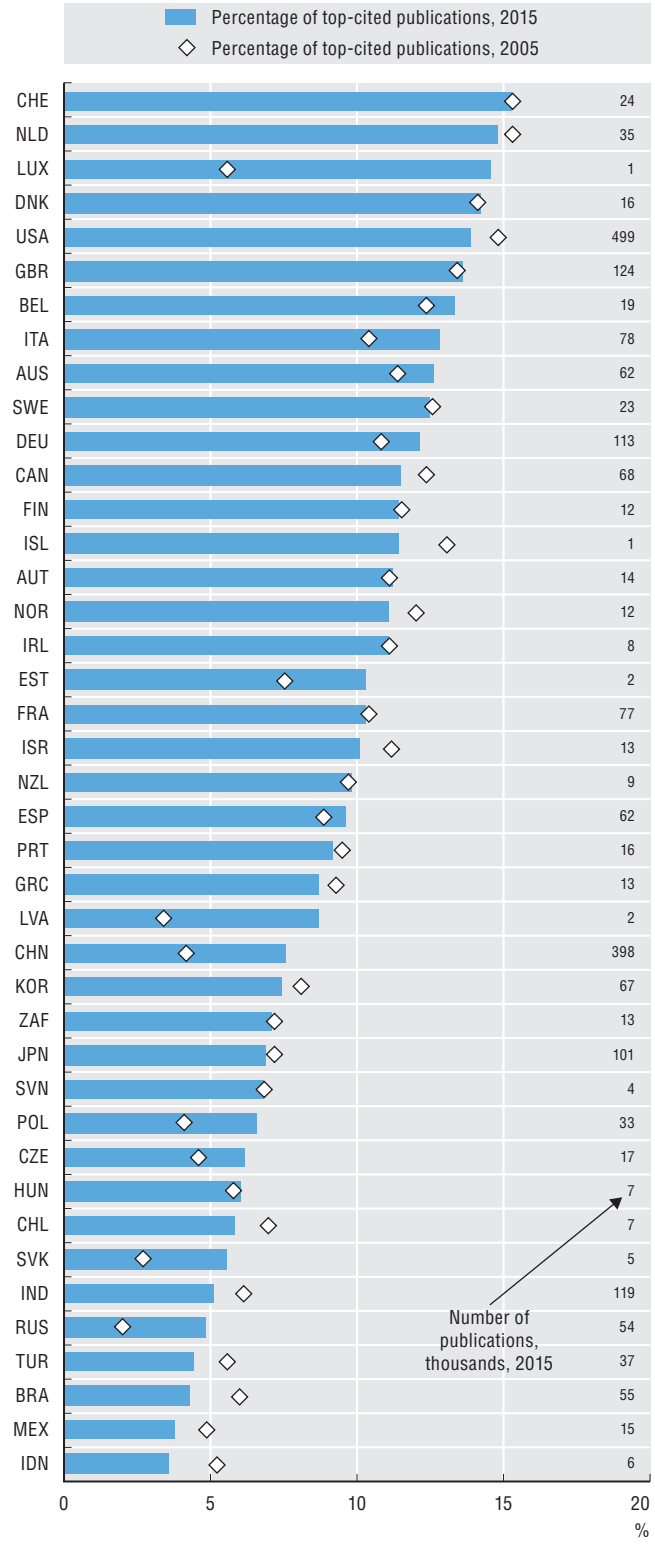
1. Research excellence and specialisation

Quantity and quality of scientific production, 2005 and 2015

Number of documents and percentage among the world's 10% most cited publications, fractional counts



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

StatLink http://dx.doi.org/10.1787/888933618745

Did you know?

Scientific production is 20-30% higher in China than the United States in fields such as computer or materials science, but is 70% lower in neuroscience.

The indicator of top-cited publications provides a "quality adjusted" measure of research output. In 2015, the United States led the production of scientific publications with nearly half a million. China accounts for the second largest number of top-cited documents, with nearly as many as Germany and the United Kingdom combined. Switzerland has the largest share of domestic scientific documents with a high citation impact, closely followed by the Netherlands.

