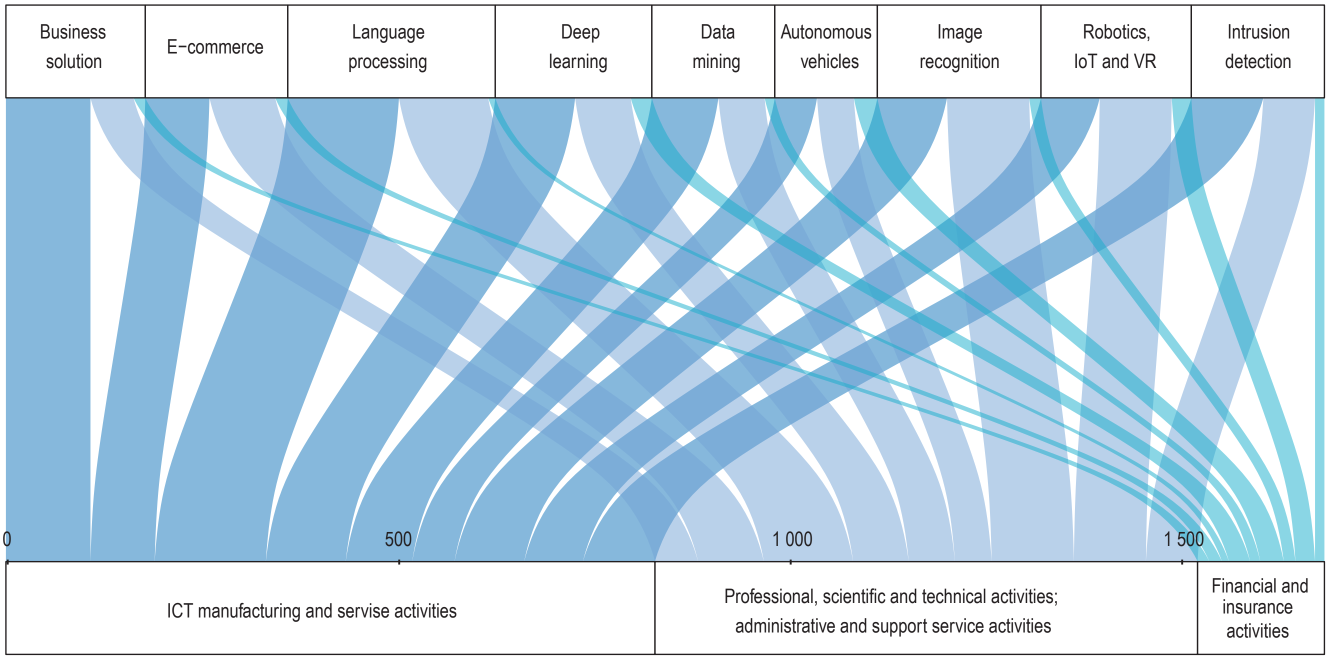
AI companies in key sectors

Companies engaging in AI-related activities belong to a wide range of sectors. More insights about the types of AI technologies that these companies are developing and applying can be gained by focusing on a few key sectors of the UK economy. In particular, *Financial services*, *Professional services*, and *ICT manufacturing and service activities* accounted for 22.7% of total employment (7.3 million persons, up from 6.0 million in 2010) and for 53% of investment (i.e. gross fixed capital formation, GFCF) in ICT equipment in 2017.

Of the 2 800 UK companies in the Glass AI sample which stated that they were actively pursuing AI-related activities, 829 appear to operate in *ICT manufacturing and services activities*, 693 in *Professional services* activities and 162 in *Financial and insurance* activities, representing 60% of the sample. The other 40% is distributed across ten sectors ranging from agriculture to real estate and construction. Some of these companies are developing and using several types of AI-related technologies, whereas others appear to be focused on a specific area. In addition, different technologies appear to be developed to relatively different extents. UK AI-active companies in *ICT manufacturing and services* are focusing their efforts on technologies related to language processing, business solutions, and deep learning. Companies in *Professional services* are especially concerned with language processing, image recognition and robotics, Internet of Things (IoT), and virtual reality-related technologies. Finally, *Finance and insurance* companies appear to be especially active in autonomous vehicles-related technologies, deep learning, robotics, IoT, and virtual reality.

7. AI-related technologies developed by UK companies, by sector, 2018

Companies in ICT, professional and financial activities



Source: OECD calculations based on Glass.ai data, January 2019. See chapter notes.

StatLink https://doi.org/10.1787/888933928407

Assigning firms to sectors

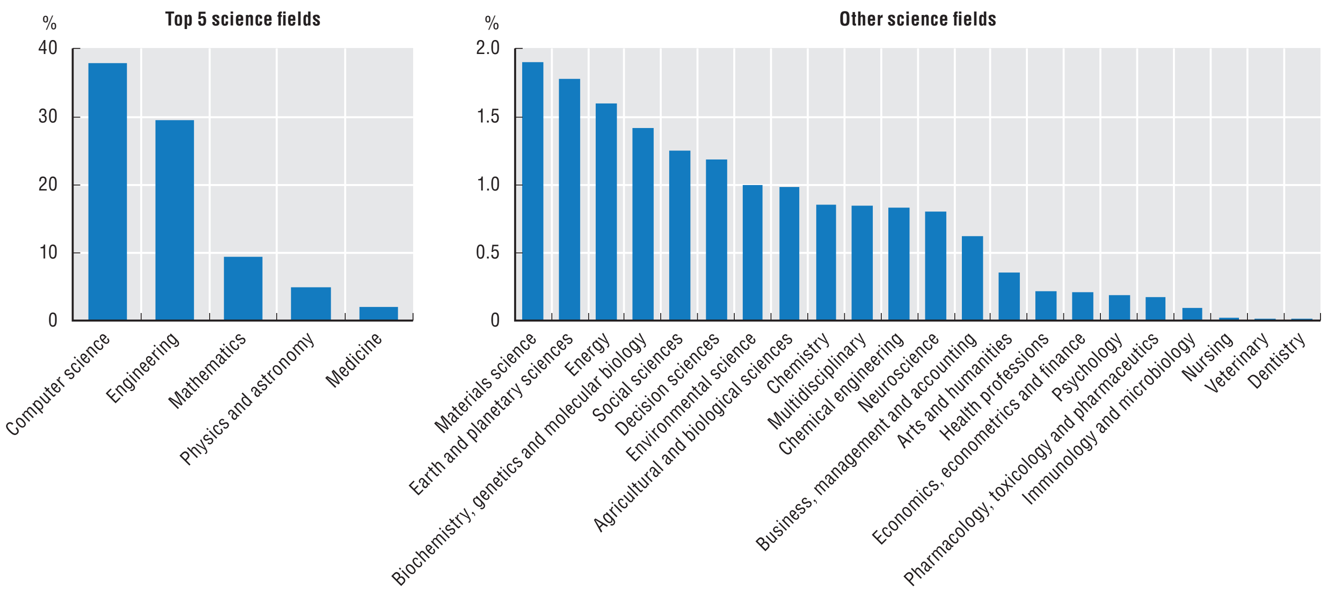
The companies in the Glass AI sample have been assigned to industrial sectors on the basis of a semantic analysis of the text provided on their websites. *Financial services* correspond to sector 64-66 "Financial and insurance activities" (i.e. section K) of ISIC Rev.4; *Professional services* correspond to sectors 69-75, 78 and 80-82 of ISIC Rev.4; and ICT manufacturing and service activities correspond to sectors 26, 61 and 62-63 of ISIC Rev.4 classification.

The science behind AI

Scientific advances related to AI are not confined to computer sciences. 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, the availability of data, and algorithms have raised the capabilities of AI, with its performance increasingly resembling that of humans in some narrow fields. Such advances enabled IBM's Deep Blue computer to beat world chess champion Garry Kasparov in 1997 and have allowed computers to distinguish between objects and text in images and videos with growing accuracy (OECD, 2017). Over the last two decades, different scientific domains have contributed to advances in AI. Text mining of keywords shows that computer science is the scientific field making the largest contribution to AI-related science: it accounts for slightly more than one-third of all AI-related documents published between 1996 and 2016. More than a quarter of all AI-related scientific publications and conference proceedings have appeared in engineering outlets and close to 10% in mathematics. About 25% of the science involving AI (drawing on it or contributing to its general advancement) occurs in a wide array of other scientific disciplines, including physics and astronomy, earth and planetary sciences, materials science, medicine and environmental science, among others. This demonstrates the pervasiveness of this new data-driven paradigm.

8. The science behind AI, 1996-2016

Scientific fields for AI-related scientific documents as a percentage of all AI-related documents



Source: OECD calculations based on Scopus Custom Data, Elsevier, Version 1.2018, January 2019. See chapter notes.

StatLink https://doi.org/10.1787/888933928426

Identifying AI-related science

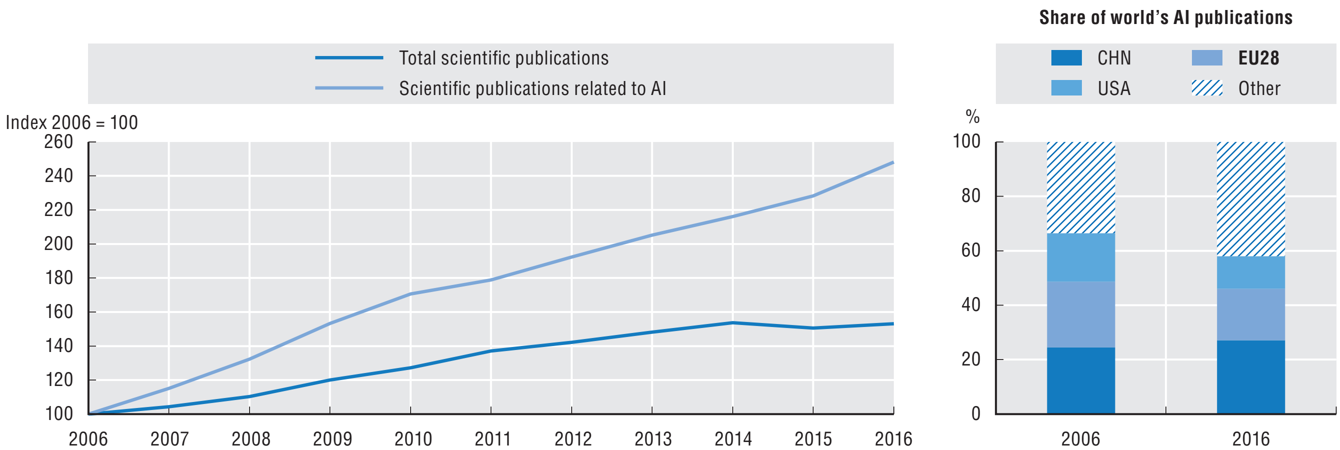
The bibliometric analysis shown here is based on data from Elsevier's Scopus®, a large abstract and citation database of peer-reviewed literature, which includes scientific journals, books and conference proceedings. The latter are particularly important in the case of emerging fields, helping to provide a more timely picture as developments are often discussed at peer-reviewed conferences prior to being published in other literature. The indicators shown here are experimental. AI-related documents (among Scopus-indexed articles, reviews and conference proceedings) are identified using a list of keywords searched for in the abstracts, titles and author-provided keywords of scientific documents. These keywords have been selected on the basis of high co-occurrence patterns with terms frequently used in journals classified as AI-focused by Elsevier. As some selected keywords may be used in non-AI settings, only those documents with two or more keywords were considered as being AI-related in order to prevent the inclusion of documents too weakly related to AI. More precise indicators could be obtained through text mining analysis of full text, but this is currently impossible for a comprehensive and representative set of scientific publications. Full text analysis could potentially allow a better distinction between AI use in science and the development of knowledge about AI itself.

Scientific excellence in AI

China produces the most AI-related scientific publications and is improving their quality. Scientific publishing related to AI has experienced a remarkable expansion over the 2006-2016 period. Since 2006, the annual volume of AI-related publications has grown by 150%, compared to 50% for the overall body of indexed scientific publications. China became the main producer of AI-related scientific publications as far back as 2006, and in 2016 had a global share of 27%. In turn, the shares accounted for by the EU28 and the United States declined over the same period to 19% and 12%, respectively. The fast growth of AI-related publishing in India (11% of the world total in 2016) has contributed to the growing share accounted for by other economies. As in other areas, different AI-related scientific publications have different levels of citation "impact", so it can be misleading to count all publications equally. The EU28 and the United States are still responsible for the greatest shares of highly cited AI-related publications (i.e. those featuring among the world's top 10% most cited publications). Their shares, however, declined between 2006 and 2016, from 29% to 25% for the EU28 and from 31% to 21% for the United States. China, India, Iran and Malaysia all more than doubled their share of top-cited AI publications over the past decade.

9. Trends in scientific publishing related to artificial intelligence, 2006-16

Index of publication counts, 2006 = 100

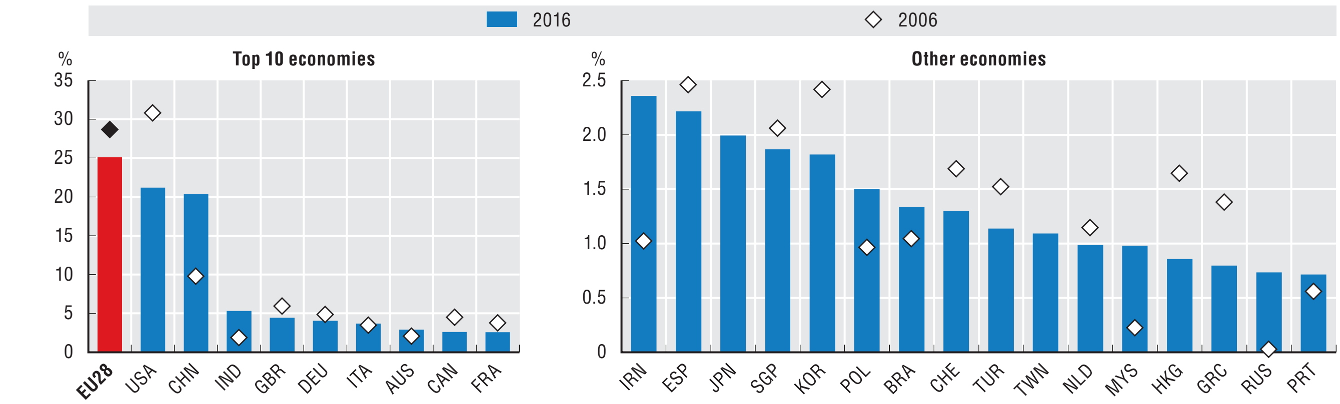


Source: OECD calculations based on Scopus Custom Data, Elsevier, Version 1.2018 and 2018 Scimago Journal Rank from the Scopus journal title list (accessed March 2018), January 2019. See chapter notes.

StatLink https://doi.org/10.1787/888933928445

10. Top-cited scientific publications related to AI, 2006 and 2016

Economies with the largest number of AI-related documents among the 10% most cited publications, fractional counts



Source: OECD calculations based on Scopus Custom Data, Elsevier, Version 1.2018 and 2018 Scimago Journal Rank from the Scopus journal title list (accessed March 2018), January 2019. See chapter notes. StatLink contains more data.

StatLink https://doi.org/10.1787/888933928464

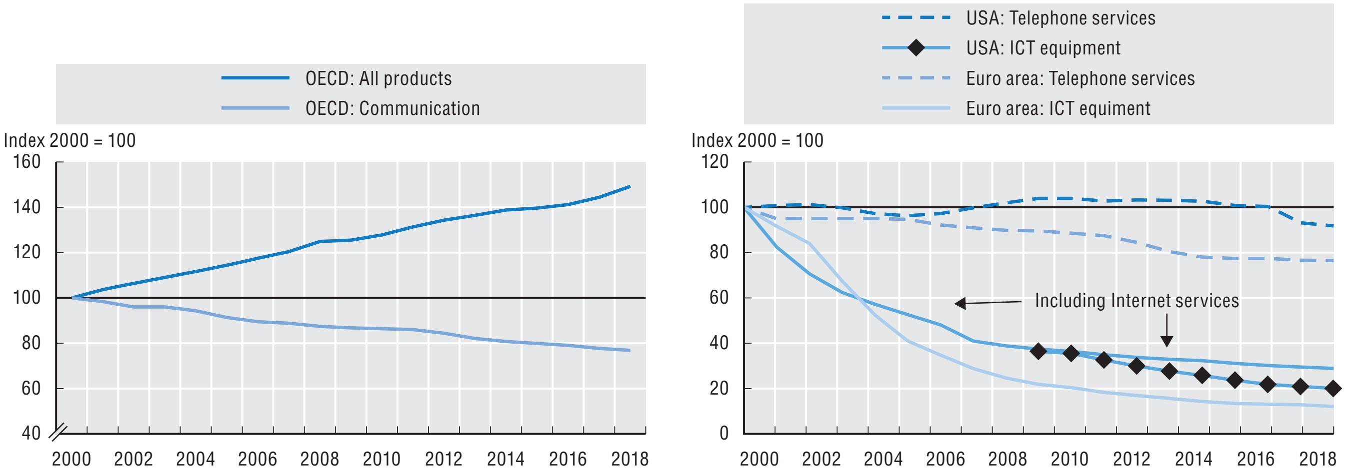
Faster and cheaper

Thanks to sustained technological progress, ICT products have become much cheaper and more powerful over time. These trends, coupled with the continuous widening of network availability, functionalities, applications and content have played a major role in promoting the use of ICT products. From 2000 to 2018, while consumer prices increased about 45% on average in the OECD area, the prices of communication-related products (i.e. excluding IT and media) decreased by more than 20%. Price dynamics vary between ICT goods and services. In the Euro area and the United States, for which detailed indices can be computed, prices decreased by 10% to 25% for telecommunication services and fell 80% or more for ICT goods.

The capabilities of digital products are rapidly evolving. Since the 1970s, the number of transistors per chip – a traditional way of considering improvements in computing power – has followed "Moore's law" by roughly doubling capacity every two years. This has been accompanied by concurrent miniaturisation: the length of the "transistor gate" is now around 7 nm, 1 500 times smaller than in the early 1970s, resulting in increased processing speed and improved energy efficiency. Storage capacity has also increased enormously, with the commercial price per Gigabyte diminishing from about USD 10 in 2000 to below USD 0.3 in 2018.

11. Consumer price indices, all products and ICT goods and services, OECD, Euro area and United States, 2000-18

Index 2000 = 100, unweighted OECD average

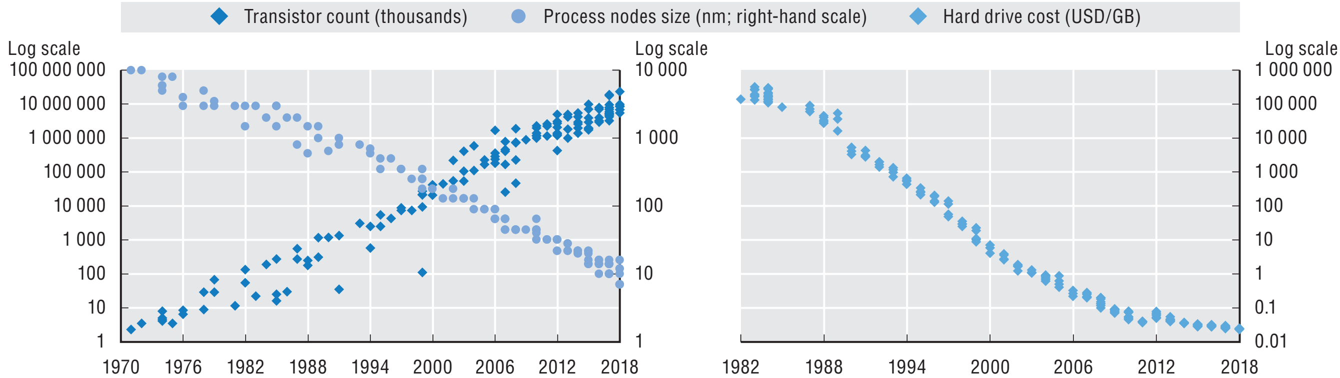


Source: OECD Consumer Price Indices (CPIs) Database; Eurostat, Harmonised Index of Consumer Prices (HICP) Statistics and United States Bureau of Labor Statistics, CPI-All Urban Consumers (Current Series), January 2019. See chapter notes. StatLink contains more data.

StatLink https://doi.org/10.1787/888933928483

12. Computing power and cost of storage, 1970-2018 and 1982-2018

Number of transistors per central processing unit (CPU) microprocessor and process size (left-hand panel), cost of storage per GB (right-hand panel)



Source: OECD based on Wikipedia, "Transistor count", www.wikipedia.org/wiki/Transistor_count; "A history of storage cost", www.mkomo.com/cost-per-gigabyte; "Disk drive prices 1955-2018", www.jcmit.net/diskprice.htm, January 2019. See chapter notes.

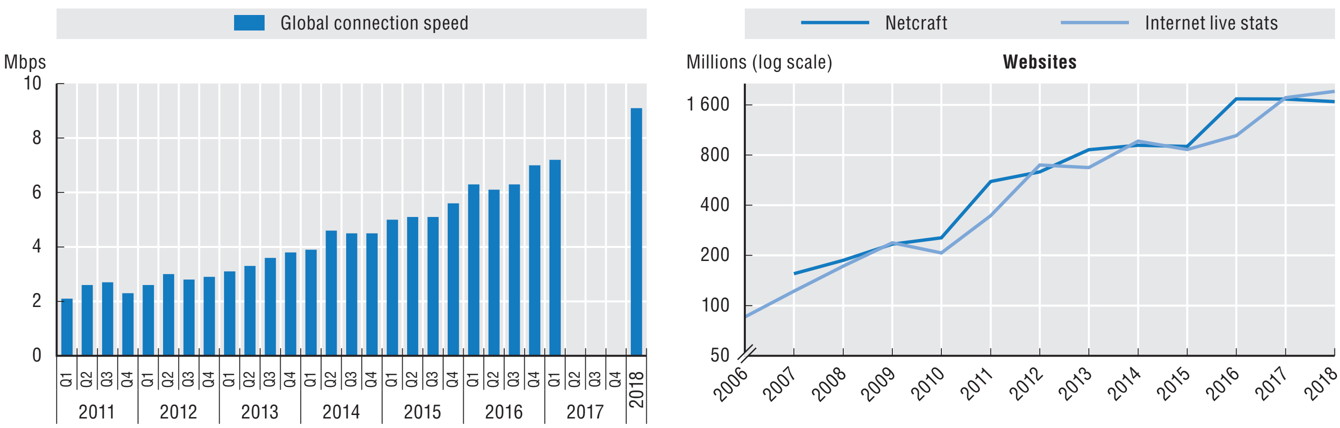
StatLink https://doi.org/10.1787/888933928502

Network and content

Infrastructure capacity is increasing, as is content. Mobile connectivity has undergone major improvements starting with the launch of 3G at the beginning of the millennium and followed by the introduction of 4G in the early 2010s. As a result, most OECD countries currently enjoy broad coverage, and 5G is now in the early stages of roll out. Wired connections have also become more widespread while deploying faster technologies such as fibre. According to commercial sources (Akamai and M-Lab), the average (fixed and mobile combined) global Internet connection speed increased from 2 Mbps to more than 9.1 Mbps between 2011 and 2018. Meanwhile, the total number of websites grew from about 100 million in 2006 to more than 1.6 billion in 2018, according to Netcraft. The number and growth of top-level domains (TLDs) associated to websites provides an indication of the increased content hosted by the Internet. TLDs grew from just above 90 million in 2005 to 280 million in 2014, and reached close to 350 million in the third quarter of 2018. By that time, the .com generic domain (gTLD) had reached 135 million, followed by the China (.cn) country domain (ccTLD), the volume of which doubled in four years to reach 23 million.

13. The increasing capacity of Internet infrastructure, 2005-18

Speed in Mbps, 2011-18 (left-hand panel), Top-level domains in millions, 2005-18 (right-hand panel)

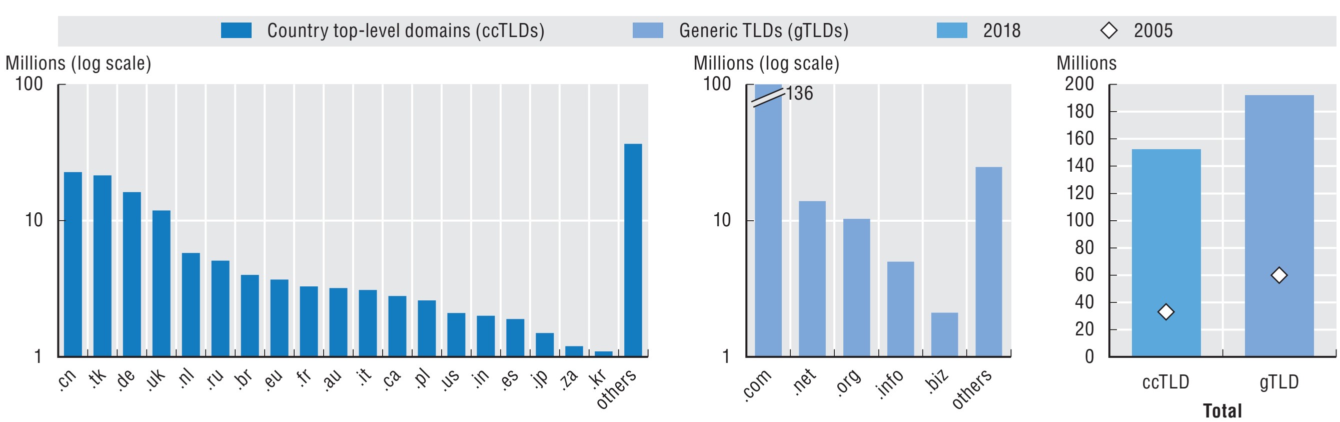


Note: These sources give only a partial perspective on developments in Internet speed. Please see pages 3.3 and 3.7 on the strengths and limitations of such sources.
Source: OECD based on Akamai, MLAB, Netcraft and Internet live stats, January 2019. See chapter notes.

StatLink https://doi.org/10.1787/888933928521

14. The increasing content hosted on the Internet, 2018

Top-level domains, millions



Note: Top-level domain (TLD) refers to the last segment of a domain name or the part that follows immediately after the "dot" symbol. TLDs are mainly classified into two categories: generic (g) and country-specific (cc) TLDs. In recent years, new gTLDs have been added to the older ("legacy") .com, .org, .net, .gov, .biz and .edu. TLDs.
Source: OECD based on Council of European National Top-level Domains Registries (CENTR), Verisign, Domaintools.com and national authorities, January 2019. See chapter notes. StatLink contains more data.

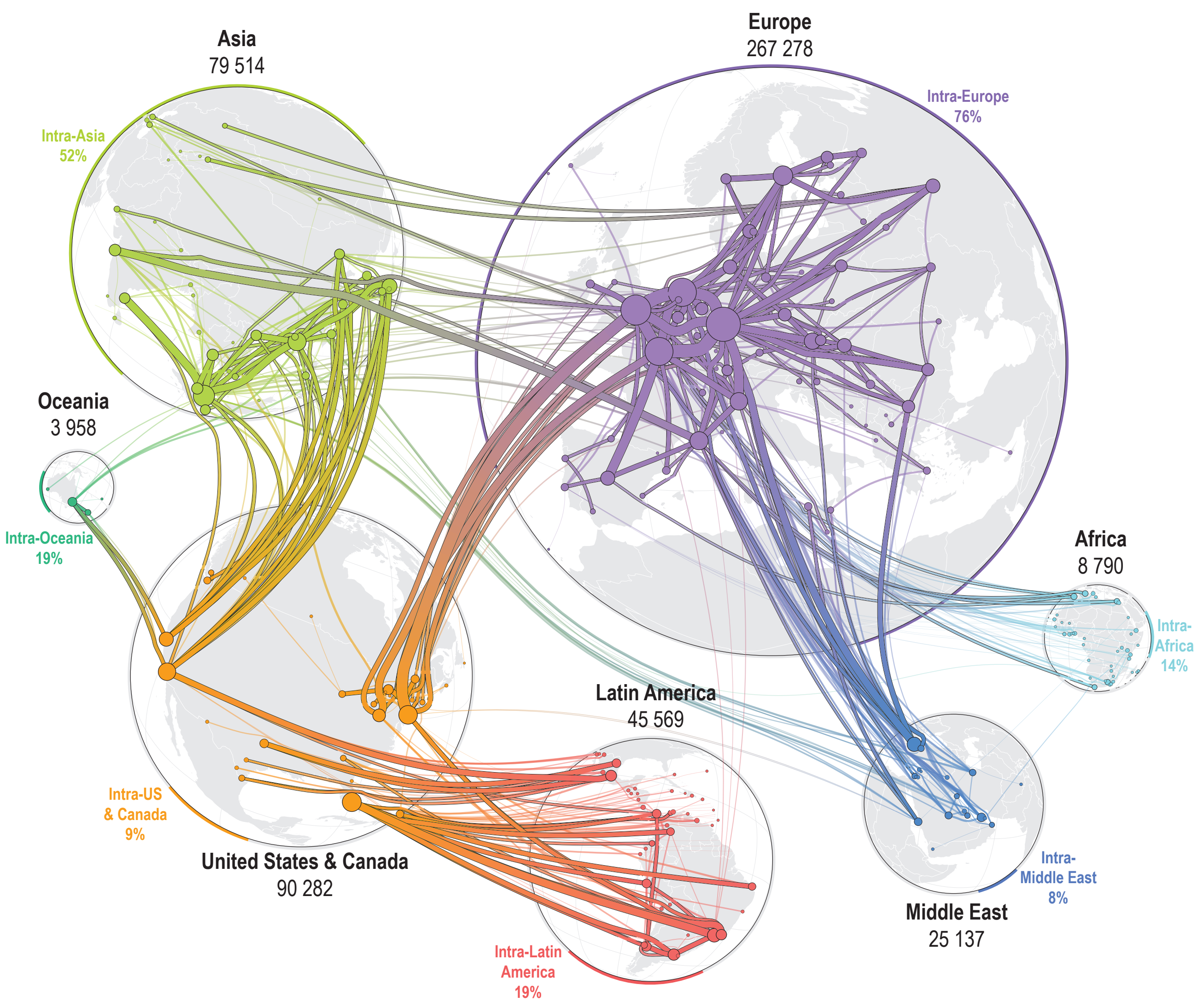
StatLink https://doi.org/10.1787/888933928540

The global data infrastructure

Capacity for data transmission is increasing everywhere, including developing economies. Cross-border data flows enable businesses to effectively co-ordinate their, supply, production, sales, after-sales, and research and development processes in global markets. At an inter-continental level, the bulk of data is transferred via sub-marine cables, making them a useful indicator of the volume of cross-border data flows. The Submarine Cable Map is an online resource provided and regularly updated by TeleGeography. According to these data, there were around 448 submarine cables in service in 2018, with a total length of roughly 1.2 million kilometres (Krisetya, Lairson and Mauldin, 2018a). Meanwhile, global Internet bandwidth reached 393 Tbps (Terabytes per second) in 2018, two-thirds of which has been deployed since 2014. Africa experienced the most rapid growth, with a compound annual rate of 45% between 2014 and 2018 (Krisetya, Lairson and Mauldin, 2018b). In 2018, 126 Tbps of capacity was inter-regional and 265 Tbps connected countries within each of the major world regions (see the Global Internet Map 2018).

15. Global Internet Map, 2018

International bandwidth between metropolitan areas



Source: Global Internet Map 2018, TeleGeography 2018, downloaded 17 January 2019.

How to read this map

The map depicts international Internet bandwidth between metropolitan areas. This includes one route for each country where the route's bandwidth is 2 Gbps or greater and top routes in countries with greater bandwidth. The circular area of each regions' projection is proportional to the bandwidth connected to cities within that region. Internet bandwidth data only includes capacity from providers that operate international bandwidth links. Private network IP links are excluded. Data are from mid-2018.

Data at the centre

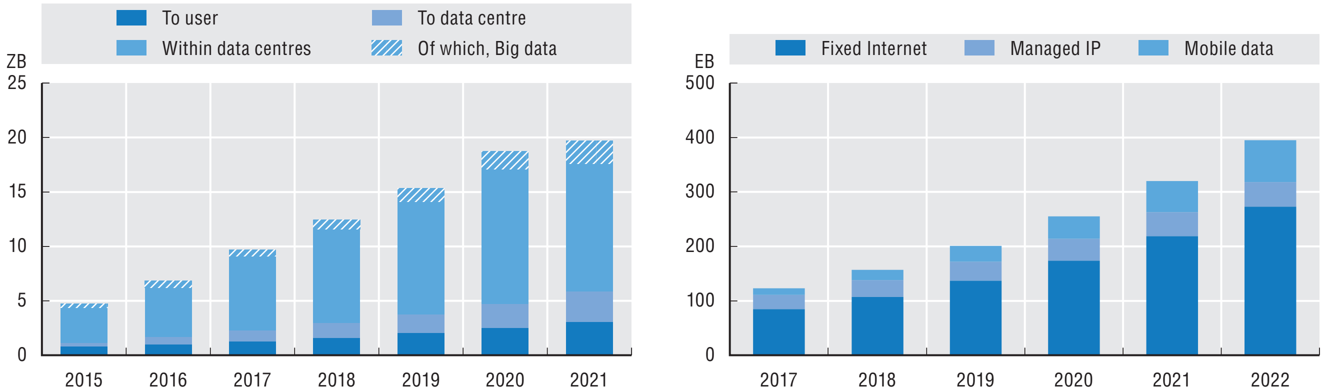
Data ownership is concentrating as the volume of data continues to rise, but its overall value remains unknown. International bandwidth usage is increasingly shifting towards content providers such as Amazon, Google, Facebook and Microsoft among others. Over the past few years, their share of international bandwidth usage has risen significantly, reaching 40% in 2017, on par with traditional Internet backbone providers (Mauldin, 2017). To ensure ever-increasing demand for their services, content providers themselves have become large players in the development of global data infrastructure, for example through the construction of submarine cables and data centres.

Data centres - servers that can be used exclusively by a firm (private cloud) or rented on demand from cloud service providers - enable the storage of data, as well as remote computing via the Internet (cloud computing). The growing importance of data analytics – the analysis of Big data coming from ubiquitously networked end-user devices and the Internet of Things (IoT) – has added to the value and growth of data centres. CISCO (2018), estimates that Global Internet Protocol (IP) traffic in 2021 will be double that of 2018, approaching 400 Exabytes/month (1 EB equals 1 000^6 bytes) in 2022; and that global traffic from data centres in 2021 will also almost double, to more than 20 Zettabytes (1 ZB equals 1000^7 bytes). Big data is expected to represent about 3 ZB of traffic within data centres, having increased almost five-fold since 2016 (Cisco, 2018).

Data flows, including across borders, can take place within businesses, between businesses (B2B), between businesses and consumers (B2C) and between machines (M2M). CISCO estimates that, in 2022, mobile networks will contribute 20% of global IP traffic, more than twice their share in 2017. Correspondingly, 41% of global traffic will originate from smartphones, up from 18% in 2017. M2M traffic is expected to grow from 3.8 EB to 25.4 EB per month and from 3.1% to 6.4% of global IP traffic. Internet video services function as the key driver of global traffic growth, accounting for about three-quarters of consumer IP traffic (itself more than four-fifths of global traffic). According to CISCO, this share will approach 82% in 2022, even without accounting for managed-IP traffic corresponding to video-on-demand. However, it is highly unlikely that video traffic explains the majority of value created from data flows. Indeed, many productive uses of data flows, such as the co-ordination of global value chains or cloud computing, may generate relatively little data traffic.

16. Global data centre traffic, by type and Consumer Internet Protocol (IP) traffic, by sub-segment, 2015-22

Zettabytes per year (left-hand panel) and Exabytes per month (right-hand panel)



Note: "To data centre" refers to traffic flowing from one data centre to another, for example, moving data between clouds, or copying content to multiple data centres as part of a content distribution network. "To user" refers to traffic that flows from the data centre to end users through, for example, streaming video to a mobile device or PC. "Within data centres" refers to traffic that remains within a data centre, for example, moving data from a development environment to a production environment within a data centre, or writing data to a storage array.

Source: OECD calculations based on Cisco Global Cloud Index 2016-2021 and Cisco Visual Networking Index 2017-2022, January 2019. See chapter notes. StatLink contains more data.

StatLink https://doi.org/10.1787/888933928559

How data travels through the Internet

The Internet is a global network of computers, each with its own Internet Protocol (IP) address (an identifier of a device on the Internet). When a file is sent from a computer in Country A to a recipient in Country B it is first broken down into different "packets". These are like little parcels of information marked with the IP address of the sender, that of the recipient, and a code identifying the sequence in which the packets are to be reassembled at the destination. Once the packets are ready, they leave the origin computer, crossing different networks and taking different routes to their destination. Routers, the traffic wardens of the Internet, guide the packets across networks, ensuring that, at each step, they take the shortest or least congested route. Once the packets arrive at their destination, the computer assembles these according to their pre-specified sequence. If a packet is missing, a signal is sent for that packet to be re-sent. When flowing between two countries, packets take different routes often crossing multiple third countries. The ultimate origin and destination of data flows is often a technical issue. For example, firms use mirror sites, which replicate webpages in different countries, to increase the speed of data transfers. In some instances, what might seem to be a domestic transfer, involves a cross-border flow (Casalini and López González, 2019).

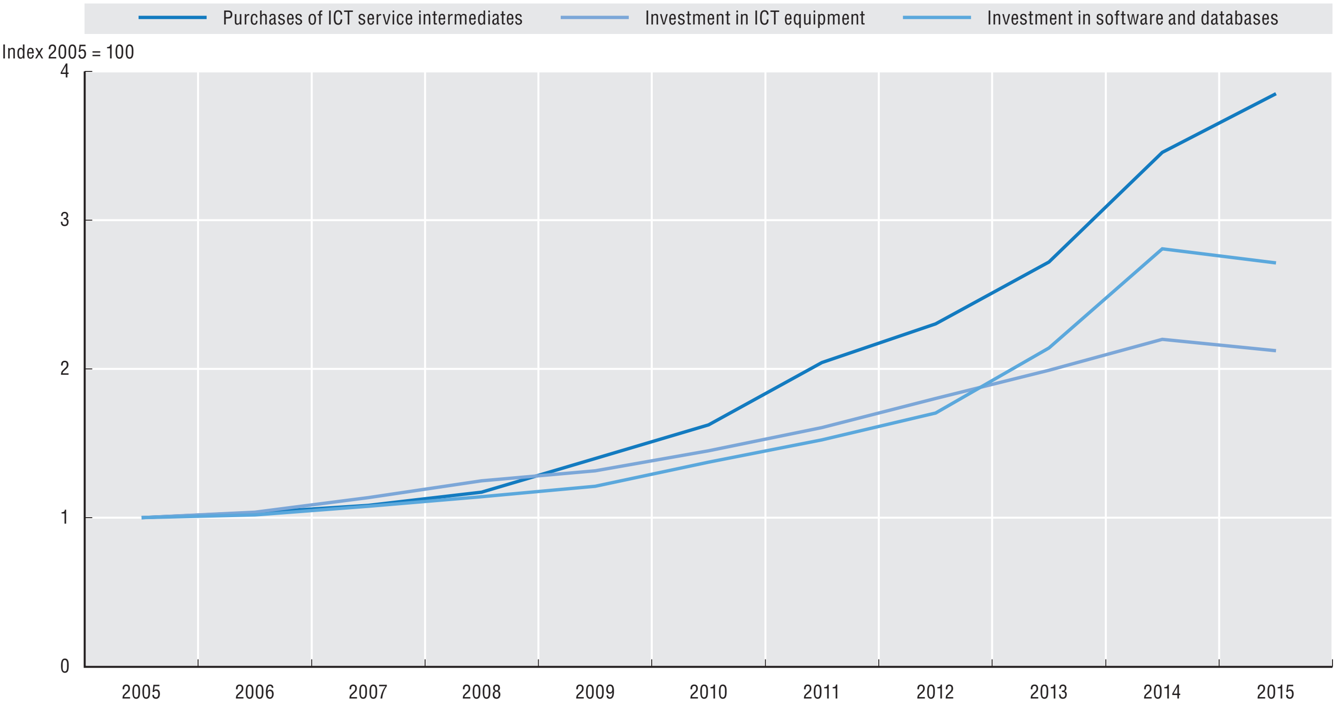
Cloud and software

The growth of cloud services has gone hand-in-hand with the diffusion of high-speed fibre broadband, the rise in quality of key storage and data processing technologies, and the availability of software tools. For firms with a high-speed broadband connection, the ability to access cloud services using a "pay on demand" function became possible with the advent of Elastic Computing Cloud, introduced by Amazon Web Services (AWS) in 2006. From 2010, adoption began to rise quickly due to the increased number of cloud providers (e.g. Google, IBM, Microsoft, and Oracle) followed by an associated decline in the price of such services (DeStefano, Kneller and Timmis, 2018). Cloud services mark a paradigm shift in ICT provision, allowing businesses and individuals to access on-demand IT services over a network, without the need to make large up-front investment in physical ICT capital. Information on companies' use of cloud computing services is still difficult to isolate in official data, at least on a basis that is comparable across countries. The OECD Inter-Country Input-Output (ICIO) table (2018 update), however, enables the identification of an industry's purchases of information services produced by companies operating in "Computer programming, consultancy and related activities" and "information services" industries which include producers of cloud computing services.

Industry-level purchases of ICT service intermediates, as a share of value added in each industry, grew more between 2005 and 2015, than software investment and investment in ICT equipment. The differentials in growth rates suggest a change in the pace of "IT outsourcing" over the decade, i.e. the growth rate in ICT intermediate services was driven mainly by purchases from foreign suppliers. By reducing or avoiding the large fixed costs associated with investment in new ICT equipment, purchases of IT services allow companies to reduce the costs of experimenting with new technologies, scaling up, and adapting technology use to the business cycle. These effects are likely to be more prominent for small, young and credit-constrained firms.

17. ICT investment and expenditure in ICT intermediate services, 2005-15

Index 2005 = 1, un-weighted average of industry-country pairs in the sample



Note: Intensities are calculated by dividing investment and expenditure by the industry-country (deflated) value added. Year-on-year growth rates in industry-country values are averaged over 33 OECD countries and industries, while accounting for the unbalanced nature of the sample. As intensities are calculated as flows of investment or intermediate consumption divided by the industry's value added, the reported growth rates are not driven by the growth of production in the industries themselves. As all values are separately deflated, growth rates do not reflect price changes in the period either.

Source: OECD calculations based on Intan-Invest data, www.intan-invest.net; EUKLEMS, www.euklems.net; OECD Inter-Country Input-Output (ICIO) Database, http://oe.cd/icio; OECD Annual National Accounts (SNA) Database, www.oecd.org/std/na; OECD Productivity Database, www.oecd.org/std/productivity-stats and OECD Structural Analysis (STAN) Database http://oe.cd/stan, December 2018. See chapter notes. StatLink contains more data.

StatLink https://doi.org/10.1787/888933928578

Chapter 1

TRENDS IN THE DIGITAL ERA

1.2 Digital transformations

All firms and industries are affected by the digital transformation, although the pace and scale differs. While almost no business today is run without ICTs, their impact depends on the type and sophistication of ICT tools integrated into business processes. Using special tabulations of enterprise data, the OECD carried out an experiment to calculate indicators of digital maturity in business. Additionally, a new OECD taxonomy of digital intensive sectors provides insights into the characteristics and dynamics of those sectors most affected by the digital transformation. New measures of the diffusion of robots (including service robots) in companies are presented, reflecting their role in transforming manufacturing. New data on the perceived impacts of digital technologies in the workplace are also analysed. Online US job vacancies data are used to examine the types of skills required for computer-related jobs. More people are connected than ever before, and many younger people are adopting an "always-on" lifestyle. Digitalisation is also changing the ways in which research is conducted and disseminated. The first results of the OECD International Survey of Scientific Authors (ISSA) reveal scientists' views on the impacts of digitalisation in their work.

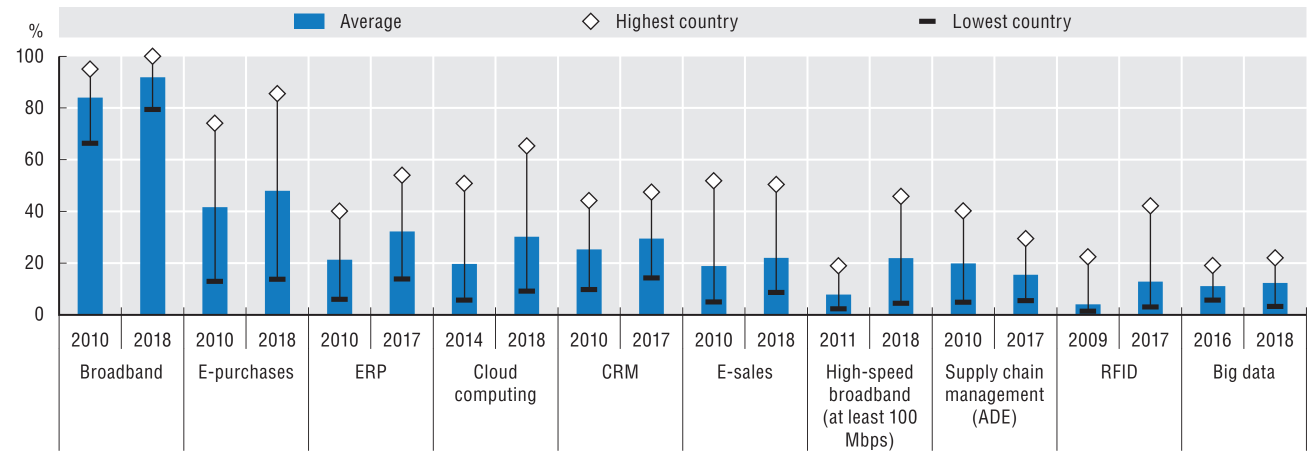
Fast adopters and the diffusion of technology

Most organisations use digital tools, but often not to their full potential. A number of major transformations – often collectively referred to as the "next production revolution" – are anticipated over the coming decade. The technological drivers of this revolution include the development of digital infrastructure and applications, such as high-speed broadband, Big data, cloud computing, 3D printing and the Internet of Things (IoT). Such technologies are increasingly affordable for smaller businesses. However, for technology diffusion to lead to productivity gains, firms must integrate the technology into their business processes and make complementary investments in skills and business models.

Recent surveys of ICT technology show that broadband access has reached saturation in large businesses. However, on average, only 20% of businesses in OECD countries benefited from high-speed broadband (100 Mbps or greater) in 2018. The adoption of digital technologies in business value chains, whether for purchases, sales or the automation of back office functions (ERP), has progressed smoothly, albeit with large differences between countries and sectors. Cloud computing services has registered the fastest increase in uptake – 50% over the four years to 2018 – when, on average, 56% of large businesses and 27% of small businesses purchased cloud computing services. A recent OECD study (Galindo-Rueda et al., 2019) based on analysis of micro-data from the Statistics Canada Survey of Advanced Technologies finds that larger firms tend to make greater use of advanced technologies, especially automated production process technologies, for which scale appears to be very important. In contrast, software and infrastructure service technologies (including cloud computing) register similar rates of uptake in both small and large Canadian firms.

18. Diffusion of selected ICT tools and activities in enterprises, OECD, 2010 and 2018

As a percentage of enterprises with ten or more persons employed

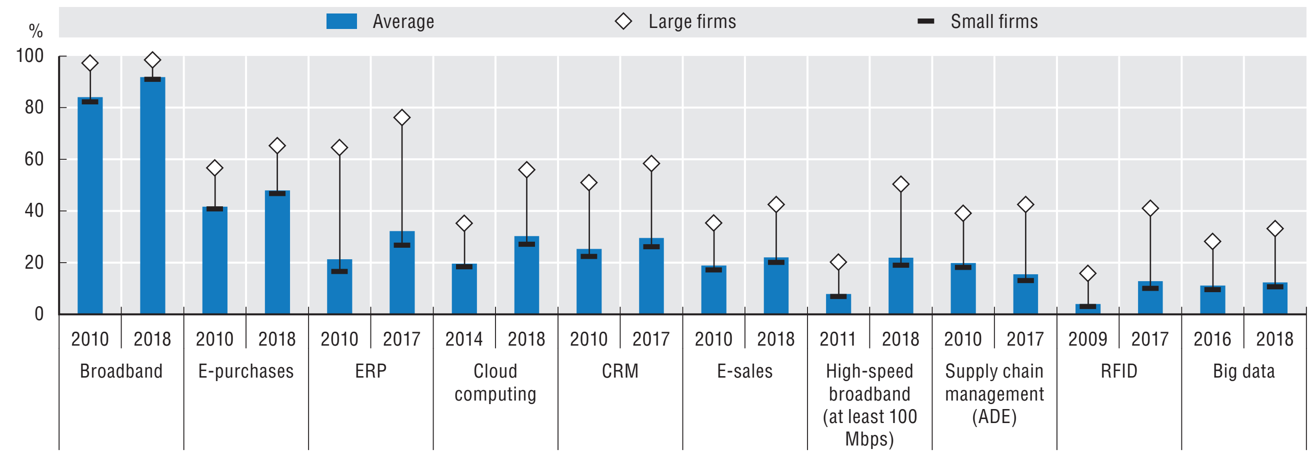


Source: OECD, ICT Access and Usage by Businesses Database, http://oe.cd/bus, January 2019. See chapter notes. StatLink contains more data.

StatLink https://doi.org/10.1787/888933928597

19. Diffusion of selected ICT tools and activities in large and small businesses, OECD, 2010 and 2018

As a percentage of enterprises with ten or more persons employed



Source: OECD, ICT Access and Usage by Businesses Database, http://oe.cd/bus, January 2019. See chapter notes. StatLink contains more data.

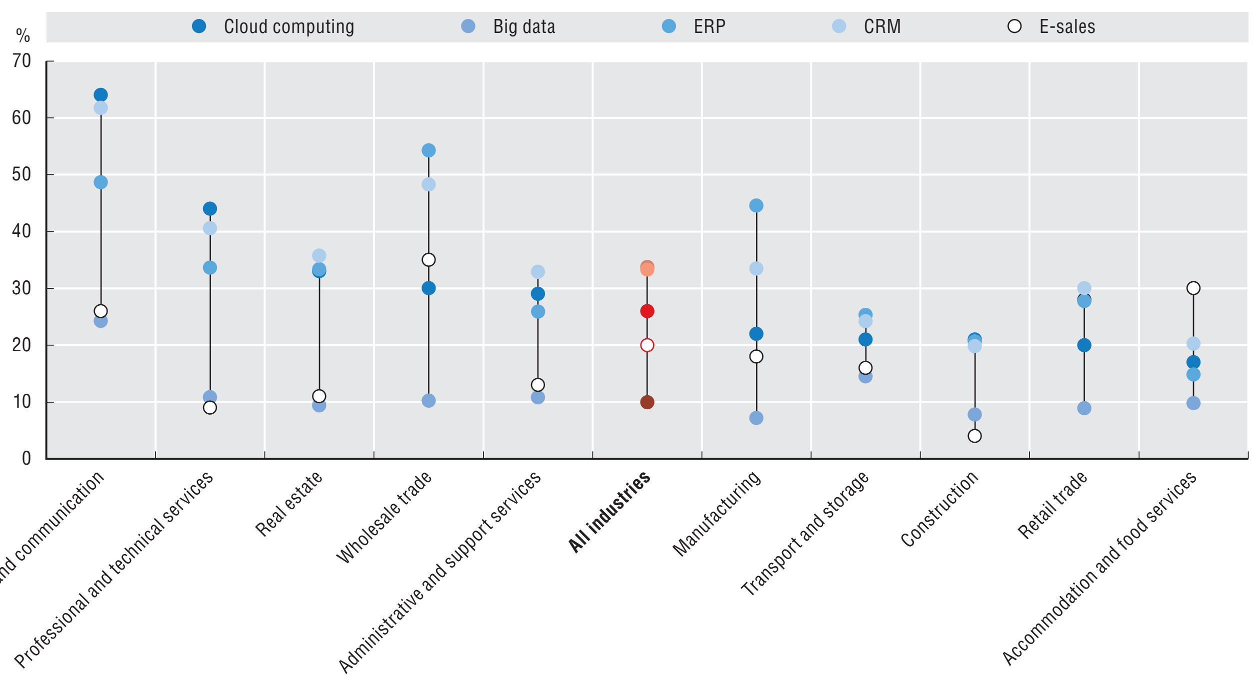
StatLink https://doi.org/10.1787/888933928616

Digital transformation in industry

Every industry is affected by the digital transformation but no single metric is able to capture its pace and extent. Due to their pervasive nature, digital technologies are profoundly transforming economies and societies. The innumerable ways in which the digital transformation is affecting production activities, both manufacturing and services, impede efforts to provide an all-encompassing definition of this multifaceted phenomenon. Recent OECD work (Calvino et al., 2018) assesses the digital intensity of sectors by looking at the technological components of digitalisation (tangible and intangible ICT investment, purchases of intermediate ICT goods and services, robots), the human capital required to embed technology in production (ICT specialist intensity), and the ways in which digital technology impacts how firms interface with the market (online sales). While the digital transformation progressively touches all sectors in the economy, it does so with differing speeds and extents. Only one sector, ICT services, stands out as being the most digital-intensive, as measured by the seven different metrics of sector digital intensity (OECD, 2017). European data from ICT use in business surveys, which allows a granular look at uptake of digital technologies along business value chains, shows that ICT services is the most digital-intensive sector. The presence of websites is rather high for businesses in every sector, and hence does not explain sectoral variations, while the use of Big data analytics is still in its infancy in almost all industries. What really discriminates digital intensity across sectors is the use of more sophisticated digital tools such as cloud computing, enterprise resource planning (ERP), and customer relations management (CRM).

20. ICT uptake by industry, EU28, 2018

As a percentage of enterprises with ten or more persons employed in each industry



Source: OECD, based on Eurostat, Digital Economy and Society Statistics, January 2019. See chapter notes. StatLink contains more data.

StatLink https://doi.org/10.1787/888933928635

Calculating indexes of digital maturity: an experiment

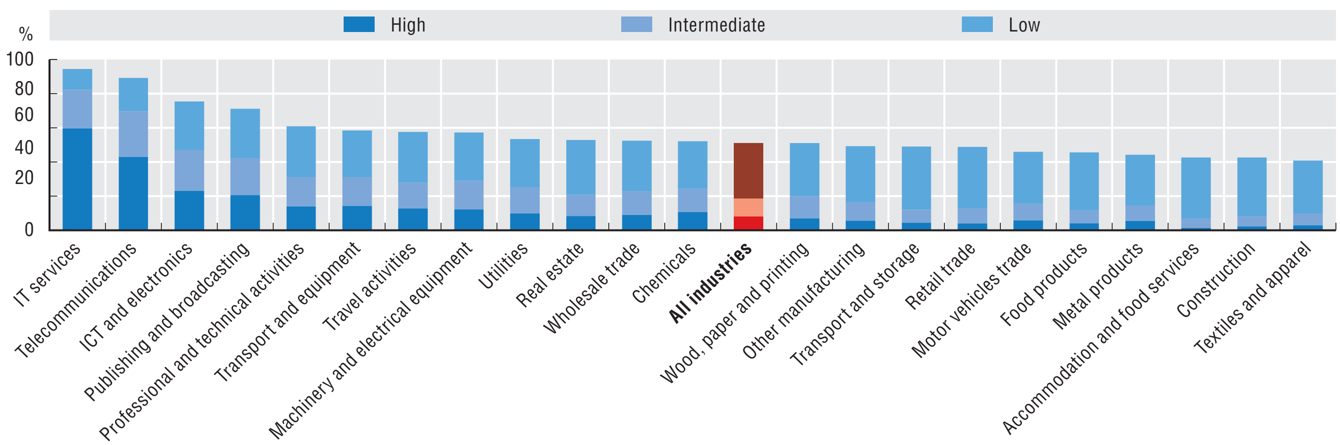
To analyse different aspects of the diffusion of digitisation in business, the OECD and Eurostat worked with participating countries to produce special tabulations of data from the 2018 European Community Survey on ICT Usage and E-commerce in Enterprises. As presented on the following page, these focus on the co-occurrence of different items along three dimensions of maturity and sophistication. *ICT capabilities*: (i) ICT training of staff, (ii) the employment of ICT specialists, and (iii) in-house performance of ICT functions (as opposed to contracting-out). *Advanced ICT functions*: (i) ICT security and data protection activities, (ii) tailoring of business management software and (iii) the development of web solutions. *Web maturity*: (i) having a website which allows for product customisation or tracks orders/visitors, and (ii) whether or not the business uses online advertising services. Enterprises were assigned a score for each based on the number of items present - from 0 (no items) to the joint occurrence of all 3 items (2 for Web maturity).

Digital maturity in industries

Businesses in Europe still have yet to exploit the full potential of the digital transformation. On average, 50% of all enterprises in the business sector, excluding financial services, have no specific *internal* ICT capabilities as measured by the availability of specific human capital. In ICT industries, such as IT services and telecommunications, 40% to 80% of enterprises possess *at least* intermediate capabilities. This compares to an overall average of 20%, while in relatively low-tech areas such as textile and apparel manufacturing and transport and storage services have rates around 10%. *ICT capabilities* tend to be associated performing of *advanced ICT functions*, but the relationship of both with *Web maturity* is weaker. Based on these benchmarks, which give only a partial view of digitalisation in firms, there are leading sectors (information and communication, travel, wholesale trade) and relative laggards (construction services and food, textile, and metal manufacturing industries). Retail trade and accommodation score high for *Web maturity*, while medium-high tech manufacturing industries, such as machinery, ICT, and electrical manufacturing, as well as professional and technical services are more oriented towards the integration of ICT applications within business processes.

21. Enterprises with internal ICT capabilities, by industry, EU countries, 2018

As a percentage of enterprises with ten or more persons employed in each industry

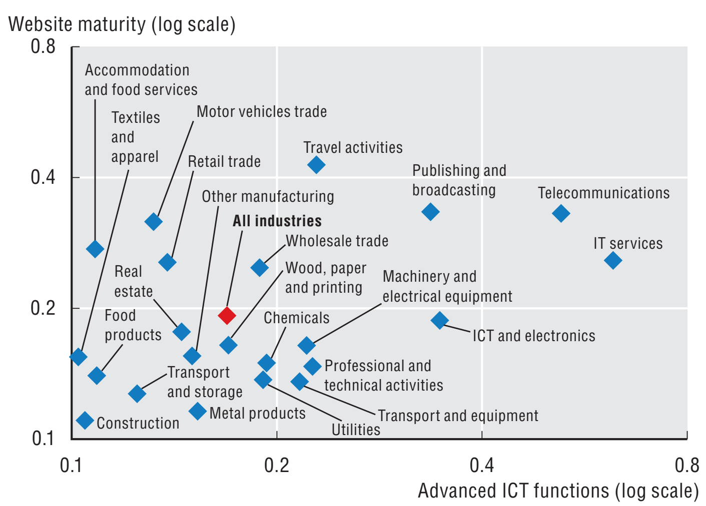


Source: OECD calculations based on Eurostat, Digital Economy and Society Statistics, January 2019. See chapter notes.

StatLink https://doi.org/10.1787/888933928654

22. Web maturity and advanced ICT functions, by industry, EU countries, 2018

Synthetic measure of uptake in firms with ten or more persons employed



Source: OECD calculations based on Eurostat, Digital Economy and Society Statistics, January 2019. See chapter notes. StatLink contains more data.

StatLink https://doi.org/10.1787/888933928673

How to read these charts

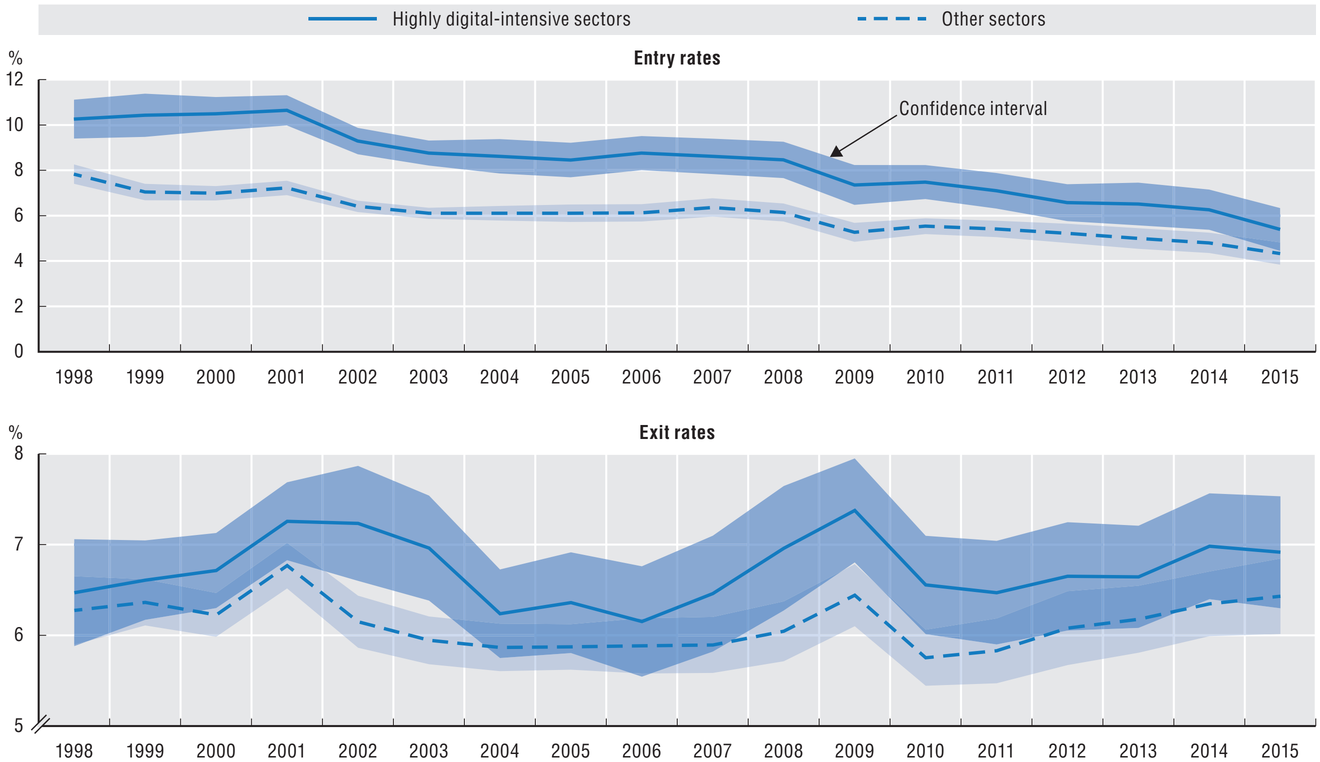
ICT capabilities are characterised as "high" when all 3 items are present, "medium" for 2 items and "low" when only 1 of the items occurs. The scatterplot presents a synthetic measure of uptake for Web maturity and Advanced ICT functions. It shows the sum of percentage shares of enterprises for each dimension divided by the theoretical maximum value (i.e. 2 or 3), to create a normalised indicator varying from 0 to 1. See "Calculating indexes of digital maturity: an experiment" on previous page.

Business dynamics and the digital transformation

Business dynamism in highly digital-intensive sectors is high but declining. While business dynamism is, on average, greater in highly digital-intensive sectors, these sectors have also experienced more significant declines in business dynamism over time – especially in terms of firm entry rates. Recent OECD work shows that highly digital-intensive sectors are more dynamic than other sectors on average – consistent with the idea that digital technologies lower entry barriers and tend to facilitate reallocation – but have experienced significant declines in dynamism since 2001, especially in terms of entry and job reallocation rates. This appears to be related, in part, to the fact that while diffusion of digital technologies continues everywhere, in highly digital-intensive sectors – where these technologies have particularly advanced application – it reaches a stage of higher technological maturity. This process is similar to past trends in other innovative sectors, and holds across countries, although there are significant differences between countries in the patterns and dynamics of highly digital-intensive sectors. In this context, institutional and policy factors, such as workers' training, the availability of venture capital, and the efficiency of business and bankruptcy regulations, play an important role in business dynamism in these sectors (Calvino and Criscuolo, 2019).

23. Changes in business dynamism, entry and exit rates, 1998-2015

Average trends within country-sector, highly digital-intensive and other sectors



Note: Sectors are classified by digital intensity (high/medium-high/medium-low/low) using a number of dimensions (ICT investment and ICT intermediates, use of robots, online sales and ICT specialists) and then grouped by quartile.
Source: OECD calculations based on the DynEmp v.2 (USA) and the DynEmp3 Databases, http://oe.cd/dynemp, January 2019. See chapter notes.

StatLink https://doi.org/10.1787/888933928692

OECD project on employment dynamics, young businesses and allocative efficiency (DynEmp)

The approach adopted by the DynEmp project is based on a common statistical code developed by the OECD, which is run in a decentralised manner by national experts from statistical agencies, academia, ministries or other public institutions, who have access to the national micro-level data. The micro-aggregated data generated by the centrally designed but locally executed program codes are then sent back for comparative cross-country analysis to the OECD. This distributed micro-data approach reduces confidentiality concerns as it aggregates information at a sufficiently high level, and achieves a high degree of harmonisation as the definition of the extracted information is the same, ensured by the centrally written computer routine. The experts also implement country-specific disclosure procedures in order to ensure that confidentiality requirements are respected. The figures shown are based on the second (DynEmp v.2) and third wave of data collection (DynEmp3) in the DynEmp project.

Mark-ups in the digital era

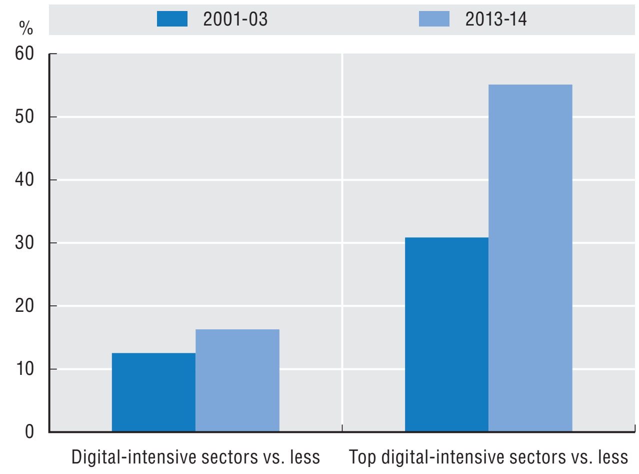
In recent years, there has been growing concern that markets around the world are becoming more concentrated and less competitive. This is sometimes attributed to the increasingly digital and globalised nature of many markets and the firms that operate within them (OECD, 2018). Digital technologies allow firms to access multiple geographical and product markets almost instantaneously, sharing ideas and exploiting increasing returns to scale, especially from intangible assets. Digital technologies are generally associated with lower costs of operations and of entry into a market, even across borders, thus potentially increasing competition among firms for the market itself. They foster the emergence of new business models, such as platforms, which further facilitate entry into other, non-digital markets, as happened in the case of Airbnb in the accommodation industry or Amazon in the retail sector.

Digital technologies can also potentially increase the market power of some firms at the expense of others. As with other general-purpose technologies, digital technologies do not diffuse instantaneously, and require complementary investments in intangible assets (e.g. in human capital and organisational capabilities) to be adopted. These knowledge-based assets are costly at the start and can take time to integrate into business models and processes. This may open a gap between leading and laggard firms. Moreover, once knowledge has been accumulated, it can be re-used without cost, allowing companies to scale up faster and more easily, and to generate increasing returns to scale. In addition, digital-intensive companies can leverage Big data analytics for targeted marketing, thus better maximising their sales. Many digital services also increase in value when the number of people using them increases (network effects), such that a potential competitor cannot extract the same level of profit until it attracts a sizeable share of the market. Over time, these characteristics may help industry leaders sustain and advance their position, and slow down the entry or growth of competitors.

According to recent OECD analysis following Calligaris et al. (2018), firms in digital-intensive sectors enjoy on average 13% to 16% higher mark-ups – the wedge between the price a firm charges for its output and the cost the firm incurs to produce one extra unit of output – than firms in less digital-intensive sectors (everything else held constant). Additionally, the wedge between the average mark-up of firms in the two groupings has grown over time. Lastly, the gap is significantly larger (up to 55%) and has increased more over time when comparing firms operating in highly digital-intensive sectors versus those in other sectors. The same analysis shows that the digital gap in firm mark-ups decreases in magnitude but remains significant when differences in international competition, intensity in intangible assets and firm patenting are taken in consideration.

24. The increasing wedge in mark-ups between firms in digital-intensive and less digital-intensive industries, 2001-03 and 2013-14

Average percentage differences at the beginning and at the end of the sample period



Note: The figure reports the estimates of a pooled OLS regression explaining firm log-mark-ups in the period, on the basis of the firm's capital intensity, age, productivity and country-year of operation, as well as a dummy variable with value 1 if the sector of operation is digital-intensive vs less digital-intensive (specifications on the left in the graph), or if the sector of operation is among the top 25% of digital-intensive sectors vs not (specifications on the right in the graph). Sectors are classified as "digital-intensive" or "highly digital-intensive" according to the taxonomy developed in Calvino et al. (2018). Mark-ups are estimated from a Cobb Douglas production function. With respect to Calligaris et al. (2018), in this elaboration the parameters of the production function have been estimated at the 3-digit industry level (rather than 2-digit), and including year dummies. Moreover, mark-ups lower than 1 but greater than 0.95 have been winsorized (rather than trimmed) to 1. Standard errors are clustered at the firm level. All coefficients are significant at the 1% level.
Source: OECD elaborations on Calligaris et al. (2018), based on Orbis® data, July 2018.

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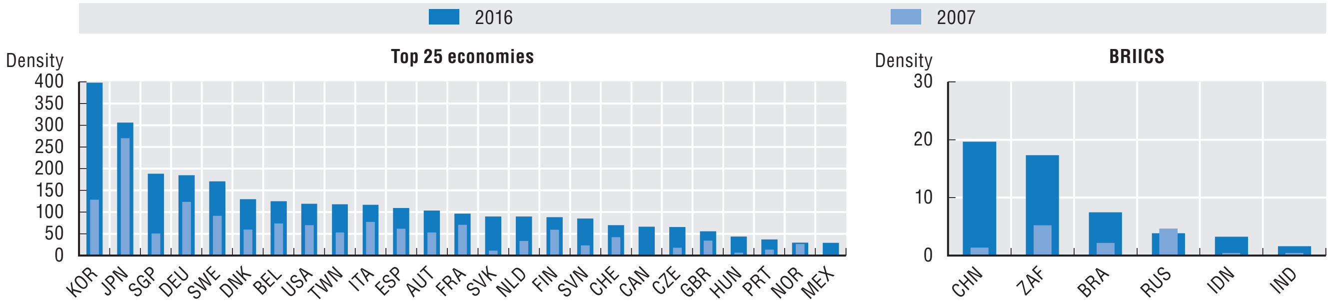
Transforming production

Robots, including service robots, are transforming manufacturing. Advances in fields such as Big data, 3D printing, machine-to-machine communication, and robots are transforming production. Comparable and representative data on the deployment of industrial robots in 2016 show that Korea and Japan lead in terms of robot density in manufacturing (i.e. the stock of robots relative to employment). Robot density in these economies is about three times that of the average OECD country. The average density in BRIICS (Brazil, the Russian Federation, India, Indonesia, China and South Africa) is significantly lower, but has increased at twice the pace of the average of the top 25 economies between 2007 and 2016. Sales of service robots are also on the rise. In 2018, the International Federation of Robotics (IFR) identified more than 700 service robot manufacturers, both for professional and personal use (IFR, 2018). For the first time, statistics on the use of both industrial and service robots, and of 3D printing have been collected within European surveys of business ICT usage. In 2018, on average, 7% of respondent enterprises with more than ten employees were deploying robots, and 4% used 3D printing. The highest penetration rates are observed in manufacturing of metal products, chemical products and machinery.

25. Top robot-intensive economies and BRIICS, 2016

Stock of robot units per 10 000 employed persons, manufacturing sector

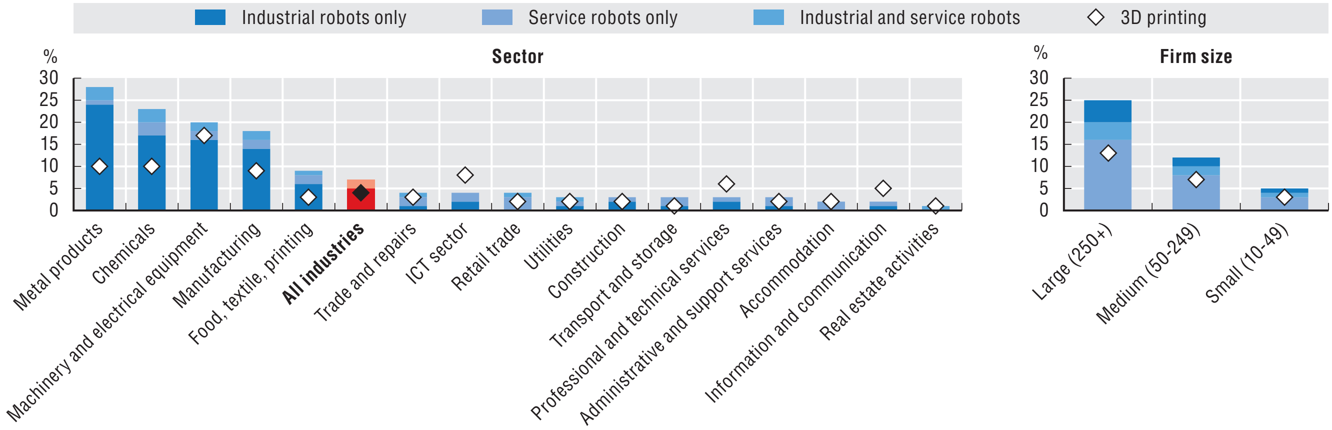


Source: OECD calculations based on International Federation of Robotics (IFR); OECD Annual National Accounts Database; OECD Structural Analysis (STAN) Database, http://oe.cd/stan; OECD Trade in Employment (TiM) Database; ILO, Labour Force Estimates and Projections (LFEP) Database and national sources, December 2018.

StatLink https://doi.org/10.1787/888933928730

26. Diffusion of robots and 3D printing in enterprises, by sector and firm size, EU28, 2018

As a percentage of enterprises in each category with ten or more persons employed



Source: OECD, based on Eurostat, Digital Economy and Society Statistics, January 2019. See chapter notes.

StatLink https://doi.org/10.1787/888933928749

What is a robot?

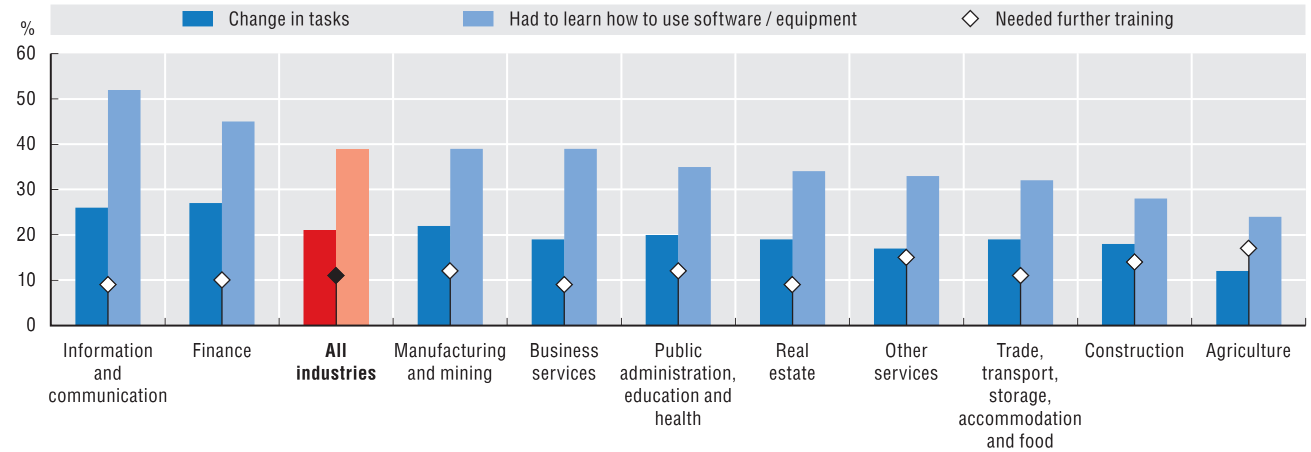
An industrial robot is defined by ISO 8373:2012 as "an automatically controlled, reprogrammable, multipurpose manipulator programmable on three or more axes, which can be either fixed in place or mobile for use in industrial automation applications". A "service robot" is a robot "that performs useful tasks for humans or equipment excluding industrial automation applications". (ISO 8373). The International Federation of Robotics collects information on shipments (counts) of industrial robots from almost all existing robot suppliers worldwide. No information on service robots is currently available. The measure of the stock of robots displayed above has been calculated by taking the first-year stock value from the IFR, adding the sales of robots for subsequent years and assuming a 10% annual depreciation. Consequently, these metrics do not capture increases in the quality of robots or their ability to perform tasks.

Transforming the world of work

Digital technologies are perceived as having diverse impacts in the workplace; in particular, their adoption is resulting in more time being spent on learning new tools and acquiring new skills. In 2018, more than half of workers in EU countries were using ICTs in their daily work. The introduction of digital tools in the workplace entails learning and adaptation and also affects workers' tasks and work organisation. In 2018, 40% of workers in the EU had to learn to use new software or ICT tools, and about one-in-ten needed specific training to be able to cope with those changes. The percentage of workers who had to learn new digital tools and the percentage who perceived changes in their work tasks were highest in ICT and finance services and in manufacturing. About 20% of workers using digital tools perceived changes in their work tasks, with the majority of them experiencing greater autonomy in organising tasks. The introduction of new digital tools, on balance, resulted in a decrease in repetitive tasks, yet 15% of workers using ICT technologies report experiencing an increase in such tasks. Workers found it easier to collaborate with colleagues but also felt their performance was more closely monitored. They often found that they needed to devote more time to acquire new skills and increased working of irregular hours was also reported. Important differences exist across countries, in particular in relation to ease of collaboration and the need to devote more time for the acquisition of skills.

27. Impacts of new software or computerised equipment at work, by industry, EU countries, 2018

As a percentage of individuals using digital tools at work

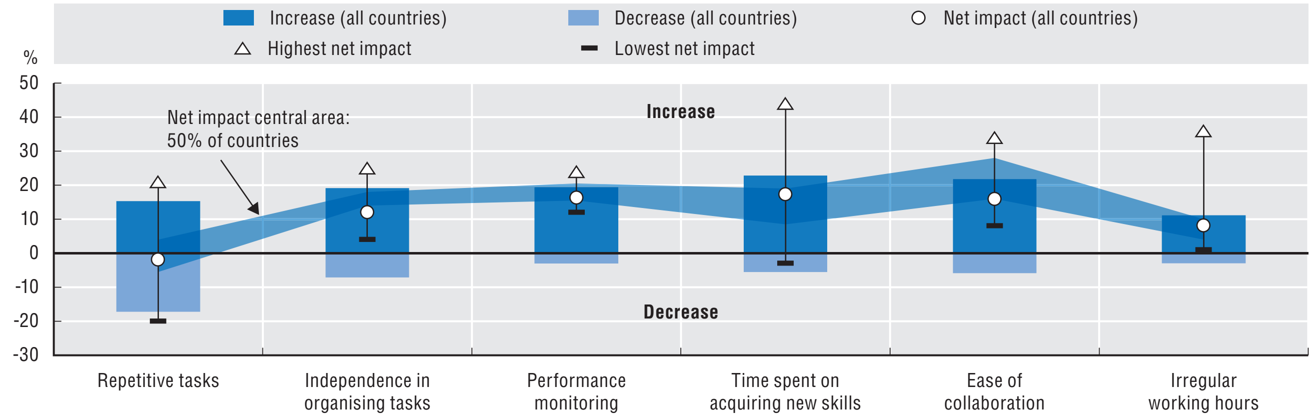


Source: OECD calculations based on Eurostat, Digital Economy and Society Statistics, January 2019. See chapter notes.

StatLink https://doi.org/10.1787/888933928768

28. Perceived impacts of digital technologies on specific aspects of work, EU countries, 2018

As a percentage of individuals using digital tools at work



Source: OECD based on Eurostat, Digital Economy and Society Statistics, January 2019. See chapter notes.

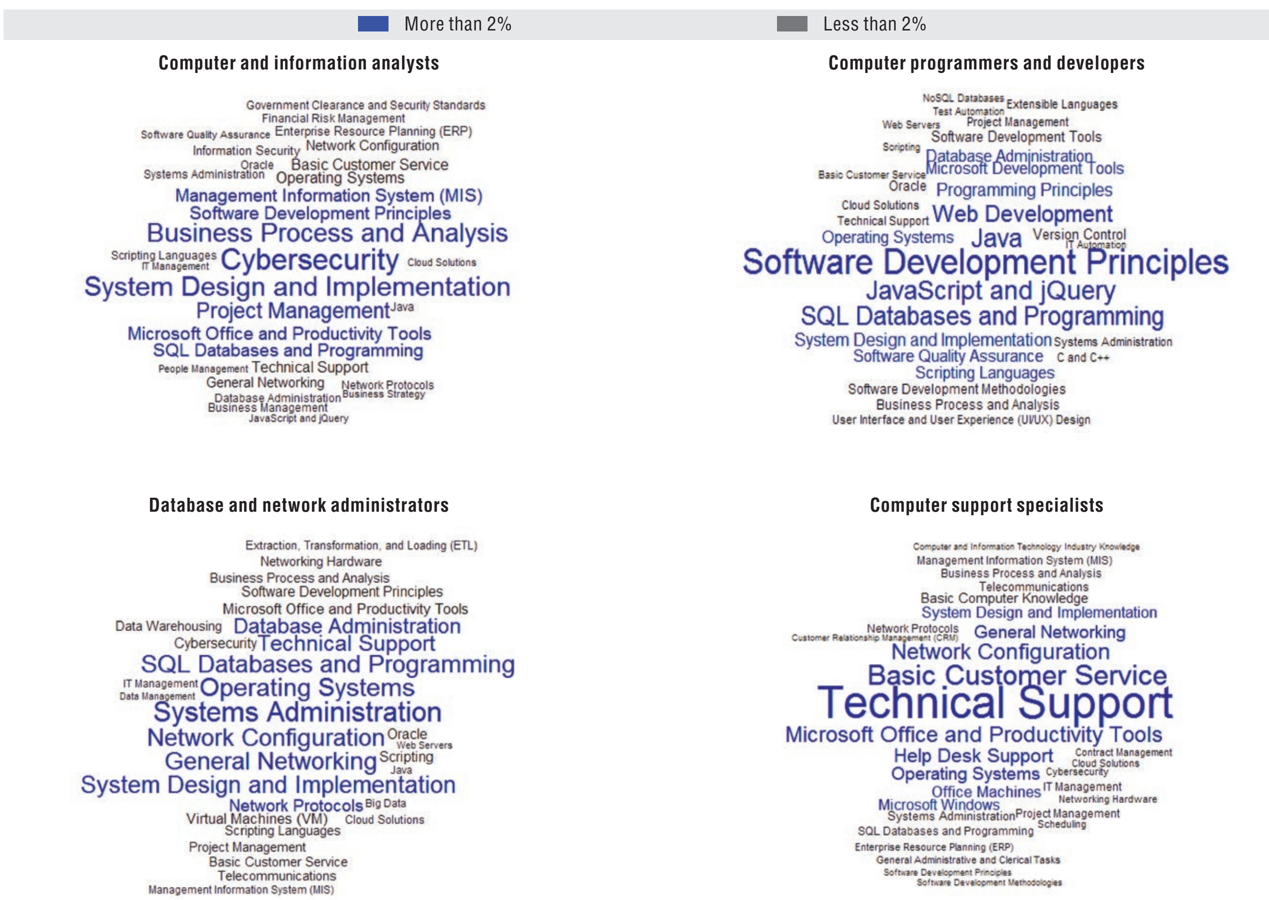
StatLink https://doi.org/10.1787/888933928787

Which skills for computer jobs?

Computer specialists are sought after, but even this narrowly defined category of jobs requires a wide array of skills – some general, some specific and many changing over time. As jobs change, so do the skills workers need to perform them. This is true for all jobs, including those in high demand, such as computer-related jobs. Burning Glass Technologies' data on online job postings shed light on the types of skills in demand and on how the skills profiles of occupations change over time. An analysis of 1.8 million job postings in the United States in 2018 for four computer-related occupations points to the types of skills in highest demand for each occupation and the types of skills for which demand has been growing fast over 2012-18. On average, one or more of up to about 500 different skills were demanded for job openings posted in these computer-related occupations, thus highlighting the heterogeneous nature of these jobs. Among the 30 skills in highest demand, some are relevant for all four occupational categories, such as knowledge of Structured Query Language (SQL) tools, system design and implementation, or software development principles. Skills related to cybersecurity are important for both computer and network specialists. The demand for some skills cuts across several of these occupations, including skills related to Java, JavaScript, and jQuery – a computer language that creates "applets" (applications designed to be transmitted over the Internet and executed by a java-compatible web browser). These skills are in high demand for computer programmers and developers, while skills related to basic customer service and help desk support are in high demand when posting vacancies for computer support specialists.

29. Top-demanded skills in computer-related jobs, United States, 2018

Top 30 skill categories demanded in online job postings



Note: The word clouds display the top 30 skills demanded in each of the occupational categories considered. The size of the words mirrors the relative frequency with which words appear. Words appearing in more than 2% of the cases in the category considered are displayed in blue.
Source: OECD calculations based on Burning Glass Technologies, www.burning-glass.com, January 2019. See chapter notes.

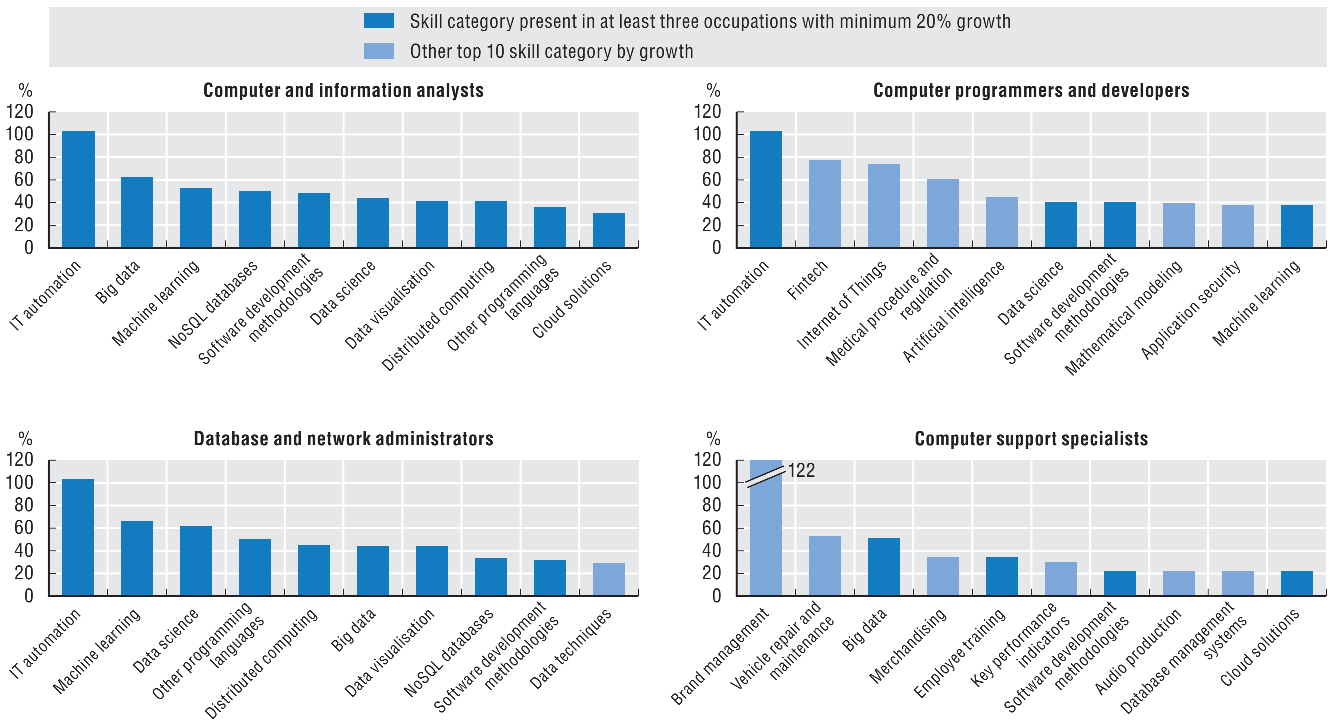
StatLink https://doi.org/10.1787/888933928806

Computer skills in growing demand

Computer-related occupations are at the heart of the development and adoption of digital technologies, but the computer-related jobs of today are likely to be different from those of tomorrow. In this rapidly changing environment, online job postings can point to fast-growing job titles or profiles in demand. For example, job postings for people working on data lakes (repositories holding vast amounts of raw data) grew rapidly in the United States between 2012 and 2018. Some of the most increasingly demanded skills are common across all computer-related occupations. Examples include "IT automation skills", "machine learning", and "Big data" or "software development methodologies". Others can be identified as fast growing across three or more of these computer occupations. The growth in demand for such technical skills is often combined with an increase in demand for complementary skills, such as the ability to train employees or industry-specific skills, such as "fintech", "medical procedure and regulation" or "brand management".

30. Top 10 skills in high demand for computer-related jobs, United States, 2012-18

Percentage increase in online job postings in each occupation over the period



Note: Only skills categories which were present in more than 2 000 vacancies in each eight-digit Standard Occupational Classification (SOC) 2010 occupation were analysed, so as to minimise the probability that a few large employers drive the resulting growth rate. Growth is calculated over the entire period.

Source: OECD calculations based on Burning Glass Technologies, www.burning-glass.com, January 2019. See chapter notes.

StatLink https://doi.org/10.1787/888933928825

Computer-related jobs and online job vacancies

Burning Glass Technologies scans more than 40 000 sources and tracks about 3.4 million unique, currently active job openings in the United States and a number of other countries. As the same job vacancies are often posted multiple times, duplicate postings, equivalent to close to 80% of all the postings collected, are removed using sophisticated algorithms. Skill requirements in job postings and workers' résumés can be expressed in different ways (e.g. "Microsoft Excel" vs. "MS Excel"), necessitating standardisation and categorisation. Occupational information is similarly derived from the reported job titles.

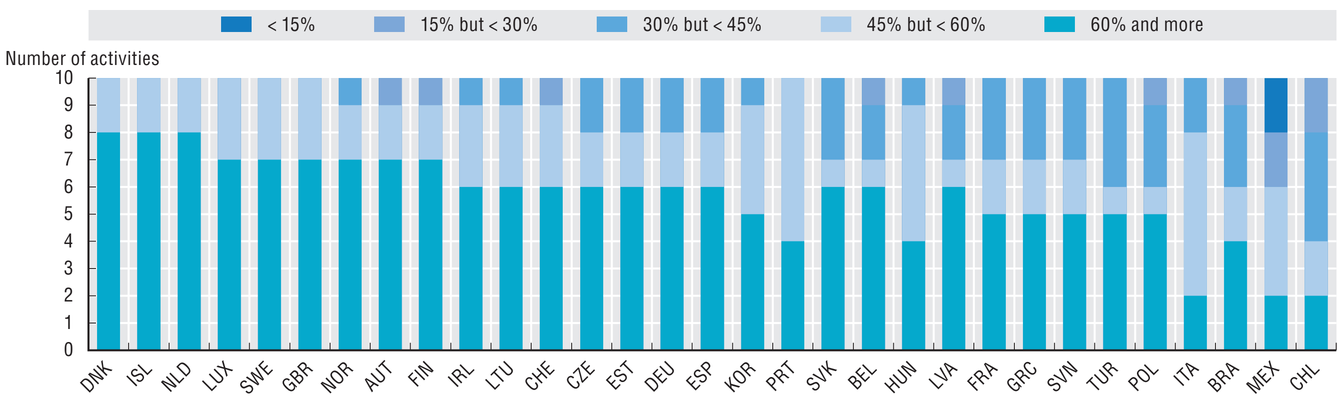
Computer and information analysts are individuals analysing science, engineering, business and other data processing problems to implement, improve, review and automate systems, computers and networks, also for security purposes. *Programmers and developers* create, modify and test the codes and scripts that allow computer applications to run; set operational specifications and formulate and analyse software requirements; analyse user needs to implement website content, graphics, performance and capacity, and may integrate websites with other computer applications. *Database and network administrators* administer, test, implement, maintain and safeguard computer databases, networks, Internet systems or segments thereof; monitor networks to ensure availability, performance and security, and may help co-ordinate network and data communications hardware and software. *Support specialists* provide technical assistance to computer users concerning the use of computer hardware and software; analyse, test, troubleshoot and evaluate existing network and Internet systems; and perform network maintenance to ensure networks operate correctly with minimal interruption.

Sophisticated adopters and uptake

Even in economies with almost universal Internet uptake, the activities many people carry out online are relatively basic and limited, pointing to a divide in digital usage. The types of activities carried out over the Internet vary widely across countries as a result of different institutional, cultural, and economic factors including age and educational attainment. Likewise, country uptake of more sophisticated activities also varies and is impacted by factors such as familiarity with online services, trust and skills. In 2017, almost 60% of Internet users carried out both online purchases and Internet banking, an almost twofold increase from around 35% in 2010. The diffusion of both these activities is strongly related to daily usage and to the overall variety of activities performed online. Controlling for Internet usage, uptake patterns differ in Germany, Switzerland, France and the United Kingdom, where individuals are relatively more likely to purchase online than to use Internet banking, while the opposite is true in the Baltic countries.

31. Sophistication of Internet use by individuals, 2018

Number of activities, out of ten, performed by shares of Internet users



Source: OECD, ICT Access and Usage by Households and Individuals Database, http://oe.cd/hhind and Eurostat, Digital Economy and Society Statistics, January 2019. See chapter notes.

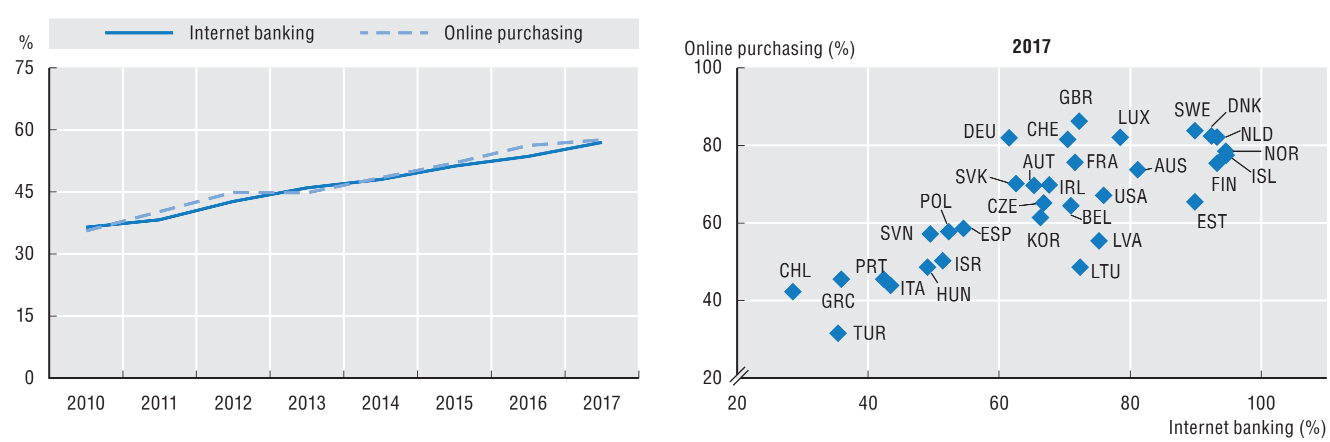
StatLink https://doi.org/10.1787/888933928844

How to read this figure

The Y axis represents the number of activities performed by a percentage share band of Internet users in a given country. For example, in Denmark, 60% or more of Internet users carry out at least 8 Internet activities, and between 45% and 60% carry out all the ten activities considered here. In Norway, instead, 60% or more of Internet users carry out at least seven activities; between 45% and 60% carry out more than 7 but fewer than 10 activities, and at least 30% but less than 45% carry out all ten activities. The ordering of the countries in the figure reflects the average number of activities weighted by the share of Internet users.

