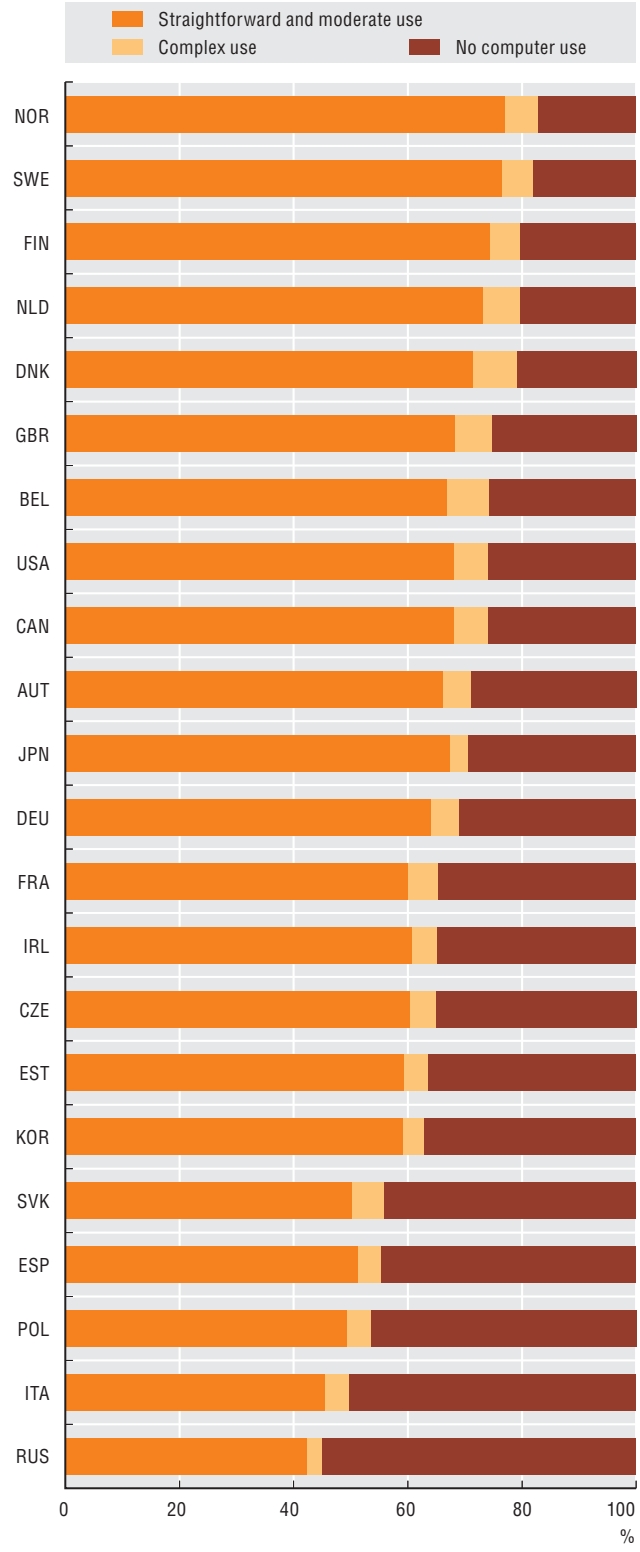
10. Skills in the digital economy

Computer use at work, 2012

Percentage shares of workers



Source: OECD, based on *Programme for International Assessment of Adult Competencies (PIAAC) Database*, June 2015. See chapter notes.

StatLink http://dx.doi.org/10.1787/888933273776

The diffusion of ICTs in the workplace is changing the way in which work is carried out and increasing the demand for new skills. These skills relate both to the effective use of new technologies and the ability to work in new working environments.

The results from the first OECD Programme for the International Assessment of Adult Competencies (PIAAC) show large differences in computer use at work across countries. In 2012, about 80% of individuals reported using a computer for work in the Nordic countries against 50% in Italy. However, most individuals reported straightforward or moderate computer use.