Countries exhibit specialisation in different scientific domains. A specialisation index provides evidence of the fields in which a given country accounts for a relatively high share of scientific production, compared to the global distribution of scientific output across fields. The relationship between specialisation and citation impact is analysed in four selected domains: Biochemistry, Computer science, Materials science and Neuroscience. While higher specialisation is associated with greater citation impact in the case of biochemistry, this is not the case for other domains. Most countries appear to be similarly specialised in biochemistry, while there is wider heterogeneity for neurosciences. India exhibits high levels of specialisation and output in the area of computer science. The Russian Federation is highly specialised in Materials science. For countries with high levels of scientific output, normalised impact scores are similar across fields. For smaller countries, pockets of excellence can be found in specific areas.

Definitions

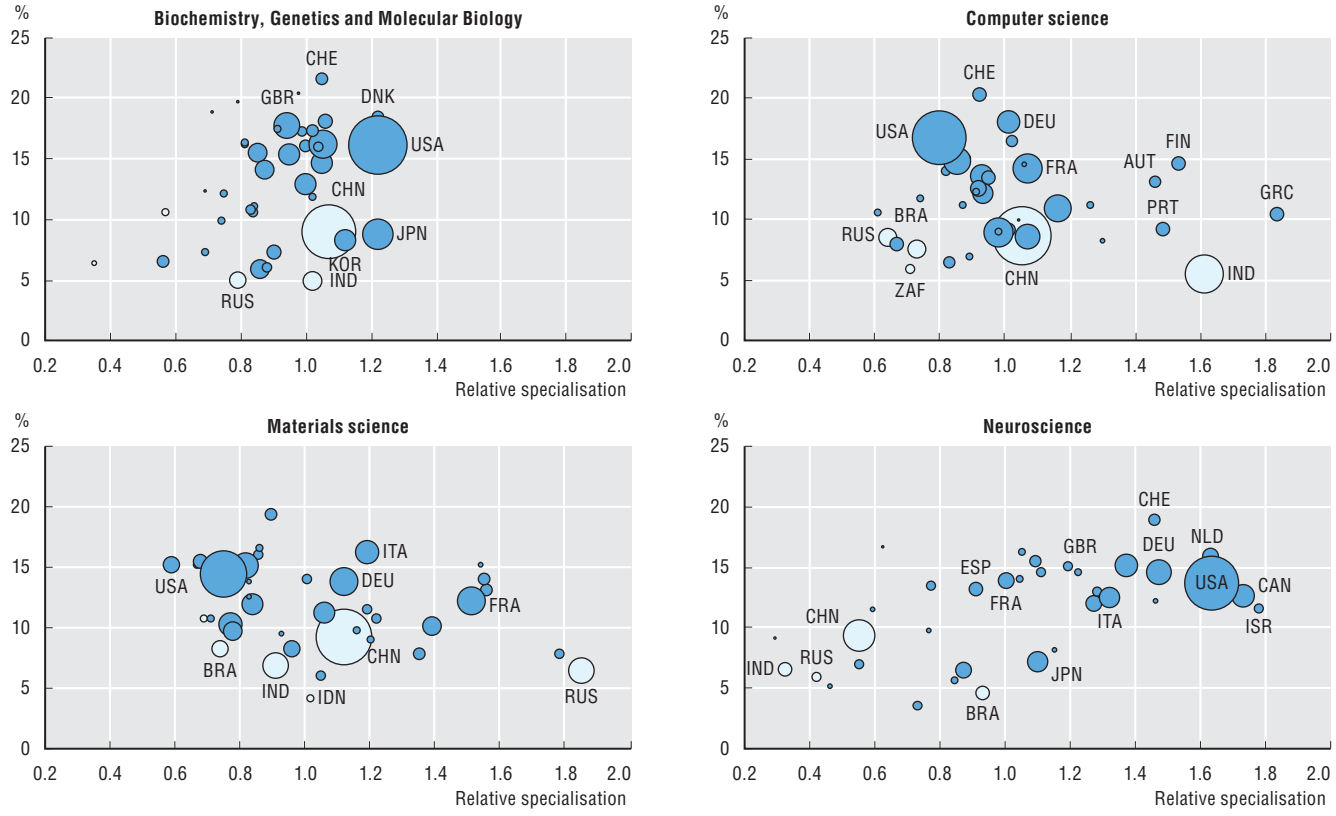
Estimates of scientific publication output are based on counts of citable documents (articles, reviews and conference proceedings), indexed within Elsevier's Scopus database, by authors with affiliations in each country. Documents are assigned on a fractional basis, according to the number of authors and their respective affiliations in that particular country.