32. Diffusion of Internet banking and online purchasing, OECD, 2010-17

Percentages of individuals (left-hand panel) and Internet users (right-hand panel)



Source: OECD, ICT Access and Usage by Households and Individuals Database, http://oe.cd/hhind, January 2019. See chapter notes.

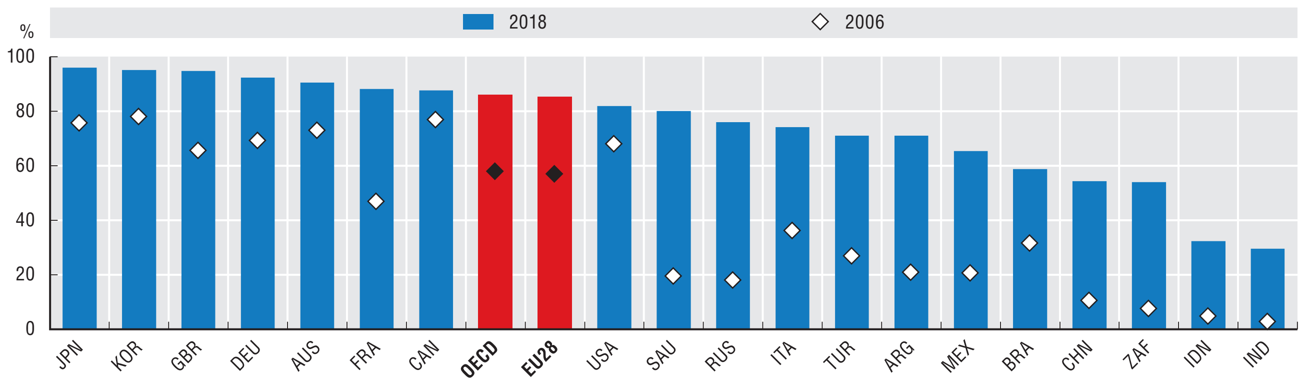
StatLink https://doi.org/10.1787/888933928863

Mind the gap

While Internet uptake is reaching saturation for the younger generation, there remains room for older generations to catch up. Today's digital economy is characterised by connectivity between users and devices, as well as the convergence of formerly distinct parts of communication ecosystems such as fixed and wireless networks, voice and data, and telecommunications and broadcasting. The Internet and connected devices have become a crucial part of everyday life for most individuals in OECD countries and emerging economies. The average share of Internet users in OECD countries grew by almost 30 percentage points between 2006 and 2018, from 56% to 85%, and more than doubled in Greece, Mexico, and Turkey. Over 50% of 16-74 year olds in Brazil, China and South Africa use the Internet nowadays, and the gap in comparison to OECD countries is narrowing. Some economies are approaching universal uptake, while there remains significant potential for catching-up in others with relatively lower income per person. There are also cross-country differences in the generational gap in usage. In the majority of OECD countries nearly all 16-24 year-olds use the Internet on a daily basis – the median value was 96% in 2018 – while for individuals in the 55-74 age bracket the median stood at 55%, with very wide differences (about 50 percentage points) between leading and lagging countries.

33. Internet users, G20 countries, 2018

As a percentage of 16-74 year-olds

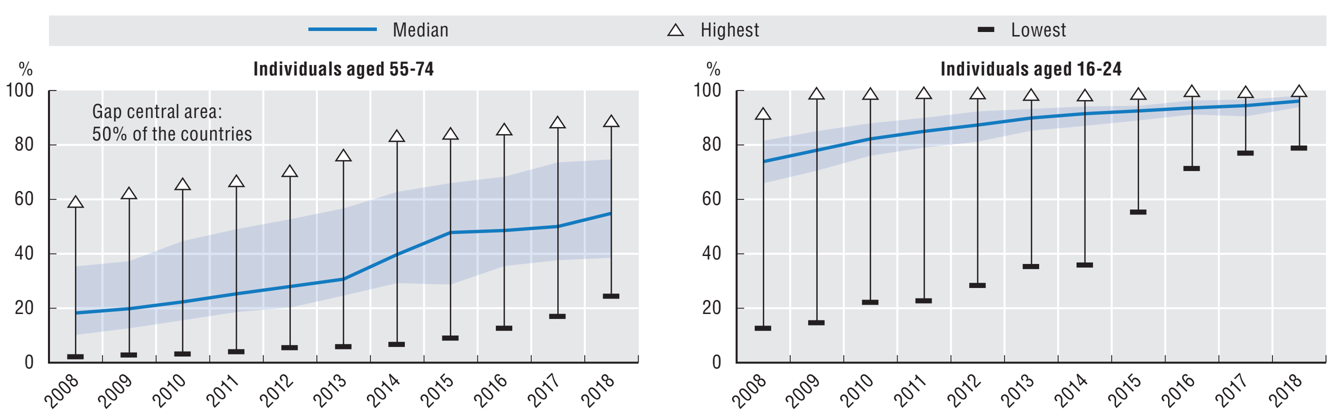


Source: OECD, ICT Access and Usage by Households and Individuals Database, http://oe.cd/hhind; Eurostat, Digital Economy and Society Statistics; ITU, World Telecommunication/ICT indicators Database and national sources, December 2018. See chapter notes. StatLink contains more data.

StatLink https://doi.org/10.1787/888933928882

34. Generational gap in Internet diffusion, OECD, 2008-18

Percentage of daily Internet users in the each age group, 55-74 and 16-24 year-olds



Source: OECD, ICT Access and Usage by Households and Individuals Database, http://oe.cd/hhind, January 2019. StatLink contains more data.

StatLink https://doi.org/10.1787/888933928901

How to read this figure

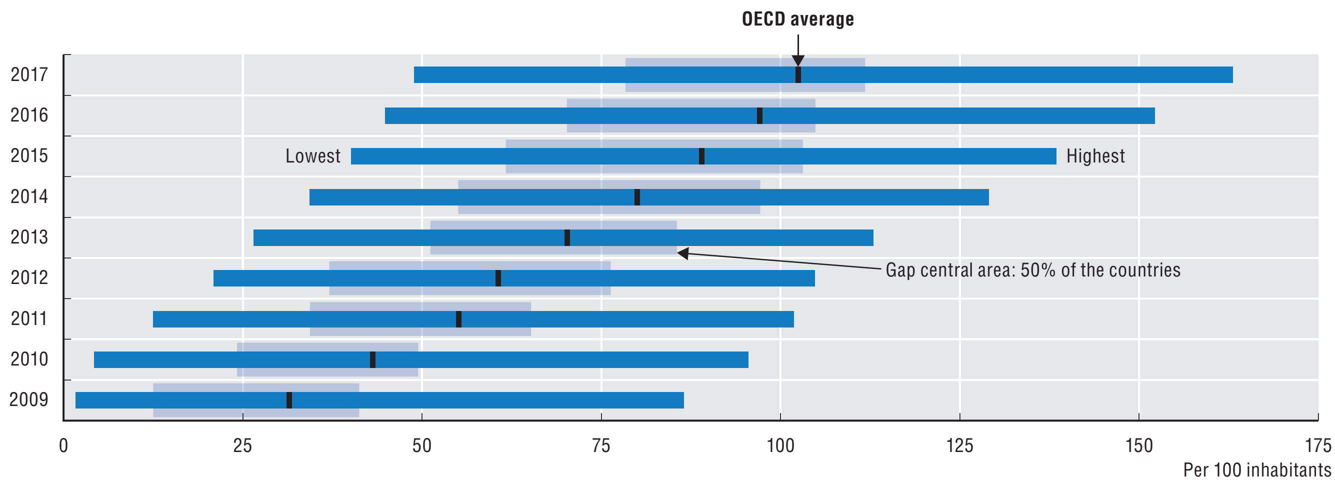
The figures show the inter-country gap of Internet use for ages 16-24 and 55-74 years respectively, between 2008 and 2018. In 2018, on average across all OECD countries, close to 95% of individuals aged 16-24 were Internet users with half of the countries ranging between the first (94%) and the third (98%) quartiles of the distribution. Internet users in the country with the lowest uptake represented 79% of the population as opposed to 100% in the country with the highest uptake.

Always-on lifestyle

Many young adults spend at least a quarter of their day online, with instant messaging and social media enabling an "always-on lifestyle". Improvements in mobile technologies have contributed substantially to the diffusion of Internet usage and broadband penetration. These advances have made online access possible for people who were previously unable to afford fixed broadband connections or found it difficult to use computers. Mobile connectivity contributes to always-on behaviour. From 2009 to 2017, the penetration of wireless subscriptions per 100 inhabitants more than tripled in the OECD area as a whole, increasing from 32 to 102. Country comparisons now range from about 50 subscriptions per 100 persons, to 160 (1.6 per person) in leading countries, with many people owning multiple independently connected mobile devices. The development of apps and increasing device sophistication favour this trend. According to ComScore (2017; 2018), mobile connections account for over half of all digital minutes in most surveyed countries, with app usage amounting to almost 90% of mobile time in 2017. Instant messaging and social networking account for the majority of time spent online. European Social Survey data reveal that the average individual aged 14 and above spent more than three hours per day on the Internet in 2016, while young people aged 14-24 spent 4.5 hours online – about 50% more. Constant connectivity is changing attitudes and behaviour in people's personal lives, with many social relations now occurring online and the distinction between work and leisure time becoming increasingly blurred. According to the Deloitte 2018 Global Mobile Consumer Survey, US consumers check their smartphones more than 50 times per day, on average, and a large majority (70%) of working adults who have work-provided mobile devices also use these outside of work.

35. Wireless broadband in OECD countries, 2009-17

Subscriptions per 100 inhabitants

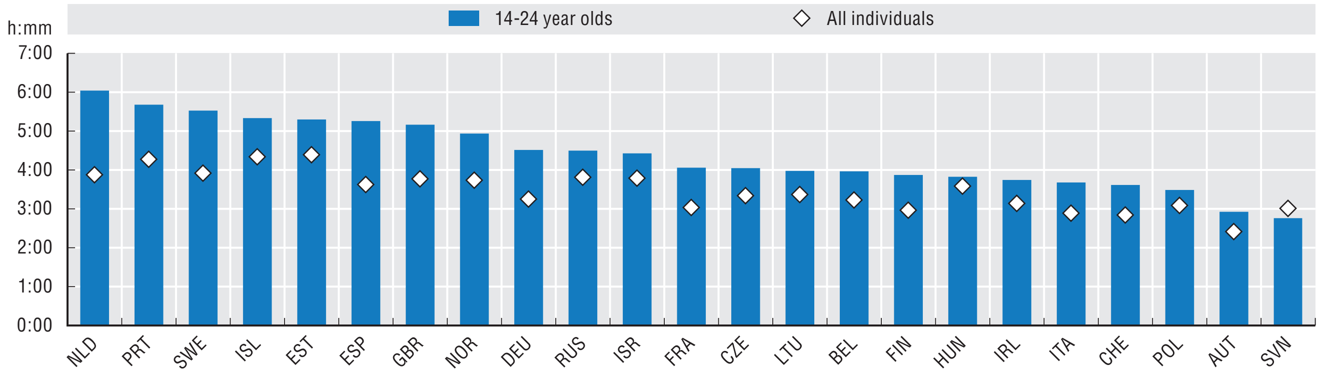


Source: OECD, Broadband Portal, http://oe.cd/broadband, January 2019. See chapter notes.

StatLink https://doi.org/10.1787/888933928920

36. Average time spent on the Internet daily, all individuals and 14-24 year-olds, 2016

Hours and minutes



Source: OECD calculations based on the European Social Survey micro-data (2016 edition), January 2019. StatLink contains more data.

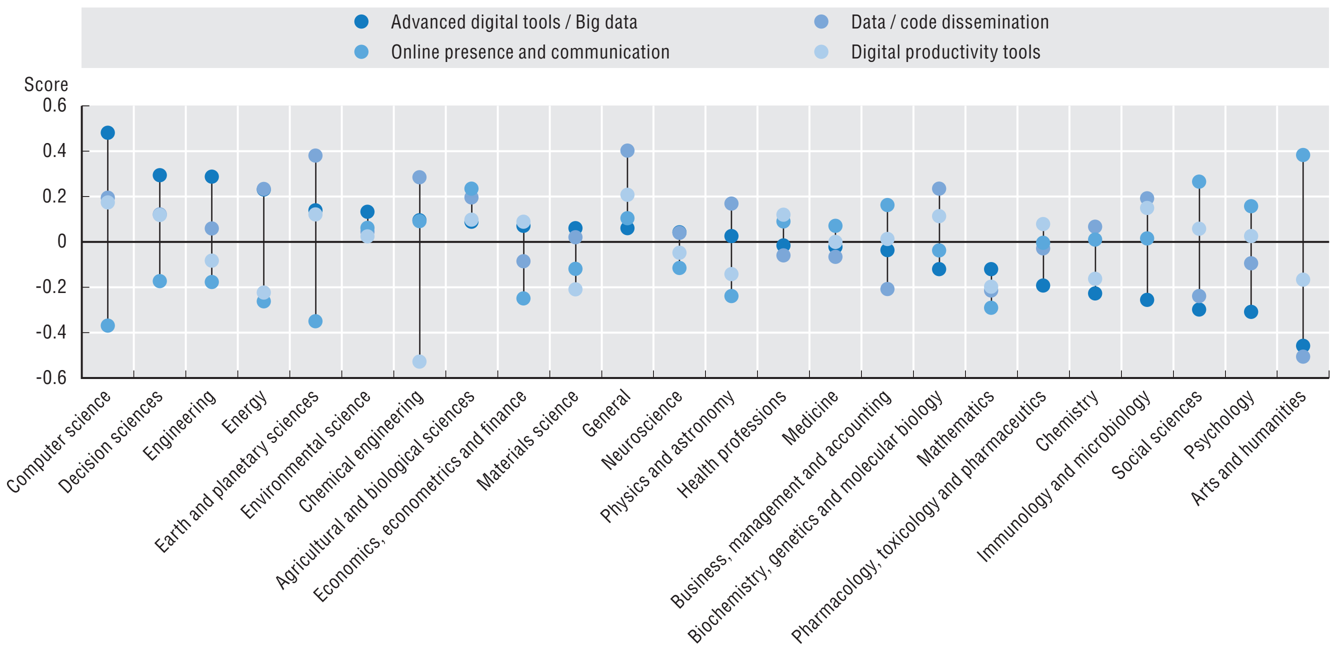
StatLink https://doi.org/10.1787/888933928939

Science going digital

Digitalisation is changing the way in which research is conducted and disseminated. In order to identify emerging patterns of digitalisation in science, a new OECD survey, the International Survey of Scientific Authors (ISSA), asks scientists questions on whether digital tools make them more productive. It also includes questions on the extent to which they rely on Big data analytics, share data and source codes developed through their research, or rely on a digital identity and presence to communicate their research. Preliminary survey results reveal contrasting patterns of digitalisation by field. The use of advanced digital tools, including those associated with Big data, is more widespread in computer and decision sciences, and engineering. The life sciences (with the exception of pharmaceutical) and the physical sciences (other than engineering) report the greatest effort to make data and/or code usable by others. There are smaller systematic differences in the reported use of productivity tools, which have much higher general adoption rates. Scholars in the engineering domains report using productivity tools less frequently. Interestingly, the fields making less use of advanced digital and data/code dissemination tools – namely social sciences, arts, and humanities – are more likely to engage in activities that enhance their digital presence and external communication (e.g. the use of social media).

37. Patterns of digitalisation in science across fields, 2018

Average standardised factor scores, by field



Note: This is an experimental indicator. This figure presents the average of four distinct standardised factor scores representing latent digitalisation indicators for each scientific field. The factor analysis is based on responses by scientists to 36 questions relating to digital or digitally enabled practices, combined in four synthetic indicators. These indicators or factors have been interpreted and labelled based on how strongly they correlate with different questions.
Source: OECD, International Survey of Scientific Authors (ISSA) 2018, preliminary results, http://oe.cd/issa, January 2019. See chapter notes.

StatLink https://doi.org/10.1787/888933928958

The OECD International Survey of Scientific Authors (ISSA)

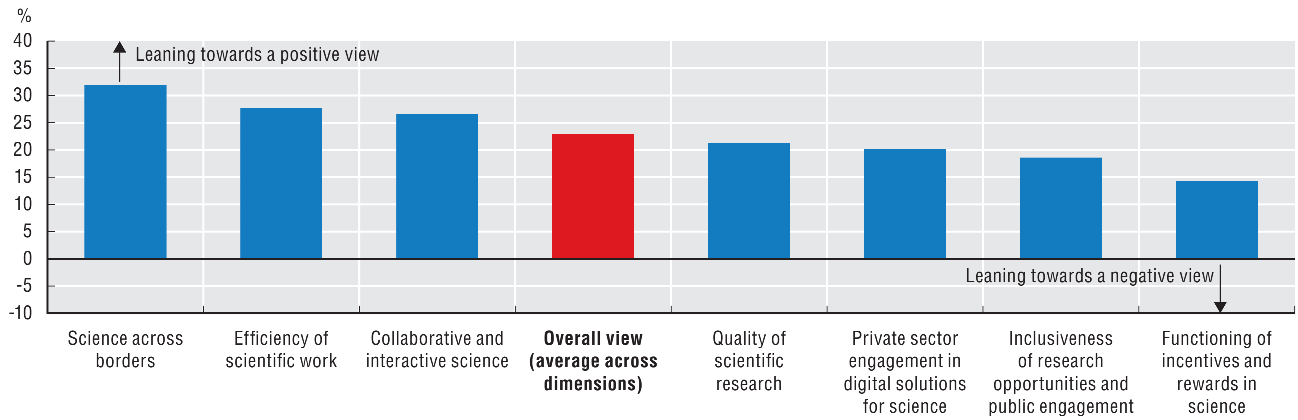
During the last quarter of 2018, the OECD contacted a large, randomly selected group of corresponding authors of scholarly documents, asking them to respond to an online survey aimed at identifying patterns of digitalisation in scientific research and exploring its drivers and potential effects. This OECD International Survey of Scientific Authors (ISSA) obtained rich information from nearly 12 000 scholars worldwide about their use of a broad range of digital tools and related practices. In order to provide an overarching and interpretable view of digitalisation patterns in science, answers to 36 questions relating to digitally enabled practices were analysed to identify four major "latent" factors. These represent how likely scientists are to: (i) make use of productivity tools to carry out regular tasks such as retrieving information and collaborating with colleagues, (ii) make data and code outputs arising from research available to others, (iii) use or develop unconventional data and computational methods, and (iv) maintain a digital identity expanding their communication with peers and the public in general. More detailed results and analysis from this study are made available on the ISSA project website (http://oe.cd/issa).

Impacts on science: scientists' views

Scientists' views regarding the impacts of digitalisation are positive overall, especially among younger authors. How do scientists themselves view the digital transformation of scientific research and its impacts? Evidence from the 2018 OECD Survey of Scientific Authors (ISSA) suggests that scientists' views are positive, on average, across several dimensions. There is strong sentiment that digitalisation has the potential to promote collaboration in general and particularly across borders, as well as to improve the efficiency of scientific research. While remaining positive, scientists appear to harbour more reservations regarding the impact that digitalisation may have on systems of incentives and rewards (e.g. the ratings of publications, citations and downloads that constitute the digital "footprint" of a scientific author). Likewise for the ability to bring together scientific communities and scientists with the public (inclusiveness), and the role of the private sector in providing digital solutions. Younger authors are more positive than their older peers, except with respect to the impacts of digitalisation on the incentive system, which may reflect concerns about their future careers. Across countries, the average sentiment towards the impacts of digitalisation seems consistent overall with results from broader population surveys on attitudes towards the impacts of science and technology (OECD, 2015). Scientists outside Europe, including those in emerging and transition economies, appear to be more positive on average regarding the impacts of digitalisation on science.

38. Scientific authors' views on the digitalisation of science and its potential impacts, 2018

Average sentiment towards "positive" digitalisation scenario, as percentage deviation from mid-viewpoint

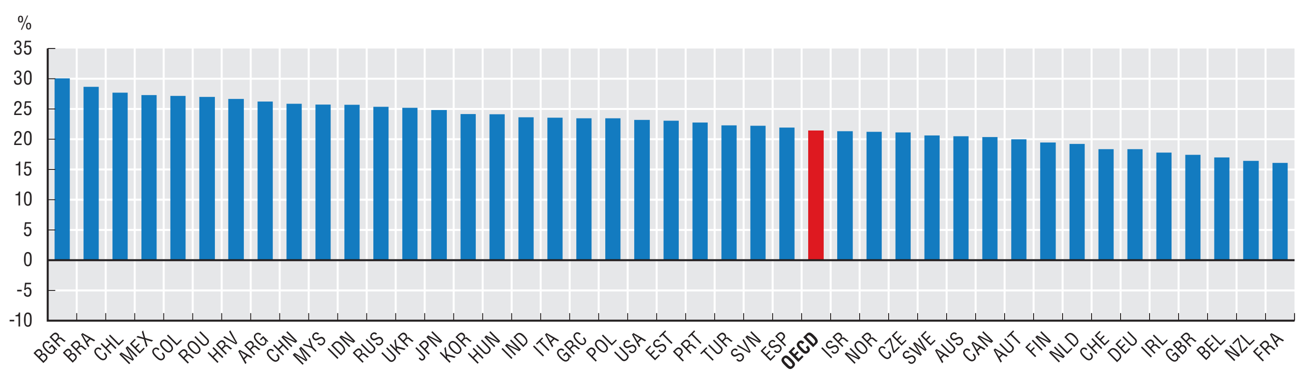


Note: This is an experimental indicator. Survey respondents were asked to rate opposing scenarios on different dimensions from (1 = fully agree with negative view) to (10 = fully agree with positive view). For interpretability, average unweighted scores on each dimension and general summary view (average across dimensions) are presented as percentage deviations from the mid-range point.
Source: OECD, International Survey of Scientific Authors (ISSA) 2018, preliminary results, http://oe.cd/issa, January 2019. See chapter notes.

StatLink https://doi.org/10.1787/888933928977

39. Scientific authors' views on the digitalisation of science, by country of residence, 2018

Average sentiment towards "positive" digitalisation scenario, as percentage deviation from mid-viewpoint



Note: This is an experimental indicator. Country results should be interpreted and compared with caution as the population of corresponding scientific authors is not uniformly representative of a country's scientific community. Only values for countries with at least 75 responses have been reported.
Source: OECD, International Survey of Scientific Authors (ISSA) 2018, preliminary results, http://oe.cd/issa, January 2019. See chapter notes.

StatLink https://doi.org/10.1787/888933928996

Notes

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.

1. Top players in emerging digital technologies, 2013-16

Data refer to IP5 families by filing date and the applicant's residence, using fractional counts. Patent "bursts" correspond to periods characterised by the 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 2015 and 2016 are incomplete.

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

2. Intensity and development speed in ICT-related technologies, 2005-15

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 2005 are included. Data for 2015 and 2016 are truncated.

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

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

3. Technology developments in artificial intelligence, 1990-2016

Patents related to AI are identified using an experimental combination of International Patent Classification (IPC) codes and keyword searches extracted from patent documents. Data refer to IP5 patent families by earliest filing date and the applicant's residence, using fractional counts. IP5 patent families are patents filed in at least two offices worldwide, one of which is one of the five largest IP offices: the European Patent Office (EPO), the Japan Patent Office (JPO), the Korean Intellectual Property Office (KIPO), the US Patent and Trademark Office (USPTO) and the National Intellectual Property Administration of People's Republic of China (NIPA). Data for 2015 and 2016 are estimates based on available data for those years.

4. Top fields of application of AI-related technologies, 2012-16

Patents related to AI are identified using an experimental combination of International Patent Classification (IPC) codes and keyword searches extracted from patent documents. Data refer to IP5 patent families by earliest filing date and technology fields, using fractional counts. IP5 patent families are patents filed in at least two offices worldwide, one of which is one of the five largest IP offices: the European Patent Office (EPO), the Japan Patent Office (JPO), the Korean Intellectual Property Office (KIPO), the US Patent and Trademark Office (USPTO) and the National Intellectual Property Administration of People's Republic of China (NIPA). Patents are allocated to application fields on the basis of their International Patent Classification (IPC) codes, following the concordance provided by WIPO (2013), revised in 2018. Data for 2015 and 2016 are incomplete.

5. Top technologies combined with artificial intelligence, by field of application, 2012-16

Patents related to AI are identified using an experimental combination of International Patent Classification (IPC) codes and keyword searches extracted from patent documents. Data refer to IP5 patent families by earliest filing date and IPC codes, using fractional counts. IP5 patent families are patents filed in at least two offices worldwide, one of which is one of the five largest IP offices: the European Patent Office (EPO), the Japan Patent Office (JPO), the Korean Intellectual Property Office (KIPO), the US Patent and Trademark Office (USPTO) and the National Intellectual Property Administration of People's Republic of China (NIPA). Patents are allocated to application fields on the basis of their International Patent Classification (IPC) codes, following the concordance provided by WIPO (2013), revised in 2018. Data for 2015 and 2016 are incomplete.

6. AI-related companies in the United Kingdom, by focus of activity, 2018

PC1 and PC2 are calculated on the basis of the Jensen-Shannon divergence and using a principal components algorithm. The number of companies are based on companies mostly active in a given topic, using simple counts.

7. AI-related technologies developed by UK companies, by sector, 2018

Data refer to the number of AI-related companies in the United Kingdom, by sector and topic area, using simple counts.

8. The science behind AI, 1996-2016

Fields are based on the SCOPUS 2-digit All Science Journals Classification (ASJC).

This is an experimental indicator. AI-related documents (among Scopus-indexed articles, reviews and conference proceedings) are identified using a list of keywords to search the abstracts, titles and keywords of scientific documents. These keywords are selected on the basis of high co-occurrence patterns with terms frequently used in journals classified as AI by Elsevier. Only those documents with two or more keywords were considered AI documents. For more details, see the forthcoming working paper at: https://doi.org/10.1787/18151965.

9. Trends in scientific publishing related to artificial intelligence, 2006-16

See note 8 above.

10. Top-cited scientific publications related to AI, 2006 and 2016

This is an experimental indicator. AI-related documents (among Scopus-indexed articles, reviews and conference proceedings) are identified using a list of keywords to search the abstracts, titles and keywords of scientific documents. These keywords are selected on the basis of high co-occurrence patterns with terms frequently used in journals classified as AI by Elsevier. Only those documents with two or more keywords were considered AI-related documents. For more details, see the forthcoming working paper at: https://doi.org/10.1787/18151965.

"Top-cited publications" are the 10% most-cited papers normalised by publication journal scientific field(s) and type of document (articles, reviews and conference proceedings). The Scimago Journal Rank indicator is used to rank documents with identical numbers of citations within each class. This measure is a proxy indicator of research excellence. Estimates are based on fractional counts of documents by authors affiliated to institutions in each economy. Documents published in multidisciplinary/generic journals are allocated on a fractional basis to the ASJC codes of citing and cited papers.

11. Consumer price indices, all products and ICT goods and services, OECD, Euro area and United States, 2000-18

For the OECD, the following data are not included in calculations: Canada (whole series), Iceland, Mexico and the United States (until 2002), Turkey (until 2004) and New Zealand (until 2007).

National indices are used for Finland and the United States until 2009, Poland until 2005, the United Kingdom until 2004 and Hungary until 2006.

Data for 2018 are limited to October.

For the Euro area, data refer to Belgium, France, Germany, Italy, the Netherlands and Spain (representing 90% of the total Euro area) until 2014.

For the United States, data for ICT equipment include Internet services until 2008.Country and item weights were used for aggregations and estimations.

12. Computing power and cost of storage, 1970-2018 and 1982-2018

The transistor count is the number of semiconductor devices on an integrated circuit (IC). Transistor count is the most common measure of IC complexity, although there are caveats. For instance, the majority of transistors are contained in the cache memories in modern microprocessors, which consist mostly of the same memory cell circuits replicated many times.

The process node (also called the technology node, process technology or simply node) refers to a specific process in semiconductor manufacturing. The size of the elements of the structure of a chip are measured in nanometres.

13. The increasing capacity of Internet infrastructure, 2005-18

Speed data for 2018 refer to the period June 2017 to May 2018.

Top-level domains data for 2018 are limited to October 2018.

14. The increasing content hosted on the Internet, 2018

Data sources are the following:

For Australia, China and Tokelau, data come from Verisign: www.verisign.com/en_GB/domain-names/dnib/index.xhtml.

For Europe and Canada: https://stats.centr.org; for Spain: www.dominios.es/dominios; for Japan: https://jprs.co.jp/en/stat; for India: https://registry.in; for the United States: www.about.us/resources/statistics; for Korea, Poland and South Africa: http://research.domaintools.com/statistics/tld-counts.

For all gTLDs except .biz: https://stats.centr.org; for .biz: www.statdns.com.

For all 2005 TLDs: www.oecd.org/sti/ieconomy/37730629.pdf.

Data for "others" are based on OECD estimates by difference.

16. Global data centre traffic, by type and Consumer Internet Protocol (IP) traffic, by sub-segment, 2015-22

Cisco Global Cloud Index 2016-21 is available at: www.cisco.com/c/en/us/solutions/collateral/service-provider/global-cloud-index-gci/white-paper-c11-738085.html.

Cisco Visual Networking Index 2017-22 is available at: www.cisco.com/c/en/us/solutions/service-provider/visual-networking-index-vni/index.html#complete-forecast.

17. ICT investment and expenditure in ICT intermediate services, 2005-15

Nominal investment in ICT tangible capital and software capital by industry and country is sourced from the OECD Annual National Accounts (SNA) Database. ICT investment estimates for Germany and Spain are provisional and sourced from EUKLEMS. Purchases of intermediate ICT services in current prices are sourced from the OECD Inter-Country Input-Output (ICIO) Database. The industry origins of intermediate ICT services are those produced by ISIC Rev.4 Division 62 (Computer programming, consultancy and related activities) and 63 (Information service activities). Both domestically produced and imported intermediates are included. Purchases by all sectors in the economy are considered. Current price investment in ICT tangible capital are deflated using hedonic price series from the OECD Productivity Database. Current price investment in software and databases is deflated using the software deflators developed by Corrado et al. (2012), extrapolated using software hedonic deflators from the OECD Productivity Database, where necessary. Purchases of ICT intermediate services are deflated by the output prices of the ICT-service producing industry in the country. When such output deflators are not available, the G7 un-weighted average deflator for the same industry is applied. Value added figures at the industry-country are sourced from the OECD Structural Analysis (STAN) Database, and complemented with information from the OECD SNA Database when missing. They are deflated using industry-specific deflators from the STAN Database or GDP deflators from the SNA Database when the former are missing.

Intensities are calculated by dividing deflated investment and expenditure by the industry-country value added. Year-on-year growth rates in industry-country values are calculated, then averaged over all countries and industries, accounting for the unbalanced nature of the sample. Growth rates are calculated at the disaggregation level reported in the ICIO. The following countries are included: Australia, Austria, Belgium, Canada, Chile, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Iceland, Israel, Italy, Japan, Korea, Luxembourg, Latvia, Mexico, the Netherlands, Norway, New Zealand, Poland, Portugal, Slovak Republic, Slovenia, Spain, Sweden, the United Kingdom and the United States.

18. Diffusion of selected ICT tools and activities in enterprises, OECD, 2010 and 2018

Broadband includes fixed connections with an advertised download rate of at least 256 Mbps.

For the most recent year, data refer to 2018 for the majority of countries included in the sample with the following exceptions:

For ERP, CRM, SCM and RFID, data refer to 2017.

For the earlier year, data refer to 2010 for the majority of countries included in the sample with the following exceptions:

For cloud computing, data refer to 2014 for the majority of countries.

For Big data, data refer to 2016.

For RFID, data refer to 2009 for the majority of countries.

For high-speed broadband, data refer to 2011 for the majority of countries.

19. Diffusion of selected ICT tools and activities in large and small businesses, OECD, 2010 and 2018

Broadband includes fixed connections with an advertised download rate of at least 256 Mbps.

For each ICT tool or activity, based on data available for 2010 and 2018, a simple OECD average was calculated for large and small firms

For the most recent year, data refer to 2018 for the majority of countries, with the following exceptions:

For ERP, CRM, SCM and RFID, data refer to 2017.

For the earlier data year, data refer to 2010 for the majority of countries, with the following exceptions:

For cloud computing, data refer to 2014 for the majority of countries.

For Big data, data refer to 2016.

For RFID, data refer to 2009 for the majority of countries.

For high-speed broadband, data refer to 2011 for the majority of countries.

20. ICT uptake by industry, EU28, 2018

For ERP and CRM, data relate to 2017.

21. Enterprises with internal ICT capabilities, by industry, EU countries, 2018

Industry coverage is as follows according to NACE Rev.2:

IT services: Computer programming, consultancy and related activities, information service activities (J62-J63);

Telecommunications: Telecommunications (J61);

Publishing and broadcasting: Publishing activities; motion picture, video and television programme production, sound recording and music publishing; programming and broadcasting (J58, J59, J60);

ICT and electronics: Manufacture of computer, electronic and optical products (C26);

Travel activities: Travel agency; tour operator reservation service and related activities (N79);

Professional and technical activities: Professional, scientific and technical activities (M69-M75);

Wholesale trade: Wholesale trade, except of motor vehicles and motorcycles (G46);

Machinery and electrical equipment: Manufacture of electrical equipment, machinery and equipment n.e.c. (C27-C28);

Transport and equipment: Manufacture of motor vehicles, trailers and semi-trailers, other transport equipment (C29-C30);

Motor vehicles trade: Trade of motor vehicles and motorcycles (G45);

Chemicals: Manufacture of coke, refined petroleum, chemical and basic pharmaceutical products, rubber and plastics, other non-metallic mineral products (C19-C23);

Utilities: Electricity, gas, steam, air conditioning and water supply (D35-D39);

All industries: All non-financial enterprises;

Retail trade: Retail trade, except of motor vehicles and motorcycles (G47);

Real estate: Real estate activities (L68);

Wood, paper and printing: Manufacture of wood and products of wood and cork, except furniture; articles of straw and plaiting materials; paper and paper products; printing and reproduction of recorded media (C16-C18);

Accommodation and food services: Accommodation, food and beverage service activities (I55-I56);

Other manufacturing: Manufacture of furniture and other manufacturing; repair and installation of machinery and equipment (C31-C33);

Metal products: Manufacture of basic metals and fabricated metal products excluding machines and equipment (C24-C25);

Transport and storage: Transportation and storage (H49-H53);

Food products: Manufacture of beverages, food and tobacco products (C10-C12);

Textiles and apparel: Manufacture of textiles, wearing apparel, leather and related products (C13-C15); and

Construction: Construction (F41-F43).

22. Web maturity and advanced ICT functions, by industry, EU countries, 2018

For industry definitions, see note 21 above.

23. Changes in business dynamism, entry and exit rates, 1998-2015

The figures are based on the year coefficients of regressions within the country-STAN a38 sector, focusing separately on sectors in the “Highly digital-intensive” and “Other sectors” groups. Average trends for highly digital-intensive sectors are reported with a solid line and for other sectors with a dashed line. The dependent variables of the regressions are, respectively, entry rates or exit rates. Confidence bands (95%) are also reported based on robust standard errors.

Figures are based on data covering manufacturing and non-financial market services, and exclude self-employment and the Coke and Real estate sectors. The countries covered are: Austria, Belgium, Brazil, Canada, Costa Rica, Finland, France, Hungary, Italy, Japan, the Netherlands, Norway, Portugal, Spain, Sweden, Turkey and the United States. Data for Japan are for manufacturing only. The classification of sectors according to digital intensity is based on Calvino et al. (2018) (top quartiles in either of the two periods considered in the study). Owing to methodological differences, figures may deviate from officially published national statistics. Data for some countries are still preliminary.

25. Top robot-intensive economies and BRIICS, 2016

Robot use collected by the International Federation of Robotics (IFR) is measured as the number of robots purchased by a given country/industry. The 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 figure covers manufacturing sectors only.

For Australia, Greece, Estonia and Slovenia, data are extrapolated from 2013 due to missing data for subsequent years.

For Canada and Mexico, stocks of robots are constructed starting from 2011 due to data availability.

For Chile and India, data refer to 2015 due to missing robot data for 2016.

The density is obtained by dividing the stock by the number of employed persons. Employment data refer to employed person and are sourced from the OECD Annual National Accounts (SNA) Database, the OECD Structural Analysis (STAN) Database or the OECD Trade in Employment (TiM) Database.

For Chinese Taipei, data are sourced from the ILO Estimates and Projections series.

For Singapore, data are sourced from the Ministry of Manpower and include non-resident employed persons.

26. Diffusion of robots and 3D printing in enterprises, by sector and firm size, EU28, 2018

An industrial robot is defined by ISO 8373:2012 as "an automatically controlled, reprogrammable, multipurpose manipulator programmable on three or more axes, which can be either fixed in place or mobile for use in industrial automation applications". A "service robot" is a robot "that performs useful tasks for humans or equipment excluding industrial automation applications". (ISO 8373). The International Federation of Robotics collects information on shipments (counts) of industrial robots from almost all existing robot suppliers worldwide. No information on service robots is currently made available. The measure of the stock of robots displayed above has been calculated by taking the first-year stock value from the IFR, adding the sales of robots for subsequent years and assuming a 10% annual depreciation. Consequently, these metrics do not capture increases in the quality of robots or their ability to perform tasks.

Industry coverage is as follows according to NACE Rev.2:

Metal products: Basic metals and fabricated metal products, except machinery and equipment (C24-C25);

Chemicals: Petroleum, chemical, pharmaceutical, rubber, plastic products and other non-metallic mineral products (C19-C23);

Machinery and electrical equipment: Computers, electric and optical products, electrical equipment, machinery and equipment n.e.c, motor vehicles, other transport equipment, furniture, other manufacturing, repair and installation of machinery and equipment (C26-C33);

Manufacturing: Total manufacturing (C10-C33);

Food, textile, printing: Food, beverages, tobacco, textile, leather, wood, pulp and paper; publishing and printing (C10-C18);

All industries: All non-financial enterprises;

Trade and repairs: Wholesale and retail trade; repair of motor vehicles and motorcycles (G45-G47);

ICT sector: ICT sector

Retail trade: Retail trade (G47);

Utilities: Electricity, gas, steam and air conditioning; water supply, sewerage, waste management and remediation activities (D35-D39);

Construction: Construction (F41-F43);

Transport and storage: Transport and storage (H49-H53);

Professional and technical services: Professional, scientific and technical activities, except veterinary activities (L69-M74);

Administrative and support services: Administrative and support service activities (N77-N82);

Accommodation: Accommodation (I55);

Information and communication: Information and Communication (J58-J63); and

Real estate activities: Real estate activities (L68).

27. Impacts of new software or computerised equipment at work, by industry, EU countries, 2018

Change in tasks refers to the survey item "Individual's main job tasks changed as a result of the introduction of new software or computerised equipment".

Had to learn how to use software/equipment refers to the survey item "Individuals had to learn how to use new software or computerised equipment for the job".

Needed further training refers to the survey item "Individuals needed further training to cope well with the duties relating to the use of computers, software or applications at work".

28. Perceived impacts of digital technologies on specific aspects of work, EU countries, 2018

Data refer to Austria, Denmark, Estonia, Finland, Germany, Greece, Hungary, Lithuania, Luxembourg, Norway, Poland, Portugal, Slovak Republic, Slovenia and Spain.

Increase and decrease values are computed as a weighted average (based on the number of worker who used a computer equipment at work) across countries included in the sample.

Net impact refers to increase minus decrease over the computed weighted average.

29. Top-demanded skills in computer-related jobs, United States, 2018

Data on skill demand by occupation are sourced from Burning Glass Technologies, and refer to the skill categories demanded in online advertisements for job vacancies in the United States in 2018. Skills demand is calculated as the number of online vacancies requiring the job candidate to display a given skill category. Multiple skill categories in the same vacancy are allowed. The font size in the picture increases with the number of vacancies in the occupation demanding the skill. Each of the skill categories represented in blue font is demanded in at least 2% of vacancies for the occupation.

The computer occupations considered represent a subset of the computer occupations identified in the 2010 Standard Occupational Classification System (SOC 2010) of the United States Bureau of Labor Statistics. "Computer and information analysts" corresponds to SOC 2010 class 15-112, "Programmers and developers" to SOC 2010 class 15-113; "Database and network administrators" to SOC 2010 class 15-114; and "Computer support specialists" to SOC 2010 class 15-115.

30. Top 10 skills in high demand for computer-related jobs, United States, 2012-18

The computer occupations considered represent a subset of the computer occupations identified in the 2010 Standard Occupational Classification System (SOC 2010) of the United States' Bureau of Labor Statistics. "Computer and information analysts" corresponds to SOC 2010 class 15-112, "Programmers and developers" to SOC 2010 class 15-113; "Database and network administrators" to SOC 2010 class 15-114; and "Computer support specialists" to SOC 2010 class 15-115.

Data on skill demand by occupation are sourced from Burning Glass Technologies, and refer to the skills demanded in online advertisements for job vacancies in the United States from 2012 to 2018. Skills demand is calculated as the number of online vacancies requiring the job candidate to display a given skill category. Only skills categories which were present in more than 2 000 vacancies in each 8-digit Standard Occupational Classification (SOC) 2010 occupation were analysed, so as to minimise the probability that a few large employers drive the resulting growth rate. Growth is calculated over the entire period. Skill categories are standardised version of the skills reported in job postings, as identified by Burning Glass Technologies. Dark blue bars in the figure represent skill categories present in at least three of the four considered occupations and display at least a 20% growth rate in each of them.

31. Sophistication of Internet use by individuals, 2018

The activities considered are as follows:

Within the last 3 months: E-mailing for private (non-work) purposes, Accessing social networking sites, Telephoning/video calling, finding information about goods and services, reading/downloading online newspapers/news magazines, uploading self-created content on sharing websites (e.g. YouTube), Internet banking.

Within the last 12 months: Downloading and installing software from the Internet, purchasing online, using software for electronic presentations (slides).

The following series refer to 2017: reading/downloading online newspapers, downloading and installing software from the Internet, using software for electronic presentations and uploading self-created content on sharing websites.

For Brazil, data refer to 2016.

For Chile, Korea, Mexico and Switzerland, data refer to 2017.

32. Diffusion of Internet banking and online purchasing, OECD, 2010-17

Data presented on the left-hand panel are based on OECD estimates.

Canada and New Zealand are not included due to data availability.

Unless otherwise stated, Internet users are defined as individuals who accessed the Internet within the last 3 months for Internet banking and the last 12 months for online purchasing. For Australia, Israel and the United States, Internet users are defined with a recall period of 3 months for both variables. For Japan, Internet users are defined with a recall period of 12 months for both variables.

For Australia, data refer to the fiscal year 2016/17 ending on 30 June.

For Israel and Japan, data refer to 2016.

33. Internet users, G20 countries, 2018

Unless otherwise stated, Internet users are defined as individuals who accessed the Internet within the last 3 months. For Canada and Japan, the recall period is 12 months. For the United States, the recall period is 6 months for 2017 and no time period is specified in 2006. For India, Indonesia, the Russian Federation, Saudi Arabia and South Africa, no time period is specified.

For Argentina, data refer to 2016 instead of 2018.

For Australia, data refer to the fiscal years 2006/07 and 2016/17 ending 30 June. The reference period is 12 months in 2006.

For Brazil, data refer to 2008 and 2016.

For Canada, data refer to 2007 and 2012. Data refer to individuals aged 16 and over instead of 16-74 in 2006. The reference period is 12 months.

For China, Korea, the Russian Federation and South Africa, data refer to 2017 instead of 2018.

For EU28, data refer to 2007 instead of 2006.

For India, data refer to 2016 instead of 2018.

For Indonesia, data refer to 2017 instead of 2018 and to individuals aged 5 or more.

For Japan, data refer to 2016 instead of 2018 and to individuals aged 15 to 69.

For Mexico, data refer to 2017 instead of 2018.

For Turkey, data refer to 2007 instead of 2006.

For the United States, data refer to 2007 and 2017.

For Argentina, China, India, Indonesia, the Russian Federation, Saudi Arabia and South Africa, data originate from the ITU World Telecommunication/ICT Indicators (WTI) Database 2018.

35. Wireless broadband in OECD countries, 2009-17

For 2009, data exclude Canada, Germany, Lithuania, Mexico, the Netherlands and Slovenia.

For 2010, data exclude Lithuania.

37. Patterns of digitalisation in science across fields, 2018

The factor analysis was applied to a set of binary variables reporting information on whether or not digital tools were used in a range of scientific activities, or whether or not more advanced digital tools (e.g. Big data analytics) were used or developed as part of an author's core scientific activities. In the initial step of the factor analysis, given the binary nature of the variables observed, tetrachoric correlations were calculated for each pair of variables.

The principal-component factor method was then applied to the resulting pairwise correlation matrix to extract the factors. The number of factors selected was forced to be four at most based on an initial observation of the eigenvalues. In a successive step, to improve the interpretability of the factor loadings, factors were rotated by applying an orthogonal rotation method, which produced factors that are uncorrelated.

The four resulting factors were interpreted and labelled based on their loadings with the observed variables. The factor "Digital productivity tools" exhibits higher loadings with the question items on the use of digital tools in milestone scientific activities, including data collection and analysis, project management, search of research material, manuscript dissemination and fundraising. The observed variables related to the features of the data and codes that are shared and made available by researchers are more strongly correlated with the factor "Data/Code dissemination". The factor "Advanced digital tools/Big data" exhibits higher loadings with the question items on the use of more advanced digital tools (e.g. Big data analytics, sensors and participative networks), whereas the factor "Online presence and communication" is more strongly correlated with the variables reporting on the use of digital tools for research findings communication, interaction with other researchers, or the use of online personal or team profiles to report on research-related activities or outputs. The factors "Digital productivity tools" and "Data/Code dissemination" explain individually around 14% of the overall variance of the observed variables, whereas the factors "Advanced digital tools/Big data" and "Online presence and communication" explain individually approximately 10% of the variance.

38. Scientific authors' views on the digitalisation of science and its potential impacts, 2018

The dimension "Science across borders" includes responses to the question item with the positive scenario "The trend towards an increasing use of digital tools in science and research facilitates personal interactions with researchers and experts abroad". The dimension "Efficiency of scientific work" includes responses to the question item with the positive scenario "The trend towards an increasing use of digital tools in science and research makes scientific and related work faster and more efficient". "Collaborative and interactive nature of science" summarises responses to the question item with the positive scenario "The trend towards an increasing use of digital tools in science and research facilitates collaboration and interdisciplinary teamwork". "Quality of scientific research" summarises responses to two question items with the positive scenarios "The trend towards an increasing use of digital tools in science and research allows to tackle problems that were previously intractable" and "The trend towards an increasing use of digital tools in science and research facilitates the verification and reproducibility of scientific findings", whereas the dimension "Private sector engagement in digital solutions for science" includes responses to the question item with the positive scenario "The trend towards an increasing use of digital tools in science and research promotes innovation in the generation of new tools and solutions for use by researchers and research administrators". "Inclusiveness of research opportunities and public engagement" includes responses to the question items with the positive scenarios "The trend towards an increasing use of digital tools in science and research helps bring science closer to the public and society at large" and "The trend towards an increasing use of digital tools in science and research provides more equal opportunities to researchers to pursue successful careers". "Functioning of incentives and rewards in science" includes answers to the question item with the positive scenario "The trend towards an increasing use of digital tools in science and research makes it easier to assess the broad impact of scientific research and provide better incentives".

39. Scientific authors' views on the digitalisation of science, by country of residence, 2018

Survey respondents were asked to rate opposing scenarios on different dimensions from (1 = fully agree with negative view) to (10 = fully agree with positive view). For interpretability, average unweighted scores on a general summary view (average across dimensions) are presented as percentage deviations from the mid-range point.

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Chapter 2
GROWTH AND WELL-BEING

The contribution of information industries to total industry value added has remained relatively stable over the past ten years. However, important compositional changes have seen a general shift towards IT and other information services, while the weight of ICT manufacturing and telecommunications services has generally declined in OECD countries. The contribution to total value added from Computer, electronics and optical manufacturing, and from telecommunication services, diminished as production shifted to other, mostly non-OECD, economies. Meanwhile, unit prices fell due to productivity growth and increased competition. On average, across OECD countries, the share of Computer, electronic and optical manufacturing dropped from 1.4% in 2006 to 1.1% of total value added in 2016, and fell especially steeply in Finland, Sweden and Ireland. The share of telecommunication services also decreased from 1.9 % to 1.4% on average.

The share of publishing and media activities in total value added grew markedly in Ireland (by 2.8 percentage points) and Sweden (by 1.3 percentage points), but remained relatively stable in most other countries. In many countries declines in other ICT industries were largely offset by increases in the value added share of IT and other information services, which rose strongly from around 1.6% to 2.2% on average. These services include computer programming and consultancy, web portals, and data processing and hosting – activities closely related to cloud computing services, which increasingly appear to be substituting for direct investment in ICT goods for many businesses. This increase was especially marked in Estonia (2.1 percentage points) and Latvia (1.8 percentage points).

Reflecting the shift towards ICT services – which are relatively more labour intensive, on average – employment in information industries accounted for 3.7% of total employment in OECD countries in 2016, more than in 2006 (3.5%). By country, shares (and trends) in employment are similar to those for value added, although in general information industries account for a much lower share of employment than value added, reflecting their comparatively high levels of labour productivity. Information industries generate over 5% of employment in Israel, Estonia, Switzerland, Iceland and Korea, but less than 2% in Chile and Turkey. In nearly all countries, IT and other information services have become the most sizeable component in employment terms, except in Switzerland and Mexico where ICT manufacturing remains the largest employer, albeit with declining shares due to productivity gains and businesses electing to source more intermediate inputs from abroad.

DID YOU KNOW?

In 2016, information industries contributed around 6% of total value added and 3.7% of employment across OECD countries.

Definitions

Information industries combines the OECD definitions of the "ICT sector" and the "content and media sector" (OECD, 2011). While this definition includes detailed (three- and four-digit) ISIC Rev.4 industrial activities (United Nations, 2008), in this analysis it is approximated by the following ISIC Rev.4 (two-digit) Divisions, due to limited data availability: "Computer, electronic and optical products" (Division 26), "Publishing, audiovisual, and broadcasting activities" (58 to 60), "Telecommunications" (61), and "IT and other information services" (62 to 63).

Value added consists of the value of production net of the costs of intermediate inputs. In practice, it includes both gross profits and wages, and at an aggregate level is equivalent to GDP.

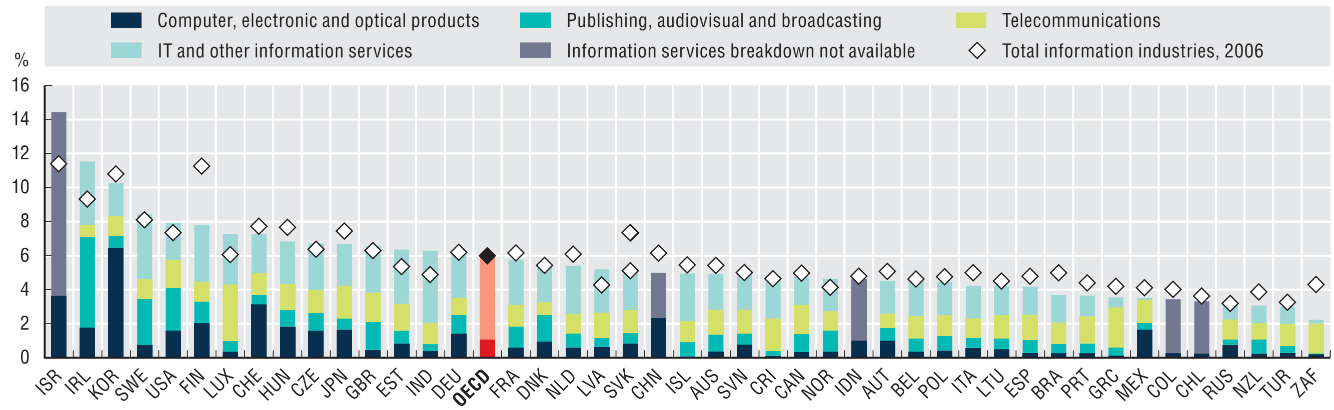
Measurability

A definition of *information industries* based on ISIC Rev.4 (two-digit) Divisions is used here because national accounts by economic activity statistics are generally not available at more detailed levels. However, this means that the following ISIC Rev.4 (three-digit) manufacturing groups are included that are *not* part of the "ICT sector" definition: "Manufacture of measuring, testing, navigating and control equipment; watches and clocks" (group 265), "Manufacture of irradiation, electromedical and electrotherapeutic equipment" (266) and "Manufacture of optical instruments and photographic equipment" (267). Furthermore, "ICT sector" services covering ICT wholesale trade (ISIC Rev.4 classes 4651 and 4652) and repair of ICT equipment (group 951) are excluded.

The extent to which the use of the full OECD ISIC Rev.4 definition of *information industries* differs from the aggregate (two-digit) approximation varies across countries. More detailed activity data may be available from underlying business statistics sources, but are rarely published as part of national accounts statistics - required for productivity measurement and analysis, for example. More detailed statistics would also allow for more focused analyses of the ICT sector, both manufacturing and service activities.

Value added by information industries, 2016

As a percentage of total value added

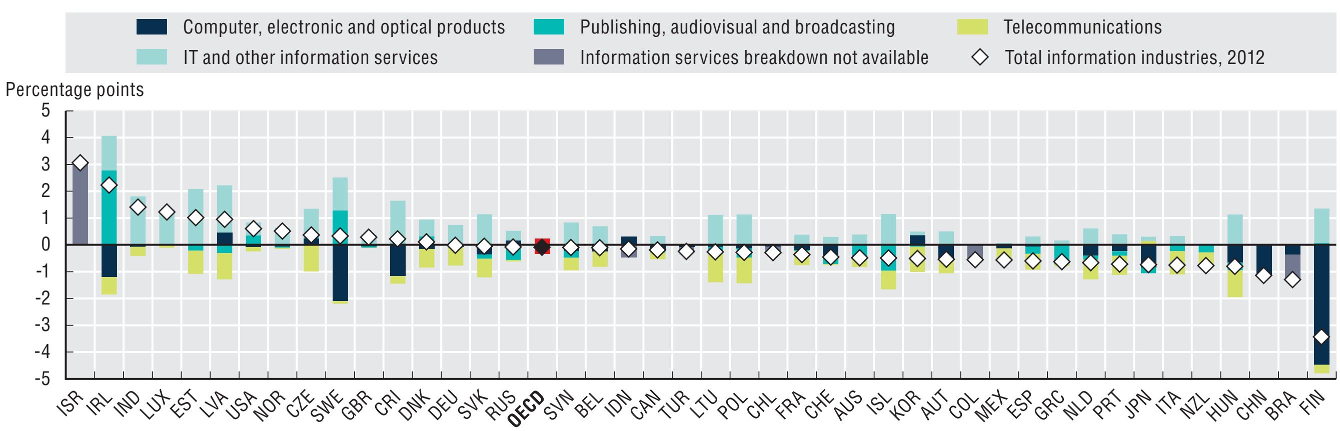


Source: OECD, STAN Database (http://oe.cd/stan), National Accounts Statistics, national sources and Inter-Country Input-Output Database (http://oe.cd/icio), December 2018. See chapter notes. StatLink contains more data.

StatLink https://doi.org/10.1787/888933929015

Change in the share of information industries in total value added, 2006-16

Percentage points

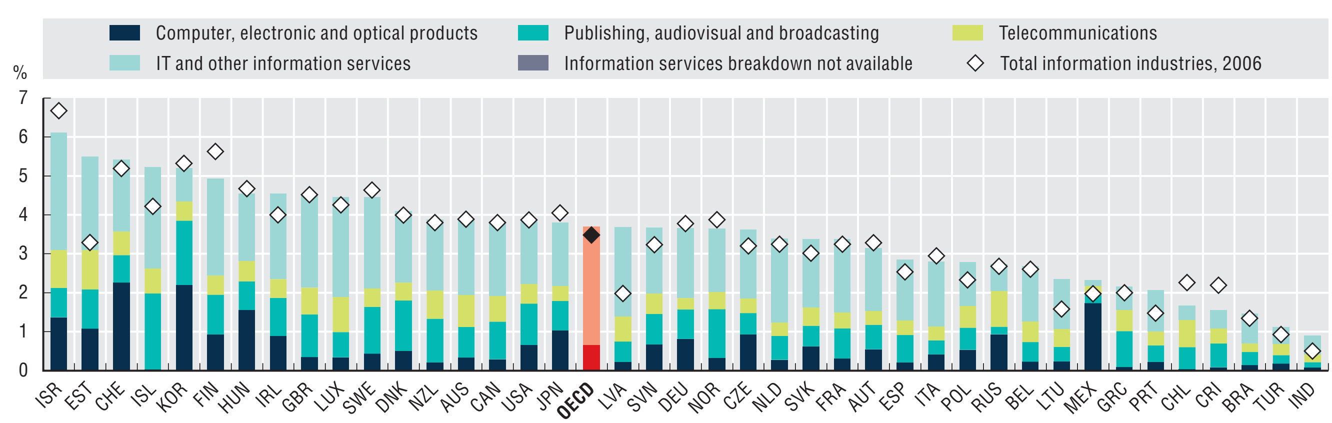


Source: OECD, STAN Database (http://oe.cd/stan), National Accounts Statistics, national sources and Inter-Country Input-Output Database (http://oe.cd/icio), December 2018. See chapter notes. StatLink contains more data.

StatLink https://doi.org/10.1787/888933929034

Employment in information industries, 2016

As a percentage of total employment



Source: OECD, STAN Database (http://oe.cd/stan), National Accounts Statistics and national sources, September 2018. See chapter notes. StatLink contains more data.

StatLink https://doi.org/10.1787/888933929053

In 2016, labour productivity in information industries was higher than in other industries in the non-agricultural business sector in almost all OECD countries – and as much as one-and-a-half times higher in Israel and Turkey. This reflects the relatively higher investment by information industries in machinery and equipment, as well as knowledge-based capital such as software and Research and Development.

The labour productivity of information industries varies among countries for reasons including the roles different countries play in global value chains (many products of information industries are highly tradable) and variations in the weight of the different components of information industries (e.g. ICT manufacturing and services). Large differences in productivity relative to the rest of the economy contribute to very high ratios of labour productivity in information industries compared to other industries in India (nearly 5 to 1), Costa Rica and Israel. In contrast, the high ratio in the United States (over 2 to 1) reflects a focus on relatively higher value-added activities, while in Korea (2 to 1) it is indicative of the strength of ICT manufacturing. Conversely, the relatively low ratios observed in countries such as Switzerland and Norway are linked to high average levels of productivity in other industries.

In Finland, the Netherlands and Austria, labour productivity levels in ICT manufacturing are markedly higher than those in information and communication services, and about twice those of the rest of the economy. This suggests concentration in high value added ICT manufacturing such as advanced components. In contrast, the comparatively low productivity levels of ICT manufacturing in Poland and Estonia suggest that these countries are hubs for more simple ICT products.

Understanding the drivers of productivity growth requires an awareness of the contribution made by each industry (OECD, 2017a). Between 2006 and 2016 – a decade during which productivity growth slowed in most countries due to the Great Recession – the contribution of information industries remained generally positive. However, this contribution varied among OECD economies, with the highest relative contributions (more than half of the total) occurring alongside robust overall productivity increases in Sweden, the United States and Germany. In France, Finland, Italy and Norway, meanwhile, productivity growth in information industries compensated for weak or negative growth in the rest of the economy.

In Sweden, the United States and Ireland, content and media industries contributed relatively strongly to productivity growth. In many countries, telecommunication and information services also provided notable contributions. In most cases, this corresponded to a fast expansion of ICT services, accompanied by employment growth, while in telecommunications it resulted chiefly from a strong reduction in employment.

DID YOU KNOW?

On average, in the OECD the level of labour productivity in information industries is about 65% higher than that of other industries in the business sector.

Definitions

Labour productivity is the amount of output (value added) produced per unit of labour input (number of persons employed or, when data allow, the number of hours worked). Industry values are computed relative to the whole economy (i.e. to GDP per person employed in each country), adjusting the indicator for differences in productivity levels across countries.

Information industries includes ICT manufacturing and information services i.e. ISIC Rev.4 Divisions 26 and 58 to 63. See page 2.1 for more detail.

The non-agricultural business sector excluding information industries refers to ISIC Rev.4 Divisions 05 to 25, 27 to 56, 64 to 66 and 69 to 82.

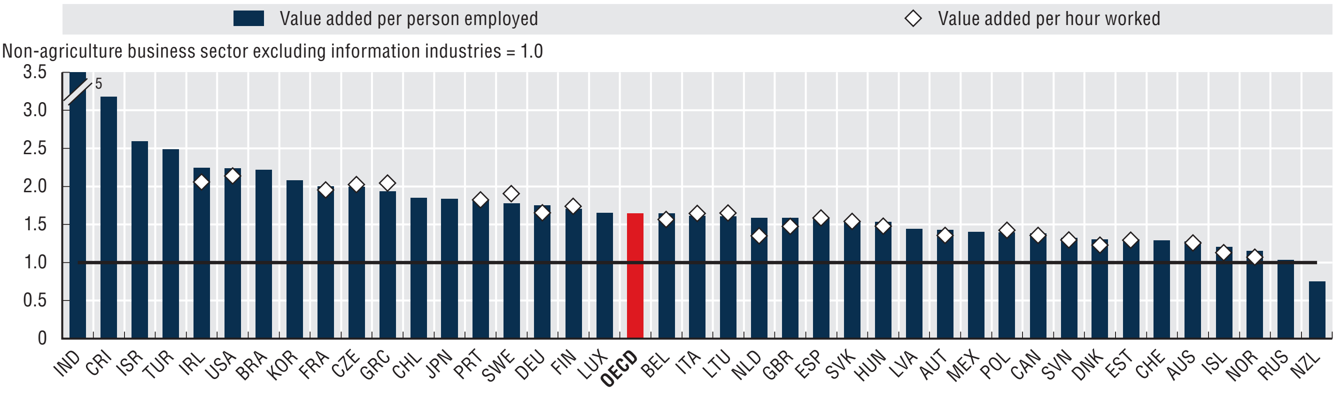
Measurability

Value added is measured in National Accounts based on structural business surveys and other sources. Persons employed is typically measured using national Labour Force Surveys. The use of persons employed rather than hours worked leaves differences in average working hours across sectors unaccounted for.

Measuring real value added can be challenging. For example, most countries assume no change in labour productivity for public administration, defence, education, human health and social work activities; these are therefore excluded. Real estate services are also excluded as their output includes a large imputation made for "services" from dwellings to owner-occupiers. In addition, industries such as construction, accommodation, and food and beverage services are characterised by high degrees of part-time work and self-employment, which can affect estimates of actual hours worked. See OECD (2017b) for more discussion of productivity measurement issues. Finally, using hedonic deflators to account for the improving quality of ICT products can significantly improve real value added measures and therefore sector productivity measures. However, such techniques are not applied in all countries and, more importantly, often applied to ICT manufacturing only, despite similar quality changes occurring in services (notably broadband).

Labour productivity in the information industries, 2016

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



Source: OECD, STAN Database (http://oe.cd/stan), National Accounts Statistics and national sources, September 2018. See chapter notes. StatLink contains more data.

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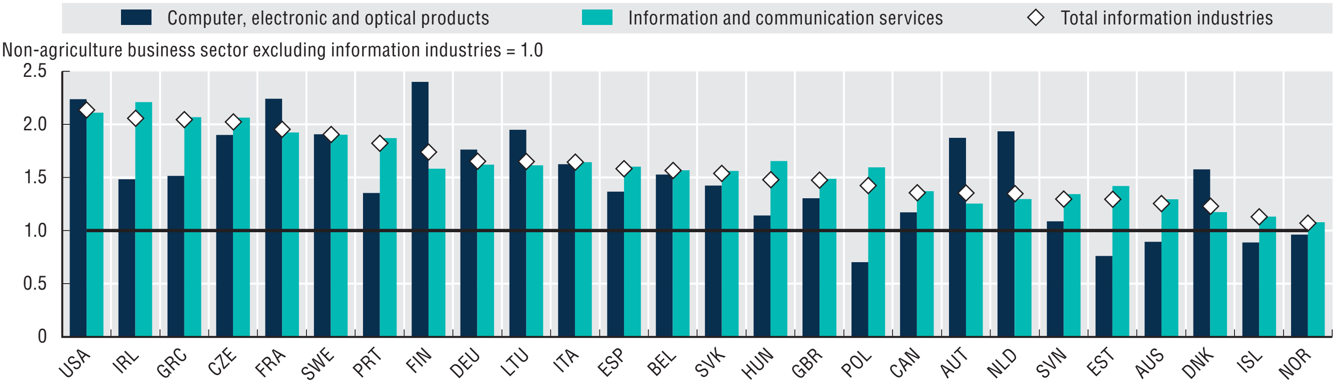
Labour productivity in information industries, manufacturing and service activities, 2016

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



Source: OECD, STAN Database (http://oe.cd/stan), National Accounts Statistics and national sources, September 2018. See chapter notes.

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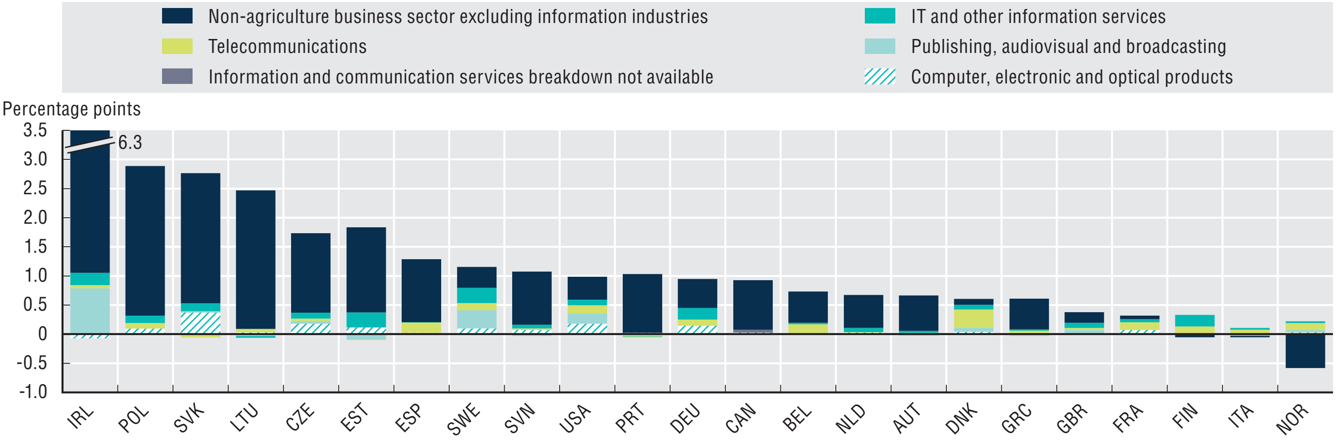
Contribution of information industries and of other sectors to non-agriculture business sector labour productivity growth, 2006-16

Percentage points at annual rates



Source: OECD, STAN Database (http://oe.cd/stan), National Accounts Statistics and national sources, September 2018. See chapter notes. StatLink contains more data.

StatLink https://doi.org/10.1787/888933929129

2.3 The demand for information industries' products

Information industries produce ICT goods and services, as well as media and content. The demand for, and uses of, these information products varies across economies, taking the form of investment, purchases of intermediate inputs for production and final consumption demand.

Investment in ICT products, on average, amounted to around 15% of total non-residential investment (Gross Fixed Capital Formation or GFCF) in 2016; a slight decrease compared to 2005. Such investment is especially strong in information industries, which account for 27% of ICT GFCF on average, and over 30% in countries including, the Czech Republic, Portugal, Sweden, Ireland and the United States. In most economies, ICT equipment is the main component of ICT investment in information industries, while software and databases represent the largest portion in the rest of the economy.

Information industries' products accounted for 7.3% of total intermediate inputs purchased in OECD economies in 2015, up 0.1 of a percentage point since 2005. The overall share of information industries' products in intermediate consumption fell by 0.6 percentage points in the EU28, while rising 1.8 points in the United States, to almost 9%. From a compositional standpoint, the demand for information industries' services, which include telecommunications, ICT services, and content and media services, is greater in high-income economies. Content and media products represented around 40% of the overall intermediate consumption of information products in New Zealand and Sweden, and as much as 70% in Ireland.

Final demand (which includes household consumption and investment by businesses) shows a similar pattern. In 2015, information industries' products comprised 6.6% of final demand in OECD economies, down from 6.9% in 2005. Within the OECD, the share of demand for computer and electronic goods is relatively high, at around 2% or above, in ICT-producing economies including Korea, Japan and Ireland. Meanwhile, demand for ICT services is greater in high-income economies such as Switzerland, Luxembourg and Sweden. Relative decreases of the final demand share of information industries' products were common between 2005 and 2015. This is especially the case for computer and electronic goods; their share of final-demand fell in 32 out of 36 economies and by 0.7 percentage points on average, to 1.4%. This decrease was particularly strong in the United States and Hungary, as well as in Chinese Taipei and Brazil. Purchases also fell slightly for content and media services, while the share of IT services rose from 1.7% to 2.3% of final demand, reaching 3% or more in Switzerland, Luxembourg, Sweden, Israel and Japan.

DID YOU KNOW?

Information industries' products represent around 15% of non-residential investment in the OECD. They account for 7% of intermediate inputs used in the economy and of final demand on average. The combined demand for information products is highest in Sweden.

Definitions

Information industries' products are the goods and services produced by businesses classified in "Manufacture of computer, electronic and optical products" (ISIC Rev.4 Division 26) and "Information and communication services" (Divisions 58 to 63). See page 2.1 for more information.

Gross Fixed Capital Formation (GFCF) refers to the acquisition of physical or intangible assets (whether new or second-hand) including the creation of assets by producers for their own use, *minus* any sales or disposals of such assets. Assets are products intended for use in production for a period of more than a year such as buildings, machines and intellectual property. Here, investment in ICT goods and services is compared to *non-residential* GFCF, which excludes investment in dwellings and focuses solely on productive fixed assets.

Intermediate consumption measures the value of goods and services (other than investment products) used as inputs for production.

Final demand is the sum of final consumption (by households, government and non-profit organisations), business investment and changes in inventories.

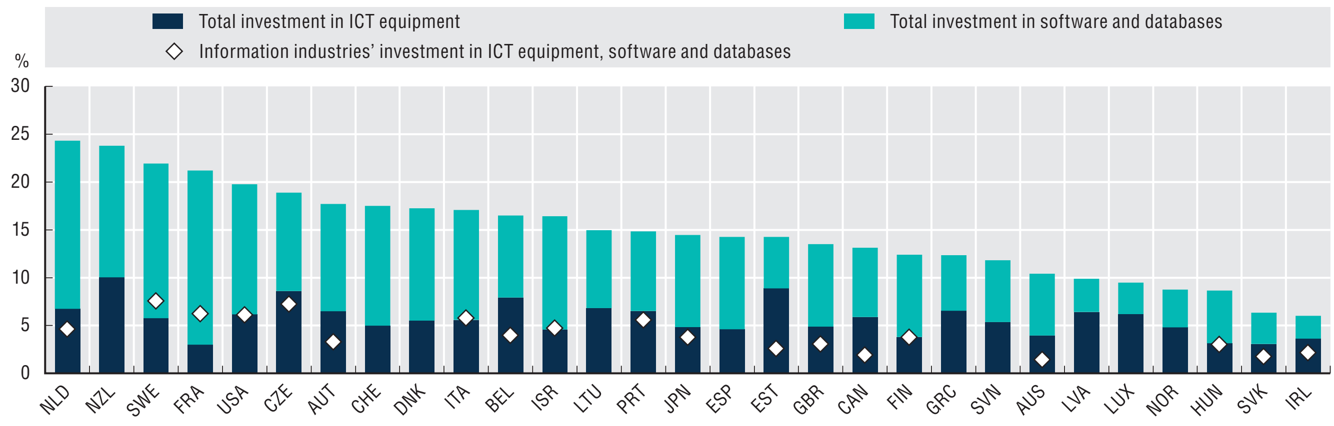
Measurability

The value of *ICT investment* comes from National Accounts. However, the availability and timeliness of detailed capital formation data varies. In particular, some economies do not isolate all ICT items, which leads to under-estimation of their share in GFCF.

The main source for estimates of the global flows of information industry products is the OECD Inter-Country Input-Output (ICIO) database. Final products purchased by individuals and intermediate and final products purchased by businesses can be domestically produced or imported. However, flows of goods and services within global production chains are not always identifiable in conventional trade statistics, or national Input-Output or Supply and Use tables. The 2018 version of the ICIO database builds on these and complementary data sources to provide estimates of flows of goods and services between 64 economies and 36 economic activities (based on ISIC Rev.4).

Investment in ICT equipment, software and databases, total economy and information industries, 2016

As a percentage of non-residential Gross Fixed Capital Formation (GFCF)

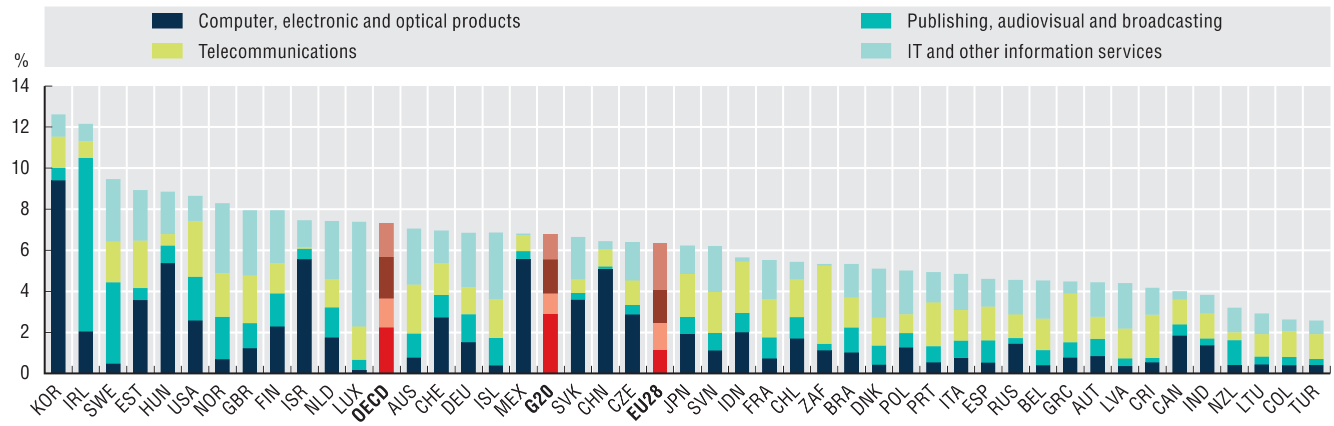


Source: OECD, Annual National Accounts Database and national sources, October 2018. See chapter notes. StatLink contains more data.

StatLink https://doi.org/10.1787/888933929148

Intermediate consumption of information industries' products, 2015

As a percentage of total intermediate consumption

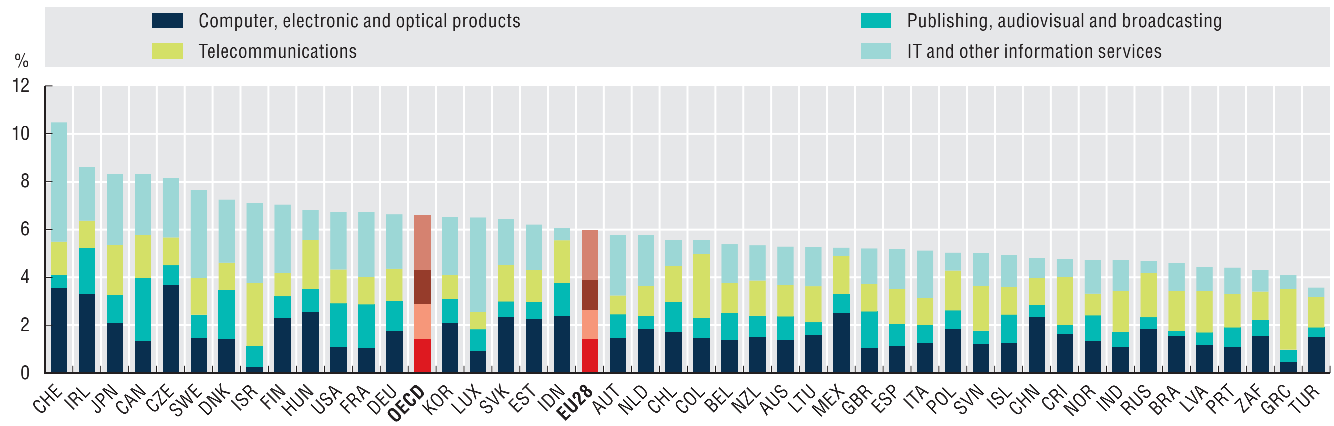


Source: OECD, Inter-Country Input-Output Database (http://oe.cd/icio), December 2018. See chapter notes. StatLink contains more data.

StatLink https://doi.org/10.1787/888933929167

Final demand for information industries' products, 2015

As a percentage of total final demand



Source: OECD, Inter-Country Input-Output Database (http://oe.cd/icio), December 2018. See chapter notes. StatLink contains more data.

StatLink https://doi.org/10.1787/888933929186

Measuring the value added generated by information industries only provides a partial view of their weight in each economy. In addition to final products, the output from domestic information industries is embodied via intermediate products in a wide range of goods and services meeting final demand (business capital investment, and household and government consumption), both domestically and abroad. Similarly, the output from other industries is embodied in many information products through domestic interconnections and participation in global value chains (GVCs); the glass in a smartphone screen is one example. Global demand for information industries' goods and services through international trade and investment can drive the activities of many other upstream domestic industries. Combining the value added generated by domestic information industries with the value added of other domestic industries embodied in global demand for information sector products constitutes a first step towards defining an "extended information footprint" (OECD, 2017a).

In 2015, the United States, Japan and China together accounted for about 50% of the global extended information footprint, up from 47% in 2005, and the EU28 for a further 21%. Although the United States remains responsible for nearly 30% of the extended information footprint, its share declined alongside, Japan and the European Union, while China's share increased from 3.4% to 14.4% over this period.

Neglecting the value added generated in other sectors of the economy to meet global demand for information final goods and services can result in under-estimation of the economic importance of these products. In the OECD, value added generated by non-ICT sectors accounts for, on average, about one- quarter of the extended information footprint, ranging from less than 20% in the United States to almost 30% in the European Union and 36% in China.

The importance of the extended information footprint can be further illustrated by considering information industries-related domestic value added as a share of GDP. East and Southeast Asian economies, for example, accounted for some of the highest shares of ICT-related value added, reaching 23% of GDP in Chinese Taipei and 18% in Singapore in 2015. Among OECD countries, Ireland, Israel, Japan, Korea, Luxembourg, Switzerland and Sweden all had shares over 10%. In general, the main contribution comes from ICT service activities, as is the case in most other OECD countries, although in Korea the largest contribution stems from ICT manufacturing and in Ireland from content and media.

Greater integration in global value chains implies that foreign demand sustains an increasing share of domestic employment. In 2015, about a quarter of OECD jobs were sustained by demand from outside the OECD, up 2 percentage points compared to 2005. The role of foreign demand reached 50% or more in small open economies, especially those with strong specialisation in the information sector. However, comparatively low and decreasing rates of foreign demand underpinned domestic employment in Canada and the United States, reflecting higher domestic orientation and outsourcing.

DID YOU KNOW?

One out of four jobs in the information industries in OECD countries was sustained by consumers in foreign markets in 2015 – and as many as eight of ten jobs in Ireland and Luxembourg.

Definitions

The extended information footprint within each country consists of the value added generated by domestic information industries and, the value added generated by other, upstream, domestic industries to produce intermediate goods and services to meet global demand for information industries' final products.

Information industries-related value added is the corresponding measure in the domestic economy, presented as a share of total value added (GDP).

Employment in information industries sustained by foreign demand consists of the share of employment in these industries corresponding to the export share in value added.

Information industries includes ICT manufacturing and information services, i.e. ISIC Rev.4 Divisions 26 and 58 to 63. See page 2.1 for more detail.

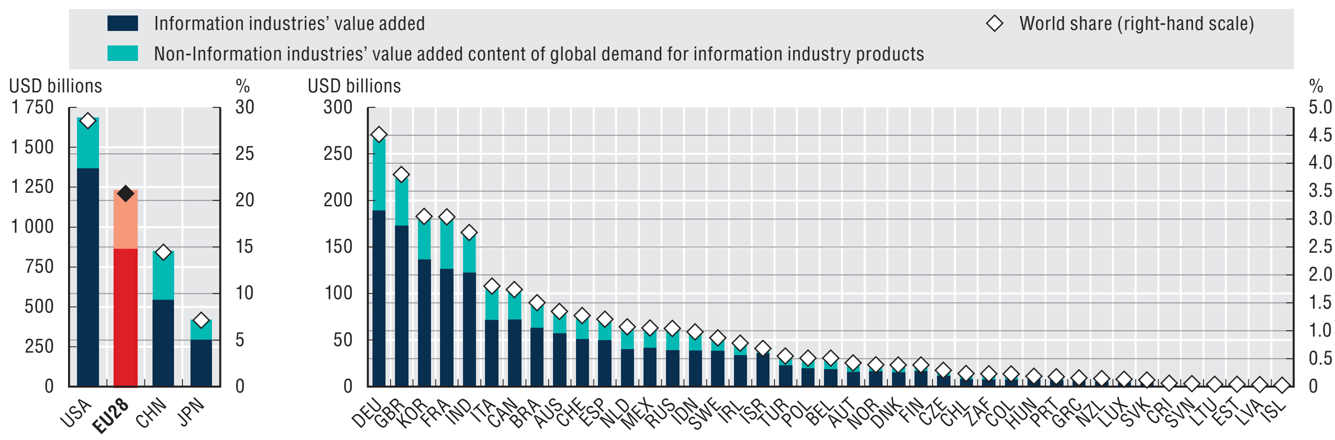
Measurability

Industry value added is generally available from national accounts statistics. However, tracking the country and industry origins of value added embodied in final goods and services requires the use of Trade in Value Added (TiVA) indicators, such as the "origin of value added in final demand", based on the OECD Inter-Country Input-Output database. This provides estimates of inter-country, inter-industry flows of intermediate and final goods and services that allow for the development of indicators on countries' participation in the global economy. The recent introduction of the ISIC Rev.4-based industry classification in the OECD ICIO database improved the measurement of extended information footprints via better identification of information services (such as telecommunications).

Job-related indicators rely on some broad assumptions. In particular, that within each industry labour productivity in exporting firms is the same as that in firms producing goods and services for domestic use only, and that all firms use the same share of imports for a given amount of output. However, exporting firms may have a higher level of labour productivity and use more imports in production. More effort is therefore required to account for firm heterogeneity within the ICIO framework to reduce potential biases.

Information industries' extended domestic value added footprint, 2015

USD billions and world share, percent

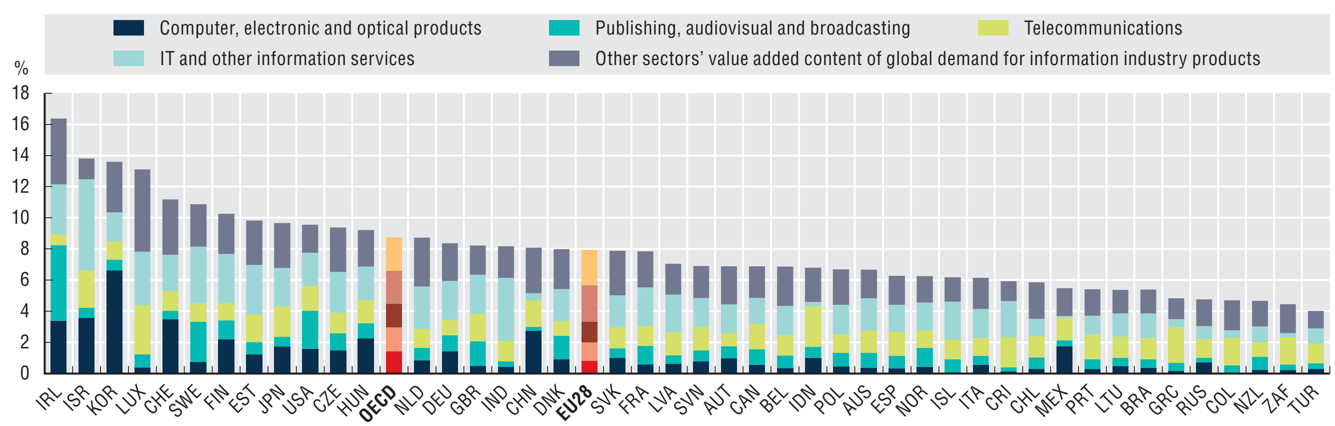


Source: OECD, Inter-Country Input-Output (ICIO) Database, http://oe.cd/icio and Trade in Value Added (TiVA) Database, http://oe.cd/tiva, December 2018. StatLink contains more data.

StatLink https://doi.org/10.1787/888933929205

Information industry-related domestic value added, 2015

As a percentage of total value added

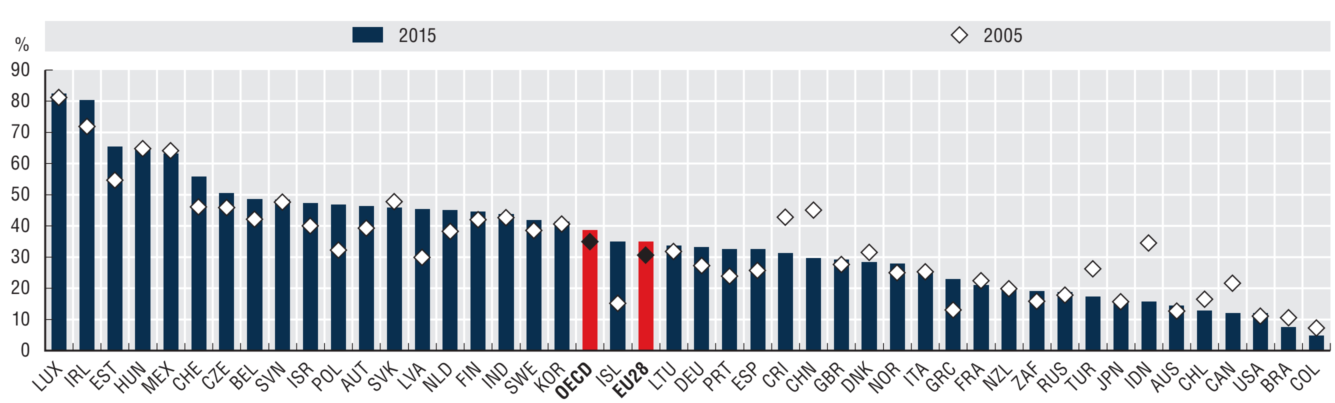


Source: OECD, Inter-Country Input-Output (ICIO) Database, http://oe.cd/icio and Trade in Value Added (TiVA) Database, http://oe.cd/tiva, December 2018. See chapter notes. StatLink contains more data.

StatLink https://doi.org/10.1787/888933929224

Jobs in information industries sustained by foreign final demand, 2015

As a percentage of jobs in information industries



Source: OECD, Trade in Employment Database, http://oe.cd/io-emp, December 2018. See chapter notes. StatLink contains more data.

StatLink https://doi.org/10.1787/888933929243

The manufacture of ICT goods is one of the most globally integrated industries. Finished ICT products are the result of numerous stages of production spread across many countries. A comparison of exports in gross and value added terms by the computer, electronic and optical products industry reveals that China accounted for 35% of global gross exports (USD 500 billion) in 2015, but its domestic value added embodied in foreign final demand ("value added exports") represented only 25% (USD 150 billion) of the global total. Gross exports are much higher (in USD) as they include value added coming from many other countries. Furthermore, ICT industry value added embodied in intermediate products may cross and re-cross borders many times prior to inclusion in final goods. The manufacture of computer, electronic and optical products is concentrated in few economies; the top four (China, Korea, Chinese Taipei and the United States) account for about 60% of exports in value added terms.

Trade in ICT services has grown in recent years and reached USD 530 billion in 2017, representing 10% of total global trade in services. As with trade in ICT goods, a few economies account for the majority of global ICT services exports. Global exports of computer and information services have surged relative to telecommunication services. Ireland, which hosts many large multinational corporations, was the leading exporter of ICT services in 2017, with over 16% of the world total. India followed at 12.5%. China is becoming a major exporter along with Germany and the United States. Together, these five economies account for 52% of total exports of ICT services, up from 40% in 2008.

In global value chains (GVCs), patterns of regional demand for certain products may differ from patterns of regional production. Comparing the locations of final demand for products with the origins of value added and carbon dioxide emitted during production, can provide insights into the structure of global industries. Previously, the majority of final demand for computer, electronic and optical products came from OECD countries. However, this share declined significantly from about 78% in 2005 to about 54% in 2015. Meanwhile, China saw its share of final demand more than triple to 20%. Over the same period, the share of value added originating in China grew from 10% to 29%. In 2015, China also accounted for 55% of carbon dioxide (CO_2) emissions related to the production of final ICT goods, up from 43% in 2005. This reflects relatively high involvement in more energy intensive parts of the production chain such as raw material extraction and processing, and basic manufacturing, with relatively lower value added contributions. OECD countries' tend to use more inputs from business service sectors, with lower energy requirements but higher value added contributions. These figures indicate that China remains a key player in global production of ICT goods, while simultaneously becoming a major consumer. In North America, the European Union and Japan, shares of global demand, value added origin, and CO_2 emissions fell sharply between 2005 and 2015.

DID YOU KNOW?

China is responsible for over one-third of ICT goods exports worldwide, while India and Ireland together account for 28% of trade in information and communication services.

Definitions

The *computer, electronic and optical products* industry refers to ISIC Rev.4 Division 26.

Exports in value added terms refers to domestic value added embodied in foreign final demand. *ICT services exports* consist of software; ICT consultancy; manufacturing, leasing and rental services for ICT equipment telecommunications services; and other ICT services sold to customers outside the national territory.

Final demand is the sum of final consumption (by households and governments), business investment and changes in inventories.

The "*origins of value added*" decomposes the value of final *computer, electronic and optical products* according to where value added was generated along production chains (from mineral extraction and manufacture of primary goods to the manufacture of complex components and final assembly).

Carbon dioxide arises from the combustion of carbon-based fuels with the resulting gas emitted into the Earth's atmosphere where it contributes to climate change.

Measurability

Estimates of the origins of value added embodied in exports and final demand, available in the Trade in Value Added (TiVA) database, are derived from Inter-Country Input-Output (ICIO) tables that present annual inter-industry flows of intermediate and final goods and services, within and across economies.

Estimates of gross exports in the TiVA database exclude re-exports and are valued at *basic prices* (i.e. distribution margins are allocated to exports of services rather than goods). Gross trade flows presented in ICIO tables are adjusted to balance across countries, thus removing any asymmetries in officially reported bilateral trade statistics. Consequently, gross trade flows in the TiVA database may not match those reported by countries.

Embodied emissions reflect CO_2 emitted by domestic and foreign firms at all stages of production and distribution. They are derived by combining ICIO tables with estimates of CO_2 emissions *from fuel use* per unit of production, by each industry in each country – drawing on IEA data: www.iea.org/geco/emissions.

Top 15 exporters of computer, electronic and optical products, in gross and value added terms, 2015

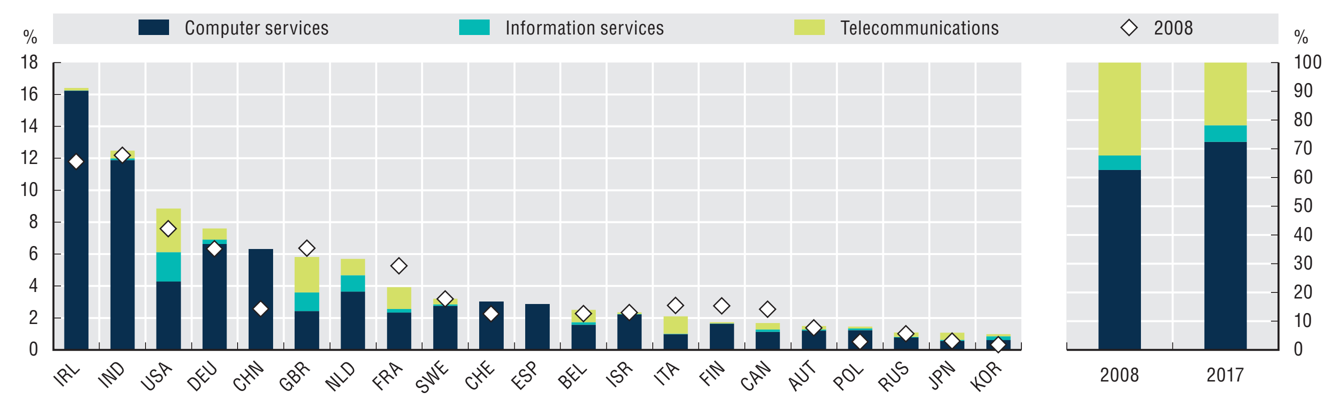
Percentage shares of global total

Source: OECD, Trade in Value Added (TiVA) Database, http://oe.cd/tiva, December 2018. See chapter notes. StatLink contains more data.

StatLink https://doi.org/10.1787/888933929262

Top exporters of information and communication services, 2008 and 2017

Percentage shares of global exports and composition of total global exports (right-hand panel)

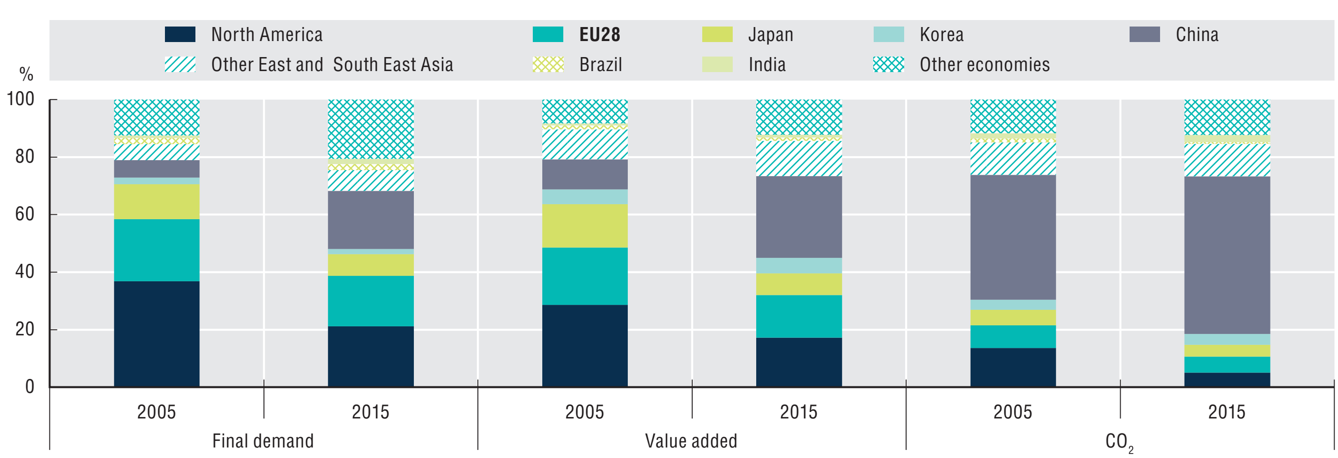


Source: OECD, Balance of Payments Statistics and WTO, Commercial Services Exports Statistics, December 2018. December 2018. StatLink contains more data.