The data on frequency of ICT use at work permit the measurement of ICT intensity of different occupations. For each country, the difference between the average ICT index value across all occupations and the OECD average can be broken down into an ICT intensity effect and an occupational composition effect. In the Nordic countries, the higher than average ICT index value is driven by the higher than average ICT intensity of different occupations (the ICT intensity effect dominates), while in the case of the United Kingdom and the United States, the composition of the workforce dominates. ICT index values below average in Germany, France or Italy are mainly explained by the lower use of ICT skills at work within occupations.

The increasing use of ICTs at work requires workers to perform different tasks and to develop complementary skills. On average, intensive use of ICTs at work is associated with greater interaction between co-workers and clients, more problem solving, less physical work and higher numeracy. For most tasks, correlations with ICTs tend to decrease with the skill level of the occupation. This suggests that shifts in skill profiles towards a higher use of ICTs may be more significant for workers in low-skilled occupations.

Definitions

Straightforward computer use includes basic routines such as data entry or sending and receiving e-mails. *Moderate* computer use refers to word-processing, use of spreadsheets or database management. *Complex* computer use encompasses developing software or modifying computer games, programming or maintaining a computer network.

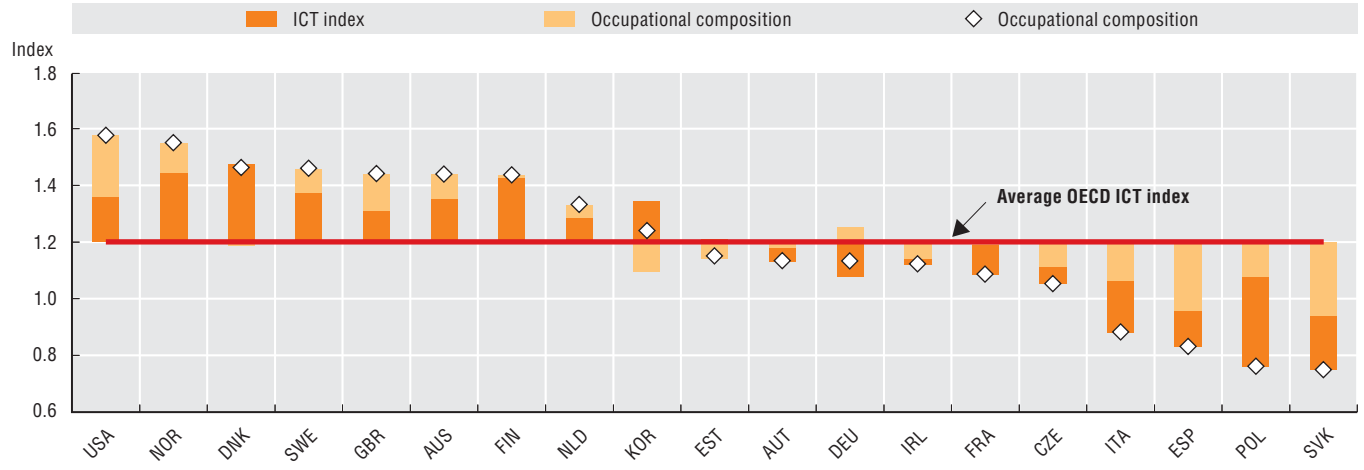
The *ICT index* is a derived variable computed within the *PIAAC Database* on the basis of questions that assess straightforward and moderate ICT use at work.

ICT intensity relates to how, on average in different occupations, workers use ICTs more (or less) compared to the OECD average. *Occupational composition* relates to how employment in a given country is more (or less) concentrated in occupations that use ICTs more (or less) compared to the OECD average.

Skills levels are defined according to the International Standard Classification of Occupations (ISCO-08): high (ISCO 1 to 3), medium (ISCO 4 to 8) and low (ISCO 9).