The specialization indicator is calculated by dividing a field's share of documents within a given country by the global share of that particular field. Economies that have field distributions very similar to that of the entire world exhibit specialisation values very close to 1.

The indicator of scientific excellence (top-cited publications) shows the percentage of a country's scientific output that is included in the group of the 10% most-cited publications in their respective scientific fields. The 2015 Scimago Journal Rank indicator is used as a complement to sort publications with identical numbers of citations within each class.

Specialisation and citation impact in science, selected fields, 2015

Percentage of documents in the top 10% ranked documents and relative specialisation, by field, fractional counts



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

StatLink http://dx.doi.org/10.1787/888933618764

Measurability

Scientific publications provide a measure of scientific production activity based on the numbers of documents published in peer-reviewed journals and indexed by data providers. Publication norms vary by field and sector (OECD and CSIC, 2016), depending on the use of review and dissemination mechanisms as well as organisational disclosure practices. Indexing may also exhibit language-related biases. Scientific excellence is approximated by measures of the distribution of citation "impact" normalised by year of publication, type of document and field(s). High citation rates may incorporate self-citation, refer to retracted papers, and fail to capture relevance to non-publishing communities.

In the case of Scopus, Elsevier uses its All Science and Journal Classification (ASJC) to classify each journal under one or more field subject. Field assignment on a journal basis is approximate, as a given journal's classification may not provide an accurate representation of each document's thematic content. To minimise this problem, documents published in generic multidisciplinary journals have been allocated on a fractional basis to the ASJC codes found in both citing and cited papers.

Notes and references

Cyprus

The following note is included at the request of Turkey:

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

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

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

Israel

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

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

3.1. Research excellence and specialisation

Quantity and quality of scientific production, 2005 and 2015

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

Specialisation and citation impact in science, selected fields, 2015

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

The relative specialisation indicator has been calculated as the ratio of a given field's share in a country's total scientific production, relative to the world's equivalent. A ratio higher than 1 signifies a high degree of specialisation, with the field's share in that country exceeding the relative importance of the field in overall global scientific output, as captured by the Scopus database. Figures have been rounded. Instances with too few documents in a given economy and field have been suppressed.

3.2. Excellence in scientific collaboration

International scientific collaboration, 2015

International collaboration is defined as the number of domestically authored publications incorporating institutional affiliations of other countries or economies, expressed as a percentage of all publications attributed to authors with an affiliation in the reference economy. This includes a relatively small proportion of documents by single authors with affiliations in different economies.

International collaboration is broken down into documents where the leading author has as first affiliation the reference economy and those where the lead author's first reported affiliation is abroad. The leading author is identified in most cases from the identity of the designated corresponding author. For the relatively small fraction of documents where that information is not available, the identity of the leading author is imputed from the first listed author.

The citation impact of scientific production and the extent of international collaboration, 2012-16

Scientific production/Output/Number of documents is the total number of citable documents (articles, reviews and conference proceedings) published in scholarly journals indexed in Scopus.

The normalised citation impact measure is derived as the ratio between the average number of citations received by documents published by authors affiliated to an institution in a given economy and the world average of citations, over the same time period, by document type and subject area.

The normalisation of citation values is item oriented (i.e. carried out at the level of the individual article). If a document is published in a journal classified as belonging to more than one subject area, an average across fields is calculated. The values show the relationship of the unit's average impact to the world average in the relevant field and type of document, which is 1 (i.e. a score of 0.8 means the unit cited is 20% below average and 1.3 means the unit cited is 30% above average).

International collaboration is defined as the number of domestically authored publications incorporating institutional affiliations of other countries or economies, expressed as a percentage of all publications attributed to authors with an affiliation in the reference economy. Single-authored documents with multiple affiliations across boundaries can therefore count as institutional international collaboration.

Multi-year figures are averages (or totals) of yearly estimates.