StatLink https://doi.org/10.1787/888933929281

Global demand for computer, electronic and optical products, 2005 and 2015

Shares of global total, by country or region of final demand, origin of value added, and origin of carbon emissions



Source: OECD, Trade in Value Added (TiVA) Database, http://oe.cd/tiva, December 2018, December 2018. StatLink contains more data.

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The OECD Framework for Measuring Well-being and Progress (http://www.oecd.org/statistics/measuring-well-being-and-progress.htm) is intended to challenge how policy makers and society as a whole think about progress. It recognises 11 dimensions of well-being that are key for a better life. Impacts of the digital transformation on these dimensions are ambiguous; both risks and opportunities exist in areas such as work-life balance, social connections, and governance and civic engagement.

Increasingly, computer-based jobs, combined with improved connectivity, allow workers to be more mobile. In many jobs, it is no longer necessary to be physically in the workplace all of the time. Instead, "teleworking", can allow workers to manage their time more flexibly and make it easier to fulfil non-work responsibilities. Teleworking has the potential to contribute job satisfaction and work-life balance, as well as to improving the gender balance in many households (Billari et al., 2017). However, such connectivity may be associated with employer expectations of constant-connectedness and increased working outside regular hours. It should also be noted that access to and use of teleworking facilities is skewed toward high-skill workers and that the burden of combining work and family life thanks to teleworking may often fall on women more than on men (Dettling, 2016).

Work is strongly linked to people's self regard and well-being. The Internet can be useful in finding work opportunities. On average, 21% of Internet users in the OECD reported looking for a job or sending a job application online in 2017 and 33% of those aged 16-24 did so. Online job search is especially common in Chile, Finland and Mexico, at around 30-40% of Internet users. Strikingly, in Finland over 60% of 16-24 year old Internet users looked online for jobs in 2017 – a time when the youth unemployment rate was relatively high at 20%. By contrast, in other OECD countries with even higher youth employment at the time, such as France and Spain, young people have not turned as strongly to the Internet as a potential solution. Indeed the second-highest rate of online job-search among Internet users aged 16-24 was seen in Iceland, where youth unemployment was among the lowest in the OECD in 2017, at 7.7%.

The Internet also provides people with a new arena for engaging in civic and political debates. This aspect of the digital transformation is sometimes seen as a risk, because online political participation is thought to exacerbate ideological divides. However, recent studies have found only limited evidence that political polarisation can be attributed to the use of online media. (Dubois and Blank, 2018). Political expression online is not inherently bad, if it comes from a place of conviction and is not corrupted by false information or targeted manipulation. At the core, it provides people with a new avenue for exchanging ideas and can give an opportunity to voice frustration and derive meaning.

DID YOU KNOW?

A quarter of people who use digital equipment at work teleworked from home at least weekly in the EU28 in 2018.

Definitions

Teleworking is broadly defined as ICT-facilitated mobile work that takes places either at home or at another location outside the normal workplace.

Political engagement online relates to individuals using the Internet for posting opinions on civic or political issues via websites such as blogs or social networks.

Measurability

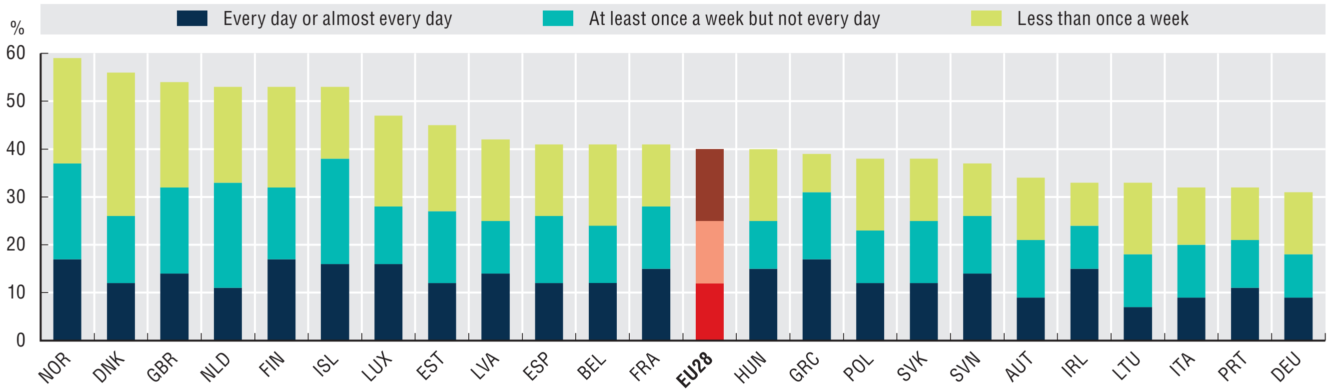
These data are gathered through direct surveys of households' ICT usage which ask if the respondent has undertaken a specific activity during the recall period. The OECD Model Survey on ICT Access and usage by Households and Individuals (OECD, 2015) proposes a wide range of activities for investigation including, telework, job search, online political engagement and many more. A recall period of 3 months (meaning the respondent should have undertaken the online activities in the 3 months prior to the survey) is recommended though some countries use different recall periods.

Ideally, measures of the impact of the digital transformation on well-being would reflect not only people's use of digital technologies, but also whether this use makes them more or less satisfied with their lives. For the moment, data limitations stand in the way of conducting such analyses. The wider challenges of measuring the impact of digital technologies on well-being are discussed in more detail on page 2.10 and in OECD (2019).

When measuring use of the Internet for activities such as job-search or political engagement, gauging the frequency and intensity of use can provide important additional information. Specific research designs can help shed light on the positive and negative effects of social media use on people's social connections and mental health. In particular, longitudinal studies can provide insights into the causal effects of social media use on various dimensions of well-being.

Individuals teleworking from home in the last 12 months, 2018

Percentage of individuals who, at work, use any type of computers, portable devices, or computerised equipment or machinery



Source: OECD, based on Eurostat, Digital Economy and Society Statistics, January 2019. StatLink contains more data.

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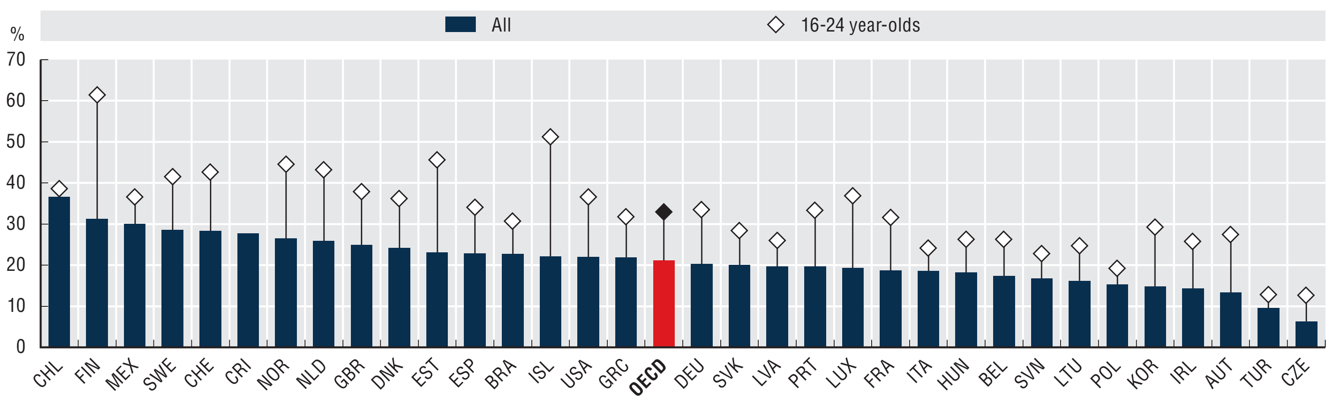
Internet users looking for a job or sending a job application online, by age, 2017

As a percentage of Internet users in each age group

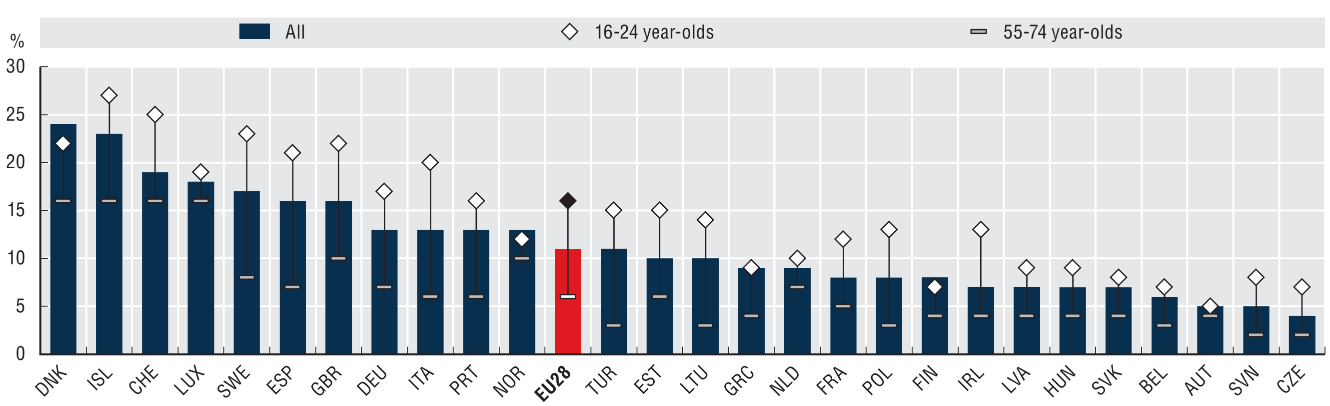


Source: OECD, ICT Access and Usage by Households and Individuals Database, http://oe.cd/hhind, December 2018. See chapter notes. StatLink contains more data.

StatLink https://doi.org/10.1787/888933929338

Individuals who used the Internet for posting opinions on civic or political issues via websites, by age, 2017

As a percentage of individuals in each age group



Source: OECD calculations based on Eurostat, Eurostat Digital Economy and Society Statistics, December 2018.

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2.7 Digital natives

The Internet permeates every aspect of the economy and society, and is becoming an essential element of young people's lives. Accordingly, policy makers need evidence of the impact of ICTs on school students' performance and well-being. Current research presents a rather mixed picture and underlines the need for additional metrics, while new indicators on students' attitudes shed light on some aspects of problematic use of the Internet.

According to the results of the 2015 OECD Programme for International Student Assessment (PISA), 17% of students in the OECD area first accessed the Internet at the age of 6 or under. For countries where data are available, less than 0.3% of 15-year-olds reported never having accessed the Internet.

The age of first access to the Internet varies across countries. Over 30% of students started using the Internet at the age of 6 or under in Denmark, Estonia, Iceland and Israel. The most common age of first access is between 7 and 9 years in about two-thirds of the countries surveyed by PISA, and 10 years and over in the remaining third.

In 2015, 43% of 15 year-olds in the OECD area spent between two and six hours a day online outside of school – a sizeable increase from less than 30% in 2012. Brazil and Chile had the largest proportion of students (over 30%) spending more than six hours a day on the Internet outside school.

Such massive Internet uptake among younger generations has led to increasing interest in the impact of online activities on children's well-being from various societal actors, including researchers, policy makers, and educational professionals, as well as parents. New evidence from PISA 2015 provides information on students' attitudes and feelings when engaged in online activities. The data show that most students enjoy using various digital devices and the Internet, but that many are at risk of problematic Internet use, as indicated by issues such as losing track of time when online and feeling bad if Internet connectivity is unavailable.

Across OECD countries, 90% of students enjoy using digital devices and 61% reported that they forget time when using them. About 55% of students in OECD countries indicate feeling bad when no Internet connection is available. In countries such as France, Greece, Portugal and Sweden, this ratio reaches about 80% compared to approximately 40% in Estonia and Slovenia. In terms of gender and income differences, girls and disadvantaged students appear to feel bad slightly more often than boys and less disadvantaged students respectively, when no Internet connection is available.

DID YOU KNOW?

In France, Greece, Portugal and Sweden, in 2015, about 80% of 15 year-olds reported feeling bad if no Internet connection was available.

Definitions

Students assessed by PISA are between the ages of 15 years, 3 months and 16 years, 2 months. They must be enrolled in school and have completed at least six years of formal schooling, regardless of the type of institution, programme followed or whether the education is full-time or part-time.

The share of *students who feel bad if no Internet connection is available* corresponds to those who stated that they "agree" or "strongly agree" with this statement. All PISA shares are reported as a percentage of respondents. Results are based on self-reporting by students.

Measurability

PISA is a triennial international survey which aims to evaluate education systems worldwide by testing the skills and knowledge of 15-year-old students who are nearing the end of their compulsory education. PISA assesses how well they can apply what they learn in school to real-life situations.

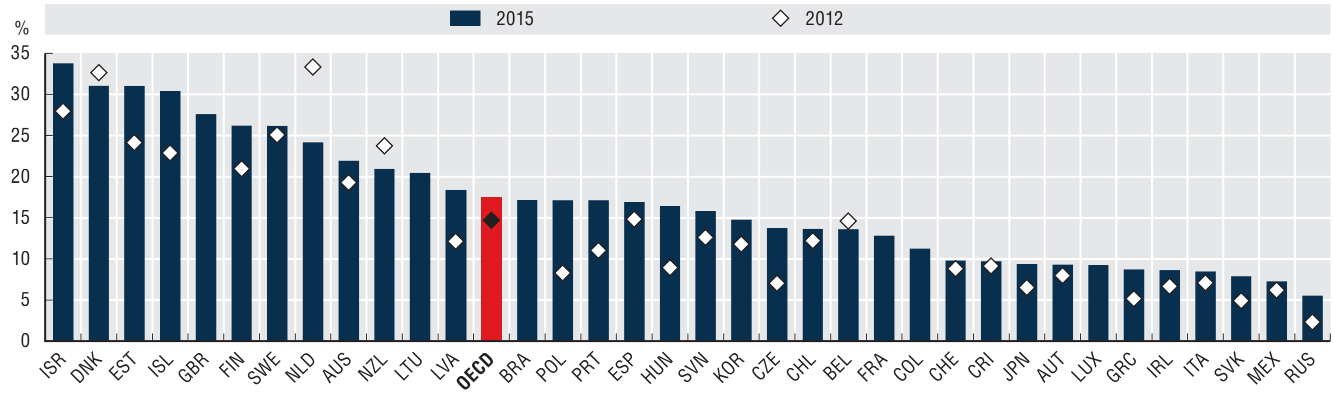
PISA 2015 assessed the skills of 15 year-olds in 72 economies. Over half a million students between the ages of 15 years, 3 months and 16 years, 2 months (a sample representing the global total of 28 million 15 year-olds) took the internationally agreed two-hour test.

The ICT familiarity questionnaire is an optional module and consists of questions on the availability of ICTs at home and school, the frequency of use of different devices and technologies, students' ability to carry out computer tasks and their attitudes towards computer use. In 2015, 47 out of 72 economies participating in PISA ran this specific module. Despite the valuable information gained as a result of implementation, the ICT questionnaire was not administered in several OECD countries (Canada, Norway, Turkey and the United States) in 2015 due largely to the high costs generated by the inclusion of these additional questions in the survey.

The increasing availability of data from multiple PISA waves has enabled the assessment of student use of ICTs both at school and outside school over time, as well as investigation of the impact on school performance, which is a key concern for education policy makers.

Students who first accessed the Internet at age 6 or under, 2015

As a percentage of 15 year-old students



Source: OECD calculations based on PISA 2015 Database, September 2018.

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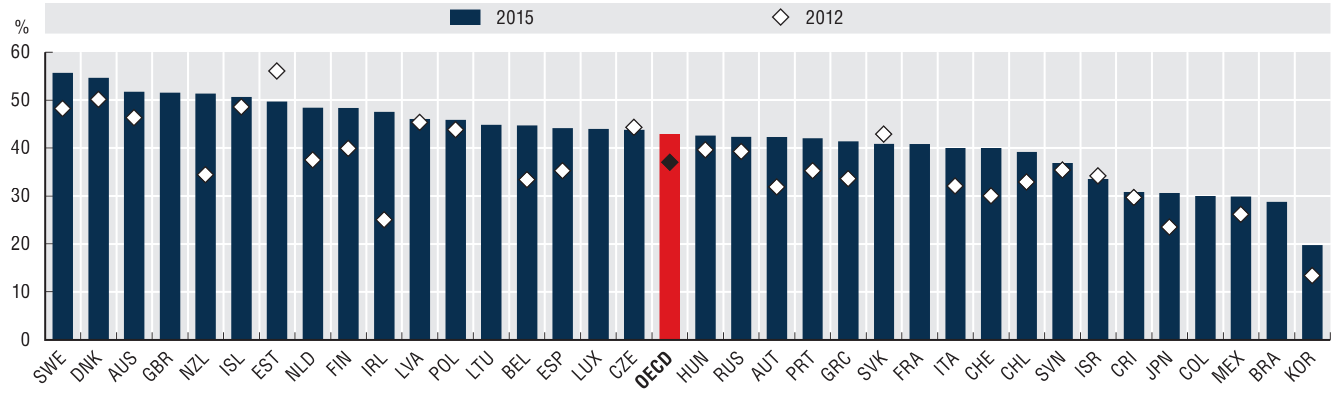
Time spent on the Internet by students outside school, 2015

Percentage of 15 year-old students spending two to six hours on the Internet during a typical weekday

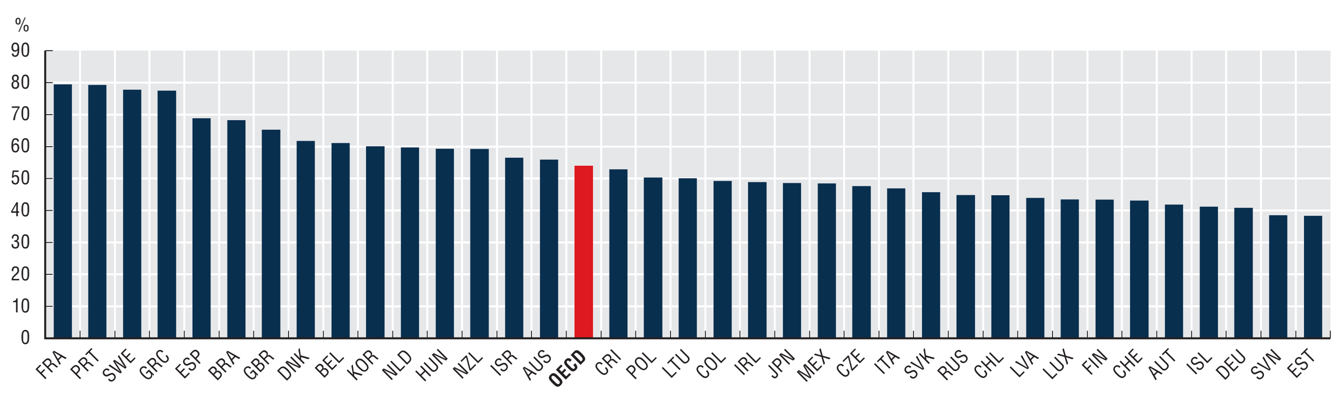


Source: OECD calculations based on PISA 2015 Database, September 2018.

StatLink https://doi.org/10.1787/888933929395

Students who feel bad if no Internet connection is available, 2015

As a percentage of 15 year-old students



Source: OECD calculations based on OECD PISA 2015 Database, September 2018.

StatLink https://doi.org/10.1787/888933929414

Online resources can help people to better understand and manage their health. However, ICTs can also adversely impact physical and mental health in a variety of ways, ranging from encouraging sedentary activities to fuelling social anxiety.

In many countries, the Internet is becoming a key channel for accessing health services that can offer increased choice as well as convenience. On average, in European Union countries, 17% of individuals aged 16-74 booked a doctor's appointment online in 2018, more than double the share in 2012 (8%). In Finland, nearly half of individuals booked an appointment online in 2018, up from 26% in 2012. Denmark and Spain also have a relatively high uptake of online booking at over 35%. A wide variety of factors influence demand and uptake of online appointment booking including population aging, which increases healthcare needs, the skills people possess, and the extent to which online booking offers a superior service compared to other channels.

Half of all individuals aged 16-74 in the OECD accessed health information online in 2018. On average, women are around one-quarter more likely to search for health information than men. Only in Korea, Turkey, Chile and Colombia do more men seek health information online. Since 2010, the share of Internet users looking online for health information has increased in almost all countries, especially in the Czech Republic, Greece, Korea and Turkey, where it more-than doubled over the period to 2018. There is also wide cross-country variation, with around twice the share of Internet users finding health information online in Finland and the Netherlands than in Brazil, Italy and Chile.

The Internet and other digital tools have dramatically increased the flow of information that workers manage - with direct effects on perceived stress levels. Research has documented new forms of information flows in a large range of work settings, such as investment analysis, managerial decision making, price setting, physician decision-making, aviation, library management and many others. These information flows occur through a range of digital media, such as e-mail, intranets and push [messaging] systems (Eppler and Mengis, 2004). The resulting information overload is associated with *technostress*, "a form of stress associated with individuals' attempts to deal with constantly evolving ICTs and the changing physical, social and cognitive responses demanded by their use" (Ragu-Nathan et al, 2008; Arnetz and Wilholm, 1997; Brod, 1984). Information overload in the work place decreases job satisfaction and leads to lower reported health status (Misra and Stokols, 2012; Ragu-Nathan et al., 2008), while perceived e-mail overload has been linked to burnout and decreased work engagement (Reinke and Chamorro-Premuzic, 2014). According to OECD calculations (OECD, 2019), the increase in job stress associated with computer-intense jobs is greatest in Denmark, Luxembourg and Norway, and lowest in Turkey, the Czech Republic and Greece.

DID YOU KNOW?

Women are around 20% more likely to access health information online than men.

Definitions

Job stress refers to people that report experiencing stress at work "sometimes" or more often.

Frequent computer use at work is defined as using a computer, laptop or smartphone at work more than half of the time.

Measurability

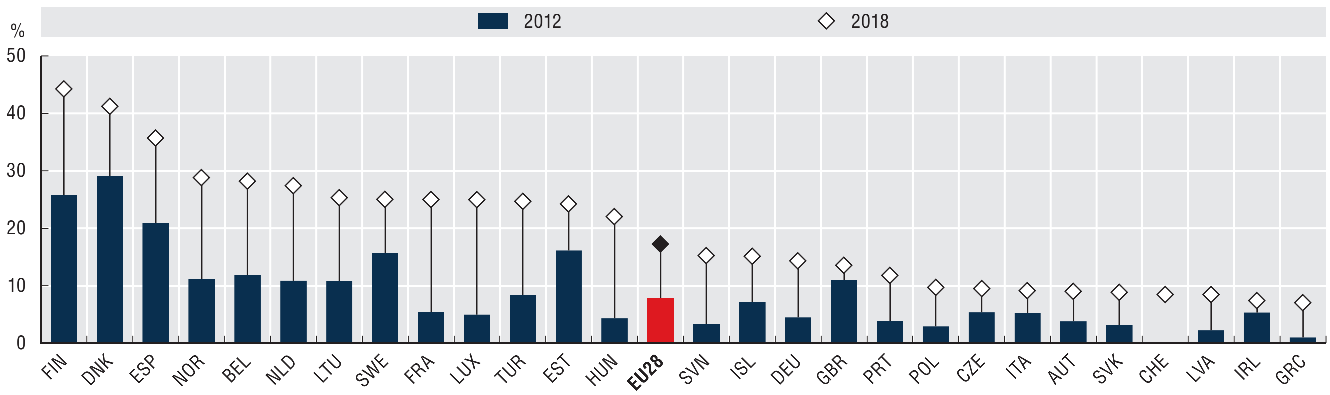
Data about online activities are typically gathered through direct surveys of household ICT usage that ask whether the respondent has undertaken a specific activity during the recall period. The OECD Model Survey on ICT Access and Usage by Households and Individuals (OECD, 2015) proposes a wide range of activities for investigation. A recall period of three months (meaning the respondent should have undertaken the online in the three months prior to being surveyed) is recommended. However, some countries use longer recall periods or specify no recall period at all. Such methodological differences impact the ability to make robust international comparisons. Data might also reflect a variety of country-specific elements, including the diffusion and ease of use of alternative channels to perform certain activities (e.g. local health services), as well as institutional aspects.

While some ICT usage surveys inquire about online information search activities, they do not currently gather any information on the usefulness or quality of that information, or the quantities consumed. Given the wide variation in the quality of information available online, such binary measures offer only a very partial initial insight into individuals' use of online information.

Access to micro-data from the European Working Conditions Survey (EWCS) has enabled an analysis of digital technology use at work and links to job stress. The increase in people experiencing stress at work uses OECD estimations of the effect size of having a computer-based job on self-reported job stress. The effect size is estimated using regression analysis that controls for age, gender, income and skill level, multiplied by the number of respondents in each country that frequently use computers at their job. The resulting effect size implies that people who frequently use computers in their job are 5.8% more likely to experience stress at work and is significant at the $p<0.01$ level. Estimates are based on the countries in the figure. (OECD, 2019).

Individuals who booked doctors' appointments online, 2018

As a percentage of all individuals

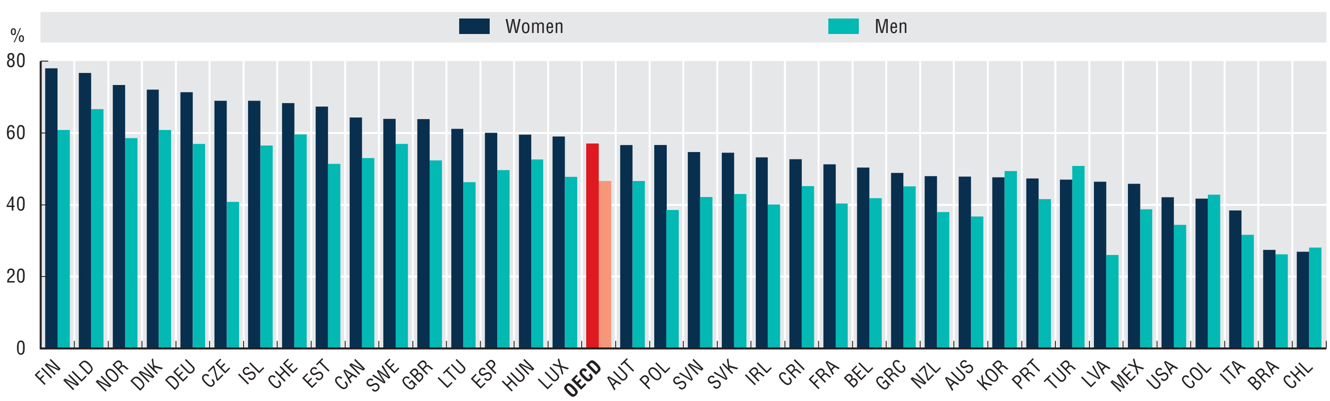


Source: OECD, based on Eurostat, Digital Economy and Society Statistics, Comprehensive Database, January 2019. See chapter notes. StatLink contains more data.

StatLink https://doi.org/10.1787/888933929433

Individuals who have used the Internet to access health information, by gender, 2018

As a percentage of individuals in each group

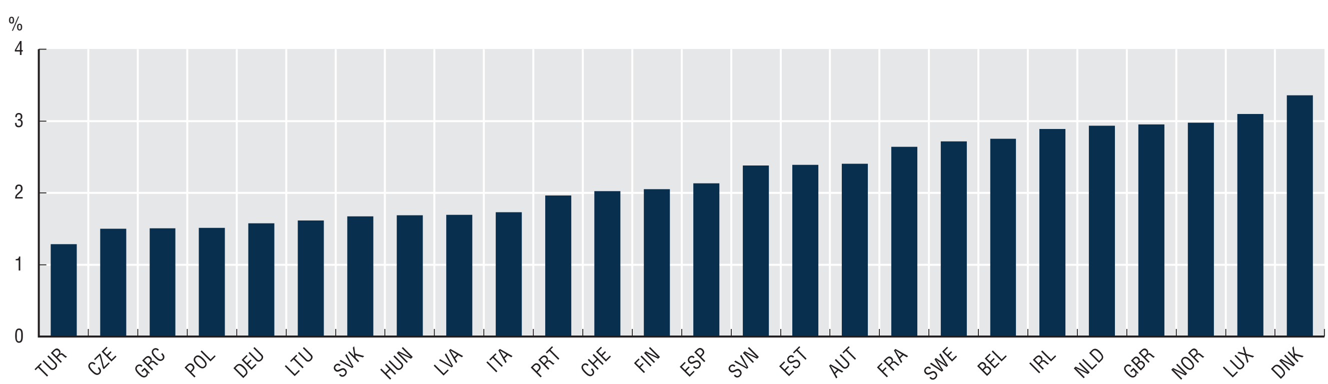


Source: OECD, ICT Access and Usage by Households and Individuals Database, http://oe.cd/hhind, January 2019. See chapter notes. StatLink contains more data.

StatLink https://doi.org/10.1787/888933929452

Workers who experienced job stress associated with frequent computer use at work, 2015

As a percentage of all workers



Source: OECD (2019), calculations based on European Working Conditions Survey (EWCS) 2015. See chapter notes.

StatLink https://doi.org/10.1787/888933929471

2.9 Digital intensity, a taxonomy of sectors

Why measure digital intensity in sectors?

The digital transformation is a multifaceted and fast-moving phenomenon that has significant impacts, including on the business processes and models of firms. As a result, the pace of technology uptake will depend, among other factors, on the type of sector in which a given firm operates. While no single indicator is able to reflect the pace of technology development and diffusion, combining indicators can provide insights into how different sectors, are positioned in terms of technology adoption.

Based on seven different metrics, Calvino et al. (2018) propose a taxonomy of sectors by digital intensity. The indicators considered highlight how the extent of digital transformation in sectors is shaped by firms' investments in "digital" assets, as well as by changes in the way companies approach markets and interact with clients and suppliers, by the (type of) human capital and skills needed, and the way production is organised. Since different sectors develop and adopt different digital technologies and business models at differing rates, sectors may appear in different parts of the taxonomy during the early 2000s (2001-03) as compared to more recent years (2013-15). In Calvino et al. (2018), industries are benchmarked according to each of the dimensions considered. An overall summary indicator of digital intensity is also proposed.

The taxonomy of sectors by digital-intensity is intended as an operational tool to help analysts and policy makers better understand and monitor the digital transformation. It is not intended to be used to measure the size of the digital economy, but rather for empirical work as a proxy variable for the digital transformation in sectors, as well as for tabulating indicators of the digital transformation according to the quartiles of digital-intensity identified. As such, the digital intensity taxonomy complements existing industry-level classifications focusing on individually considered measures, such as R&D expenditure, ICT or information industries, or firms' innovative activities.

What are the challenges?

Calvino et al. (2018) use information, covering the period 2001-2015, for 36 sectors in 12 countries, namely: Australia, Austria, Denmark, Finland, France, Italy, Japan, the Netherlands, Norway, Sweden, the United Kingdom and the United States. Sectors are classified according to ISIC Rev.4. The indicators considered were:

- ICT equipment and software investment relative to total fixed investment;
- Intensity in purchases of ICT intermediate goods and services relative to output;
- Stock of robots per employee;
- Number of ICT specialists over total employment (often referred to as "ICT-specialist intensity"); and
- Propensity to engage in e-commerce sales.

For each indicator, cross-country averages are calculated at the sector level and used to benchmark each sector relative to all the others. The "global" taxonomy summarises these dimensions into an overall benchmark. It lists sectors according to their relative position in the overall economy's ranking and groups them into "high", "medium-high", "medium-low" and "low" digital intensity, depending on whether sectors appear in the top 25% (or quartile, denoted as "high"), in the bottom 25% ("low"), or in between the two. The figure shows the digital intensity of different sectors in the overall ranking. The darker the colour, the higher the digital-intensity of the sector.

The availability and coverage of internationally comparable data from official sources dictated the choice of indicators used for the ranking, as well as countries and years covered. Measures related to frontier technologies such as machine learning or 3D printing could not be included as data by country, industry and year are currently scant. The few gaps in the remaining time series were filled with alternative sources where available, or extrapolation and interpolation. Some of the indicators considered only relate to a subset of sectors, due to the design of the underlying data sources (e.g. surveys).

Each of the seven indicators proposed raised specific challenges. For instance, identifying "ICT-specialist" occupations required an understanding of cross-occupational differences in workers' involvement in the production of ICT goods and services, rather than in their use of ICT tools on the job. In the absence of official data sources, information on robot use was obtained from the International Federation of Robotics. The time series required assumptions on, among others, the depreciation of robots over time and the way in which annual robot sales data should be transformed into an estimated stock.

Some challenges remain unaddressed. Indicators of ICT (equipment and software) investment, for instance, only capture an industry's direct investment in ICT capital goods, but do not account for the value of ICT embodied in other types of capital. This, in turn, can affect the relative position of sectors sourcing ICT capital indirectly, in other words, through purchases of goods that contain many ICT parts or devices e.g. complex machines. Conversely, the intensity in purchases of ICT goods and services may be over-estimated, as data are sourced from Input-Output rather than Supply-Use tables.

By providing information at the product rather than industry level, Supply-Use tables allow for a more precise mapping of the ICT goods and services that industries use as intermediates.

Taxonomy of sectors by digital-intensity, overall ranking, 2013-15

ISIC Rev.4 industry denomination	Quartile intensity	ISIC Rev.4 industry denomination	Quartile intensity
Agriculture, forestry, fishing	Low	Wholesale and retail trade, repair	Medium-high
Mining and quarrying	Low	Transportation and storage	Low
Food products, beverages and tobacco	Low	Accommodation and food service activities	Low
Textiles, wearing apparel, leather	Medium-low	Publishing, audiovisual and broadcasting	Medium-high
Wood and paper products, and printing	Medium-high	Telecommunications	High
Coke and refined petroleum products	Medium-low	IT and other information services	High
Chemicals and chemical products	Medium-low	Finance and insurance	High
Pharmaceutical products	Medium-low	Real estate	Low
Rubber and plastics products	Medium-low	Legal and accounting activities, etc.	High
Basic metals and fabricated metal products	Medium-low	Scientific research and development	High
Computer, electronic, optical products	Medium-high	Advertising and other business services	High
Electrical equipment	Medium-high	Administrative and support service	High
Machinery and equipment n.e.c.	Medium-high	Public administration and defence	Medium-high
Transport equipment	High	Education	Medium-low
Furniture; other manufacturing; repairs	Medium-high	Human health activities	Medium-low
Electricity, gas, steam and air cond.	Low	Residential care and social work activities	Medium-low
Water supply; sewerage, waste	Low	Arts, entertainment and recreation	Medium-high
Construction	Low	Other service activities	High

Source: Calvino et al. (2018) based on Annual National Accounts, STAN, ICIO, PIAAC, International Federation of Robotics, World Bank, Eurostat Digital Economy and Society Statistics, national Labour Force Surveys, US CPS, INTAN-Invest and other national sources.

Prices are an additional challenge. Deflators are needed for a number of the indicators considered but may not be available, leading to the use of less appropriate alternatives. Purchases of intermediates, for instance, are deflated using output prices for ICT-goods vs ICT-service- producing industries, but doing so prevents differences between domestic and international (import) prices from being taken into account. Furthermore, ICT and software investment figures are deflated using country-level price series that do not always account for quality improvements in the underlying technology ("hedonic adjustment"), depending on the country considered.

Options for international action

The effort to measure how the digital transformation impacts different industries and countries will continue, and may rely on improved data timeliness and availability across countries. Additional data collection and international harmonisation would allow future studies to encompass other important dimensions of the digital transformation, such as the quality of ICT-related human capital, the generation of ICT-related technological innovation (e.g. patents) and services e.g. through the use of trademark data, or the production and use of data. Further efforts towards the creation of hedonic price series for ICT investment would also help, as would the production of new price indices for ICT intermediate goods and service consumption. For indicators to provide a timely picture of the continuously evolving dynamics at hand, data and information also need to be readily processed and harmonised.

The level of disaggregation at which data are collected and/or made available is another area for development. Companies in the same industry share similar technological opportunities, market structure, nature of production and knowledge requirements. However, technology generates and diffuses differently within industries, such that industry-level data hide significant heterogeneity, with each industry likely to have relative "leader" and "laggard" firms. To this end, and to be able to provide policy-relevant timely indicators, it would also be important for countries to expand the scope of business surveys to gather more information on technology generation and/or use at the micro-level, and to further invest in the harmonisation of relevant questionnaires across countries.

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Why develop indicators of well-being in the digital age?

While various aspects of the digital economy are carefully recorded in official statistics, certain key impacts of the digital transformation on human well-being remain poorly understood. This measurement gap is important, especially in the context of a recent push by policy makers and statisticians to produce alternative measures of societal progress. Economic measures are not sufficient to make important policy decisions and broader metrics that reflect people's full life experiences are necessary to evaluate progress (Stiglitz, Sen, and Fitoussi, 2009). Statistics, therefore, need to be adjusted and expanded to ensure they incorporate aspects that matter to people.

In terms of the digital transformation, this means keeping track of the pace of the transformation and the way it impacts businesses, the economy and society as a whole, and also considering the impacts of digital transformation on people themselves. At present, evidence of the impacts of the digital transformation on well-being is still scarce in many areas. For example, relevant data on people's experiences of mental health or social lives are not collected frequently, especially not in a harmonised manner. The OECD Framework for Measuring Well-Being and Progress (http://www.oecd.org/statistics/measuring-well-being-and-progress.htm) includes objective and subjective indicators of well-being outcomes covering 11 dimensions. A similar approach can be used to evaluate how the digital transformation affects these well-being outcomes.

Survey vehicles are an important source of both self-reported objective and subjective data, and can provide insights into a variety of well-being dimensions in the context of the digital transformation. These include job satisfaction, teleworking, digital addiction, self-reported victimisation (e.g. cyber-bullying and experiences of online harassment) and subjective well-being. Data from surveys can be used to build indicators of people's life experiences in the context of the digital transformation, as well as to attempt to establish causal relationships between the rise of emerging technologies and various well-being outcomes, provided that the appropriate data are available.

What are the challenges?

Currently, official data for many self-reported indicators are lacking or their relevance to the digital transformation is limited due to the unavailability of appropriate covariates. Many household or other surveys that include variables on subjective well-being and other measures of domain-specific satisfaction do not feature detailed variables on the frequency of use of personal digital devices, and often do not distinguish between devices (e.g. computers, mobile phones and tablets). This impedes the monitoring of people's subjective well-being in the context of digital advances. Equally, surveys on ICT access and usage do not include questions on life evaluations or evaluations of people's emotional state (referred to as "affect"), even though these may be of particular relevance for studying the well-being impacts of digital technologies.

In addition, as digital technology use becomes ubiquitous it no longer suffices to collect binary data on people's technology use. Rather, understanding the impact of digital technologies on people's lives requires measuring the intensity and frequency of their use, both in terms of time spent online and variety of activities. Few internationally comparable official surveys include detailed variables on time spent online or time spent using digital devices, especially combined with well-being outcome variables.

The causal impacts of the use of digital technologies on people's mental and physical health, social connections and their evaluations of their own lives remain inconclusive. Larger studies rely on primarily correlational data, whereas more experimental studies are rarely comparable across countries and feature small sample sizes. The inclusion of sets of questions on digital technology use and self-reported life evaluations and affect in large panel studies, such as is the case with the British Household Panel Survey (BHPS), can provide more insights into how the digital transformation affects people's self-reported life experiences.

Options for international action

One important goal from the perspective of conducting cross-country comparisons is ensuring harmonisation of survey vehicles across countries. The OECD Model Survey on ICT Access and Usage by Households and Individuals encourages the alignment of Internet-use related measures across OECD countries. While it has been partially adopted in a number of OECD countries, adoption still varies widely, particularly outside the European Statistical System. Moreover, because digital technology use trends change so quickly, it is important that data are collected regularly to ensure comparability across countries.

One way to shed more light on the potential impacts of technology use is to include well-being outcome variables and questions on ICT use intensity in the same survey vehicle. As an example, the 2018 Canadian Internet Use Survey collected information on whether individuals have consciously "taken a break" from the Internet because they felt their usage was too high. The OECD model survey on Internet Use by Households and Individuals will be revised as part of the process to implement the measurement roadmap set out in this publication. During this process, the potential for collecting well-being-relevant information will be assessed alongside other priorities.

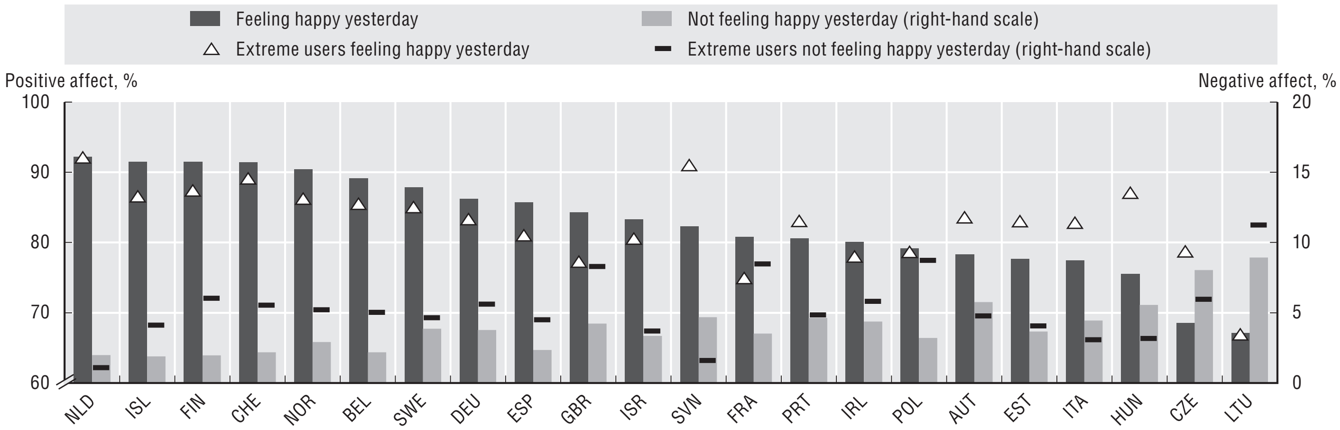
The European Social Survey (ESS) incorporates a measure of daily Internet use in minutes and another measure that resembles the OECD recommended question on positive affect[1] (OECD, 2013). While this does not provide insight into causality, it does show that experiences of low positive affect (scores of 4 or below on an 11-point scale) are more common among extreme Internet users in most countries surveyed.

More sophisticated conclusions on digital technology use and subjects such as mental health rely on the timely response of survey designers to the emergence of new technologies and the inclusion of well-being covariates. Besides including subjective well-being questions in ICT surveys, the depth of the digital transformation also warrants the inclusion of detailed ICT use variables in general surveys (e.g. household and labour force surveys).

In addition, several time-use surveys have included measures of experienced well-being, such as the American Time Use Survey (ATUS) and the French Enquête Emploi du Temps (EDT). Increased use of digital technologies may crowd out time spent on activities that are potentially more conducive for well-being, such as physical activities, socialising in person or sleeping. Harmonised adoption of experienced well-being questions in time use surveys, in combination with detailed covariates on digital device usage, would enable an improved understanding of how new technologies are affecting people's emotional states.

Extreme Internet use and positive and negative affect, 2016

Percentage of moderate and extreme Internet users experiencing high and low positive affect



Note: High positive affect denotes people who rate themselves 7 or higher on a scale from 0 to 10 that asks whether they consider themselves happy. Low positive affect denotes people who rate their happiness state a 4 or lower. Extreme users are classified as Internet users who use the Internet more than six hours per day on the Internet using a device such as a computer, tablet or smartphone, either for work or personal purposes.

Source: OECD, based on European Social Survey, Round 8, December 2018.

StatLink https://doi.org/10.1787/888933929072

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1. The ESS question asks for respondents' happiness "taking all things together". Because it does not include a specific reference period, it is not ideal as a measure of positive affect.

Why use economic statistics to measure the digital transformation?

Digital technology in its broadest sense has had a significant impact on the economy in recent years, transforming and disrupting numerous production processes and activities, while generating significant benefits to society at large. Consumers increasingly purchase goods and services online (e-commerce) and have access to a range of (typically) free services, such as search engines, social networks, media and so on. Businesses are able to capitalise on digital tools and data to boost productivity and penetrate new markets.

The pace of change has been unprecedented and in its wake many have questioned the ability of statistical information systems and concepts to keep up. However, from a conceptual standpoint this challenge has been met, at least with respect to the current GDP accounting framework – the 2008 System of National Accounts (see Ahmad and Schreyer, 2016). It is also clear that some aspects of the present statistical information system, notably those concerning the classification of firms, products and transactions, have lagged behind the digital transformation. In addition, questions are being raised about the scope of the GDP production boundary to capture, for example, new digitally enabled services produced by households for themselves – such as online content or transport and accommodation services facilitated through online platforms

Notwithstanding the evidence that digitisation has exacerbated longstanding measurement challenges, particularly with regard to price and quality changes in rapidly changing industries and products, these effects are mitigated when looking at broader measures of economic activity and inflation, and cannot explain the current productivity slowdown (Ahmad, Ribarsky and Reinsdorf, 2017; Reinsdorf and Schreyer, 2017). However, the inability to articulate the actual size of the digital economy – through references to actors, products, transactions and so on – in core accounts continues to create questions about what aspects are and are not captured in macro-economic statistics. This in turn fuels a broader mis-measurement hypothesis. These challenges can be met through the use of a digital satellite account that delineates key digital actors and transactions within the National Accounts Framework.

What are the challenges in developing a digital satellite account?

In response to this challenge, in 2017 the OECD created an Informal Advisory Group on Measuring GDP in a Digitalised Economy in order to develop new classifications and accounting tools better equipped to describing this digital reality and to provide metrics that highlight the scale of the digital transformation.

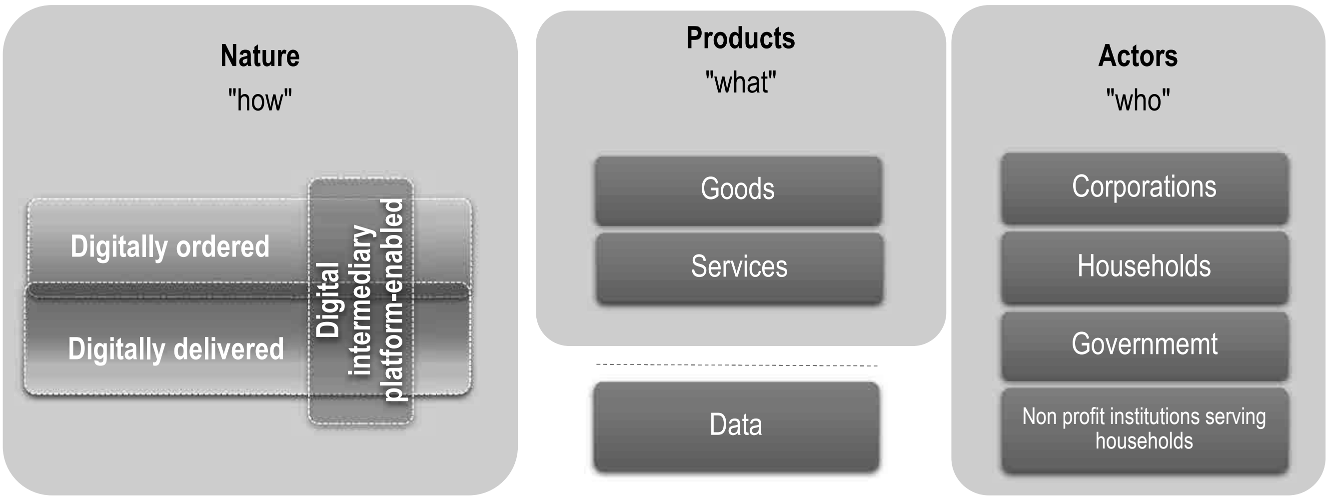
From the outset the framework was designed to provide a broadly holistic view of the digital economy that could respond to the multitude of questions posed by analysts and policy makers, notably those that current mainstream statistical information systems are unable to answer.

The multi-dimensional nature of these questions meant that the framework could not be built exclusively around mono-dimensional aspects such as industries (producers), consumers (households and industries), products (digital and non-digital) or transactions (digitised and non-digitised), as each approach provides only a partial view. That being said, a central unifying theme broad enough to reflect multi-dimensional policy needs is elusive, but revolves around the concept of digital transactions. A consensus has emerged around the idea that any framework needs to be able to separately identify transactions based on their "digital nature" (i.e. digitally ordered, digitally delivered and/or digital intermediary platform enabled), partly because of their different economic impact, but also because of the different ways in which transactions are recorded in the accounts. The following figure presents an overview of the conceptual unifying framework.

Importantly, the framework has been designed to capitalise on blocks that can, at least in theory, be readily derived from current information sets, and are in line with current international accounting standards. But, as depicted in the first column of the framework diagram, it also goes further through its inclusion of many non-monetary digital transactions not typically included in GDP, but which may have important economic implications (e.g. in relation to measures of welfare). Special mention should be made in this respect of the explicit reference to data (see the third column of the framework diagram). Under current international accounting standards, the acquisition of data without a monetary transaction is treated as "free". As such, much of these data appear neither as a good nor a service in the accounts. There is, however, considerable interest in monetising these flows, and indeed their value in the underlying databases (where they are included under the category of enablers) that support their business models, in order to better understand how they contribute to production (see Ahmad and Ribarsky, 2018; Ahmad and Van de Ven, 2018).

The operationalisation of these principles to develop a digital satellite account builds on national supply and use tables (a core part of current national statistical information systems). These provide detailed information on the production process, the origin of various goods and services (supply), and the destination of these goods and services (use) (see Mitchell, 2018). The digital satellite account goes further by requesting more detailed breakdowns of goods and services based on the modes of ordering and delivery, providing more information on one of the most visible manifestations of digitalisation - electronic ordering (e-commerce), electronic delivery and platform enabled transactions. It also recommends separate breakdowns and new groupings of producers relevant for the digital economy (e.g. digital intermediary platforms, e-sellers and firms dependent on intermediary platforms).

Conceptual framework



International actions to further the implementation of the digital satellite account

The proposed template for capturing information on the digital economy within a macro-economic framework, received positive support at the previously mentioned Informal Advisory Group of experts, as well as the Advisory Expert Group (AEG) on National Accounts, and is expected to gain formal agreement from the relevant OECD bodies in 2019.

Countries will be requested to start populating the proposed template at the beginning of 2019. Due to its complexity and the novelty of the information required, including the requirement to make new delineations in actors and modes of supply (the "how" in the framework diagram), countries are not expected to be able to fully populate the template at this early stage in the process. However, the template is intended to motivate the uptake and development of changes in statistical information and classification systems necessary over the medium term. That being said, even a partial approach in the short term will be able to deliver significant new insights, as the template deliberately builds on work already undertaken or initiated by countries and the international statistical community that aims to separately identify key elements of the digital economy. Some countries have already started to populate parts of the satellite account and have developed indicators on topics such as e-commerce, digital enabling industries, and consumer use of digital products and services.

Completion of the template is the first step in creating a more comprehensive satellite account, and will be supported by the exchange of country practices and information on ongoing initiatives aimed at addressing specific measurement aspects of the digital economy.

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Notes

Cyprus

The following note is included at the request of Turkey:

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

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

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

Israel

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

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

2.1 Information industries

Value added by information industries, 2016

For Canada, the value added shares refer to 2014.

For Brazil, China, Colombia, Indonesia, Latvia, New Zealand, Poland, Portugal, South Africa, Spain, Sweden and Turkey, the value added shares refer to 2015.

For China and Indonesia, estimates are based on the OECD Inter-Country Input-Output (ICIO) Database.

Change in the share of information industries in total value added, 2006-16

For Brazil, China, Colombia, Indonesia, Latvia, New Zealand, Poland, Portugal, Spain, Sweden and Turkey, the change in value added shares refer to the 2006-15 period.

For Canada, the change in value added shares refer to the 2007-14 period.

For China and Indonesia, estimates are based on the OECD Inter-Country Input-Output (ICIO) Database.

Employment in information industries, 2016

For Brazil, India, Japan and Luxembourg, employment shares refer to 2015.

2.2 Productivity

Labour productivity in the information industries, 2016

Real estate activities (68) are excluded from calculations as the value added of this sector includes an imputation made for dwelling services provided and consumed by home-owners.

Labour productivity is calculated as current price value added per person employed and per hour worked. Ratios are presented relative to the productivity of non-agriculture business sector excluding information industries

It is preferable to measure labour productivity based on hours worked rather than number of persons engaged. However, detailed hours worked per activity are sometimes not available. In such cases, a substitute based on employment is used to maximise country coverage.

The difference between the two measures reflects the average hours worked per person engaged. Higher relative value added per person reflects higher hours worked per person in the information industries.

For Brazil, Canada and Mexico, labour productivity estimates are based on jobs instead of persons engaged.

Labour productivity in information industries, manufacturing and service activities, 2016

Real estate activities (68) are excluded from calculations as the value added of this sector includes an imputation made for dwelling services provided and consumed by home-owners.

Labour productivity is calculated as current price value added per hour worked. Ratios are presented relative to the productivity of non-agriculture business sector excluding information industries.

It is preferable to measure labour productivity based on hours worked rather than number of persons engaged. However, detailed hours worked per activity are sometimes not available. In such cases, a substitute based on employment is used to maximise country coverage.

The difference between the two measures reflects the average hours worked per person engaged. Higher relative value added per person reflects higher hours worked per person in the information industries.

Contribution of information industries and of other sectors to non-agriculture business sector labour productivity growth, 2006-16

Real estate activities (68) are excluded from calculations as the value added of this sector includes an imputation made for dwelling services provided and consumed by home-owners.

Labour productivity is measured per hour worked. The contributions are calculated relative to the productivity growth of non-agriculture business sectors.

For Canada, data refer to 2006-14.

2.3 The demand for information industries' products

Investment in ICT equipment, software and databases, total economy and information industries, 2016

Gross fixed capital formation shares exclude dwellings.

Information industries for Australia, Estonia and Israel refer to Information and Telecommunications services (ISIC Rev.4 Divisions from 58 to 63).

For Ireland, investment in information industries includes ICT equipment only (no software available).

Intermediate consumption of information industries' products, 2015

Information industries cover the following ISIC Rev.4 Divisions: Computer, electronic and optical products (26); Publishing, audiovisual and broadcasting (58 to 60); Telecommunications (61) and IT and other information services (62, 63).

Final demand for information industries' products, 2015

Information industries cover the following ISIC Rev.4 Divisions: Computer, electronic and optical products (26); Publishing, audiovisual and broadcasting (58 to 60); Telecommunications (61) and IT and other information services (62, 63).

2.4. Value added and jobs

Information industry-related domestic value added, 2015

The 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.

Jobs in information industries sustained by foreign final demand, 2015

The OECD estimate is an unweighted average.

The EU28 estimate is a weighted average, and includes intra-EU trade.

2.5. Trade in digital products

Top 15 exporters of computer, electronic and optical products, in gross and value added terms, 2015

Estimates of gross exports in the TiVA database exclude re-exports and are valued at basic prices (i.e. trade and distribution margins are excluded). They refer to gross exports by the Computer, electronic and optical products industry. Exports in value added terms refers to the domestic value added generated by the Computer, electronic and optical products industry that is embodied in foreign final demand.

The Computer, electronic and optical products industry corresponds to ISIC Rev.4 Division 26.

2.6. Well-being and the digital transformation

Internet users looking for a job or sending a job application online, by age, 2017

Unless otherwise stated, Internet users are defined as individuals who accessed the Internet within the last 3 months. For Korea, the recall period is 12 months. For the United States, the recall period is 6 months.

For Brazil, data refer to 2016.

For Costa Rica, data refer to individuals aged 18-74 instead of 16-74.

2.8. Digital transformation and health

Individuals who booked doctors' appointments online, 2018

Data refer to individuals who used the Internet to make an appointment with a practitioner via a website.

For Switzerland, data refer to 2014.

Individuals who have used the Internet to access health information, by gender, 2018

Unless otherwise stated, Internet users are defined for a recall period of 3 months. For Canada, Colombia and Korea, the recall period is 12 months. For the United States, the recall period is 6 months in 2015, and no reference period was specified in 2010.

For Australia, data refer to the fiscal year 2016/17 ending on 30 June.

For Brazil, data refer to 2016 instead of 2018.

For Canada, data refer to 2012 instead of 2018.

For Chile, Colombia, Mexico and Switzerland, data refer to 2017 instead of 2018.

For Costa Rica, data refer to 2017 and to individuals aged 18-74 instead of 16-74.

For New Zealand, data refer to 2012 instead of 2018.

For the United States, data refer to 2015.

Workers who experienced job stress associated with frequent computer use at work, 2015

The share of workers experiencing stress at work associated with having a computer-based jobs is computed using OECD estimations of the effect size of having a computer-based job on self-reports of job stress. The effect size is estimated using regression analysis that controls for age, gender, income and skill level and then multiplied by the number of respondents in each country that frequently use computers at their job. The resulting effect size implies that people who frequently use computers in their job are 5.8% more likely to experience stress at work and is significant at the $p<0.01$ level. Estimates are based on the pool of countries included in this figure. Frequently using computers refers to using computers more than half of the time at work and experiencing job stress refers to experiencing stress either "Sometimes", "Most of the time" or "Always".`

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Chapter 3

ENHANCING ACCESS

Broadband communication networks and the services provided over them support a variety of economic and social development goals, relating to health, financial inclusion, and education, among many others. ITU World Telecommunication/ICT Indicators Database shows that fixed broadband subscriptions have increased by 89% worldwide within just seven years – from 532 million in 2010 to one billion in 2017. Switzerland has the highest fixed broadband penetration in the OECD, with almost one subscription for every two inhabitants, while the OECD average is just below one per three inhabitants.

Communication operators have deployed fibre optics further into their networks, but often rely on other "last mile" technologies, such as copper, wireless and coaxial cable, where fibre does not reach all the way to customers' premises. For this reason, the share of fibre (to the home/premises) can be relatively low in some high-income countries. Last mile technologies can provide relatively high connection speeds, but fibre boasts the highest maximum speeds. Countries without legacy telecommunications networks may be able to leapfrog directly to fibre – according to ITU data, it represents almost 70% of total fixed broadband subscriptions in China, for example – though these countries still tend to have lower broadband penetration overall.

A comparison of the average prices for specific OECD fixed broadband baskets, between 2013 and 2018, shows that "high usage" subscriptions appear to have decreased in cost, while prices for "low usage" have remained more stable. Prices can also vary widely between countries, with the average for the three most costly countries being around three times more than the average of the three least costly.

These price baskets are designed to provide a snapshot of prices at any given time, rather than a series. The lowest cost plan is selected at each point in time and may be different from earlier plans (e.g. with higher speed or an increased amount of data). In addition, these measures are not adjusted for the varying social, economic and geographic situations influencing prices in different countries. It is nonetheless worth considering an average for all OECD countries as an indicator of trends in these two segments of the market. However, declining unit prices do not mean that all users are paying less; consumers may choose to pay more for plans that offer higher included amounts of data, higher speeds, and so on, or may incur costs to switch plans.

The Services Trade Restrictiveness Index (STRI) for telecommunication services endeavours to capture characteristics of the policy environment that can restrict the free international trade of fixed, mobile and Internet services. Common restrictions include limitations on foreign ownership, government ownership of major suppliers, screening of foreign investment, and nationality or residency requirements for directors and managers. Pro-competitive reforms in the telecommunications sector are associated with a substantial reduction in the trade costs for business services in the overall economy. Since telecommunications is a capital-intensive network industry, improving access to essential facilities and reducing switching costs may enable new entrants to compete with incumbent firms.

DID YOU KNOW?

Korea, Japan, Latvia, Lithuania and Sweden are the only OECD countries where fibre makes up the majority of broadband connections.

Definitions

Fixed broadband penetration refers to the number of subscriptions, per 100 inhabitants, to services with a 256 Kbps advertised download speed or greater, provided over DSL, cable, fibre-to-the-home (FTTH), fibre-to-the-building (FTTB), satellite, terrestrial fixed wireless, or other fixed-wired technologies.

Fibre broadband refers to subscriptions where fibre reaches the subscriber's premises or terminates no more than 2 metres from an external wall.

The *high usage* fixed broadband basket provides 200 GB of download data; *low usage* provides 20 GB of data.

Measurability

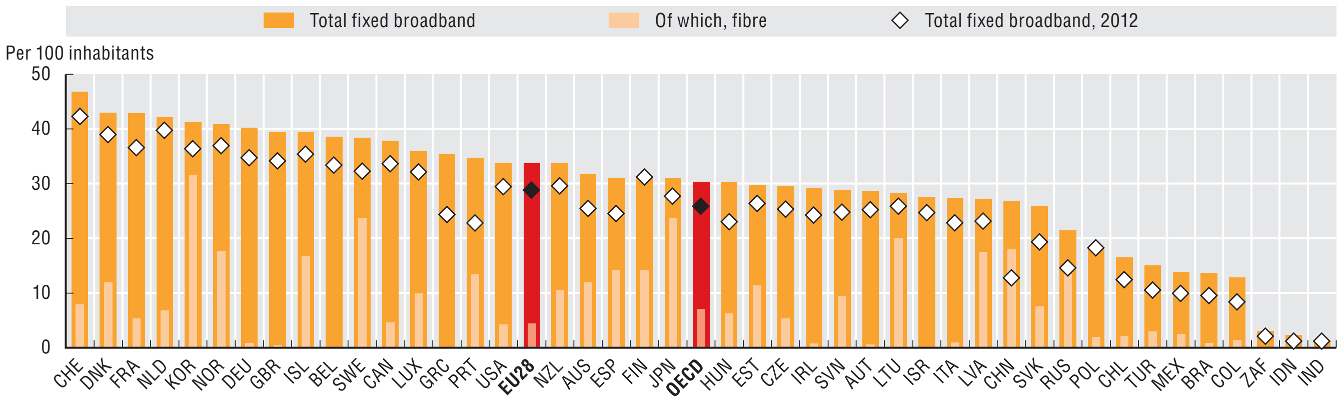
Broadband subscription data are typically supplied to the OECD and ITU by communications regulators that collect them directly from network operators according to common definitions. It is not currently possible to delineate business and consumer subscriptions and so both are counted. The data are presented in relation to the population in each country. Broadband subscription penetration rates do not provide information about the prices that users pay, realised connection speeds, or whether there are restrictive data caps. Countries performing well in one measure may be weaker in another.

OECD broadband pricing data are gathered directly from the websites of a set of three network operators with a combined market share of at least 70%. All DSL, cable, and fibre offers with advertised speeds over 256 Kbps are included. Offers relate to month-to-month services advertised clearly on operator websites and should be available in the country's largest city. For more information see the OECD Broadband Price Baskets Methodology (OECD, 2017). The ITU also surveys prices for monthly subscriptions to entry-level fixed-broadband plans offering 1GB or more data from the 193 ITU member states. See: https://www.itu.int/en/ITU-D/Statistics/Pages/definitions/pricemethodology.aspx.

Launched in 2014, the *OECD Services Trade Restrictiveness Index (STRI)* is an evidence-based diagnostic tool that provides an up-to-date snapshot of services trade barriers in 22 sectors across 44 countries, representing over 80% of global services trade. The indices presented summarise binary, hierarchical and quantitative data into composite indicators. For more information see: http://www.oecd.org/tad/services-trade/methodology-services-trade-restrictiveness-index.htm

Fixed broadband subscriptions, by technology, December 2017

Per 100 inhabitants

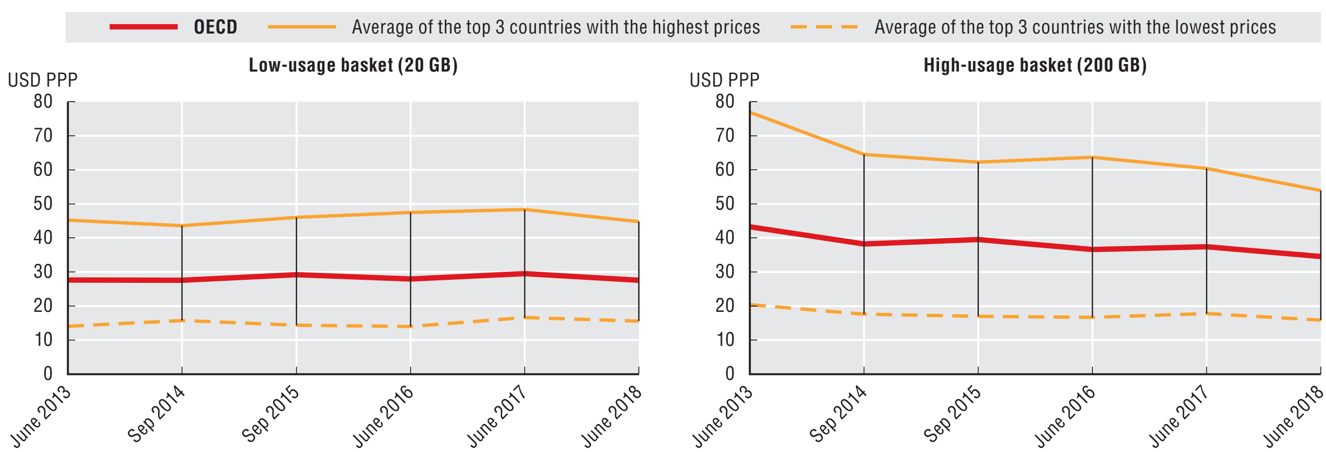


Source: OECD, Broadband Portal, http://www.oecd.org/sti/broadband/broadband-statistics; ITU World Telecommunication/ICT Indicators Database, September 2018 and EU Digital Scoreboard 2017: Strengthening the European Digital Economy and Society.

StatLink https://doi.org/10.1787/888933929490

Trends in fixed broadband monthly subscription prices, OECD, 2013-18

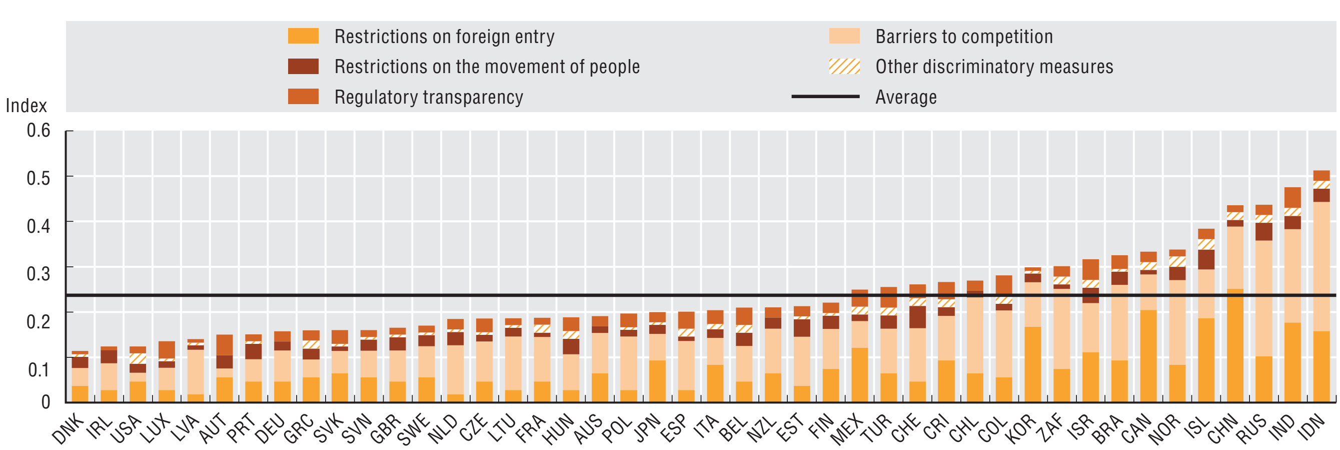
OECD average and spread between averages of prices in the three most and least costly countries



Source: OECD calculations based on Strategy Analytics Ltd. Teligen Tariff & Benchmarking Market data using the OECD Methodology, https://www.strategyanalytics.com, June 2018. StatLink contains more data.

StatLink https://doi.org/10.1787/888933929509

Telecommunication Services Trade Restrictiveness Index (STRI), 2017



Source: OECD, Services Trade Restrictiveness Index, https://oe.cd/stri-db, September 2018. See chapter notes. StatLink contains more data.

StatLink https://doi.org/10.1787/888933929528

Growth in mobile broadband subscriptions has far outstripped fixed broadband growth since 2010, with worldwide subscriptions increasing from 825 million in 2010 to 4.6 billion in 2017 (ITU World Telecommunication/ ICT Indicators Database), and now accounting for 82% of all broadband access paths in the world (77% in the OECD area). Mobile broadband take-up is much higher than fixed broadband take-up relative to population size, with around three subscriptions per two inhabitants in Japan and Finland, and an OECD average of one subscription per inhabitant. In all countries, the majority of subscriptions include both calls and data, though data-only subscriptions have over 40% market share in Estonia and Japan.

Increases in mobile broadband penetration can be rapid. Since 2010, China and India have experienced roughly 25-fold growth in mobile broadband subscriptions, while Mexico witnessed a 17-fold increase. In some countries the relatively limited availability and affordability of fixed broadband can be an important contributing factor to strong growth in mobile broadband subscriptions. For example, India saw more than 127 million additional subscriptions in 2017.

Mobile data usage is growing exponentially in some countries, particularly Finland, where almost 16 GB data were used each month per subscription on average in 2017. Use was above 6 GB monthly, and more than double the OECD average of 3 GB in Austria, Estonia, Latvia and Lithuania. In contrast, average usage remains below 1 GB monthly in Greece and the Slovak Republic. Between 2015 and 2017, average data usage more than doubled in two-thirds of countries and quintupled in Lithuania. Network capacity will need to continue to expand in order to meet the rapidly increasing demand for data.

Prices for mobile broadband connectivity have fallen between 2013 and 2018, as shown by a comparison of average prices for specific OECD mobile broadband baskets representing “low usage” and “high usage”. Prices can also vary widely between countries, with the average for the three most costly countries being around five to seven times that of the three least costly countries in 2018.

These baskets provide a snapshot of the lowest-cost plans with the relevant data and call amounts for each period. Importantly, these statistics track available prices rather than customer uptake. Although a given basket may become available for a lower price, many users might be unable to take-up the offer due to contractual lock-in or may opt for more expensive packages with additional data, calls or ancillary services such as SMS and online content. However, an average for all OECD countries may nonetheless be considered as an indicator of general trends in these two segments of the market.

DID YOU KNOW?

The number of mobile broadband subscriptions more than doubled between 2010 and 2017 – reaching more than one per OECD inhabitant for the first time.

Definitions

Mobile broadband penetration includes subscriptions to mobile-broadband networks that provide download speeds of at least 256 Kbps (e.g. using WCDMA, HSPA, CDMA2000 1x EV-DO, WiMAX IEEE 802.16e and LTE), and excludes subscriptions using only GPRS, EDGE or CDMA 1xRTT networks. Figures relate to the number of handset-based and computer-based (USB/dongles) mobile-broadband subscriptions to the public Internet that are regarded as active, based on either a recurring subscription fee for data/Internet access or the subscriber having accessed the Internet in the last three months.

High usage mobile broadband offers include 2 GB of download data and 900 minutes of voice calls. *Low usage* includes 500 MB of data and 100 minutes of calls.

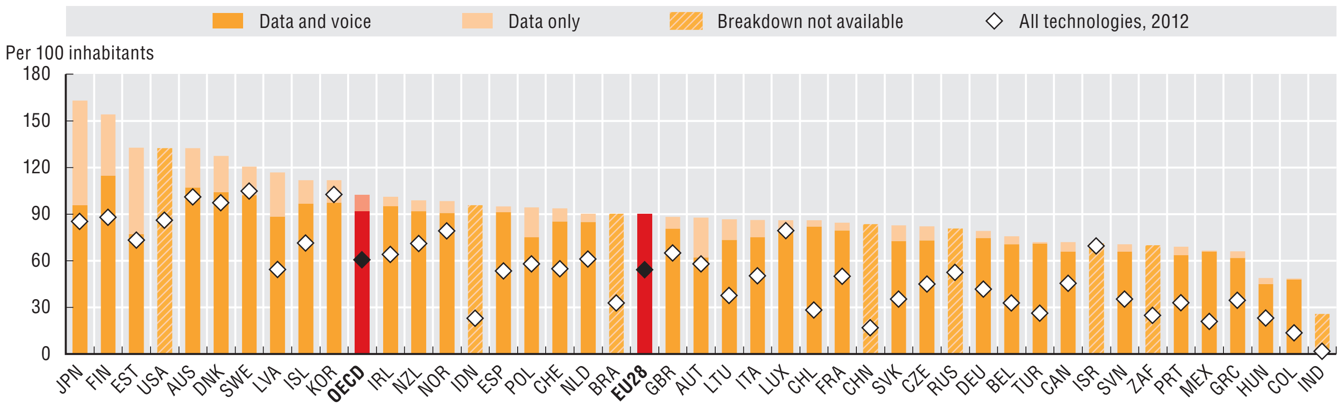
Measurability

Mobile broadband subscriptions data, including data usage volumes, are typically supplied to the OECD or ITU by communications regulators that collect them directly from network operators according to common definitions. Data for wireless broadband subscriptions have improved greatly in recent years, especially with regard to the measurement of data only and data and voice mobile subscriptions. It is not currently possible to delineate business and consumer subscriptions, so both are counted. Even so, the data are typically presented in relation to the population of people in each country

OECD mobile broadband prices data are gathered directly from network operator websites. They cover at least the two largest mobile network operators, with a 50% or greater combined market share (by subscriber numbers). Offers include 3G and 4G mobile phone services, including post-paid, prepaid and SIM-only tariffs. Data and voice offers are treated separately from data only. Handsets are not included. Offers relate to month-to-month services advertised clearly on operator websites and should be available in the country’s largest city. For more information see the OECD Broadband Price Baskets Methodology (OECD, 2017). The ITU also collects prices for mobile broadband subscriptions from operator websites; focusing primarily on prepaid services that are popular in many non-OECD countries: https://www.itu.int/en/ITU-D/Statistics/Pages/definitions/pricemethodology.aspx.

Mobile broadband subscriptions, by package type, December 2017

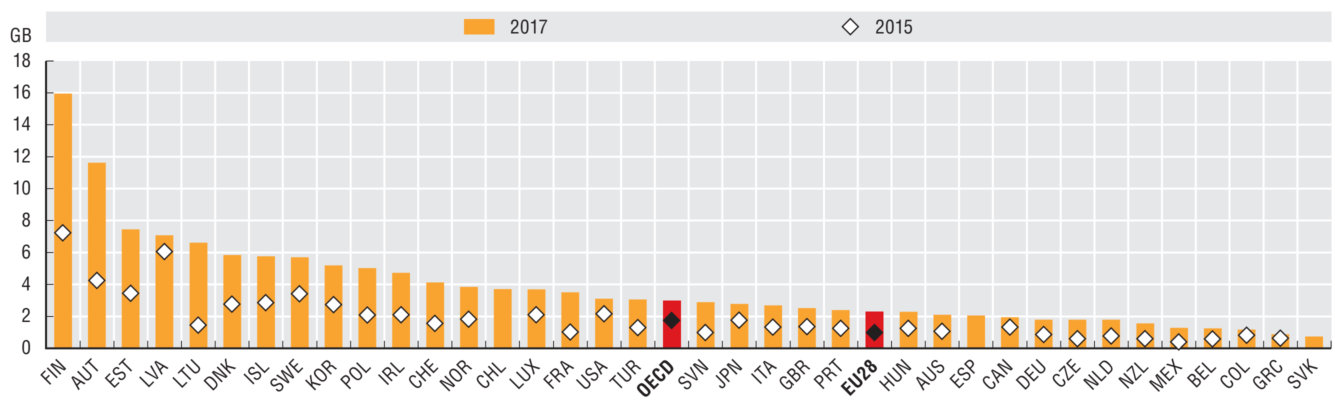
Per 100 inhabitants



Source: OECD, Broadband Portal, http://www.oecd.org/sti/broadband/broadband-statistics; ITU World Telecommunication/ICT Indicators Database, September 2018 and EU Digital Scoreboard 2017: Strengthening the European Digital Economy and Society.

StatLink https://doi.org/10.1787/888933929547

Average monthly mobile data usage per mobile broadband subscription, GB, 2017

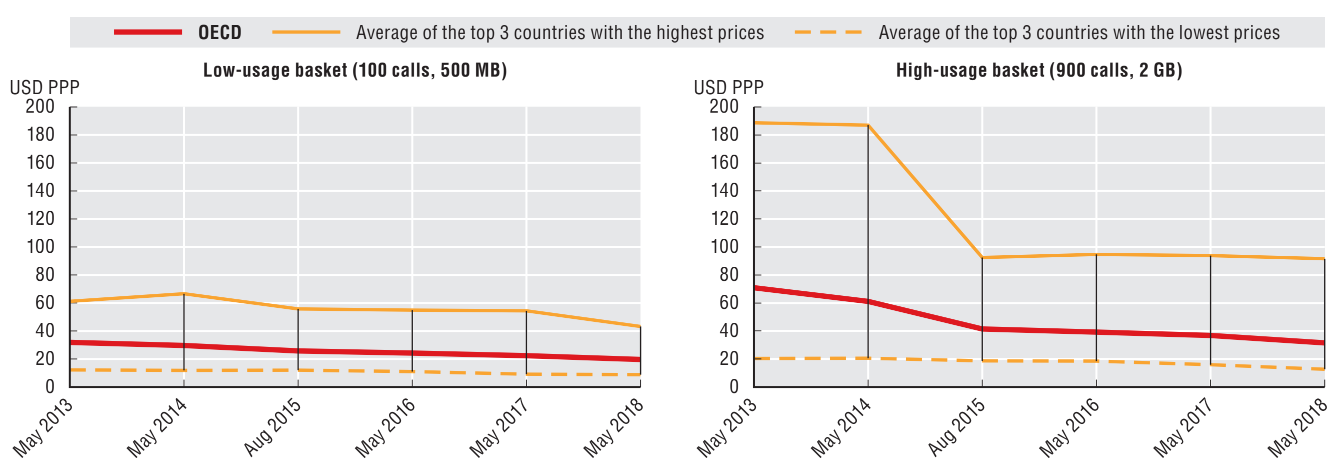


Source: OECD, Broadband portal, http://www.oecd.org/sti/broadband/broadband-statistics, September 2018. See chapter notes.

StatLink https://doi.org/10.1787/888933929566

Mobile broadband monthly subscription pricing trends, OECD, 2013-18

OECD average and spread between averages of prices in the three most and least costly countries



Source: OECD calculations based on Strategy Analytics Ltd. Teligen Tariff & Benchmarking Market data using the OECD Methodology, https://www.strategyanalytics.com, June 2018.

StatLink https://doi.org/10.1787/888933929585

Access speeds determine the applications the Internet can be used for – by both businesses and consumers. In terms of retail (consumer) service offers, speeds vary considerably, with most consumer fixed broadband subscriptions already marketed at over 10 Mbps. Nevertheless, a significant proportion of subscriptions still offer between 2 Mbps and 10 Mbps. As of 2017, the leading advertised download speed in OECD countries was 10 Gbps (10 000 Mbps), though only a small number of consumer offers were available at that level. Offers marketed at 1 Gbps are increasingly common in countries where fibre to the premises or upgraded cable broadband networks are in place. This is particularly the case in countries with high population densities, such as Japan and Korea, as well as in an increasing number of cities in the United States. Gigabit speeds are most commonly found where there is either strong infrastructure competition between operators or competition between retail providers using wholesale networks.

Business users, educational institutions, and the public sector can often access tailored high-speed products such as leased lines between specific locations. However, these cannot be analysed separately in the statistics currently available.

Many OECD countries have on-going national broadband strategies setting objectives for speeds and coverage. Targets of 100 Mbps or more are becoming increasingly common; by 2020, the United States aims to have broadband speeds of 100 Mbps or more available to 80% of households, while the targets in Norway and Austria are for 90% and 99% coverage, respectively. In Australia, the "National Broadband Network" aims to deliver peak wholesale download data rates of at least 25 Mbps to all premises by 2020. Some smaller countries can target even greater speeds: Luxembourg aims to have 1 Gbps connections for all businesses and households in place by 2020, and Sweden is aiming for 98% coverage by 2025 (OECD, 2018a). As strategies are implemented, their impacts will be reflected in indicators of Internet speed.

Even in countries where connections advertised at 1 Gbps or greater are available, delivering these speeds to all geographical locations remains a challenge. It is also common for the actual speed experienced by users to be below the advertised speed. Different approaches exist for gauging Internet speed, each with its own limitations and caveats. It is important to examine multiple sources on speeds to obtain a rounded view of performance. Measurements from Ookla and M-lab, which allow users to self-test their connection speeds, provide complementary measures that contrast with contracted speed tiers data. For example, in Switzerland 84% of subscriptions have a contracted speed greater than 100 Mbps, as do over 60% in Sweden and Portugal. Average speeds measured by Ookla are just over 100 Mbps in Sweden and Switzerland, and slightly less (70 Mbps) in Portugal, but M-lab measurements typically show markedly lower speeds. Together, these sources give a complementary and nuanced, although still partial, view of experienced speeds.

DID YOU KNOW?

In Europe, Switzerland, Sweden, Portugal and Belgium have the greatest uptake of fast broadband with over 50% of connections being faster than 100 Mbps.

Definitions

Internet speed relates to the amount of data passing through a network connection in a second. The most fundamental unit of digital data is the "bit" (a 0 or 1 in binary code). A kilobit is 1 000 bits, a megabit is 1 000 kilobits, and a gigabit is 1 000 megabits. Speed is therefore expressed in kilobits per second (Kbps), megabits per second (Mbps), and Gigabits per second (Gbps).

Measurability

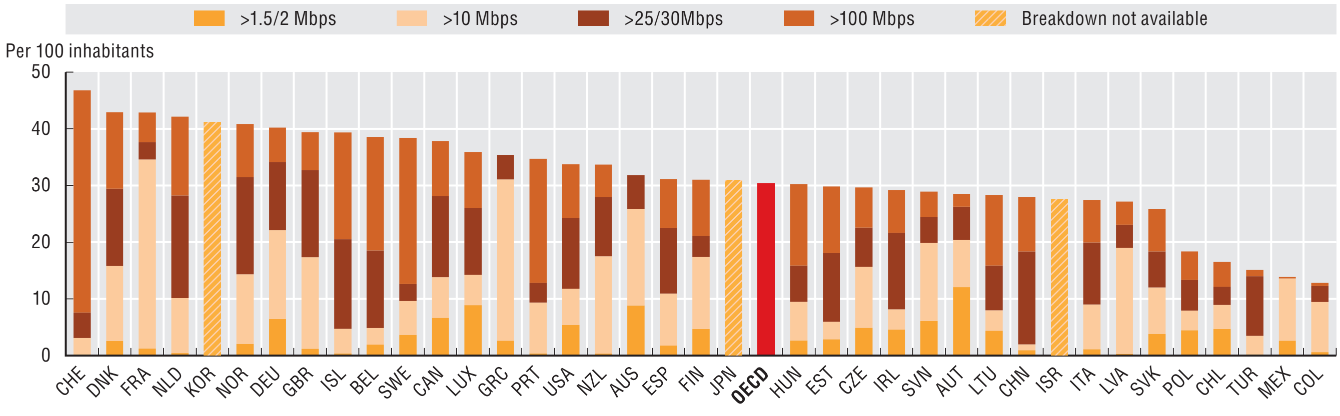
These data focus on download speed (i.e. of data flowing from the Internet to the user's device). This is a function of data availability and the fact that this measure is the most widely used performance metric. Nevertheless, the speed at which data moves in the opposite direction (upload speed) is also an important aspect of overall connection quality, along with reliability. This is especially relevant for businesses that rely increasingly on large amounts of data and digital products flowing in both directions (e.g. as a result of adopting cloud computing services or Internet of Things devices).

There is a potential gap between the speeds advertised to customers and those actually experienced by users. Regulators collect information on the advertised download speed of subscriptions and these are compiled to show subscriptions broken down by speed tiers - a view of the "theoretical" speed of subscriptions. It is necessary to select speed tiers that are useful for analysis and reflect the increases in advertised speeds over time. Such indicators are available on the OECD broadband portal: http://oe.cd/broadband.

Various tools can provide some insight on experienced download speeds, as well as other quality-of-service parameters. The Ookla measure reflects wired or wireless broadband speed achievable 'on-net', while the M-Lab Network Diagnostic test is primarily for identifying Internet bottlenecks rather than computing averages of upload and download speeds from different user populations. Neither fully represent the overall Internet experience and each provides only a partial view on of Internet speed. Nevertheless, they provide useful partial indicator available for both OECD and non-OECD countries. Broadband quality measurement, including speed measurement, is further addressed on page 3.7.

Fixed broadband subscriptions, by contracted speed tiers, December 2017

Per 100 inhabitants

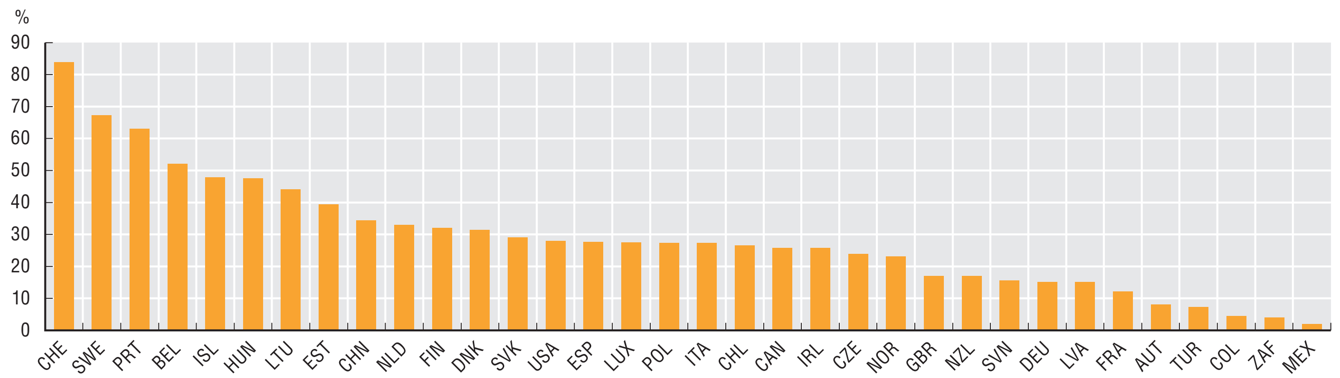


Source: OECD, Broadband portal, http://www.oecd.org/sti/broadband/broadband-statistics and ITU World Telecommunication/ICT Indicators Database, September 2018.

StatLink https://doi.org/10.1787/888933929604

Fixed broadband subscriptions with contracted speed faster than 100 Mbps, December 2017

As a percentage of fixed broadband subscriptions

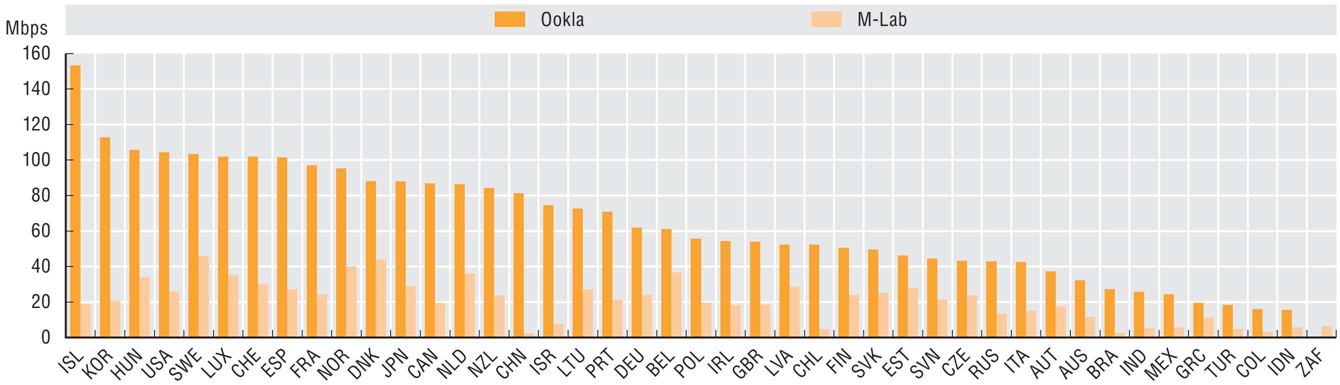


Source: OECD, Broadband portal, http://www.oecd.org/sti/broadband/broadband-statistics and ITU World Telecommunication/ICT Indicators Database, September 2018. See chapter notes.

StatLink https://doi.org/10.1787/888933929623

Average experienced download speed of fixed broadband connections, 2018

Ookla and M-lab measurements



Source: OECD, based on Ookla, October 2018 and M-Lab (Worldwide broadband speed league) as measured between June 2017 and May 2018.

StatLink https://doi.org/10.1787/888933929642

The Internet is a key infrastructure for businesses, individuals, and the public sector alike and continues to expand rapidly. Originally designed as a research network, the Internet's subsequent commercialisation and expansion have necessitated updates to the data protocols that ensure its functioning. IPv6 was introduced in 1999 to succeed IPv4 and provides significantly greater address space but is being implemented relatively slowly. While around 50% of Internet traffic in Belgium uses the IPv6 data protocol, the share in most countries appears to be 20% or less.

The Internet of Things (IoT) includes all devices and objects whose state can be altered via the Internet, with or without the active involvement of individuals. While these connected objects may require the involvement of devices considered part of the "traditional Internet", laptops, tablets and smartphones are excluded from this definition (OECD, 2018b). Such devices could soon be a fundamental part of the everyday lives of people in OECD countries and beyond. IoT applications span major economic sectors including health, education, agriculture, transportation, manufacturing, power generation and distribution, and many more. One part of the underlying infrastructure of the IoT is machine-to-machine (M2M) communication. Among OECD economies, Sweden has by far the highest penetration (number of M2M SIM cards per inhabitant), although this is chiefly because M2M SIM cards supplied and registered in Sweden are provided to companies throughout the European Union. The number of M2M SIM-cards is growing fast and has doubled in the OECD area between 2014 and 2017.

The rapid spread of digital technologies and the reliance on digitised information creates new challenges for the protection of sensitive data and ensuring the confidentiality of network communications. Secure servers used for the exchange of sensitive information, such as passwords and credit card numbers, are vital infrastructure underpinning e-commerce and many other online activities. According to data from the June 2018 Netcraft survey, 32.6 million secure servers (which implement SSL/TLS), were deployed worldwide in June 2018, up 72% from 19 million servers in June 2017. Growth rates accelerated markedly in 2014, having grown by around 20% year-on-year previously. In 2018, the United States accounted for the largest number of secure servers (12 million), representing 37% of the world total, followed by Germany (3.6 million, 11%) and the United Kingdom (1.6 million, 5%). The United Kingdom also has the highest rate of secure servers in comparison to the total number of servers in the country, at 33% in 2018, and up from 18% a year earlier. However, the share of secure servers in most countries is still low relative to the total number of servers. For example, in the United States less than 3% of all servers hosted use SSL/TLS, while the OECD average is only 3.2%. This is just one specific aspect of cybersecurity, further indicators can be found in Chapter 8.

DID YOU KNOW?

M2M SIM cards are an important foundational technology for the Internet of Things. The number of M2M subscriptions in the OECD doubled between 2014 and 2017.

Definitions

Internet Protocol (IP) consists of the rules and formats for data sent over the Internet. The newest iteration, IP version 6 (IPv6), was introduced in 1999 and offers significantly greater address space (number of potential web addresses) than the preceding IPv4.

Machine to machine (M2M) on mobile networks refers to SIM-cards that are assigned for use in machines and devices and which are not part of a consumer subscription. This includes SIM-cards in personal navigation devices, smart meters, trains, automobiles and so on. Dongles for mobile data and tablet subscriptions are excluded.

Secure servers are servers implementing Transport Layer Security (TLS) or Secure Sockets Layer (SSL) protocols. Internet browsers and web servers use these to exchange sensitive information. They rely on a certificate authority (trusted third parties such as Symantec and GoDaddy), which issues a digital certificate containing a public key and information about its owner, and can confirm that a given public key belongs to a specific website.

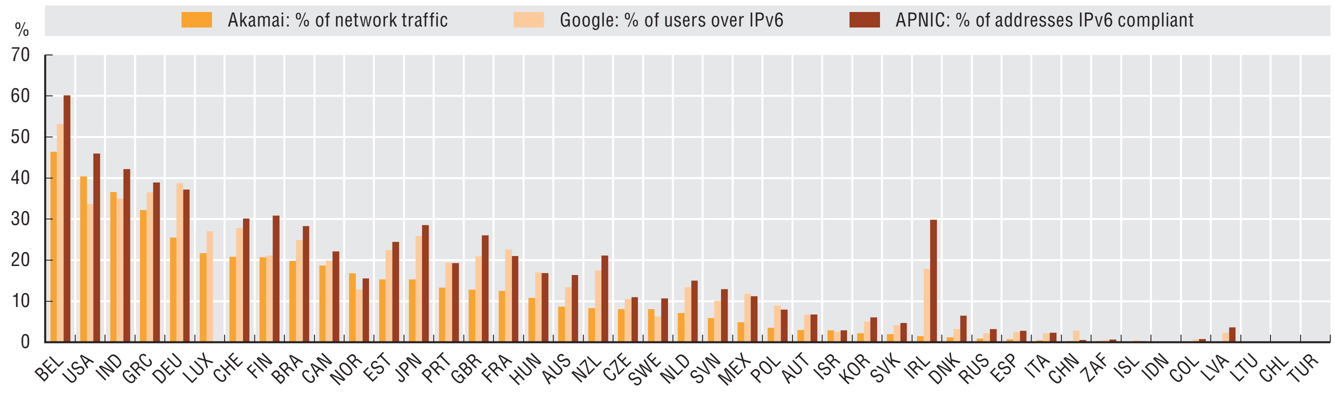
Measurability

Measuring an evolving process such as worldwide adoption of IPv6 requires the use of different methodologies to assess different parts of the Internet (OECD, 2014). These data present complementary information on the share of traffic transiting the Akamai Content Delivery Network that uses IPv6, the share of users accessing Google via IPv6, and the share of Internet addresses provided by APNIC and other Regional Internet Address Registries that are IPv6 compliant. Together, this provides a multi-faceted, albeit partial, view of IPv6 adoption.

The OECD Broadband Portal (http://oe.cd/broadband) publishes key telecommunication market indicators based on information from communication regulators and official statistical agencies in OECD countries. Within the set of indicators, most OECD countries now provide data on M2M SIM cards.

Netcraft carries out monthly secure server surveys covering public secure websites (excluding secure mail servers, intranet and non-public extranet sites) using electronic tools to ascertain whether public servers have implemented TLS or SSL.