Index of ICT use at work, 2014

Cross-country differences in ICT intensity of occupations and occupational composition

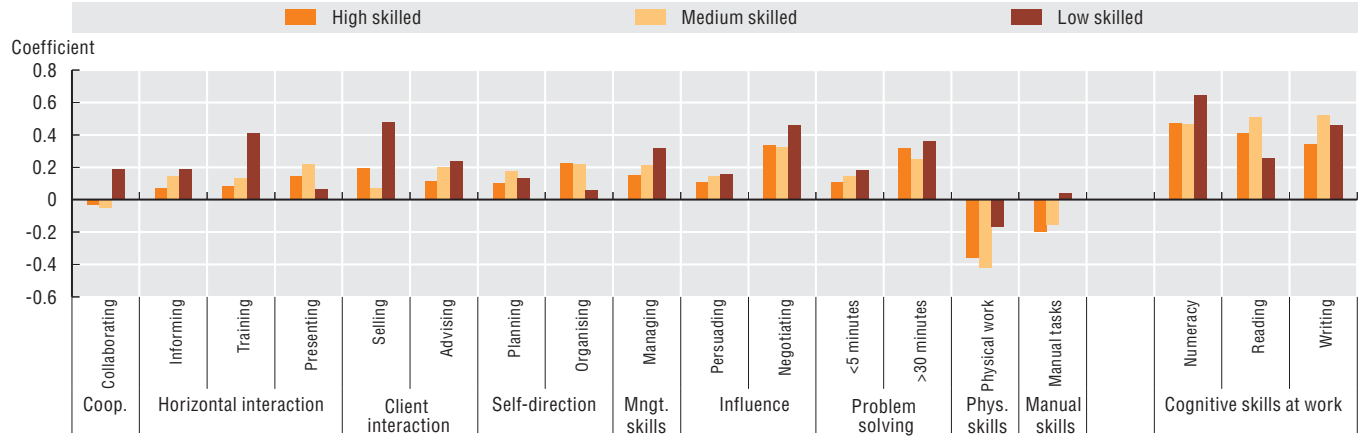


Source: OECD, based on *Programme for International Assessment of Adult Competencies (PIAAC) Database*, June 2015. See chapter notes.

StatLink http://dx.doi.org/10.1787/888933273786

ICT complementary skills, by skill level, 2012

Pairwise correlation coefficients between ICT and other skills used at work



Source: OECD calculations based on *Programme for International Assessment of Adult Competencies (PIAAC) Database*, June 2015. See chapter notes.

StatLink http://dx.doi.org/10.1787/888933273796

Measurability

The PIAAC survey collects information on the performance frequency of certain tasks at work. The indicator provides only an indirect measure of the skills required in a given occupation, based on the self-evaluation of workers in that occupation.

Questions about ICT use at work are directed only at PIAAC respondents who report "having experience with computers in the current/last job". To correct for the upward bias resulting from this selection, the ICT index has been adjusted by attributing the lowest possible value to respondents who reported having no computer experience at work.

Correlations between ICT usage and other tasks and cognitive skills in PIAAC are based on a large set of countries, but at one point in time only. The results are therefore representative of many countries, but do not capture *changes* in skills associated with ICTs. National surveys, such as the German IAB/BIBB, the British Skills Survey or the Dutch Skills Survey, enable changes in ICTs and tasks to be tracked over time, but may reflect country-specific features. The analysis of the O*NET survey in the United States tends to confirm the results based on PIAAC and presented above.

Notes and references

Cyprus

The following note is included at the request of Turkey:

"The information in this document with reference to 'Cyprus' relates to the southern part of the Island. There is no single authority representing both Turkish and Greek Cypriot people on the Island. Turkey recognises 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 recognised by all members of the United Nations with the exception of Turkey. The information in this document relates to the area under the effective control of the Government of the Republic of Cyprus."

Israel

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

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

2.1. Investment in knowledge

Spending on higher education, 2011

Core educational services include all expenditures directly related to instruction: all expenditures on teachers, school buildings, teaching materials, books, and administration of schools. Other expenditures include ancillary education expenditures, such as housing, meals and transport provided by institutions, and R&D expenditures at higher education institutions.

For Brazil, Canada, Hungary, Ireland, Poland, Portugal and Switzerland, data refer to public institutions only.

For Canada, data refer to 2010.

For Chile, data refer to 2012.

Gross domestic expenditure on R&D, by type, 2013

Data for total GERD (all types of R&D) refer to 2003 and 2013. Data by type of R&D correspond to the same reference year as GERD or, in their absence, are based on component shares for the most recent available year: 2012 for Denmark, France, Italy, the Netherlands, the United Kingdom and Portugal, and 2011 for Austria, Ireland and Greece.

Shares by type of R&D are based on total GERD, including capital expenditures, except for Chile, Norway, the Russian Federation, Spain and the United States. For these countries, estimates are based on current R&D estimates.

For Australia, data for total GERD refer to 2004 and 2011.

For Ireland, data for total GERD refer to 2012.

For Israel, defence R&D is partly excluded from available estimates.

For Switzerland, data for total GERD refer to 2004 and 2012.

For South Africa, data for total GERD refer to 2012.

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

R&D intensity ratios are normalised using official GDP figures. These are compiled according to the *System of National Accounts* (SNA) 2008, except for Chile, China, Japan, the Russian Federation and Turkey, where figures are available on the basis of SNA 1993.

ICT investment, by asset, 2013

For Norway, Spain and Sweden, data refer to 2012.

For Portugal, data refer to 2011.

Data for Iceland, Israel, Mexico, New Zealand and the Slovak Republic were incomplete and only represent the asset for which data were available.

National sources (used only for investment data) include the National Statistical Institutes of Canada, Denmark, Germany, Japan, the Netherlands, New Zealand, Switzerland, the Central Bank of Korea and the United States Bureau of Economic Analysis (BEA).

2.2. Higher education and basic research

Higher education expenditure on R&D, 2013

General University Funds (GUF) estimates identify the component of general institutional grants received by the higher education sector that are ultimately used for R&D. Estonia, Poland and the United States report no relevant grants fitting the GUF description. No estimates are available for China, the Czech Republic, Germany, Hungary, Korea, Luxembourg, Mexico, the Netherlands, Portugal and Turkey. The GUF figures correspond to the same reference year as HERD or, in their absence, are based on shares for the most recent available year: Belgium (2011), France, Israel and Italy (2012).

For Australia and Switzerland, data refer to 2004 and 2012.

For Austria, data refer to 2004 and 2013.

For Israel and Korea, R&D in the social sciences and humanities are not included in 2003 estimates.

For Mexico, data refer to 2011.

For South Africa, data refer to 2012.

For the United States, figures reported refer to current expenditures, but include a depreciation component which may differ from the actual level of capital expenditure.

R&D ratios are normalised using official GDP figures. These are compiled according to the *System of National Accounts* (SNA) 2008 except for Chile, China, Japan, the Russian Federation and Turkey, where figures are available on the basis of SNA 1993.

Funding of R&D in higher education, 2013

When estimates for "direct government" and "GUF" are not available separately, the class "subtotal government" is used to encompass both categories.

For Australia, Israel, Italy, Portugal, South Africa and Switzerland, data refer to 2012.

For Austria, Belgium and Mexico, data refer to 2011.

For the previous period's share of higher education R&D financed by business enterprise and private non-profit, data refer to 2003 except for Australia, Austria, France, Israel, Portugal and Switzerland (2002), Belgium, Mexico and South Africa (2001), Chile (2007), and Italy and Luxembourg (2005).

For Australia, Australian competitive grants (ACG) – federal and other schemes – are identified separately and included respectively in direct government and private non-profit.

For China, expenditure by source of funds is divided into government, business enterprise, funds from abroad and "other". These categories slightly differ from those in the *Frascati Manual*. Money that has no specific source of financing has been allocated to "other sector (domestic)". This includes self-raised funding, in particular for independent research institutions (IRIs, formerly GRIs) and the higher education sector, and leftover government money from previous years/grants.