IPv6 adoption by country, 2017

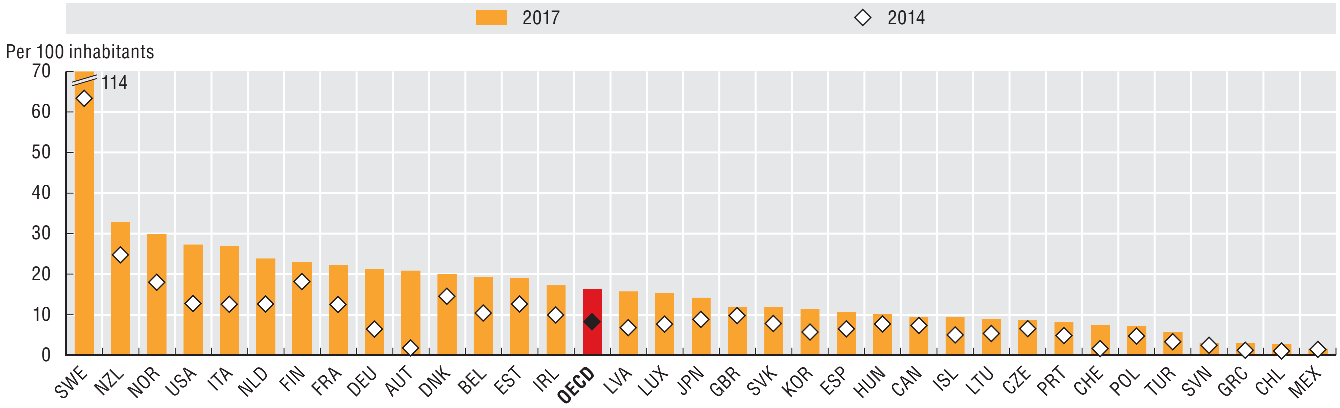


Source: OECD, based on Akamai, APNIC and Google data, 2018. See chapter notes.

StatLink https://doi.org/10.1787/888933929661

M2M SIM card penetration, 2017

Per 100 inhabitants

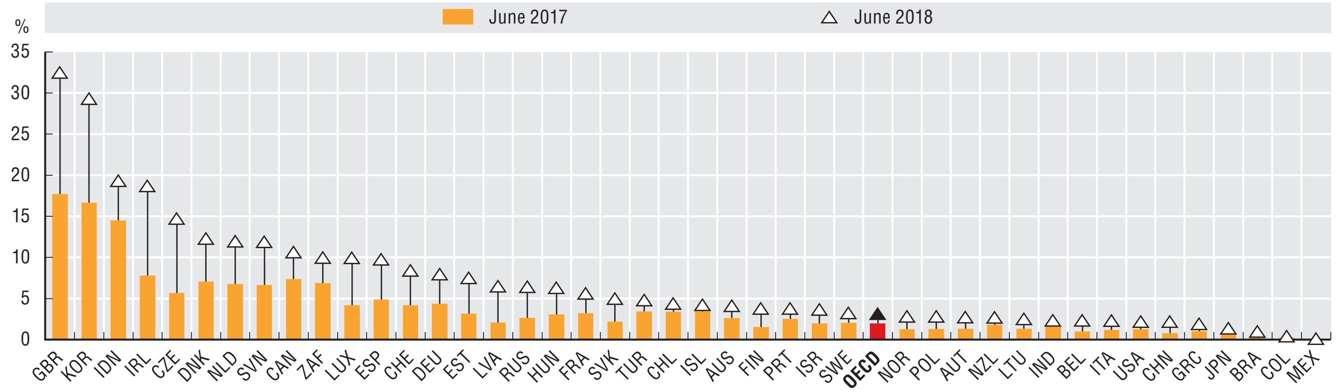


Source: OECD, Broadband portal, http://www.oecd.org/sti/broadband/broadband-statistics, September 2018. See chapter notes.

StatLink https://doi.org/10.1787/888933929680

Web servers using digital certificates, by host country, June 2018

Percentage of Internet hosts implementing TLS/SSL in each country



Source: OECD, based on Netcraft, www.netcraft.com, July 2018. See chapter notes.

StatLink https://doi.org/10.1787/888933929699

Broadband connections in households are an indicator of people's access to information and services. Disparities in broadband access are partly explained by urban-rural divides within countries, particularly in countries with lower per capita incomes. Urban-rural divides in access can occur for a variety of reasons including fixed broadband networks not extending into some rural areas (lack of availability), lower uptake in rural areas, which may be associated with broadband prices being higher in harder-to-serve areas, incomes being lower, etc., and divides in terms of broadband quality (speed, latency, reliability and so on. See page 3.7 for more information).

Information from regulators shows that rural households, in many OECD countries, are less likely to be covered by, and thus have the option to purchase, fixed broadband with a contracted speed of 30 Mbps or more. Such a speed is sufficient to support relatively demanding, but increasingly commonplace, consumer applications such as streaming high-definition video. In almost half of the countries presented, fewer than 50% of rural households are located in areas with such connections available. Country size, topology and population spread are important factors in this regard. In Luxembourg and the Netherlands, almost all households, both urban and rural, are covered by broadband of 30 Mbps or more. Speeds of 1 Gbps are also common in both urban and rural areas in Japan and Korea. However, rural availability is much lower in countries such as Finland and Sweden, which have vast, sparsely populated, mountainous regions. France stands out, with only 52% of all households being covered in 2017.

Household ICT usage surveys provide a different perspective through statistics on connections purchased by households. However, these data also include broadband subscriptions with contracted speeds below 30 Mbps (and as slow as 256 Kbps). Results show that urban and rural households have roughly equal uptake of such connections in many OECD countries. However, the disparity remains wide in some other countries: twice as many urban households than rural households were connected to broadband in Brazil, and urban led rural by over 20 percentage points in Greece and Portugal in 2018. These and other countries have seen marked increases in both urban and rural broadband coverage since 2010.

Taken together, these statistics indicate that households' demand for connectivity appears roughly equal in both urban and rural areas in OECD countries. However, rural areas are often served by slower connections than urban areas, which may limit the ways in which rural households and businesses can benefit from Internet access.

A large majority of businesses today make use of ICTs. In 2018, on average 92% of enterprises in OECD countries had a broadband subscription. However, the share with contracted speeds of 30 Mbps or more is often much lower. For example, less than half of EU firms with broadband have speeds of 30 Mbps or more, and only 40% of EU small businesses have such speeds. Nevertheless, the share of businesses with subscriptions of 30 Mbps or more has at least doubled since 2011 in all countries shown.

DID YOU KNOW?

In many OECD countries, fewer than half of rural households are located in areas where fixed broadband of 30Mbps or more is available.

Definitions

Available indicates that a commercial fixed line subscription with a speed of 30Mbps or more is offered for the household to purchase if they wish.

Broadband connections refers fixed line broadband services (i.e. of 256 Kbps advertised speed or more) subscriptions purchased by households or businesses. Fixed broadband comprises DSL, cable, fibre-to-the-home (FTTH), fibre-to-the-building (FTTB), satellite, terrestrial fixed wireless and other fixed-wired technologies.

According to the OECD Regional Typology (Brezzi et al., 2011), a region is classified as *rural* if more than half of the population lives in local units with a population density below 150 inhabitants per square kilometre and *urban* if less than 15% live in such low-density local units. In Japan and Korea the threshold is 500 inhabitants, as population density exceeds 300 inhabitants per square kilometre nationally.

Firm size classes are defined as small (10 to 49 persons employed), medium (50 to 249) and large (above 250).

Measurability

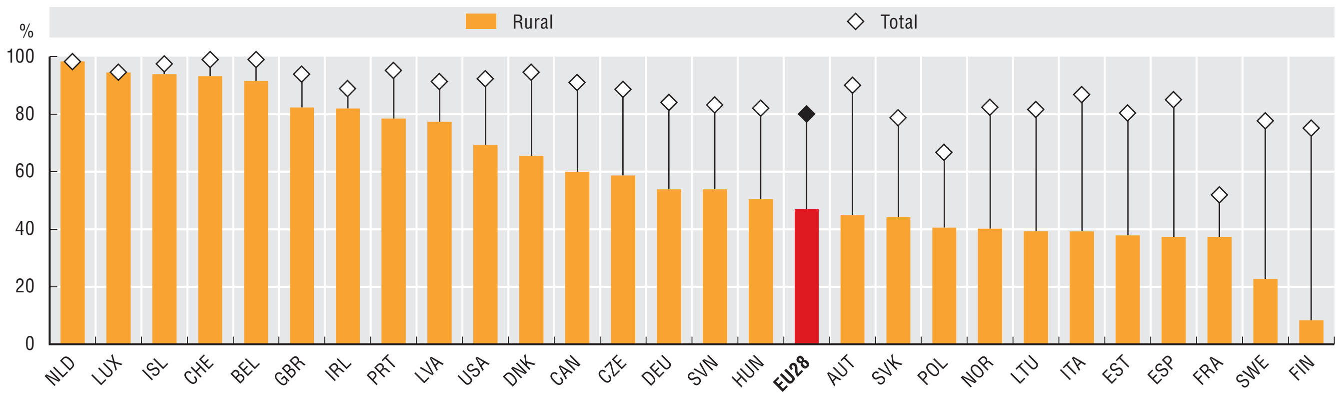
Information on broadband availability is collected and reported by communications regulators.

Data on household and business broadband connections are gathered through surveys on ICT usage. These allow for the collection of useful contextual details in comparison to subscriptions data from regulators, though surveys are less suited to collecting specific technical details. Surveys are generally carried out annually but are less frequent in Australia and Canada. The OECD actively encourages the collection of comparable information in this field through guidelines in the "Model Survey on ICT Access and Usage by Households and Individuals" (OECD, 2015a). and "Model Survey on ICT Access and Usage by Businesses" (OECD, 2015b)

The OECD Regional Typology is based on population density, hence it cannot discriminate between regions close to a large populated centre and remote regions. To account for these differences, it has been extended to include an additional criterion based on the driving time needed for 50% of the population of a region to reach a population centre (Brezzi et al., 2011). At present, the extended typology has only been computed for regions in North America and Europe.

Households in areas where fixed broadband with a contracted speed of 30 Mbps or more is available, total and rural, 2017

As a percentage of households in each category

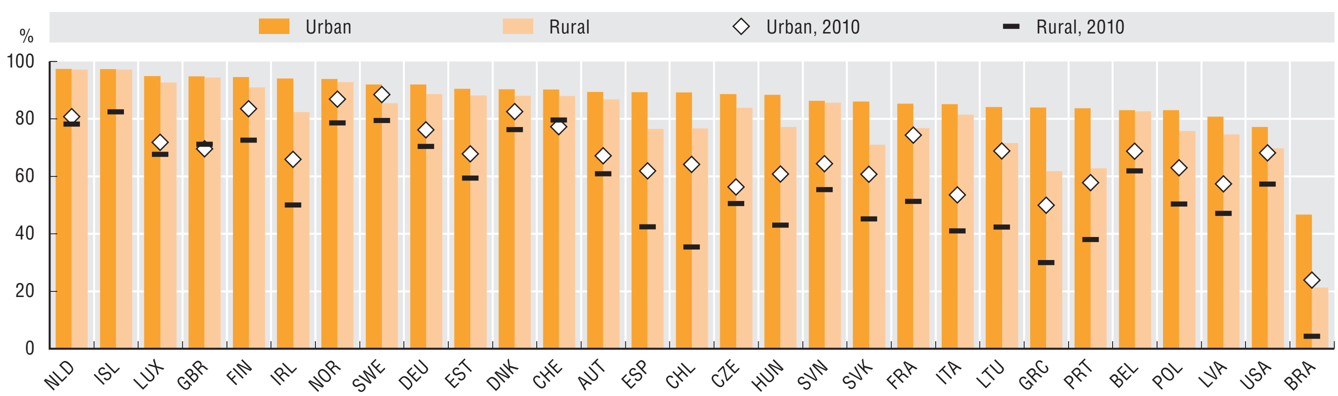


Source: OECD calculations based on CRTC, Communications Monitoring Report, 2017(Canada); EC, Study on Broadband Coverage in Europe 2017 (European Union) and FCC, 2018 Broadband Deployment Report (United States). See chapter notes.

StatLink https://doi.org/10.1787/888933929718

Households with broadband connections, 256 Kbps or greater, urban and rural, 2018

As a percentage of households in each category

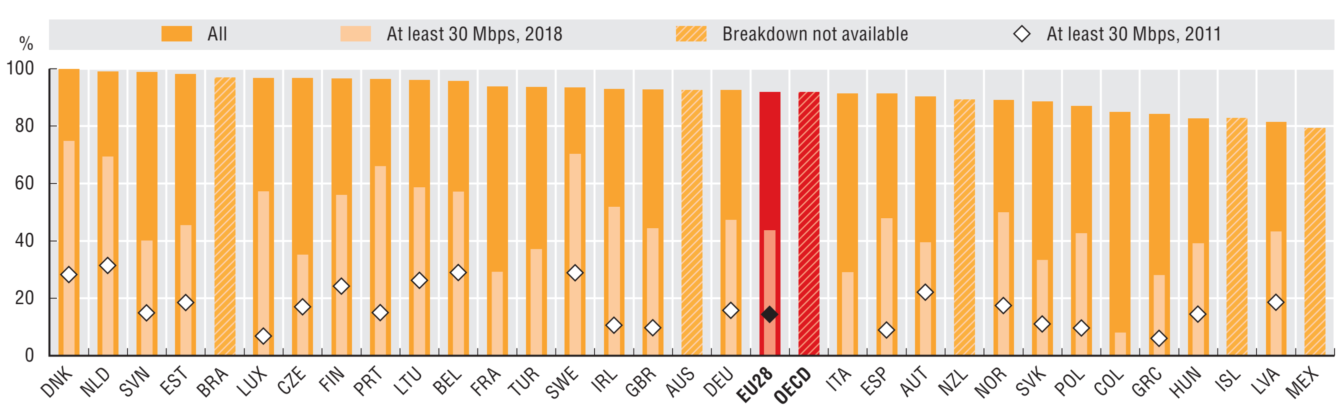


Source: OECD, ICT Access and Usage by Households and Individuals Database, http://oe.cd/hhind, December 2018. See chapter notes.

StatLink https://doi.org/10.1787/888933929737

Enterprises with broadband connections, by speed, 2018

As a percentage of all enterprises



Source: OECD, ICT Access and Usage by Businesses Database, http://oe.cd/bus, December 2018. See chapter notes.

StatLink https://doi.org/10.1787/888933929756

Why are indicators on the Internet of Things needed?

The term "Internet of Things" (IoT) refers to the connection of an increasing number of devices and objects over time to the Internet. Following the convergence of fixed and mobile networks, and between telecommunications and broadcasting, the IoT represents the next step in the convergence between ICTs and economies and societies. It holds the promise to substantially contribute to further innovation, growth and social prosperity, and as with any such development, policy makers and other stakeholders need evidence to inform the decisions they will take in the coming years. Accordingly, the Cancun Declaration (https://oe.cd/DigitalEcoDeclaration) invited the OECD to further work on emerging technologies, including the Internet of Things, to enable countries to fully embrace their benefits and to strengthen the collection of internationally comparable statistics (OECD, 2016).

What are the challenges?

The IoT is expected to grow exponentially, connecting many billions of devices within a relatively short time (OECD, 2015). IoT devices related to energy management, security, entertainment, transport, health, manufacturing and other activities will be present in many homes and workplaces. A key question, therefore, is how to prioritise measurement of those elements of the IoT that are of most relevance to policy makers. For example, in the case of IoT use in manufacturing, sometimes referred to as "Industry 4.0", decision makers may wish to know not only how many robots are in operation, but also how many are connected. Moreover, in the case of fully automated vehicles, they will need to know not only how many units are connected, but also their potential demands on communication infrastructures, such as the flow of large amounts of data.

A single fully automated vehicle, for example, may generate far more data than several thousand mobile users. This could have profound implications for decisions relating to cellular spectrum, the location of data centres, requirements for faster broadband access, and backhaul capacity to name just a few areas. Autonomous vehicles and other technologies will also raise issues around privacy and security (e.g. due to the inclusion of location tracking capabilities, cameras, and so on), as well as interoperability, numbering, and standardisation. Statistical definitions and indicators of IoT should therefore support these diverse policy areas and objectives, to the extent possible.

In addition to information on the growth of demand for communication infrastructures, a further critical aspect for measurement is the impact of the IoT on productivity, GDP, and growth. In order to assess any measure of the influence of IoT on GDP, however, it is important to have a suitable indicator of the size of the IoT. This was made clear by the U.S. Bureau of Economic Analysis (BEA), which endeavoured to measure the influence of the digital economy on GDP (Barefoot et al., 2018) but could not measure the IoT component, despite its importance, given the inherent measurement difficulties and complexity of allocating the "digital" component of the connected devices when accounting for the value added.

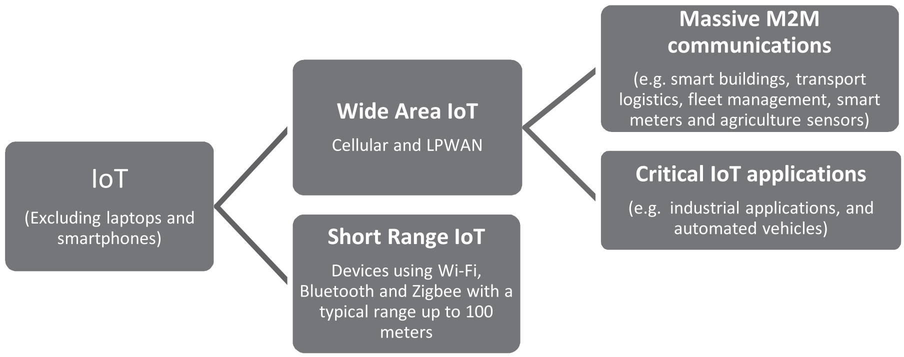
Options for international action

In order to develop measures of the IoT, it is necessary to arrive at a definition. The OECD has adopted the following definition of IoT: "The Internet of Things includes all devices and objects whose state can be altered via the Internet, with or without the active involvement of individuals. While connected objects may require the involvement of devices considered part of the "traditional Internet", this definition excludes laptops, tablets and smartphones already accounted for in current OECD broadband metrics." (OECD, 2018b).

The OECD has also developed a framework (taxonomy) with a breakdown of the IoT into categories, given that different types of connected devices will have different network requirements. For example, critical IoT applications such as remote surgery and automated vehicles will require high reliability and low latency (minimal delay in computer optimisation) connectivity, whereas sensors used for some agricultural applications may be less sensitive to latency or network speeds. Efforts to take into account these subcategories (e.g. massive machine-type communications and critical IoT), are in line with OECD information on country needs related to IoT devices (e.g. from France, Japan, Korea and Portugal), and consistent with the way in which other stakeholders developing IoT business cases are currently measuring the IoT (e.g. Ericsson and CISCO).

One of the key issues for data collection is identifying the best source. One example is data on connected robots; producers of robots and the suppliers of connectivity may both have relevant data but identifying which to use, or how to use both together, is a key challenge. Similarly, information on autonomous vehicles might be available through national vehicle registries, vehicle producers, or connectivity providers. To date, the OECD has gathered data on the number of machine-to-machine (M2M) connections on cellular wireless networks. However, as IoT devices increasingly become Internet Protocol (IP) based and platform-agnostic (i.e. operating on mobile, fixed and other networks), the issue of how to measure the number of such devices and assess their implications for communication networks will increasingly become a challenge.

OECD taxonomy of the IoT for measurement purposes



Source: OECD, 2018.

Policy interest in the diffusion of IoT-enabled devices has guided the introduction of a number of questions in surveys of ICT usage by households and businesses. In the case of households, interest has been focused primarily on the use of smart home appliances (in Australia, Canada, Europe, Japan, Korea, Mexico and the United States), as well as wearable devices (Japan and Korea). The main question is whether household surveys are a reliable source for tracking the diffusion of IoT devices, as respondents may be unaware of whether their devices are connected or not.

With regards to ICT use in business surveys, the focus has been on questions related to RFID (Australia, Europe, Korea and Japan). One promising measurement avenue relates to surveys of business' use of advanced technologies, such as the Statistics Canada Survey of Advanced Technology (SAT). This survey provides a rather unique opportunity for modelling the links between a particularly broad range of technology and business practice use, on the one hand, and innovation behaviour, on the other[1]. Building on technology-based taxonomies, it would be possible to introduce questions on the use of IoT-related technologies and applications, and analyse their diffusion in businesses of different sizes and sectors, as well as the joint impact of IoT and business practices on firms' innovation and performance.

Beyond statistical surveys, the wide range of IoT applications provides new opportunities for measurement, such as IoT search engines that scan the world of connected devices on the Internet, sensor-based data generated by "smart meters", and data transmission between driverless vehicles.

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1. The SAT 2014 survey collects, among other things, data on Advanced Material Handling, Supply Chain and Logistics Technologies (including RFID technologies); Advanced Business Intelligence Technologies (including software as a service); Advanced Design and Information Control Technologies (including sensor network and integration) and Advanced Processing and Fabrication Technologies (including robots with sensing and vision systems).

Why are indicators on broadband quality needed?

The actual performance of broadband connections, (i.e. broadband quality), is critical to meeting consumers', policy makers', and regulators' various objectives. Broadband performance is a fundamental metric for consumers to make informed choices, as it reflects the quality of their experience and enables them to assess any differences between advertised speeds and actual speeds. For policy-makers and regulators, being able to assess broadband performance is essential to ensuring the accessibility of online services and to ascertaining whether services are meeting their goals for overall market development (e.g. competitiveness, coverage). In 2012, the OECD was tasked with assessing available datasets that provide robust data offering like-for-like comparisons over time, and with working towards a long-term goal of co-ordinated measurement of speed and other service qualities (OECD, 2012).

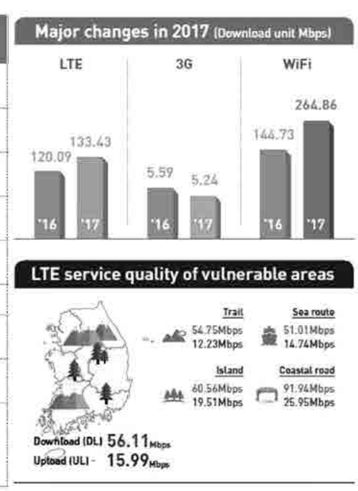
One key aspect of connection quality is download and upload speed. Measures can refer to advertised speeds (describing the theoretical maximum speed that can be expected) or the actual experienced speed. While widespread penetration of broadband is observed in OECD countries, there is a vast difference in the speeds available to users and hence the applications from which they can benefit. To reflect these differences, the OECD broadband portal, (https://oe.cd/broadband), provides a breakdown of fixed broadband subscriptions by speed tiers, ranging from subscriptions with speeds as low as 256 Kbps to over 100 Mbps. However, these are advertised speeds and not actual experienced speeds, which can be significantly lower.

In addition to broadband speeds, other quality factors such as latency or data packet loss have become increasingly important. Latency – the round-trip time for information between two devices on the network – is key for many advanced applications such as Virtual Reality and Augmented Reality, remote robotics, fully automated vehicles, and haptic technologies (present in remote surgery and industrial IoT applications). These require ultra-reliable broadband. In this respect, the fifth generation (5G) of broadband wireless networks, and increasing deployment of fixed backhaul (e.g. fibre) necessary for both mobile and fixed networks will help to meet these increasing demands. Another quality measure, data packet loss, is more common in wireless networks and can significantly affect their reliability, and hence critical services that need to be delivered error-free and in real-time, such as remote surgery or air-traffic monitoring. These factors, in addition to security considerations and the robustness of networks in the event of disasters, affect the ways in which digital services can be accessed, used, and in turn, the value generated for businesses and consumers. They should therefore be included in a rounded assessment of broadband quality.

One example of a co-ordinated quality assessment of communication networks comes from the National Information Society Agency (NIA) in Korea. The assessment focuses primarily on coverage and speed, including speeds experienced in challenging environments such as in costal or mountain areas and on sea routes. It also incorporates multiple perspectives, including official testing by regulators, self-evaluation by operators, quality evaluations by users.

Summary of Korea Quality of Communication services evaluation framework and select results, 2017

Type		Evaluated service	Evaluated area
Government evaluation	Quality evaluation	Three wireless Internet types : LTE, WiFi, 3G	440 areas nationwide (369 local areas for the WiFi service)
		Giga-class wired Internet (500Mbps, 1Gbps)	Service coverage area (603 households in 16 cities)
		All wired Internet service sections and international sections	International section (US, Japan, UK, Hong Kong)
		Mobile communication voice calls (2G, 3G, VoLTE)	Vulnerable areas (92 areas)
	Coverage inspection	Three wireless Internet types : LTE, WiFi, 3G	200 areas nationwide (369 local areas for WiFi coverage)
		broadband internet	All service coverage areas
Self-quality evaluation of service providers		broadband internet (100Mbps급)	All service coverage areas
		Mobile communication voice calls (2G, 3G, VoLTE)	250 areas nationwide
User's quality evaluation		One wireless Internet type : LTE	· (Distributed App) All service coverage areas · (Evaluation team) Separated by 16 cities and provinces



Source: NIA, 2017.

Quality should also be considered in the context of "access divides", such as between businesses of different sizes, or households of different incomes or locations. When quality is not considered, disparities in broadband uptake between urban and rural areas appear small in many countries. Indeed, in several countries such as Luxembourg, Norway and the United Kingdom, rural households are more likely to have subscriptions to broadband than urban households. However, there is evidence that, despite advances in recent years, rural areas still tend to have relatively slower, less reliable connections than urban areas (see page 3.5). Recognising these challenges to broader economic and social developments, various OECD countries have been developing programmes, within national broadband strategies or regional development strategies, to close the urban-rural digital divide. In order to meaningfully assess such divides, both within and across countries, robust and comparable information on relevant aspects of quality must be made available.

What are the challenges?

The download speeds advertised by communication operators, as collected in OECD broadband subscriptions statistics, can be very different to the average speeds experienced by subscribers. A rounded and nuanced assessment of speed therefore needs to encompass multiple perspectives and sources including information on connection technology (e.g. fibre), the type of subscriber (e.g. retail or business), and indicators of the speeds actually experienced by users.

The OECD collects information on connection technology but, as with other indicators, businesses cannot yet be distinguished from retail customers. Indicators on experienced speed are available from market players such as content delivery networks (e.g. Akamai), online service providers (e.g. Netflix), online speed test tools (e.g. Ookla and M-Lab, see page 3.5), and other firms operating key components of the Internet. Together these could provide a cross-section of all types of users, but each gives only give a partial perspective on experienced speeds and the broader Internet experience.

Furthermore, statistics on the availability of high-speed broadband networks in rural and remote areas are not available across all OECD countries. While national broadband maps are insightful, data on coverage by speed tiers in rural versus urban areas would allow for cross-country comparison and a meaningful evaluation of quality gaps in broadband access.

Looking at quality more broadly, information on service reliability (outages, packet loss rates, etc.) is not widely available.

New opportunities are emerging in terms of "crowd-sourced" and open data that have the potential to empower consumers by making unprecedented information available to them. These sources, however, may not always provide the information needed to inform specific policy and regulatory goals. As a number of factors can influence results, broadband quality measurement faces greater potential hurdles on the path to international agreement and acceptance than telecommunication subscriptions measures did.

Options for international action

In June 2014, as a follow-up to the 2012 Broadband metrics workshop, the OECD published a report on Access Network Speed Tests (OECD, 2014). The report reviewed information on official speed tests to date, as well as the strengths and drawbacks of their methodologies, emerging good practices, and the challenges to undertaking a harmonised approach across OECD countries. Network speed tests in OECD countries can be found at the following link: http://www.oecd.org/internet/speed-tests.htm.

To build upon this foundation, examples of gathering data on coverage by speed tiers in rural versus urban areas (e.g. NIA, 2017) could be collated to serve as models for others and provide a template for co-ordinated indicators.

One further avenue involves collating and comparing information from third party sources that have the scale to generate useful indicators of the performance of different networks spread around the world (e.g. the Akamai content delivery network, Netflix streaming video service, and online gaming services such as STEAM). This includes data on speeds across individual networks and also aggregated statistics at the national level (OECD, forthcoming).

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Notes

Cyprus

The following note is included at the request of Turkey:

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

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

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

Israel

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

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

3.1. Connectivity

Telecommunication Services Trade Restrictiveness Index (STRI), 2017

The STRI indices take values between 0 and 1, with 1 being the most restrictive. They are calculated on the basis of the STRI regulatory database, which records measures on a most-favoured-nation basis. Preferential trade agreements are not taken into account.

3.2 Mobile connectivity

Average monthly mobile data usage per mobile broadband subscription, Gb, 2017

EU28 refers to the EEA (European Economic Area) and to Q2 2016 instead of 2015 and Q3 2017 instead of 2017. Data for Q2 2016 include the EU countries and Norway, but exclude Sweden and the United Kingdom. Data for Q3 2017 include EU countries and Norway.

For Switzerland, the 2017 data are based on OECD estimates.

3.3 Speed

Fixed broadband subscriptions with contracted speed faster than 100 Mbps, December 2017

For China and South Africa, data originate from the ITU World Telecommunication/ICT Indicators Database.

3.4 Internet infrastructure

IPv6 adoption by country, 2017

Akamai: % of traffic transiting network; Google: % of users accessing Google over IPv6; APNIC: % of IPv6 capable addresses in South East Asia and Oceania.

M2M SIM card penetration, 2017

For Hungary, Latvia and Mexico, data refer to 2015 instead of 2014.

For Switzerland, 2017 data are based on OECD estimates.

Web servers using digital certificates, by host country, June 2018

Sites are those where the common name in the certificate matched the host name, and the certificate's digital signature was not detected as being self-signed.

3.5 Universal access

Households in areas where fixed broadband with a contracted speed of 30 Mbps or more is available, total and rural, 2017

Rural areas: For EU countries, rural areas are those with a population density less than 100 per square kilometre. For Canada, rural areas are those with a population density less than 400 per square kilometre. For the United States, rural areas are those with a population density less than 1 000 per square mile or 386 people per square kilometre.

Fixed broadband coverage: For EU countries, coverage of NGA technologies (VDSL, FTTP, DOCSIS 3.0) capable of delivering at least 30 Mbps download was used. For the United States, coverage of fixed terrestrial broadband capable of delivering 25 Mbps download and 3 Mbps upload services was used; data refer to 2016.

Households with broadband connections, 256 Kbps or greater, urban and rural, 2018

For Brazil, data refer to 2016 instead of 2018. Areas are defined as urban or rural according to local legislation, as compiled by the NSO. Reported data refer to urban (densely populated) and rural (thinly populated).

For Chile, data refer to 2012 and 2017. For the year 2012, large urban areas refer to a contiguous set of local areas, each of which has a density superior to 500 inhabitants per square kilometre, where the total population for the set is at least 50 000 inhabitants. Rural areas refer to a contiguous set of local areas belonging neither to a densely populated nor to an intermediate area. An intermediate area refer to a contiguous set of local areas, not belonging to a densely populated area, each of which has a density superior to 100 inhabitants per square kilometre, and either with a total population for the set of at least 50 000 inhabitants or adjacent to a densely populated area.

For Switzerland, data refer to 2012 and 2017.

For the United Kingdom, data refer to 2009 instead of 2010.

For the United States, data refer to 2017 instead of 2018. Population density categories are approximated based on a household's location in a principal city, the balance of a metropolitan statistical area (MSA) or neither. To protect respondent confidentiality, the information has been redacted from some observations in the public use datasets. Beginning in 2017, the CPS Supplement no longer asks separately about mobile broadband use inside and outside the home. Instead, households are simply asked whether anyone uses a mobile data plan (irrespective of location). In order to approximate mobile broadband access at home, households were included if they reported mobile data plan use and home Internet use.

Enterprises' broadband connectivity, by speed, 2018

For Australia, data refer to the fiscal year 2015/16 ending on 30 June.

For Brazil, data refer to 2016. Broadband is defined by type of connection rather than download speed. The definition includes: DSL, cable modem, fibre, radio, satellite and 3G/4G.

For Colombia, data refer to the main type of Internet connection that businesses use.

For Iceland, data refer to 2014.

For Korea, data refer to both fixed and mobile broadband.

For New Zealand, data refer to the fiscal year 2015/16 ending on 30 June.

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Chapter 4

INCREASING EFFECTIVE USE

In 2018, 86% of individuals aged 16-74 years in the OECD area were Internet users and 77% used the Internet on a daily basis following a sustained rise in adoption from about 58% accessing the Internet, and 36% daily users in 2006. Internet usage tends to be less ubiquitous outside the OECD, with fewer than 60% of individuals accessing the Internet in Brazil, China and South Africa, and less than 40% in India and Indonesia. Mobile technology has played a particularly important role in driving Internet uptake, with 70% of OECD users accessing the Internet via mobile devices. In the EU28, the share of households choosing not to have Internet access at home because "access was not needed" (i.e. content was not useful or not interesting) dropped from 20% in 2006 to 6% in 2017.

Internet usage continues to vary widely across OECD countries and among social groups. In 2018, over 97% of individuals aged 16-74 used the Internet in Iceland, Denmark, Norway and Luxembourg but only around 70% did so in Mexico and Turkey. In Indonesia and India, the share was around 30%. In Chile, Korea and Iceland almost all Internet users access the Internet daily but such frequent use is less common in Japan and Poland.

The types of activities carried out over the Internet vary widely across countries, linked to diverse institutional, cultural and economic factors, including age and educational attainment. Internet usage for more sophisticated activities also varies by country and is impacted by factors such as familiarity with online services, trust, and skills. In all OECD countries, one of the main online activities is participation in social networks, although online shopping is even more popular in some countries such as the United Kingdom and the Netherlands, and markedly so in Germany, Switzerland, and France. In nearly all countries, the share of online purchasers in 2018 was higher than in 2010. The increase was notable in countries with a lower uptake at the beginning of the period such as Mexico.

The number and complexity of the activities individuals undertake online can give an indication of their sophistication as Internet users. The indicator presented here is derived from individual micro-data made available by Eurostat for countries in the European Statistical System (ESS). In 2016, in a majority of countries included in the sample, over half of individuals made "diversified and complex use" of the Internet including activities linked to e-finance, learning and creativity (e.g. uploading of creative content). However, less than 40% of individuals engaged in such activities in Poland and Italy. These cross-country disparities in diversified and complex use shed light on a digital divide in terms of Internet uses, despite access to the Internet progressively becoming universal.

DID YOU KNOW?

Over three quarters of individuals in the OECD use the Internet every day, and two thirds use the Internet to shop online.

Definitions

Internet users are individuals who accessed the Internet within the three months prior to being surveyed. Different recall periods apply for some countries (see chapter notes). *Daily users* are individuals accessing the Internet approximately every day in a typical week (i.e. excluding holidays).

Cloud storage relates to use of the Internet as a storage space to save files for private purposes. *Content creation* relates to uploading self-created content on sharing websites such as social networks.

Individuals making diversified and complex use of the Internet perform, on average, the largest number and variety of activities (more than 8 out of the eleven 11 online activity types surveyed). Such individuals account for the majority of online activities linked to e-finance, learning and creativity – relatively complex activities performed by a relatively small share of individuals.

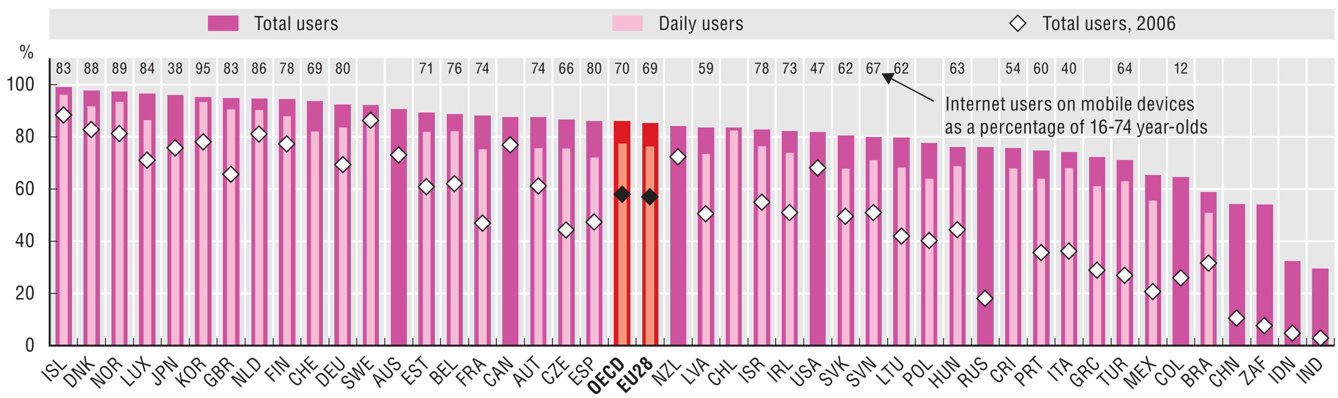
Measurability

Data on Internet usage and online activities are typically gathered through direct surveys of households' ICT usage. Surveys ask if the respondent has undertaken a specific activity during the recall period. The OECD Model Survey on ICT Access and Usage by Households and Individuals (OECD, 2015a) proposes a wide range of activities for investigation. A recall period of three months is recommended (meaning the respondent should have undertaken the online activity in the three months prior to being surveyed); however, some countries use longer recall periods or have no recall period at all.

The European Community Survey on ICT Usage in Households and by Individuals provides information on the actions that individuals perform online. These can be grouped into eleven 11 major areas: communication, social networks, access to information, entertainment, creativity, learning, e-health, e-banking, e-finance, e-government, and e-commerce. The identification of individuals making diversified and complex use of Internet is based on a clustering algorithm (k-means) that groups individuals according to the similarity of their online activities. The clustering algorithm was run on the entire sample of OECD countries with available data, sourced from the European Community Survey on ICT Usage in Households and by Individuals (2016).

Total, daily and mobile Internet users, 2018

As a percentage of 16-74 year-olds

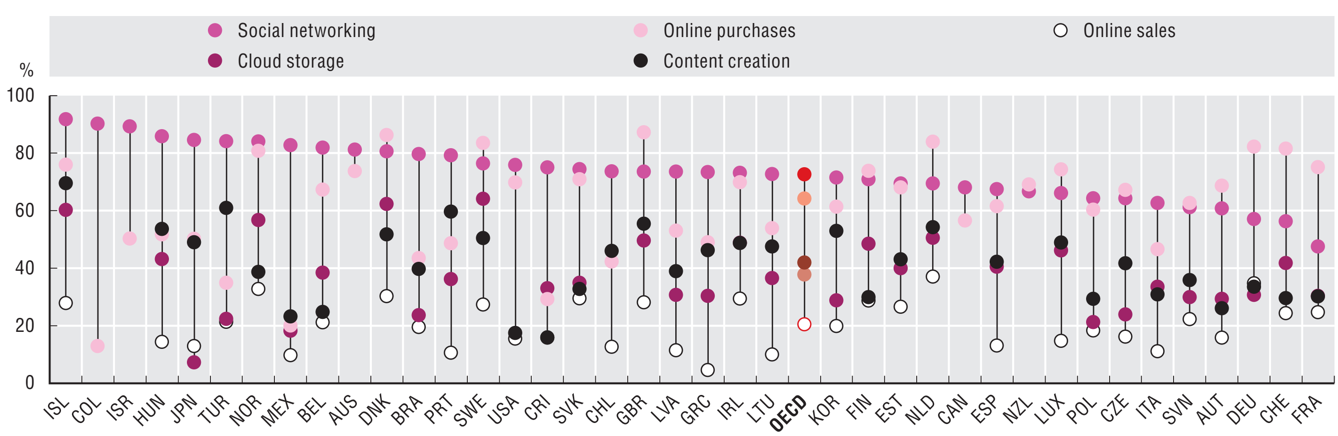


Source: OECD, ICT Access and Usage by Households and Individuals Database, http://oe.cd/hhind; Eurostat, Digital Economy Statistics; ITU, World Telecommunication/ICT indicators Database and national sources, December 2018. See chapter notes. StatLink contains more data.

StatLink https://doi.org/10.1787/888933929775

Diffusion of selected online activities among Internet users, 2018

As a percentage of Internet users

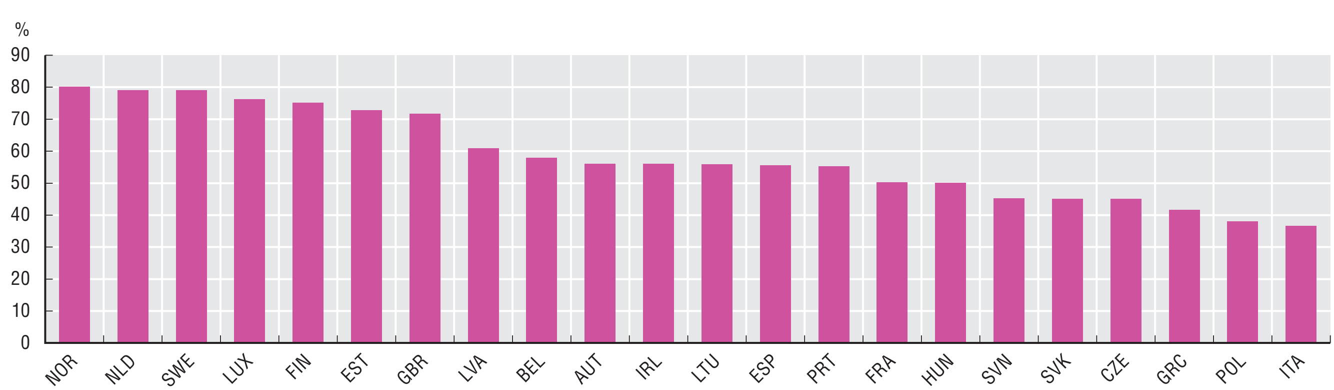


Source: OECD, ICT Access and Usage by Households and Individuals Database, http://oe.cd/hhind, December 2018. See chapter notes. StatLink contains more data.

StatLink https://doi.org/10.1787/888933929794

Individuals with diversified and complex use of the Internet, 2016

As a percentage of all individuals



Source: OECD (forthcoming), *Skills Outlook 2019: Skills and Digitalisation*, OECD publishing, Paris. See chapter notes.

StatLink https://doi.org/10.1787/888933929813

In OECD countries, few businesses operate without using some form of ICTs. Nevertheless, the extent to which ICT tools are integrated into business processes varies across countries, with key explanatory factors including differences in firm and industry composition.

In 2018, Finland had the largest proportion of enterprises using cloud computing (65%). Meanwhile, use of cloud services in Germany (22%) was lower than the OECD average (30%), but German businesses had the highest uptake of customer relationship management software (CRM), alongside the Netherlands (both 47%). Korea had the highest proportion of enterprises using radio frequency identification (RFID, 42%), but the lowest uptake of Big data analytics by businesses (3%).

On average, 23% of OECD enterprises made sales via e-commerce in 2017 - an increase of only 4 percentage points since 2009. Large differences among countries remain, however. In New Zealand, half of enterprises sell online, while fewer than one-in-ten do so in Mexico. Differences in the definition of e-sales used may explain some of the variation between countries but in many cases a key cause is likely to be differences in the prevalence of large firms relative to smaller firms in some economies (OECD, 2017a). On average, 43% of larger firms engaged in e-sales in 2018, compared to only 21% of small enterprises.

Enterprises can use various tools and technologies to support their e-commerce activities. *Ad hoc* tabulations from the 2018 European Community Survey of ICT Usage in Enterprises were used on a pilot basis to investigate aspects of digital maturity in firms. This included a number of relatively advanced website features – the possibility for visitors to customise or design online goods or services, the ability to track the status of orders placed, or offering personalised content on the website for recurrent visitors – as well as businesses' use of online advertising services. In all countries except Denmark, the majority of businesses do not use any of these functions. While, on average, 32% of businesses make some use of them, only 6% of firms pursue relatively more sophisticated online sales strategies combining one or more of these website features with online advertising. In countries with especially high Internet uptake, the share is much higher - 12% of firms in the Netherlands and 11% in Denmark and Sweden.

The usefulness of such features and services varies with business size and the geography of the market they serve (as well as other factors such as the nature of products offered). In particular, small businesses, focussed on serving local markets may see little need to sell or actively market online even if they have an online presence. By contrast, on average 14% of large firms offer one or more such website features and use online advertising services, with over 25% of large firms in Denmark, Sweden and Belgium doing so.

DID YOU KNOW?

In 2017, out of all firms in reporting OECD countries, 95% had a broadband connection, but only 23% made sales via e-commerce.

Definitions

Enterprise resource planning (ERP) systems are software-based tools for managing internal information flows. *Customer relationship management (CRM)* software is a program for managing a company's interactions with customers, employees and suppliers.

Cloud computing refers to ICT services accessed over the Internet including servers, storage, network components and software applications.

Big data analytics refers to the analysis of vast amounts of data generated by activities carried out electronically and through machine-to-machine communications.

An *e-commerce* transaction describes the sale or purchase of goods or services conducted over computer networks by methods designed specifically for the purpose of receiving or placing orders (OECD, 2011).

Recurrent visitor features refers to the provision of personalised content on the website for regular/recurrent visitors.

Firm size classes are defined as small (10 to 49 persons employed), medium (50 to 249) and large (above 250).

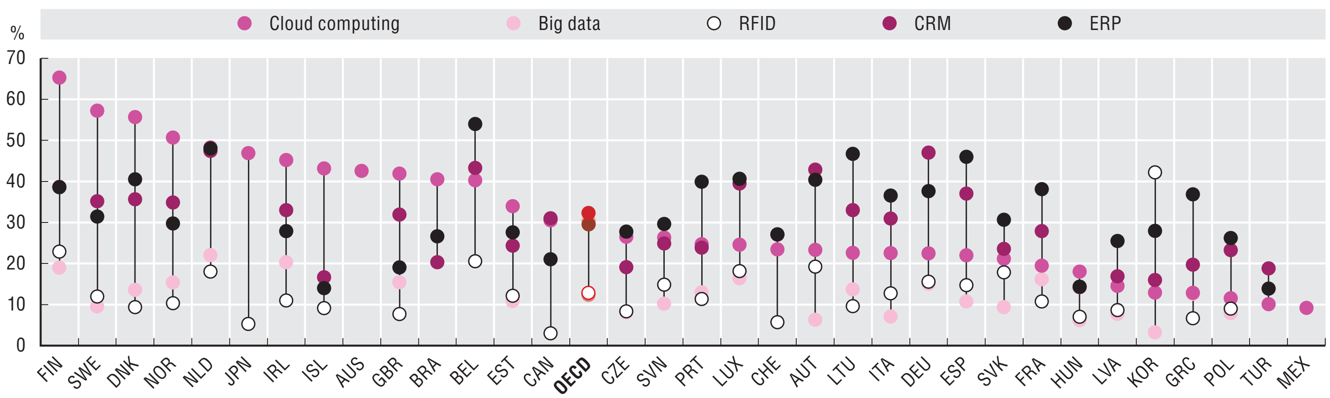
Measurability

These data are generally collected through direct surveys of ICT usage by businesses, though not all OECD countries undertake specific surveys on this subject. Aside from differences in the survey, the majority of indicators correspond to generic definitions that proxy the functionalities and potential uses of ICT tools. For example, various software with different functionalities are found within ERP systems, and there are substantial differences in the sophistication of these systems and their degree of implementation. Cloud computing services and Big data raise similar issues (OECD, 2017a).

Measurement of e-commerce presents several methodological challenges that can affect international comparability. These include the adoption of different practices for data collection and estimation, as well as the treatment of outliers and the extent of e-commerce carried out by multinationals. Other issues include differences in sectoral coverage of surveys and lack of measures concerning the actors involved (B2B, B2C, etc.). Convergence of technologies brings additional challenges for the treatment (and surveying) of emerging transactions, notably over mobile phones, via SMS or through the use of devices that enable near-field communication.

Diffusion of selected ICT tools and activities in enterprises, by technology, 2018

As a percentage of enterprises with ten or more persons employed

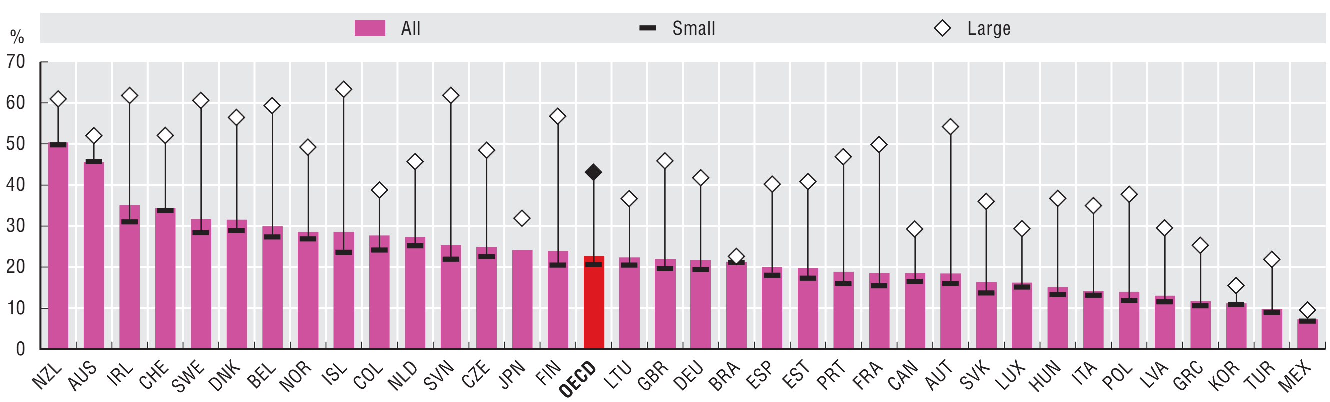


Source: OECD, ICT Access and Usage by Businesses Database, http://oe.cd/bus, December 2018. See chapter notes.

StatLink https://doi.org/10.1787/888933929832

Enterprises engaged in sales via e-commerce, by firm size, 2017

As a percentage of enterprises in each employment size-class

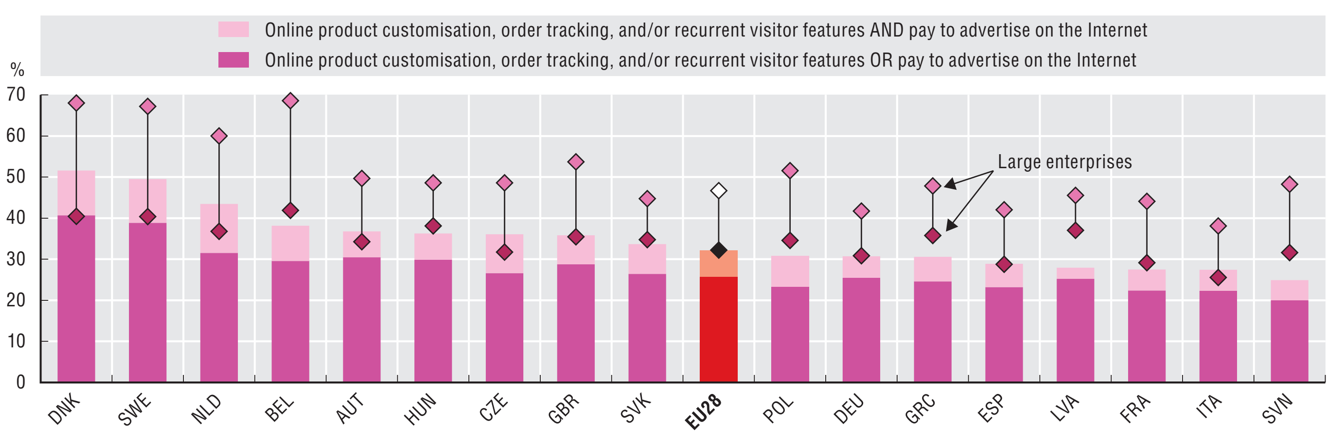


Source: OECD, ICT Access and Usage by Businesses Database, http://oe.cd/bus, December 2018. See chapter notes. StatLink contains more data.

StatLink https://doi.org/10.1787/888933929851

Enterprises' advanced web sales functionalities and online advertising, by size, 2018

As a percentage of enterprises with ten or more persons employed



Source: OECD, based on Eurostat, Digital Economy and Society Statistics, December 2018. See chapter notes. StatLink contains more data.

StatLink https://doi.org/10.1787/888933929870

Access to, and the ability to use, ICTs are increasingly important for businesses of all sizes. In 2017, on average, around 12% of workers were in occupations involving a high frequency of ICT, underlining the high ICT content of these jobs. Furthermore, many additional jobs involve at least some ICT tasks. The share of workers in ICT-intensive occupations increased in almost all countries from between 2011 to and 2017. In the United Kingdom, the United States and Luxembourg, over 16% of workers are now in ICT-intensive occupations.

New technologies can augment workers' capabilities. Cloud computing, in particular, is opening up an array of new business processes, by allowing firms, particularly young and small ones, on-demand use and payment for powerful computing services. Almost 30% of businesses in the OECD area reported using cloud services in 2018, up from 22% in 2014. The propensity to use cloud computing varies considerably across countries and sectors, as well as between small and large firms. On average, only 27% of small firms in the OECD area use cloud services, against 39% of medium firms and 55% of large firms.

The declining cost of data storage and processing have facilitated the collection of large volumes of data and the adoption of Big data analytics. On average, 12% of businesses in the countries for which data are available performed Big data analysis in 2018, with this share rising to 22% of businesses in the Netherlands and over 20% in Belgium and Ireland. Although the cloud, and the advent of easier-to-use analytical tools have made Big data analysis more attainable for all firms, large firms are still by far the biggest users of Big data analytics; 33% on average, and over half of large firms in Belgium and the Netherlands analyse Big data. Big data analysis requires access to a sufficiently large pool of data, and large firms are more likely to have such volumes of existing data at their disposal. Meanwhile, small and medium-sized firms are increasingly able to complement their own data with data acquired from other sources.

Exploiting the potential of Big data also requires access to specific skills, in terms of new analytical techniques such as parallel processing or visualisation tools. In many cases, the transition to Big data analytics also requires changes in the organisational practices of both enterprises and institutions, as well as the development of rules for data storage and exchange that comply with data protection rules (e.g. health records). Managers have a key role to play in leading adoption and their knowledge of technologies can be an important factor in businesses' adoption and effective use of technologies such as cloud services and Big data analytics. For example, in Australia, insufficient knowledge of cloud computing services was found to be the most common factor-limiting uptake, affecting nearly one-in-five businesses (ABS, 2017).

DID YOU KNOW?

Almost 30% of OECD businesses reported using cloud services in 2018, with shares ranging from 65% in Finland to around 10% in Mexico, Poland and Turkey.

Definitions

ICT task-intensive occupations have a high propensity to include ICT tasks at work ranging from simple use of the Internet, through use of word processing or spreadsheet software, to programming. ICT task-intensive occupations comprise: business services and administration managers (ISCO occupation 121); sales, marketing and development managers (122); information and communications technology service managers (133); professional services managers (134); physical and earth science professionals (211); electrotechnology engineers (215); architects, planners, surveyors and designers (216); university and higher education teachers (231); finance professionals (241); administration professionals (242); sales, marketing and public relations professionals (243); software and applications developers and analysts (251); and database and network professionals (252); information and communications technology operations and user support (351), (see Grundke et al., forthcoming).

Firm size classes: are defined as small (10-49 persons employed), medium (50-249) and large (250 and more).

Cloud computing refers to ICT services over the Internet to access servers, storage, network components and software applications.

Big data analytics refers to the analysis of vast amounts of data generated by activities carried out electronically and through machine-to-machine communications.

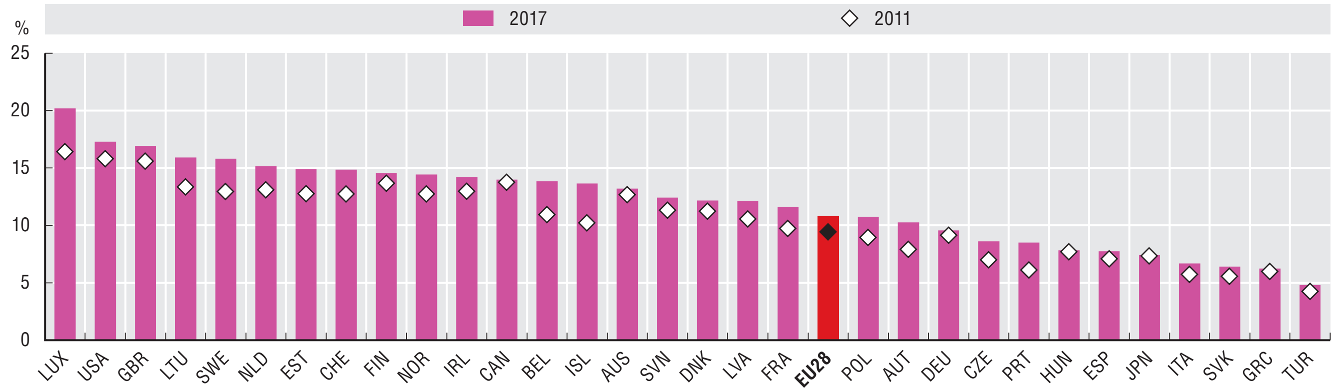
Measurability

The ICT task intensity of jobs is assessed using exploratory factor analysis of responses to 11 items on the OECD Programme for International Assessment of Adult Competencies (PIAAC) survey, which relates to the performance of ICT tasks at work. See Grundke et al., 2017 for the detailed methodology.

Data on cloud services and the use of Big data analytics use are gathered through direct surveys of ICT usage by businesses. The questions used are typically generic and do not elicit details about the specific functionalities, tools or devices that respondents use. Surveys are generally carried out annually but are less frequent in some countries. The OECD actively encourages the collection of comparable information in this field through guidelines in the "Model Survey on ICT Access and Usage by Businesses" (OECD, 2015b).

Workers in ICT task-intensive occupations, 2017

As a percentage of all workers

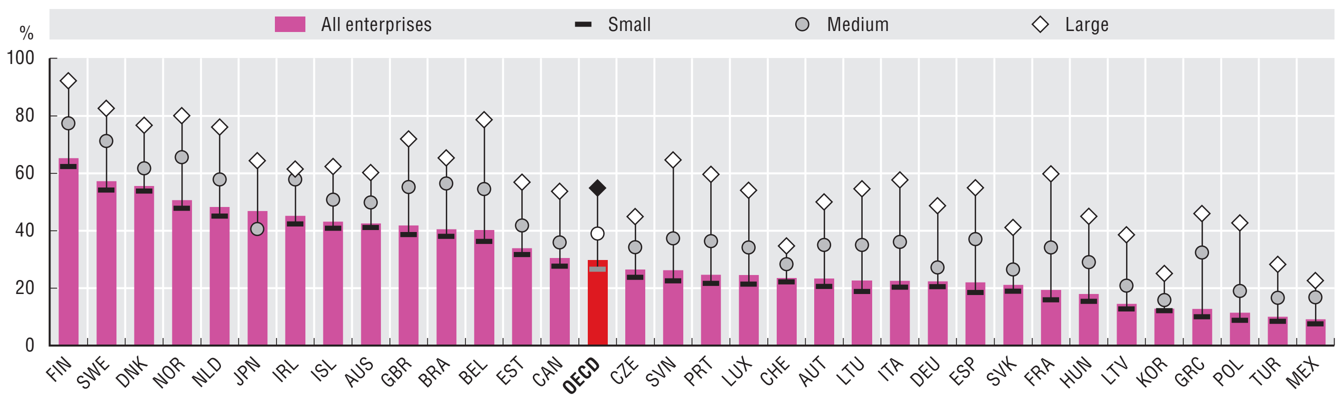


Source: OECD calculations based on European Labour Force Surveys, national labour force surveys and other national sources, December 2018. See chapter notes. StatLink contains more data.

StatLink https://doi.org/10.1787/888933929889

Enterprises purchasing cloud computing services, by size, 2018

As a percentage of enterprises in each employment size class

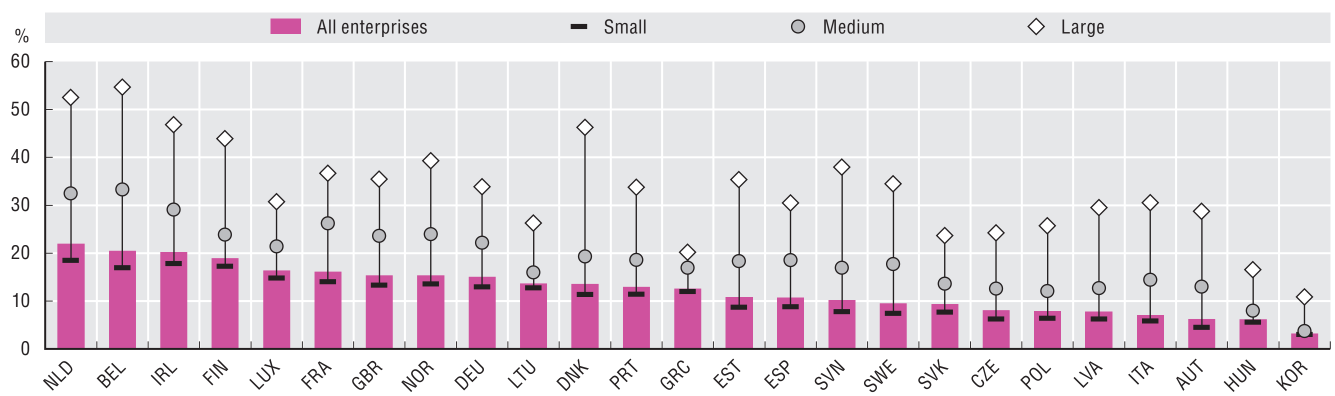


Source: OECD, ICT Access and Usage by Businesses Database, http://oe.cd/bus, December 2018. See chapter notes.

StatLink https://doi.org/10.1787/888933929908

Enterprises performing Big data analysis, by size, 2018

As a percentage of enterprises in each employment size class



Source: OECD, ICT Access and Usage by Businesses Database, http://oe.cd/bus, December 2018. See chapter notes.

StatLink https://doi.org/10.1787/888933929927

E-commerce can substantially widen the choice of products available to consumers, as well as increasing the convenience of the shopping experience. In 2018, 64% of all OECD Internet users made a purchase online, up from 48% in 2010. Although online sales still represent a limited share of business' revenue (17% in EU countries), e-commerce has significantly disrupted traditional distribution channels for some products.

In all countries, the share of Internet users making online purchases in 2018 was higher than in 2010, and reached as much as 87% in the United Kingdom. In Denmark, the Netherlands, Sweden, Germany, Switzerland and Norway over 80% of Internet users shop online. In some countries that started with a lower level of uptake, such as Lithuania and Mexico, these shares more than tripled over the period. The proportion of online purchasers among users aged 16-24 was, on average, around 20 percentage points higher than among users aged 55-74.

The items most commonly purchased online in 2018 were clothes and sports goods (44% of Internet users in the EU purchased these), travel and holiday accommodation (37%), event tickets (27%) and reading materials (24%). In almost all countries presented, clothes and sports goods were also among the top-3 fastest growing categories of products over the period 2013-2018. The share of Internet users buying clothes online grew most strongly, by over 20 percentage points, in Ireland and the Netherlands.

Estonia experienced particularly strong growth in people buying travel and accommodation online, at around 30 percentage points. This category has been notably impacted by the digital transformation. Previously, it was common to use a travel agent to book travel, accommodation and other related products together; however the Internet has empowered consumers to book these items themselves – and often separately – allowing the customer to tailor choices to their requirements and potentially to make savings.

Films and music together constitute another product category that has been heavily disrupted by online (streaming) services, and was often among the top fastest growing categories, especially in Nordic countries.

Nevertheless, on average across OECD countries, about one-third of Internet users do not make online purchases. In the European Union, 69% of Internet users who did not purchase online gave preferring to shop in person as a justification. This share was 70% or greater in countries such as Switzerland, the Netherlands, Sweden, the United Kingdom and Germany even though there is high general uptake of e-commerce in these countries.

A more concerning potential barrier to e-commerce participation relates to the skills needed to make purchases online. This barrier was cited by 20% of EU Internet users who did not shop online, and the rate is around 40% in Spain and Portugal – equivalent to roughly 15-20% of all Internet users in these countries. This barrier could become a policy concern if competition from online vendors causes physical stores to close and leaves such people without access to certain products.

DID YOU KNOW?

Clothes are the most widely purchased category of products online, despite the fact that customers are unable to try them on prior to ordering.

Definitions

Internet users are individuals who have accessed the Internet within the last three months prior to being surveyed. Different recall periods apply for some countries (see chapter notes).

An *e-commerce transaction* describes the sale or purchase of goods or services conducted over computer networks by methods specifically designed for the purpose of receiving or placing orders (OECD, 2011).

Measurability

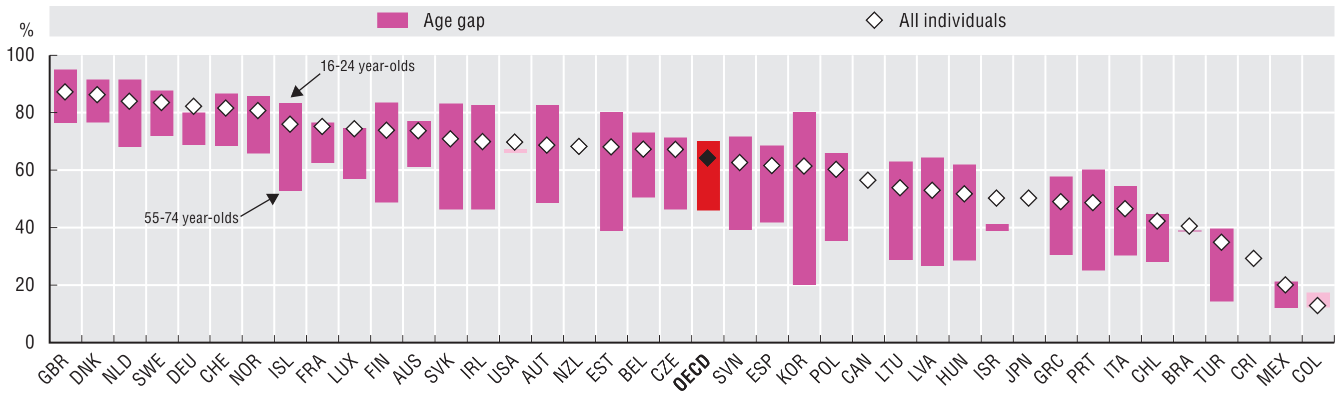
These data are typically gathered through direct surveys of household ICT usage in the same way as data are collected on Internet usage – by asking if the respondent has undertaken a specific activity during the recall period. The OECD Model Survey on ICT Access and Usage by Households and Individuals (OECD, 2015a) proposes a wide range of activities for investigation. A recall period of three months is recommended (meaning the respondent should have undertaken the online purchase in the three months prior to being surveyed); however, some countries use longer recall periods or have no recall period at all. Such methodological differences mean that care should be taken when making international comparisons.

Some surveys also collect additional or contextual information such as details on the types of products purchased or barriers to undertaking certain activities online. Other barriers can be investigated in addition, such as security and privacy concerns (see Chapter 8).

Measurement of e-commerce presents several methodological challenges that can affect international comparability, such as differing data collection practices as well as practices for estimations and the treatment of outliers. E-commerce carried out by multinationals can be especially challenging to measure. In the case of demand-side surveys, consumers generally have poor recall with regard to certain types of questions, such as the countries from which they purchased items. Furthermore, a significant proportion of users are not necessarily aware of the origin of websites they use for shopping or may not recall the amounts spent. In addition, digital products downloaded or streamed over the Internet are increasingly common, for these it is especially difficult for the consumer to identify the country of origin.

Individuals who purchased online in the last 12 months, by age, 2018

As a percentage of Internet users in each age group

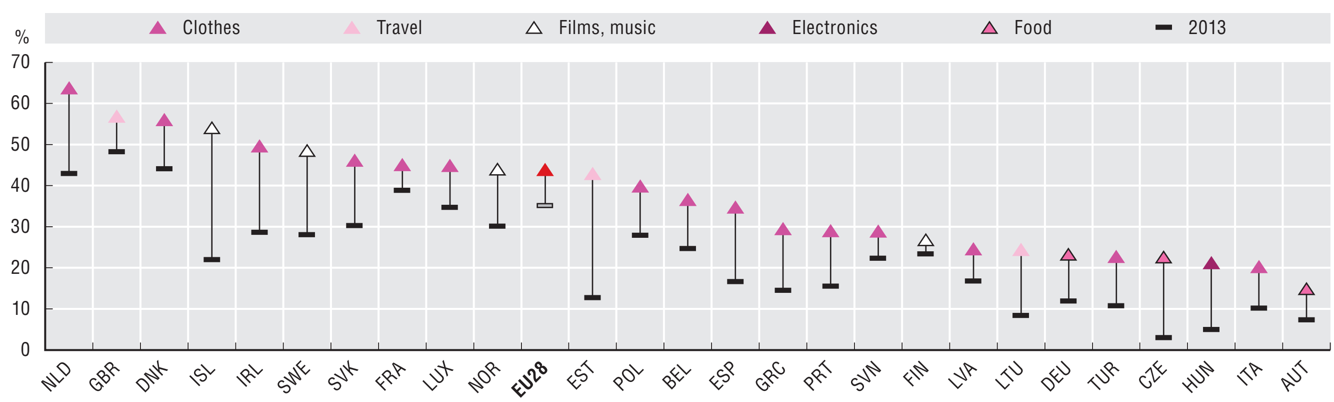


Source: OECD, ICT Access and Usage by Households and Individuals Database, http://oe.cd/hhind, December 2018. See chapter notes. StatLink contains more data.

StatLink https://doi.org/10.1787/888933929946

Fastest growing products ordered online, 2013-18

Percentage of Internet users ordering each product in 2018 (triangle) and change from 2013 (horizontal marker)

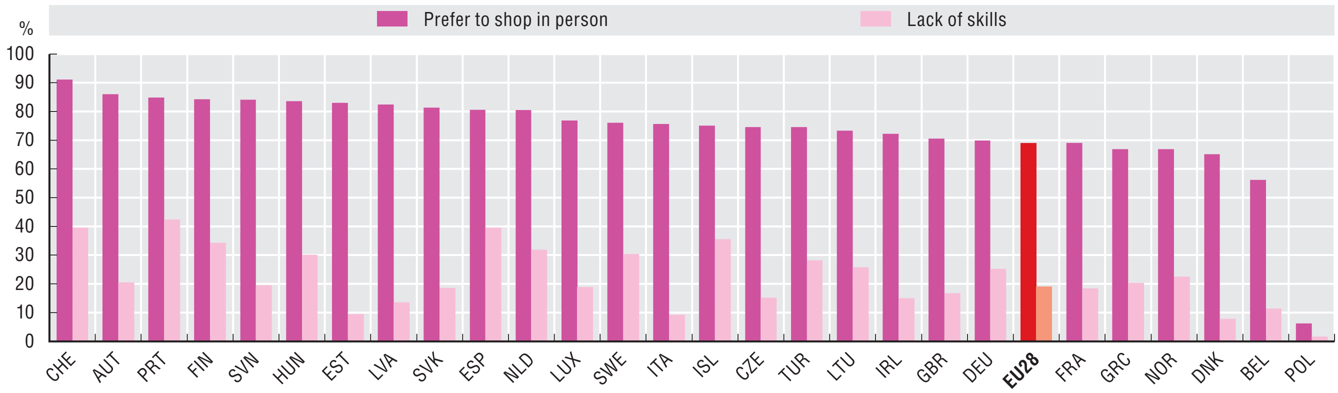


Source: OECD, based on Eurostat, Digital Economy and Society Statistics, Comprehensive Database, December 2018. StatLink contains more data.

StatLink https://doi.org/10.1787/888933929965

Reluctance to buy online in the last 12 months due to a preference to shop in person or lack of skills, 2017

As a percentage of Internet users who did not buy online in the last 12 months



Source: OECD, based on Eurostat, Digital Economy and Society Statistics, Comprehensive Database, September 2018. See chapter notes.

StatLink https://doi.org/10.1787/888933929984

Public authorities are embracing digital technologies to make processes, services and information more easily accessible and less burdensome. The share of individuals using the Internet to interact with public authorities in OECD countries has increased from 45% in 2010 to 56% in 2018. Differences between countries remain large, however, ranging from over 80% in the Nordic countries to 7% in Japan and 6% in Colombia.

Use by individuals with low or no formal education remains significantly lower than usage by other groups in all countries, at around half that of individuals with tertiary education. Cross-country variations may reflect differences in Internet usage rates, the availability of e-government services and the propensity of users to perform administrative procedures online, as well as data comparability.

One important example is the provision of digital systems for filing tax returns. All OECD and BRIICS countries offer online tax filing for at least some types of tax (personal income taxes, corporate income taxes, or value added tax filings by businesses). Significant levels of online filing for both personal and corporate income taxes are found in Brazil, Italy, Chile, the Netherlands, Portugal, Ireland, Korea, Australia and India. This trend is driven by a shift towards compulsory online filing. It should be noted, though, that the share of the businesses and especially of individuals required to file tax returns varies considerably between countries. In the case of Estonia, online filing of personal income tax returns is not mandatory but 99% of personal returns are filed via this channel.

Despite the availability of online payment facilities in many countries, data on uptake are sparse. In Norway, 100% of payments for personal and corporate income, and value added taxes are made online, as are more than 80% of payments in Italy, Ireland and New Zealand. In contrast, payment via an agency is more popular than online payment in Brazil.

In 2018, the share of individuals citing unavailability of online submission channels as a reason for not submitting forms to public authorities online is was generally low, at around 2% or less in most countries with such data. Germany is a notable outlier in this regard: over 7.2% stated that online submission was not available for forms they had needed to send. While unavailability of online submission channels appears to have increased in several countries, this is most likely to reflect survey respondents having increased awareness of unavailability, as a result of being more likely to seek to submit forms online, rather than the closure of previously existing online submission channels.

DID YOU KNOW?

All OECD and BRIICS countries offer online tax filing for at least some types of personal or business taxes.

Definitions

Individuals' online interactions with public authorities range from the simple collection of information on government websites to interactive procedures where completed forms are sent via the Internet. They exclude interaction via e-mail (for businesses) or manually typed e-mails (for individuals). It should be noted that the need to submit forms, as well as the availability of online submission channels, varies between countries.

Public authorities refers to both public services and administration activities. These may be authorities at the local, regional or national level.

A *tax return* is a declaration of income, sales and other details made by or on behalf of the taxpayer. Forms are often provided by the tax authorities for this purpose. *Corporate tax returns* relate to business' income, while *personal tax returns* relate to individual or household income.

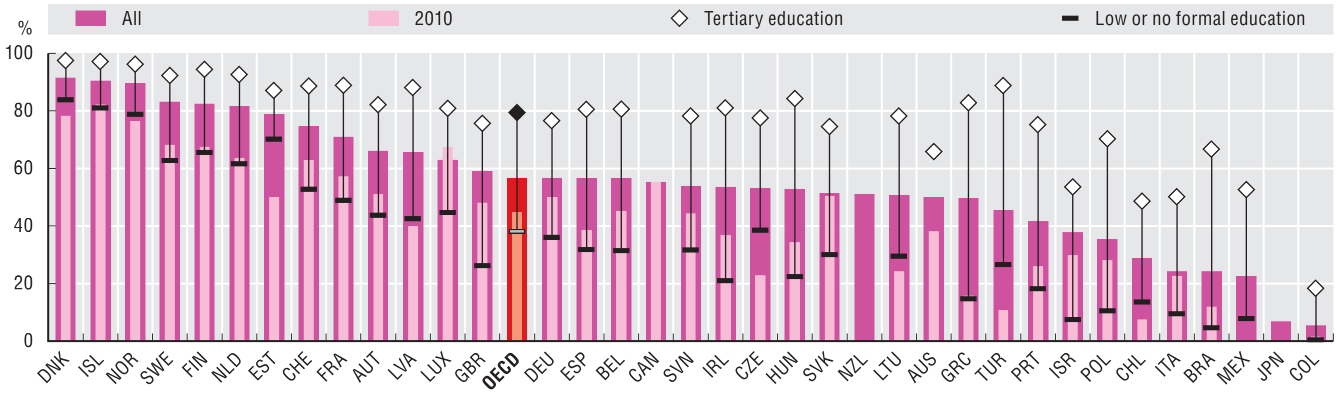
Measurability

Tax authorities in OECD member and partner economies provide data on tax returns to the OECD according to standardised definitions. These data are a by-product of administering national tax systems. Nevertheless, a number of countries do not provide data on tax returns filed online and few provide information on online payments, limiting the ability to compare all taxes across all countries. It should be noted that tax-filing requirements and channels vary between countries. For more information, see OECD, 2017b.

Data on individuals' interactions with public authorities are collected through surveys on ICT usage in households and by individuals. The OECD actively encourages the collection of comparable information through its "Model Survey on ICT Access and Usage by Households and Individuals" (OECD, 2015a). The European Community Survey on ICT Usage in Households and by Individuals collects additional information on whether or not respondents actually needed to submit official forms in the period. This can vary greatly depending on the administrative systems in different countries and is taken into account in the European Union Digital Economy and Society Index (European Commission, 2018). However, such detail is not available for other OECD countries and so no such adjustment is made in the indicators presented here.

Individuals who used the Internet to interact with public authorities, by educational attainment, 2018

As a percentage of individuals in each group

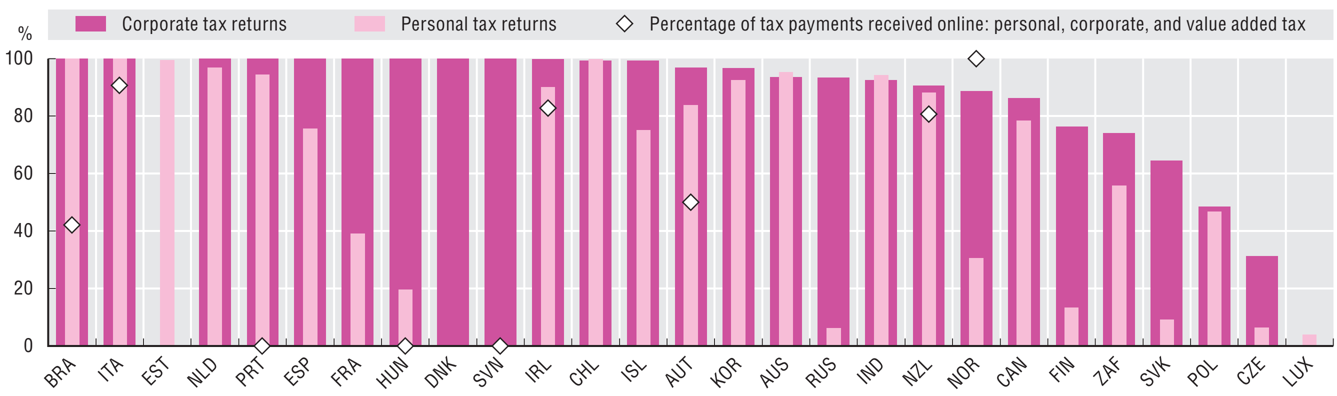


Source: OECD, ICT Access and Usage by Households and Individuals Database, http://oe.cd/hhind, December 2018. See chapter notes. StatLink contains more data.

StatLink https://doi.org/10.1787/888933930003

Personal and corporate income tax returns filed online, 2015

As a percentage of tax filings and payments

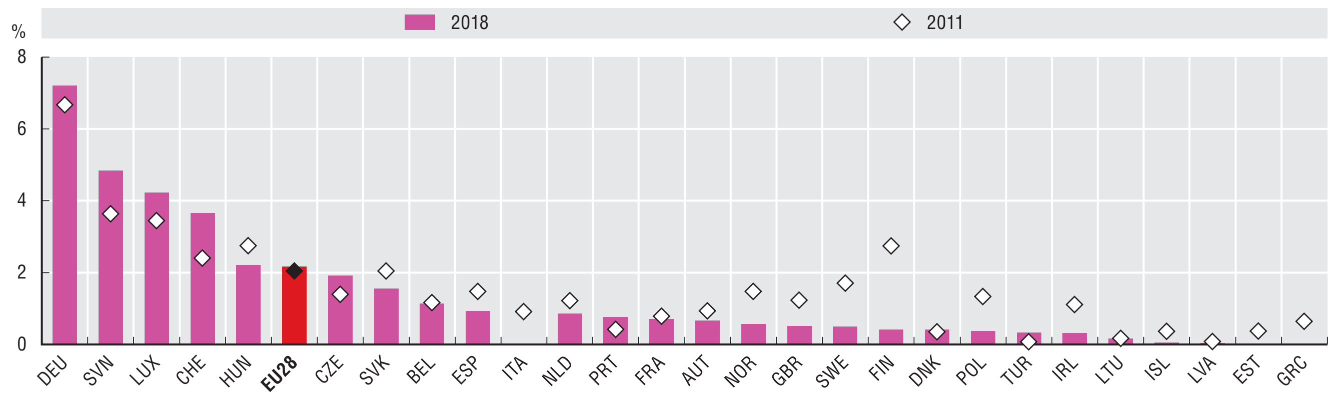


Source: OECD (2017b). See chapter notes. StatLink contains more data.

StatLink https://doi.org/10.1787/888933930022

Individuals who did not submit forms to public authorities online due to service availability, 2018

As a percentage of all individuals



Source: OECD, ICT Access and Usage by Households and Individuals Database, http://oe.cd/hhind, December 2018. See chapter notes.

StatLink https://doi.org/10.1787/888933930041

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

The Survey of Adult Skills, a product of the OECD Programme for the International Assessment of Adult Competencies (PIAAC), is designed to measure adults' proficiency in several key information-processing skills, namely literacy, numeracy and problem solving in technology-rich environments. Such test-based skill assessments have a strong advantage in comparison to other sources, as they provide a normalised, internationally comparable picture across countries.

In PIAAC, literacy and numeracy assessments cover a range of contexts including work, personal life, education and training, and society, economy and the environment. Tasks undertaken at levels three, four and five correspond to the highest levels of proficiency in numeracy and literacy. With a few exceptions, countries exhibit comparable ratios of top and low performers in numeracy and literacy assessments. In Japan, Finland, Sweden and the Netherlands, around 60% of 16-64 year-olds performed at the highest levels of numeracy and literacy, as opposed to less than 15% in Turkey, Chile and Indonesia.

The PIAAC assessment of problem solving in technology-rich environments refers to specific types of problems that individuals deal with when using ICTs. It contains three levels with levels two and three representing the most sophisticated tasks. Across all OECD countries for which data are available, slightly more than 30% of 16-64 year olds performed at the highest levels of the skills assessment, with the majority performing at level two, rather than at level three (which indicates the highest degree of proficiency).

Training is one crucial way to up-skill individuals to meet their personal digital skills needs. With the widespread use of digital technologies, alternative training channels such as massive open online courses (MOOCs) have become popular, especially among younger people. In 2018, around 11% of Internet users in the EU28 undertook free online training courses or self-studied to improve their skills related to the use of computers, software or applications; only 3% undertook self-paid training courses. About 12% of Internet users reported having received on-the-job training from co-workers or supervisors and 9% took part in a training course paid for or directly provided by their employer.

DID YOU KNOW?

The share of young workers with good skills for problem solving in technology-rich environments is almost five-times that of the oldest workers.

Definitions

Numeracy refers to the ability to access, use, interpret, and communicate mathematical information and ideas in order to engage in and manage the mathematical demands of a range of situations in adult life. The assessment involves managing a situation or solving a problem in a real-world context, by responding to mathematical content/information/ideas represented in multiple ways.

Literacy refers to the ability to understand, evaluate, use and engage with written texts, in order to participate in society, achieve goals, and develop knowledge and potential. The assessment encompasses a range of skills from the decoding of written words and sentences to the comprehension, interpretation and evaluation of complex texts. It does not, however, involve the production of text (writing).

Problem solving in technology-rich environments refers to the ability to use digital technologies, communication tools and networks to acquire and evaluate information, communicate with others and perform practical tasks. The assessment focuses on the abilities needed to solve problems for personal, work and civic purposes by setting appropriate goals and plans, as well as accessing and making use of information through computers and computer networks.

On-the-job training comprises informal learning activities undertaken at work, often with input from other individuals such as co-workers or supervisors. It is surveyed as a separate item from training paid for or provided by the employer.

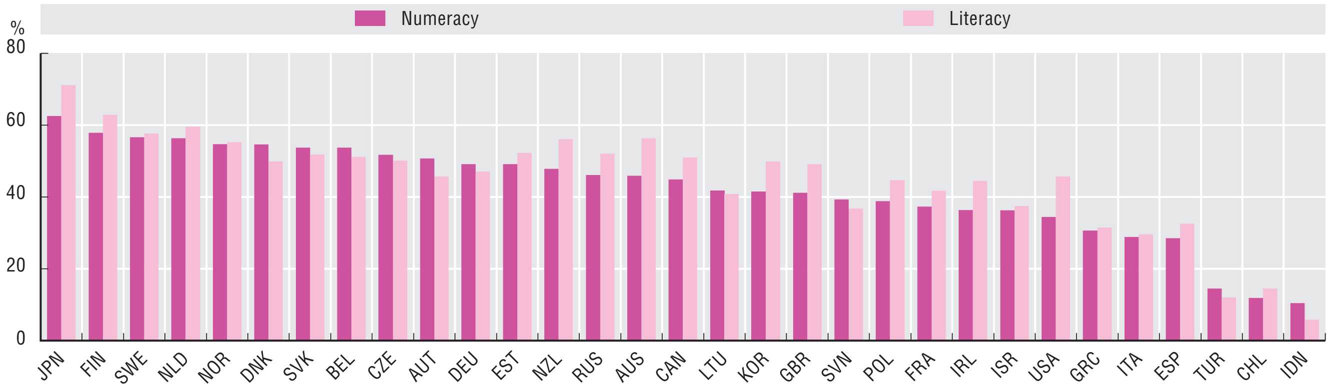
Measurability

This analysis encompasses both cognitive and non-cognitive skills, (i.e. skills that are generally only partially learnt at school and that relate to people's attitudes and personality). Literacy, numeracy and problem solving in technology-rich environments are cognitive skills that are measured through assessment tests. Measures for non-cognitive skills and social skills have been developed using information about the tasks that workers perform on the job from the OECD Programme for International Assessment of Adults (PIAAC).

Figures related to problem solving in technology-rich environments are based on a subset of PIAAC countries, as France, Italy and Spain did not participate in the relevant assessment tests.

Proficiency in numeracy and literacy, 2012 or 2015

Percentage of 16-65 year-olds scoring at levels 3, 4 and 5

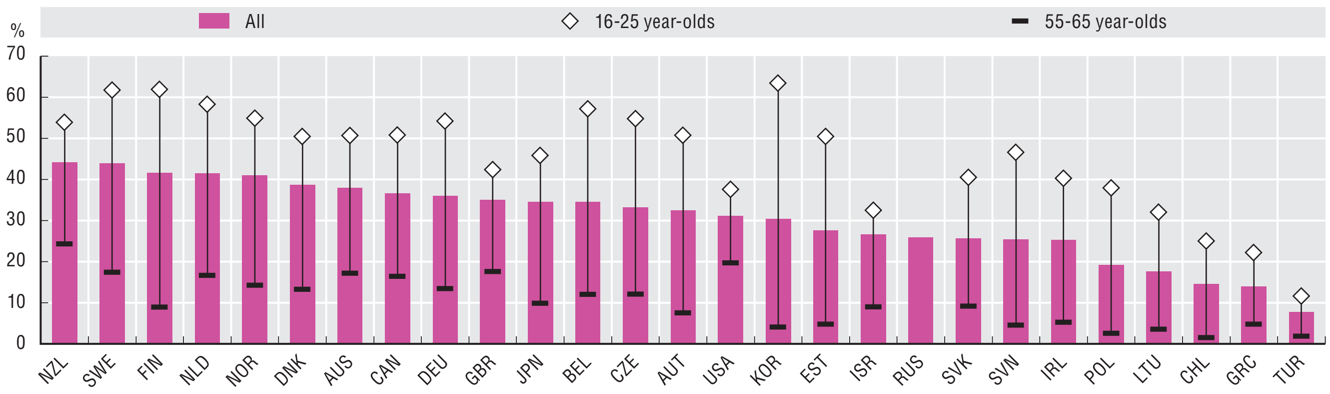


Source: OECD calculations based on Survey of Adult Skills (PIAAC) Database, September 2018. See chapter notes.

StatLink https://doi.org/10.1787/888933930060

Proficiency in problem solving in technology-rich environments, by age, 2012 or 2015

Percentage of 16-65 year-olds scoring at levels 2 and 3 in each age group

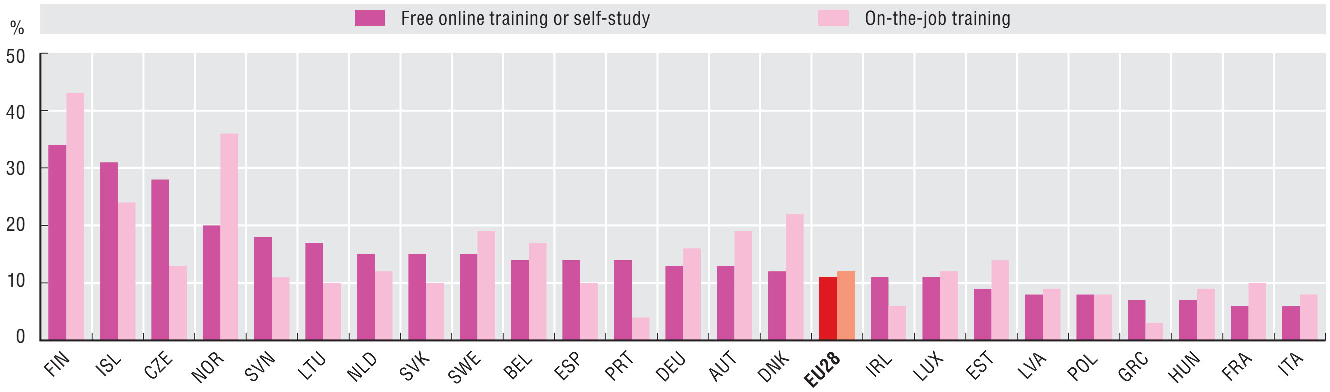


Source: OECD calculations based on Survey of Adult Skills (PIAAC) Database, September 2018. See chapter notes. StatLink contains more data.

StatLink https://doi.org/10.1787/888933930079

Individuals who carried out training to improve their digital skills, by type, 2018

As a percentage of Internet users



Source: OECD, based on Eurostat, Digital Economy and Society Statistics, Comprehensive Database, December 2018. See chapter notes.

StatLink https://doi.org/10.1787/888933930098

Why are indicators on e-commerce needed?

E-commerce has been high on the agenda for policy makers since the mid-1990s. In 1998, the OECD Ministerial Conference on Electronic Commerce in Ottawa recognised e-commerce as a global driver of growth and economic development (OECD, 1998). In 2016, the OECD Ministerial Declaration on the Digital Economy called for policies to "stimulate and help reduce impediments to e-commerce within and across borders for the benefits of consumers and business" (OECD, 2016).

The e-commerce landscape has become increasingly dynamic in recent years. New players have emerged and established actors have taken on new roles. Some barriers to e-commerce, such as Internet access have been greatly reduced, while new barriers, such as concerns about security and privacy, have become more prominent. Above all, new opportunities have arisen to unlock the potential of e-commerce to boost growth and consumers' welfare. (OECD, 2019a). As technological change and new business models alter the e-commerce landscape, policy faces challenges in a range of areas, including consumer protection, tax, competition, and environmental policy. Sound statistics on e-commerce are necessary to design, monitor and implement these policies. However, statistical information on consumer and operator behaviour and on the effects of online platforms is still scarce.

What are the challenges?

The OECD first developed a statistical definition of e-commerce in 2001. Based on this, OECD and partner countries collect data on e-sales and e-purchases by individuals and businesses, through two dedicated surveys on ICT usage. The definition of e-commerce and its implementation in surveys are regularly adjusted for new technological developments and usages. This definition is also a central component of the OECD digital supply-use table and digital trade measurement frameworks (see pages 2.11 and 9.6).

Nevertheless, measurement of e-commerce through the ICT usage surveys presents methodological challenges. These include the adoption of different practices for data collection and estimations, the treatment of outliers, the extent of e-commerce carried out by multinationals, and the imputation of values from ranges recorded in surveys. Sectoral coverage of surveys and limited information on the actors involved are also issues. Convergence of technologies brings additional challenges for the treatment (and surveying) of emerging transactions, notably over mobile phones, via SMS or using devices that enable near field communication (NFC).

While ICT use surveys have been successful in measuring the diffusion of e-commerce among individuals and firms, collecting information on the value of e-commerce transactions and on the flows of cross-border e-commerce has proven more difficult. Individuals find it hard to recollect online expenditure values and do not always know whether they are purchasing from a domestic or a foreign supplier. Furthermore, the accounting systems of many businesses do not differentiate online and offline transactions or identify the location of customers and suppliers. In addition, because business-to-consumer transactions increasingly include digital products downloaded or streamed over the Internet, it is difficult for survey respondents to identify the country of origin.

Beyond survey data, several other sources have been used to approximate e-commerce transactions, including cross-border flows. These include the aggregation of data from company reports, payment data, parcel shipments or Internet traffic, among others (UNCTAD, 2016). However, each of these only provides a partial and potentially biased perspective on e-commerce. Approaches aggregating company reports are often restricted to small sub-populations of firms (e.g. large firms, online-only retailers). Payment data are typically limited to a specific method of payment and might contain certain transactions that are not related to e-commerce (e.g. payments via NFC). Additionally, the geography of cross-border payments does not always reflect the geography of cross-border e-commerce, as payment processing can be outsourced to a third country. Parcel shipments only relate to physical products and mostly do not provide detailed information on the value of shipments. More importantly, not all parcel shipments are the result of e-commerce transactions. The geographic origins of Internet traffic to retailers' websites, sometimes used as a proxy for cross-border transactions, does not account for the value of resulting shipments.

Options for international action

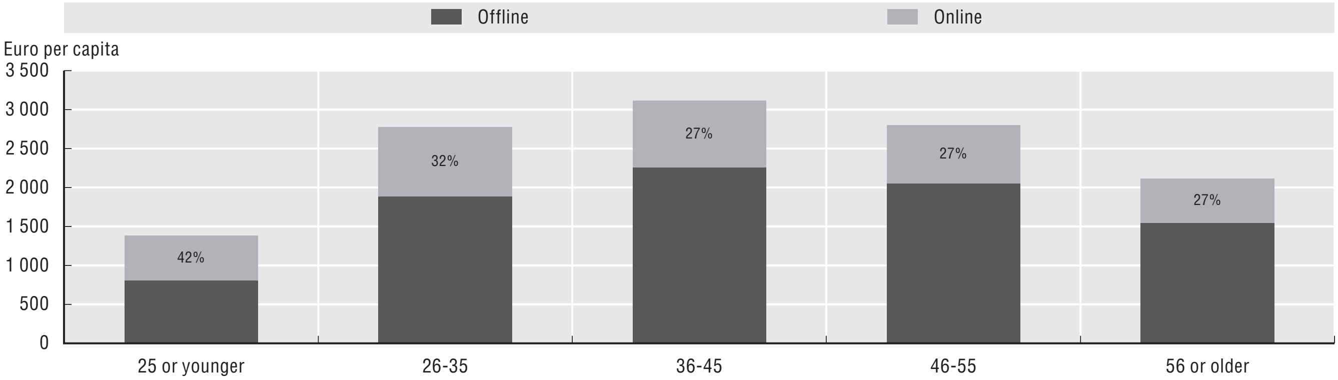
There are three main axes to International initiatives to improve the measurement of e-commerce. The first is to improve the quality of the data collected through ICT use surveys. For example, a consortium of seven European countries led by Finland (Eurostat, 2017) tested a set of new questions to capture developments in e-commerce, including demand-driven orders, bookings and reservations, window shopping, standing orders, marketplaces and within-group transactions. The findings of this work are being reflected in the European ICT usage surveys and could be considered for inclusion by other countries.

The second axis is the inclusion of e-commerce questions in other surveys that may be better suited to measuring e-commerce volumes. In general, measuring the value of e-commerce requires detailed information that cannot be collected through ICT surveys. Instead, the framework of the Structural Business Surveys appears more appropriate for firms to report e-sales and e-purchases values (Eurostat, 2017). Similarly, it may be easier for individuals to record e-purchases as part of Household Expenditure Surveys, which typically include a diary of daily expenses. As both Structural Business Surveys and Household Expenditure Surveys feed into the System of National Accounts, and are harmonised among countries, international organisations can play an important role in developing these surveys to collect better information on e-commerce.

Finally, private Big data sources, (e.g. from banks, credit cards companies, etc.) provide insights in areas where surveys are less effective. For instance, businesses, and especially individuals, buying online typically ignore the location of the seller, an issue complicated further by online platforms. Private source data may become a useful complement to official, survey-based statistics. One example is a collaboration between the OECD and Spanish Bank BBVA, in which an analysis of credit card transactions by BBVA customers in Spain provided novel insights into the consumption patterns of consumers online and the determinants of domestic and cross-border expenditure flows (OECD, 2019b).

Offline and online payments in Spain, by age, 2016

Euro per capita



Source: OECD calculations based on BBVA data, November 2018.

StatLink https://doi.org/10.1787/888933930117

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4.8 Measuring cloud computing services

Why are indicators on cloud services needed?

New technologies and business models are fundamentally changing the way in which businesses access and use software and hardware (DeStefano et. al., 2019). Cloud services mark a paradigm shift in ICT provision, allowing businesses and individuals to access on-demand IT services over a network. Data processing and storage takes place in a remote data centres which will typically have a scalable and resilient modular design. These can offer businesses, especially small and medium- sized enterprises, cost- reduction opportunities and increased flexibility.

While there are undoubtedly broader impacts for businesses, such as enabling wider access to the latest technologies by lowering barriers to adoption, the most important, fundamental impact of moving to cloud provision of business ICT is on cash flow. Simply put, firms can now access powerful ICTs on a "pay-as-you-go" basis, avoiding the need to finance large capital expenditures on servers, maintenance and the like. For established businesses, this makes managing their money much easier, and the scalability of cloud services reduces risk exposure. For new firms, this can reduce financing needs and lead to more start-ups securing funding.

As a consequence of this shift, ICTs may become less visible in firms' production costs (as recorded in financial reports), while simultaneously becoming ever more vital to their productive activities. Alongside this, the shift to cloud services is likely to reduce the efficacy of existing policies incentivising purchases of ICT equipment and software. It is therefore vital to measure cloud services, in order to determine their impacts on firm-level performance and aggregate productivity, and to manage associated infrastructural needs (e.g. bandwidth) and other policy implications. The OECD digital supply and use table framework distinguishes a separate product category to capture the amount of cloud services purchased by firms (see page 2.11).

What are the challenges?

The nature of cloud services allows them to be used anywhere with a reliable Internet connection, while the cloud services are "produced" from any combination of data centres located across the globe. Even where a given customer's data is known to be housed in a specific data centre, it is also likely to be duplicated (e.g. backed-up) in one or more other locations, with the network dynamically determining where the data should be accessed and processed. This means that the location where production of cloud services takes place can also vary dynamically. Meanwhile, payments by the end-user for those services may be made to a different economic territory. Challenges arise in measuring, and ensuring the coherence of, transactions between the ultimate owner of the cloud computing infrastructure, the unit where the infrastructure is located, and the end-user. This exacerbates other challenges related to measuring digitally traded services (see page 9.6).

In addition, the capital-substituting nature of cloud services can have material implications for economic statistics, including recorded GDP. Fundamentally, businesses (and others) are continuing to use ICTs in their business processes - for data storage, processing, access, analysis and so on - as they long have. However, the way they access these components is changing considerably – moving away from a local provision model towards local terminals used to access cloud services. In National Accounts terms, this implies a switching from investment in hardware such as servers to increased intermediate consumption expenditure, which reduces value added at the level of the enterprise, other things being equal. It is likely that specific questions on cloud computing services will need to be included in business surveys in order to fully understand the scale of substitution towards the cloud.

In the current Central Product Classification (CPC), category 8315 "Hosting of information technology (IT) infrastructure provisioning service" is likely to capture some cloud-related transactions. However, it may be necessary to incorporate a specific product, or sub-product breakdown, for cloud services to provide a complete view. Furthermore, source data and product categories do not always align well with common definitions of cloud computing (BEA, 2018). This makes it difficult to assess the rate of growth of consumption of cloud services and how it compares to decreases in ICT investment among firms.

This shift also implies a concentration of ICT investment in the balance sheets of a relatively small number of cloud service providers, many of which deliver services, and have data centres, in many countries. In principle, this capital formation will be captured in national statistics under investment categories such as software, buildings, and ICT hardware - whether these are developed on own account or procured from third parties. However, an explicit category for cloud based infrastructure should be considered, along with methods to estimate this investment through aggregating related expenditures by producers of cloud services.

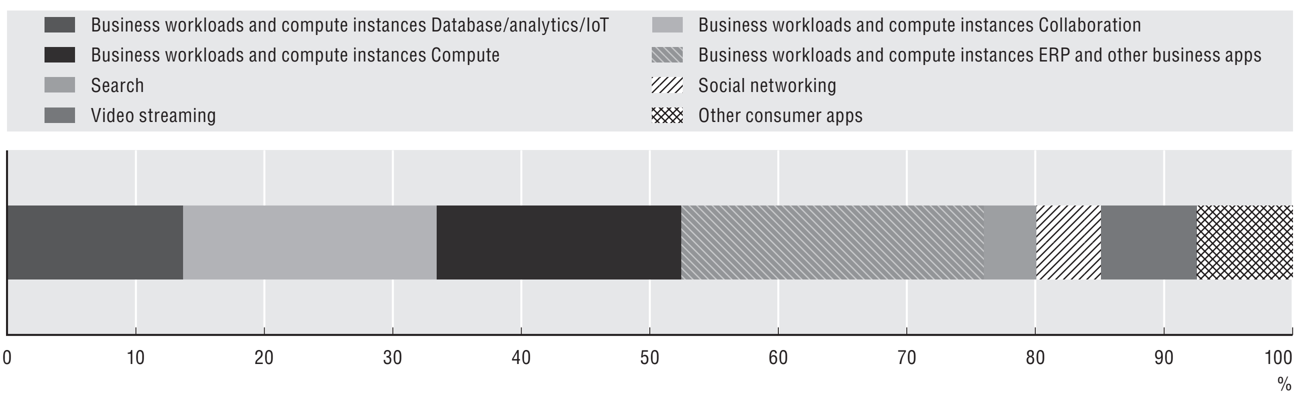
Measures of price change are also important. Existing deflators do not always appear to account for the rapid quality improvements observed in cloud services. By using archived online price lists and press releases from cloud services providers to construct a price index for cloud services, it has been argued that quality-adjusted prices are declining even more rapidly than nominal prices (Coyle and Nguyen, 2018). Nevertheless, there are significant challenges with such an approach, including the wide range of different products offered by each provider, a lack of expenditure weights for these products, and the fact that quality improvements tend to be continuous. A further complicating factor is the proliferation of cloud computing services that are provided to end users free of charge or through a "freemium" model where basic service is free but payment is required for additional features such as extra storage. This is especially common in products targeted at individuals rather than businesses, such as personal email services. Such services are likely uncounted in measures based on transactions and may also act as a substitute for paid software.

Business ICT use surveys give an indication of how many firms use cloud services in each country. Additional detail on services used and the perceived outcomes in terms of production costs, sales and productivity can be collected to provide contextual and policy- relevant information. Nevertheless, the extent and impacts of cloud services can only be understood by finding ways to measure the amounts paid, the volumes of cloud services used and the extent of substitution from ICT investments toward cloud services. The upcoming 2019 Survey of Digital Technology and Internet Use in Canada will attempt to measure the sale of cloud services from an enterprise perspective. Nevertheless, ICT usage surveys may need to be complemented by other means for collecting data (e.g. expenditure on cloud services). A natural fit might be the business expenditure component of structural business statistics. However, without a specific cloud services category in the CPC, such presentations are likely to rely on experimental collection of additional breakdowns.

Much relevant information might be available from cloud services providers themselves, including information on installed capacity, use volumes and the types of applications using cloud services. However, obtaining data from these large multinational companies can be challenging. There is therefore a need to identify viable strategies that minimise the burden on them (e.g. imposed by multiple countries making separate data requests). Another key concern for cloud service providers is the commercial sensitivity of such information.

Global data centre workloads and compute instances, by application, 2016

As a percentage of total data centre workloads and compute instances



Source: OECD, based on Cisco (2018). See chapter notes.

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Options for international action

Given the evident role of cloud services as a keystone digital technology, they have been classified separately in digital supply-use tables currently under development by the OECD (see page 2.11). The next step is the collection, by countries, of separate data on cloud services to demonstrate the viability of including a separate category for cloud services in a future revision of the CPC. Alongside this, the OECD and others should build upon previous work to establish internationally agreed definitions and classifications of types of cloud services for statistical purposes, and to operationalise these in business ICT usage surveys in order to gain additional insights into the use of different cloud services.

In addition, it may be possible to reach an agreement with some of the largest cloud services firms to provide standardised data to the OECD under a non-disclosure agreement. The data could then be aggregated to provide an overall view of the cloud services market while mitigating commercial sensitivities. As it is likely that cloud services providers will have some knowledge of where their customers are based (e.g. based on the payment address), this approach might help to shed light on the flows of cloud services being provided into different countries.

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4.9 The potential of survey micro-data

Why are micro-based indicators needed?

Enterprise-level information on the diffusion of digital technologies is essential to ascertain their impact on firms' business processes, performance and productivity. Such insights can help develop appropriate policies to strengthen business performance in the digital transformation. Unlike sectoral or macro statistics, firm-level data allow heterogeneity of businesses' characteristics to be accounted for.

What are the challenges?

Although National Statistical Offices (NSOs) always produce their business ICT usage statistics from micro-level information, the main objective remains aggregated indicators. In addition, statistical surveys are not designed to be reused in combination with one another and, due to *negative selection* criteria, joint samples tend to be small, skewed towards larger firms and offer limited time series for individual firms.

Confidentiality rules currently prevent micro-data from different countries from being pooled. For example, at the present time, and unlike EU survey data on innovation, anonymised EU survey data on ICT use in business are not available at the Eurostat Safe Centre. Moreover, results from individual analyses are seldom comparable across countries. Nevertheless, NSOs in several countries systematically integrate survey data with administrative sources, have started redesigning collection practices, produce new (multi-dimensional and distribution-related) statistics and indicators, or undertake micro-level analysis, including through international research projects.

To demonstrate the potential of ICT firm-level data, the OECD began an exploratory study in 2018.[1] The initial phase explored associations between variables as well as differences in adoption modes across industries or and in relation to structural aspects of enterprises.

The results provide several insights. Two main dimensions explain most of the variability in behaviour of enterprises with respect to ICT usage (from slightly above 50% in the United Kingdom and 90% or more in Italy, Poland and Sweden). The first dimension (contributing up to two-thirds of the explained variability) relates to the organisation and management of production. Its key underlying variables are the diffusion of connected computers among workers, the presence of ICT specialists, IT training of personnel and the adoption of e-business tools (enterprise resource management and customer relationship management). The second dimension is mostly composed of variables related to web-sales, including having a website with cart functionality and the possibility of tracking orders, which do not require in-house technological capability.

Enterprises have been aggregated into three clusters, which hold for all four countries:

1. "Low ICT uptake" - mostly composed of low-tech, relatively small firms;
2. "Only web oriented" - with a large presence of traditional service activities
3. "High ICT uptake"

The four countries differ in the share of enterprises and employment falling into the three clusters, but in all countries labour productivity in the "high ICT uptake cluster" was much higher than those in the other two clusters.

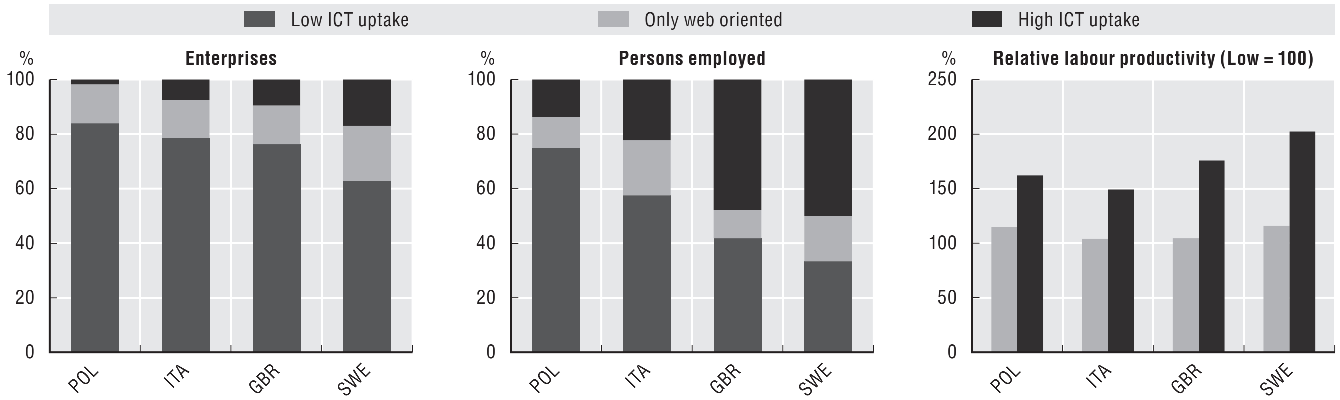
This exploratory analysis also permitted a more in-depth look at enterprise characteristics associated with ICT adoption. Finding, for instance, that while larger, more productive enterprises operating in high-tech manufacturing (HTM) and in knowledge-intensive service (KIS) activities are strongly represented in the *ICT intensive* cluster, this cluster also contains a sizeable component of smaller companies operating in other industries. Further investigation is needed to understand drivers of ICT uptake by these firms.

The Italian statistical institute (Istat) was able to enrich its analysis by adding supplementary variables obtained by linking records from the ICT survey with business archives and registers on workers' characteristics. This showed that the education of the workforce plays a similar role to the diffusion of connected computers in enterprises, and that both capital intensity of production and job tenure play a positive role in the *digital maturity* dimension.

1. Under the aegis of the OECD Working Party on Measurement and Analysis on the Digital Economy (WPMADE), a group of NSOs (from Italy, Poland, Sweden and the United Kingdom) volunteered to perform coordinated micro-data analyses on the 2017 European Community Survey on ICT Usage in Businesses micro-data. The Italian NSO (Istat) developed and distributed the common code.

Business digital maturity countries, 2017

Percentage shares and levels relative to the "low ICT uptake" cluster



Source: OECD, ICT usage by businesses micro-data exploratory project, preliminary results, November 2018. See chapter notes.

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Options for international action

The OECD has pioneered a distributed approach to empirical analysis of confidential micro-data. The Organisation provides a common framework through which experts meet and identify common research and policy questions, the indicators and the econometric modelling are agreed upon, and software routines are developed in-house, and then researchers with access to individual countries' micro-data each perform identical analysis and compile results. These are then compared and analysed by the OECD or by participating countries.

A first large-scale and pioneering OECD project based on the distributed approach exploited innovation survey data in 20 countries (OECD, 2009). The latest and ongoing OECD initiatives are the DYNEMP project (https://oe.cd/dynemp), now in its third cycle, which uses business register data to analyse employment dynamics, young businesses and allocative efficiency, and the MULTIPROD project (https://oe.cs/multiprod) on the micro drivers of aggregate productivity. The OECD has also developed a Micro-data lab, which compiles and links large-scale administrative and commercial datasets at the micro level, often requiring licensing agreements. The exploitation of large datasets, for example, on patents, trademarks, design rights, scientific publications and company information, enables analyses of emerging technologies and their links to firms' performance. Several indicators in this publication draw on those datasets.

There have been several efforts in past years to exploit the potential of firm-level survey data on ICT.[2] The ongoing OECD exercise described here shows that this approach has great potential to deliver insights into the digital transformation of businesses, and for collaborative, cutting-edge research. Indeed, a systematic and co-ordinated analysis of the type proposed might lead to the definition of information-rich synthetic indicators, as well as to useful criteria for the selection of variables in surveys. Additionally, the possibility of integrating data from different sources represents a strategic asset for a better understanding of dimensions related to ICT adoption but that cannot be included in surveys due to the need to minimise response burden.

Applying a distributed approach to the analysis of ICT use micro-data represents a pragmatic way of addressing issues of access to confidential data to provide the evidence base needed by policy makers, thereby enhancing the relevance and usability of official statistics. Exercises of this kind also contribute to building the case for the development of linked micro-data as statistical infrastructures in countries and to improved access to micro-data by researchers.

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2. For example, the OECD ICT-Enabled Innovation project, which linked ICT and innovation surveys for a few countries (Spiezia, 2011). Other examples are the EU funded project "ESSLimit", which linked ICT, innovation and business surveys for 15 European countries (Eurostat, 2012), and the ESSLait on Linking of Microdata to Analyse ICT Impacts (Eurostat, 2013), which also covered other variables such as exports and ICT skills.

Notes

Cyprus

The following note is included at the request of Turkey:

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

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

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

Israel

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

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

4.1 User sophistication

Total, daily and mobile Internet users, 2018

Unless otherwise stated, Internet users are defined as individuals who accessed the Internet within the last 3 months. For Canada, Colombia and Japan, the recall period is 12 months. For the United States, the recall period is 6 months for 2017 and no time period is specified in 2006. For New Zealand, the recall period is 12 months for 2006. For India, Indonesia, the Russian Federation and South Africa, no time period is specified.

For Australia, data refer to the fiscal years 2016/17 and 2006/07 ending on 30 June. The reference period is 12 months in 2006. For Brazil, data refer to 2016 and 2008. For Canada, data refer to 2012 and 2007. Data refer to individuals aged 16 and over instead of 16-74 in 2006. The reference period is 12 months. For Israel, data refer to 2016 instead of 2018 and to all individuals aged 20 and over instead of 16-74. For Japan, data refer to 2016 instead of 2018 and to individuals aged 15 to 69. For Chile, China, Colombia, Costa Rica, Indonesia, Korea, Mexico, the Russian Federation, South Africa, Switzerland and the United States, data refer to 2017 instead of 2018. For EU28, data refer to 2007 instead of 2006.

Notes for all users:

For Colombia, data refer to 2008 instead of 2006.

For New Zealand, data refer to 2012 instead of 2018. The reference period is 12 months in 2006.

For Turkey and the United States, data refer to 2007 instead of 2006.

For Costa Rica, data refer to 2017 instead of 2018.

For China, India, Indonesia, the Russian Federation and South Africa, data originate from ITU, World Telecommunication/ICT Indicators (WTI) Database 2018.

For India, data refer to 2016 instead of 2018.

For Indonesia, data include individuals aged 5 or more.

Notes for daily users:

For Italy, data refer to 2017 instead of 2018.

For Costa Rica, OECD estimates are based on data provided by MICITT (Ministry of Science, Technology and Telecommunications).

For the Russian Federation, data originate from ITU, World Telecommunication/ICT Indicators (WTI) Database 2018 and refer to 2016 instead of 2018 and to individuals aged 15-72 instead of 16-74.

Notes for mobile users:

For Costa Rica, OECD estimates are based on data provided by MICITT (Ministry of Science, Technology and Telecommunications).

For Korea, the reference period is 12 months.

For New Zealand, data originate from Statistics New Zealand. Data refer to individuals aged 15 to 74, to 2012 instead of 2018 and to mobile access and include individuals using cellular and wireless. Individuals may use both.

Diffusion of selected online activities among Internet users, 2018

Unless otherwise stated, Internet users are defined as individuals who accessed the Internet within the last 3 months. For Canada, Colombia, Japan, Korea and New Zealand, the recall period is 12 months. For the United States, the recall period is 6 months.

For Australia, data refer to the fiscal year 2016/17 ending on 30 June, except for “Telephone” (2012/13).

For Brazil, data refer to 2016.

For Canada and New Zealand, data refer to 2012.

For Chile, Colombia, Korea, Mexico, Switzerland and the United States, data refer to 2017.

For Costa Rica, data refer to 2017 and to individuals aged 18-74 instead of 16-74.

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

For Japan, data refer to 2016 and to individuals aged 15-69 instead of 16-74. For “Content creation” and “Cloud”, data refer to 2015.

Individuals with diversified and complex use of the Internet, 2016

Individuals with diversified and complex use are individuals who perform, on average, the largest number (more than 8 out of the 11 types of major online activities) and variety of activities. They are also those who perform the bigger share of activities linked to e-finance, learning and creativity – activities performed by the smallest range of individuals which can also be considered more complex activities.

4.2. E-business

Diffusion of selected ICT tools and activities in enterprises, by technology, 2018

Unless otherwise stated, only enterprises with ten or more employees are considered.

For Brazil, data refer to 2017.

For Canada, data refer to 2013, except for cloud computing (2012).

For Japan, data refer to 2016 and include businesses with 100 or more employees instead of 10 or more.

For Korea, data refer to 2016, except for cloud computing (2015).

For Switzerland, data refer 2015 and to businesses with five or more employees instead of ten or more.

For ERP, CRM and RFID, data relate to 2017.

Big data: For United Kingdom, data refer to 2016.

Cloud computing: For Australia, data refer to the fiscal year 2015/16 ending on 30 June. For Canada, data refer to enterprises that have made expenditures on “software as a service” (e.g. cloud computing). For Iceland, data refer to 2014. For Mexico, data refer to 2012.

RFID: for Iceland, data refer to 2014.

Enterprises engaged in sales via e-commerce, by firm size, 2017

Unless otherwise stated, only enterprises with 10 or more employees are considered. Small firms are defined as companies with between 10 and 49 employees, medium firms as companies with between 50 and 249 employees, SMEs as companies with between 10 and 249 employees and large firms as companies with 250 or more employees.

For Australia, data refer to the fiscal year 2015/16, ending on 30 June.

For Brazil, data do not exclude manually typed emails or any other such channels.

For Canada, data refer to 2013; medium-sized enterprises have 50-299 employees and large ones have 300 or more employees. Sales online over the Internet may include EDI sales over the Internet as well as website sales, but do not include sales via manually typed e-mail or leads.

For Japan, data refer to businesses with 100 or more employees instead of 10 or more. Medium-sized enterprises have 100-299 employees and large firms have 300 or more employees.

For Mexico, data refer to 2012 and to businesses receiving orders via the Internet, instead of over computer networks.

For New Zealand, data refer to the fiscal year 2015/16 ending on 30 June.

For Switzerland, data refer to 2011.

Enterprises' advanced web sales functionalities and online advertising, by size, 2018

Recurrent visitor features refers to the provision of personalised content on the website for regular/recurrent visitors.

4.3 Business capabilities

Workers in ICT task-intensive occupations, 2017

ICT task-intensive occupations are defined according to the taxonomy described in: Grundke, Horvát and M. Squicciarini (forthcoming), "ICT intensive occupations: A task-based analysis", *OECD Science, Technology and Innovation Working Papers*, OECD Publishing, Paris.

ICT task-intensive occupations are defined by three-digit Groups of the 2008 revision of the International Standard Classification of Occupations (ISCO-08): Business services and administration managers (121); Sales, marketing and development managers (122); Information and communications technology service managers (133); Professional services managers (134); Physical and earth science professionals (211); Electrotechnology engineers (215); Architects, planners, surveyors and designers (216); University and higher education teachers (231); Finance professionals (241); Administration professionals (242); Sales, marketing and public relations professionals (243); Software and applications developers and analysts (251); Database and network professionals (252) and Information and communications technology operations and user support (351).

For Canada, data refer to 2016.

For Japan, data refer to 2015.

Enterprises purchasing cloud computing services, by size, 2018

For Australia, data refer to the fiscal year 2015/16 ending 30 June.

For Brazil, data refer to 2017 and comprise an aggregation of four different items collected separately.

For Canada, data refer to 2012 and to enterprises that have made expenditures on software as a service (e.g. cloud computing). Medium-sized enterprises have 50-299 employees. Large enterprises have 300 or more employees.

For Iceland, data refer to 2014.

For Japan, data refer to 2016 and to businesses with 100 or more employees. Medium-sized enterprises have 100-299 employees. Large enterprises have 300 or more employees.

For Korea, data refer to 2015.

For Mexico, data refer to 2012.

For Switzerland, data refer to 2015 and to firms with five or more employees.

Enterprises performing Big data analysis, by size, 2018

For Korea and the United Kingdom, data refer to 2016.

4.4 E-consumers

Individuals who purchased online in the last 12 months, by age, 2018

For Colombia and the United States, the age gap in lighter blue is reversed. Individuals aged 55-74 have a slightly higher propensity to purchase online than individuals aged 16-24.

Unless otherwise stated, Internet users are defined for this indicator as individuals who accessed the Internet within the last 12 months. For Australia and Israel, the recall period is 3 months. For the United States, the recall period is 6 months.

For Australia, data refer to the fiscal year 2016/17 ending on 30 June. In 2016/17, the information provided is taken from a question wording that differs slightly from other countries: “In the last 3 months, did you personally access the Internet for any of the following reasons: Purchasing goods or services?”.

For Brazil, data refer to 2016.

For Costa Rica, data refer to individuals aged 18-74 instead of 16-74.

For Chile, Colombia, Costa Rica, Korea, Mexico, Switzerland and the United States, data refer to 2017.

For Canada, data refer to 2012.

For Israel, data refer to 2016 and to individuals aged 20 and over instead of 16-74 and 20-24 and instead of 16-24, having used the Internet for purchasing goods or services in the last three months. This include all types of goods and services.

For Japan, data refer to 2016 and to individuals aged 15-29 instead of 16-24.

For New Zealand, data refer to 2012 and include individuals who have made a purchase through the Internet for personal use, which required an online payment in the last 12 months.

Reluctance to buy online in the last 12 months due to a preference to shop in person or lack of skills, 2017

“Lack of skills” refers to individuals who, in the last 12 months, have not ordered goods or services over the Internet, because they lack the necessary skills.

“Prefer to shop in person” refers to individuals who, in the last 12 months, have not ordered goods or services over the Internet, because they prefer to shop in person, prefer to see the product, have a loyalty to specific shops or due to force of habit.

4.5 E-citizens

Individuals who used the Internet to interact with public authorities, by educational attainment, 2018

Unless otherwise stated, data refer to the respective online activities in the last 12 months.

For Australia, data refer to the fiscal years 2010/11 and 2012/13 ending on 30 June. Data refer to “Individuals who have used the Internet for downloading official forms from government organisations’ web sites, in the last 12 months” and “Individuals who have used the Internet for completing/lodging filled in forms from government organisations’ web sites, in the last 12 months”.

For Brazil, data refer to 2016 instead of 2018.

For Colombia and Switzerland, data refer to 2017 instead of 2018.

For Canada, data refer to 2012 instead of 2018.

For Chile, data refer to 2009 and 2017.

For Israel, data refer to 2016 instead of 2018 and to individuals aged 20 and more instead of 16-74, and 20-24 instead of 16-24. Data relate to Internet use for obtaining services online from government offices, including downloading or filling in official forms in the last three months.

For New Zealand, data refer to 2012 and to individuals using the Internet for obtaining information from public authorities in the last 12 months.

For Japan, data refer to 2016 instead of 2018 and individuals aged 15-69 instead of 16-74, and 15-29 instead of 16-24, using the Internet for sending filled forms via public authority websites in the last 12 months.

For Mexico, data refer to 2016 instead of 2018. Using e-government services includes the following categories: "communicate with the government", "consult government information", "download government formats" and "perform government procedures".

Personal and corporate income tax returns filed online, 2015

For Iceland, the corporate tax return data refer to 2014.

Individuals who did not submit forms to public authorities online due to service availability, 2018

For Switzerland, data refer to 2014 and 2017.

For Turkey, data refer to 2012 instead of 2011.

4.6 Enablers of effective use

Proficiency in numeracy and literacy, 2012 or 2015

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

For the United Kingdom, data refer to England only.

For the Russian Federation, the PIAAC sample does not include the population of the Moscow municipal area. The data published, therefore, do not represent the entire resident population aged 16-65, but rather the population of the Russian Federation excluding the population residing in the Moscow municipal area.

Proficiency in problem solving in technology-rich environments, by age, 2012 or 2015

The data for the following 21 countries from the first round of PIAAC refer to the year 2012: Australia, Austria, Belgium (Flanders), Canada, Czech Republic, Denmark, Estonia, Finland, Germany, Ireland, Italy, Japan, Korea, the Netherlands, Norway, Poland, the Russian Federation (excluding Moscow), Slovak Republic, 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.

For the United Kingdom, data refer to England only.

For the Russian Federation, the PIAAC sample does not include the population of the Moscow municipal area. The data published, therefore, do not represent the entire resident population aged 16-65, but rather the population of the Russian Federation excluding the population residing in the Moscow municipal area.

Individuals who carried out training to improve their digital skills, by type, 2018

Digital skills refer to the use of computers, software or applications.

4.8 Measuring cloud computing services

Global data centre workloads and compute instances, by application, 2016

A server workload and compute instance is defined as a set of virtual or physical computer resources that is assigned to run a specific application or provide computing services for one or many users. A workload and compute instance is a general measurement used to describe many different applications, from a small, lightweight SaaS application to a large computational private cloud database application. For the purposes of this study, if a server is not virtualised, then one workload and compute instance is equivalent to one physical server. When there is virtualisation, one virtual machine or a container, used interchangeably, is counted as one workload and compute instance. The number of virtual machines per server will vary depending on various factors, which include the processing and storage requirements of a workload and compute instance, as well as the type of hypervisor being deployed. In cloud environments, both non-virtualised servers and virtualised servers, with many virtual machines on a single virtualised server, are deployed. The increasing migration of workloads and compute instances from end-user devices to remotely located servers and from premises-based networks to cloud networks creates new network requirements for operators of both traditional and cloud data centre environments (Cisco, 2018).

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Chapter 5

UNLEASHING INNOVATION

Investment in knowledge is key to driving and adapting to the digital transformation. Among other things, this can take the form of investment in education, information and communication technologies (ICT) and in intangible assets such as Software, and Research and Development (R&D).

Tertiary education has expanded worldwide to support the supply of highly educated individuals and to meet rising demand for skills, especially cognitive skills. Policy makers are particularly focused on the supply of scientists, engineers and ICT experts, because of their direct involvement in technical change and the ongoing digital transformation (OECD, 2017a). In 2016, 23% of students graduating at tertiary level within the OECD did so with a degree in the natural sciences, engineering, and information and communication technologies (NSE & ICTs, which includes qualifications in mathematics and statistics). NSE and ICT graduates accounted for around one-third of all tertiary graduates in Germany and India.

In the OECD area, 31% of graduates in NSE & ICT in 2016 were women. This indicates considerable under-representation compared to men. Shares range from 16% in Japan and 18% in Chile to 43% in India and 44% in Poland, the countries closest to achieving gender parity in this area.

Investment in knowledge-based capital as recorded in National Accounts (KBC), which includes Software and databases alongside R&D and other intellectual property products, is an important element of the knowledge base. Computer software and databases (which excludes the value of any data therein) constitute the main component of ICT investment in most countries, ranging from 23% of total ICT investment in Latvia to 86% in France. Comparing 2016 to 2006, OECD investment in ICT assets remained stable at 2.4% of GDP. This stability, at a time of on-going digital transformation, might be explained *in part* by decreasing prices of ICT products and by substitution between capital investment and purchases of cloud computing and other ICT services, which allow users to access software, storage, processing power and other systems through the Internet without buying ICT assets outright.

Software and databases account for below half of KBC investment in most countries. On average across the OECD, 62% consists of "R&D and other intellectual property products", which include Creative, artistic and literary originals. Typically, investment in R&D assets is the vast majority; these accumulate both as a result of R&D being conducted in the country and from R&D assets being imported (often in the form of patented entities).

As an activity defined by the pursuit of new knowledge, R&D is an important facet of the knowledge base that helps to bring about advances in digital technologies. Businesses are the main drivers of R&D performance, with 2016 R&D expenditures equivalent to 1.6% of GDP, on average, in the OECD area and as much as 3.3% in Korea and 3.8% in Israel. Information industries are particularly strong contributors in these countries, accounting for just over half of all business R&D. Information industries also represent over 40% of business R&D in Estonia, Finland, the United States, Turkey and Ireland, further confirming the knowledge-intensive nature of these industries.

DID YOU KNOW?

In India there are almost 600 000 tertiary ICT graduates a year, about five times as many as in the United States.

Definitions

The *natural sciences, engineering and ICT* fields of study correspond to the following fields in the International Standard Classification of Education (ISCED) 2013 classification: 05 Natural sciences, mathematics and statistics; 06 Information and Communication Technologies; and 07 Engineering, manufacturing and construction.

Tertiary level graduates are individuals that have obtained a degree at ISCED-2011 Levels 5 to 8 in the given year (2016).

ICT investment refers to gross fixed capital formation (GFCF) of "information and communication equipment" and "computer software and databases". The value of data *within* databases is not included.

Business expenditure on R&D (BERD) includes all expenditure on R&D performed by business enterprises, irrespective of funding sources.

Information industries includes ICT manufacturing and information services i.e. ISIC Rev.4 Divisions 26 and 58 to 63. See page 2.1 for more detail.

Measurability

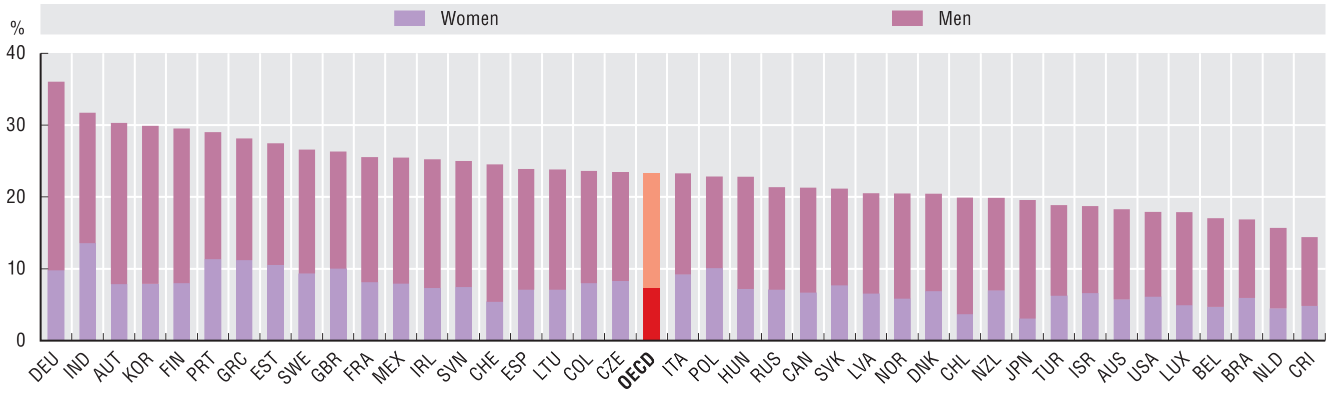
Indicators on graduates by field of education are computed on the basis of annual data jointly collected by the UNESCO Institute for Statistics, the OECD and Eurostat. The data collection aims to provide internationally comparable information on key aspects of education systems in more than 60 countries worldwide http://www.oecd.org/education/database.htm.

The value of *ICT investment* comes from National Accounts. However, the availability and timeliness of detailed capital formation data varies. In particular, some economies do not isolate all ICT items, resulting in under-estimation.

BERD is measured through official surveys on the volume and nature of businesses' R&D expenditures. The surveys, or related sources such as business registers, also provide relevant contextual information such as the number of persons employed and the main productive activity undertaken (i.e. main source of value added). This is the primary way in which R&D activities are classified to industries, as recommended in the OECD Frascati Manual 2015 (http://oe.cd/frascati).

Tertiary graduates in natural sciences, engineering and ICTs (NSE & ICT), by gender, 2016

As a percentage of all tertiary graduates



Source: OECD calculations based on OECD, Education Database, September 2018.

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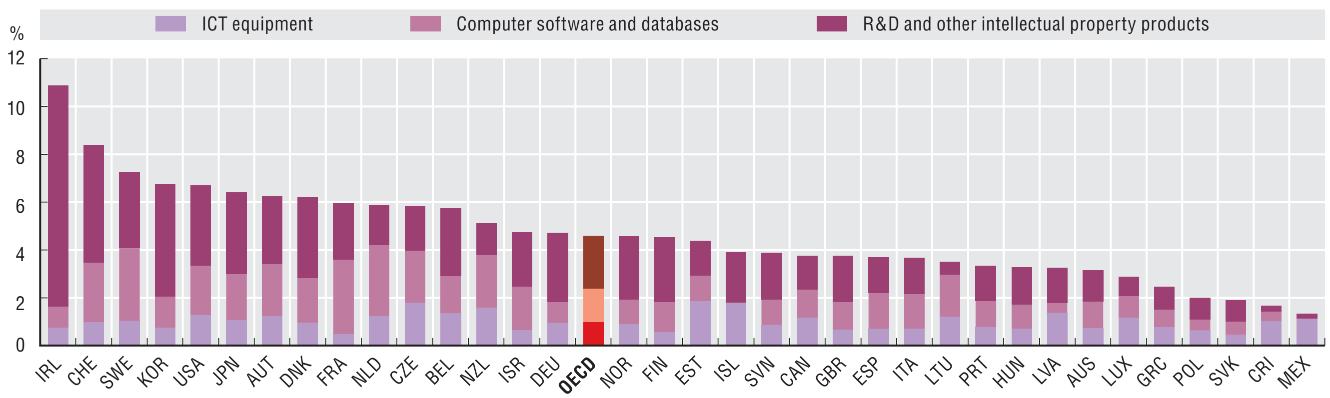
Investment in ICT equipment, computer software and databases, R&D and other intellectual property products, 2017

As a percentage of GDP



Source: OECD, National Accounts Statistics; Eurostat, National Accounts Statistics and national sources, February 2019. See chapter notes. StatLink contains more data.

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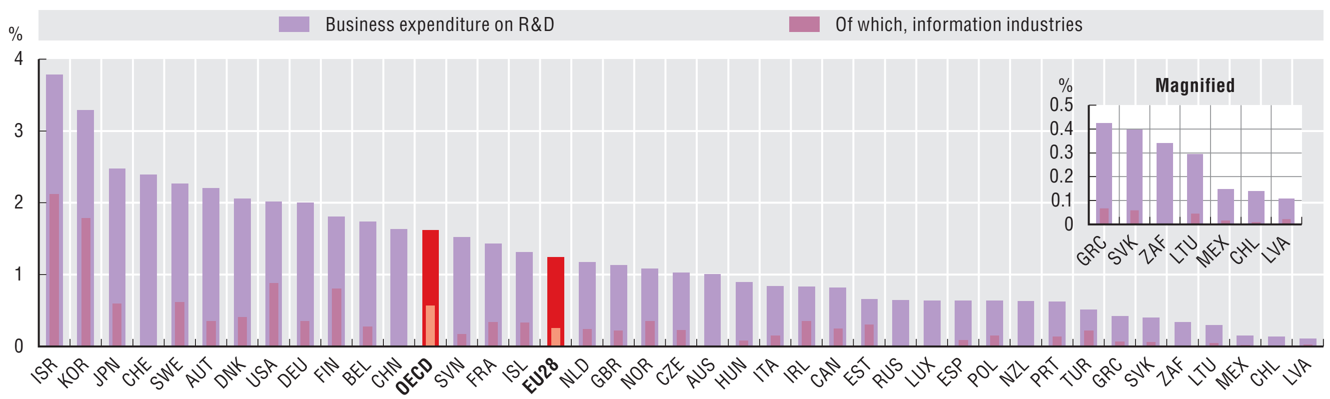
Business R&D expenditure, total and information industries, 2016

As a percentage of GDP



Source: OECD, ANBERD Database, http://oe.cd/anberd, December 2018, and Main Science and Technology Indicators Database, http://oe.cd/msti, July 2018. See chapter notes. StatLink contains more data.

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Advances in scientific knowledge are key to developing new digital technologies. Over the last decade, China almost trebled its contribution to computer science journals, overtaking the United States in the production of scientific documents in this field. However, the share of documents that are in the world's top-cited (top 10% normalised by type of document and field) is still close to 7%, less than the world average and well below the United States at 17%. The rate of computer science publications from China which are highly cited has nonetheless more than doubled since 2006, making China the second-largest producer worldwide. In some countries, such as Italy, Israel, Luxembourg and Poland, the production of scientific research in the field of computer science carries a much higher relative citation rate compared to overall scientific production within those countries. Nearly 20% of computer science publications by Switzerland-based authors feature among the world top-10% cited scientific documents. This figure reaches 25% for Luxembourg although with a much smaller level of scientific production.

Scientific activity makes intensive use of digital tools and generates digital assets in the form of new data and software. A new 2018 OECD pilot survey, the International Survey of Scientific Authors (ISSA), focuses on measuring the digitalisation of science. Preliminary findings show that, on average, 60% or more of scientific publications generate new data and new software codes. Countries with higher levels of R&D intensity are, on average, also more likely to report high shares of scientific production that generate new computer code, either alone or in combination with new data. More than 45% of survey respondents resident in Korea reported developing new code, mostly in combination with data, compared to 20% in Mexico. Data generation is more widespread and evenly distributed. In computer science and decision sciences, more than 50% of respondents generate code, closely followed by physics and astronomy. Code generation is least common in the arts and humanities, and in chemistry, at less than 10% of respondents.

Scientific research represents an important foundation for technological advancement and innovation. By identifying non-patent literature, in particular scientific articles, cited in patent documents, it is possible to gain insights into linkages between scientific progress and new inventions. Digital technologies build mostly on digital-related science, with electrical or information engineering articles cited in 37% of digital patents and computer and information sciences articles cited in 20%. However, digital technologies can be applied in a wide range of fields and therefore, digital patented technologies also draw on scientific production from a broad variety of other areas, especially the physical sciences (12%) and various medical domains, in addition to art, languages and others.

DID YOU KNOW?

The United States accounted for around 70% more top-cited scientific publications on computer science than China in 2016. This gap has shrunk from nearly 500% in 2006.

Definitions

Computer science publications consist of citeable documents (articles, conference proceedings and reviews) featured in journals specialising in this field. "Top-cited publications" are the 10% most-cited papers normalised by scientific field and type of document (OECD and SCImago Research Group, 2016).

Research data include numerical scores, textual records, images and sounds that can be used as primary sources for scientific research. *Code* includes custom-developed software and code, laboratory notebooks and other computer-enabled documents describing every step of the research work and protocols followed.

Digital (ICT) patent families are identified using the list of IPC codes in Inaba and Squicciarini (2017).

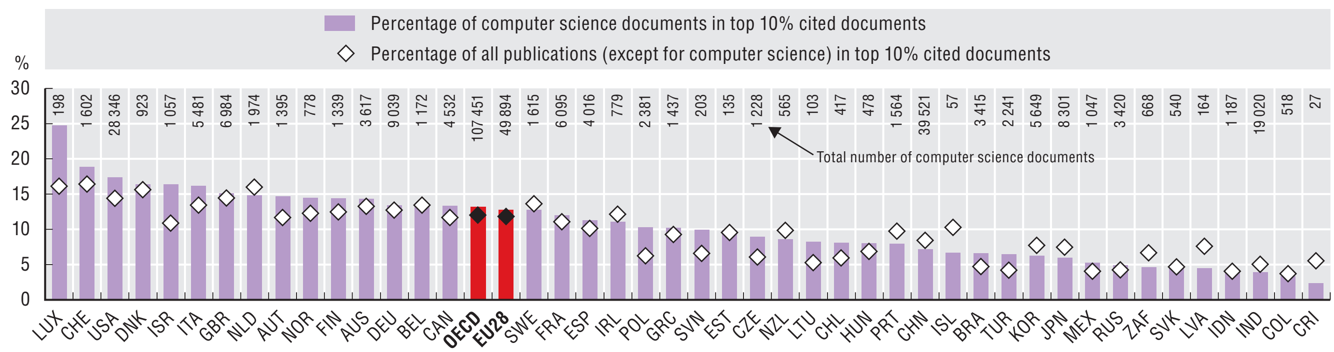
Measurability

Identifying the digital-related content of research outputs is a major challenge. Bibliographic indices provide a readily available source of data for illustrative purposes, though with interpretability and coverage limitations. Using publishers' journal classifications would lead to understatement of the digital intensity of science due to the pervasiveness of digital research. Alternatives are scanning publications for content or directly contacting authors. The OECD ISSA 2018 survey does the latter approach in order to gather insights on the use of digital tools and the contribution of science to the digitalisation process (see page 5.6). It should be noted, however, that not all so-called "data scientists" publish in scholarly journals, which form the basis for identifying and contacting authors.

Published patent documents contain references to prior art on which inventions rely, including previous patents and non-patent literature (NPL). Analysing the link between patents and scientific literature cited in patent documents helps to uncover the links between science and innovation. The Max Planck Digital Library has developed robust methods to link NPL with scientific reference data (see Knaus and Palzenberger, 2018). This analysis is based on data elaborated by the Max Planck Institute for Innovation and Competition using information provided in the Clarivate Web of Science (see Poege et al., 2018).

Top 10% most-cited documents in computer science by country, 2016

As a percentage of documents in the top 10% ranked documents, by field, fractional counts



Source: OECD calculations based on Scopus Custom Data, Elsevier, Version 1.2018; and 2018 Scimago Journal Rank from the Scopus journal title list (accessed March 2018), January 2019. See chapter notes. StatLink contains more data.

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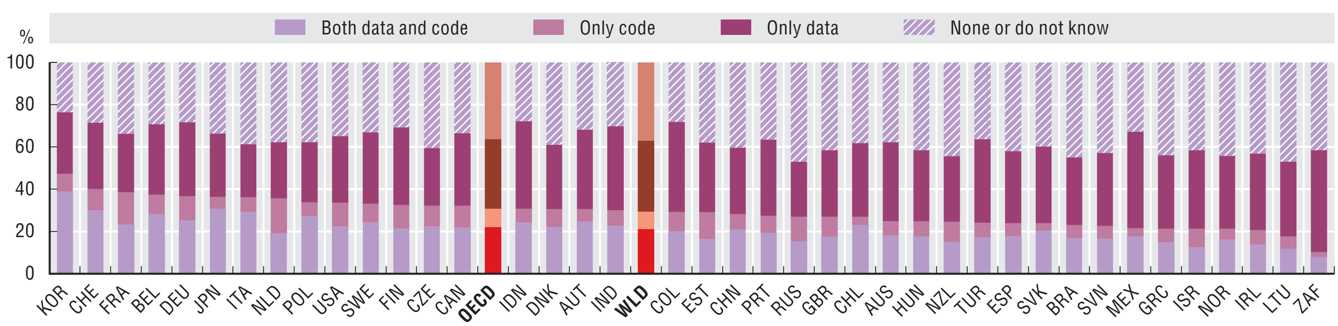
Scientific production resulting in new data or code, by country of residence, 2017

As a percentage of responses to the ISSA 2018 survey



Source: OECD, International Survey of Scientific Authors (ISSA) 2018, preliminary results, http://oe.cd/issa, December 2018. See chapter notes. StatLink contains more data.

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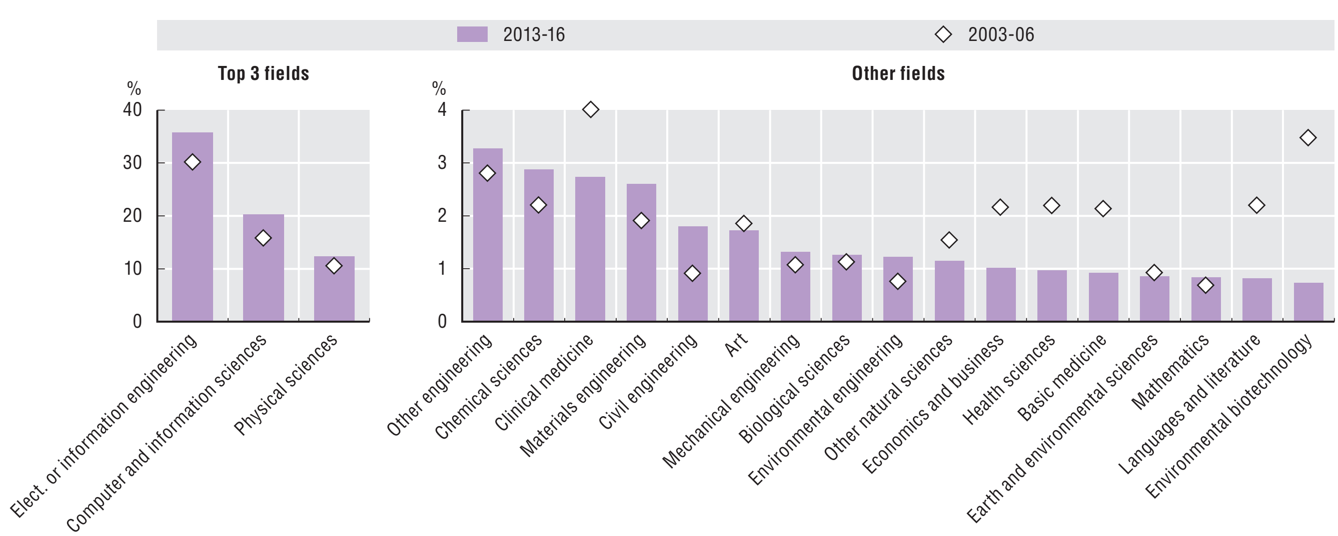
Scientific knowledge embedded in digital patents, by scientific fields, 2003-06 and 2013-16

Distribution of top 20 fields of scientific articles cited by IP5 patent families in ICT



Source: OECD calculations based on data elaboration courtesy of the Max Planck Institute for Innovation and Competition, and OECD, STI Micro-data Lab: Intellectual Property Database, http://oe.cd/ipstats, December 2018. See chapter notes. StatLink contains more data.

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Competing in information and communication technology (ICT) markets worldwide requires innovations and technological developments to be bundled with appealing designs, while ensuring that consumers are able to recognise the new and often complex products on offer.

Over 2013-16, digital-related technologies, as proxied by patents, accounted for about 33% of all IP5 patent families filed by OECD countries, representing a slight decrease on the share observed a decade earlier (36%). In contrast, China increased its share of ICT patent families by one-quarter and its IP5 patent portfolio became the most specialised in ICT. In the Russian Federation, India and Portugal, the share of patents related to ICT more than doubled, and it increased by almost two-thirds in Ireland, also due to the several technology companies establishing operations there.

A comparison of design patents that protect the "look and feel of products" filed between 2004-07 and 2014-17 in the United States, shows the importance of ICT product design. ICT designs grew slightly in the US market, relative to designs in general (+0.1 percentage point). In contrast, they declined as a share of all design filings in Europe (-0.8 percentage points) and in Japan (-2.5 percentage points).

Meanwhile, China doubled its share of ICT design patents filed in the United States (from 13% to 26%), increased its share of ICT designs registered in Japan by almost a third (to 21%) and maintained its registered design share in European markets (16%). This illustrates how China has moved beyond ICT manufacture to include design.

The share of trademarks that are ICT-related and registered by organisations in OECD countries grew in all markets considered. The highest increase was observed in 2014-17 in the European market (up 6 percentage points to 37% from 2004-07), with similar growth in the US market (up 5 percentage points to 24%), and a very strong increase in trademarks filed in the Japanese market (up 23 percentage points to 36%).

Overall, OECD countries seem to move progressively towards ICT IP bundling strategies, which place relatively more emphasis on the look and feel of products and on extracting value from branding. Conversely, BRIICS countries, in particular China, India and the Russian Federation, appear to be pursuing technological catch-up strategies, and to protect their products through designs and brands (OECD, 2017a).

DID YOU KNOW?

Digital assets represent 55% to 65% of the portfolio of protected intellectual property owned in Korea, comprising patents, trademarks and design rights.

Definitions

Patents protect technological inventions (i.e. products or processes providing new ways of doing something or new technological solutions to problems). *IP5 patent families* are patents filed in at least two offices worldwide, including one of the five largest IP offices: the European Patent Office (EPO), the Japan Patent Office (JPO), the Korean Intellectual Property Office (KIPO), the US Patent and Trademark Office (USPTO) and the National Intellectual Property Administration of People's Republic of China (NIPA).

Patents in digital-related technologies are identified using International Patent Classification (IPC) codes (see Inaba and Squicciarini, 2017).

Designs protect new and/or original shapes, configurations or ornamental aspects of products.

Trademarks are distinctive signs, (e.g. words and symbols), used to identify the goods or services of a firm from those of its competitors.

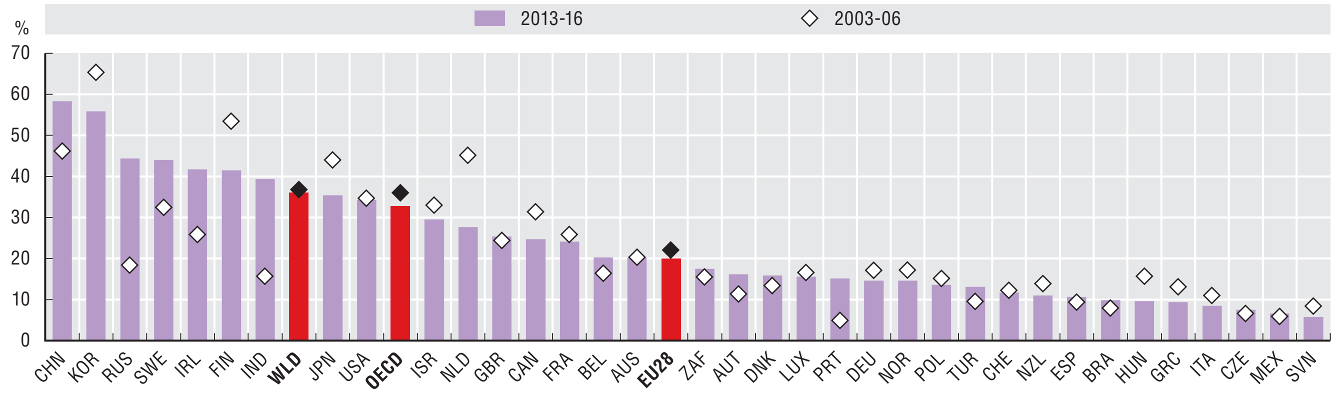
ICT-related designs and trademarks are identified following an experimental OECD approach based on the WIPO Locarno and Nice Classifications, respectively, and combine a normative approach with the use of ICT-related keywords.

Measurability

Intellectual property (IP) rights follow a territoriality principle. Patents, designs and trademarks are protected only in the countries where they are registered. Using information on the priority date of patents (i.e. the date of the first filing of a patent, which has subsequently been filed in other IP jurisdictions, thus extending the geographical scope of protection), allows for the reconstruction of patent families and avoids duplications when counting IP assets. The same cannot be done for trademarks and designs, as information about identical registrations is seldom available. In the United States, designs are protected through design patents (at the USPTO), whereas in Europe (e.g. at the European Union Intellectual Property Office, EUIPO) and in Japan (at the JPO), designs are protected through the registration of industrial designs. As opposed to the case of patents, data availability constraints do not allow for the reconstruction of design and trademark portfolios protected at the IP5 offices.

Patents in ICT-related technologies, 2003-06 and 2013-16

As a percentage of total IP5 patent families, by country of ownership



Source: OECD, STI Micro-data Lab: Intellectual Property Database, http://oe.cd/ipstats, November 2018. See chapter notes. StatLink contains more data.

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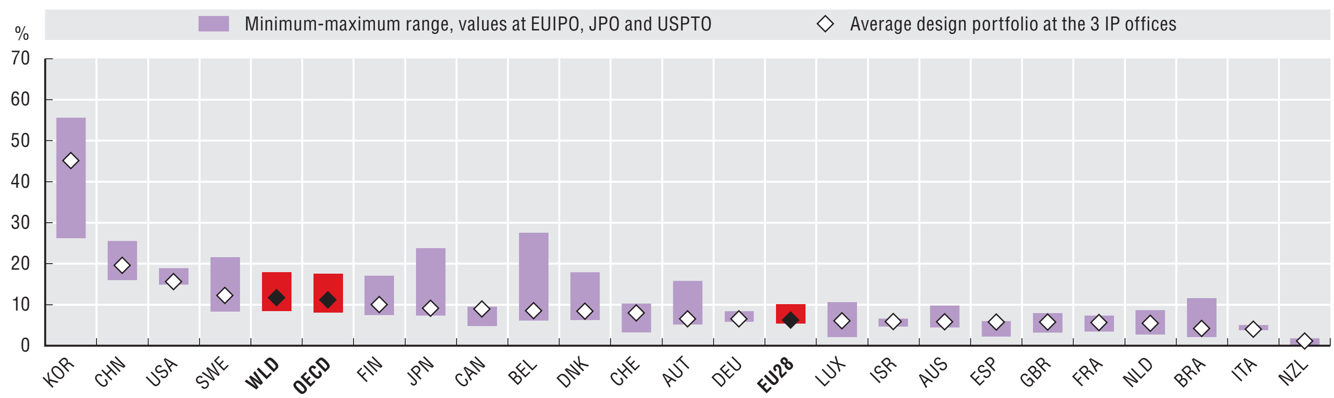
ICT-related designs, 2014-17

As a percentage of total designs, EUIPO, JPO and USPTO



Source: OECD, STI Micro-data Lab: Intellectual Property Database, http://oe.cd/ipstats, September 2018. See chapter notes. StatLink contains more data.

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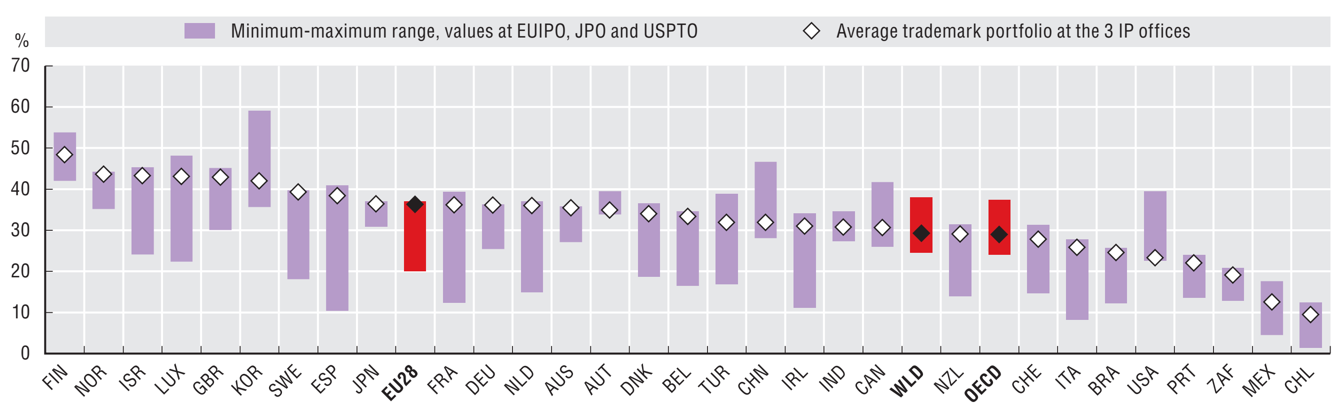
ICT-related trademarks, 2014-17

As a percentage of total trademarks, EUIPO, JPO and USPTO



Source: OECD, STI Micro-data Lab: Intellectual Property Database, http://oe.cd/ipstats, September 2018. See chapter notes. StatLink contains more data.

StatLink https://doi.org/10.1787/888933930326

Digitalisation and the diffusion of information and communication technologies (ICTs) have revolutionised the way in which firms and markets operate, with important differences in business dynamism between digital-intensive and other sectors of the economy. Higher levels of business dynamism are associated with higher productivity. Analysis based on the OECD *DynEmp3* database shows that digital-intensive sectors are, on average, characterised by higher business dynamism, as indicated by higher job reallocation rates and a larger share of young firms (see Calvino and Criscuolo, 2019 for further discussion).

In order to assess the role of market entry and business dynamism in top digital-intensive sectors, three key indicators have been analysed: average firm entry rates, exit rates and post-entry employment growth of entrants after five years. Digital-intensive sectors have higher entry rates than average in all countries analysed. They also have higher exit rates in most countries considered, though the magnitude of these differences is smaller than for entry rates. Cross-country differences in the sample are significant. Austria, the Netherlands and Turkey show the highest differences between the highly digital-intensive and all sectors of the economy.

Examination of the average post-entry employment growth of new firms five years after entry shows that surviving entrants in highly digital-intensive sectors grow faster, on average, than those in other sectors of the economy. Although this is true for most countries, the magnitude of the difference varies. The largest differences occur in Costa Rica, Portugal and Finland, whereas differences are smaller in Hungary, Turkey, the Netherlands and Japan.

Higher business dynamism in sectors characterised by stronger digital intensities is likely related to the diffusion of digital technologies, with the associated emergence of a wide range of new applications and business models. This is also consistent with the fact that these technologies have lower entry barriers and tend to facilitate interaction, information flows and access to markets, thus creating more opportunities for experimentation. ICTs are highly pervasive general-purpose technologies that stimulate entry and innovation not only in sectors producing them, but also in other digital-intensive sectors.

Access to finance for new and innovative firms involves both debt and equity finance. Venture capital (VC) is an important source of equity funding, especially for young technology-based firms. Available industry level data show that VC investments in 2017 were concentrated in the ICT sector in many countries, especially Lithuania, Luxembourg, Spain, the United Kingdom and the United States. The latter represents the biggest market for VC, where four in every ten dollars of VC went to the ICT sector, amounting to 0.17% of GDP.

DID YOU KNOW?

The most digital-intensive sectors are often more dynamic and scale-up faster than other sectors of the economy.

Definitions

Entry rates are the number of entering units divided by the number of entering and incumbent units.

Exit rates are the number of exiting units over the number of exiting and incumbent units.

Post-entry employment growth is the ratio between total employment at time $t + 5$ over total employment at time t of surviving entrants.

Highly digital-intensive sectors are those in the upper ("high") quartile of the distribution by digital intensity. They consist of Computer and electronics; Machinery and equipment; Transport equipment; Telecommunications; IT; Legal and accounting; Scientific R&D; Marketing and other business services; and Administrative and support services. See Calvino et al. (2018), Table 3.

Venture capital is private capital provided by specialised firms acting as intermediaries between primary sources of finance (insurance, pension funds, banks, etc.), private start-up and high-growth companies, with shares that are not freely traded on any stock market.

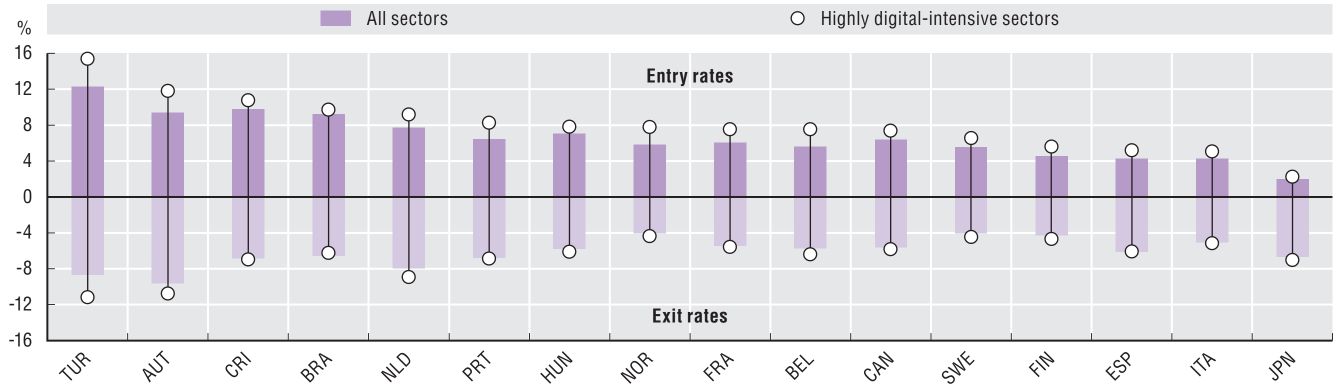
Measurability

The figures report unweighted averages across sectors and available years for the period 1998-2015 in the "Highly digital-intensive" and "All sectors" groups using "transition matrices" or yearly flow data from the OECD *DynEmp3* database. The "transition matrices" summarise growth trajectories of cohorts of units from year t to year $t + j$. The analysis focuses on cohorts of entrants followed for five years (with t = 1998, 2001, 2004, 2007, 2010 and j = 5). Figures are based on manufacturing and non-financial market services, with the exception of Japan where only manufacturing data are available. Self-employment and the Coke and Real estate sectors are excluded from the analysis. A detailed coverage table is available in Calvino and Criscuolo (2019).

Data on venture capital are drawn from national or regional venture capital associations and commercial data providers. There is no standard international definition of venture capital or breakdown by stage of development. The OECD Entrepreneurship Financing Database aggregates original data to fit the OECD classification of venture capital by stages. Venture capital investment is influenced by differences in tax and innovation incentive regimes across countries.

Business dynamism, average entry and exit rates, 1998-2015

Highly digital-intensive and all sectors

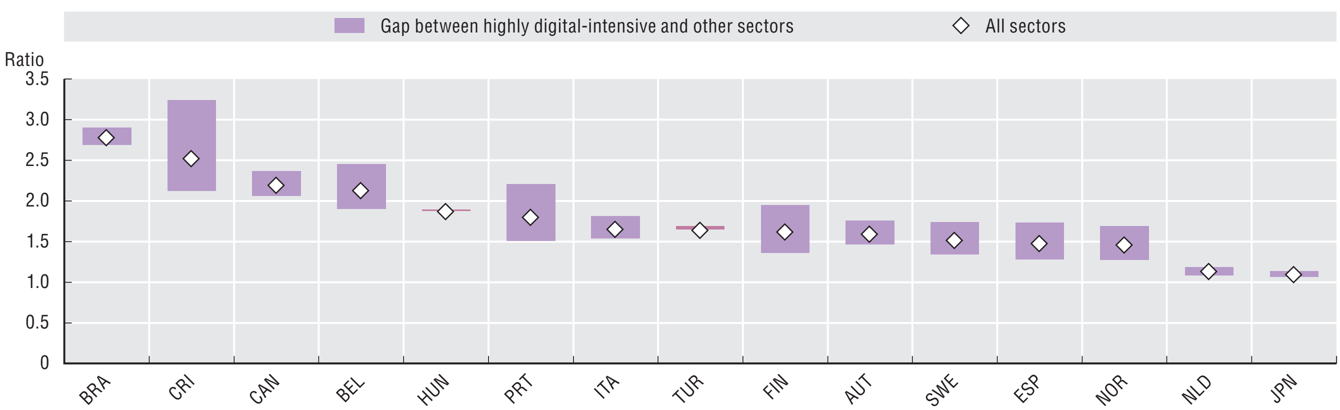


Source: OECD calculations based on DynEmp3 Database, http://oe.cd/dynemp, January 2019. See chapter notes.

StatLink https://doi.org/10.1787/888933930345

Business dynamism, average post-entry employment growth, 1998-2015

Highly digital-intensive and all sectors

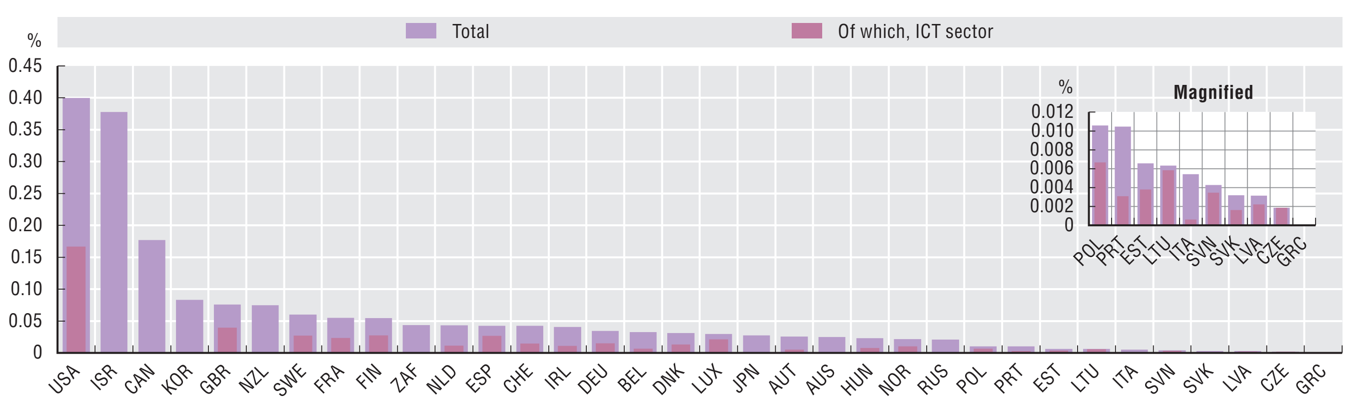


Source: OECD calculations based on DynEmp3 Database, http://oe.cd/dynemp, January 2019. See chapter notes.

StatLink https://doi.org/10.1787/888933930364

Venture capital investment in the ICT sector, 2017

As a percentage of GDP



Source: OECD, Entrepreneurship Financing Database, November 2018. See chapter notes.

StatLink https://doi.org/10.1787/888933930383

Technology is profoundly influencing government openness. Rapid technological progress has significantly increased the amount of data generated in societies, including by government organisations. Open government data (OGD) can be used to strengthen public governance by improving the design of public services with a citizen-driven approach, enhancing public sector efficiency and responsiveness, and spurring public sector integrity and accountability. By ensuring OGD availability, accessibility and use by public, private and civic actors, governments can design more evidence-based and inclusive policies, stimulate innovation inside and outside the public sector, motivate data-driven civic engagement, better-inform citizens' personal decisions and enhance public trust. Making data and evidence available across government departments and ministries contributes to better policy making, greater coordination and empowers businesses and civil society to also contribute.

The OECD Open-Useful-Reusable government data (OURdata) index measures government efforts to promote data availability and accessibility, and to stimulate data use and re-use outside and inside government. France, the United Kingdom and Korea are particularly advanced in promoting OGD, while some other countries still have yet to meet OGD best practices (see OECD, 2017b).

Most countries have "open-by-default" policies, thus scoring relatively highly for data accessibility (0.2 on average in the OECD out of a potential 0.33). Provisions for accessibility also score relatively highly in most countries (0.22 on average). However, the extent of central/federal initiatives to promote data re-use (such as "hackathons" and co-creation events) and inside governments (via training and information sessions for civil servants) varies greatly and is reflected in relatively weaker scores for government support for re-use (0.12 on average). Moreover, few countries monitor the economic and social impact of open data, as well as the impact of open data on public sector performance, with Korea as a notable exception. Most OECD governments regularly consult stakeholders on data needs, but few have developed a central/federal data portal as an exchange, collaboration and crowdsourcing platform where users can provide feedback for continuous improvement. Such consultations may also include representatives of the citizens to whom much data held by governments relates directly or indirectly. This offers the chance for concerns citizens may have about governments holding and "opening" such data (e.g. in relation to privacy) to be aired and addressed. Empowering users and supporting platforms of exchange among businesses, civil society and government organisations is a key next step to promoting re-use and achieving positive impacts.

The Global Open Data Index (GODI) provides a complementary view on the extent to which government data in 15 key areas are open. Government budgets, national statistics, procurement and national laws are generally the most openly available, while water quality, government spending and land ownership information are among the least open.

DID YOU KNOW?

Korea and France have the most developed systems for promoting open government data availability, accessibility and re-usability.

Definitions

Government data include data held by national, regional, local and city governments, international government bodies and other public institutions.

The OURdata index takes a maximum value of 1 when a country has measures across all of the component dimensions and a value of 0 when no measures exist.

Data availability summarises the content of the government's open-by-default policy, stakeholder engagement for the prioritisation of data release and the availability of strategic open government data (OGD) on national portals (e.g. national election results, national public expenditures and, national censuses).

Data accessibility summarises the availability and implementation of formal requirements relating to the publication of OGD, with an open licence, in open formats and with descriptive metadata, as well as stakeholder engagement to improve data quality.

Data reusability summarises the existence of policies for re-use. These consist of: active *data promotion initiatives and partnerships*, such as through events targeting different groups of (potential) users; *data literacy programmes in government*, which encourage public servants to utilise open government data, and *monitoring of impacts* on public sector performance or wider social/economic impacts.

Open data and content can be freely used, modified and shared by anyone for any purpose. The Global Open Data Index (GODI) assesses government data in 15 key areas from government spending to weather forecasts, and takes a maximum value of 100 when data are openly licenced, machine readable, easily downloadable, up-to-date and free of charge.

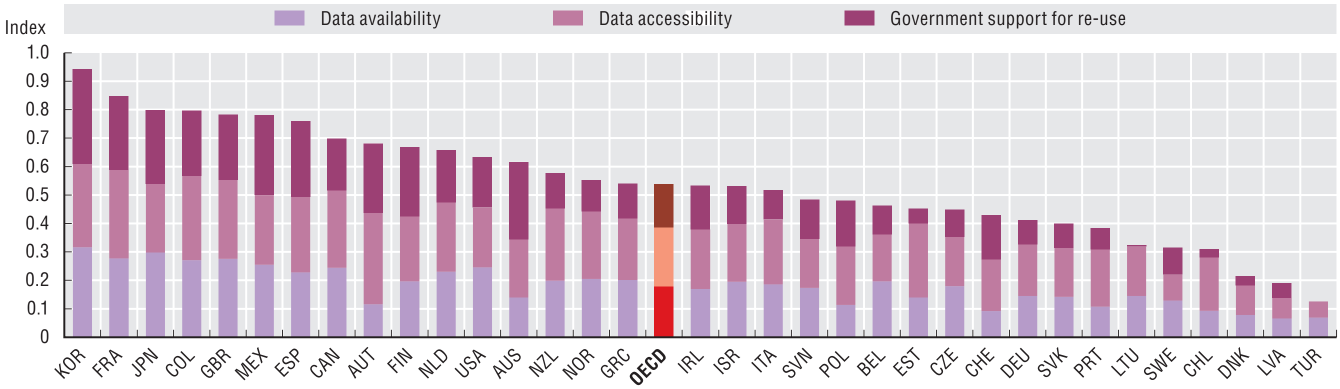
Measurability

The OECD Survey on open Government Data was conducted in late 2016. Responses, predominantly from chief information officers in OECD countries, provided evidence of current practices and procedures regarding OGD, which were then analysed to ensure the soundness of the results. The dataset comprises 140 data points, which refer only to central/federal government. See OECD, 2017b.

The GODI is crowdsourced from civil society participants and individually assesses the openness of government data in 15 key areas. For full information see: https://index.okfn.org/about/.

Open-Useful-Reusable Government Data Index, 2017

1.0 = all openness criteria met

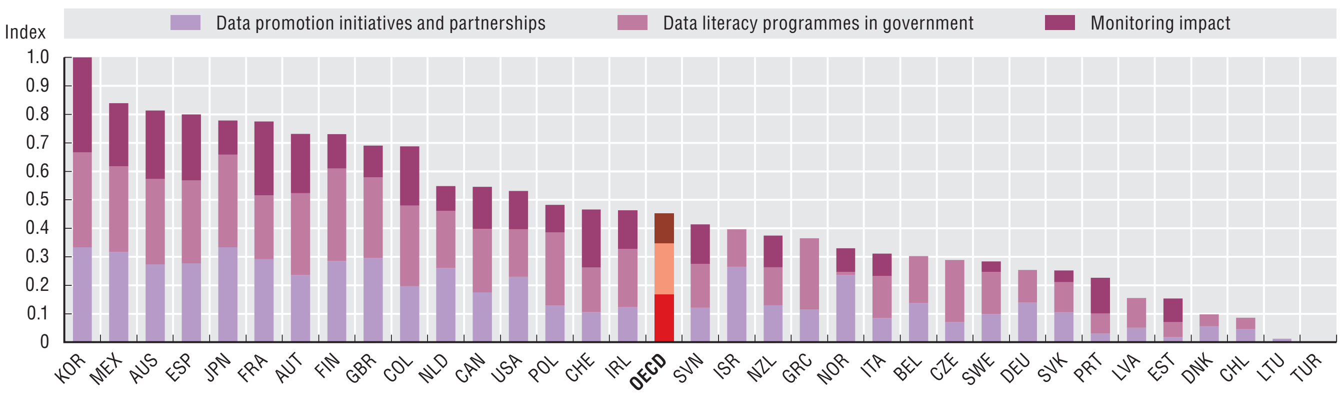


Source: OECD (2018). See chapter notes.

StatLink https://doi.org/10.1787/888933930402

Useful government data, government support for data re-use, 2017

1.0 = all openness criteria met

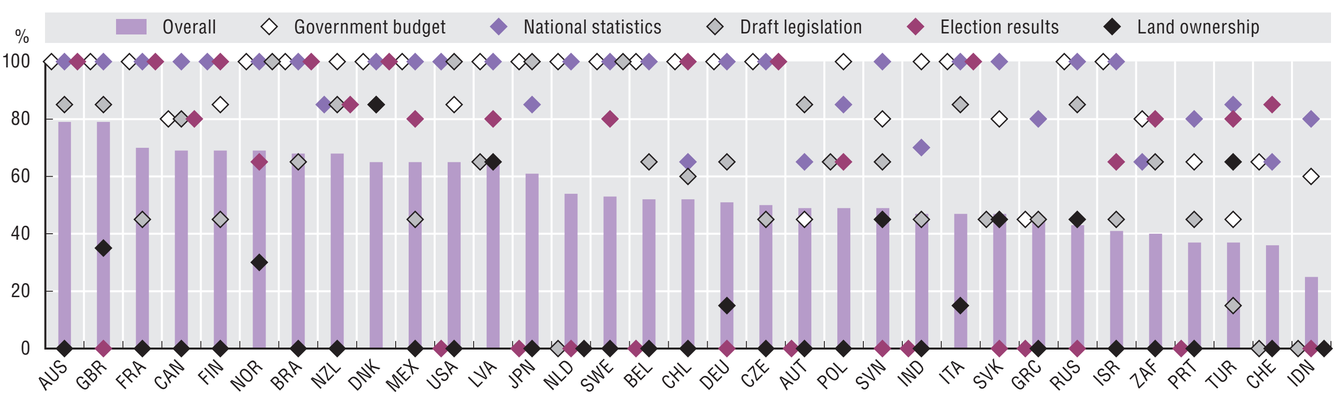


Source: OECD (2018). See chapter notes.

StatLink https://doi.org/10.1787/888933930421

Global Open Data Index, total and selected categories, 2016

100 = all openness criteria met



Source: OECD, based on Open Knowledge International, http://index.okfn.org, October 2018. See chapter notes.

StatLink https://doi.org/10.1787/888933930440

Why are indicators on the digitalisation of scientific research needed?

Ministers from OECD countries and partners meeting at the OECD Ministerial Meeting held in Daejeon (Korea) in 2015 recognised in their joint declaration (www.oecd.org/sti/daejeon-declaration-2015.htm) that science, technology and innovation (STI) are being revolutionised by the rapid evolution of digital technologies. These technologies are changing the way in which scientists work, collaborate and publish; increasing the reliance on access to scientific data and publications; opening new avenues for public engagement and participation in science and innovation; facilitating the development of research co-operation between businesses and the public sector; and contributing to the transformation of innovation. The OECD was asked to monitor this transformation and invited to convene the international community working on STI data and indicators to develop new thinking and solutions for empirical evidence to guide policy. The 2016 OECD Blue Sky Forum (http://oe.cd/blue-sky) identified the digitalisation of STI both as a priority object of measurement and as a fundamental enabler of future statistical and analytical work (OECD, 2018).

What are the challenges?

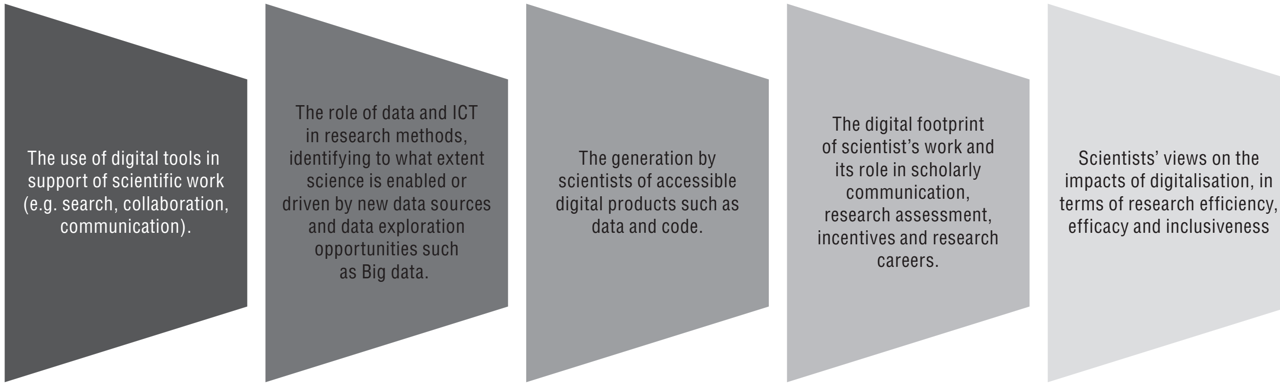
Tracing the resources invested in expanding knowledge of the possibilities of digitalisation and their outputs requires data infrastructures with a wider scope that provide high levels of detail. Research domains evolve over time and new paradigms emerge that draw upon existing research. Conventional practices and categories, though necessary, are not sufficient to track the digitalisation of research and its impact on digital transformation. New text- mining tools enable the extraction of relevant information from qualitative sources to produce indicators about the nature, method and purpose of research. Provided the underlying data are sufficiently rich and comprehensive and the use of the mining techniques is sound, it is possible to estimate with some accuracy the share of scientific production related to topics such as AI or the percentage of funding agency support for R&D projects that makes use of AI tools. However, the databases that can in principle support this type of analysis are often fragmented, difficult to gain access to, and challenging to combine and use.

Data users increasingly demand access to a very fine-grained level of detail that can be hard to reconcile with the preservation of confidentiality and, depending on the way in which data are used to inform decisions, may induce selective disclosure of information by individuals or organisations, if this is in their interest. Because project funding and career decisions are influenced by quantitative indicators, a roadmap for science measurement in the digital age has to address the potential trade-off between reconciling data availability and integrity arising from exploiting new sources. Another key challenge is to connect measures of science digitalisation to policy measures.

Options for international action

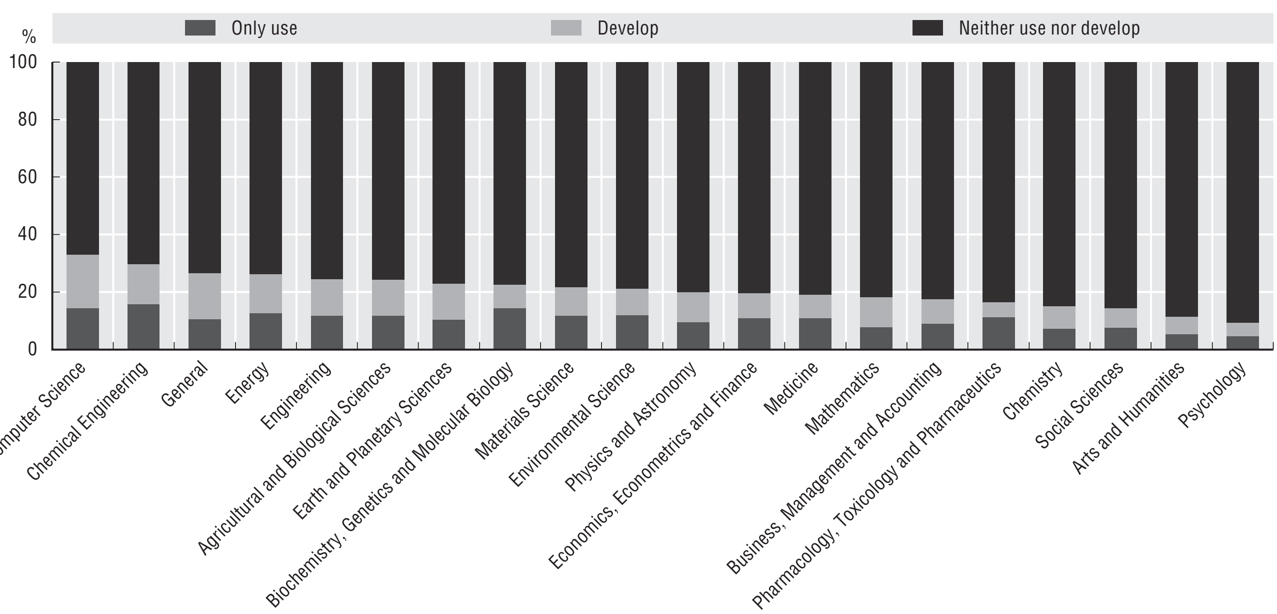
Initiatives to leverage information captured by digital systems to measure both scientific research and its digital transformation has been supported by consortia of independent non-profit organisations, academia and business that promote the growing adoption of standards. These standards target digital objects that capture multiple dimensions of scientific activity, such as documents, projects, data and code, allowing them to be persistently identified and retrieved, and also enabling them to be interpreted, linked or attributed to individuals and their organisations. The ORCID identifier (https://orcid.org) is a salient example of the new data infrastructure about science and research, having attained high adoption rates among serving researchers, their organisations, and many publishers and research funders. Although the main motivation for STI data infrastructures with such features is to facilitate scientific and related management processes rather than statistics, these data can provide the basis for higher quality statistics and indicators. Administrative reporting requirements often set out the basis for what official surveys can collect from respondents. Different groups within the science and science management community can work to ensure the integrity of the information, but there are significant career and commercial interests at play, as well as co-ordination challenges.

Because of the current limitations of available sources of information about some rapidly evolving dimensions of science, the OECD has been experimenting with the development of a dedicated survey tool. The OECD International Study of Scientific Authors (ISSA) is a new global survey-based initiative that was first piloted in 2015 to explore the changing scientific publishing landscape; its 2018 edition examined how science is going digital. ISSA explores a range of key dimensions that are potentially relevant across all fields of science:



The ISSA 2018 results show that the digitalisation of science is not limited to scientific fields that specialise in computer science or IT engineering. They also indicate significant potential for greater IT adoption in general scholarly practice, as well as for harnessing the potential of data-driven research. The ISSA 2018 survey highlights potential limits to the adoption of the digital footprint of research as a basis for new science indicators.

Use and development of Big data across scientific domains, 2018



Source: OECD International Survey of Scientific Authors (ISSA), 2018, preliminary results, http://oe.cd/issa, January 2019. See chapter notes.

StatLink https://doi.org/10.1787/888933930459

The experience of the ISSA study confirms several of the challenges of conducting surveys in the digital age, especially when trying to ensure trust between data collector and respondent. The ISSA survey is ultimately an exploration mechanism aimed at developing working knowledge on emergent topics of high policy relevance. This can help provide a potential basis for distributed data collection within countries and a mechanism for ongoing dialogue between the OECD and the global science community.

Reference

OECD (2018), *OECD Science, Technology and Innovation Outlook 2018: Adapting to Technological and Societal Disruption*, OECD Publishing, Paris, https://doi.org/10.1787/sti_in_outlook-2018-en.

Why are indicators on open source software needed?

Software for which source code is public and can be freely copied, shared and modified is called "open source software" (OSS).[1] It is often co-authored using online version control repositories such as GitHub, and may also be bundled into a "package" and uploaded to a "package manager" platform, to be downloaded and re-used by others. There is an incentive to make code as abstract and re-useable as possible, be it within a single program, an organisation or even worldwide as it is inefficient to rewrite code repeatedly (Hunt and Thomas, 1999).

Open source innovation has become a ubiquitous element of digital innovation. Today, open source tools such as Apache servers, Linux operating systems and countless machine learning libraries underpin the functioning of the digital economy. Even market actors famous for proprietary software now see value in OSS. In 2018, Microsoft was the largest contributing organisation to open source projects on the GitHub platform (GitHub, 2018), and acquired it for USD 7.5 billion, while IBM bought Red Hat, an open source operating system, for USD 34 billion.

Despite its contribution to productivity gains in firms (Nagle, 2014), OSS, like other free assets, is a product provided at zero cost, and as such not recorded in the System of National Accounts. Accordingly, the capital services provided by these free assets are also valued with a zero price. Equally, an increasing number of academic outputs take the form of impactful software, which are not accounted for either.[2]

To better understand and measure how the digital transformation is shaping the economy, it is essential to gain insights on OSS. For this reason, the Digital Supply and Use Tables (see page 2.11) include a line for the product category "free services and assets", and as a consequence invite countries to develop methods to estimate the monetary value of these products.

What are the challenges?

Measuring OSS is fraught with conceptual and practical difficulties. Since it is generally the product of collaboration between a wide variety of actors, attributing credit for its creation is difficult, as is estimating its value. In addition, the data available from online sources may at times be incomplete or difficult to interpret.

Statistical frameworks such as the System of National Accounts typically require the identification of a producer and a consumer of an output, but this distinction is often blurred in the case of OSS. Open source developments rely on consumers being able to modify and improve software. Collaborative coding sites generally display projects hosted on a user or organisation's page, but the code itself may be authored by many other users, or even authored by one user and "committed" (approved) by another.

Furthermore, it is difficult to measure the quality of OSS contributions. Weighting them by the number of lines modified may to some extent help, but relies on the assumption that more is better (while it may in fact reflect less efficient programming). Possible alternatives consider the popularity suggested through users "starring" repositories to bookmark them and signal interest (as is done in GitHub); and by the numbers of times a software package is downloaded. Additional quality indicators could be built using information on dependencies between packages (i.e. packages requiring other packages to run), or by analysing actual coding scripts for the use of different packages.

Assigning a monetary value to code is also fraught with difficulty, given the potential diversity of software use and developers' profiles. Robbins et al. (2018) use a combination of average wages, intermediate inputs, capital service costs and lines of code, to estimate that OSS in four languages (R, Python, Julia and JavaScript) is worth USD 3 billion worldwide.

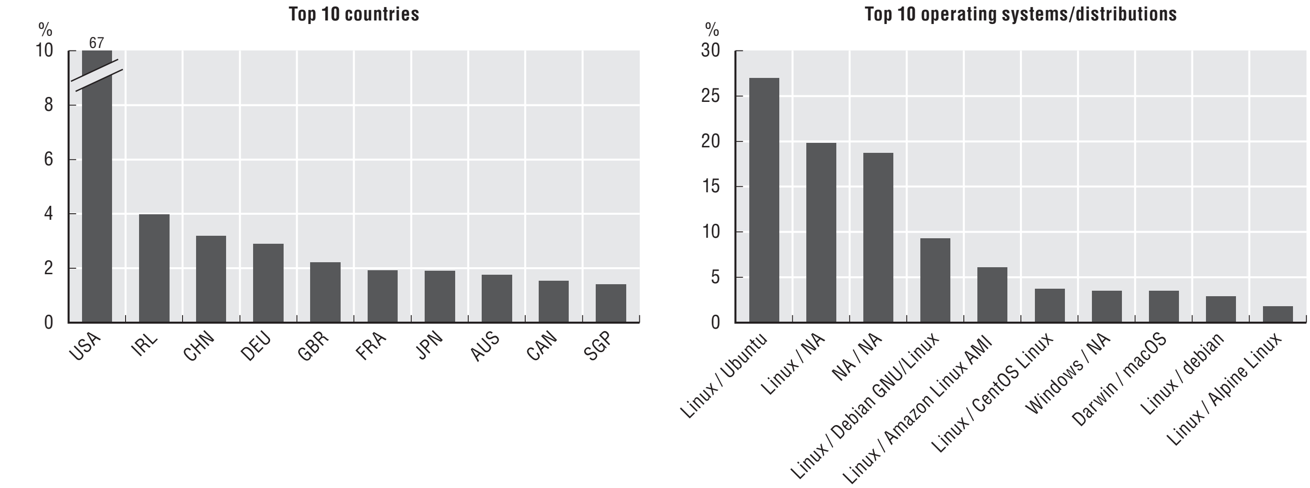
Additional measurement challenges include the sheer volume and quality of data available, and the fact that available data are unstructured, often incomplete, and require computing power and advanced programming skills to be collected and exploited. For instance, many platform users only make public a username rather than a full name, often without complementary information on their geographical location or affiliation.[3] In addition, geographical data obtained from IP addresses may not accurately reflect the location of users or producers due to the use of remote servers.

As an illustration, data suggests that downloaders of Python packages are most frequently located in the United States (over 65%), followed by Ireland and China. However, data on operating systems suggests that a significant share of downloads may come from remote cloud servers. This is most evident in the case of the Amazon Linux AMI distribution (over 6% of downloads), which is used on Amazon Web Services cloud servers. It is likely that the location of cloud servers contributes to making such country-level statistics inaccurate.

1. See the Open Source Initiative for a more comprehensive definition of open source software, https://opensource.org/osd-annotated.
2. Some efforts to track the academic contributions are conducted (see http://depsy.org).
3. Although this may sometimes be possible using data from package managers, as in OECD (2018).

Top 10 countries and operating systems/distributions, 2016-18

As a percentage of Python package downloads



Source: OECD, based on Pypi Database on Google BigQuery, accessed on 28 November 2018.

StatLink https://doi.org/10.1787/888933930478

Options for international action

Some actors (e.g. libraries.io) have begun to compile and harmonise data from different sources, thus contributing to addressing the challenge of dealing with a dizzying volume and variety of data sources. The OECD could work with these actors to pool and harmonise (some of) the datasets available, with the aim of obtaining country-level data for use in international comparisons.

The 2018 OECD Oslo Manual further proposes a potential survey question on knowledge flows that inquires whether an organisation made use of open source. The OECD International Survey of Scientific Authors 2018 also included questions relating to the development and sharing of code on online platforms and repositories (see page 5.6). The OECD could further help to develop expenditure-based and survey-based approaches, for assessing usage, time and cost spent on the development of open source software.

The OECD has already analysed open source software patterns by gender (OECD, 2018) and for artificial intelligence (OECD, forthcoming), and could work further to estimate the value and contribution of OSS to the digital transformation. Other potential avenues of work include understanding the spillovers triggered by open source collaboration networks, or the ways in which OSS output relates to other forms of science and innovation output, such as scientific publications and patents.

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Why use the Internet as a source for statistical data?

The Internet has become an indispensable infrastructure for economies and societies. An ever growing share of economic transactions, communication and information supply takes place online. Many of these online actions leave digital "footprints" that can be observed using tools that scan, gather, interpret, filter and organise information from across the Internet, providing a foundation for the use of the Internet as a statistical data source (IaSD). Online data may be of use in combination with, or as a substitute for, data collected by traditional instruments such as statistical surveys or off-line administrative sources. For example, online retailers' websites can be a useful source of information about prices while social media may provide information related to employment, population or societal wellbeing.