For Denmark, higher education funds are included in government funds.

For Israel, defence R&D is partly excluded from available estimates.

For Germany, higher education and private non-profit funds are included in government funds.

In Luxembourg's survey, R&D data by source of funds are broken down as percentages between: Enterprise group, Ministry of Economy, Partner enterprise of R&D projects, European Commission, International organisations, Other foreign sources (other national governments, higher education, others).

For Poland, there are no General University Funds (GUF) as described in the *Frascati Manual*. The Ministry of Science and Higher Education finances the majority of teaching activities.

Notes and references

Basic research performed in the higher education and government sectors, 2013

Data refer to the sum of current and capital expenditures, except for Chile, Norway, the Russian Federation, Spain and the United States, for which only current costs are included in estimates reported to the OECD.

For Australia, data refer to 2008.

For Austria, Greece and Ireland, data refer to 2011.

For Denmark, France, Italy, the Netherlands, Portugal, the Russian Federation, South Africa, Switzerland and the United Kingdom, data refer to 2012.

For Mexico, data refer to 2009.

For Israel, defence R&D is partly excluded from available estimates.

For the Netherlands, part of expenditures dedicated to experimental development and within the higher education sector are reported within basic research. Additionally, PNP expenditures are included in the government sector.

For Switzerland, the government sector refers to the federal or central government only.

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

2.3. Science and engineering

Tertiary education graduates in natural sciences and engineering, 2012

Data refer to graduates at the ISCED-97 5A and 6 levels, and ISCED-97 fields 3 (Science) and 4 (Engineering, manufacturing and construction).

For Australia, data refer to 2011.

For Brazil, Canada, Chile and Greece, data refer to 2004 and 2012.

For Estonia, data refer to 2005 and 2012.

For France, data refer to 2009.

For Luxembourg, data refer to 2008 and 2012.

For Norway, Portugal, Switzerland, the United Kingdom and the United States, data refer to 2003 and 2012.

For the Russian Federation, data refer to 2006 and 2012.

For Slovenia, data refer to 2005 and 2012.

Graduates at doctorate level, by field of education, 2012

For Brazil, China and Norway, figures are based on national sources: for Brazil, *Capes Database*, Ministry of Education of Brazil, July 2015; for China, Educational Statistics website of the Ministry of Education of the Peoples' Republic of China, July 2015; for Norway, the Nordic Institute for Studies in Innovation, Research and Education (NIFU), June 2015.

For Brazil and China, an approximate conversion of nationally available information was carried out and mapped onto the ISCED-1997 classification of fields of study.

For Australia, data refer to 2011.

For Brazil and China, data refer to 2013.

For France and Poland, data refer to 2009.

For Norway, data are based on NIFU's Doctoral Degree Register, which also includes "Licentiate" degrees (equivalent to a doctorate degree).

New doctorates in natural sciences and engineering, 2008-12

For Brazil and China, an approximate conversion of nationally available information was carried out and mapped onto the ISCED-1997 classification of fields. Figures are based on national sources: for Brazil, *Capes Database*, Ministry of Education of Brazil, July 2015; for China, Educational Statistics website of the Ministry of Education of the Peoples' Republic of China, July 2015.

Owing to data availability by field of education, data refer to the 2007-11 average for Australia; 2009-12 average for China; 2007-09 average for France and Poland; and 2011-12 average for Italy.

2.4. Doctorate holders

General notes for all figures:

For Australia, data refer to 2011.

For Germany, Greece and the Netherlands, data refer to 2013.

For Greece, there is limited coverage of non-permanent residents.

For Greece and the Netherlands, data refer to doctoral graduates from 1990 onwards.

Additional notes:

Doctorate holders in the working age population, 2012

For Canada, Chile and New Zealand, data refer to 2011.

For Iceland, there is no breakdown between men and women.