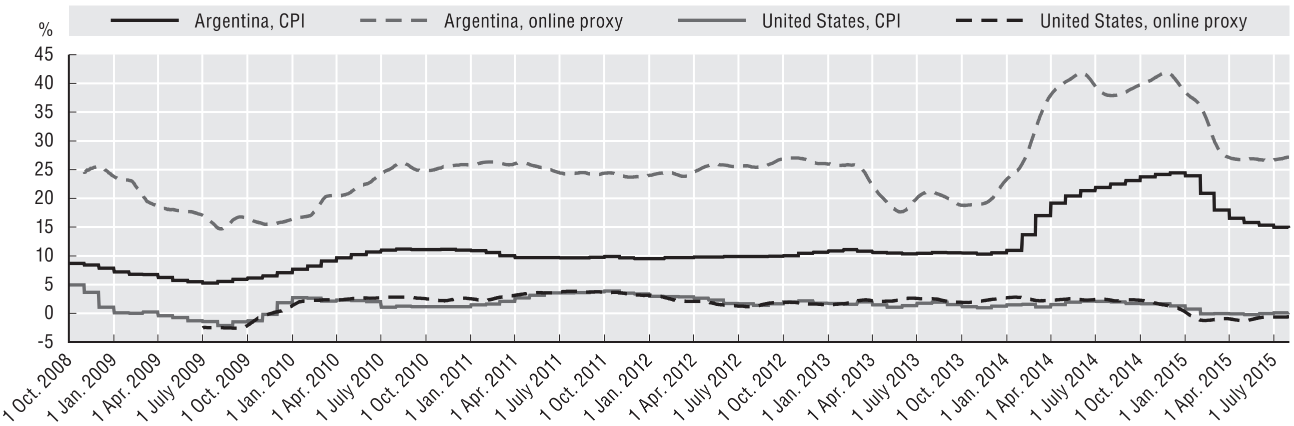
The relatively short history of Internet based social and behavioural research (Hewson et al, 2016) shows that online data can support different elements of statistical activity within national statistical organisations (NSOs) at different steps of the statistical value chain:

- *Identifying and sampling the population of interest*. Internet data can enable efficient updating of registers of statistical units based on Internet presence (e.g. businesses with their own websites or active in online marketplaces), thereby supporting the design of data collection processes.
- *Data collection*. In many instances, web-reading techniques may enable the search for and retrieval of information online that may not otherwise be available with comparable levels of timeliness, detail and exhaustiveness (Bean, 2016). Such data can be timely, especially compared to data collected through traditional survey approaches; Internet search patterns can provide early warning signs about upcoming economic downturns or of health issues emerging in the population, for example. Use of the Internet has the potential to free up NSO resources and reduce response burdens so that surveys can be implemented where they are most effective.
- *Verification / imputation*. Information from the Internet can be used to verify data from other sources, such as surveys. In addition, the use of online information to identify commonalities between respondents and non-respondents may be of use in making imputations to ensure statistics are representative of the target population.
- *Dissemination*. By releasing their statistics online, NSOs also contribute to the enhancement of IaSD for use by expert and interested users, including other NSOs and international organisations.

The use of IaSD is already a reality in many NSOs or is progressively being tested for production environments (e.g. Statistics Canada, US Census Bureau). This opens up avenues to implement subject, object, relationship and network-based measurements (CBS, 2012) that make the most of a vast array of data, including text, images, sound and video files. Of particular interest are data generated in transaction and social media platforms across users through content and service mediation. One example is the "Billion Prices project", an academic initiative aimed at comparing official and alternative, Internet retailer-based measures of inflation, drawing on transaction data. Official data can in some cases be challenged or confirmed, hinting at possible leading indicators.

Comparing official CPI and Internet-based consumer price inflation estimates, 2008-15

Annual Consumer Price Index inflation rates, Argentina and United States, 2008-15



Source: OECD calculations based on Cavallo and Rigobon (2016).

StatLink https://doi.org/10.1787/888933930497

Website metadata, hyperlinks to other sites, logs, cookies and website/subscriber analytics also represent key sources for understanding data flows and network effects. Behavioural data from devices such as smartphones or wearable technology carried by individuals, that record data such as location, physical activity and health status, offer additional opportunities to develop new statistics addressing previously unmeasurable phenomena, and the capacity to measure actual behaviour as an alternative to reported behaviour. IaSD therefore has the potential to help address potential response and reporting bias, especially around sensitive phenomena.

What are the challenges?

Internet data acquisition modalities can range from the use of robots/crawlers to delivery of data though Application Programming Interfaces (APIs). In addition to technical issues, including software and infrastructure requirements, IaSD requires that the data used are legally cleared for the intended statistical use. NSOs may lack the legal rights to make use of privately owned data available online, but a legislative basis for this can be put in place.

By virtue of its nature, the Internet presents all the features of Big data (i.e. vast volume, update frequency, coherence, complexity, representativeness of the population of interest). Such data requires non-conventional tools which NSO staff may not be fully trained or equipped to use. In addition, borders do not apply to the Internet, whereas the activities of NSOs are mostly confined to their own jurisdictions. Linking Internet information to real-world entities can thus be especially challenging. Most importantly, it may be difficult to assess the integrity and provenance of data retrieved from online sources.

Each use case needs to be assessed on its own merits. Government transparency requirements of administrative procedures may enable NSOs to reliably source governmental administrative data online (e.g. procurement or grant data; patent filings). Information disclosure (or suppression) online can be influenced by organisational objectives. For example, online job listings may not signal a willingness to hire for advertised posts, but rather provide a job market scanning mechanism or a company may advertise its activity in some areas to boost its image while keeping other operations secret. In order to secure integrity, the IaSD agenda requires that primary information providers are able to trust that the information provided in online environments will not be used against them, while information users need to feel reassured that the information provider has nothing to gain by reporting or withholding false information. To enable this, IaSD often relies on ensuring privacy and confidentiality (e.g. between platform owners, their users and NSOs).

Options for international action

The OECD Recommendation on Good Statistical Practice, advocates that NSOs, as a collective, explore Internet-based sources, and the combination of these with existing sources for official statistics. The United Nations Statistics Division (UNSD) provides an inventory of Internet-based Big data projects in NSOs (https://unstats.un.org/bigdata/inventory.cshtml). In order to ensure the quality of official statistics when such sources are used, the formulation of explicit policy towards the use of Big data (including the Internet and private data) has to consider access, legal, technical and methodological implications.

International action is particularly pertinent for the purposes of demonstration and mutual learning, especially around quality-assurance. International action is also relevant for addressing the measurement of phenomena across jurisdictional boundaries, such as those relating to globalisation or cross-country analysis (Schreyer, 2015). Collective action can drive a move towards the development and adoption of standards that favour disambiguation and interoperability of the Internet footprint under conditions that are suitable for good statistical practice. NSOs may increasingly leverage and contribute to the development of global Internet information commons that could in the future be vital statistical infrastructure for examining cross boundary phenomena. Examples include the work led by private non-for-profit international consortia to consolidate online registers of organisations, curating administrative data sources published in isolation by governments and public bodies, and rendering them accessible and usable online.

As a collective group, NSOs and International Organisations including the OECD should work to develop a fruitful dialogue with the owners of Internet-based platforms that are facilitating growing shares of online activity - and have access to the associated digital footprint.

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Notes

Cyprus

The following note is included at the request of Turkey:

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

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

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

Israel

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

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

5.1 Knowledge base

Investment in ICT equipment, computer software and databases, R&D and other intellectual property products, 2017

Investment is based on gross fixed capital formation.

For Germany, Korea and Spain, ICT equipment are estimates based on last available share.

For Iceland, data correspond to business sector investment in "office machinery and computers".

For Mexico, data only include ICT equipment (i.e. "computer hardware and telecommunications").

Business R&D expenditure, total and information industries, 2016

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

Data on total business expenditure on R&D (BERD) refer to 2016, except for Australia (2015), New Zealand (2015), South Africa (2015) and Switzerland (2015).

Estimates on R&D expenditure in the information industries are not available for Australia, China, Luxembourg, New Zealand, the Russian Federation, South Africa and Switzerland. Figures on information industries correspond to the same reference year as total BERD or, in their absence, are based on shares for the most recent available year: Austria (2015), Belgium (2015), Canada (2015), Chile (2015), France (2013), Greece (2015), Ireland (2015), Korea (2015), Latvia (2015), Poland (2015) and Sweden (2015).

Zone estimates (OECD and EU28) correspond to member countries' R&D intensity averages weighted by GDP in purchasing power parity. For information industries, they exclude countries where no data are available: Australia, Luxembourg, New Zealand and Switzerland for the OECD aggregate, and Bulgaria, Croatia, Cyprus, Luxembourg and Malta for the EU28.

5.2 Science and digitalisation

Top 10% most-cited documents in computer science by country, 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. Documents published in multi-disciplinary/generic journals are allocated on a fractional basis to the ASJC codes of citing and cited papers.

The field Computer Science comprises the following sub-fields: Artificial Intelligence, Computational Theory and Mathematics, Computer Graphics and Computer-Aided Design, Computer Networks and Communications, Computer Science Applications, Computer Vision and Pattern Recognition, Hardware and Architecture, Human-Computer Interaction, Information Systems, Signal Processing, and Software.

Scientific production resulting in new data or code, by country of residence, 2017

This is an experimental indicator. It is not necessarily representative of the researcher population in each country. Only countries with at least 75 responses have been reported.

Scientific knowledge embedded in digital patents, by scientific fields, 2003-06 and 2013-16

Data refer to IP5 patent families in ICT-related technologies that cite scientific publications, by filing date and scientific fields using fractional counts. Patents in ICT are identified using the list of IPC codes in Inaba and Squicciarini (2017). Scientific fields are derived from data elaborated and consolidated by the Max Planck Institute for Innovation and Competition, based on linked non-patent literature citations to scientific article data (see Poege et al., 2018). Scientific fields are aggregated to fields of R&D as provided in the OECD Frascati Manual (2015). Data for 2013-16 are incomplete.

5.3 Innovative outputs

Patents in ICT-related technologies, 2003-06 and 2013-16

Data refer to IP5 families, by filing date, according to the applicants' residence using fractional counts. Patents in ICT are identified using the list of IPC codes in Inaba and Squicciarini (2017). Only economies with more than 250 patents families in the periods considered are included. Data for 2015 and 2016 are incomplete.

ICT-related designs, 2014-17

Data refer to design applications filed at the European Union Intellectual Property Office (EUIPO) and the Japan Patent Office (JPO), and design patents filed at the US Patent and Trademark Office (USPTO), by filing date, according to the applicants' residence using fractional counts. ICT-related designs refer to subclasses 14-01 to 14-04, 14-99, 16-01 to 16-06, 16-99, 18-01 to 18-04 and 18-99 of the Locarno Classification. Shares are calculated for countries with more than 100 designs filed at the EUIPO, 100 design patents at the USPTO, and more than 25 designs filed at the JPO during the period considered. Figures for 2014-17 are partial.

ICT-related trademarks, 2014-17

Data refer to trademarks filed at the European Union Intellectual Property Office (EUIPO), the Japan Patent Office (JPO) and the US Patent and Trademark Office (USPTO), by filing date, according to the applicants' residence using fractional counts. ICT-related trademarks refer to trademark application designating classes 9, 28, 35, 38, 41 and/or 42 of the Nice Classification, and containing ICT-related keywords in the goods and services description. Shares are calculated for countries with more than 250 trademarks filed at the EUIPO and the USPTO, and more than 25 trademarks filed at the JPO during the period considered. Figures for 2017 are partial.

5.4 Market entry

Business dynamism, average entry and exit rates, 1998-2015

Figures for each country report unweighted averages of entry and exit rates across STAN a38 industries and available years for the time period 1998-2015, focusing separately on sectors in the "Highly digital-intensive" and "All sectors" groups. A coverage table is available in Calvino and Criscuolo (2019).

Figures are based on data covering manufacturing and non-financial market services, and exclude self-employment and the Coke and Real estate sectors. Data for Japan are for manufacturing only. The classification of sectors according to digital intensity is based on Calvino et al. (2018) (top quartiles in either of the two periods considered in the study). Owing to methodological differences, figures may deviate from officially published national statistics. Data for some countries are still preliminary.

Business dynamism, average post-entry employment growth, 1998-2015

For Hungary and Turkey, the gap, though very small, is inverted such that the other sectors have slightly higher post-entry employment growth than the highly digital-intensive sectors.

The figure reports the ratio between total employment at t + 5 over total employment at time t of surviving entrants. Figures for each country report unweighted averages across STAN a38 sectors and available years (cohorts) for the period 1998-2015, focusing on the gap between the highly digital-intensive and other sectors groups. Cohorts can start in 1998, 2001, 2004, 2007 and 2010. A coverage table is available in Calvino and Criscuolo (2019).

Figures are based on data covering manufacturing and non-financial market services, and exclude self-employment and the Coke and Real estate sectors. Data for Japan are for manufacturing only. The classification of sectors according to digital intensity is based on Calvino et al. (2018) (top quartiles in either of the two periods considered in the study). Owing to methodological differences, figures may deviate from officially published national statistics. Data for some countries are still preliminary.

Venture capital investment in the ICT sector, 2017

For Israel, data refer to 2014.

For Japan and South Africa, data refer to 2016.

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

Data providers are: Invest Europe (European countries), ABS (Australia), CVCA (Canada), KVCA (Korea), NVCA/Pitchbook (United States), NZVCA (New Zealand), PwCMoneyTree (Israel), RVCA (the Russian Federation), SAVCA (South Africa) and VEC (Japan).

5.5. Open government data

Open-Useful-Reusable Government Data Index, 2017

Each component of the index can take a maximum value of 0.33.

Useful government data, government support for data re-use, 2017

Each component of the index can take a maximum value of 0.33.

Global Open Data Index, total and selected categories, 2016

Open data and content can be freely used, modified and shared by anyone for any purpose. The Global Open Data Index (GODI) assesses government data in 15 key areas and takes a maximum value of 100 when data are openly licenced, machine readable, easily downloadable, up-to-date and free of charge.

The 15 areas of government data covered are: government budget, national statistics, procurement, national laws, administrative boundaries, draft legislation, air quality, national maps, weather forecast, company register, election results, locations, water quality, government spending and land ownership.

5.6 The digitalisation of science

Use and development of Big data across scientific domains, 2018

This is an experimental indicator. “Big data” captures authors whose teams use or develop “data with size, complexity and heterogeneity features that can only be handled with unconventional tools and approaches)”. The use of “Hadoop” is presented as an example in the survey. The results exclude scientific domains with less than 75 responses reported.

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Chapter 6

ENSURING GOOD JOBS FOR ALL

ICT specialist occupations and other ICT task-intensive occupations made a positive contribution to employment growth in almost all countries between 2011 and 2017, including in countries where employment fell overall. In Luxembourg, where employment increased by 21% over this period, ICT specialists accounted for one-in-ten new jobs, and a further three jobs were in other ICT task-intensive occupations. In the United States, employment grew by around 10%; one third of these additional jobs were in ICT task-intensive occupations.

ICT specialists are most likely to work in Information industries, whereas ICT task-intensive occupations are pervasive in a variety of sectors. In the countries presented, approximately a quarter to a half of employees in the information industries are ICT specialists. Other ICT task-intensive occupations make up a relatively small share of ICT industries' employment in most countries. These nevertheless represent a majority of ICT-related employment in other industries, which employ around four people in other ICT task-intensive occupations for every one ICT specialist, on average.

The ways in which digital technologies are changing jobs, and the implications arising therefrom, is a key concern for workers, employers and governments. Identifying the tasks that are most likely to be substituted by technology – those involving basic exchange of information, buying and selling, and simple manual dexterity – and the workers performing them helps to shed light on what the future of work may look like. The OECD Survey of Adult Skills (PIAAC) dataset provides a detailed breakdown of the tasks workers perform on the job. Each worker can thus be assigned a probability of being impacted by digital technologies, and by automation, in particular. According to Nedelkoska and Quintini (2018), 14% of jobs across all countries in the sample have a high (over 70%) likelihood of being automated, while another 32% have a 50% to 70% probability of facing significant change. Workers in these jobs perform several automatable tasks, alongside tasks that are not currently automatable. Meanwhile, the estimates also suggest that about a quarter of jobs have a less than 30% chance of automation. Overall, these estimates indicate that automation could affect a wide range of jobs, though the nature and extent of these impacts will vary greatly across occupations, industries and countries.

The estimates also highlight significant differences across countries, with automation highly likely to affect between 6% and 33% of all jobs. Similarly, the share of jobs estimated to have a significant likelihood of change varies between 23% and 43% of all jobs. These, however, are not necessarily the jobs displaying the lowest skill requirements. Marcolin et al. (2018) show that the relationship between skill and routine intensity is negative but not very strong, and insignificant for jobs which display medium routine intensity.

DID YOU KNOW?

For every 10 additional jobs created in the European Union between 2011 and 2017, four were in ICT task-intensive occupations.

Definitions

ICT specialists are individuals employed in tasks related to developing, maintaining and operating ICT systems and considered, where ICTs are the main part of their job. The operational definition applied here corresponds to the following ISCO-08 occupations: 133 (Information and communications technology service managers), 215 (Electrotechnology engineers), 251 (Software and applications developers and analysts), 252 (Database and network professionals), 351 (Information and communications technology operations and user support), 352 (Telecommunications and broadcasting technicians), and 742 (Electronics and Telecommunications Installers and Repairers). For further details, see OECD and Eurostat (2015).

ICT task-intensive occupations have a high propensity to include ICT tasks at work ranging from simple use of the Internet, through use of word processing or spreadsheet software, to programming. See page 4.3 for more details on the occupations included.

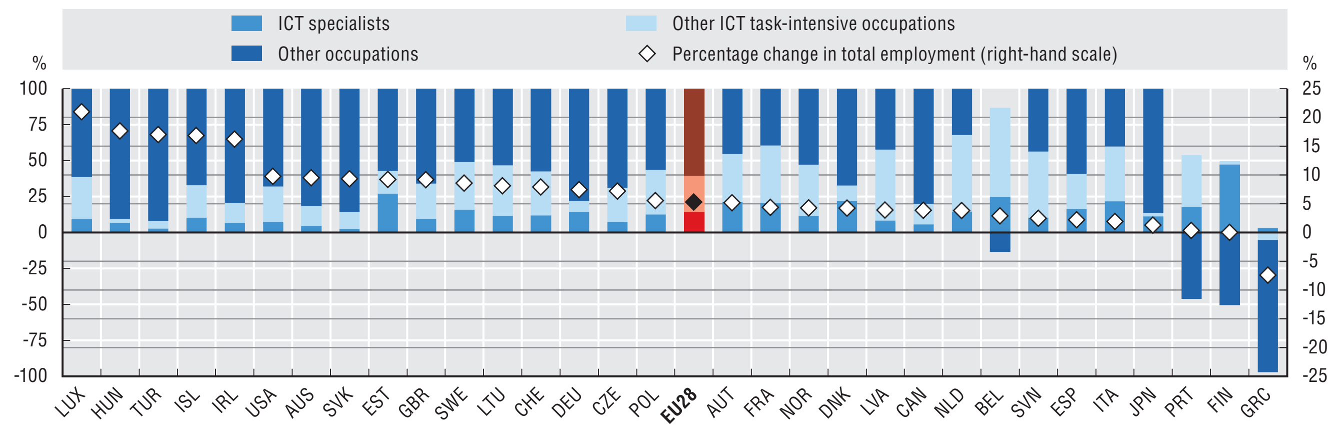
Information industries combines the OECD definitions of the "ICT sector" and the "content and media sector" (OECD, 2011). While this definition includes detailed (three- and four-digit) ISIC Rev.4 industrial activities (UN, 2008), in this analysis it is approximated by the following ISIC Rev.4 (two-digit) Divisions, on account of data availability: "Computer, electronic and optical products" (Division 26), "Publishing, audiovisual and broadcasting activities" (58 to 60), "Telecommunications" (61), and "IT and other information services" (62 to 63).

Measurability

Changes in employment levels in each country can be "normalised" to highlight the relative contributions of the different occupation groups to the total change in employment between two periods. The aggregate increase or decrease in employment in each occupation group is expressed as a percentage of the total absolute change in employment in each country. The gains and losses represent the sum of occupation groups with positive changes and the sum of occupation groups with negative changes, respectively. Using a finer occupation breakdown would produce different estimates for total gains and losses, though total net changes would remain the same.

Contributions to changes in total employment, by occupation, 2011-17

As a percentage of total absolute changes in employment



Source: European Labour Force Surveys, national labour force surveys and other national sources, December 2018. See chapter notes.

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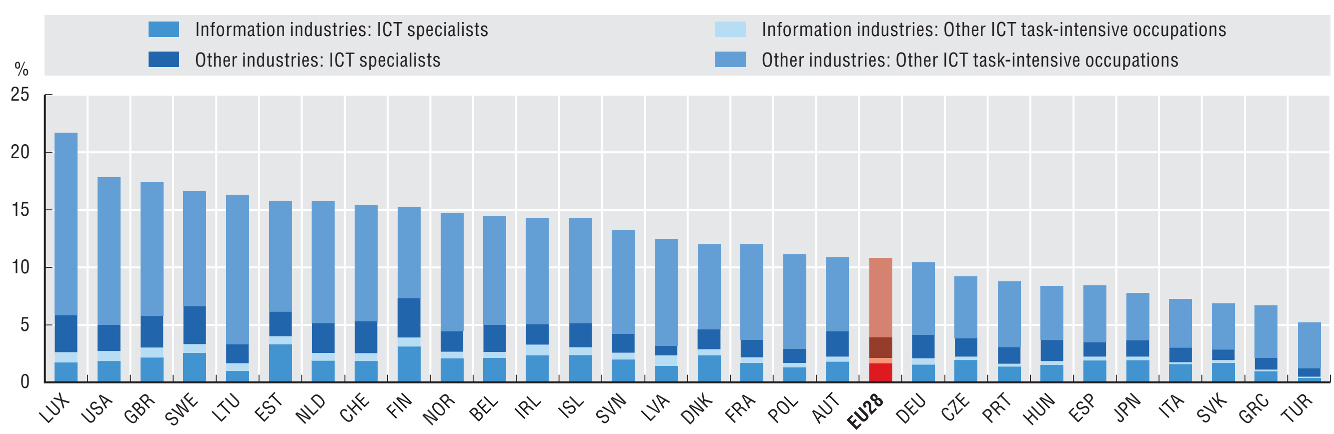
Employment in ICT specialist and ICT task-intensive occupations within and outside information industries, 2017

As a percentage of total employment



Source: European Labour Force Surveys, national labour force surveys and other national sources, December 2018. See chapter notes.

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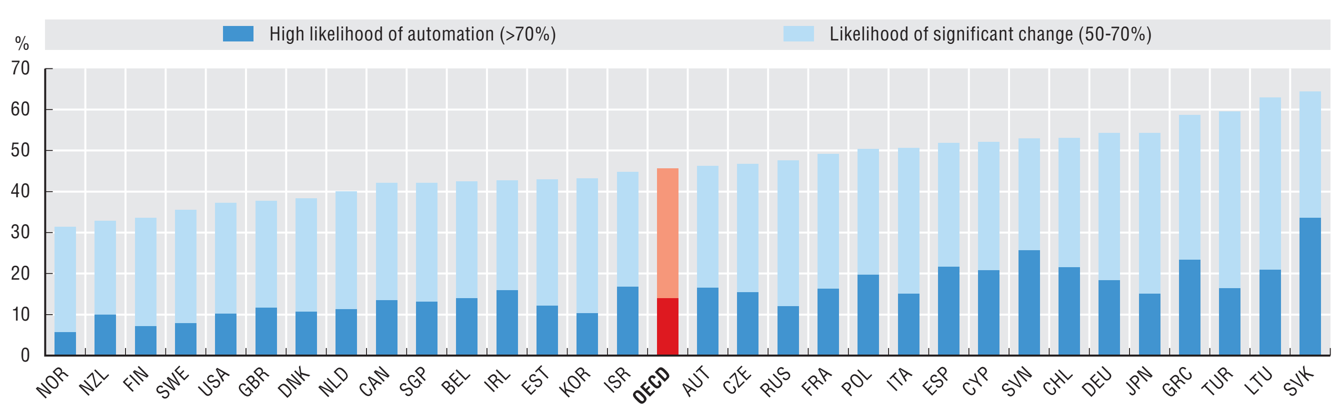
Likelihood of automation or significant change to jobs, 2012 or 2015

As a percentage of all jobs



Source: Nedelkoska and Quintini (2018). See chapter notes.

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Between 2006 and 2016, total employment in the OECD area grew by 6.9% (a net gain of about 38 million jobs). Examining the contributions towards these net changes shows that the sectors with the highest digital intensity made a strong contribution to employment gains in many countries: around four of every ten additional jobs in the OECD area, and as many as eight-in-ten jobs created in the Slovak Republic. In contrast, the contribution from medium-high digital intensity sectors was much smaller, on average, across the OECD (3.7%), as relatively strong positive contributions in some countries such as Poland, Chile and Mexico were balanced by strong negative effects in Greece, Finland, Italy and others. In almost all countries where aggregate employment fell between 2006 and 2016, the greatest declines were in low digital intensity sectors, while medium-low digital intensity sectors also experienced a decline in employment. Overall, this suggests that the more digitally intensive sectors have contributed to employment growth more strongly than other sectors.

ICT skills are in high demand. All things being equal (including education and other workers' skills), the higher the ICT task intensity of a job, the higher the hourly wage earned. However, estimates suggest that the pay-off for working in ICT task-intensive jobs varies widely across countries. In Korea and the United States, workers in jobs requiring a 10% higher intensity of ICT tasks than the country average earn hourly wages that are more than 3.5% higher. Conversely, workers in Israel and Turkey enjoy relatively lower returns on ICT task-intensive jobs (i.e. only about 1%). Returns on ICT task-intensive jobs depend on many factors including a country's supply of and demand for ICT skills, and its wage structure (OECD, 2017; Grundke et al., 2018).

Recently, some have expressed concern over potential imbalance between the demand for and the supply of ICT specialists in the labour market (OECD, 2017b). According to data available for European countries, over half of firms trying to recruit ICT specialists reported difficulties in doing so. The number of ICT specialist vacancies in each responding business is not known. Nevertheless, this equates to a relatively small percentage of all enterprises reporting hard-to-fill vacancies for ICT specialists – about 5% in 2018. However, the share of businesses overall having difficulties with filling ICT specialist roles has increased nearly two percentage points, from 3% in 2012, on average. A majority of countries have seen the share of firms reporting recruitment difficulties increase, with especially large rises in Slovenia and Italy, where the rate of businesses with hard-to-fill ICT specialist vacancies tripled between 2012 and 2018. The Netherlands has the highest rate, at 9% in 2018, nearly three-times the 2012 figure. Meanwhile, markedly fewer businesses in Iceland and Poland reported hard-to-fill ICT specialist vacancies in 2018 compared to 2012.

DID YOU KNOW?

Of the 38 million jobs added in the OECD area between 2006 and 2016, around four-in-ten were in highly digital-intensive sectors.

Definitions

Sectors were classified by digital intensity (*high/medium-high/medium-low/low*) using a number of dimensions (ICT investment and ICT intermediates, use of robots, online sales and ICT specialists) and then grouped by quartile (Calvino et al., 2018). Examples of high digital-intensity sectors include transport equipment, ICT services, finance and insurance, legal and accounting, R&D, advertising and marketing. Examples of medium-high digital-intensity sectors include ICT equipment and machinery, wholesale and retail, publishing, audiovisual and broadcasting (see page 2.9 for more information).

The *ICT task-intensity* of a job describes the frequency with which ICT tasks (ranging from simple use of the Internet, word processing or spreadsheet software, to use of programming language) are undertaken at work.

ICT specialists are defined in the European Community Survey on ICT Usage in Businesses as "employees for whom ICT is the main job, for example, to develop, operate or maintain ICT systems or applications".

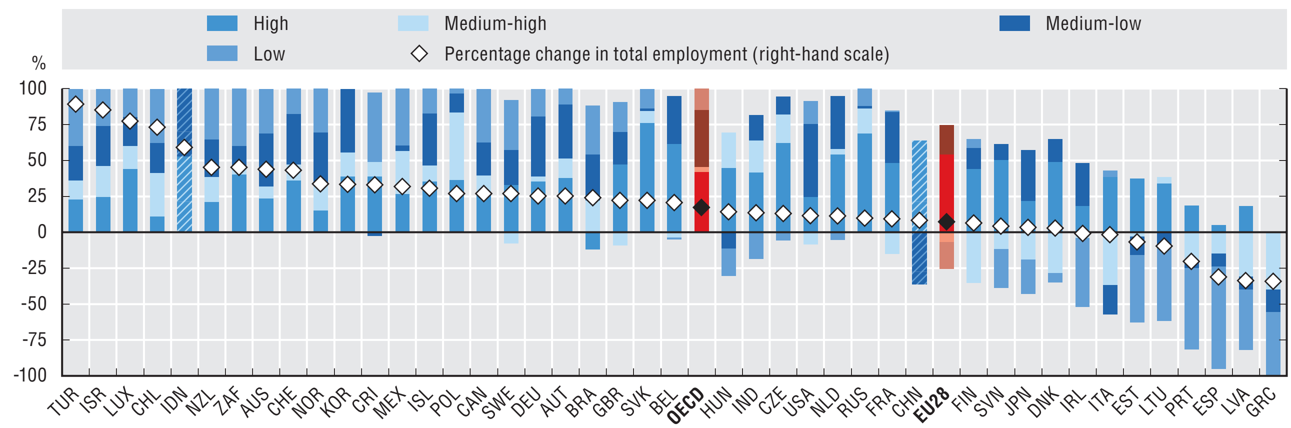
Measurability

Changes in employment levels in each country can be "normalised" to highlight the relative contributions of sectors of different digital-intensities to employment gains or losses. The aggregate increase or decrease in employment in sectors of each digital-intensity is expressed as a percentage of the total absolute change in employment in each country. Using a finer activity breakdown (e.g. ISIC Rev.4 two-digit Divisions) would produce different estimates for total gains and losses, though total net changes would remain the same.

The ICT task intensity of jobs is assessed using exploratory factor analysis of responses to 11 items on the OECD Programme for International Assessment of Adult Competencies (PIAAC) survey, which relates to the performance of ICT tasks at work. See Grundke et al., 2017 for the detailed methodology. Labour market returns on task intensities are based on OLS wage regressions (Mincer equations) using data from PIAAC. Estimates rely on the log of hourly wages as the dependent variable and on a number of individual-related control variables including age, years of education, gender and other skill measurements, as well as industry dummy variables as regressors (Grundke et al., 2018).

Contributions to changes in total employment, by digital intensity of sectors 2006-16

As a percentage of total absolute changes in employment



Source: OECD calculations based on STAN Database, http://oe.cd/stan, National Accounts Statistics, national sources and Inter-Country Input-Output Database, http://oe.cd/icio, December 2018. See chapter notes. StatLink contains more data.

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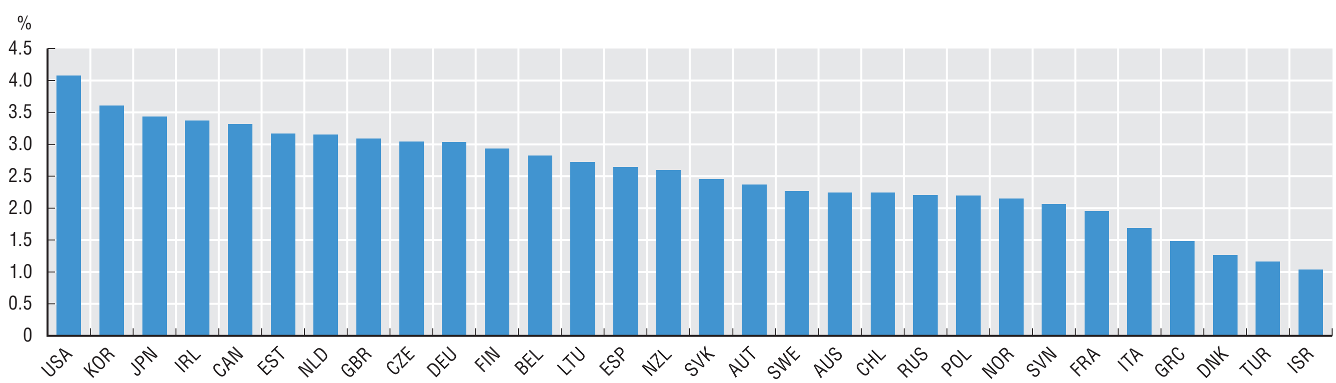
Labour market returns to ICT tasks, 2012 or 2015

Percentage change in hourly wages for a 10% increase in ICT task intensity of jobs at the country mean

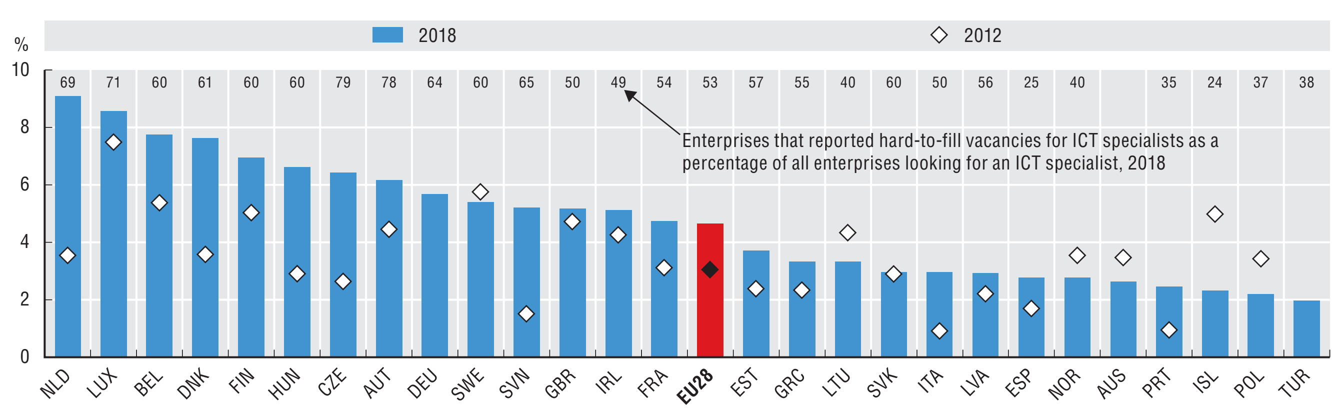


Source: OECD (2017a), calculations based on the Survey of Adult Skills (PIAAC) Database, June 2017. See chapter notes.

StatLink https://doi.org/10.1787/888933930592

Enterprises that reported hard-to-fill vacancies for ICT specialists, 2018

As a percentage of all enterprises



Source: OECD, ICT Access and Usage by Businesses Database, http://oe.cd/bus, December 2018. See chapter notes. StatLink contains more data.

StatLink https://doi.org/10.1787/888933930611

Information and communication technologies (ICTs) are changing jobs and the workforce. Jobs differ in their ICT task intensity – the frequency with which ICT tasks are undertaken – with jobs in occupations such as software, finance, sales and marketing generally more ICT task intensive, while jobs in areas such as accommodation and food, and health and social work tend to have relatively lower ICT task intensity. The average ICT task intensity of jobs ranges from around 40% in the Russian Federation and Turkey to nearly 60% in Scandinavian countries. In almost all countries, the average ICT task intensity of jobs held by women is greater than that of men, with differences being most pronounced in Eastern European countries, as well as in the Russian Federation. Japan and Korea are the only countries where the average ICT task intensity of jobs held by men markedly exceeds that of women.

In terms of ICT-related tasks performed at work, "exchanging e-mails or entering data into databases" is the most common" activity - undertaken at least once a week by over 80% of people who use computers or computerised equipment at work in the EU28. Creating or editing electronic documents is also commonplace, with over 60% of workers performing these tasks. Almost one-in-four workers in European Union countries use social media for work purposes at least once a week, although the data do not distinguish the active posting of content from more passive uses, such as using social media to follow news.

On average, 30% of workers in the European Union use online applications to receive tasks or instructions for work, at least once a week. This includes those finding work through online platforms, as well as a wide range of situations such as workers in e-commerce fulfilment centres or hospital staff who receive instructions via apps on smart devices (e.g. the location of a product in a warehouse or of a patient in a hospital). About 11% regularly work on "developing and maintaining IT systems and software". The highest proportion is found in Slovenia (18%) and the lowest in the Slovak Republic (4%).

Self-assessments offer one perspective on the extent to which workers' skills match the ICT-related tasks needed for their work. In 2018, about 64% of workers using computers or computerised equipment at work in the European Union reported that their skills corresponded well to ICT-related aspects of their work duties. Meanwhile, 11% reported needing further training to cope with the ICT-related demands of their job. This figure is lower than the share of people whose ICT skills may be under-utilised: on average 25% declared that their digital skills exceed the requirements of their jobs. Considerable variation exists between countries, however. In Spain, France and Italy, nearly 20% of workers feel that they need further ICT training, while in Germany, Norway and Iceland, over a third report having more advanced ICT skills than used in their work duties.

DID YOU KNOW?

In most OECD countries, women work in jobs that are more ICT task-intensive, on average, than men.

Definitions

The *ICT task intensity of a person's job* describes the frequency with which they undertake ICT tasks at work. The ICT tasks considered relate to the frequency of: using word processing and spreadsheet software; using programming language; making transactions via the Internet (banking, selling/buying); using e-mails and the Internet; using ICT for real-time discussions; reading and composing letters, emails and, memos; and use of computers on the job. See Grundke et al., (2017), for details.

Computers and computerised equipment include computers, laptops, smartphones, tablets, other portable devices, and other computerised equipment or machinery such as those used in production lines, transportation or other services.

Receiving tasks via apps consists of the use of applications to receive tasks or instructions (excluding e-mails).

Occupation-specific software relates to specialist software for design, data analysis, processing and so on.

Digital skills (mis)match at work is based on self-declarations regarding individuals' skills relating to the use of computers, software or applications at work. Responses relate to the main paid job in cases of multiple employment.

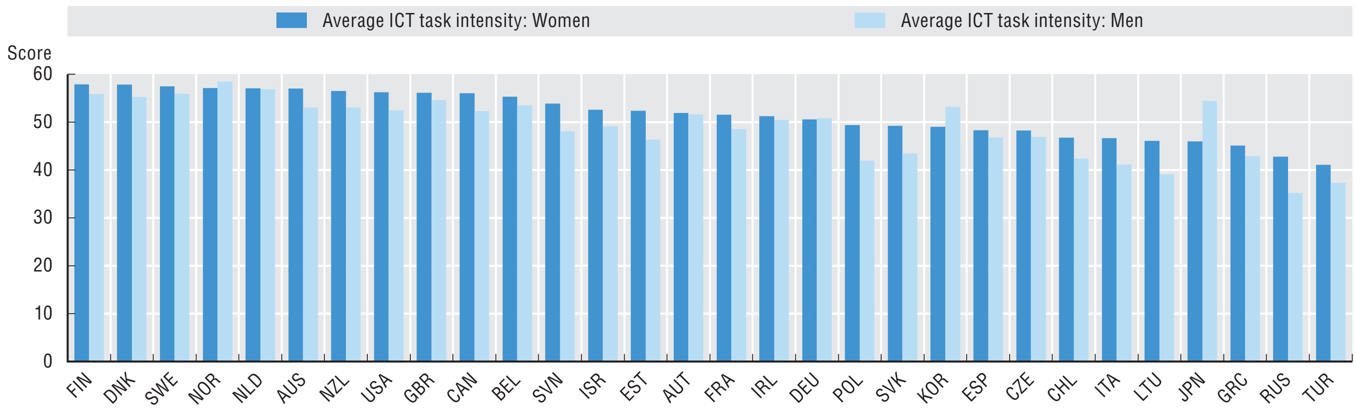
Measurability

The ICT task intensity of jobs is assessed using exploratory factor analysis of responses to 11 items on the OECD Programme for International Assessment of Adult Competencies (PIAAC) survey relating to the performance of ICT tasks at work. The detailed methodology can be found in Grundke et al. (2017). Compared to earlier studies, this approach helps to distinguish between the tasks that workers perform on the job and the skills with which they are endowed.

The 2018 European Community survey on ICT usage in households and by individuals contained a special module on ICT usage at work. This provides information on various dimensions related to the use of ICTs for working activities including the types of ICT-related undertaken regularly and some elements on digital skills (mis)match.

ICT task intensity of jobs, by gender, 2012 or 2015

Average scores

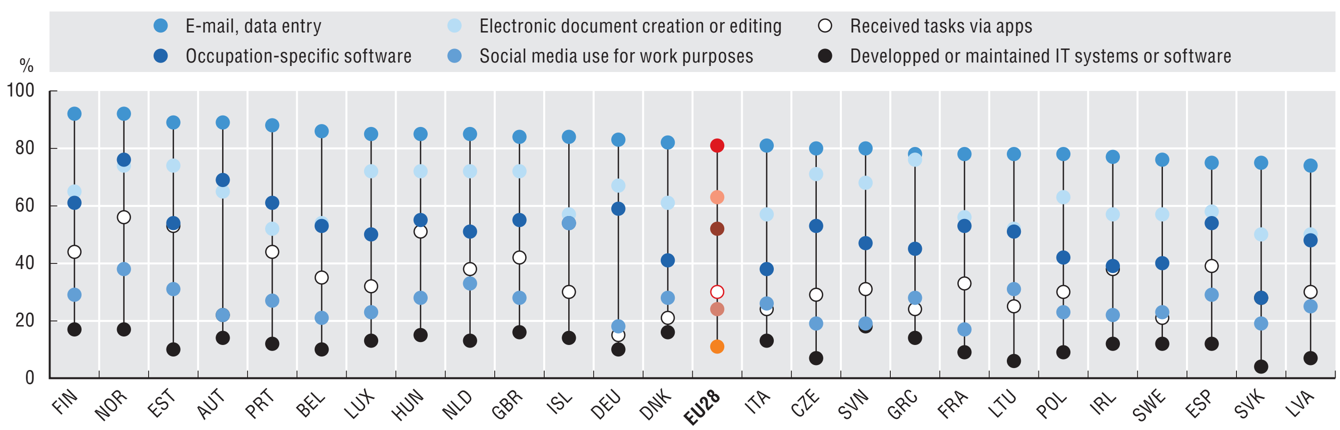


Source: OECD calculations based on the Survey of Adult Skills (PIAAC) Database, October 2018. See chapter notes. StatLink contains more data.

StatLink https://doi.org/10.1787/888933930630

Computer-based tasks performed by individuals at work at least once per week, 2018

As a percentage of individuals who use computers or computerised equipment at work

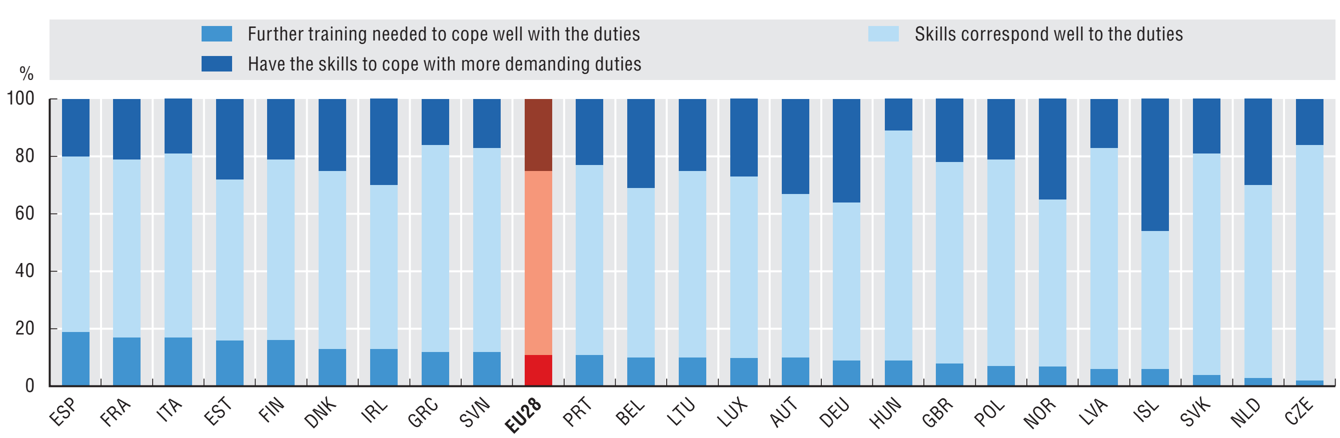


Source: OECD, based on Eurostat, Digital Economy and Society Statistics, January 2019. See chapter notes.

StatLink https://doi.org/10.1787/888933930649

Digital skills (mis)match at work, 2018

As a percentage of individuals who use computers or computerised equipment at work



Source: OECD, based on Eurostat, Digital Economy and Society Statistics, January 2019.

StatLink https://doi.org/10.1787/888933930668

Certain skills and qualifications, such as those related to science, engineering and ICTs are especially useful for thriving in the context of the digital transformation. In 2016, out of all tertiary graduates in OECD countries, 6% did so with degrees in natural sciences, mathematics and statistics; 14% in engineering, manufacturing and construction; and nearly 4% in ICT fields. It should be noted, though, that modern degree programmes in other fields can also endow students with relevant ICT skills. For example, graduates in the arts, graphic design, journalism and information, 6% of all tertiary graduates in OECD countries, are increasingly involved in activities related to production and management of digital content.

Firm-based training is an important means of complementing and building upon academic and other qualifications. Employees in highly digital-intensive industries are more likely than others to engage in training - by 7 percentage points on average, though differences vary markedly across the countries for which data are available. In general, employers in highly digital-intensive industries are more likely to engage in formal training, leading to official qualifications, than employees in less digital-intensive sectors, whereas the inverse is true for on-the-job training.

Workers performing non-routine tasks or ICT-intensive tasks are generally endowed with relatively higher skills than other workers are. Firm-based training helps to motivate and reward employees, as well as to align their competences to firms' needs. Training may also help to reduce income inequality and provide low-skilled workers with the skills needed to navigate the digital transformation. Evidence nevertheless suggests that most training further upskills medium and high-skilled workers rather than being undertaken by lower skilled workers. In all countries high-skilled workers have the highest incidence of training, almost 75% on average, compared to almost 55% of medium-skilled workers engaging in training on average and 40% of low-skilled workers doing so. On average, in the countries considered, between 30% (the Russian Federation and Greece) and 76% (the Netherlands, Denmark and Finland) of workers engaged in some training. With the exception of Turkey, only a quarter or less of workers receiving training are low skilled, whereas high-skilled workers account for between a quarter (Austria) and three-quarters (Russian Federation) of those receiving training.

DID YOU KNOW?

Low-skilled workers are most in need of training to adapt to a digitalising workplace but are less likely to engage in firm-based training than other workers.

Definitions

Tertiary-level graduates are individuals who have obtained a degree at ISCED-2011 Levels 5 to 8.

The *creative and content* fields of study comprise the arts (including graphic design) journalism and information.

Firm-based training is employer-provided (i.e. funded) worker training.

Formal training refers to organised training undertaken outside of the work environment and results in the attainment of an official qualification.

On-the-job training may take place both inside or outside a firm, but does not typically lead to the attainment of a formal qualification.

Sectors were classified by digital intensity (*high/medium-high/medium-low/low*) using a number of dimensions (ICT investment and ICT intermediates, use of robots, online sales and ICT specialists) and then grouped by quartile. *Highly digital-intensive sectors* are those in the upper ("high") quartile of digital intensity. Examples include transport equipment, ICT services, finance and insurance, legal and accounting, R&D, advertising and marketing. See page 2.9 for more information.

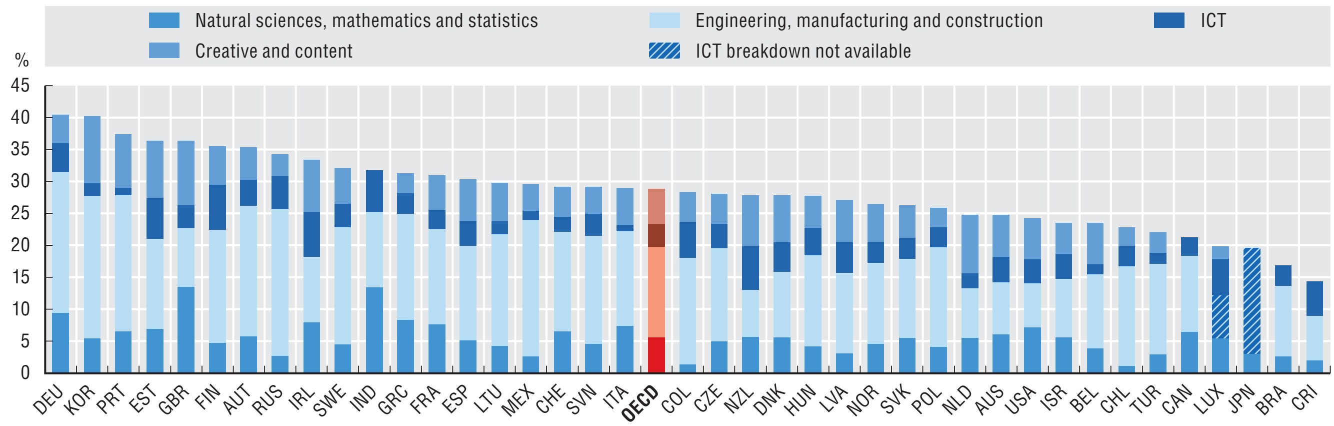
Measurability

Indicators on graduates by field of education are computed on the basis of annual data collected jointly by the UNESCO Institute for Statistics, the OECD and Eurostat. The data collection process aims to provide internationally comparable information on key aspects of education systems in more than 60 countries worldwide. See http://www.oecd.org/education/database.htm.

Firm-based training endows workers with the skills needed to perform in their job and to transition between jobs – which becomes especially important in an era of fast technological change that is changing the nature of jobs. The Survey of Adult Skills (PIAAC) surveys thousands of individuals in each participating country and gathers information on workers' participation in training (among other aspects of their working life). Training figures are based on the number of employees that reported having received training at least once in the year. Both public and private sectors are covered. Numbers are weighted to obtain countrywide representativeness. Frequencies may hide differences in the length of the training period across individuals and countries.

Tertiary graduates in the natural sciences, engineering, ICTs, and creative and content fields of education, 2016

As a percentage of all tertiary graduates

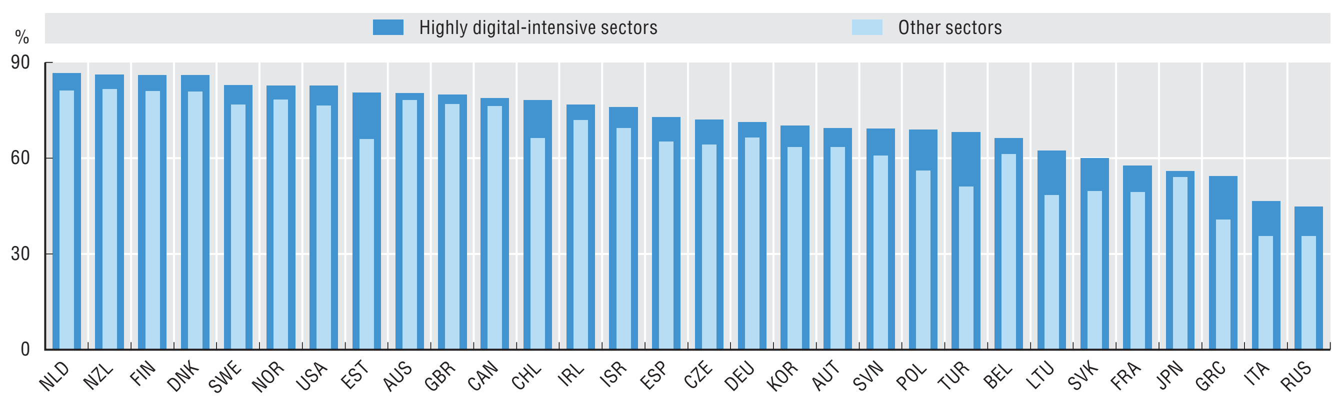


Source: OECD calculations based on OECD Education Database, September 2018. See chapter notes.

StatLink https://doi.org/10.1787/888933930687

Workers receiving firm-based training, highly digital-intensive and other sectors, 2012 or 2015

As a percentage of workers in each sector group

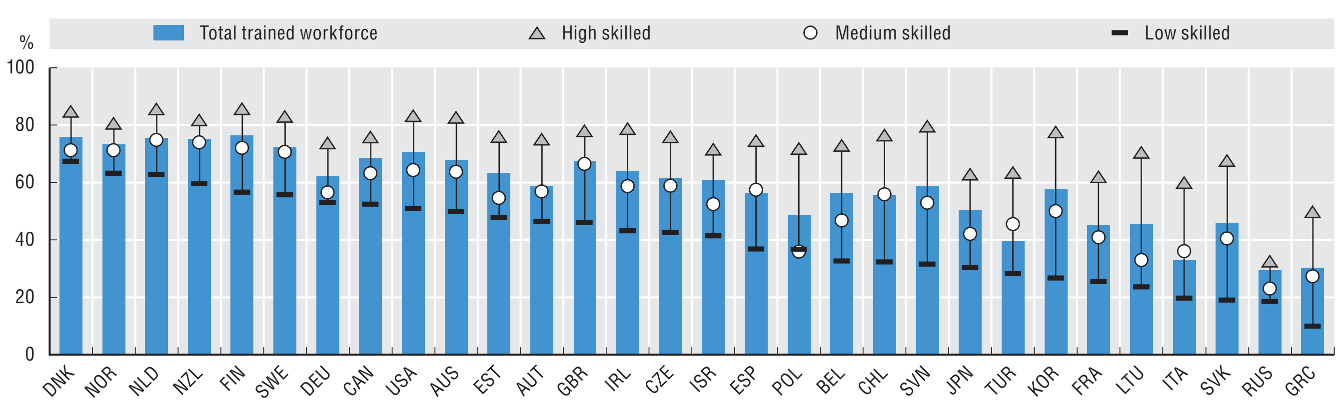


Source: OECD calculations based on the Survey of Adult Skills (PIAAC) Database, June 2017. See chapter notes. StatLink contains more data.

StatLink https://doi.org/10.1787/888933930706

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

As a percentage of workers in each category



Source: OECD calculations based on the Survey of Adult Skills (PIAAC) Database, October 2018. See chapter notes.

StatLink https://doi.org/10.1787/888933930725

The digital transformation has changed, and will continue to change, many aspects of work. Numerous jobs now involve computer use, and in the future, it is likely that people will need to adapt to working with computers in new ways, such as in "teams" comprising both human and artificial intelligence.

Learning new things, thinking creatively and problem solving are likely to be especially valuable traits for adapting to and gaining from workplace digitalisation. In all countries, people aged 25-34 score more highly in terms of readiness to learn and creative thinking than those aged 55-65. In Finland, the Slovak Republic, Slovenia and the Russian Federation, women generally score more highly than men, while in Belgium and Japan the opposite is observed. Age and gender-related differences are generally more considerable across countries than within individual countries; this underlines the role of cultural and societal factors in shaping personal characteristics and the need for tailored policy responses (OECD, 2017a).

Governments can play an important role in helping workers and employers to adapt to changes driven by digitalisation. In 2016, OECD governments spent almost 0.4% of GDP on active labour market policies, on average. Chief among these in many countries is training to help people gain the skills needed for work, including ICT skills. As the digital transformation continues, skills needs are likely to change as more routine tasks become automated (see page 6.1). Other schemes can help people find and try potentially suitable jobs.

The digital transformation also brings new business opportunities. Government support can help people start companies based around digital technology, although spending on start-up incentives is much less than on most other schemes, except in Spain and France.

Alongside the adaptability of workers themselves, and of managers who play a key role in determining how employers adopt new technologies and adapt to the digital transformation, social partners (trade unions and employers' organisations) can also help in ensuring that workers and companies reap the benefits of technological change. Through social dialogue and collective bargaining, they can spread best practices in terms of technology usage and help employers to adapt working hours and the way work is organised. Furthermore, social partners can help to enhance labour market adaptability, for example by providing training and reskilling in the case of mass layoffs. On average, 32% of wage earners in OECD countries with the right to bargaining were covered by collective agreements in 2016. In a time of rapid change, and despite declines in membership and coverage, the role of social partners in finding tailor-made solutions, managing transitions, and anticipating and filling skills needs may be more important than ever.

DID YOU KNOW?

OECD governments spend 0.13% of GDP on training for unemployed people and workers at-risk of involuntary unemployment. The digital transformation may significantly increase the need for support.

Definitions

Readiness to learn is based on six PIAAC questions relating to inquisitiveness and investigation, desire to learn, and problem solving.

Public expenditure on active labour market policies relates to central and local public authority spending on schemes aimed at individuals who do not work but would like to do so, or who are at risk of involuntary job loss ("targeted persons").

Training includes targeted institutional and workplace-based training.

Employment incentives include schemes where the employer covers the majority of the labour cost, and job rotation/sharing schemes where a targeted person substitutes for an employee for a fixed period.

Direct job creation relates to new jobs where the majority of the labour costs are funded by public funds for a limited period.

Placement and related services are typically provided by the public employment service or other publicly financed bodies. They include employment counselling, referral to opportunities for work, information services and so on.

Start-up incentives encourage targeted persons to start businesses or to become self-employed.

Collective bargaining is defined as "all negotiations which take place between an employer, a group of employers or one or more employers' organisations, on the one hand, and one or more workers' organisations, on the other, for determining working conditions and terms of employment; and/or regulating relations between employers and workers; and/or regulating relations between employers or their organisations and a workers' organisation or workers' organisations" (ILO, 1981).

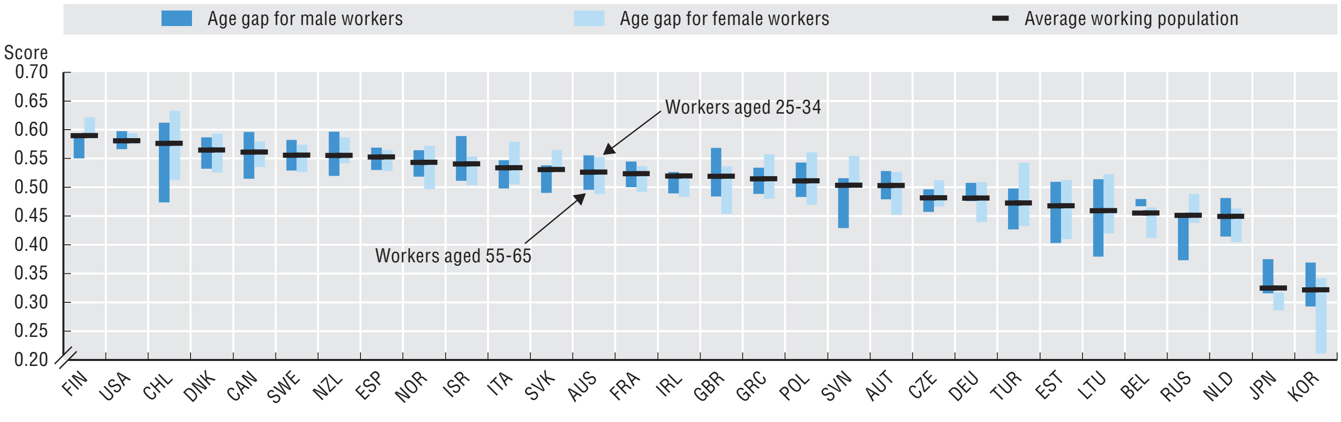
Measurability

The readiness to learn and creative thinking indicator was developed using exploratory factor analysis. It relies on six PIAAC items related to openness to new experiences and creative thinking, including "relate new ideas into real life" and "like learning new things". Detailed methodology in Grundke et al. (2017).

OECD data on public expenditure on labour markets are based mainly on information about individual labour market programmes appearing in state budgets and the accounts and annual reports of bodies implementing the programmes.

Readiness to learn, by gender and age, 2012 or 2015

Average scores

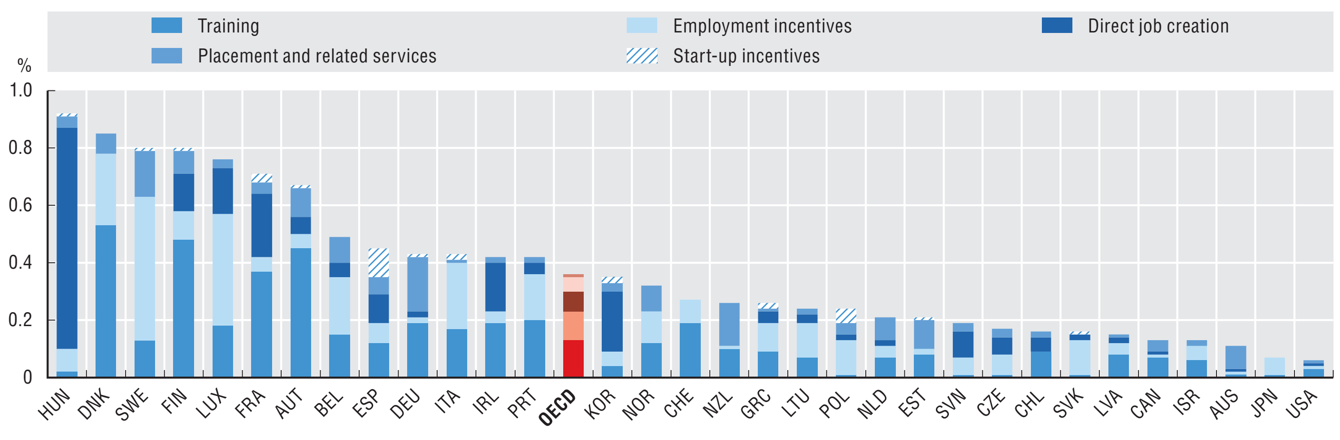


Source: OECD (2017a), calculations based on Survey of Adult Skills (PIAAC) Database, June 2017. See chapter notes.

StatLink https://doi.org/10.1787/888933930744

Public expenditure on active labour market policies, 2016

As a percentage of GDP

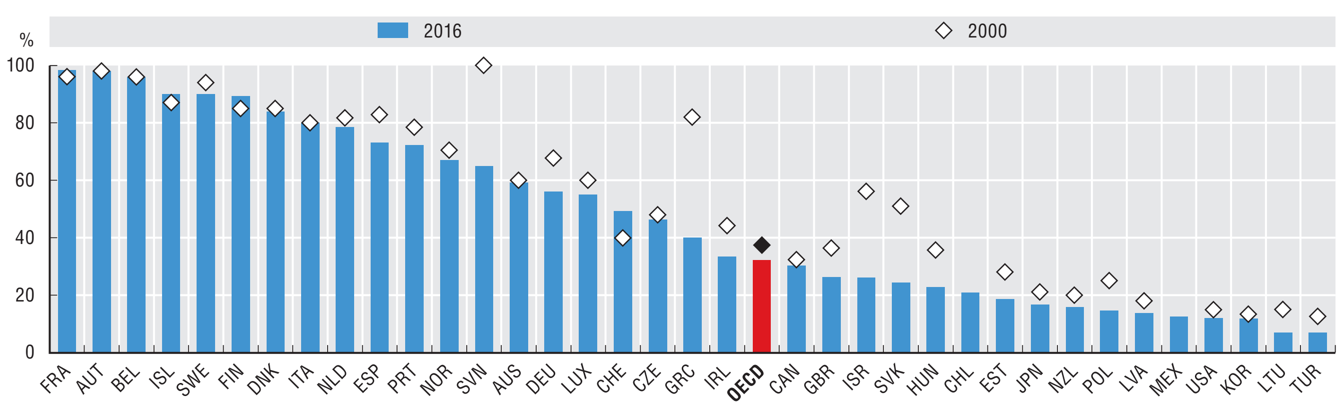


Source: OECD, Labour Market Programmes Database, October 2018. See chapter notes.

StatLink https://doi.org/10.1787/888933930763

Employees covered by collective agreements, 2016

As a percentage of employees with the right to bargaining



Source: OECD, Collective Bargaining Coverage Database, October 2018. See chapter notes.

StatLink https://doi.org/10.1787/888933930782

Why are indicators on platform workers needed?

Platform workers are individuals who use an app (such as *Uber*) or a website (such as *Amazon Turk*) to match themselves with customers, in order to provide a service in return for money. They offer a diverse range of services including transport, coding and writing product descriptions.

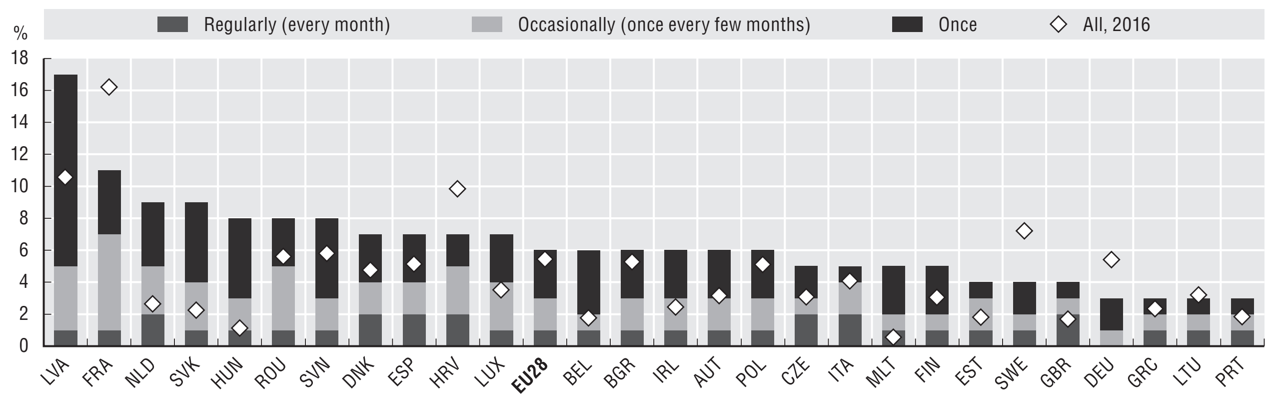
The emergence of online platform work, and the new forms of work that it brings, has the potential to boost employment, increase flexibility for workers, and especially for employers, and to serve as a means to transition to regular employment. However, platforms also facilitate flexible work arrangements, which could lead to an increase in poorer quality jobs, with poor career prospects, and contribute to a segmented labour market (Mira d'Ercole and MacDonald, 2018). In addition, the self-employed are not usually covered by the same labour market protections as full-time permanent employees, and may suffer from low wages (Broecke, 2018).

At present, the provision of policy advice is hampered by a lack of comparable and consistent statistics on the number of platform workers, their characteristics, and the characteristics of their jobs and tasks (Mira d'Ercole and MacDonald, 2018). In particular, there is a need for data that are comparable across countries, across time and with existing labour market statistics.

There have been several attempts to estimate the number of platform workers. Initial attempts made use of existing data sources, combined with strong assumptions. A number of specific surveys conducted by both researchers and private agencies followed. More recently, official statistical agencies of OECD member states have asked questions on platform work in labour force surveys and Internet usage surveys. Nevertheless, estimates of the number of platform workers vary widely, both across countries and across surveys for the same country.

Individuals who have offered services on a platform, 2018

As a percentage of all individuals



Source: European Commission (2018). See chapter notes.

StatLink https://doi.org/10.1787/888933930801

What are the challenges?

There is currently no accepted standard definition of platform work and many respondents to surveys demonstrated a limited understanding of the concept. For example, the U.S. Bureau of Labor Statistics included a detailed description of platform work in their 2017 questionnaire. However, many respondents misunderstood the definition, for example, answering "yes" in regard to whether they made use of a computer or mobile app in their job, when this was evidently not the case. After removing obviously incorrect responses (e.g. hairstylists that said they did their work entirely online), the estimated number of platform workers fell from 3.3% to 1% (Bureau of Labor Statistics, 2018).

An additional challenge to gaining information on the characteristics of platform workers, and the characteristics of their jobs and tasks, is that the small number of platform workers (with most estimates ranging from 0.5% to 2%) leads to small sample sizes. This can limit the statistical precision about specific characteristics of very small groups in the population (O'Farrell and Montagnier, 2019).

Although using administrative data, such as social security or tax data, may overcome problems of sample size, such data has shortcomings that particularly affect the measurement of platform workers. Some administrative datasets may not record platform work performed as a secondary job. In addition, due to ambiguities in the regulation of digital work platforms, workers may be omitted from some datasets (e.g. due to falling below VAT reporting thresholds). The tendency for online platforms to exist in unclear regulatory categories (e.g. the blurred lines between hailing of cabs on the street and pre-booking of chauffeurs) creates obstacles to the use of administrative data. Finally, comparability is limited by differences between systems of administration across countries.

Options for international action

There are several possible methodologies for measuring platform workers and their characteristics, as well as those of their job or tasks, each of which has different advantages and disadvantages. The most appropriate method depends on the research objectives, the resources available, and the trade-offs faced by researchers or statistical agencies.

Potential next steps could include collaborative work to formulate standard questions for inclusion in labour force surveys, ICT usage surveys, or time-use surveys to estimate the number of platform workers. It is also necessary to decide upon the appropriate survey for different topics. For example, one survey may be appropriate for questions regarding the service provided (e.g. whether services are delivered physically or online), but inappropriate for questions regarding hours worked or whether platform work is a person's primary or secondary job. Finally, more experimentation in terms of the ordering of questions and the use of prompting questions may be necessary before such questions are included in surveys.

Partnerships between government agencies and online platforms to improve tax collection have the potential to improve administrative data sources. For example, the Estonian Tax and Customs Board (ETCB) has reached an agreement with two ride-sharing platforms to share their data with the ETCB. However, drivers must first give consent to share their data, which can lead to selection bias (OECD, 2018). Meanwhile in France, from 2019 onwards, online platforms will be obliged to report an individual's annual gross income to the tax authorities (Code Général des Impôts, article 1649, quarter A bis).

Finally, the use of some alternative large datasets can also provide useful insights into the characteristics of platform workers. For example, economists at JP Morgan Chase Institute investigated the characteristics of platform workers by using data from the checking accounts of those who received payments from online platforms (Farrell, Greig and Hamoudi, 2018). Web-scraping can also be useful as shown with the Online Labour Index (OLI) measuring the use of a sample of online labour platforms over time across countries and occupations; although it does not estimate the absolute number of online workers, it does capture trends.

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Why are indicators on skills in the digital era needed?

The digital transformation creates two major challenges for national skills development systems. First, despite growing awareness that the skills profile of citizens and workers in the future will be very different from that of the past, identifying essential skills with certainty is difficult due to rapid technological change. Once these skills have been identified, the second challenge is to ensure that skills development systems adjust sufficiently fast to match the demand for new skills.

Indicators for skills in the digital era are key to addressing both challenges: identifying new demand for skills and monitoring the output of skills development systems.

What are the challenges?

Digital transformation is increasing demand for new skills along three lines. First, the production of ICT products and services – software, webpages, e-commerce, cloud-based computing, Big data and so on – requires ICT specialist skills to program, develop applications and manage networks. Second, workers across a wide-range of occupations need to acquire generic ICT skills to be able to use such technologies in their daily work (e.g. access information online, use software, etc.). Finally, the use of ICTs is changing the way in which work is carried out and increasing demand for ICT-complementary skills (e.g. the capability to compile and analyse information, communicate on social networks, brand products on e-commerce platforms, and so on).

Automation and changes to the way in which work is organised are also likely to significantly affect the relevant skill mix of workers (OECD, 2016a). Automation is altering the distribution of tasks between humans and machines. Robots tend to be skill-biased – they complement skilled workers and substitute for unskilled ones (Autor, 2015; Nedelkoska and Quintini, 2018; OECD, forthcoming). In addition, digital technologies are allowing firms to distribute work in new ways and increase the use of temporary labour. With the introduction of innovative online platforms, new intermediary firms are connecting individual providers with individual customers, turning some full-time, long-term jobs into an uneven flow of "on-demand" tasks.

Current skills statistics, however, do not seem sufficient to address the scope and pace of such changes. The majority are based on educational attainments acquired in formal education, vocational training with standardised content or occupational classifications with codified and predictable tasks. As boundaries between disciplines fade away, the task content of occupations changes and the skills bundles required by new tasks are transformed. However, current skills statistics carry little information for the design of skills development systems.

In addition, digital technologies are creating new opportunities for skills development. Massive Online Open Courses (MOOCs), Open Educational Resources (OER), and blended (on- and off-line) instruction are modifying learning methods and giving more people access to flexible, good quality resources. However, too few of these changes are captured by available statistics. More detailed and timely statistics are needed to forecast long trends, identify emerging skill demands, and respond with an adequate supply of education and training.

Options for international action

There are at least four areas where stronger international co-ordination could lead to better skills statistics: job tasks surveys, skills assessments, expert and science-based technology evaluations and online job vacancies. Each of these four approaches has its own limitations, but their combination seems able to provide useful and timely insights into the changes in skills demand driven by digitalisation (Spiezia, 2018).

Job tasks surveys are very useful to identify how job characteristics change over time and to infer the implications of these changes on the demand for skills. Very few countries, however, have established surveys of this type. The US Occupational Information Network (O*NET) is one of the best-known (https://www.onetonline.org/), and in the United Kingdom, the Employer Skills Survey provides a comprehensive picture of skills needs and training investment, including vacancies and skills shortages, employee skill gaps and the recruitment of education leavers and young people (https://www.gov.uk/government/publications/ukces-employer-skills-survey-2015-uk-report). In Germany, the BIBB/BAuA Labour Force Surveys (https://www.bibb.de/en/2815.php) provide information on the workplace as well as on the relationship between education and employment. One main reason why job tasks surveys are not common is the high cost of developing and conducting such surveys. Importantly, the measurement of workers' skills is based on self-reporting and no formal assessment is carried out on their actual skill levels. Skills assessment surveys, therefore, function as a key complementary tool to improve understanding of skills needs.

The OECD Programme for the International Assessment of Adult Competencies (PIAAC) and the OECD Programme for International Student Assessment (PISA) are well known, cross-country skills assessment programmes. As with the job tasks surveys, PIAAC asks questions about a range of job characteristics and work skills. In addition, PIAAC tests participants through formal tests in order to assess their literacy and numeracy skills and their ability to solve problems in technology-rich environments (i.e. to use these tools to access, process, evaluate and analyse information effectively).

While PIAAC targets adults, PISA tests the skills and knowledge of 15-year-old students in science, mathematics, reading, collaborative problem solving and financial literacy. Like PIAAC, PISA not relies on the respondent's self-assessment but also carries out formal tests of these skills.

A third, useful approach to identifying emerging skills needs is to ask experts for their assessment of what tasks, currently performed by humans, can or could be performed by digital technologies within a short time horizon. A widely cited study by Frey and Osborne (2013), which estimates that 47% of US employment is at a high risk of automation over the next several decades, is based on this approach. In 2016, the OECD asked a group of 11 computer scientists to review the test questions in PIAAC and to identify the questions that could be answered by machines today. Overall, the experts' assessment suggests that the level of computer performance in three skill areas – literacy, numeracy and problem solving – is comparable to that of many workers. Only 13% of the workforce in OECD countries uses the three PIAAC skills on a daily basis and demonstrates a proficiency clearly exceeding the capabilities that computers are capable of reproducing (Elliot, 2017a). Based on a review of computer science research literature, Elliot (2017b) argues that IT capabilities could provide the reasoning, vision and movement skills required in most current jobs. Only in the area of language skills, does the analysis suggest that a substantial number of current jobs have skill requirements that clearly outstrip the IT capabilities demonstrated in the research literature. For this approach to become useful for skills development policies, expert and science-based assessment should be carried out systematically, considering more specific tasks and occupations, and across different countries. This is clearly one avenue where official statistics should consider greater investment.

Finally, online job vacancies have major potential as a source of information on the characteristics of job offers, job seekers and the duration of job postings. They are able to track labour market movements in real time, providing high-frequency data. Furthermore, they permit analysis of shifts in job profiles based on a large range of job requirements on skills, education and experience. Nevertheless, online job vacancies also have some shortcomings, including restricted coverage, biased samples and low international comparability, which future developments in data collection and treatment may be able to overcome.

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Notes

Cyprus

The following note is included at the request of Turkey:

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

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

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

Israel

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

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

6.1 Jobs

Contributions to changes in total employment, by occupation, 2011-17

ICT specialist occupations are defined by three-digit groups of the 2008 revision of the International Standard Classification of Occupations (ISCO-08): Information and communications technology service managers (133), Electrotechnology engineers (215), Software and applications developers and analysts (251), Database and network professionals (252), Information and communications technology operations and user support (351), Telecommunications and broadcasting technicians (352) and Electronics and telecommunications installers and repairers (742).

ICT task-intensive occupations are defined according to the taxonomy described in: Grundke, R., Horvát, P. and M. Squicciarini (forthcoming), "ICT intensive occupations: A task-based analysis", *OECD Science, Technology and Innovation Working Papers*.

Other ICT task-intensive occupations include the following three-digit ISCO-08 Groups: Business services and administration managers (121); Sales, marketing and development managers (122); Professional services managers (134); Physical and earth science professionals (211); Architects, planners, surveyors and designers (216); University and higher education teachers (231); Finance professionals (241); Administration professionals (242) and Sales, marketing and public relations professionals (243).

For Canada, data refer to 2011-16.

For Japan, data refer to 2011-15.

Employment in ICT specialist and ICT task-intensive occupations within and outside information industries, 2017

ICT specialist occupations are defined by three-digit groups of the 2008 revision of the International Standard Classification of Occupations (ISCO-08): Information and communications technology service managers (133), Electrotechnology engineers (215), Software and applications developers and analysts (251), Database and network professionals (252), Information and communications technology operations and user support (351), Telecommunications and broadcasting technicians (352) and Electronics and telecommunications installers and repairers (742).

ICT task-intensive occupations are defined according to the taxonomy described in: Grundke, R., Horvát, P. and M. Squicciarini (forthcoming), "ICT intensive occupations: A task-based analysis" *OECD Science, Technology and Innovation Working Papers*.

Other ICT task-intensive occupations include the following three-digit ISCO-08 groups: Business services and administration managers (121); Sales, marketing and development managers (122); Professional services managers (134); Physical and earth science professionals (211); Architects, planners, surveyors and designers (216); University and higher education teachers (231); Finance professionals (241); Administration professionals (242) and Sales, marketing and public relations professionals (243).

Information industries cover the following ISIC Rev.4 Divisions: Computer, electronic and optical products (26); Publishing, audiovisual and broadcasting (58 to 60); Telecommunications (61) and IT and other information services (62, 63).

For Denmark, Ireland, Japan, Portugal, Turkey and the EU28 aggregate, data refer to 2015.

Jobs likelihood of automation or significant change, 2012 or 2015

Jobs are at high risk of automation if their likelihood of being automated is at least 70%. Jobs at risk of significant change are those with a likelihood of being automated estimated at between 50% and 70%. Data are sourced from Nedelkoska and Quintini (2018), "Automation, skill use and training", *OECD Social, Employment and Migration Working Paper*, No. 202, OECD Publishing, Paris, https://doi.org/10.1787/2e2f4eea-en.

The data for the following 24 countries from the first round of PIAAC refer to the year 2012: Australia, Austria, Belgium (Flanders), Canada, Czech Republic, Denmark, Estonia, Finland, France, Germany, Ireland, Italy, Japan, Korea, the Netherlands, Norway, Poland, the Russian Federation (excluding Moscow), 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.

For the Russian Federation, the PIAAC sample does not include the population of the Moscow municipal area. The data published, therefore, do not represent the entire resident population aged 16-65, but rather the population of the Russian Federation excluding the population residing in the Moscow municipal area.

6.2 Employment dynamics

Contributions to changes in total employment, by digital intensity of sectors, 2006-16

Digital intensity is defined according to the taxonomy described in Calvino et al. (2018).

For Brazil, China, Costa Rica, India, Indonesia and the Russian Federation, data refer to 2006-15

Low digital-intensive sectors are defined according to ISIC Rev.4: Agriculture, hunting, forestry and fishing (Divisions 01 to 03), Mining and quarrying (05 to 09), Food products, beverages and tobacco (10 to 12), Electricity, gas and water supply; sewerage, waste management and remediation activities (35 to 39), Construction (41 to 43), Transportation and storage (49 to 53), Accommodation and food service activities (55 to 56) and Real estate activities (68).

Medium-low digital-intensive sectors include: Textiles, wearing apparel, leather and related products (ISIC Rev.4 Divisions 13 to 15), Chemical, rubber, plastics, fuel products and other non-metallic mineral products (19 to 23), Basic metals and fabricated metal products, except machinery and equipment (24 to 25), Education (85) and Human health and social work activities (86 to 88).

Medium-high digital-intensive sectors include: Wood and paper products; printing (ISIC Rev.4 Divisions 16 to 18), Machinery and equipment (26 to 28), Furniture; other manufacturing; repair and installation of machinery and equipment (31 to 33), Wholesale and retail trade, repair of motor vehicles and motorcycles (45 to 47), Publishing, audiovisual and broadcasting activities (58 to 60), Public administration and defence; compulsory social security (84) and Arts, entertainment and recreation (90 to 93).

High digital-intensive sectors include: Transport equipment (ISIC Rev.4 Divisions 29 to 30), Telecommunications (61), IT and other information services (62 to 63), Financial and insurance activities (64 to 66), Professional, scientific and technical activities; administrative and support service activities (69 to 82) and Other service activities (94 to 96).

More digital-intensive sectors consists of high and medium-high digital-intensive sectors.

Labour market returns to ICT tasks, 2012 or 2015

The ICT task intensity of the jobs indicator relies on exploratory state-of-the-art factor analysis and captures the use of ICTs on the job. It relies on 11 items from the OECD Survey of Adult Skills (PIAAC) ranging from simple use of the Internet to the use of a word processor, spreadsheet 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 Survey of Adult Skills (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 other skill measures detailed in Grundke et al., 2018), 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, Czech Republic, Denmark, Estonia, Finland, France, Germany, Ireland, Italy, Japan, Korea, the Netherlands, Norway, Poland, the Russian Federation (excluding Moscow), 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.

For the Russian Federation, the PIAAC sample does not include the population of the Moscow municipal area. The data published, therefore, do not represent the entire resident population aged 16-65, but rather the population of the Russian Federation excluding the population residing in the Moscow municipal area.

Enterprises that reported hard-to-fill vacancies for ICT specialists, 2018

For Australia, data refer to the fiscal year fiscal year 2015/16 ending on 30 June.

For Iceland, data relate to 2017 instead of 2018.

For Portugal, data relate to 2014 instead of 2012.

6.3. ICT skills in the workplace

ICT task intensity of jobs, by gender, 2012 or 2015

The ICT task intensity of jobs indicator relies on exploratory state-of-the-art factor analysis and captures the use of ICTs on the job. It relies on 11 items from the OECD Survey of Adult Skills (PIAAC) ranging from simple use of the Internet to the use of a word processor, spreadsheet software or a programming language. The detailed methodology can be found in Grundke et al. (2017).

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

For the Russian Federation, the PIAAC sample does not include the population of the Moscow municipal area. The data published, therefore, do not represent the entire resident population aged 16-65, but rather the population of the Russian Federation excluding the population residing in the Moscow municipal area.

Computer-based tasks performed by individuals at work at least once per week, 2018

Computers and computerised equipment include computers, laptops, smartphones, tablets, other portable devices, and other computerised equipment or machinery, such as those used in production lines, transportation or other services.

Receiving tasks via apps comprises the use of applications to receive tasks or instructions (excluding e-mails). Occupation-specific software relates to specialist software for design, data analysis, processing and so on.

6.4 Education and training

Tertiary graduates in the natural sciences, engineering, ICTs, and creative and content fields of education, 2016

The “Creative and content” field includes arts (including graphic design), journalism and information.

For Japan, “Creative and content” fields of education are not presented due to data availability.

Workers receiving firm-based training, highly digital-intensive and other sectors, 2012 or 2015

Employed workers engaged in on-the-job training have undertaken a training activity either offered in the workplace or provided by external educational structures. Proportions are estimated by summing all workers in highly digital-intensive (vs. other) sectors, who engage in training, and dividing this by the sum of all workers employed in highly digital-intensive (vs. other) sectors.

Highly digital-intensive sectors are sectors ranked in the top quartile of the digital intensity of all sectors, as estimated in Calvino et al. (2018).

Point estimates and confidence intervals are estimated using PIAAC sampling and replicate.

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

For the Russian Federation, the PIAAC sample does not include the population of the Moscow municipal area. The data published, therefore, do not represent the entire resident population aged 16-65, but rather the population of the Russian Federation excluding the population residing in the Moscow municipal area.

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 the number of a country's workers displaying a given skill level. 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 ISCED-1997 category 4 degree. Values are reweighted to be representative of the countries' populations. The total trained workforce is the proportion of workers in a country who engaged in training at least once in the year.

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

For the Russian Federation, the PIAAC sample does not include the population of the Moscow municipal area. The data published, therefore, do not represent the entire resident population aged 16-65, but rather the population of the Russian Federation excluding the population residing in the Moscow municipal area.

6.5 Adaptability

Readiness to learn and creative thinking, 2012 or 2015

The readiness to learn and creative thinking indicator is built using exploratory state-of-the-art factor analysis. It relies on six items related to openness to new experiences and creative thinking. The detailed methodology can be found in Grundke et al. (2017).

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

For the Russian Federation, the PIAAC sample does not include the population of the Moscow municipal area. The data published, therefore, do not represent the entire resident population aged 16-65, but rather the population of the Russian Federation excluding the population residing in the Moscow municipal area.

Public expenditure on active labour market policies, 2016

For Greece, Italy, Luxembourg and Spain, data refer to 2015.

OECD data on public expenditure on labour markets are based mainly on information about individual labour market programmes appearing in state budgets and the accounts and annual reports of bodies implementing the programmes.

Public expenditure on active labour market policies relates to spending by central and local public authorities on schemes aimed at the following "targeted persons": unemployed (i.e. not in work, actively seeking), inactive (i.e. would like to work, not actively seeking) or employed but at risk of involuntary job loss.

Placement and related services are typically provided by the public employment service or other publicly financed bodies. They include employment counselling and case-management, referral to opportunities for work, information services and so on.

Training includes targeted institutional and workplace-based training of targeted persons.

Employment incentives include incentives where the employer covers the majority of the labour cost, and job rotation/sharing schemes where a targeted person substitutes for an employee for a fixed period.

Direct job creation relates to new jobs where the labour cost is majority funded by public funds for a limited period.

Start-up incentives encourage targeted persons to start businesses or to become self-employed.

Employees covered by collective agreements, 2016

For the Czech Republic, Denmark, Finland, Italy, Korea, Portugal, Slovak Republic, Slovenia and Sweden, data refer to 2015 instead of 2016.

For Estonia, data refer to 2001 and 2015.

For France, data refer to 2004 and 2014.

For Greece, data refer to 2013 instead of 2016.

For Hungary, Ireland and Luxembourg, data refer to 2014 instead of 2016.

For Israel and Poland, data refer to 2012 instead of 2016.

For Latvia, data refer to 2002 instead of 2000.

For Lithuania, data refer to 2002 and 2015.

For Mexico, data refer to 2012.

For Norway, data refer to 2002 and 2014.

For Switzerland, data refer to 2001 and 2014.

6.6 Platform-mediated workers

Individuals who have offered services on a platform, 2018

Platforms include capital platforms. Capital platforms are platforms, which mainly facilitate the renting (or buying) of capital items, such as property.

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Chapter 7

PROMOTING SOCIAL PROSPERITY

The Internet and connected devices have become a crucial part of most individuals' daily lives in OECD economies. Even so, there can be considerable differences in Internet uptake between different groups in society, linked primarily to age and education, often intertwined with income levels.

Individuals with higher levels of educational attainment are more likely to use the Internet. This may be partly because they are more likely to have experience of Internet use from their studies and subsequent careers, but could also be a function of a greater likelihood of having sufficient disposable income to afford fixed and mobile connectivity. In 2018, the proportion of individuals with tertiary education using the Internet was above 92% in all OECD countries except the United States (89%). The share was 83% in the Russian Federation and 77% in Indonesia, but was 95% in Brazil.

There are wider differences across countries in terms of the share of people with lower levels of educational attainment who use the Internet. The share of Internet users among individuals with low or no formal education ranges from over 90% in Iceland, Denmark, Norway and Luxembourg, to less than 40% in Greece, Colombia, Brazil and Indonesia. In Israel and Mexico, the difference in Internet uptake between high and low-education individuals was almost 50 percentage points. People with lower education are therefore a potential focus for strategies to foster digital inclusion.

These disparities are even greater among the 55-74 age group within which 88% of tertiary graduates are Internet users in the OECD, but only 44% of those with low or no formal education use the Internet on average. The difference between these two groups is very large in some countries, reaching over 70 percentage points in Poland and the Slovak Republic. Action to equip people in this age group with certain ICT skills may help to address some issues common among older generations. For instance, the ability to use email, online messaging or video calling may help to reduce the risk of loneliness in later life by making it easier to stay in touch with friends and family, and the ability to use online systems may make it easier to access health services (see page 2.8).

In 2018, Internet usage among women in OECD countries was equal to that among men, at 86% on average. The difference was most pronounced in Turkey, where Internet usage among women was around 14 percentage points below that of men. Large differences exist in the total share of women of different ages who use the Internet. On average, in the OECD area 97% of women aged 16-24 and 68% of women aged 55-74 use the Internet. Nevertheless, the share of women aged 55-74 is increasing quite steadily, rising from 61% on average just a year earlier in 2016. These age cohort trends suggest that the gap is likely to reduce considerably within a few years.

DID YOU KNOW?

There is very little disparity in Internet use among Nordic countries, where people of all ages, genders and education levels are highly likely to use the Internet.

Definitions

Internet users are individuals who accessed the Internet within the last three months prior to surveying. Different recall periods have been used for some countries (see chapter notes).

Tertiary level graduates are individuals that have obtained a degree at ISCED-2011 Levels 5 to 8 – consisting primarily of bachelor, masters, and doctoral degrees or equivalents.

Individuals with *low or no formal education* are those who have at most ISCED-2011 Level 1 (primary) or 2 (lower secondary) qualifications.

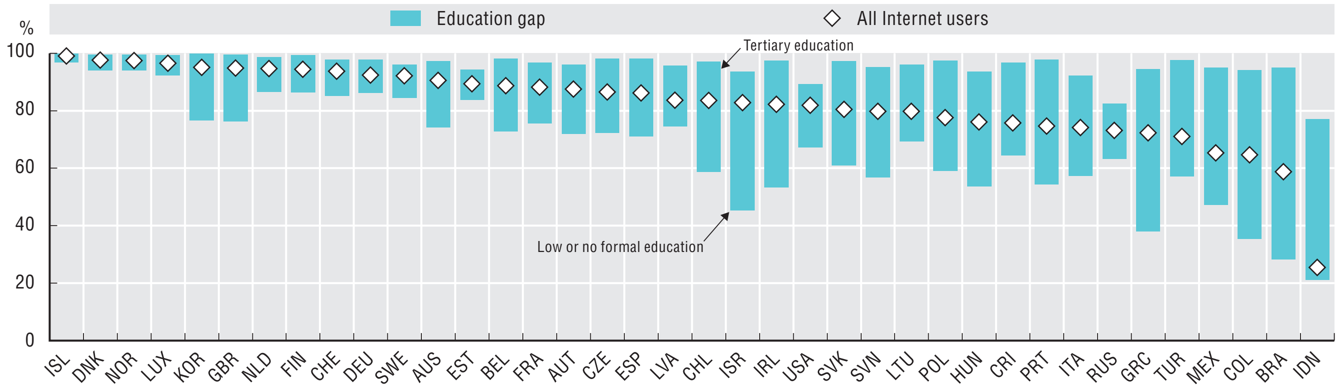
Measurability

In order to identify "Internet users", it is first necessary to define how recently an individual must have used the Internet in order to be counted. A recall period of three months (meaning the respondent should have used the Internet in the three months prior to being surveyed) is recommended. Nevertheless, some countries use longer recall periods or specify no recall period at all; such methodological differences impact the ability to make international comparisons.

These data are generally gathered through direct surveys of ICT use in households and by individuals, or the use of questions in broader household surveys such as Labour Force Surveys or general surveys of living conditions (e.g. in Italy and the United Kingdom). Not all OECD countries survey ICT usage by households and individuals. Furthermore, data availability for specific indicators also varies (see chapter notes). Surveys are undertaken on a multi-year or occasional basis in Australia, Canada, Chile, Israel and New Zealand, but take place annually in other countries. In the European Union, survey response is compulsory in only eight countries. Breakdowns of indicators by age or educational attainment groups may also raise issues about the robustness of information, especially for smaller countries, owing to sample size and survey design.

Gap in Internet use, by educational attainment, 2018

As a percentage of individuals in each category

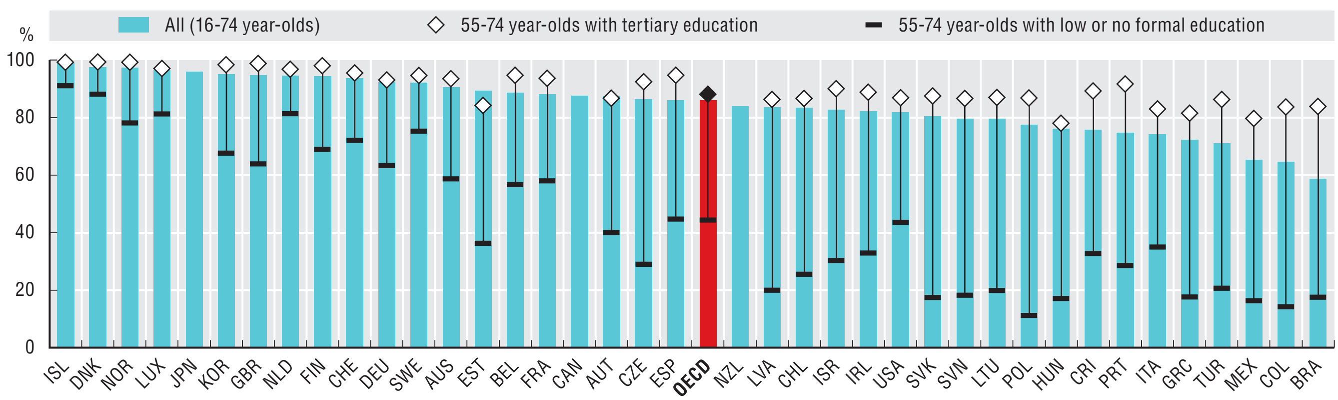


Source: OECD, ICT Access and Usage by Households and Individuals Database, http://oe.cd/hhind and ITU, World Telecommunication/ICT indicators Database, January 2019. See chapter notes. StatLink contains more data.

StatLink https://doi.org/10.1787/888933930820

Internet users, by age and educational attainment, 2018

As a percentage of individuals in each category

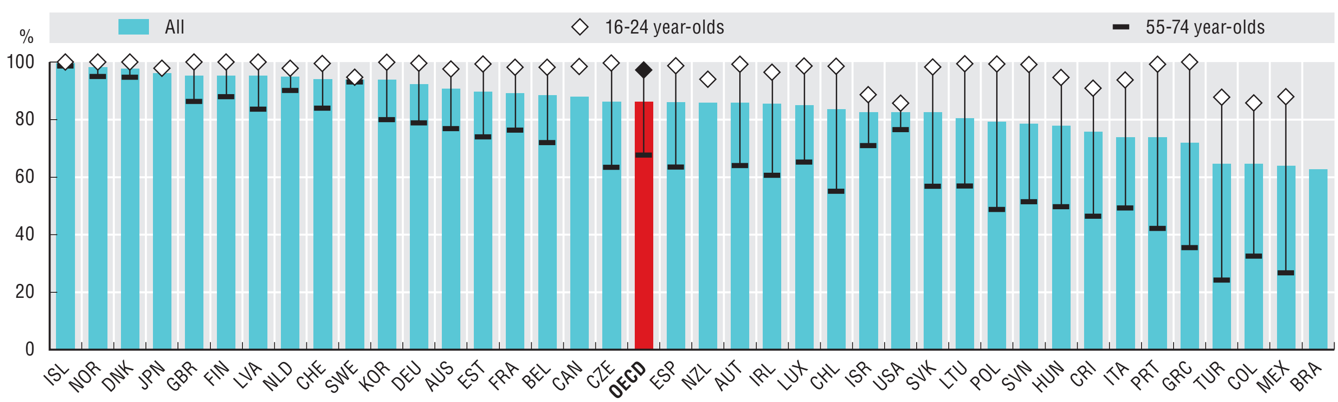


Source: OECD, based on Eurostat, Digital Economy and Society Statistics, Comprehensive Database, December 2018. See chapter notes. StatLink contains more data.

StatLink https://doi.org/10.1787/888933930839

Women Internet users, by age, 2018

As a percentage of individuals in each age group



Source: OECD, ICT Access and Usage by Households and Individuals Database, http://oe.cd/hhind, December 2018. See chapter notes.

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7.2 Skills in the digital era

Solid cognitive skills coupled with problem-solving skills and other competencies necessary to carry out tasks in online environments are key for individuals to prosper in the digital society, including at school and the workplace, and in learning new skills.

Students aged 15 years who are top performers in science, mathematics and reading in the OECD Programme for International Student Assessment (PISA) can be considered to be among the best equipped to adapt to the scale, speed and scope of digital transformations. In 2015, about 15% of 15-year-olds were top performers in OECD countries with notable cross-country differences. Their share reached 26% in Japan and Korea, but remained below 5% in Chile, Turkey and Mexico. Academic all-rounders (those who achieved Level 5 or 6 in science, reading and mathematics) have the highest level of proficiency. They can draw on and use information from multiple direct and indirect sources to solve complex problems, and can integrate knowledge from across different areas. Such exceptional skills can provide a significant advantage in a competitive, knowledge-based global economy (OECD, 2016).

Evidence from the OECD Programme for International Assessment of Adult Competencies (PIAAC) enables a similar view to be drawn for adults. Individuals with a well-rounded skill set in terms of literacy, numeracy and problem solving in technology-rich environments can be expected to use digital tools more efficiently, to carry out more sophisticated activities online, and to better adapt to digital transformations. Countries with higher shares of top-performing students also exhibit higher shares of adults with well-rounded skills (the same is true for lower performance). This underlines the importance of formal education. Furthermore, the share of individuals lacking basic skills in Chile and Turkey is comparable to that of individuals with a well-rounded skill set in Finland, Norway and Sweden, pointing to a skills' gap among OECD countries.

Programming skills are continuing to gain importance as a key competence for prospering in the digital society. In many countries, children are starting to learn programming at increasingly younger ages and opportunities for developing software skills at the secondary and tertiary levels have been widening in most OECD countries over recent years. In 2017, 15% of 16-24 year-olds in the EU28 undertook a programming activity in the past 12 months, compared to 6% for the entire population. This ratio has increased since 2015 in most countries.

The majority of young programmers in all countries presented are men, although the gender gap varies between countries. In 2017, women comprised 10% of 16-24 year-old software programmers in the Czech Republic and Slovenia, compared to about 38% in France, Switzerland and Spain.

DID YOU KNOW?

In 2017, women comprised 10% of 16-24 year-old software programmers in the Czech Republic and Slovenia, compared to about 38% in France, Switzerland and Spain.

Definitions

Top performers in science, mathematics and reading are students aged 15-16 who achieved the highest level of proficiency (i.e. Levels 5 and 6) in the OECD PISA assessment.

On the basis of the OECD's PIAAC assessment, individuals *lacking basic cognitive skills* score at *Level 1 or below* in literacy and numeracy and *below Level 1* in problem solving in technology-rich environments (including those failing the ICT core assessment and those who have no computer experience). Individuals with a *well-rounded cognitive skill set* are those scoring at *Level 3 or above* in literacy and numeracy and at *Level 2 or above* in problem solving in technology-rich environments.

Individuals who can program relates to the self-declared ability to "write code in a programming language", as measured by the 2017 European Community survey on ICT usage in households and by individuals.

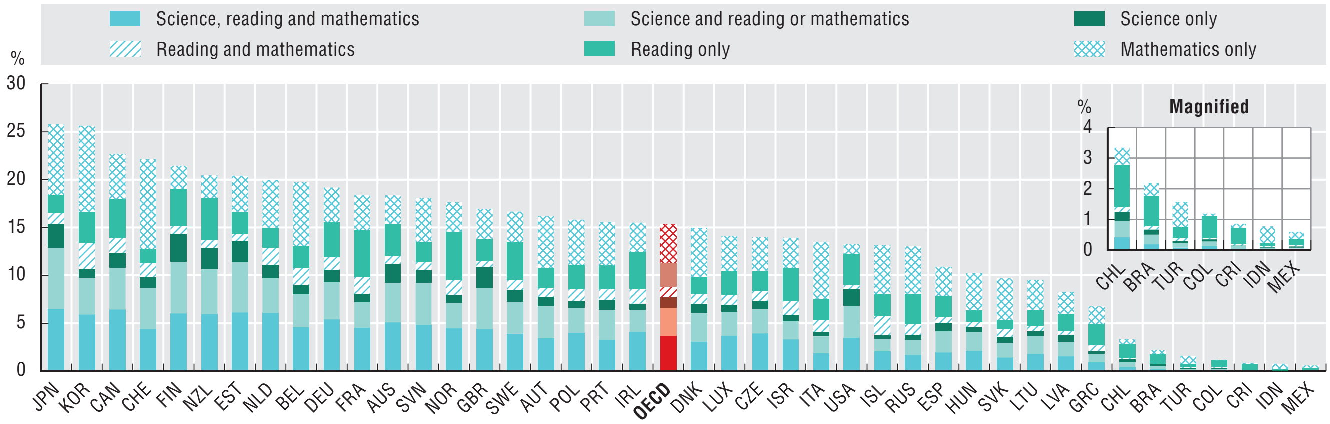
Measurability

The OECD Programme for International Student Assessment (PISA) has been undertaken every three years since 2000. Students included in the assessment are between the ages of 15 years, 3 months and 16 years, 2 months. They must be enrolled in school and have completed at least six years of formal schooling, regardless of the type of institution, the programme followed, or whether the attendance is full-time or part-time. Across 72 countries and economies, over half a million students, (a sample representing the global total of 28 million 15-year-olds) took the internationally agreed two-hour test in 2015.

The OECD Programme for the International Assessment of Adult Competencies (PIAAC) survey measures adult proficiency in key information-processing skills (literacy, numeracy and problem solving in technology-rich environments) and collects data on how adults use their skills at home, at work and in the wider community. The 2012 and 2015 waves cover 32 countries with a sample of 5 000 individuals in each country.

Top performers in science, mathematics and reading, 2015

As a percentage of 15 year-old students



Source: OECD, PISA 2015 Database, December 2018.

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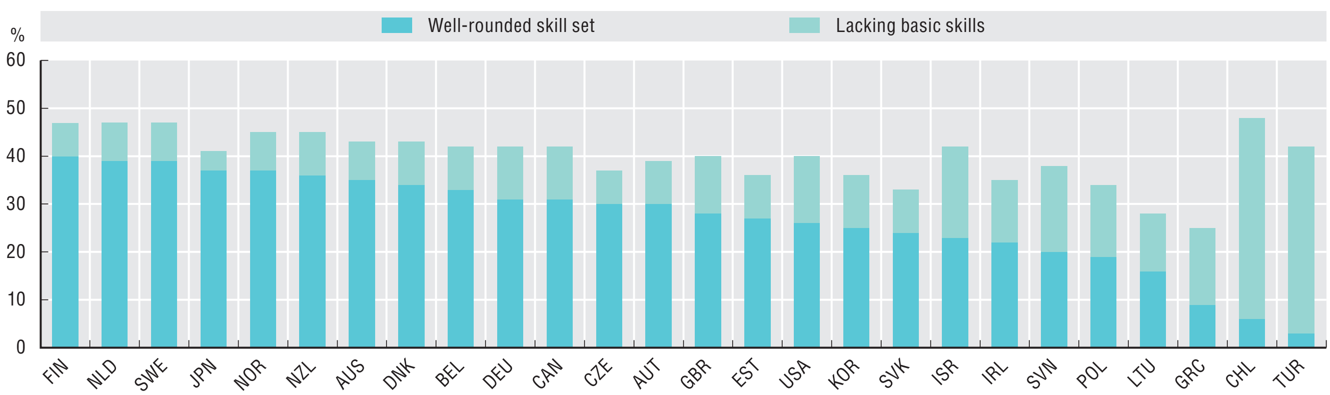
Individuals' skill mix, 2012 or 2015

Percentage of 16-65 year-olds having a well-rounded cognitive skill set or lacking basic cognitive skills



Source: OECD (2019b). See chapter notes.

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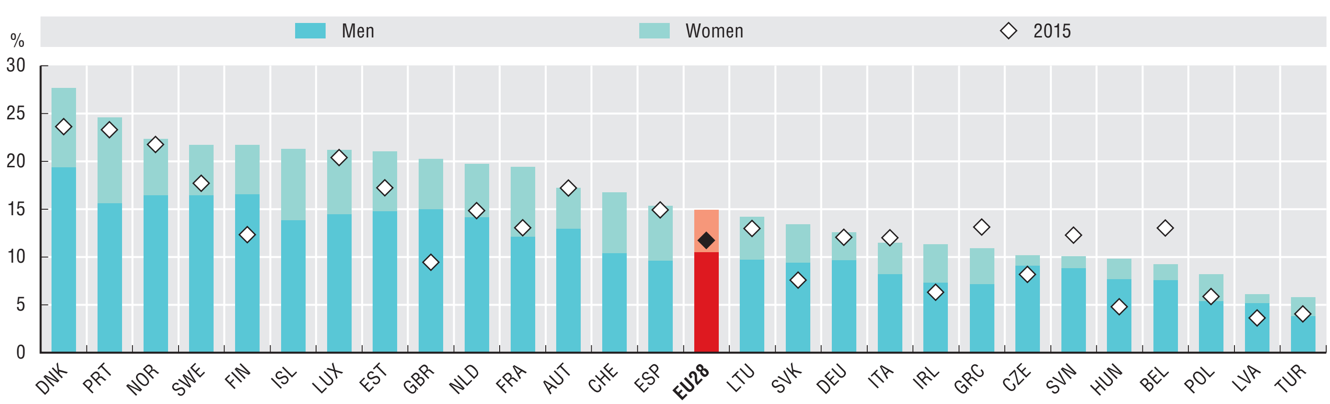
16-24 year-old individuals who can program, by gender, 2017

As a percentage of all Internet users aged 16-24



Source: OECD, based on Eurostat, Digital Economy and Society Statistics, Comprehensive Database, September 2018. See chapter notes.

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The Internet has fundamentally changed a variety of daily activities, from communicating with others, to shopping and banking, to finding information and entertainment content.

On average, in the OECD area, 63% of Internet users accessed online social networks in 2018. Social media can enable individuals to maintain existing social relationships and to build new ones. Evidence on the impact of online social networks on real-life social connections and mental health is mixed. Some warn that online social contact may crowd out real-life interactions and lower the quality of face-to-face contact (Rotondi et al., 2017). However, much evidence supports the idea that online social networks enhance social capital (Dienlin et. al, 2017; Liu et. al., 2016). Nevertheless, it is likely that not all segments of society benefit from online social networks to the same extent. For example, people with mobility issues (e.g. the elderly) could benefit greatly from online networks but are less likely to have the skills needed to access and use them.

Online banking services are now widely available in OECD countries, often via apps as well as websites. On average, 66% of Internet users in the OECD area used online banking in 2018, though this proportion varies from 15% or less in Japan and Mexico, to over 90% in Estonia, the Netherlands and the Nordic countries. While uptake of on-line banking in these countries increased by only 5-10 percentage points between 2010 and 2017, reflecting their longstanding near-ubiquitous use, adoption has increased strongly in many other countries, tripling in Greece, and roughly doubling in Turkey and the Czech Republic since 2010. In almost all countries, individuals from households in the highest income quartile are most likely to use online banking, while those in the lowest quartile tend to have a much lower uptake. In some countries, the lowest income households may tend not use banking services at all, or use small local banks that do not offer online banking, leading to a wide disparity in uptake. For example, in Brazil online banking use was 58 percentage points higher amongst people from the highest income households than the lowest income households in 2016.

The Internet offers ready access to an almost infinite pool of information. In 2017, on average, 65% of people aged 16-74 in the OECD area used the Internet to access news content – an increase of around one-third compared to 2010. In Iceland, Norway and Korea, online news usage reaches 90% of people aged 16-74, whereas in Chile and Colombia, where Internet access itself is more limited, the share is around 20%. However, the quality of information available online can be highly variable. While in some cases online news offers an important alternative to printed or television news influenced by political or business interests, it can be challenging for users to ensure that the news they read online is correct and un-biased. As such, skills such as critical thinking, healthy scepticism, and the ability to research around news topics are likely to become increasingly important.

DID YOU KNOW?

On average in the OECD, 90% of young people aged between 16 and 24 use the Internet for social networking, compared to 32% of 55-74 year olds.

Definitions

Internet users are individuals who accessed the Internet within the last three months prior to surveying. Some countries use different recall periods (see chapter notes).

Online news refers to “individuals using the Internet for reading online sites/newspapers/news magazines”.

Measurability

These data are typically gathered through direct surveys of households’ ICT usage, which ask if the respondent has undertaken a specific activity during the recall period. The OECD Model Survey on ICT Access and Usage by Households and Individuals (OECD, 2015) proposes a wide range of activities including social networking, e-banking, reading online news and many more. A recall period of three months (meaning the respondent should have undertaken the online activities in the three months prior to being surveyed) is recommended, though some countries use longer recall periods or specify no recall period at all. Such methodological differences may impact international comparisons.

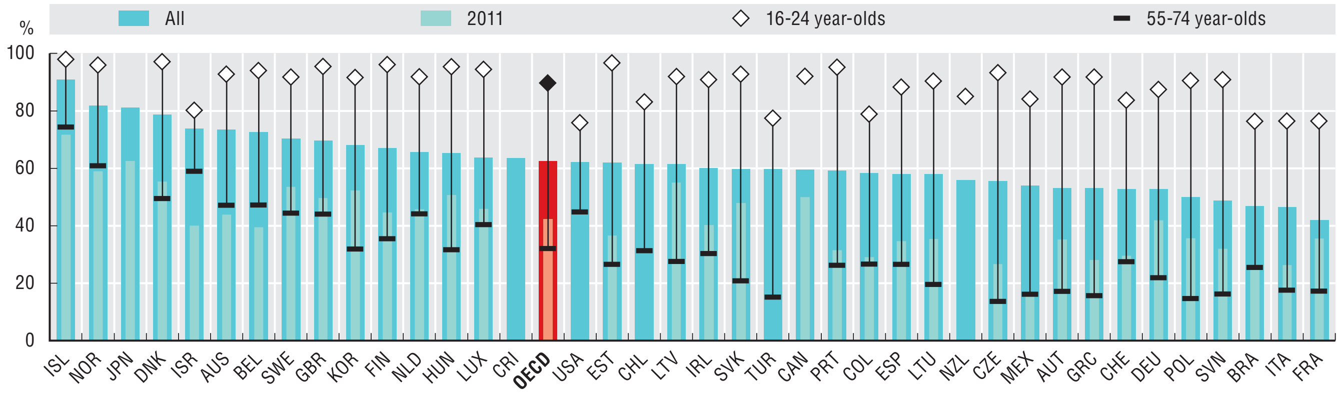
Data might also reflect a variety of country-specific elements, including the diffusion and ease of use of alternative channels to perform certain activities (e.g. bank branches and ATMs in the case of banking services), as well as institutional aspects. For example, in Korea the amount of money individuals are allowed to transfer via the Internet is subject to limitations on grounds of security.

Measuring the frequency and intensity of social network use would provide important additional information. Specific research designs can help shed light on the positive and negative effects of social media use on people’s social connections and mental health. Longitudinal studies have the potential to be particularly instrumental in gaining insight on the causal effects of social media use on various dimensions of well-being.

While some ICT usage surveys inquire about online information search activities, they do not currently gather any information on the usefulness or quality of that information, or the quantities consumed. Given the wide variation in the quality of information available online, such binary measures offer only a very partial initial insight into individuals’ use of online information.

Individuals who used the Internet to access social networking sites, by age, 2018

As a percentage of individuals in each age group

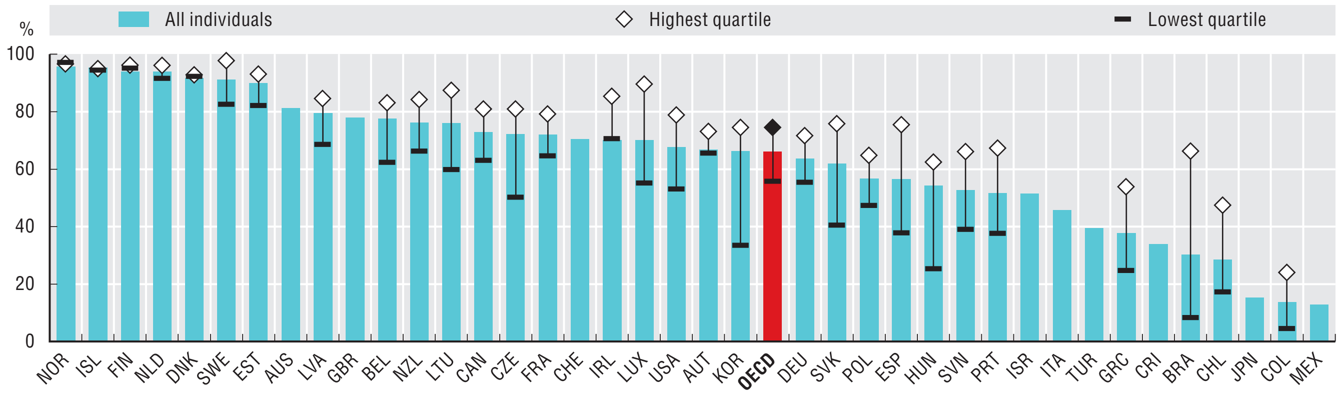


Source: OECD, ICT Access and Usage by Households and Individuals Database, http://oe.cd/hhind, December 2018. See chapter notes.

StatLink https://doi.org/10.1787/888933930934

Individuals who used the Internet for Internet banking, by income, 2018

As a percentage of Internet users in each household income quartile

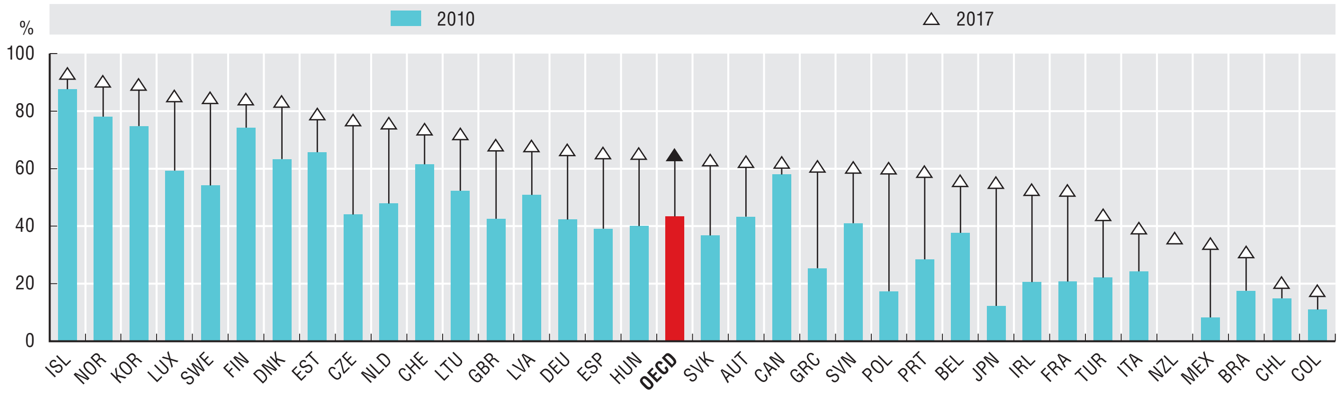


Source: OECD, ICT Access and Usage by Households and Individuals Database, http://oe.cd/hhind, December 2018. See chapter notes.

StatLink https://doi.org/10.1787/888933930953

Individuals who used the Internet to access news online, 2017

As a percentage of all individuals



Source: OECD, ICT Access and Usage by Households and Individuals Database, http://oe.cd/hhind, October 2018. See chapter notes.

StatLink https://doi.org/10.1787/888933930972

In addition to creating a range of opportunities, the digital transformation introduces various new risks and downsides that can affect peoples' lives and well-being. These risks occur in each dimension of the OECD Framework for Measuring Well-being and Progress (http://www.oecd.org/statistics/measuring-well-being-and-progress.htm), and are often difficult to measure. Since well-being is inherently a multidimensional concept, this section cannot do justice to the wide variety of risks posed or the nuances associated with them. Instead, it highlights a few key risks for which data are available in the areas of work-life balance, governance and social connections, each of which have gathered significant attention in the public debate.

Constant connectedness to the Internet presents a potential risk for workers' leisure time and mental health. Time spent on e-mail outside work and organisational expectations that workers should be available at all times have been shown to significantly lower people's satisfaction with their work-life balance (Belkin et al., 2016). Workers with computer-intensive jobs are more likely to experience worries outside the workplace than those whose jobs are not ICT-intensive. This effect exists for both high-skilled and low-skilled workers in most countries. Connected devices can also enable employers to monitor behaviour and performance in new ways. However, the potential productivity benefits from such tools need to be balanced against privacy concerns and the potential for negative effects on employees' well-being.

Disinformation has gained increasing attention as digital technologies facilitate faster and wider dissemination. While disinformation is neither new nor necessarily illegal, some have raised concerns that it negatively impacts individuals and society more broadly (European Commission, 2018); (United Kingdom House of Commons, 2018); (Ministry of Foreign Affairs of Denmark, 2018); (Swedish Civil Contingencies Agency, 2018). While difficult to measure precisely, one indication of the extent of disinformation is self-reported exposure to "completely made-up stories". This suggests that many individuals across the OECD have been exposed to disinformation, with substantial variation across countries, from nearly 50% of respondents in Turkey to under 10% in Denmark and Germany.

Cyberbullying is a product of newly emerged opportunities for public and private harassment especially, among children and teenagers. Exposure to cyberbullying can lead to severe mental health problems, such as anxiety, depression and self-harm (Lindert, 2017). Rates of cyberbullying experiences vary substantially across countries and are not necessarily associated with Internet penetration. It should be noted that online harassment can affect adults as well as children and can be based on many characteristics such as sexual orientation or gender identity. It is therefore imperative to find ways of making the online space safe for people from all parts of society.

DID YOU KNOW?

Girls are more often the victims of cyberbullying than boys in all but four OECD countries.

Definitions

Cyberbullying can take many forms, such as sending harmful messages, impersonating others online, sharing private messages, uploading photographs or videos of another person, and creating hateful websites or social media pages. This measure refers to cyberbullying by messages only.

Disinformation is defined as all forms of false, inaccurate or misleading information designed, presented and promoted to intentionally cause public harm or for profit.

Frequent computer users refers to workers who use digital devices for at least three quarters of working time

Measurability

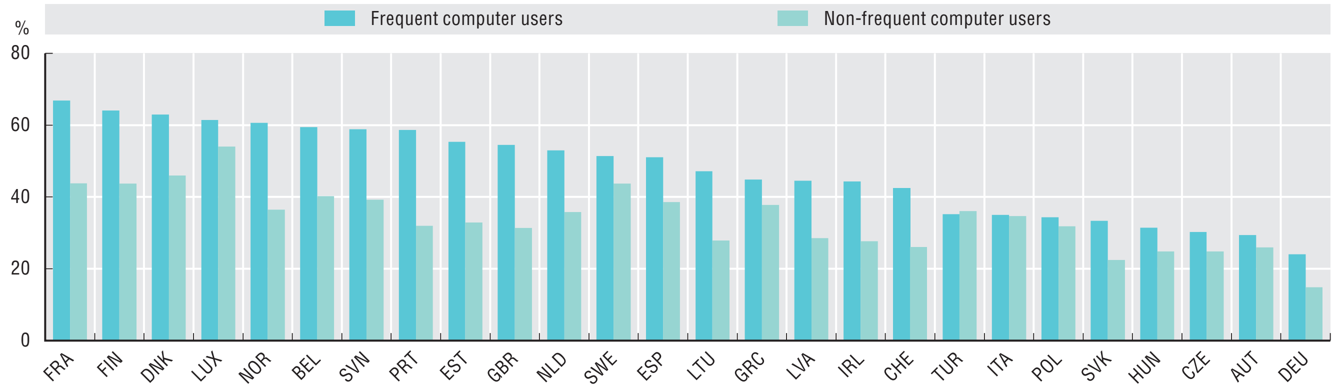
Micro-data from the European Working Conditions Survey (EWCS) show that individuals who frequently use computers at work experience more worries about work outside of work, when controlling for individual characteristics (OECD, 2019a). It is unclear whether this stems from the use of digital devices outside work time or from stress accumulated during work time. Forthcoming data from the 2018 Canadian Internet Use Survey will provide an insight into the extent to which employees are expected to monitor their work e-mail or be reachable outside normal office hours.

Official surveys have not yet responded to the emergence of disinformation by including questions on the topic. The Reuters Institute for the Study of Journalism has conducted a large-scale survey on self-reported encounters in nationally representative panels in 37 countries, providing a rare source of comparable data (Newman et. al., 2018). It should be noted, however, that such self-reported measures captures the individual's *perception* of the veracity of information, rather than the actual degree of accuracy. Furthermore, this measure does not provide insight into the aggregate impact of disinformation as it does not measure how many people have actually seen or have been affected by it.

Surveys that include questions on cyberbullying are administered either at home or at school; settings that may influence children admitting having been the victim of cyberbullying, even if responses are kept confidential. More regular surveys with wider country coverage, harmonised definitions and potentially with coverage of adults as well as children would greatly improve understanding of online harassment.

Individuals worrying about work outside working time, 2015

Percentage of individuals using computers at work

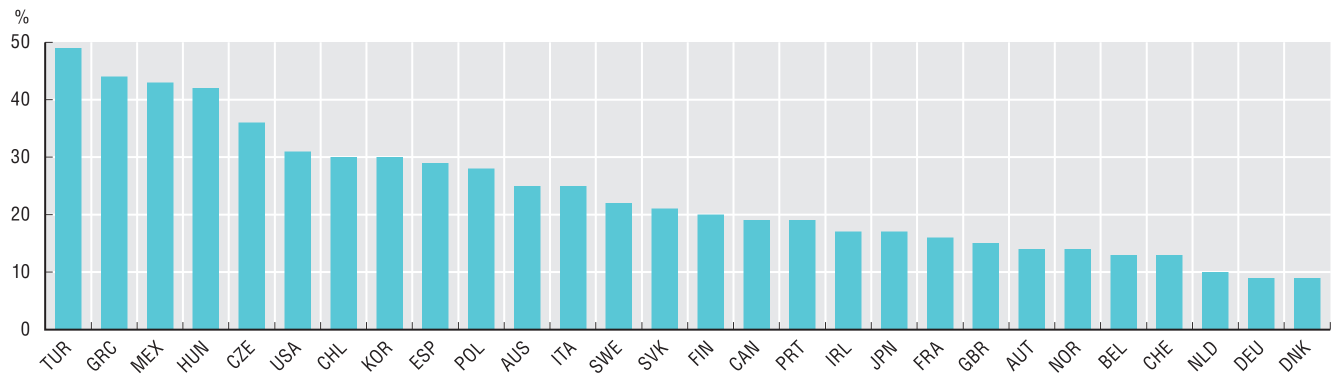


Source: OECD, based on European Working Conditions Survey (EWCS), November 2018. See chapter notes.

StatLink https://doi.org/10.1787/888933930991

Self-reported exposure to disinformation, 2018

Percentage of individuals who reported having come across completely made-up stories in the previous week

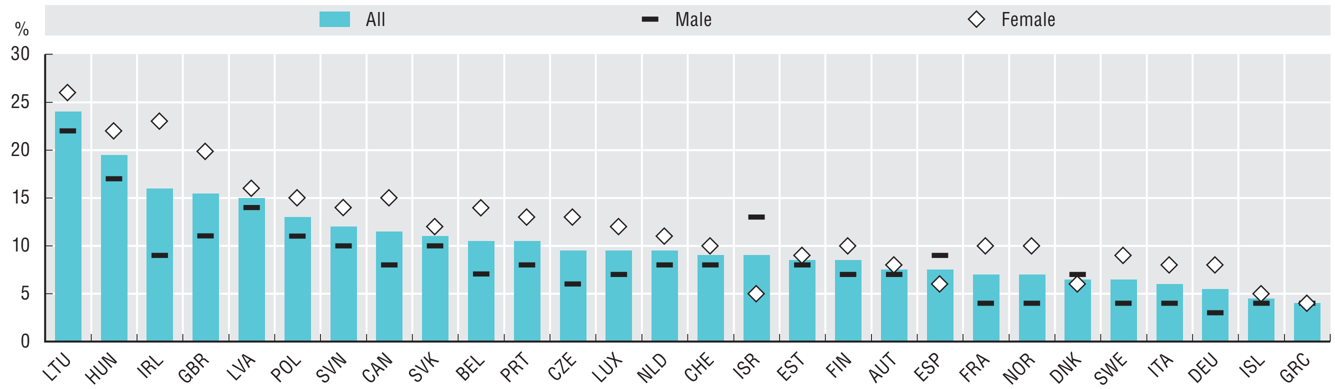


Source: Newman et al. (2018).

StatLink https://doi.org/10.1787/888933931010

Children's exposure to cyberbullying through messages, by gender, 2013

As a percentage of 15 year-olds in each group



Source: WHO (2016). See chapter notes.

StatLink https://doi.org/10.1787/888933931029

The production and use of information products is associated with the generation of "greenhouse gases", such as carbon dioxide (CO_2). The amount of CO_2 produced by information industries, relative to the amount of output produced, varies greatly between countries. Air Emissions Accounts (based on the UN System of Environmental Economic Accounting), show that in most European countries less than 5 tonnes of CO_2 are produced for each million USD of output from the information industries. Meanwhile rates of over 20 tonnes have been observed in Poland, Slovak Republic and Hungary. Many different factors contribute to this situation, including the prevalence of ICT manufacturing and the extent to which each country relies on fossil fuels for electricity production. The carbon-intensity of information industries has remained stable or fallen in many countries since 2008, with Spain, Poland and Hungary as notable exceptions.

It is also possible to examine the "carbon footprint" of information industry products consumed in different countries. These products account for almost 7% of carbon embodied in products consumed in Ireland, but for less than 2% in Saudi Arabia and Israel. ICTs and electronics goods are key products in this regard, accounting for the majority of emissions in most countries.

These goods also constitute an environmental challenge at the end of their lifecycle, creating increasing levels of electronic waste. Improper and unsafe treatment and disposal through open burning or in dumpsites poses significant risks to the environment and human health, and also present several challenges to the achievement of the Sustainable Development Goals. The proliferation of digital technologies to more users and into ever more types of devices, coupled with rapid technological advances, is also resulting in shortening replacement cycles that are driving e-waste generation (Baldé et al., 2017).

In OECD countries, 17 kg of e-waste was produced per inhabitant in 2016, equivalent to 41 kg per USD 100 000 of GDP. E-waste per capita ranges from almost 30 kg per person in Norway to 8 kg in Turkey and less in countries such as China and India - broadly consistent with the penetration of digital technologies in these countries. Due to its relatively high GDP per inhabitant, Luxembourg has the lowest rate of e-waste relative to GDP at 21 kg.

Nevertheless, it should be noted that technology can, in some cases, substitute for other polluting activities. For example, by enabling teleworking technology may contribute to reducing emissions related to commuting (OECD, 2010). The environmental challenges created by e-waste, which often contains hazardous and environmentally damaging substances, can be mitigated through careful management. In European countries, the volume of e-waste recycled or re-used was around 40% of the amount generated, reaching 64% in Sweden.

DID YOU KNOW?

ICTs and electronic goods are a major contributor to information industry carbon emissions, as well as representing the main component of e-waste.

Definitions

E-waste refers to all items of electrical and electronic equipment that have been discarded as waste without the intent of re-use (STEP, 2014). It includes cooling and freezing equipment, screens and monitors, lamps, large equipment (e.g. washing machines and solar panels), small equipment (e.g. vacuum cleaners, microwaves and electronic toys), and small IT and telecommunications equipment such as mobile phones, personal computers and printers.

E-waste generated refers to the amount of e-waste generated in a given year. *E-waste* recycled or reused refers to the amount of e-waste collected through official channels and subsequently used again for the same purpose or reprocessed into other products, materials or substances.

Carbon dioxide is a gas arising from the combustion of carbon that is emitted into the Earth's atmosphere and is one cause of climate change. *Carbon footprint* refers to the carbon dioxide emissions embodied in products.

Measurability

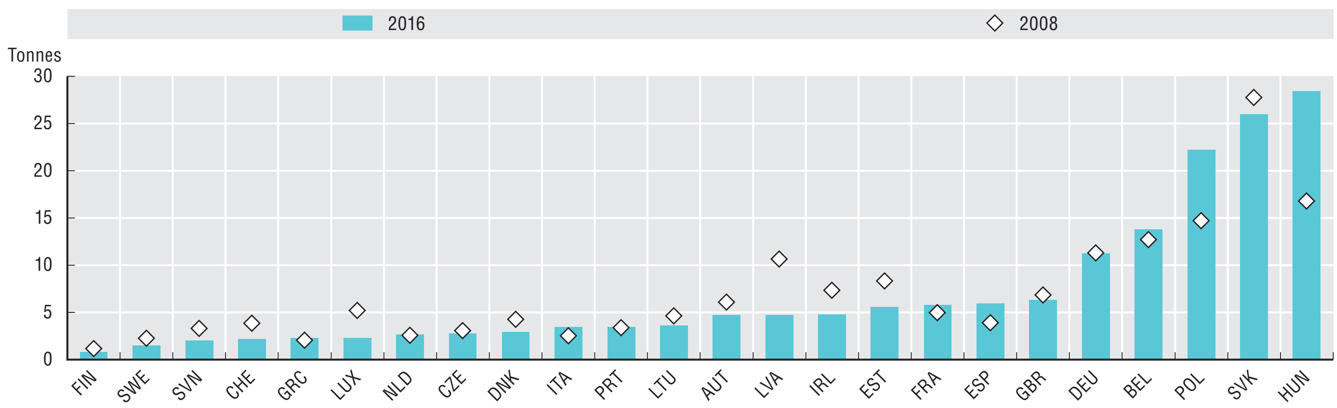
Estimates of CO_2 emissions by information industries come from the OECD, Air Emissions Accounts Database, which integrates economic and environmental information from national sources and international databases using National Accounts concepts, definitions and classifications. The "carbon footprint" estimates the accumulated CO_2 from all stages of production and distribution emitted by domestic and foreign firms, during the production of final goods and services. Estimates combine global input-output tables with CO_2 emissions from fuel use, (https://www.iea.org/geco/emissions) per unit of production, for each industry in each country.

The Global E-Waste Monitor 2017 (Baldé et al., 2017) estimated stocks of e-products for each country, and from those the amounts being discarded in each year. Due to a lack of direct data on sales of e-products, new additions to the stock are estimated based on imports *less* exports. Domestic production is also included for EU countries and Norway.

Recycling and reuse figures are provided to Eurostat by national authorities, under the Waste Electrical and Electronic Equipment (WEEE) directive, based on surveys and administrative data from waste collectors and treatment facilities.

Carbon dioxide emissions produced by information industries, 2016

Tonnes of carbon dioxide per million USD of information industry output

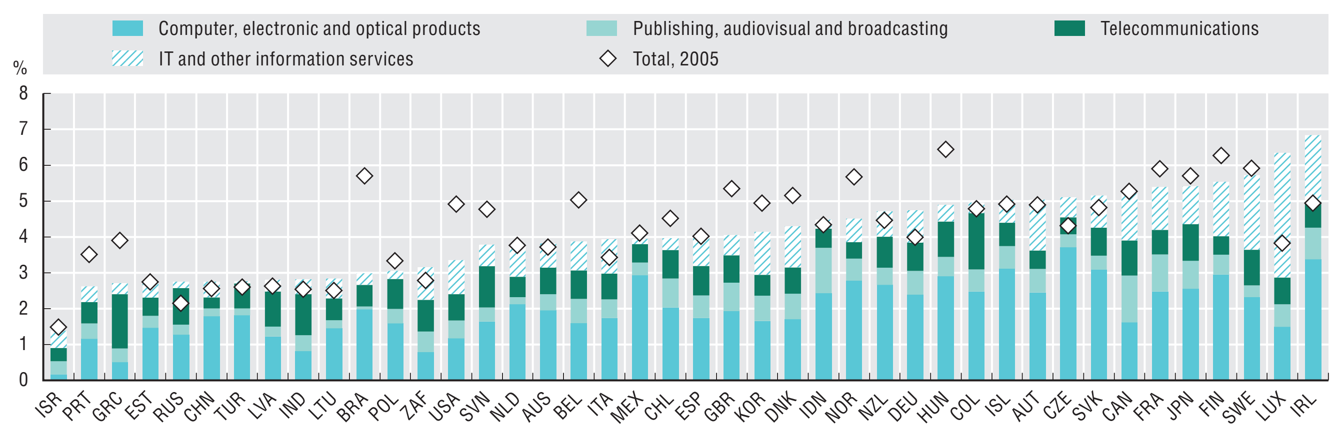


Source: OECD calculations based on Air Emissions Accounts and Annual National Accounts Database, December 2018. See chapter notes. StatLink contains more data.

StatLink https://doi.org/10.1787/888933931048

Carbon footprint of information industry products, 2015

As percentage of total demand-based emissions

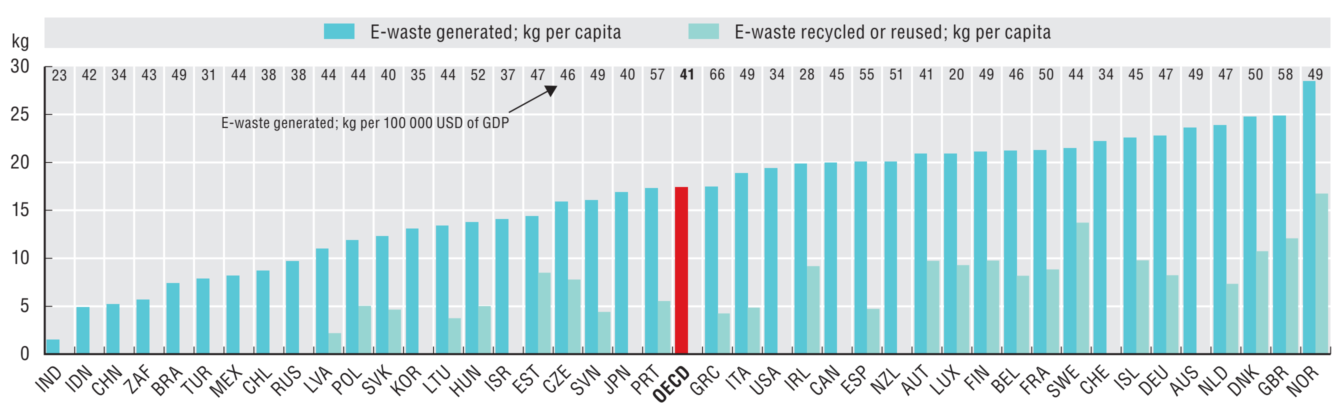


Source: OECD calculations based on OECD, Inter-Country Input-Output (ICIO) Database, http://oe.cd/icio, December 2018 and IEA (2018). See chapter notes. StatLink contains more data.

StatLink https://doi.org/10.1787/888933931067

E-waste generation and recycling or reuse, 2016

Kilogrammes per capita and per 100 000 USD of GDP



Source: OECD based on Baldé et al. (2017); Eurostat, Waste Electrical and Electronic Equipment (WEEE) Statistics and OECD, Annual National Accounts Database, December 2018. See chapter notes.

StatLink https://doi.org/10.1787/888933931086

Why are indicators on online platforms needed?

Online platforms are an increasingly important feature of both national economies and the global economy. Examples are well known and can be found in an ever-increasing variety of activities including transport, delivery and logistics, accommodation, finance, household tasks and many more. While platforms are often aimed primarily at consumers, some focus on business customers.

Platforms have disrupted many of the markets they have entered. One of the most notable ways is through empowering individuals to become producers by giving them easy access to potential customers on a previously impossible scale. Measurement issues related to understanding the numbers of platform workers, their characteristics, the work they do, and so on, are addressed on page 6.6.

Policy makers need to be able to assess and compare across countries the speed with which platforms are transforming markets and the subsequent impacts on firms and market dynamics, as well as on people and communities. Economic statistics do not currently give a clear and integrated answer to key questions about the role, nature and size of platforms.

What are the challenges?

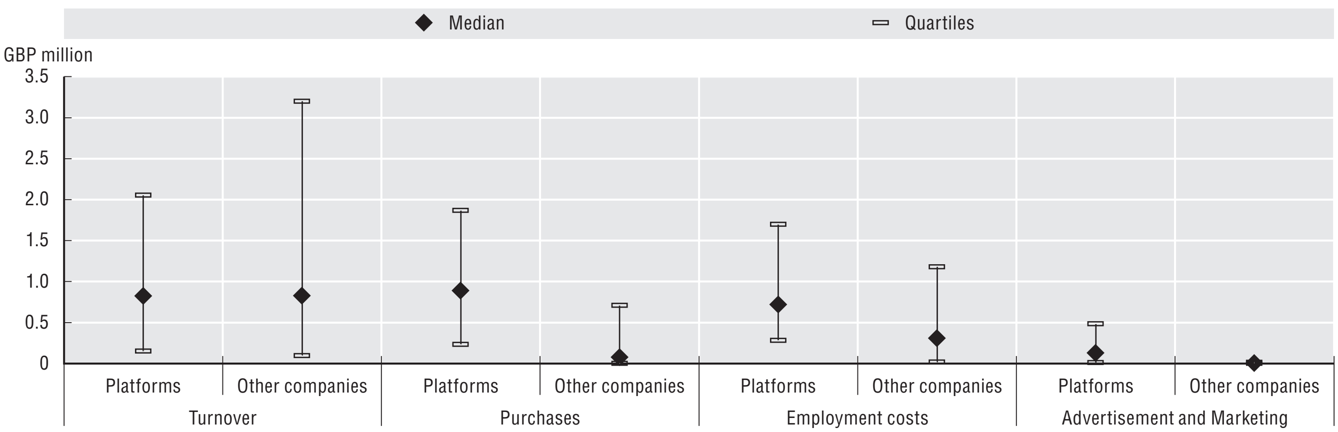
A prerequisite for robust and comparable measurement is a theoretically sound, practically implementable and internationally agreed definition. Building on work by the European Commission and others, the OECD has developed the following definition: "*An online platform is a digital service that facilitates interactions between two or more distinct but interdependent sets of users (whether firms or individuals) who interact through the service via the Internet*" (OECD, 2019).

There will also be a need for meaningful typologies of online platforms. Both the OECD and the United States Bureau of Economic Analysis have worked to develop typologies of platforms based on their activities and business models (Li et al., 2018; OECD, 2019). In addition, several private sector analysts have proposed various typologies of online platforms (Evans and Gawter, 2016; Farrell, Grieg and Hamoudi, 2018). Certain sub-populations of platforms are of particular policy interest, notably platforms that facilitate the "sharing" or "collaborative" economy. International agreement is needed on the typologies to be used for measurement purposes, as international comparisons will rely on broad adoption.

Beyond definitions and classifications, the main challenge will be obtaining data. In principle, much of the relevant information on online platform companies can be gathered in the same way as for other companies, through inclusion in business surveys. Several countries have taken a proactive approach to covering platforms; for example, the United Kingdom Office for National Statistics identified (sharing-economy) platforms and included these in the Annual Business Survey and the E-commerce survey in 2016 (Beck et al., 2017). This provided information on the platforms' turnover, purchases, employment costs and marketing expenditures, as well as their use of online technologies for comparisons with non-platform businesses.

United Kingdom Annual Business Survey variables, online platforms and other businesses, 2017

Median and inter-quartile ranges, millions of pound sterling



Note: Platforms refer here to sharing economy platforms.

Source: OECD, based on Beck et al. (2017).

StatLink https://doi.org/10.1787/888933931105

This approach relies on the platform having a physical or legal presence, such as a subsidiary company, in a country that can be contacted for survey. However, the online nature of platforms' business models means that they are often active in countries without having any formal presence there. Furthermore, large international platforms can have complicated structures, with transactions being routed and processed in multiple ways. This can make it challenging for statistical agencies in any one country to get a holistic view of a platform's activities. Furthermore, it is likely to lead to platform companies receiving data requests from many countries. International co-ordination on collecting data from online platforms has the potential to yield better quality data and to minimise the reporting burden on online platform companies.

Experiences of gathering information directly from platform companies have varied greatly. If working relationships and collection channels can be developed, it is clear that, because online platforms are based entirely around digital systems, they are likely to hold a considerable amount of information that would be useful for statistical purposes. This includes transaction numbers and values, as well as information on the products customers buy and the prices paid (potentially useful for inflation statistics), on supplier and customer locations (relevant for international trade statistics), and other policy-relevant information such as the number of nights for which a property is rented out. However, such information is also likely to be commercially sensitive. This, and concerns about privacy, disclosure, and so on, would need to be managed in any attempt to gather statistical data from platform companies.

Other surveys might also be used to gain information on online platforms and the customers and suppliers that make transactions through them, such as ICT usage surveys, Labour Force Surveys, household expenditure surveys, and time-use surveys. Third-party data sources can also provide useful insights. For example, the JP Morgan Chase Institute used data on millions of transactions by Chase Bank clients in the United States to identify a sample who were active in the platform economy. This allowed analysing the income of individuals who are active on different types of online platforms. Key insights included an apparent high turnover of participants offering services via online platforms, indicated by 58% of the sample having platform earnings for only three or fewer months of the year, and an apparent slowing of uptake as the "traditional" labour market strengthened (Farrell, Grieg and Hamoudi, 2018). Data from tax administration systems and web-scraped data may also be of use.

Options for international action

To date, efforts to measure online platforms' activities, and the transactions facilitated through them, have been rather piecemeal and tended to focus on a specific subset of platforms (e.g. sharing economy platforms). Measurement approaches have focused primarily on business and household survey sources with administrative data in a supporting role and limited exploration of the potential of alternative data sources (e.g. web-scraped data). Such estimates could feed into Digital Supply and Use Tables (see page 2.11) and digital trade measures (see page 9.6), in which transactions via digital intermediary platforms are separately distinguished in the supply and use of products, while platforms are also presented separately from other businesses.

There is scope for the OECD and other International Organisations to establish definitions of online platforms and taxonomies of different types of platforms. This is a key step toward wider uptake of survey-based approaches and developing internationally comparable data.

The international nature of many of the biggest platforms also poses challenges for country-based measurement initiatives. Such issues are common in measuring Multi-National Enterprise (MNE) activities more generally. Platforms should also be included in any wider efforts to improve MNE measurement. In addition, the OECD should investigate the possibility of establishing an online community through which experiences, case studies and experiments can be shared and discussed.

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7.7 Measuring digital government maturity

From E-Government to Digital Government

The fast-paced digital transformation of today's societies and economies is changing expectations of public sector performance and requires new capacities for governments to adapt to the new digital environment. This has driven a shift in public administrations' approaches to the use of technology and data.

After decades of efforts aimed at digitising existing paper-based processes and procedures, and to making public services available online, including on mobile phones, governments are progressively using digital technologies to innovate how they design, operate and deliver services. The goal is to meet the increasing public demand for engagement and services in ways that better respond to users' needs, while improving public sector performance and openness. This has taken the form of a move from using digital technologies in support of government efficiency toward using them to influence and shape public governance outcomes in order to increase societal wellbeing and public trust.

This shift, understood as the evolution from "e-government" to "digital government", is framed by the 2014 OECD Recommendation of the Council on Digital Government Strategies (OECD, 2014). The Recommendation aims to help governments adopt more strategic approaches in the use of technologies with the aim of fostering more open, participatory and innovative government. The 12 key recommendations call for a cultural change within public administrations from the use of digital technologies to better support for public sector operations toward the integration "from the start" of digital technologies in government strategies and policies for public sector reform and modernisation.

The need for digital government indicators

The challenge today for most, if not all, governments is to continue the process of maturing to become "fully digital" – taking steps to promote the evolution from e-government to digital government. As a result, there is a need for tools to identify gaps and areas in need of improvement; these will be essential in helping governments understand their advancement towards a digitally transformed public sector. However, most of the current international measurement instruments are still chiefly focused on governments' use of technology to support the digitisation of existing processes, procedures and services ("e-government"), rather than focusing on elements characterising a digital government.

The OECD Digital Government Indicators project is a first attempt to measure such digitalisation of the public sector. It represents the culmination of several years of collaboration between the OECD Digital Government Unit within the Public Governance Directorate and the OECD Working Party of Senior Digital Government Officials (E-Leaders). It is founded upon a theoretical framework based on the 2014 Recommendation of the Council on Digital Government Strategies and a number of resulting peer reviews (OECD, 2018a, 2018b, 2017). The Digital Government Framework identifies six key dimensions of digital government and aims to assess governments' maturity in those domains (OECD, forthcoming):

1. User-driven (i.e. governments that listen to users' need);
2. Government as a platform (i.e. governments working together with the public to address common challenges);
3. Digital by design (i.e. rooting digital transformation within governments);
4. Data-driven (i.e. governments using data as a key strategic asset);
5. Pro-activeness (i.e. governments anticipating needs and delivery of services); and
6. Open by default (i.e. governments that are transparent and accountable).

Digital government indicators

Data related to each of these dimensions are gathered through surveys sent by the OECD to public administrations. These data will then be used to develop a suite of Digital Government Indicators, in the form of a "maturity index", encompassing all six dimensions of a digital government and showing the maturity in each. This will enable governments to assess their current level of digital maturity (i.e. gradual progress towards becoming a fully digital government) and provide a basis to monitor their efforts towards implementation of the Recommendation.

Although the index will provide a benchmark across countries, the focus will not be restricted to the ranking; it will also enable assessment of the current stage of advancement in each dimension. To support this, the indicators will provide details allowing users to pinpoint specific areas within each dimensions (sub-dimensions) and, thereby, spot weaknesses and gaps and thereafter identify areas for action to increase overall digital maturity.

The Digital Government Indicators aim to provide an innovative, relevant and useful policy tool for governments to advance towards becoming "fully digital", and a monitoring tool to help governments assess their progress in implementing the Recommendation.

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Notes

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.

7.1. Digital inclusion

Gap in Internet use, by educational attainment, 2018

Unless otherwise stated, Internet users are defined as individuals who accessed the Internet within the last 3 months. For Colombia, the recall period is 12 months. For the United States, the recall period is 6 months.

For Australia, data refer to the fiscal year 2016/17 ending on 30 June 2017.

For Brazil, Indonesia and the Russian Federation, data refer to 2016.

For Chile, Colombia, Korea, Mexico, Switzerland and the United States, data refer to 2017.

For Costa Rica, data refer to 2016 and to individuals aged 18-74 instead of 16-74.

For Indonesia, data refer to 2016 and to individuals aged 5 years and over instead of 16-74.

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

Internet users, by age and educational attainment, 2018

Unless otherwise stated, Internet users are defined as individuals who accessed the Internet within the last 3 months. For Canada, Colombia and Japan, the recall period is 12 months. For the United States, the recall period is 6 months.

For Australia, data refer to the fiscal year 2016/17 ending on 30 June.

For Brazil, data refer to 2016.

For Canada, data refer to 2012.

For Chile, Colombia, Costa Rica, Korea, Mexico, Switzerland and the United States, data refer to 2017.

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

For Japan, data refer to 2016 and to individuals aged 15 to 69 instead of 16-74.

For New Zealand, data refer to 2012.

Women Internet users, by age, 2018

Unless otherwise stated, Internet users are defined for this indicator as individuals who accessed the Internet within the last 12 months. For Australia and Israel, the recall period is 3 months. For the United States, the recall period is 6 months.

For Australia, data refer to the fiscal year 2016/17 ending on 30 June.

For Brazil, data refer to 2016.

For Canada and New Zealand, data refer to 2012.

For Chile, Colombia, Costa Rica, Korea, Mexico, Switzerland and the United States, data refer to 2017.

For Israel, data refer to 2016 and to women aged 20 and over instead of 16-74 and 20-24 instead of 16-24.

For Japan, data refer to 2016 and to women aged 15-69 instead of 16-74 and 15-29 instead of 16-24.

7.2. Skills in the digital era

Individuals' skill mix, 2012 or 2015

Data refer to 2012 for all countries except Chile, Greece, Israel, New Zealand, Slovenia and Turkey (2015).

For Belgium, data refer to Flanders only.

For the United Kingdom, data refer to England only.

16-24 year-old individuals who can program, by gender, 2017

For Italy, data refer to 2016 instead of 2017.

7.3 Daily life

Individuals who used the Internet to access social networking sites, by age, 2018

Unless otherwise stated, Internet users are defined as individuals who accessed the Internet within the last 3 months. For Korea and New Zealand, the recall period is 12 months. For the United States, the recall period is 6 months.

For Australia, data refer to the fiscal years 2016/17 and 2010/11 ending on 30 June. The information provided is drawn from responses to a question whose wording differs slightly to that requested: "Activities of Internet access at home, in the previous 3 months – Social networking".

For Brazil, data refer to 2010 and 2016.

For Canada, data refer to 2010 and 2012.

For Chile, data refer to 2017.

For Colombia, data refer to 2012 and 2017.

For Costa Rica, data refer to 2017 and to individuals aged 18 to 74 instead of 16-74.

For Israel, data refer to 2010 and 2016 and relate to Internet usage for discussion and communication groups, such as chats, forums, WhatsApp, Facebook, Skype, Twitter, etc. Data refer to individuals aged respectively 20 and more instead of 16-74 and 20-24 instead of 16-24.

For Japan, data refer to 2012 and 2016 and to individuals aged 15-69 instead of 16-74.

For New Zealand, data refer to 2012.

For Korea and Switzerland, data refer to 2010 and 2017.

For Mexico, data refer to 2013 and 2017.

For the United States, data refer to 2017.

Individuals who used the Internet for Internet banking, by income, 2018

Unless otherwise stated, Internet users are defined as individuals who accessed the Internet within the last 3 months. The recall period is 12 months for Canada, Colombia, Japan, Mexico and New Zealand, and 6 months for the United States.

For Australia, data refer to the fiscal year 2016/17 ending on 30 June.

For Brazil, data refer to 2016.

For Canada and New Zealand, data refer to 2012.

For Chile, data refer to 2017.

For Colombia, data refer to 2017 and to the second lowest quartile instead of the lowest quartile.

For Costa Rica, data refer to 2017 and to individuals aged 18-74 instead of 16-74.

For Japan, data refer to 2016 and to individuals aged 15-69 instead of 16-74.

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

For Iceland, data refer to 2017.

For Korea, Mexico and Switzerland, data refer to 2017.

For the United States, data refer to 2017 and include Internet banking, investing, paying bills online and other financial services.

Individuals who used the Internet to access news online, 2017

Data refer to individuals using the Internet for reading online news sites/newspapers/news magazines in the previous three months.

For Brazil, data refer to 2010 and 2016.

For Canada, data refer to 2010 and 2012.

For Chile and Colombia, data refer to 2013 and 2017.

For Japan, data refer to 2012 and 2016.

For New Zealand, data refer to 2012.

7.4 Downsides to the digital transformation

Individuals worrying about work outside working time, 2015

Frequent computer use refers to workers who use digital devices at work at least three-quarters of the time.

Children's exposure to cyberbullying through messages, by gender, 2013

Children's exposure to cyberbullying refers to the share of children aged 15 who report having been cyberbullied by messages at least once.

7.5 Digital transformation and the environment

Carbon dioxide emissions produced by information industries, 2016

For Ireland and Switzerland, data refer to 2015.

Carbon footprint of information industry products, 2015

The carbon footprint of information industry products is a measure of the accumulated CO_2 emissions from all stages of production and distribution, by domestic and foreign firms, that are required to produce information industry final goods and services. The estimates are derived by combining global input-output tables with CO_2 emissions from fuel use per unit of production, for each industry in each country.

E-waste generation and recycling or reuse, 2016

Electronic waste (or e-waste) refers to all items of electric and electronic equipment and its parts that have been discarded by its owner as waste, without the intent of re-use. In this analysis, it covers six waste categories: 1. Temperature equipment; 2. Screens, monitors; 3. Lamps; 4. Large equipment; 5. Small equipment; and 6. Small IT and telecommunication equipment.

E-waste ratios per USD are based on the GDP expressed in current PPPs for the year 2016.

For Italy and Slovenia, data refer to 2015.

Data on recycling or reuse are only available for the European Union countries and Norway.

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Chapter 8

STRENGTHENING TRUST

8.1 Digital security

The digitisation of information and network connectivity are creating new challenges for the protection of sensitive data and network communications, affecting the trust of businesses and individuals in online activities.

Having a formal ICT security policy is a sign that an enterprise is aware of digital risks. In 2015, about 32% of European enterprises had a formally defined ICT security policy. However, this proportion varied widely across countries and by firm size. While 27% of European small firms had a formal ICT security policy in 2015, the proportion was lower in the United States at 23% (US National Cyber Security Alliance and Symantec, 2011).

Evidence from the Canadian Survey on Cyber Security and Cybercrime shows that, in 2017, only 13% of Canadian businesses had a written policy in place to manage or report digital security incidents. Meanwhile 21% businesses, almost twice as many, reported that they were involved in a digital security incident, which affected their operations. Large businesses (41%) were more than twice as likely as small businesses (19%) to have identified such an incident.

On average, 23% of Internet users in the OECD area reported experiencing a digital security incident in 2015, with notable differences across countries. In Hungary and Mexico, this share was nearly 40%, as opposed to less than 10% in the Czech Republic, the Netherlands and New Zealand.

The share of Internet users affected by a computer virus or other computer infection, with a resulting impact in terms of loss of information or time, has decreased since 2010 in most countries. This is possibly due to the integration of anti-virus software into operating systems and increased general awareness around the issue. In 2016, only 21% of Internet users in the OECD area experienced a security breach; however, the proportion was much higher in Japan at 65%.

National digital security strategies describe how countries prepare and respond to attacks against their digital networks. They can be considered an important dimension of national readiness in terms of digital security risk management. Across all countries covered globally in the ITU's Global Cybersecurity Index 2017, only 38% reported having a published digital security strategy, with 11% having a dedicated standalone strategy. Another 12% of countries had a cybersecurity strategy under development.

Despite half of countries not having a digital security strategy, 61% do have national emergency response team (i.e. CIRT, CSRIT or CERT). However, only 21% publish metrics on cybersecurity incidents. This makes it difficult to objectively assess incidents based on evidence in most countries and therefore to determine the efficiency of protection measures.

DID YOU KNOW?

In 2016, 65% of Internet users in Japan were affected by a computer virus or other computer infection, which caused a loss of information or time.

Definitions

ICT security refers to measures, controls and procedures applied to ICT systems to ensure the integrity, authenticity, availability and confidentiality of data and systems.

SMEs contracting out digital security services refers to the share of SMEs that have a formal ICT security policy where the security and data protection are mainly performed by external suppliers.

The *impact* of a computer virus or other computer infection refers to loss of information or time.

The *Global Cybersecurity Index* is computed on the basis of the following pillars: *legal* (legal institutions and frameworks dealing with cybersecurity and cybercrime); *technical* (technical institutions and frameworks dealing with cybersecurity); *organisational* (policy co-ordination institutions and strategies for cybersecurity development at the national level); *capacity building* (the existence of research and development, education and training programmes, as well as; certified professionals and public sector agencies fostering capacity building), and *co-operation* (refers to partnerships, co-operative frameworks, and information-sharing networks).

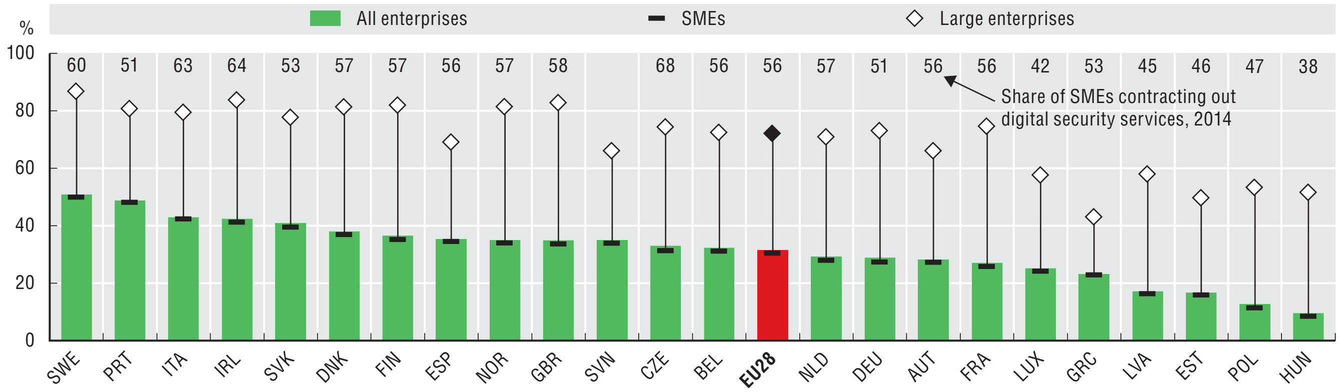
Measurability

Official data on digital security in firms and digital security incidents experienced by individuals are traditionally collected through ICT usage surveys. Countries within the European Statistical System cover these topics through special modules administered every few years. However, given the increasing policy relevance of digital security and trust, both from the perspectives of businesses and individuals, there is a need for additional and more timely metrics. The recently developed OECD measurement framework on Digital Security Risk Management in Firms (see page 8.6) is expected to provide more detailed information in the future.

In 2014, UN Member States committed to support ITU initiatives on cybersecurity, including the Global Cybersecurity Index (GCI), in order to promote government strategies and the sharing of information on efforts across industries and sectors. Data used to compute the 2017 GCI originate from an online survey, administered between January and September 2016, in the 193 ITU countries and the Palestinian Authority. Due to a lack of internationally comparable statistics on digital security from the perspective of governments, qualitative data from the 2017 GCI data collection are presented here to provide a general picture of national initiatives on digital security.

Enterprises having a formally defined security policy, by size, 2015

As a percentage of enterprises in each employment size class



Source: OECD, based on Eurostat, Digital Economy and Society Statistics, Comprehensive Database, September 2018. See chapter notes.

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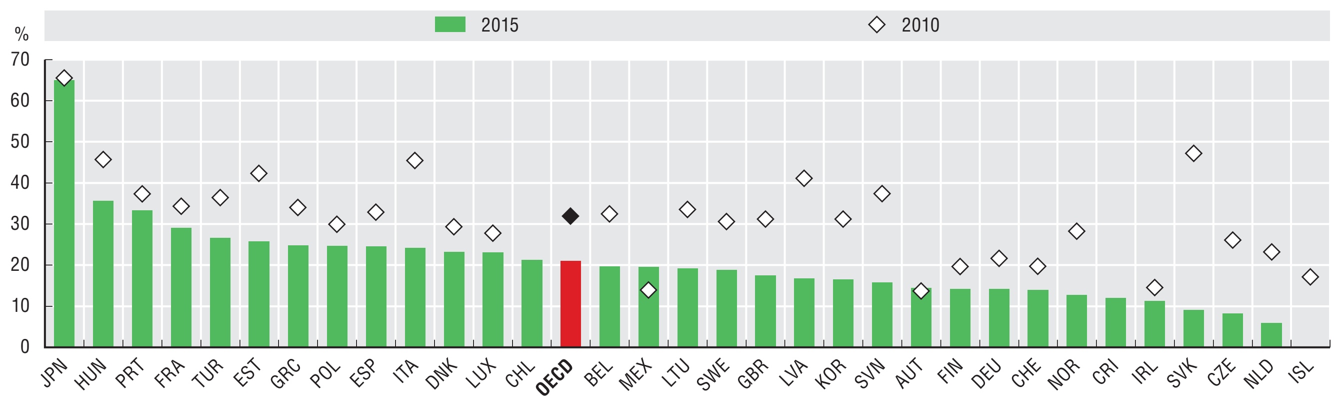
Individuals affected by a computer virus or other computer infection with impacts, 2015

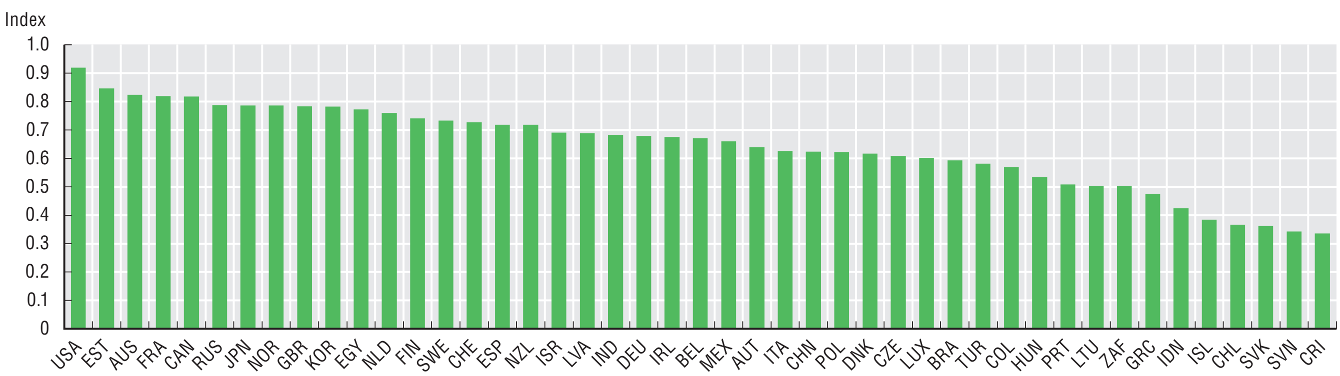
As a percentage of Internet users



Source: OECD, ICT Access and Usage by Households and Individuals Database, http://oe.cd/hhind, November 2018. See chapter notes.

StatLink https://doi.org/10.1787/888933931143

Global Cybersecurity Index, 2017



Source: ITU, Global Cybersecurity Index 2017. StatLink contains more data. See chapter notes.

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With the greater availability of online services and social media, individuals are increasingly providing personal information, sometimes unknowingly, to service providers and online platforms. The digitisation of information and enhanced network connectivity create new challenges for the protection of personal data, while attacks and fraudulent use take place on a regular basis.

In 2016, more than 70% of Internet users in the European Union provided personal information online, with many also performing actions to control access to these data. Young and highly educated individuals show the greatest propensity to share personal information online, but also take actions to control access to the information more often. Men tend to be slightly more willing than women to share private information online in over two-thirds of the countries surveyed. In the same year, 64% of individuals in the United States had an online account containing health, financial or other types of sensitive data (PEW, 2017).

In 2017, 46% of all Internet users in Europe refused to allow the use of personal information for advertising and 40% limited access to their profile or content on social networking sites. More than one-third of Internet users read privacy policy statements before providing personal information and restricted access to their geographical location (OECD, 2017). In 2013, 55% of Internet users in the United States reported that they had taken steps to avoid observation by specific people, organisations or the government (PEW, 2013).

Concerns about the protection and security of personal data are also frequently reported as a reason for not submitting official forms online. In 2018, 18% of the individuals in the EU28 chose not to submit forms to public authorities and, on average, 20% among those cited privacy and security concerns as a reason for not doing so. This was particularly the case in Hungary (40%), Switzerland (37%) and Germany (34%). Other reasons for not submitting official forms include lack of skills and service availability.

In 2015, around 3% of all Internet users across OECD countries for which data are available reported having experienced a privacy violation in the three months prior to being surveyed. This share was highest in Chile (8%), Korea and Italy (about 6%). In countries such as Norway, Portugal, Sweden and Turkey, there was a notable increase in privacy violations as reported by individuals between 2010 and 2015. In 2016, 64% of individuals in the United States experienced or had been notified of a significant data breach pertaining to their personal data or accounts (PEW, 2017).

Personal data breaches (i.e. breaches of personal data confidentiality as a result of malicious activities or accidental losses) are a major cause of privacy violations (see page 8.7). In addition, individuals' privacy can be affected by the extraction of complementary information that can be derived, by "mining" available data for patterns and correlations, many of which do not need to be personal data. Regulatory measures such as the General Data Protection Regulation (GDPR) in the European Union allow giving control to individuals over their personal data.

DID YOU KNOW?

Young individuals have a higher propensity to provide personal information on the Internet than older ones.

Definitions

Personal information refers to information that the user considers private and would not necessarily disclose to the public, such as personal, contact and payment details or other individual information.

Online submission of official forms refers to interactions through which individuals submit official forms to public authorities via the Internet. Data exclude manually typed e-mails.

Individuals having chosen not to submit official forms online are those who did not submit official forms, although they had to, due to reasons such as lack of skills or knowledge, concerns about data protection and security of personal data or another person's involvement (e.g. consultant, tax advisor).

Privacy violations refer to the abuse of personal information that has been sent via the Internet and/or other violations such as the abuse of pictures, videos or personal data uploaded onto community websites.

Measurability

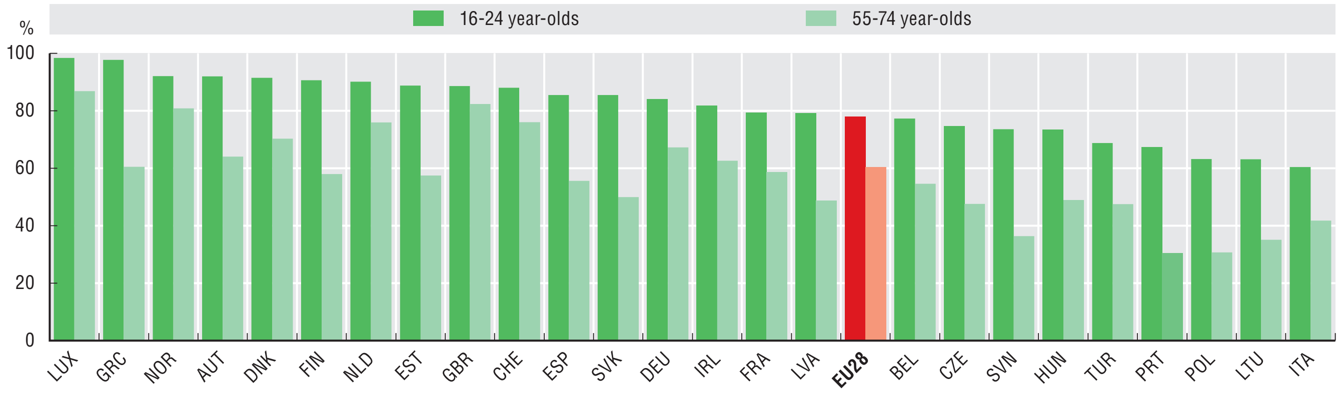
Information on the disclosure and protection of personal information online is traditionally collected through surveys on ICT usage in households and by individuals. Both the European Community and OECD model surveys on ICT usage ask direct questions about security and privacy, including on the use of protection from IT threats, the frequency of security updates and security incidents.

The 2014 revision of the OECD Model Survey on ICT Access and Usage by Households and Individuals (OECD, 2015) includes a specific module on security and privacy, based on policy-relevant questions from the OECD Working Party on Security and Privacy in the Digital Economy.

Despite the high policy relevance of online privacy protection, data coverage remains scarce in the OECD countries where questions or modules on these issues are not administered in official ICT usage surveys on a yearly basis. In this respect, internationally comparable data collection from Privacy Enforcement Authorities and timely statistics from businesses represent potential alternative data sources to strengthen the evidence base for decision-making.

Individuals who provided personal information over the Internet, by age, 2016

As a percentage of Internet users in each group



Source: OECD, based on Eurostat, Digital Economy and Society Statistics, Comprehensive Database and OFS, Omnibus TIC 2017 survey, September 2018. See chapter notes. StatLink contains more data.

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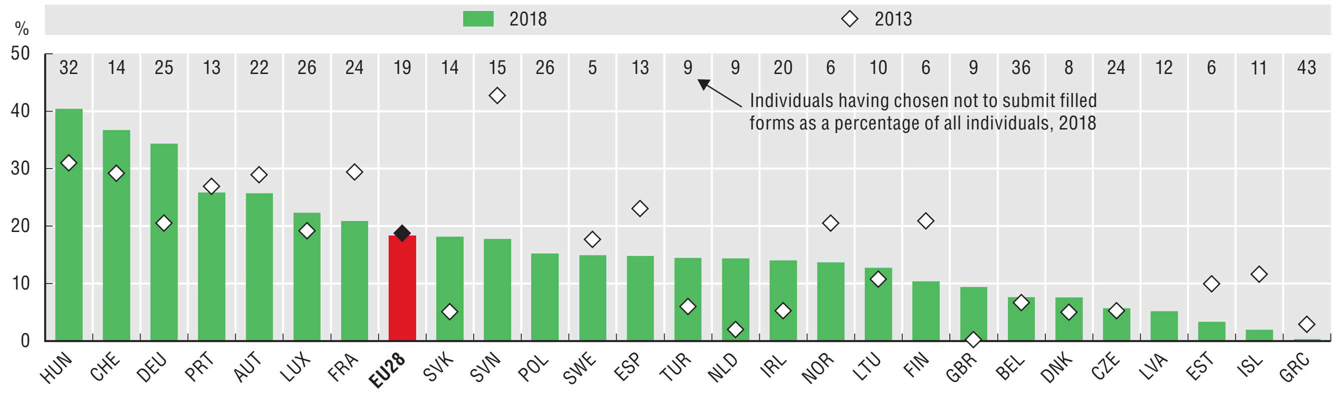
Individuals who did not submit official forms online due to privacy and security concerns, 2018

As a percentage of individuals having chosen not to submit official forms online



Source: OECD, based on Eurostat, Digital Economy and Society Statistics, Comprehensive Database, December 2018. See chapter notes.

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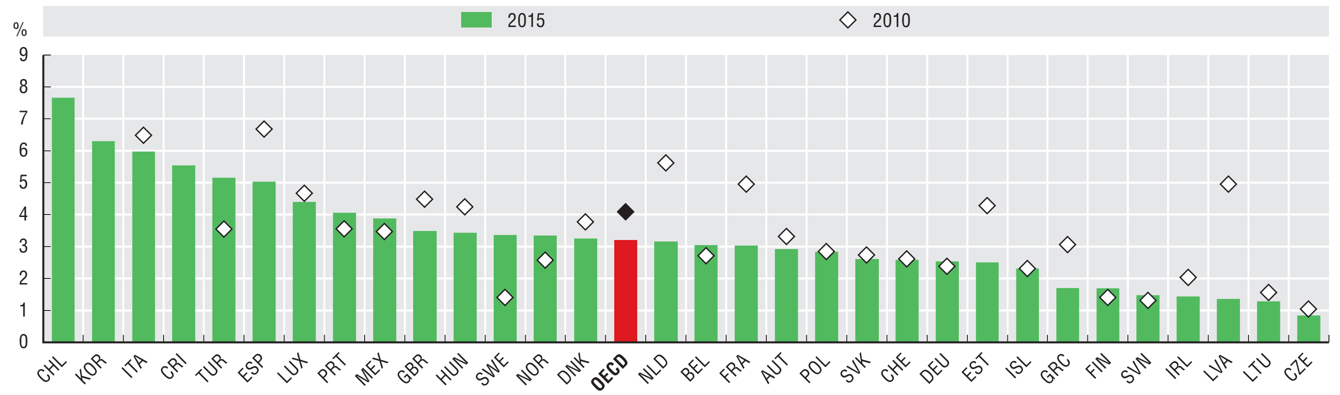
Individuals who experienced privacy violations, 2015

As a percentage of Internet users



Source: OECD, ICT Access and Usage by Households and Individuals Database, http://oe.cd/hhind, September 2018. See chapter notes.

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8.3 | Skills for managing digital security risks and privacy

The ability of organisations and people to manage digital security risk and privacy is key to fostering trust in online environments. From a business perspective, management of digital security risk needs to be integrated across the entire business process in order to be effective. It may be undertaken internally by employees or outsourced depending on the business strategy and the availability of resources, including skills present in the workforce. From an individual perspective, awareness of security and privacy threats and the competencies to prevent and respond to them are crucial for prospering in the digital society.

In 2017, ICT security and data protection functions were performed mainly by own employees in about 22% of enterprises in EU28 countries. Differences according to firm size are notable. Given the composition of the business population in most economies, this is driven mostly by the behaviour of smaller firms. Large firms are considerably more likely to perform such functions internally (57% on average) as compared to small ones (19%). In countries such as Slovenia, Austria, Latvia and Poland, the share of large firms with own employees in charge of ICT security and data protection was above 65% of all large firms.

With the almost universal uptake of digital technologies, such as smartphones, digital security and privacy skills are playing an increasingly important role in individuals' daily lives. New evidence from the European Community Survey of ICT Usage in Households and by Individuals suggests that about 60% of smartphone users in the EU28 have restricted or refused access to their personal data at least once when using or installing an app, in contrast to 28% who have never done so. The share of those who were unaware of the existence of such functionalities was rather low (7% on average) indicating strong overall awareness of digital security and privacy threats related to smartphone use.

Training allows individuals to heighten their awareness while gaining more up-to-date digital security and privacy skills in a context of fast technological change. In the EU28, about 20% of individuals who carried out a learning activity related to the use of computers in 2018 received training on IT security or privacy management. The propensity to learn about these topics was greater among highly skilled individuals in most of the countries with available data, especially in Austria, Finland, Ireland and Hungary.

These variables from ICT usage surveys allow for the computation of internationally comparable statistics, which shed light on the availability of digital security and privacy skills across countries and link them to other usage metrics both for firms and individuals.

DID YOU KNOW?

In 2018, only 7% of smartphone users in the EU28 did not know it was possible to restrict or refuse access to their personal data when using or installing an app.

Definitions

ICT security and data protection tasks include security testing and developing or maintaining a security software.

Business size classes are defined as *small* (from 10 to 49 persons employed) and *large* (250 and more).

Personal data restriction when using or installing an app on a smartphone relates to information such as the location or contact list.

Measurability

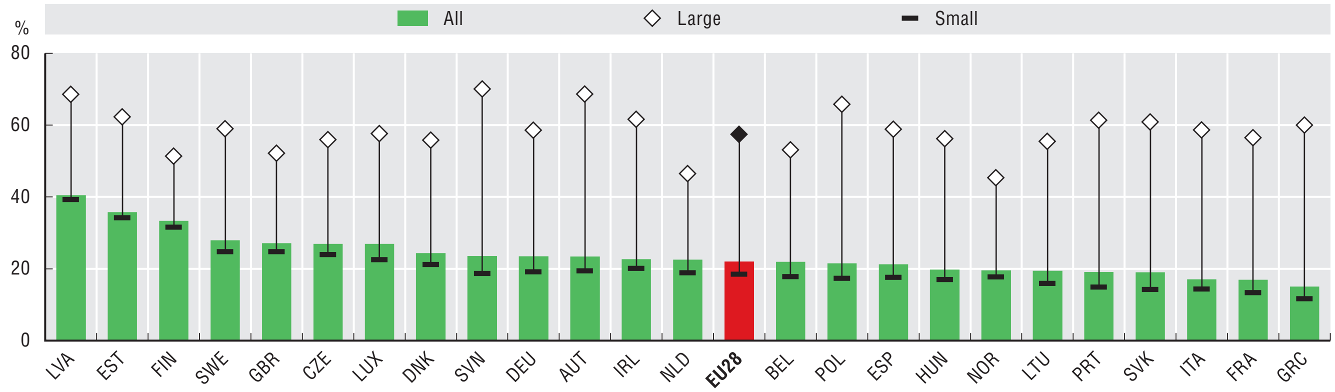
Official information on digital security skills can be collected from various sources including education (fields of education) or employment (occupation) statistics. However, such level of detail is not always available in an internationally comparable fashion. In this respect, it is possible to compute proxy indicators with information from business ICT usage surveys, for example, on different IT security activities performed by employees. Likewise, ICT usage surveys in households and by individuals provide valuable proxy metrics through questions related to online activities and security and privacy-related training.

Ideally, data on individuals' digital skills should not be collected based on a given technology, as the pace of technological change is rather rapid and digital skills are increasingly device agnostic. However, depending on the policy needs, statistical agencies can introduce special modules focusing on the use of a particular technology. In this vein, the trust, security and privacy module of the 2018 European Community Survey on ICT Usage in Households and by Individuals has been administered for the first time with a focus on smartphones. New evidence shown here therefore focuses on individuals' digital security and privacy skills when using or installing an app on a smartphone.

This module also collects information on the availability of a security software or service (e.g. antivirus, antispam or firewall) on individuals' smartphones as well as their experience of loss of information, documents, pictures or other kind of data resulting from a virus or other hostile type of programs.

Enterprises where ICT security and data protection functions are mainly performed by own employees, 2017

As a percentage of enterprises in each employment size class



Source: OECD, based on Eurostat, Digital Economy and Society Statistics, Comprehensive Database, December 2018. StatLink contains more data.

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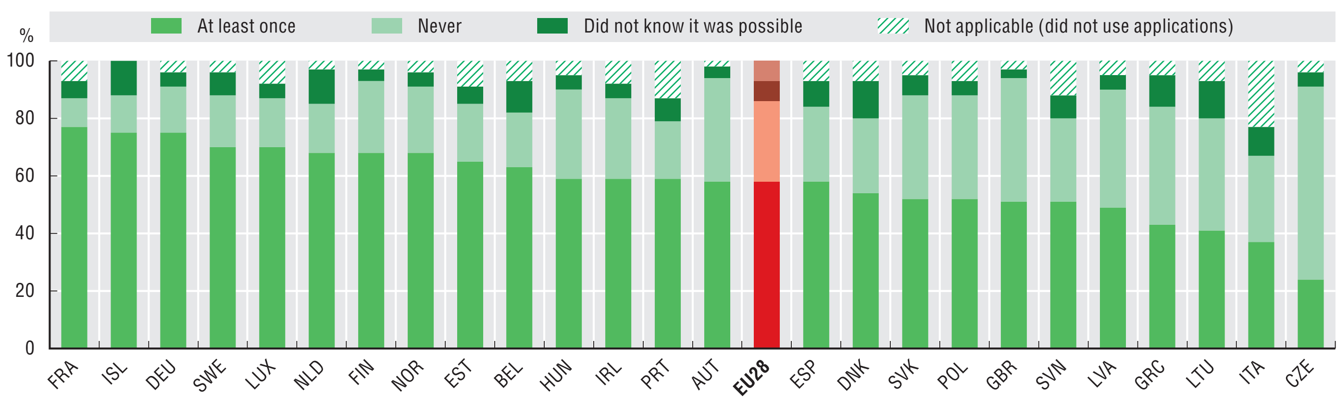
Individuals who restricted or refused access to their personal data when using or installing an app on a smartphone, 2018

As a percentage of individuals using a smartphone for private purposes

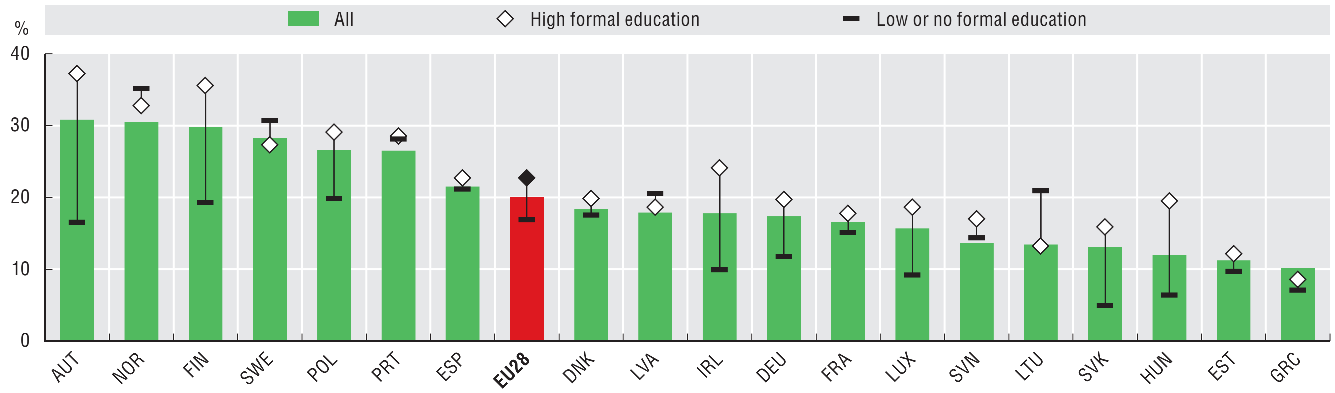


Source: OECD, based on Eurostat Digital Economy and Society Statistics, January 2019.

StatLink https://doi.org/10.1787/888933931257

Individuals who undertook training on IT-security or privacy management, by educational attainment, 2018

As a percentage of individuals undertaking a learning activity related to the use of computers in each category



Source: OECD, based on Eurostat, Digital Economy and Society Statistics, Comprehensive Database, January 2019.

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The volume of e-commerce transactions has been on the rise, alongside the growing importance of platform intermediation (see page 6.6), changes in business models and the enhancement of individuals' digital skills.

However, about a third (36%) of Internet users in OECD countries did not purchase online in 2018. Among the reported reasons for not doing so are payment security and privacy concerns. These reasons affected in 2017 25% of Internet users in the EU28 who did not make online purchases in the last 12 months. This share peaked at nearly 70% in Portugal and Finland, compared to less than 10% in Korea, the Czech Republic, Estonia and Poland. Another frequently reported barrier to online purchases is post-transaction trust concerns, for example, related to receiving or returning goods, or complaint and redress concerns. In 2017, these concerns affected 16% of Internet users in the EU28 who did not make online purchases in the year prior to being surveyed. The shares of Internet users reporting these concerns decreased between 2009 and 2017 in most countries with available data, but it increased considerably in others such as Portugal, Finland, Turkey, Norway and Iceland.

The e-commerce experience remains rather positive for a large majority of people who buy online in the European Union. In 2017, 70% of online shoppers did not encounter any problems and only 3% reported experiencing fraud. Online buyers in Southern European countries seem to express higher satisfaction and lower fraud incidence in comparison to those in Northern European countries, Luxembourg and the United Kingdom. In these countries, individuals are relatively more likely to shop online, increasing in turn the likelihood of experiencing incidents.

The growing importance of global online platforms for business-to-consumer and consumer-to-consumer transactions has improved access to suppliers from across the world that offer competitive prices and payment facilities. Very often, consumers are invited to use rating and review mechanisms to provide feedback on their online purchase experience. In such transactions, trust emerges as the key currency.

The results of the 2017 OECD Survey of Consumer Trust of Peer Platform Markets (PPMs) show that, in all ten countries included in the study, at least 30% of consumers who went ahead with purchases despite being unsure about the seller/provider did so because they trusted the platform. These shares reached about 50% in Turkey and the United States. On average, 26% reported that the possibility of rating or reviewing the seller or the provider after the completion of the transaction led them to complete their online purchase despite being unsure whether to trust them.

The main findings of this survey indicate that is no single key to trust: Secure payment, data security and the ability to see pictures of goods or services are the top drivers. PPM consumers take a nuanced view of ratings and reviews, which are considered important, but not necessarily crucial. The more consumers use PPMs, the more they trust them.

DID YOU KNOW?

70% of online shoppers in the EU28 did not encounter any problems in 2017 and only 3% reported experiencing fraud.

Definitions

Payment security and privacy concerns relate to the provision of credit card details or personal details over the Internet.

Online purchases are a component of e-commerce. They include transactions of goods and services "conducted over computer networks by methods specifically designed for the purpose of receiving or placing orders" (OECD, 2011). For individuals, whether sellers or purchasers, such transactions typically occur over the Internet. Online purchases are typically measured over a 12-month recall period because e-commerce is not always a high-frequency activity.

Fraud includes issues such as non-receipt of goods/services purchased online, misuse of credit card details and so on.

Purchasers on a peer platform refers to consumers who have bought goods from other people (e.g. via online marketplaces) and those who have hired people to perform household tasks through online platforms, as well as users of more collaborative platforms such as those for ride and accommodation sharing.

Measurability

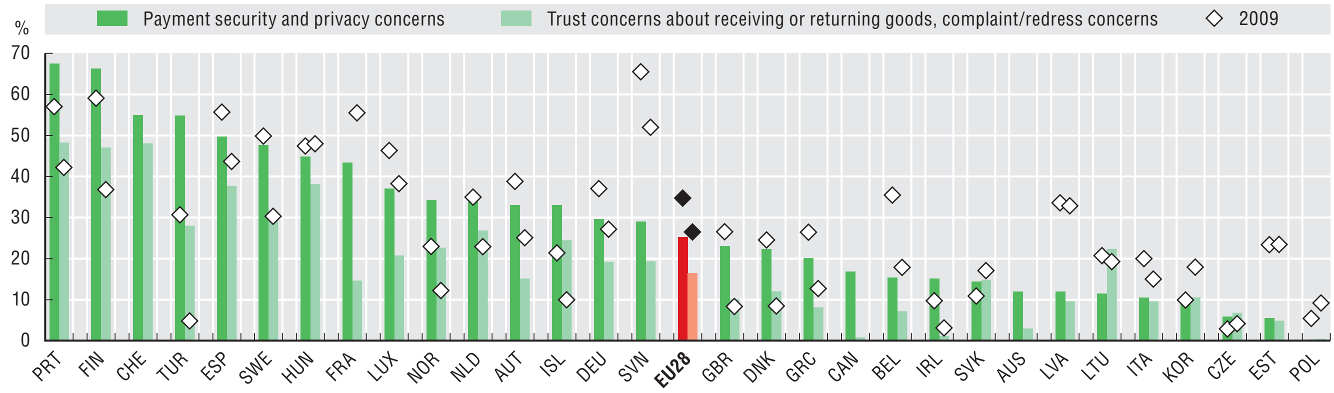
Individuals' e-commerce activities are usually monitored through surveys on ICT usage in households and by individuals. The European Community survey regularly addresses the reasons for not undertaking a given activity online. Recently, the e-commerce module of the survey included also a question that allows individuals to report on their online purchasing experiences.

The OECD Survey of Consumer Trust of Peer Platform Markets (PPMs) was conducted in 2017 across ten countries with the aim of identifying the key drivers of trust for peer consumers when transacting in PPMs, as well as the extent to which the trust-enhancing mechanisms and initiatives put in place by peer platforms respond to consumer needs. The survey focused on consumers with experience in using PPMs but included one question for consumers that had not yet engaged with PPMs.

To further strengthen the evidence base of consumer policies in the digital era, the OECD aims to develop a "Guide to measuring consumer trust in the digital economy" in the course of 2019-20 within the work undertaken by the Committee on Consumer Policy.

Reluctance to buy online due to payment security, privacy and consumer redress concerns, 2017

As a percentage of Internet users who did not buy online in the last 12 months



Source: OECD, based on Eurostat, Digital Economy and Society Statistics, Comprehensive Database and national sources, December 2018. See chapter notes.

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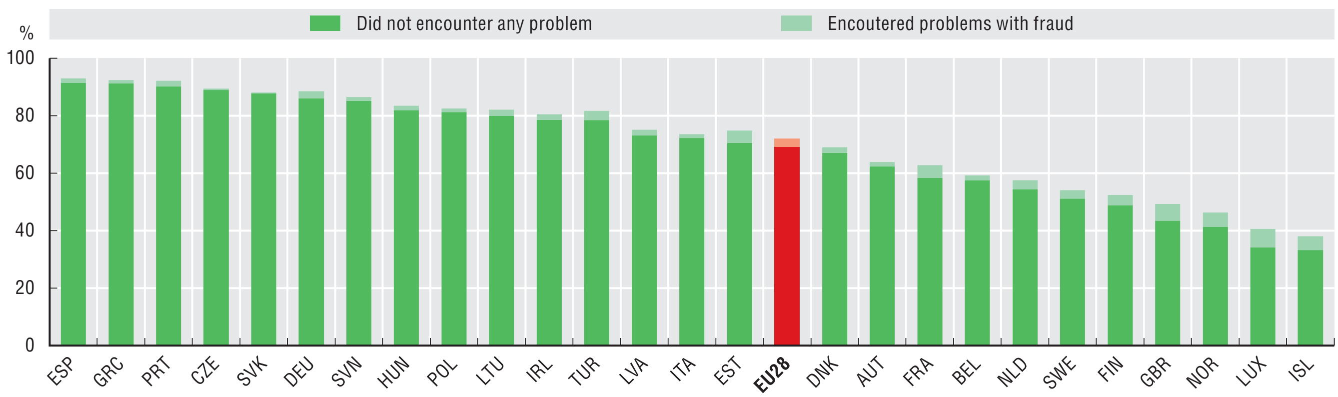
Individuals' online purchase experience, 2017

Percentage of individuals who ordered goods or services over the Internet in the last 12 months

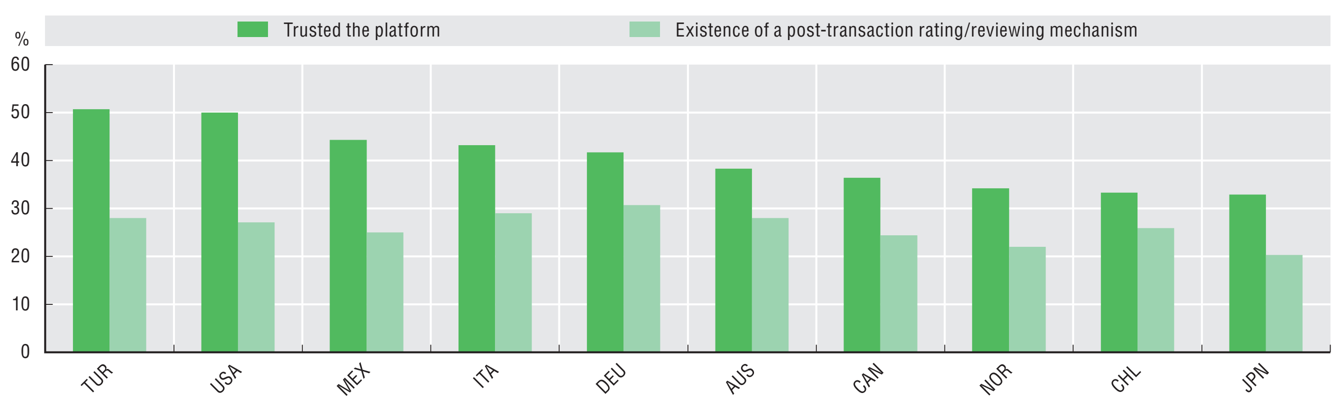


Source: OECD, based on Eurostat, Digital Economy and Society Statistics, Comprehensive Database, December 2018.

StatLink https://doi.org/10.1787/888933931314

Reasons for purchasing on a peer platform despite being unsure whether to trust the seller/provider, 2017

Percentage of all purchasers on a peer platform who went ahead with purchase while unsure of seller/provider



Source: OECD calculations based on the OECD Survey of Consumer Trust of Peer Platform Markets, September 2018.

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Online social networks and media have become an integral part of the daily life of billions of Internet users. Such platforms, particularly popular with the younger generation, enable individuals to interact with each other through a range of "free" online services. They also enable access to news and to information on a range of goods and services available online while generating advertising revenue for the social networks themselves and incremental revenue for businesses through sales driven by online advertising and influencing consumer purchasing behaviour.

The provision of personal information is a starting point for individuals' interaction on social media. In 2015, 30% of Internet users in the EU28 did not provide personal information to online communities due to security concerns with notable cross-country differences. This ratio was above 40% in most Northern European countries but less than 10% in the Czech Republic, Lithuania and Turkey. In a majority of countries included in the sample, the percentage of individuals with such concerns remained stable between 2010 and 2015, but doubled in others such as Estonia and Greece.

Individuals do not always have control over the personal information they are requested to provide on social media, including its use and re-use by third parties. This can raise concerns over a perceived lack of control and over monitoring of online activities that could lead to online profiling and targeted advertising. In 2016, only 26% of individuals in the EU28 reported being comfortable with social networks' use of information about their own online activities to tailor advertisements. Individuals in Denmark (41%) were most likely to be comfortable with this practice, while those in Latvia (14%) and the Czech Republic (13%) were least comfortable.