For Denmark and the Netherlands, data exclude doctorates awarded abroad.

For Korea, data refer only to national citizens.

For Switzerland, data refer to 2013.

Due to the small sample size, the following data should be treated with caution: for Luxembourg and Norway, data on female doctorate holders; for Estonia, data on both female and male doctorate holders.

For Chinese Taipei, data include only PhDs in the National Profiles of Human Resources in Science and Technology (NPHRST) compiled by STPI, NARL: *http://hrst.stpi.narl.org.tw/index.htm#noticeChinese.pdf*.

This indicator combines data from different statistical sources as described below.

Sources (Doctorate holders): Australia, Chinese Taipei, Chile, Denmark, Germany, Greece, Korea, the Netherlands, Portugal, the Russian Federation, Slovenia and Switzerland: OECD Careers of Doctorate Holders 2014. Belgium, Estonia, Finland, France, Hungary, Ireland, Israel, Italy, Latvia, Luxembourg, the Slovak Republic, Spain, Sweden, the United Kingdom and the United States: *OECD Educational Attainment Database 2014*. Austria, the Czech Republic, Iceland, Norway and Poland: EU Labour Force Survey (Microdata), June 2015. Canada and New Zealand: *Database on Immigrants in OECD Countries (DIOC) 2010/11*.

Employment rate of doctorate holders and other tertiary graduates, 2012

For Canada, Chile, Estonia and New Zealand, data refer to 2011.

For the United States, data refer to 2013. Doctorate holders' data exclude those with a doctorate in humanities, education, business, law and communications.

Due to the small size sample, the following data should be treated with caution: the doctorate employment rate of women in Belgium, the Czech Republic, Estonia, Norway and Luxembourg.

For Denmark, Belgium, the Netherlands, and the United States, data exclude doctorates awarded abroad.

For Korea, data refer only to national citizens.

This indicator combines data from different statistical sources as described below.

Sources (Doctorate holders): Australia, Chile, Denmark, Germany, Greece, Korea, the Netherlands, Portugal, the Russian Federation, Slovenia and the United States: OECD Careers of Doctorate Holders 2014. Belgium, Finland, France, Hungary, Ireland, Israel, Italy, Luxembourg, the Slovak Republic, Sweden, Switzerland and the United Kingdom: *OECD Educational Attainment Database 2014*. Austria, the Czech Republic, Spain, Norway, Poland and Slovenia: EU Labour Force Survey (Micro-data), June 2015. Canada, Estonia and New Zealand: OECD *Database on Immigrants in OECD Countries (DIOC) 2010/11*.

Sources (other tertiary levels): OECD Educational Attainment Database 2014. For Canada, Estonia and New Zealand: OECD *Database on Immigrants in OECD Countries (DIOC) 2010/11*.

Doctorate holders by economic activity, 2012

For presentational reasons and to preserve cell confidentiality rules, grouped economic activities combine different section headings of ISIC Rev. 4, as listed below. Manufacturing, agriculture, mining and other industrial activities includes Sections A, B, C, D, E and F. Professional services and related market services includes J, K, L and M. Human health and Public administration includes O and Q. Other services includes G, H, I, N, R, S, T and U.

For Denmark and the Netherlands, data excludes doctorates awarded abroad.

For Switzerland, data refer to 2013.

For the United States, data refer to population aged 25 years and over.

Notes and references

Sources: Australia, Denmark, Germany, Greece, the Netherlands, Portugal, Switzerland: OECD Careers of Doctorate Holders 2014. Austria, Belgium, the Czech Republic, Estonia, Finland, France, Spain, Hungary, Iceland, Ireland, Italy, Luxembourg, Norway, Poland, the Slovak Republic, Slovenia, Sweden and the United Kingdom: EU Labour Force Survey (Micro-data), June 2015. The United States: Current Population Survey (detailed tables on educational attainment), July 2015.