Online platforms and other Internet services provide individuals with new ways to connect, debate and gather information. However, the spread of news designed to intentionally mislead readers has become an increasing issue that can affect people's understanding of reality and the functioning of democracies (European Commission, 2018). In 2018, the level of trust in online social networks and messaging apps was generally similar to that in video-hosting websites and podcasts.

Across the EU28, only 26% of respondents reported trusting the news and information they accessed through online social networks and messaging apps, with the level of trust ranging from 41% in Portugal to 17% in Austria and Germany. Online social networks and messaging apps were one of the two least-trusted sources of news and information (along with video-hosting websites and podcasts) in most of the countries included in the sample.

DID YOU KNOW?

In 2015, 30% of Internet users in the EU28 did not provide personal information to online communities due to security concerns.

Definitions

Online social media refers to forms of electronic communication (e.g. websites for social networking and microblogging) through which users create online communities to share information, ideas, personal messages and other content (e.g. videos).

Personal information refers to information that the user considers private and would not necessarily disclose to the public, such as personal, contact and payment details or other individual information.

Online advertising is a marketing strategy that involves the use of the Internet as a medium to obtain website traffic and target consumers with marketing messages.

Measurability

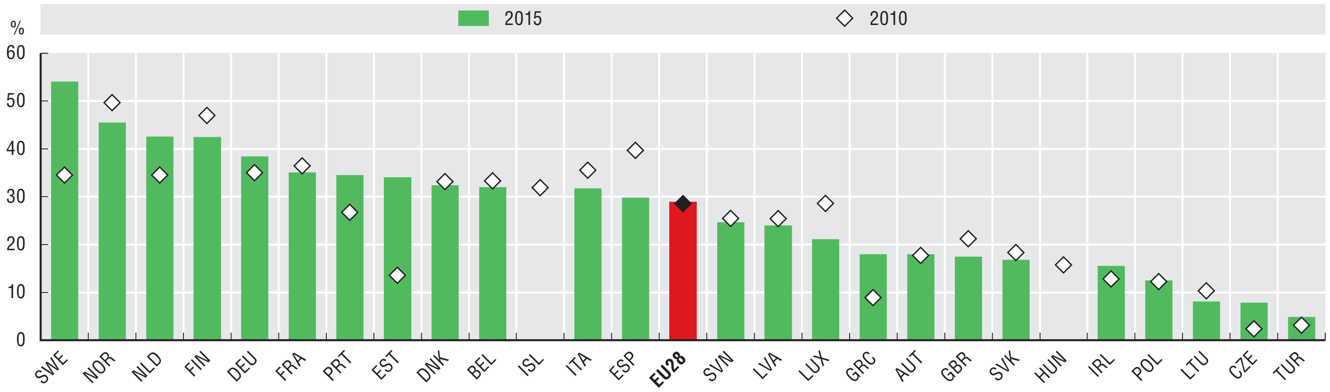
The special module on "Internet Security" of the 2015 European Community Survey on ICT Usage in Households and by Individuals provides comparable data on security concerns preventing individuals doing a range of online activities: ordering or buying goods or services for private use, carrying out banking activities (e.g. account management), providing personal information to online communities for social and professional networking, communicating with public services or administrations, downloading software, music, video files, games or other data files and using the Internet with a mobile device (e.g. laptop) via wireless connection from places other than home.

Eurobarometers are thematic public opinion surveys conducted at the request of the European Commission that obtain relatively rapid results by focusing on a specific target group. Different social and demographic groups are interviewed via telephone in their mother tongue. The Flash Eurobarometer survey on fake news and disinformation online (European Commission, 2018) was carried out in the EU28 countries in February 2018 and covered a sample of 26 576 individuals aged 15 years and above. The Special Eurobarometer survey on online platforms (European Commission, 2016) was carried out in the EU28 countries in April 2016 and covered a sample of 27 969 individuals aged 15 years and above.

As is the case for all public opinion surveys, interpretation of the results is subject to caution. As the samples used are relatively small (about 1 000 respondents in each country), marginal differences observed across countries might be the result of sampling errors or differences in respondents' understanding of the questions and may not necessarily represent differences in the underlying population.

Individuals who did not provide personal information to online communities due to security concerns, 2015

As a percentage of Internet users

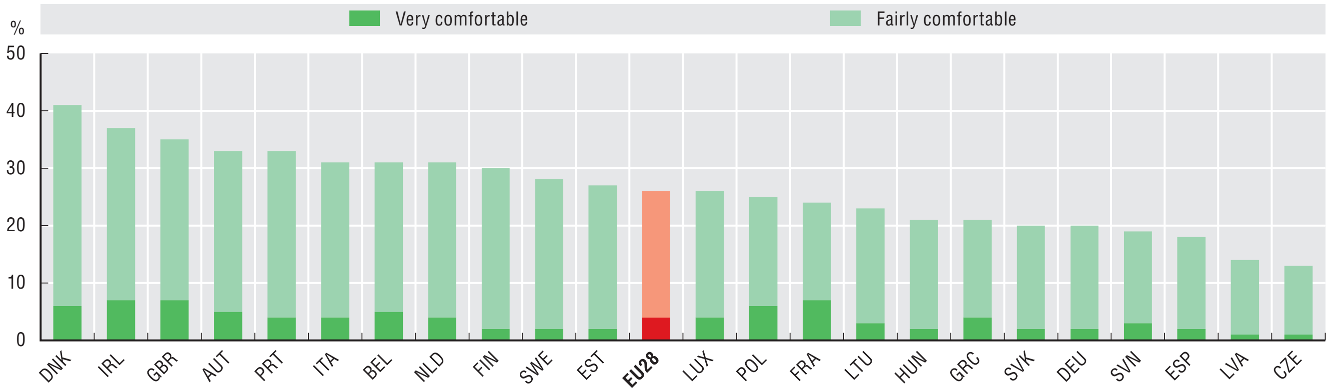


Source: OECD, based on Eurostat, Digital Economy and Society Statistics, Comprehensive Database, September 2018. See chapter notes.

StatLink https://doi.org/10.1787/888933931352

Attitudes towards online advertising on social media, 2016

Percentage of respondents, "To what extent are you comfortable or not with the fact that online social networks use information about your online activity and personal data to tailor advertisements or content to what interests you?"

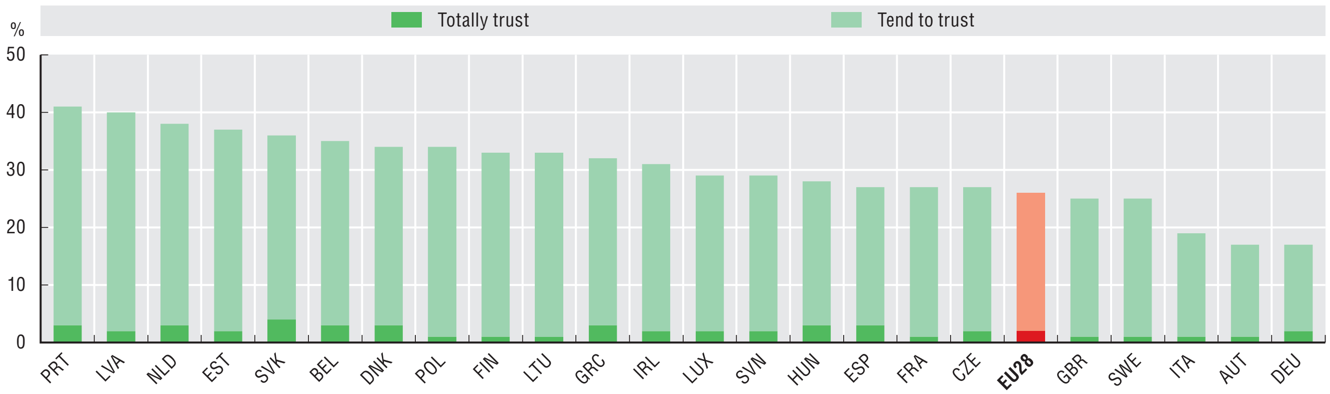


Source: European Commission (2016). See chapter notes.

StatLink https://doi.org/10.1787/888933931371

Trust in information accessed on social networks and messaging applications, 2018

Percentage of respondents, "How much do you trust or not the news and information you access through online social networks and messaging apps?"



Source: European Commission (2018). See chapter notes.

StatLink https://doi.org/10.1787/888933931390

8.6 Digital security in businesses

Why are indicators on digital security in businesses needed?

Digital security incidents expose individuals, businesses and governments to a variety of risks and attacks that target digital-dependent critical infrastructures and essential services such as energy, transport, finance and health. They can undermine business competitiveness, the ability to innovate and position in the marketplace and threaten the core functioning of economies and societies. Effective digital security risk management is essential for businesses to be able to minimise the frequency and negative impact of these incidents and thereby take advantage of and thrive during digital transformation.

Digital security threats and incidents continue to grow in number and sophistication, with significant consequences. For example, according to the 2017 Allianz Risk Barometer Survey, the perceived risk related to cybercrime and digital security incidents remained the third highest global business risk in 2017 for the second year in a row, up from 15th in 2013 (Allianz, 2016; 2017). Concurrently, the probability of a massive incident involving data fraud and theft was ranked fifth by the 2017 World Economic Forum Global Risks report, (WEF, 2017).

Digital security risk is a concern shared by the entire business community, but one that may have especially serious consequences for smaller businesses. While large businesses and organisations likely have the institutional and financial capacity to develop appropriate digital security risk management, studies in a number of OECD countries suggest that this is not the case for small and medium enterprises (SMEs), and particularly micro-enterprises, which can face managerial, skill, knowledge and financial constraints.

The scarcity of reliable evidence on which to base digital security risk management decisions and public policy actions calls for metrics and analytics to understand different digital security risk management practices, both in small and larger firms, within a context of rapid technological change.

What are the challenges?

While the frequency and severity of digital security incidents has grown, the ability to measure, analyse, understand and manage them efficiently has not kept pace. At a methodological level, there is a lack of consensus on definitions, typologies and taxonomy, as well as a paucity of historical data on digital security incidents, threats and vulnerabilities. Concepts such as threats, vulnerabilities, incidents and impacts are often used together under broad, all-encompassing terms. This lack of standard definitions has led to uncertainties regarding both the frequency and impact of digital security risk and has prompted calls for a more uniform approach.

The development of a more reliable and comprehensive dataset on digital security incidents and digital risk management practice requires a consensus on typology and taxonomy, a trusted public-private digital security incident repository and incentives to promote reporting of incidents and data sharing by organisations.

At an organisational level, improving information-sharing practices on digital security risk is a cornerstone of national digital security strategies of many OECD countries. In spite of the increasing numbers of collaborative information-sharing platforms and networks, how an organisation captures, stores and uses data, shares information and intelligence, and increases knowledge is frequently subject to substantial impediments.

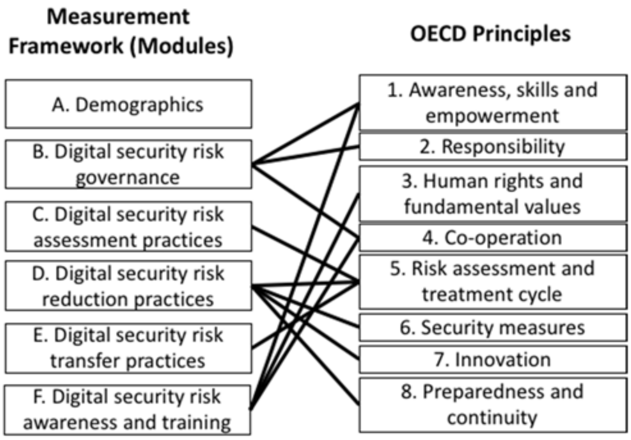
Options for international action

A number of different fora and initiatives by government, academia, the insurance sector and other private sector stakeholders are exploring ways to meet the requirements for establishing a typology of incidents, incentives for incidence reporting and data sharing. The value proposition of a data repository for information on digital security incidents, including possible data requirements and system attributes, is also being discussed by insurance companies and governments in a number of countries, such as France, the United Kingdom and the United States. The OECD has started to examine these various initiatives as part of its work on improving the evidence base on digital security and privacy policy-making following the 2016 Cancun Ministerial on the Digital Economy and in the context of an OECD project on the digital security insurance market.

In this context, the OECD first reviewed existing surveys that had sought to provide data related to digital security risk. It was found that past surveys typically included few questions on the digital security risk management practices of businesses and where they did, such questions were often limited to technical measures. This is not in line with the 2015 OECD Recommendation of the Council on Digital Security Risk Management for Economic and Social Prosperity ("Security Recommendation"), which emphasises the economic and social dimensions of digital security risk (OECD, 2015).

Once the deficiencies in the evidence base had been identified, the OECD sought to improve measurement in this area by developing a framework to assess the digital security risk management practices of businesses. This measurement framework comprises six modules and 18 associated indicators. It draws heavily on the Security Recommendation, as shown in the figure below. Following the OECD model survey framework, national statistical offices or other organisations could adopt the individual modules, as necessary.

Mapping of the measurement framework with the OECD Principles on Digital Security Risk Management for Economic and Social Prosperity



Source: OECD (2019).

Finally, a survey instrument was designed with the goal of understanding the digital security risk management practices the specific population of risk managers. This survey instrument was subjected to cognitive testing in Brazil by Cetic.br in March-April 2018. It has then reviewed and piloted by the Federation of European of Risk Management Associations (FERMA) between July and September 2018. The outcomes of the pilot suggest that the measurement framework based on the OECD Security Recommendation is robust. However, improvements could be made to the design of the survey instrument. These changes primarily relate to the length of the survey in terms of the time required to respond and slight adjustments to the questions and their response options. A simpler version of the survey would allow for the collection of information from less data-intensive firms that may not necessarily have a dedicated person or unit responsible for digital security risk management (OECD, 2019).

The OECD has long supported co-operation on the management of digital security risk for economic and social prosperity, alongside other organisations that focus on defence and international security, criminal law enforcement and technical standards. The OECD has produced analyses and Recommendations since the early 1990s. This dialogue, inclusive of all stakeholders, has proved instrumental in developing digital security policies that build trust in the global digital environment, while preserving Internet openness, innovation and digitally driven growth.

In this respect, the recently launched Global Forum on Digital Security for Prosperity (http://www.oecd.org/internet/global-forum-digital-security) represents another milestone, as it engages stakeholders in a collaborative process to build partnerships and share experiences and good practice on digital security risk and its management. The Forum does also help to consolidate a network of governmental officials and non-governmental experts dealing with digital security for prosperity in OECD and partner countries and facilitate a convergence of views towards building a trusted and resilient digital environment.

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Why are indicators on individuals' trust needed?

With the Internet and connected devices playing an increasingly important role in individuals' everyday activities, trust has emerged as a key factor underpinning transactions in the digital economy. Governments, businesses and individuals all need to trust and be trusted to reap the full benefits offered by the digital transformation.

The intangible nature of data exchanges makes it harder for individuals' to control the use and reuse of their personal data in different jurisdictions. Personal data are first collected or accessed, then stored, aggregated, processed and finally used and analysed. With the advent of artificial intelligence/deep learning, data can be also machine generated. Each of these steps has special features and involves different stakeholders. In the digital era, trust needs to be built between individuals who own and consent (although not always realising they have done so) to provide their personal data online, without necessarily controlling its use and organisations who analyse and use insights from these data while being bound by the laws and ethics around data collection, storage, analysis and use.

What are the challenges?

The more people, businesses or governments are connected, communicate and transact online, the greater the potential efficiencies. However, many of these communications and transactions are effected among unknown players that may not encounter each other again. Some of these exchanges may be unreliable and some may involve intentionally false or biased information.

Despite the broadly acknowledged importance of trust for the digital transformation, no common definition captures all aspects of this complex phenomenon. Recently, the OECD Guidelines on Measuring Trust (OECD, 2017a) defined trust (p. 42) as "a person's belief that another person or institution will act consistently with their expectations of positive behaviour". The OECD measurement guidelines focus specifically on interpersonal and institutional trust. Interpersonal trust can be generalised (in unknown people or situations) or limited (to known people).

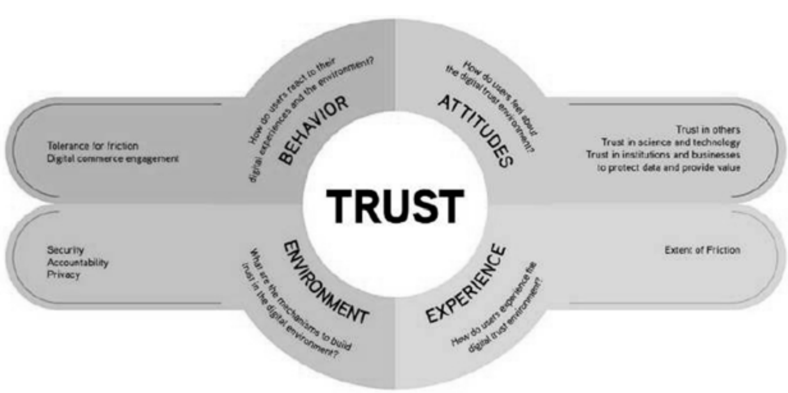
In addition to the difficulty of defining this multidimensional concept, the measurement of trust does not have a long tradition, particularly within official statistics. This partly reflects a paucity of evidence on the validity and reliability of different measures of trust, as well as – until recently – a lack of strong policy demand for such metrics (OECD 2017a). Hence, from a measurement perspective, no unique framework exists under which to classify the different approaches used to measure trust.

Options for international action

The starting point for a measurement roadmap is to define what needs to be measured. There are several possible trust questions/dimensions around the interactions of actors in the digital environment that could be measured and monitored. Often questions are articulated around the drivers of trust and the barriers to trusting.

In 2017, using a large number of official and private data sources[1], Chakravorti and Chaturvedi (2017) provide an update of the Mastercard's Digital Evolution Index 2014 with an analysis of "digital trust" under four pillars: (i) the trustworthiness of the digital environment for each country, (ii) the quality of users' experience, (iii) the attitudes towards key institutions and organisations and (iv) users' behaviour when interacting in the digital world.

Pillars of digital trust



Source: Chakravorti and Chaturvedi (2017).

1. Akamai, BlueTriangle Technologies, PCRI, CIGI-IPSOS, Edelman, Euromonitor, Freedom House, Google, GSMA, ILO, ITU, Numbeo, Web Index, Wikimedia, World Bank, World Economic Forum and the World Values Survey.

Another set of questions relate to consumers' trust. Trust is a particularly distinctive feature for the peer platform markets (PPMs) that have grown massively with the rise of the digital economy. In this regard, the OECD has examined a number of mechanisms that peer platforms have developed to help engender trust in and use of their services (e.g. initiatives such as ratings and reviews). In 2017, the OECD conducted a survey on consumer trust across ten member countries with a focus on customers with experience in using PPMs (OECD, 2017b).

Nowadays connected and wearable devices provide access to large amounts of real-time personal data that can be extremely valuable to those who can exploit them. More recently, the OECD has undertaken two projects to strengthen the evidence base for privacy and personal data protection, a project on improving the comparability of data breach notification reporting by Privacy Enhancement Authorities and a scoping work on measuring individuals' trust in online environments following a personal data breach.

Overall, it is possible to categorise the different approaches to measuring trust into two broad groups: direct or survey based measures and experiments. As detailed in OECD (2017a), at the most basic level, a long tradition of survey questions consists of directly asking individuals questions on their trust in others (e.g. Almond and Verba, 1963) and institutions (e.g. World Value Surveys). On a more sophisticated level, Morrone, Tontoranelli and Ranuzzi (2009) measure trust through individuals' expectations about the behaviour of others (e.g. on the likelihood of returning a lost wallet). Although the use of such expectation-oriented questions, drawing on specific hypothetical scenarios, can be considered as rather limited, they set a distinctly different conceptual task for respondents than direct questions about trust and provide additional information.

In parallel, a wide literature has focused on comparing actual trusting behaviour in experimental settings with survey questions on trust (see the OECD's Trust Lab, https://www.oecd.org/sdd/trustlab.htm). Another measurement approach consists of collecting information through questions on individuals' experiences that can provide indirect information without being directly focused on the subject. The New Zealand General Social Survey is an example of data collection using these types of questions, which in turn allow for elaboration of various metrics on trust by individuals. For instance, interpersonal trust metrics are drawn from questions on individuals' interactions with others via lending or giving various objects, providing emotional or moral support, helping with different tasks and providing information and advice.

Another avenue to explore is the longstanding literature on the public acceptance of science and individuals' perception of new technologies, which contains valuable lessons for the measurement of individuals' digital trust. In addition to surveys, methods for media monitoring, measuring intensities, semantic networks and story types have been used, to grasp trends of public interest in science in various studies. Due to advances in information and communication technologies, automatic systems of continuous media monitoring have become possible.

Policy priorities for measurement in this area will need to be developed together with the relevant policy communities along a common framework. As Castaldo et al. (2010) explain, "We know much better what trust does than what trust is". The measurement of trust in online environments is challenging but needs to be pursued to substantiate the policy debate, as a thriving digital economy is not possible without trust.

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Notes

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.

8.1. Digital security

Enterprises having a formally defined security policy, by size, 2015

SMEs are defined as companies with between 10 and 249 employees and large firms as companies with 250 or more employees.

Individuals affected by a computer virus or other computer infection with impacts, 2015

Unless otherwise stated, Internet users are defined as individuals who accessed the Internet within the last 12 months.

For Chile, data refer to 2014.

For Costa Rica, data refer to OECD estimates for 2017 based on data provided by the National Institute of Statistics and Censuses and by the Ministry of Science, Technology and Telecommunications (MICITT). Internet users are defined as individuals who accessed the Internet within the last three months.

For Japan, data refer to 2016 instead of 2015.

For Korea, data refer to 2011 and 2017.

For Mexico and Switzerland, data refer to 2017 instead of 2015.

Global Cybersecurity Index, 2017

The GCI includes 25 indicators and 157 questions. The indicators used to calculate the GCI were selected on the basis of the following criteria: i) relevance to the five GCA pillars and in contributing towards the main GCI objectives and conceptual framework; ii) data availability and quality and iii) possibility of cross verification through secondary data.

Various levels of cybersecurity development among countries, as well as the different cybersecurity needs reflected by a country's overall ICT development status were taken into consideration. The index is computed on the basis of the assumption that the more developed cybersecurity is, the more complex the solutions observed will be. Therefore, the further a country confirms the presence of pre-identified cyber solutions, the more complex and sophisticated the cybersecurity commitment allowing a higher score.

8.2 Online privacy

Individuals who provided personal information over the Internet, by age, 2016

For Switzerland, data refer to 2017.

Individuals who did not submit official forms online due to privacy and security concerns, 2018

For Switzerland, data refer to 2014 and 2017.

Individuals who experienced privacy violations, 2015

Except otherwise stated, Internet users are defined as individuals who accessed the Internet within the last 12 months.

For Chile, data refer to 2014.

For Costa Rica, data refer to individuals aged 18-74 instead of 16-74.

For Korea, data refer to 2017 and include both private and business-related purposes.

For Mexico, data refer to 2017 instead of 2015. From 2015 onwards, information was collected through an independent thematic survey, unlike previous years during which information was obtained through a module administered in various surveys. This methodological change must be taken into account when comparing data prior to 2015. In 2017, data refer to the following response item: "Fraud with information (financial, personal, etc.)".

For Switzerland, data refer to 2014 instead of 2015. In 2014, data relate to individuals "Having experienced a security problem within the last 12 months".

8.4 E-consumer trust

Reluctance to buy online due to payment security, privacy and consumer redress concerns, 2017

For Australia, data refer to the fiscal year 2012/13 ending on 30 June.

For Canada, data refer to 2012.

For countries included in the European Statistical System, in 2017 "Payment security and privacy concerns" does not include "privacy concerns".

8.5. Online social networks

Individuals who did not provide personal information to online communities due to security concerns, 2015

Internet users are defined as individuals who accessed the Internet within the last 12 months.

Attitudes towards online advertising on social media, 2016

Other response items are the following : “Very uncomfortable”, “Fairly uncomfortable”, “Do not use the Internet”, “Do not use online platforms” and “Don’t know”.

Trust in information accessed on social networks and messaging applications, 2018

Other response items are the following : “Tend not to trust”, “Do not trust at all” and “Don’t know”.

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Chapter 9

FOSTERING MARKET OPENNESS

The digital transformation affects all industries – including both manufacturing and services – albeit at different speeds and scales. The extent to which digital-intensive industries are integrated into global value chains (GVCs) can be measured by tracking the origins of value added embodied in final demand. Estimates of foreign value added in domestic demand highlight the importance of production activities abroad in producing final goods and services for domestic consumers, both directly (through imports of final goods and services for consumption) and indirectly (as a component of domestic output consumed locally).

While digital-intensive industries account for about 44% of global production, on average in the OECD, they are the origin of half of the foreign value added needed to satisfy domestic demand. There is some variation across countries, with shares of over 60% in Ireland and Switzerland (representing 31% and 20% of total final demand, respectively), while in Latvia and Lithuania only 40% of foreign value added in final demand comes from more digital-intensive sectors.

Large economies such as Brazil, China, Japan and the United States, have much lower shares of foreign value added in domestic final demand, as they have a greater internal capacity to produce final goods and services (and the necessary intermediate products) to meet domestic demand. However, while the United States has the lowest share of foreign value added in domestic demand of OECD countries (12%), the sheer size of its economy means that in USD terms it is by far the biggest consumer of foreign value added: 2.2 USD trillion, of which, 1.2 USD trillion (55%) comes from more digital-intensive industries.

In the specific case of information industries, on average in 2015, 45% of the value of information industry products produced worldwide consisted of foreign value added (compared to 39% in total manufactures and business services). This value ranged from more than 80% in Luxembourg and 60% in Estonia to less than 20% in Israel and the United States. Regional interdependence is clear, especially in EU countries, for which other members are a key source of demand for information industries' products.

The production of manufactured goods relies on a range of intermediate service inputs, from wholesale and transport to IT, finance and other professional business services. This is reflected in the service content of manufactured exports which, on average, accounted for one-third of the value of manufactured exports in OECD countries in 2015. Of this, 75% came from digital-intensive services activities (both domestic and foreign). In other words, on average, 25% of the value of manufactured exports comes from digital-intensive services industries such as ICT and financial services. For some countries, notably Ireland, Luxembourg and the Netherlands, this share exceeds 30%, while for most large countries the shares range from 18% to 23%.

DID YOU KNOW?

Digital-intensive services are critical for manufacturing exports. On average, 25% of the value of manufactured exports from OECD countries is value added from digital-intensive services.

Definitions

Value added consists of the value of production, net of the costs of intermediate inputs. In practice, it includes both gross profits and wages, and at an aggregate level is equivalent to GDP.

Sector digital intensity is based on a number of dimensions: ICT investment, use of ICT intermediates, use of robots, online sales and employment of ICT specialists. Industries are then classified into quartiles from most to least digital-intensive. Here the quartiles are summarised as *more digital-intensive sectors* (upper two quartiles) and *less digital–intensive sectors* (lower two quartiles). Examples of the former include ICT equipment, transport equipment, ICT services, finance, R&D, marketing, publishing, audiovisual and broadcasting services, public administration and defence, arts and entertainment services. See page 2.9 for more information.

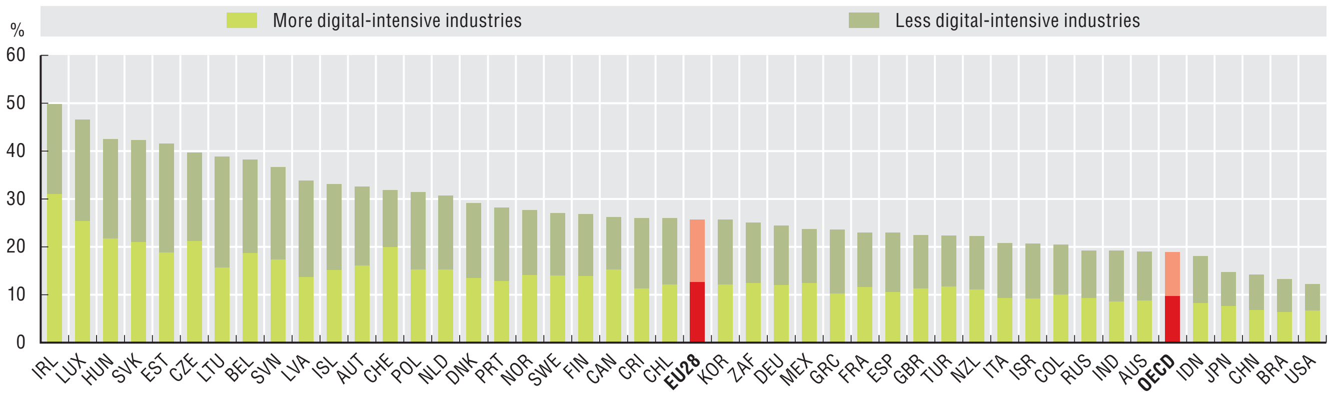
Measurability

The *Trade in Value Added* (TiVA) database provides indicators on the domestic and foreign origins of value added embodied in exports and in final demand. They are derived from the OECD *Inter-Country Input-Output* (ICIO) database which estimates the flows of goods and services between 64 countries and 36 industries from 2005 to 2015. Tracing global flows of value added provides insights for the analysis of GVCs that are not always evident from trade statistics.

Estimates of foreign value added content in exports or in final demand are often referred to as "backward linkages" in GVCs, while domestic value added content in partner countries' exports (or foreign final demand) are referred to as "forward linkages". Both are used to provide an indication of GVC participation and, given the different perspectives, are best analysed separately. Changes in participation in GVCs not only reflect changes in specialisation towards activities at the beginning or end of value chains, but can also reflect fluctuations in commodity prices. For example, a surge in crude oil prices could result in an increase in import content for many countries. The TiVA indicators become volatile if oil intensive products are traded along multi-country production chains. Thus, care should be taken when interpreting measures of GVC participation over time.

Foreign value added satisfying domestic demand, by digital intensity, 2015

As a percentage of total domestic demand

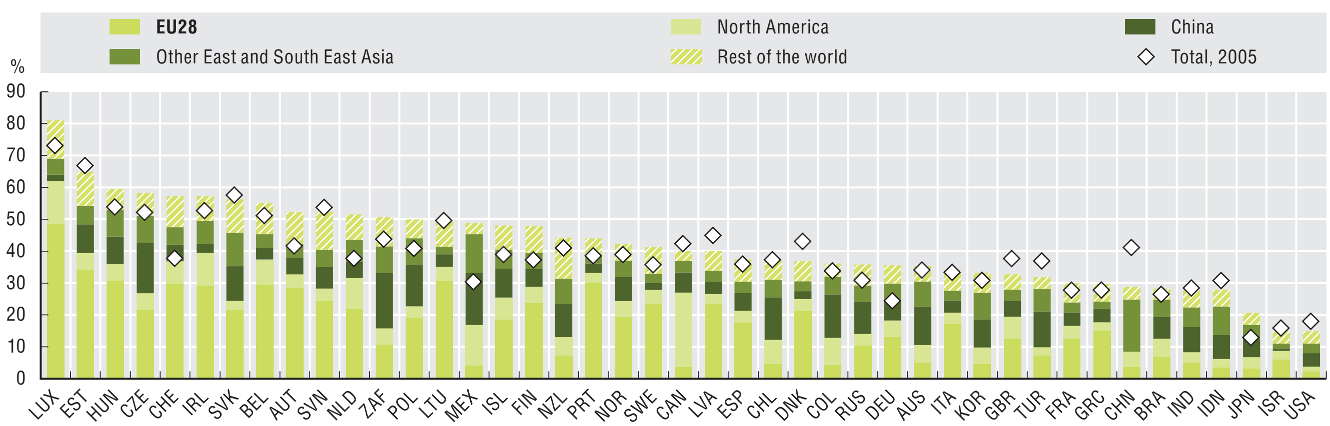


Source: OECD, Trade in Value Added (TiVA) Database, https://oe.cd/tiva, December 2018. See chapter notes. StatLink contains more data.

StatLink https://doi.org/10.1787/888933931409

Foreign value added satisfying domestic demand for information industries' products, by source region, 2015

As a percentage of total domestic demand for information industry products

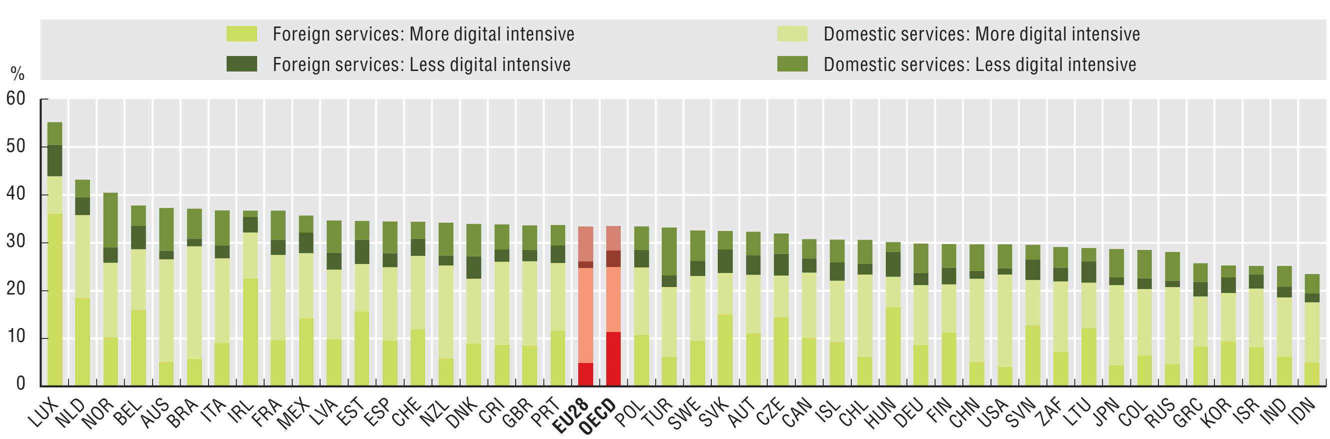


Source: OECD, Trade in Value Added (TiVA) Database, https://oe.cd/tiva, December 2018. See chapter notes. StatLink contains more data.

StatLink https://doi.org/10.1787/888933931428

Services value added embodied in manufacturing exports, by origin and digital intensity, 2015

As a percentage of total manufacturing exports



Source: OECD, Trade in Value Added (TiVA) Database, https://oe.cd/tiva, December 2018. See chapter notes. StatLink contains more data.

StatLink https://doi.org/10.1787/888933931447

The digital transformation greatly affects trade. In particular, the Internet has made it easier to buy, sell and deliver certain services, such as telecommunications and audiovisual content, across borders. It has also enabled cross-border electronic delivery of financial, business and knowledge services, such as sales and marketing, management, administration, and back office services, engineering, R&D, and education (UNCTAD, 2015). Furthermore, the Internet has also led to new categories of services, such as web search.

Extended Balance of Payments Services (EBOPS) statistics allow trade in a number of "potentially ICT-enabled services" (UNCTAD, 2015) to be examined. Of these, *Telecommunications, computer and information services* – which includes many services inextricably linked with digital technologies such as software production and database services – is a key component in many countries, comprising 8% of services imports and 10% of services exports on average in the OECD area.

The Internet, secure networks, synchronised databases and other ICTs are a crucial enabler of financial services trade. Financial services are a particularly key component of services trade in Luxembourg, comprising over half of both services imports and exports, and are also particularly notable exports in the United Kingdom (24% of services exports) and Switzerland (17%).

Charges for the use of intellectual property rights are a particularly notable component of imports in both Ireland and the Netherlands (41% and 28% of services imports, respectively), with the latter having a similar share of intellectual property in services exports (25%). While these payments are often digitally facilitated, the extent to which the contracts granting rights are delivered in digital form is unknown, as is the extent to which the property rights relate to digital properties.

The Internet can facilitate access to global markets, creating new opportunities for consumers and businesses. Key factors affecting the uptake of cross-border e-commerce include IT infrastructure, regulatory frameworks and economic integration. In 2018, 45% of enterprises in the EU28 made cross-border e-commerce sales. Of these, 43% made sales to customers in other EU countries and 26% made sales to customers outside the European Union. The proportion of cross-border sellers to other EU countries was highest in Austria (67%) and Luxembourg (64%). Greece and Ireland had the highest shares of sellers to customers in non-EU countries (almost 40%). Meanwhile, Sweden stands out because 15% of firms there make cross-border e-commerce sales to customers outside the EU only; this share is 5% or lower in other countries and 1.5% on average.

DID YOU KNOW?

In 2018, 43% of EU businesses selling online made cross-border sales to customers in other EU countries and 26% made sales to non-EU customers.

Definitions

Telecommunications, computer and information services (EBOPS SI1-3) covers the transmission or broadcast of sound, images, data, etc. by telephone, radio, television, email, etc. and other means. Installation services for network equipment are excluded. Sales of customised and non-customised *software* and related licences are also included, as well as *other services* such as hardware and software consultancy, implementation, installation, maintenance, and repair, web page development and hosting, systems maintenance and supporting training. Predominantly digital services such as news agency services, database design and delivery services, and web search portals are covered.

Audiovisual services (EBOPS SK1) include the production of film, radio, television and musical content, which these days are usually stored and transmitted in digital form. Live performances are excluded but recordings are included.

Charges for the use of intellectual property include franchises and trademark licensing fees, licenses to use the outcomes of research and development, and licenses to reproduce software, audiovisual, and other products.

An *e-commerce transaction* describes the sale or purchase of goods or services conducted over computer networks by methods specifically designed for the purpose of receiving or placing orders (OECD, 2011). For individuals, whether sellers or purchasers, such transactions typically occur over the Internet. For enterprises, e-commerce sales include all transactions carried out over webpages, extranet or Electronic Data Interchange (EDI) systems.

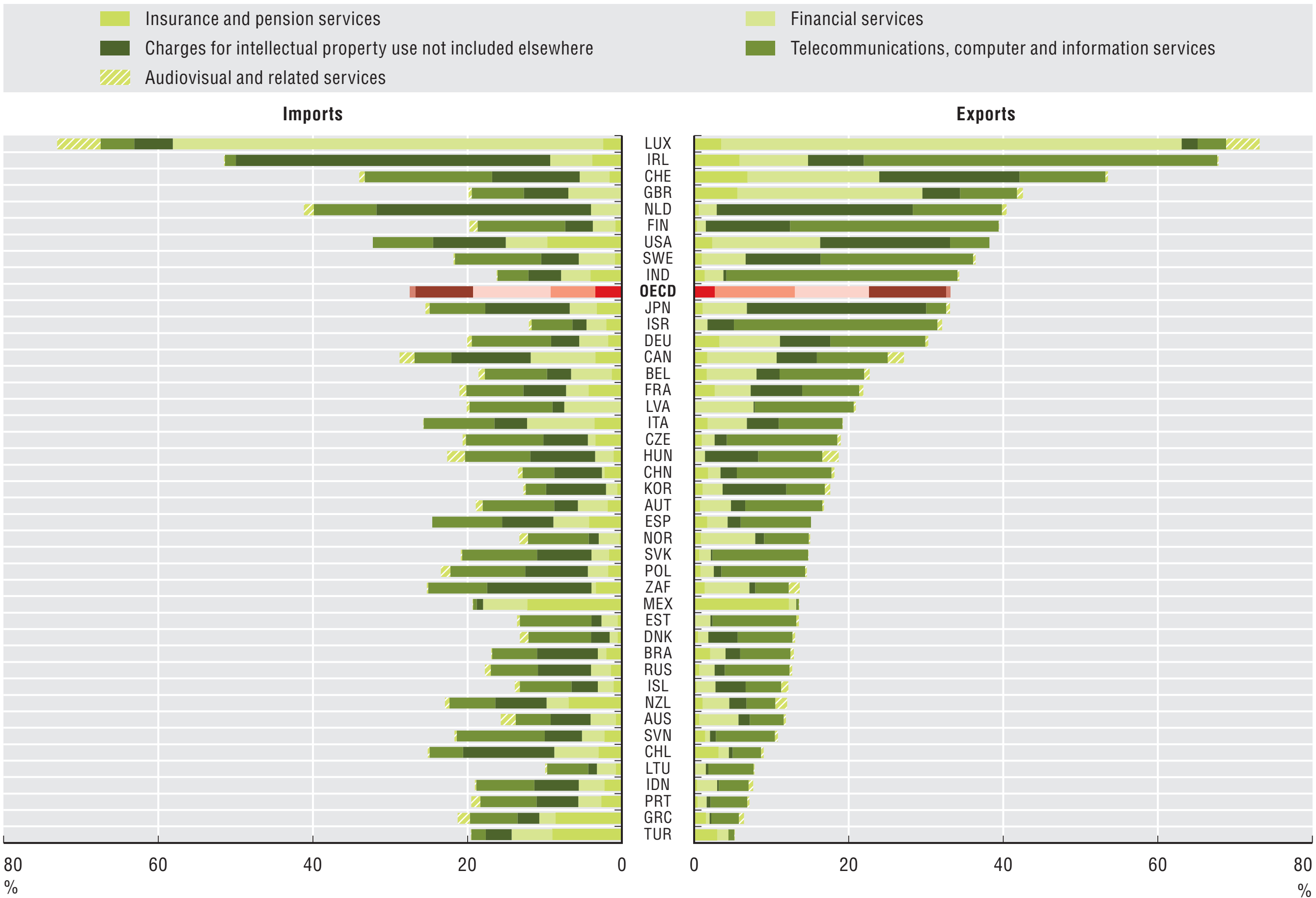
Measurability

Imports and exports of "predominantly digitally deliverable services" are measured through business surveys in the context of compiling Balance of Payments statistics. EBOPS provide additional details on the products traded, however digitally delivered services are not routinely isolated so it is necessary to focus on the products that are most clearly digitalised.

Cross-border e-commerce transactions are captured in some countries' ICT usage surveys. Methodological variations affect comparability including the adoption of different practices for data collection and estimations. See page 4.7 for more information on e-commerce measurement.

Trade in predominantly digitally deliverable services, 2017

As a percentage of total services exports and imports, respectively

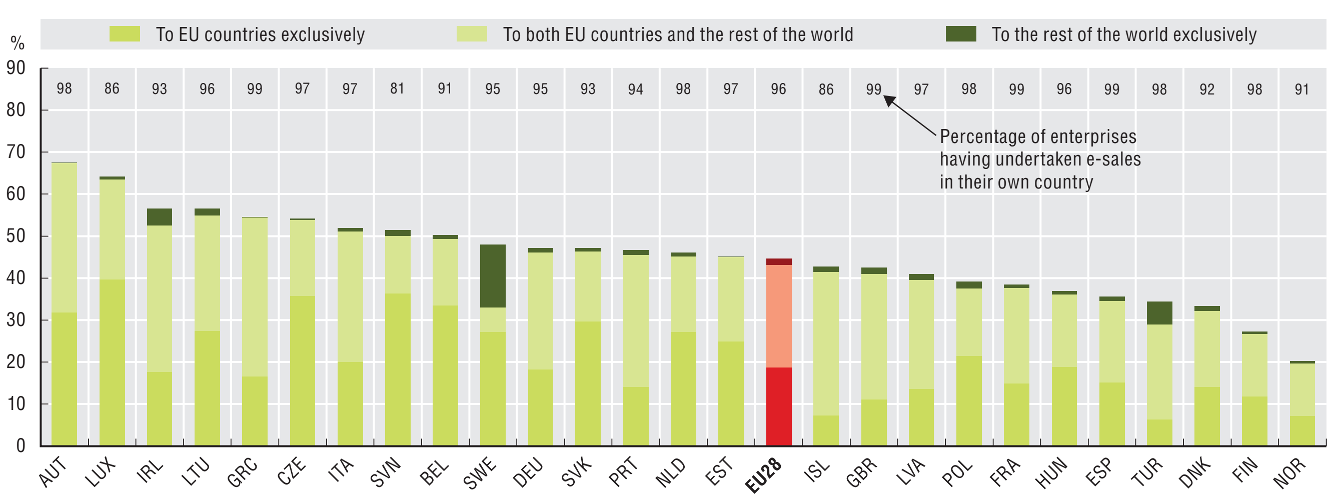


Source: OECD, International Trade in Service Statistics (ITS), based on EBOPS 2010, https://www.oecd.org/sdd/its/EBOPS-2010.pdf; WTO, Trade in Commercial Services, October 2018. See chapter notes. StatLink contains more data.

StatLink https://doi.org/10.1787/888933931466

Enterprises having undertaken cross-border e-commerce sales, by customer region, 2016

As a percentage of all enterprises having undertaken e-commerce sales



Source: OECD, based on Eurostat, Digital Economy and Society Statistics, Comprehensive Database, September 2018. See chapter notes. StatLink contains more data.

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The digital transformation has led to significant reductions in the costs of engaging in international trade, changing both how and what is traded (Lopez-Gonzalez and Jouanjean, 2017). Along with the rise of digitally enabled or delivered services trade, digitalisation is also driving increased trade in physical goods. However, measuring trade in digitally enabled, digitally ordered, and potentially, with the emergence of 3D printing, digitally delivered goods, is challenging. Page 9.6 outlines related efforts in this regard.

With growing digitalisation, the measures affecting trade in goods are changing (Lopez-Gonzalez and Ferencz, 2018). "Smart" goods, such as smart speakers, e-readers and Internet of Things devices, combine characteristics of goods and services and require Internet access. They are affected by measures such as tariffs or at-the-border costs, but also by issues traditionally associated with trade in services and access to digital networks.

Effectively applied tariffs provide an illustration of direct market access barriers for ICT goods (notwithstanding other technical measures). Across OECD countries, the average effectively applied tariff on ICT goods was 2.07% in 2005, falling to 0.73% in 2017. Applied tariffs in OECD partner countries, though also falling, remain high. They were were almost 12%, in Argentina and Brazil in 2017, and around 6% – nearly ten times the OECD average – in China and India.

E-commerce is leading to increased international trade in parcels, which makes *de minimis* thresholds increasingly important, especially for SMEs and individuals buying online. It also raises issues for the efficiency and management of customs procedures. *De minimis* regimes vary widely. Australia and the United States have the highest thresholds at around USD 800. In contrast, China and Switzerland set levels below USD 10, while in EU countries, India and Colombia they are closer to USD 200 (see Lopez-Gonzalez and Ferencz, 2018 for a discussion).

The delivery of goods ordered online remains subject to physical connectivity constraints. As trade costs can represent a sizeable share of the value of small consignments, how fast and at what cost a parcel can clear a border can considerably impact the engagement of individuals and smaller firms in digital trade. Simplification and streamlining of border processes and controls, as well as automation of procedures, can help speed the movement of goods through customs. Other areas such as the transparency of trade-related information and predictability of border procedures also support smooth trade. Technology itself, in the form of automation and dematerialisation of border processes, can also assist in faciltitating this expanded trade. The OECD Trade Facilitation Indicators (TFIs) capture elements of all such measures. The performance of the OECD and emerging economies in 2017 in areas such as transparency and predictability, streamlining procedures or automating border processes reflects significant implementation efforts. Across the board, the most challenging areas relate to co-ordinated border management.

DID YOU KNOW?

Tariffs on ICT goods in China and India are 8 times higher than those applied in OECD countries, and 16 times higher in Argentina and Brazil.

Definitions

Effectively-applied tariffs are calculated as the lower of the average "most favoured nation" tariff (applied under general WTO rules) and the average preferential tariff (applied under preferential trade agreements).

Tariffs on ICT goods are taxes or duties paid on imports of those products primarily produced by the ICT manufacturing industry.

De minimis regimes allow goods not exceeding a certain *threshold* value to be exempted from import duties and taxes as well as from certain declaration procedures.

Trade Facilitation Indicators (TFIs) cover the full spectrum of border procedures and measure the extent to which countries have introduced and implemented trade facilitation measures in absolute terms, as well as their performance relative to others. Each TFI indicator is composed of several specific, precise and fact-based variables related to existing trade-related policies and regulations and their implementation in practice. Each component can take a maximum value of 2, indicating maximum performance in that area. For details on each component, see (OECD, 2018), Table 1.1.

Measurability

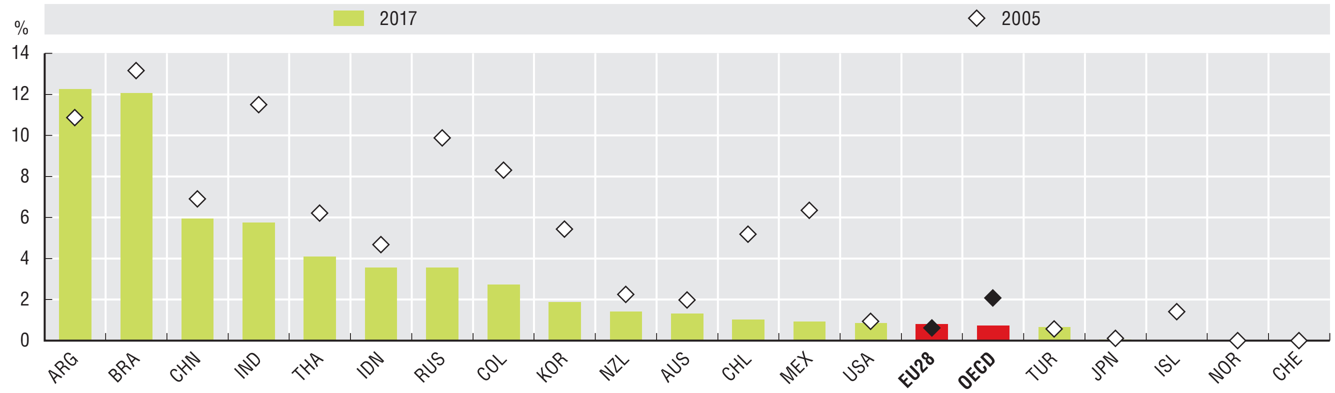
The Global Express Association, an express delivery carriers' organisation, regularly compiles information on *de minimis* regimes available from publicly available sources (e.g. customs agency websites).

The Trade Analysis Information System (TRAINS) database provides data on tariff barriers to trade.

The OECD TFIs cover 163 countries based on a detailed questionnaire collecting factual information that is geographically comparable and consistent over time. Data come from three types of sources: (a) publicly available information included in the websites of relevant border agencies, official publications such as Customs Codes, annual reports or public databases; (b) direct submissions from countries; and (c) factual information from the private sector –, in particular express industry associations and companies operating worldwide. Discrepancies are investigated by the OECD and datasheets sent to countries for validation. For full details, see: https://oe.cd/tfi.

Effectively applied tariffs on ICT goods, 2017

Simple average as a percentage of import value



Source: OECD, based on UNCTAD, Trade Analysis Information System (TRAINS), December 2018. See chapter notes.

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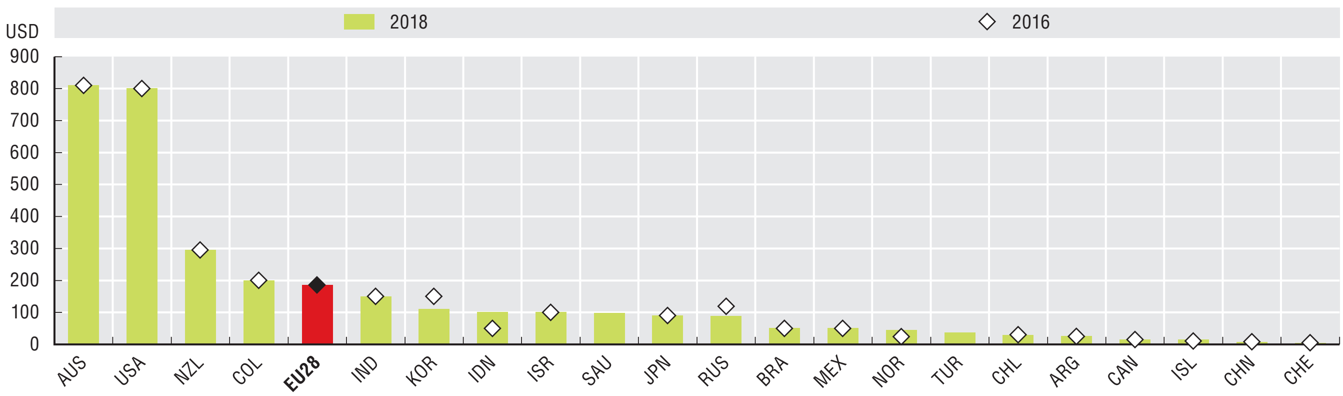
***De minimis* value thresholds for customs duties, 2018**

Applying to express shipments

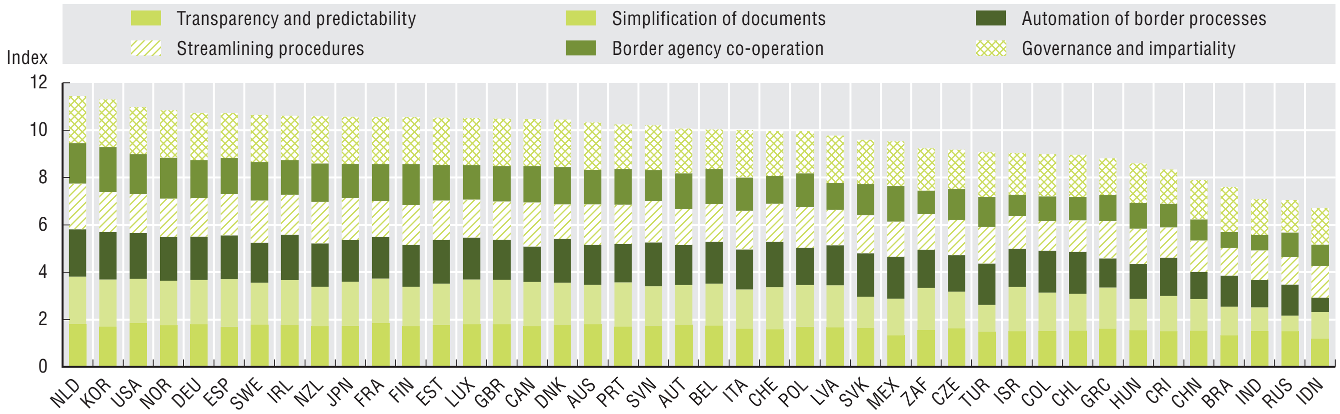


Source: OECD, based on Global Express Association, December 2018. See chapter notes.

StatLink https://doi.org/10.1787/888933931523

Trade Facilitation Indicators, 2017

2 = maximum performance that can be achieved in each area (overall potential maximum = 12)



Source: OECD, Trade Facilitation Indicators Database, https://oe.cd/tfi, September 2018. See chapter notes. StatLink contains more data.

StatLink https://doi.org/10.1787/888933931542

The rapid acceleration of digital transformation has a profound impact on trade in services, making it easier for traditional services to be traded across borders, as well as enabling the emergence of new services that create value from data. However, existing and emerging trade barriers may hinder innovation and create obstacles to the movement of digitally enabled services across borders.

The OECD Digital Services Trade Restrictiveness Index (Digital STRI) is a new tool that identifies, catalogues and quantifies cross-cutting barriers that affect trade in digitally enabled services across 44 countries, covering OECD members and key partner countries (Ferencz, 2019). Its objective is to help policy makers identify regulatory bottlenecks and design policies that foster more diversified and competitive markets for digital trade. The Digital STRI indices for 2018 range between 0.04 and 0.48, (1.0 indicates full restriction), with an average of 0.18 across all countries. There are 29 countries below and 15 countries above the average.

Breaking down the Digital STRIs for 2018 into five policy areas reveals a diverse and complex regulatory environment for digital trade across countries. The results show that challenges remain, especially in relation to access to communications infrastructure and movement of information across networks. Additional challenges relate to measures that affect all types of electronic transactions such as differing standards for electronic contracts and payments. Other impediments such as the obligation to establish a local presence before engaging in digital trade are also common across countries.

Comparing the index over time shows how the global regulatory environment governing digital trade has developed in recent years. While the regulatory environment has remained stable in a majority of countries, those with changes have generally tightened the regulatory environment for digital trade. Compared to 2014, the first data point in the Digital STRI, ten countries have higher index values in 2018, and only three countries have lower values.

Indeed, in this period, close to 80% of the changes captured in the digital STRI over this period were trade restrictive. Looked at across the years, the number of restrictive policy changes has been relatively stable, whereas the extent of liberalisation has gradually decreased. Policy changes involving tightening are diverse in nature, but tend to concentrate around measures related to infrastructure and connectivity, such as a lack of pro-competitive regulation on interconnection measures and increased limitations on cross-border data flows and data localisation. Liberalisation and pro-competitive reforms in key services sectors underpinning the digital transformation (e.g. telecommunications) also help to substantially reduce trade costs for business services (OECD, 2017).

DID YOU KNOW?

According to the digital STRI index 2018, the regulatory environment affecting trade in digitally enabled services is complex and diverse across countries, with ample room to reduce trade barriers, in particular those affecting communications infrastructure and seamless connectivity.

Definitions

Infrastructure and connectivity comprises Digital STRI measures covering restrictions related to interconnection on communication infrastructures and restrictions affecting connectivity (e.g. measures affecting cross-border data flows).

Electronic transactions are Digital STRI measures covering barriers affecting electronic transactions (e.g. non-recognition of e-signatures).

Payment systems are Digital STRI measures that affect payments made through electronic means (e.g. restrictions on Internet banking).

Intellectual property rights are Digital STRI measures of domestic policies related to the protection and enforcement of trademarks, copyright and related rights.

Other barriers to trade in digitally enabled services are Digital STRI measures of barriers to trading in digitally enabled services that do not fall under the previous policy areas (e.g. performance requirements, limitations on downloading and streaming, or restrictions on online advertising).

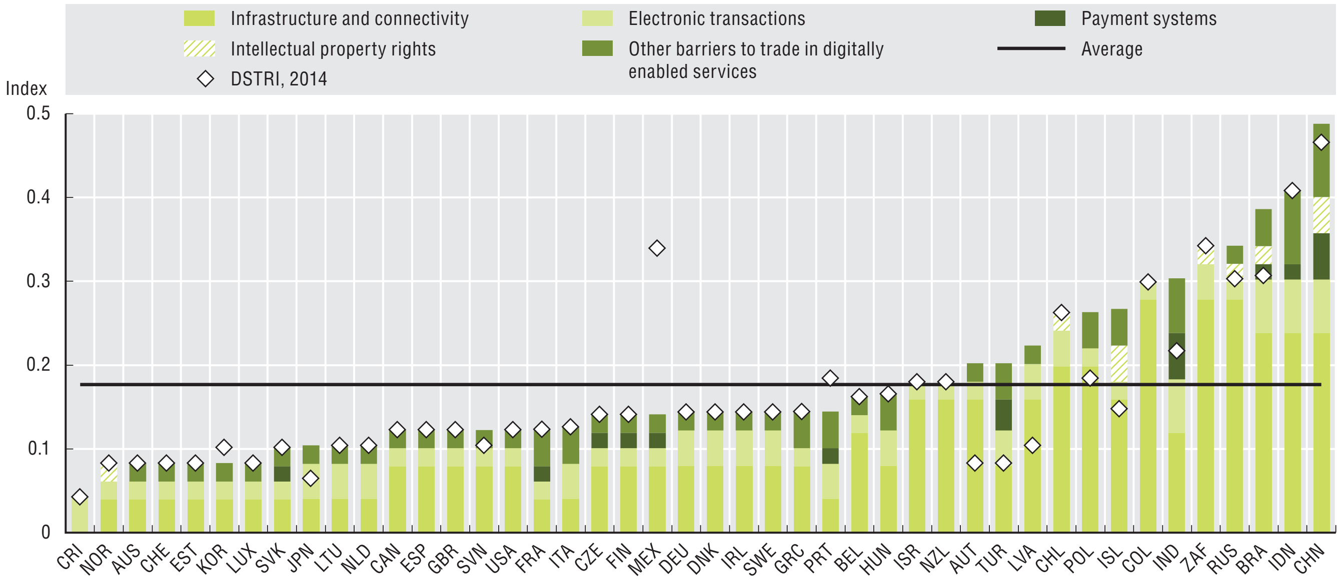
Policy changes are alterations recorded in the regulatory database across the years as a result of changes in laws and regulations in each country.

Measurability

The Digital STRI builds on the methodology and data gathered in the OECD Services Trade Restrictiveness Index (STRI). The indices presented summarise binary, hierarchical and quantitative data into composite indicators. For more information, see https://oe.cd/STRI-methodology. The Digital STRI comprises two components: a regulatory database that collects information on regulatory barriers from countries' publicly available laws and regulations, and composite indices measuring the trade restrictiveness of these policies. The indices take values between 0 and 1, where 0 indicates an open regulatory environment for digitally enabled trade and 1 indicates a completely closed regime.

Digital Services Trade Restrictiveness Index (DSTRI), 2018

Simple average, 1.0 = most restrictive



Source: OECD, Services Trade Restrictiveness Index, https://oe.cd/stri-db, December 2018. See chapter notes. StatLink contains more data.

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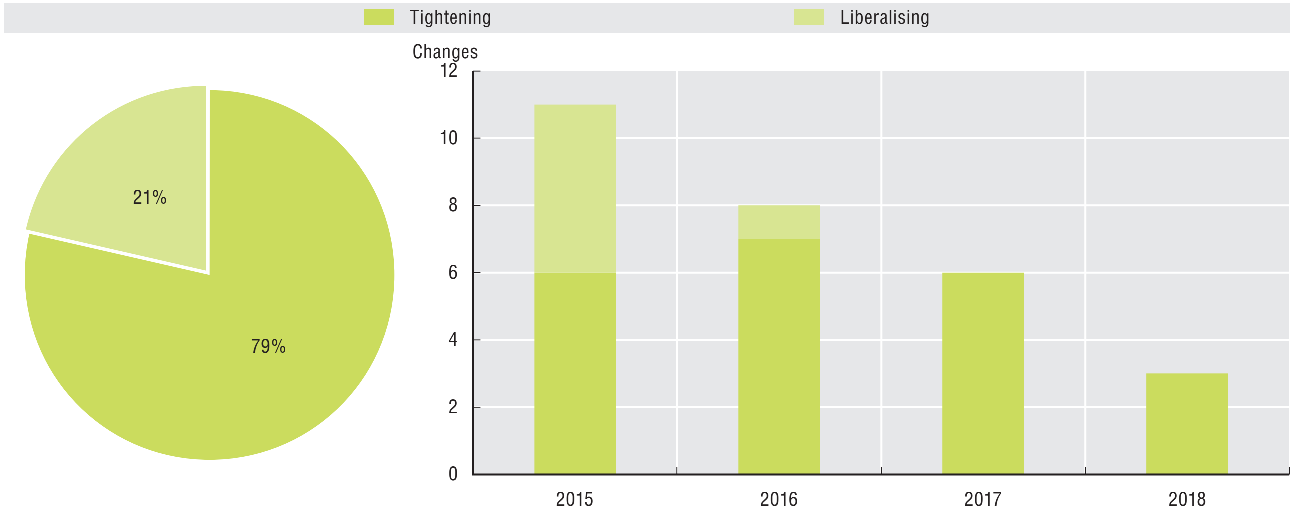
Policy changes affecting trade in digitally enabled services across 44 countries, 2015-18

Nature of changes (left-hand panel) and number of changes (right-hand panel)



Source: OECD, Services Trade Restrictiveness Index, https://oe.cd/stri-db, December 2018. See chapter notes.

StatLink https://doi.org/10.1787/888933931580

Digital technologies are often widely applicable and globally marketable, leading inventors to seek intellectual property protection for them in multiple markets. The United States is an especially important market, as almost all (92%) IP5 patent families (patents filed in two or more countries, at least one being in the top 5 national patent offices) for ICT-related technologies are filed at the United States Patent and Trademark Office (USPTO). China has the second most filings at almost 60%. The top inventor country for ICT-related IP5 patent families filed at the USPTO is Japan (24%), rather than the United States (17%), but US-located inventors account for around a quarter of ICT-related IP5 patent families at the European Patent Office and over half at patent offices in Canada, Australia and Israel.

Developing digital technologies can entail significant investment in research and development (R&D). ICT-related patents make-up a considerable portion of the top 2000 R&D-performing companies' patent portfolios, especially in ICT services, publishing and broadcasting, and telecommunications industries. The majority of patents held by top R&D-performers in the computers and electronics industry are also ICT-related. Finance and insurance stands out as an industry that is not directly related to ICT, but where a large share of patents are ICT-related (70%).

Most of the top R&D-performing companies are multinational enterprises (MNEs). One potential effect that can be associated with this is the diffusion of technologies across borders. Hosting a local MNE affiliate can be one way for economies to gain access to certain technologies. Similarly, one business may take a stake in another business, at home or abroad, to gain access to technology it owns. The extent to which such transactions happen across borders depends on the extent of regulatory and other restrictions in the investee country. The OECD Foreign Direct Investment Regulatory Restrictiveness Index (FDI RRI) gathers information on the strength of statutory restrictions in each country related to the taking of equity stakes in domestic companies by foreign parties, requirements for official approval, rules on the appointment of directors and other key personnel, and other areas of potential restriction. Overall, FDI restrictiveness still varies markedly between countries. Indonesia and China have the highest overall scores, at around 0.3. In China, the telecommunications sector – which is especially reliant on digital technologies – is particularly highly restricted (0.75). Telecommunications restrictions are also higher than the average level of restriction in non-European OECD countries and in Sweden. EU countries show relatively fewer restrictions, with many having zero restrictions in telecommunications.

DID YOU KNOW?

40% of patents held by the top R&D-performing companies worldwide are ICT-related.

Definitions

Patents protect technological inventions, (i.e. products or processes providing new ways of doing something or new technological solutions to problems). *IP5 patent families* are patents filed in at least two offices worldwide, including one of the five largest IP offices: the European Patent Office (EPO), the Japan Patent Office (JPO), the Korean Intellectual Property Office (KIPO), the US Patent and Trademark Office (USPTO) and the National Intellectual Property Administration of People's Republic of China (NIPA).

ICT-related patents are identified using International Patent Classification (IPC) codes (see Inaba and Squicciarini, 2017).

Top R&D companies are the 2000 corporations with the highest reported worldwide R&D expenditures in 2014 (Daiko et. al., 2017).

Foreign Direct Investment (FDI) comprises foreign investors' equity in and net loans to enterprises resident in the reporting economy. The FDI *Regulatory Restrictiveness Index (FDI RRI)* provides an indication of the extent of barriers to FDI in each country: 1 indicates measures that fully restrict foreign investment, while 0 indicates no regulatory impediments to FDI.

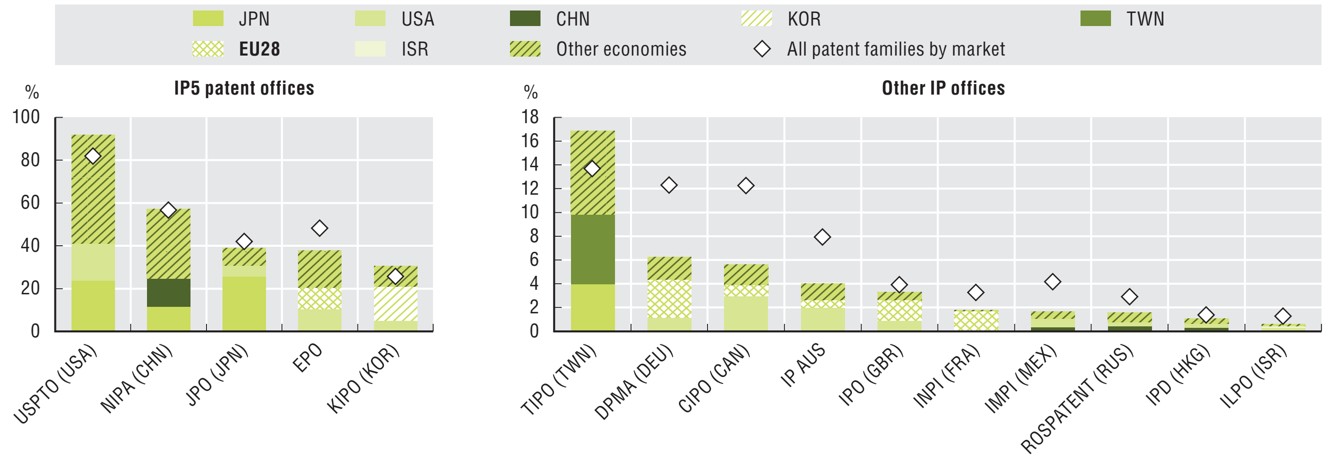
Measurability

Patent data are provided to the OECD by the EPO, JPO, KIPO, USPTO and NIPA. IPC codes attributed by patent examiners during the examination process indicate the technological domains to which inventions belong.

The FDI RRI measures statutory restrictions on foreign direct investment across 22 sectors. The Index covers four types of measures: (i) foreign equity restrictions, (ii) screening and prior approval, (iii) rules on key personnel, and (iv) other restrictions on foreign enterprises. The score for each sector is obtained by adding the scores for all four types of measures, and re-scaling this to a maximum value of 1. The 22 sector scores are then averaged to yield the overall score for each country. The main source of information is the list of country reservations under the OECD Code of Liberalisation of Capital Movements and their lists of exceptions and of other measures reported for transparency under the National Treatment Instrument (NTI). Additional sources include official national publications and information gathered by the Secretariat in the preparation of OECD Investment Policy Reviews.

Markets for digital technologies, top 15 IP offices, 2013-16

Share of IP offices in ICT-related IP5 patent families and two most common IP5 inventor economies at each IP office



Source: OECD, STI Micro-data Lab: Intellectual Property Database, http://oe.cd/ipstats, November 2018. See chapter notes.

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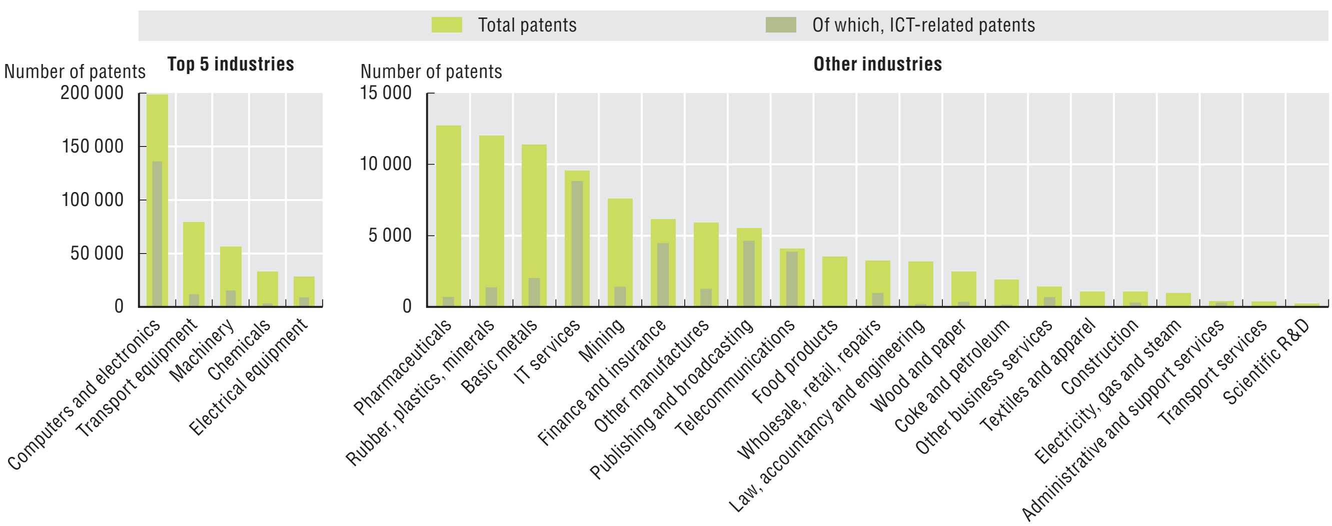
Patent portfolio of top R&D companies, by industry, 2013-16

Total and ICT-related IP5 patent families



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, November 2018. See chapter notes.

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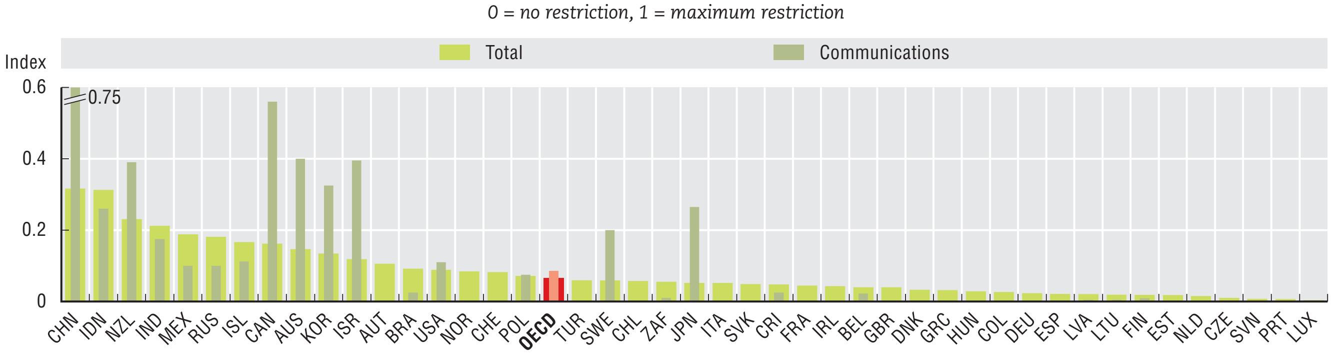
Foreign Direct Investment Regulatory Restrictiveness Index, 2017

0 = no restriction, 1 = maximum restriction



Source: OECD, FDI Regulatory Restrictiveness Index Database, http://www.oecd.org/investment/fdiindex.htm, December 2018. See chapter notes. StatLink contains more data.

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Why is measurement of digital trade needed?

Digital technologies have made it easier to engage in trade, co-ordinate global value chains (GVCs), and diffuse ideas, thereby changing how firms organise international trade, what they sell and to whom. This has led to more numerous and complex international trade transactions involving combinations of goods, services and data crossing different borders. Today, international trade needs to be quicker and more reliable than ever before to meet growing demand for just-in-time delivery and "on demand" access to goods and services.

Although digital-related transactions have existed for many years, exponential increases in scale and the emergence of new and disruptive players have transformed production processes and industries, including many that were previously mostly unaffected by globalisation. Relatively young companies, such as Netflix and Spotify, have quickly scaled using digital channels to deliver entertainment services globally. However, despite growing attention to "digital trade", little internationally comparable information on its size, nature and evolution currently exists. This inhibits a full understanding of the resulting policy challenges.

What are the challenges?

One impact of digitalisation has been an increase in small parcel trade. As the value of parcels often falls below the *de-minimis* thresholds adopted by customs authorities, there is a concern – albeit one that recognises that the impact on overall values of trade is likely to be marginal – that small parcel trade may not be fully captured in official statistics. Significant improvements already underway in customs clearance procedures and tracking systems in many countries will help to establish whether there is systematic underestimation.

More significant challenges exist in the area of (digitally delivered) trade in services, particularly to households. Many European economies are now beginning to use VAT returns from firms to improve on current measurement. These approaches typically lead to upward revisions at the product level. For example, households import 6% and 30%, respectively, of total imports of computer services and audio-visual products in Denmark, but the overall impact remains small, amounting to revisions of less than 0.4% of total imports.[1]

Ensuring that cross-border flows of intellectual property-related services align with core accounting concepts remains a significant challenge. Even when mismeasurement is not an issue, there remain challenges around interpretation[2], as was illustrated by the 26% upward revision to Irish GDP in 2015 (OECD, 2016). The broader issue of measuring intra-firm trade is exacerbated by large non-monetary data flows and delivery of services via affiliates abroad, which are also difficult to capture.

Notwithstanding these issues, a key problem for the development of statistics on digital trade is that current statistical classification systems do not routinely delineate digitally ordered or delivered trade flows from those that are not. In other words, it is hard to identify digital trade through the prism of current classifications.

To address these challenges, countries are exploring new data sources, such as credit card information, and developing projects linking business register data with customs data to provide information on the size of imports and exports by e-tailers (classified as NACE 47.91), or linking other sources. They are also exploring the scope for adding new questions to existing surveys. Costa Rica, with support from UCTAD, recently developed estimates of digitally delivered services using this approach. However, resource constraints and pressure to reduce respondent burden present a challenge in many countries.

Other challenges relate to when, how and by whom trade flows should be recorded. Digital intermediary platforms, which facilitate transactions for a fee, do so without ever taking ownership of the products involved. The identification of these platforms in business registers, their classification in terms of the actual services they provide, and the treatment of the transactions they facilitate – including which parts should actually recorded as being cross-border, and with which partner country – pose significant conceptual and empirical challenges.

Finally, current frameworks also struggle to identify the take-up of digital tools and technologies to engage in trade. OECD's Statistics and Data Directorate Informal Advisory Group on Measuring GDP in a Digitalising Economy is conducting work to address this need (see also page 2.11).

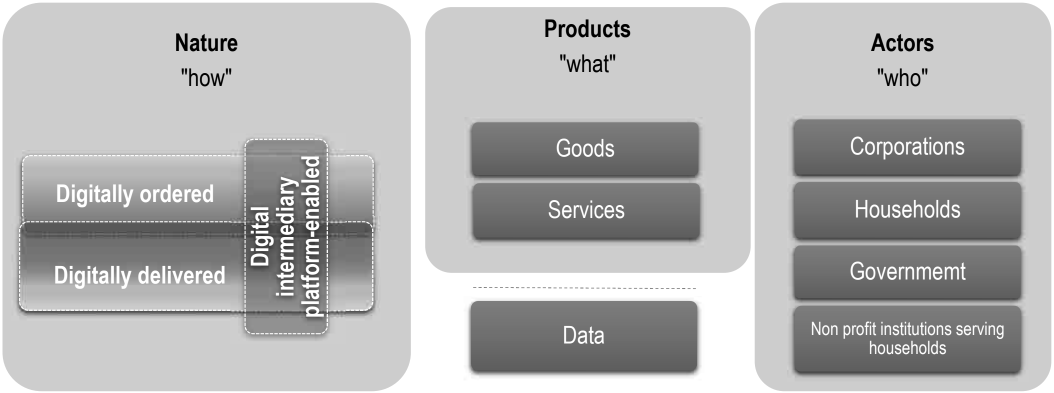
Options for international action

Efforts to better measure and identify digital trade follow a conceptual framework that defines digital trade as all international trade flows that are either digitally ordered, digital-intermediary platform-enabled or digitally delivered. The framework follows existing international statistical standards and classifications relevant for trade (BPM6 and EBOPS,

1. Burman and Sølvsten Khalili (2018), 'Measuring import of Digitally Enabled Services to Private consumers', Statistics Denmark.
2. http://www.oecd.org/iaos2018/programme/IAOS-OECD2018_Schreyer-vandeVen-Ahmad.pdf

IMTS and Harmonised System) and also capitalises on existing statistical definitions for e-commerce (OECD, 2011), OECD classifications of ICT goods and services, and definitions of ICT-enabled transactions developed by the TGServ Group).

Conceptual measurement framework for digital trade



Note: "Data" reflects only those cross-border data flows that do not entail a monetary transaction but do support one.
Source: Adapted from OECD (2017).

Among the key aspects of the work going forward is the development of a Handbook on Measuring Digital trade, co-ordinated by the OECD and WTO-led inter-agency Task Force on International Trade Statistics (TFITS). This taskforce brings together representatives from international agencies (OECD, UNCTAD, WTO, IMF, EUROSTAT, UN and the World Bank Group) plus more than 25 countries including Brazil, China, India, Indonesia, the Russian Federation, South Africa and Thailand, in addition to many OECD member states.

The Handbook builds on two OECD-IMF stocktaking exercises involving more than 70 countries (statistical offices and central banks) and numerous discussions across various fora in recent years, including at the OECD Working Party on Trade in Goods and Services, IMF BOPCOM and the Eurostat Working Group on Balance of Payments Statistics.

The first release of the Handbook, designed to be a living document, will be made available on-line in the first quarter of 2019. It will consist of five substantive chapters presenting:

1. A definition of digital trade - and a conceptual framework that provides recommendations on how transactions should be recorded (in particular those relating to digital intermediary platforms);
2. Best practice on measuring cross-border digitally ordered goods and services, with a focus on the sectors involved and the nature of the transactions (which services and whether they are cross-border or not);
3. Best practice on identifying digital intermediary platforms, with recommendations on the recording of related flows and, in particular, recommendations on the recording of transactions of non-resident platforms intermediating the provision of goods and services by domestic suppliers to domestic consumers;
4. Best practice on measuring digitally delivered services; and
5. Recommendations for estimating trade in digital goods and trade in digital services, building on existing and proposed classifications of goods and services, and using existing trade related product classifications.

The Handbook will deliver on the G20 mandate (G20, 2017) to develop a definition and typology of digital trade, highlight gaps in measuring and mapping digital trade, identify potential biases in international trade statistics, and, based upon emerging national statistical practices, provide recommendations on data sources and accounting standards.

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

OECD (2016), "Irish GDP up by 26.3% in 2015?", OECD, Paris, http://www.oecd.org/sdd/na/Irish-GDP-up-in-2015-OECD.pdf

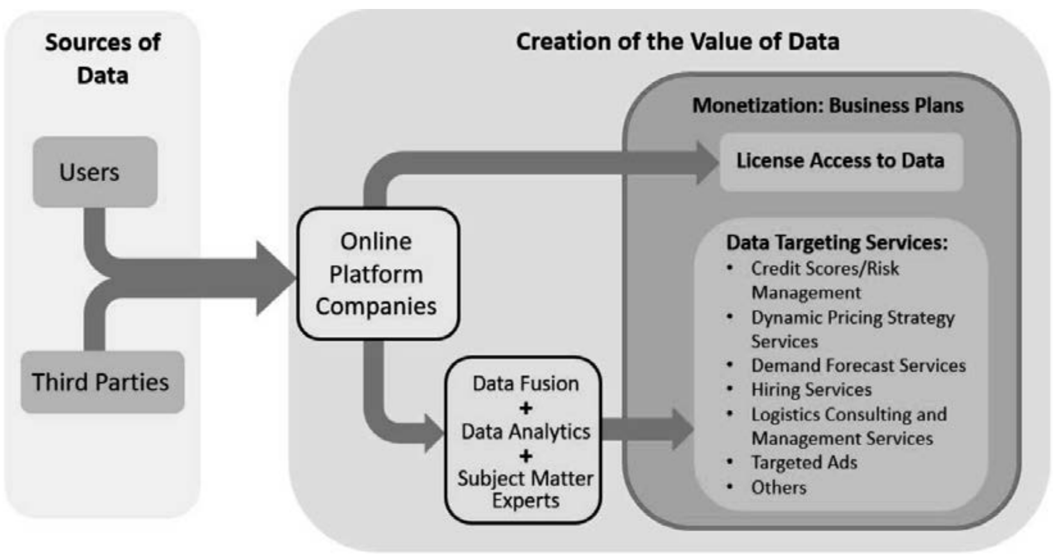
G20 (2017), "G20 Priorities on Digital Trade", G20, Dusseldorf, http://www.g20.utoronto.ca/2017/170407-digitalization-annex3.html

Why are indicators on business data and data flows needed?

Businesses have long been using data, but in recent years both the scale of data usage and its central importance for many business models has increased exponentially. "Data-enhanced businesses" augment their existing business models and processes with new, data-driven processes to enhance their production, distribution or marketing, while for "data-enabled businesses", such as online platforms, data are a key enabler of their core business model. Data also help businesses to co-ordinate better within and across global value chains, facilitate international transactions and can enable new or improved products and services. The value of data to businesses will depend on how and where in the business value chain they are put to use. Since data flows are likely to differ vastly across firms and sectors, there is a need to decompose and analyse data business models and value chains in detail, considering factors such as the types of data involved, their origin, the way they are used and institutional context (e.g. within an MNE or not). For example, Li et al. (2018) have analysed the nature and role of data in various online platform businesses.

There is not yet a consensus on the best way to measure and value different types of data and data inputs in the production process. The challenges of doing so are further exacerbated by the international nature of many business models, which entail related cross-border data flows. Without proper measurement and valuation, it also becomes difficult to assess the role data plays in terms of firm performance or product market structures. These measurement problems arise at the company, industry and country levels. They hamper the accuracy of national statistics and, in consequence, the development of effective and well-targeted policies aimed at fostering growth in the digital era.

The nature and role of data in online platforms



Source: Li et al. (2018).

What are the challenges?

There is no off-the-shelf method for valuing data, despite the fact that they have a significant and often critical value to businesses. While there are standard units for data (e.g. Megabyte, Gigabyte, Terabyte, Zettabyte, etc.), it is clear that these cannot form a meaningful basis for data valuation (HM Treasury, 2018; OECD, 2019). Even if stocks and flows of data were to be reliably measured, the value of data depends on the information they carry, which further depends on the context in which the data are generated and used. The same package of bits and bytes can thus have different economic implications in different contexts.

This implies a need for detailed metadata to contextualise any raw measures of data volume. While some classifications of data based on type, sources, uses and so on do exist (e.g. Abrams, 2014), there is also no established typology of data for statistical purposes that provides a common way of understanding and contextualising data prior to addressing measurement challenges. A key challenge, both theoretically and practically, is the non-rivalrous nature of data (Mandel, 2017; OECD, 2013). This means that data can be used multiple times (e.g. in different contexts) without inherently diminishing their value. In principle, data can be exploited and re-exploited infinitely at low marginal cost; it is data infrastructure and analytics that are the primary costs related to data re-use.

The increasing digitalisation of the global economy is not only driving data flows within countries but increasingly across borders (European Commission, 2017). Digitalisation enables the physical detachment of data collection, aggregation, analysis, storage and use or monetisation; each of these can take place in multiple countries, making it difficult to compile complete and robust measures of data and data flows. For example, data points are collected from the users of online social media platforms free of charge and, hence, they do not generate any financial transactions in the country where the user is based. However, once those data points are transferred and aggregated with millions of other data from across the globe they become the basis for data analytics and thus for value creation. Eventually, they are monetised by the provision of data-based services (e.g. targeted advertising) or by database licensing. An important, related challenge is transfers of data between affiliates within multinational enterprises (van der Marel, 2015), though this is an extension of measurement issues relating to MNEs' transactions generally.

This international dispersion amplifies the challenges of measuring stocks and flows of data, and indeed challenges the concept of "national stocks" of data assets, which would result from treatment of computerised databases as assets in the System of National Accounts. Another related challenge is establishing whether data assets should be considered as "produced assets" in the same way as machinery, equipment, buildings and research and development, or as "non-produced assets" similar to land, leases and licences, and marketing assets. This has non-trivial implications for economic statistics such as GDP (as outlined in Ahmad and van de Ven, 2018).

Options for international action

A first step is likely to consist of building upon initial work to establish internationally accepted classifications and taxonomies relating to data and data flows for statistical purposes, as a foundation for understanding and describing these entities. The OECD is currently working on such a taxonomy, which aims to group data into categories defined by its characteristics, such as ownership, exclusivity, privacy, tradability, source, completeness and trustworthiness, regardless of whether the data were actively collected or passively observed. Such a taxonomy would be a useful tool in helping to contextualise data volumes to gain a sense of the associated value.

Beyond this, potential measurement and/or valuation approaches for data and data flows include:

- Valuation based on market prices: this involves observing market transactions for different types of data (according to data typology), for example, transactions through data brokers/marketplaces.
- Estimates based on business models and data value chains: analysis focusing on particular businesses and their business models, and dissecting specific global data value chains, could help to identify when and where value is being created and how data stocks and flows enter this picture.
- Formal appraisals of data value arising from business mergers and acquisitions may give insight into the relative values of some types of data.
- Valuation through costs, for example, costs of collection, cleaning, aggregation, processing, storage, maintenance, enrichment, analysis, etc. (somewhat similar to own account software)
- Superimposing Input-Output tables with data-flow tables to assess whether flows of value added are accompanied by flows of data.

Allowance for recording transactions related to data has been made in the Digital Supply and Use Tables (see page 2.11). The OECD is working with the statistical and academic community to develop measures to meet these and other user needs.

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Notes

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.

9.1 Global value chains

Foreign value added satisfying domestic demand, by digital intensity, 2015

Digital intensity is defined according to the taxonomy described in: Calvino et al. (2018).

More digital-intensive industries = Medium-high and high digital-intensive industries.

Less digital-intensive industries = Medium-low and low digital-intensive industries.

EU28 and OECD represent weighted averages of countries' foreign value added in domestic demand, with intra-regional value added flows between countries considered as foreign value added flows.

Foreign value added satisfying domestic demand for information industries' products, by source region, 2015

Information industries cover the following ISIC Rev.4 Divisions: Manufacture of computer, electronic and optical products (26); Publishing, audio-visual and broadcasting activities (58 to 60); Telecommunications (61) and IT and other information services (62 to 63).

North America comprises Canada, Mexico and the United States; Other East and South East Asia consists of Brunei Darussalam, Hong Kong, Indonesia, Japan, Cambodia, Korea, Malaysia, Philippines, Singapore, Thailand, Chinese Taipei and Viet Nam.

Services value added embodied in manufacturing exports, by origin and digital intensity, 2015

Digital intensity is defined according to the taxonomy described in Calvino et al. (2018).

More digital-intensive industries = Medium-high and high digital-intensive industries.

Less digital-intensive industries = Medium-low and low digital-intensive industries.

Services are defined according to ISIC Rev.4 Divisions 41 to 98 (i.e. including construction).

EU28 is treated as a single economy (i.e. exports to non-EU countries only and intra-EU value added flows are treated as domestic flows, so that foreign value added is non-EU value added content in EU exports).

9.2 Trade

Trade in predominantly digitally deliverable services, 2017

This figure covers the EBOPS items SF: Insurance and pension services; SG: Financial services; SH: Charges for the use of intellectual property not included elsewhere; SI: Telecommunications, computer and information services; and the sub-item SK1 Audiovisual and related services.

For Chile, China, Indonesia, Mexico, New Zealand and Switzerland, Audiovisual and related services include Other personal, cultural and recreational services.

Enterprises having undertaken cross-border e-commerce sales, by customer region, 2016

For Iceland, data refer to 2012.

For Turkey, data refer to 2014.

9.3 Measures affecting trade in goods

Effectively applied tariffs on ICT goods, 2017

For Thailand, data refer to 2015 instead of 2017.

De minimis value thresholds for customs duties, 2018

From 1 July 2018, Australia has required online platforms, retailers and re-delivers, who ship goods costing AUD 1,000 or less from offshore to Australian consumers, to charge and remit GST on those sales to the Australian Taxation Office. This charge occurs at the point of sale and does not require the goods to be stopped at the border and there is no border charges or customs duty.

For Brazil, data refer to *de minimis* for shipments from the United States.

For Mexico, the *de minimis* threshold is 300 instead of 50 for postal shipments.

For New Zealand, data refer to postal shipments only.

For the Russian Federation, data only include personal shipments and samples, except medicine, herb medicine, wildlife-related products, quarantined items such as agricultural, livestock and marine products, nutritional supplement, food, alcoholic beverages, tobacco, cosmetics (only applied to functional cosmetics, placenta-containing cosmetics, cosmetics containing steroids and hazardous cosmetics) and others.

Figures 2016: https://global-express.org/assets/files/Customs%20Committee/de-minimis/GEA-overview-on-de-minimis_April-2016.pdf

Figures 2018: https://global-express.org/assets/files/Customs%20Committee/de-minimis/GEA%20overview%20on%20de%20minimis_9%20March%202018.pdf

Trade Facilitation Indicators, 2017

The area "Transparency and predictability" groups indicators in terms of information availability, involvement of the trade community, advance rulings, appeal procedures, and fees and charges. The area "Border agency co-operation" groups indicators in terms of domestic and cross-border agency co-operation.

9.4 Measures affecting trade in services

Digital Services Trade Restrictiveness Index (DSTRI), 2018

These are calculated on the basis of the STRI regulatory database, which records measures on a most-favoured-nation basis. Preferential trade agreements are not taken into account.

Policy changes affecting trade in digitally enabled services across 44 countries, 2015-18

Data refer to the following countries: Australia, Austria, Belgium, Brazil, Canada, Chile, China, Colombia, Costa Rica, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, India, Indonesia, Ireland, Israel, Italy, Japan, Korea, Latvia, Lithuania, Luxembourg, Mexico, the Netherlands, New Zealand, Norway, Poland, Portugal, the Russian Federation, Slovak Republic, Slovenia, South Africa, Spain, Sweden, Switzerland, Turkey, the United Kingdom and the United States.

9.5. Technology across borders

Markets for digital technologies, top 15 IP offices, 2013-16

Data refer to IP5 families, by filing date, IP office of destination and top two locations of the inventors, using fractional counts. Patents in ICT are identified using the list of IPC codes in Inaba and Squicciarini (2017). Data for 2015 and 2016 are incomplete.

Patent portfolio of top R&D companies, by industry, 2013-16

Data refer to IP5 families, by filing date, owned by top R&D companies, using fractional counts. Top corporate R&D companies are those ranked according to their R&D expenditures in 2014. Patents in ICT are identified using the list of IPC codes in Inaba and Squicciarini (2017). Data for 2015 and 2016 are partial. Only industries with at least two company headquarters in the top 2 000 corporate R&D sample having filed for patents during 2013-16 are included.

Foreign Direct Investment Regulatory Restrictiveness Index, 2017

The FDI RRI measures statutory restrictions on foreign direct investment in 68 countries, including all OECD and G20 countries, and covers 22 sectors. Four types of measures are covered: (i) foreign equity restrictions, (ii) screening and prior approval requirements, (iii) rules for key personnel and (iv) other restrictions on the operation of foreign enterprises. The score for each sector is obtained by adding the scores for all four types of measures, and re-scaling this to a maximum value of 1. The 22 sector scores are then averaged to yield the overall score for each country. The main source of information is the list of countries' reservations under the OECD Code of Liberalisation of Capital Movements and their lists of exceptions and other measures reported for transparency under the National Treatment Instrument (NTI). Additional sources include official national publications and information gathered by the Secretariat in the preparation of OECD Investment Policy Reviews, as well as by other international organisations.

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OECD, Broadband Portal, *http://oe.cd/broadband*

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OECD, STI Micro-data Lab: Intellectual Property Database, *http://oe.cd/ipstats*

OECD, Structural Analysis (STAN) Database, *http://oe.cd/stan*

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STI Micro-data Lab

The STI Micro-data Lab, a data infrastructure project of the OECD Directorate for Science, Technology and Innovation (STI), gathers and links large-scale administrative and commercial micro-level datasets. These micro-data, which complement and enhance official statistics like macro-aggregated or survey-based data, have the advantage of being granular in nature and comprehensive in time and geographical coverage.

These include administrative data on intellectual property (IP) assets, including patents, trademarks and registered designs that are collected in the framework of the OECD-led IP Statistics Task Force composed of representatives from IP offices worldwide. Bibliometric records on scientific publications and company level information, originating from private providers, as well as data on open source software, complement the micro-data.

The different micro datasets of the STI Microdata Lab can be used in an independent fashion, e.g. to develop indicators related to specific analytical questions, or combined in such a way as to generate new information related to a broader array of issues or to more complex dynamics. By providing detailed information about the behaviour of economic agents and the way science and technology develop, these data help address policy-relevant questions, such as those related to the generation and diffusion of new technologies, the different ways in which firms innovate, science-industry links, researchers' mobility patterns or the role of knowledge-based assets in firms' economic performance.

The STI Micro-data Lab is open to visiting researchers. Access is granted free of charge upon the submission of a formal request, and subject to the respect of confidentiality rules and to the project being of mutual interest to the OECD and the visiting fellow(s).

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