Section headings for economic activities in ISIC Rev. 4:

A	Agriculture forestry and fishing
B	Mining and quarrying
C	Manufacturing
D	Electricity, gas, steam, air conditioning
E	Water supply; sewerage, waste management and remediation activities
F	Construction
G	Wholesale and retail trade, repair of motor vehicles and motorcycles
H	Transportation and storage
I	Accommodation and food service activities
J	Information and communication
K	Financial and insurance activities
L	Real estate activities
M	Professional, scientific and technical activities
N	Administrative and support activities
O	Public administration and defence; compulsory social security
P	Education
Q	Human health and social work activities
R	Arts, entertainment and recreation
S	Other service activities
T	Activities of households as employers
U	Activities of extraterritorial organisations and bodies

2.5. Researchers

R&D personnel, 2013

For Austria, data refer to 2004 and 2013.

For Canada, Ireland, Israel, the OECD zone, South Africa and the United States, data refer to 2012.

For Iceland and Mexico, data refer to 2011.

For Switzerland, data refer to 2004 and 2012.

For the United States, 2012 data for researchers have been estimated based on contemporaneous data on business researchers and past data for other sectors.

Researchers, by sector of employment, 2013

For a number of countries, methodological improvements were adopted over the period 2003-13, which may hinder data comparisons over time.

For Iceland, data refer to 2001 and 2011.

For Israel, South Africa and the United States, data refer to 2012.

For Mexico, data refer to 2004 and 2011.

For Switzerland, data refer to 2004 and 2012.

Previous year data points for the share of business researchers refer to 2003 except for Austria and Finland (2004).

For China and Israel, the military part of defence R&D is excluded.

For the Netherlands, the private non-profit sector is included in the government sector.

For Norway, data refer to university graduates instead of researchers in the business sector.

For Sweden, data refer to university graduates instead of researchers in the business sector before 2005.

For the United States, 2012 data for researchers have been estimated based on contemporaneous data on business researchers and past data for other sectors.

Female researchers, by sector of employment, 2013

For Austria, Belgium, Denmark, Germany, Greece, Iceland, Ireland, Israel, Luxembourg and Sweden, data refer to 2011.

For France, Italy, Portugal and South Africa, data refer to 2012.

For the Netherlands, the private non-profit sector is included in the government sector.

2.6. Research excellence

The quantity and quality of scientific production, 2003-12

"Top-cited publications" are the 10% most-cited papers in each scientific field. This measure is an indicator of research excellence. Estimates are based on whole counts of documents by authors affiliated to institutions in each economy.

Field specialisation in scientific publication output, 2003-12

The "Relative activity index" is calculated by computing the ratio between a field's output share within the reference country and the corresponding share at world level. The index shows the extent of a country's specialisation in one field relative to the global "norm".

Excellence rate for top two scientific fields within countries, 2003-12

The 10% most-cited documents is an indicator of scientific excellence. This rate indicates the amount (in percentage) of a unit's scientific output included in the set of the 10% most-cited papers in their respective scientific fields. This measure is an indicator of the high quality of research output of a unit.

Results displayed exclude multidisciplinary fields. Data on top three fields, including multidisciplinary, are available as more data.

2.7. Organisational capital

General notes for all figures:

Identification of occupations that relate to organisational capital (OC) is based on survey results from the Programme for the International Assessment of Adult Competencies (PIAAC), classified according to the International Standard Classification of Occupations (ISCO, 2008).

Additional notes:

Employment and investment in organisational capital, 2011-12

Employment and investment are calculated for the total economy and expressed as ratios of total employed persons and total value added, respectively.

Investment in organisational capital, by industry and firm size, 2011-12

The industry classification used is ISIC Rev. 3. Small firms have between 1 and 50 employees, medium firms between 51 and 250 employees, and large firms more than 250 employees.

Investment in organisational capital, by industry, 2011-12

The industry classification used is ISIC Rev. 3. The Agriculture sector has been removed due to poor coverage of OC occupations.

2.8. Firm-specific training

General note for all figures:

Identification of investment in firm-specific training is based on survey results from the Programme for the International Assessment of Adult Competencies (PIAAC) and external data (LFS, SNA and OECD sources).

Notes and references

Additional notes:

Firm-specific training: Employment and investment by type, 2011-12

Employment figures are calculated as the ratio of total employed persons receiving training at least once per year, by type of training (formal vs. on-the-job), over total employment in the economy.

Investment figures are calculated as investment by type of training over total gross value added.

Investment in firm-specific training by type, industry and firm size, 2011-12

Investment figures are calculated as investment by type of training and size of the employing company, over gross value added in the industry.

Small firms have between 1 and 50 employees, medium firms between 51 and 250 employees, and large firms more than 250 employees.

Investment in firm-specific training by industry, 2011-12

Investment figures are calculated as investment by type of training over gross value added in the industry.

The confidence interval is calculated as the 90th percentile over the 10th percentile of the cross-country distribution. The country code on the top of the bar indicates the country with the training intensity closest to the 90th percentile of the cross-country distribution of industry values.

2.9. Public sector intangibles

Investment in organisational capital in the public and private sectors, 2011-12

"Private" refers to OC investment in private entities operating in the business sector (ISIC Rev. 3 Codes 01 to 72 and 74). Investment is divided by total gross value added in the same sectors, adjusted by the share of employees working in private entities over total employment in those sectors.

"Public" refers to OC investment in public entities operating in ISIC Rev. 3 Sectors 73 and 75 to 93. Investment is divided by total gross value added in the same sectors adjusted by the share of employees working in public entities over total employment in those sectors.

Identification of occupations that relate to organisational capital (OC) is based on survey results from the Programme for the International Assessment of Adult Competencies (PIAAC), classified according to the International Standard Classification of Occupations (ISCO, 2008), the *Structural Analysis (STAN) Database* and other data sources.

Investment in firm-specific training in the public and private sectors, 2011-12

"Private" refers to investment in firm-specific training in private entities operating in the business sector (ISIC Rev. 3 Codes 01 to 72 and 74). Investment is divided by total gross value added in the same sectors, adjusted by the share of employees working in private entities over total employment in those sectors.

"Public" refers to investment in firm-specific training public entities operating in ISIC Rev. 3 Sectors 73 and 75 to 93. Investment is divided by total gross value added in the same sectors adjusted by the share of employees working in public entities over total employment in those sectors.

Investment in firm-specific training is estimated using survey results from the Programme for the International Assessment of Adult Competencies (PIAAC), the *Structural Analysis (STAN) Database* and other data sources.

Employees contributing to organisational capital who receive training, public and private sectors, 2011-12

Identification of firm-specific training and organisational capital is based on survey results from the Programme for the International Assessment of Adult Competencies (PIAAC) and external data (LFS, SNA, OECD sources).

The figure refers to managers and non-managers who are receiving training at least once in the year, as a percentage of total employed managers and non-managers in the sector. Figures for "Public" refer to employed persons in a public establishment in industries ISIC Rev. 3 73 and 75 to 93. Figures for "Private" refer to employed persons in a private establishment in industries ISIC Rev. 3 1 to 72, and 74. "Total trained OC" reports the percentage of employed persons contributing to organisational capital (OC) who received training at least once in the year.

2.10. Skills in the digital economy

Computer use at work, 2012

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.

For the United Kingdom, data refer to England only.

Index of ICT use at work, 2014

Data for the average OECD ICT index refer to the simple average value of the index across 19 countries presented here.

ICT complementary skills, by skill level, 2012

Data show average coefficient values across the following countries covered by the PIAAC sample: Australia, Austria, Belgium, Canada, the Czech Republic, Denmark, Estonia, Finland, France, Germany, Ireland, Italy, Japan, Korea, the Netherlands, Norway, Poland, the Russian Federation, the Slovak Republic, Spain, Sweden, the United Kingdom and the United States.

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.

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