Top 10% most-cited documents and patterns of international collaboration, 2015

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

Top-cited documents are distributed according to whether these documents are domestic or foreign-led (i.e. whether the leading author has as first affiliation the reference economy or whether the lead author's first reported affiliation is abroad). The leading author is identified in most cases from the identity of the first designated corresponding author. For the relatively small fraction of documents where that information is not available, the identity of the leading author is imputed from the first listed author. Domestically led documents may or may not entail international collaboration, leading to a distinction between domestic-led international collaborations and domestic-only documents.

3.3. International mobility of the highly skilled

Internationally mobile students enrolled in tertiary education, 2015

Data refer to foreign students for the Czech Republic, Italy, Korea, the Slovak Republic and Turkey. Foreign students are defined on the basis of their country of citizenship; these data are not comparable with data on international students and are therefore presented separately in the table and figure.

Total enrolments include all international or foreign students. The distribution is based on the number of students with a known field of education.

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

Fields of study refer to the ISCED-F 2013 Fields of education classification.

For Japan, data on Information and communication technologies are included in other fields.

For the Netherlands, total tertiary education excludes the doctorate level.

For the United States, Health and welfare includes all inter-disciplinary programmes, including those without a specific arts and humanities component.

International and domestic doctoral students in natural sciences, engineering and ICT (NSE & ICTs), 2015

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

Fields of study refer to the ISCED-F 2013 Fields of education classification.

For Japan, data on Information and communication technologies are included in the other fields.

Highly educated individuals in the working-age population, by place of birth, 2015

Highly educated individuals are defined as an individual who's highest level of successfully completed education or training corresponds to ISCED-11 level 5 and above.

For Korea, data refer to 2013. The immigrant status is defined on the basis of nationality, not on the basis of country of birth.

For the United States, data include people over 55 who are still in education.

The indicator is computed based on the following data sources: European Labour Force Survey (EULFS); Labour Force Survey (Australia, Canada, Israel and New Zealand); Encuesta de Caracterización Socioeconómica Nacional (CASEN) (Chile); Foreign Labour Force Survey (Korea); Encuesta Nacional de Ocupación y Empleo (ENOE) (Mexico); and United States Current Population Survey (CPS).

3.4. Scientists on the move

International bilateral flows of scientific authors, 2006-16

Data are based on the main country affiliation for authors captured in at least two documents published and indexed in the Scopus database over the 2006-2016 period. Counts are based on the number of authors with distinct country affiliations in their first and last recorded publication within this period. Flows to and from interim affiliations are not taken into account in this figure. In the case of multiple country affiliations (approximately 2% of documents), the most recurrent country (modal) affiliation for that author is used.

International mobility of scientific authors, 2016

Estimates are based on the comparison between the main affiliation of a given author with a Scopus Author ID publishing in 2016 and the closest available publication in a previous year. Only authors with two or more publications are considered. A mobility episode is identified in 2016 when an author who is affiliated to an institution in a given economy in his/her last publication in 2016 was previously affiliated to an institution in a different economy. Authors are assigned a given status from the perspective of the last destination in 2016. The "stayers" status is assigned if the main affiliation for both 2016 and pre-2016 correspond to the reference economy. The "returnee" status is assigned to those who move affiliation into the reference economy, but were affiliated to it in their first recorded publication. From the perspective of the previous economy of author affiliation, individuals can be computed as outflows, and the count is incorporated in the data presentation. Data are presented sorted by the share of outflows in the extended sum of possible mobility profiles from the perspective of a reference economy (stayers, returnees, inflows and outflows).

The indicator is represented as the ratio between the number of authors in the relevant category, divided by the (absolute) sum of authors in the reference economy in 2016, plus the outflows from that economy recorded in 2016. The indicator can be adjusted to focus on the profiles of authors from the perspective of the final country of affiliation, as shown in additional variables where shares for new inflows, returnees and stayers add up to 100.

Expected citation impact of scientific authors, by mobility profile in 2016

This is an experimental indicator.

Estimates are based on the comparison of 2015 Scimago Journal Rank (SJR) scores for the documents published by scientific authors, based on the journal rank corresponding to an author publishing in 2016, and on their mobility record up to 2016 counting from 2001. Only authors with two or more publications are considered. A mobility episode is identified in 2016 when an author who is affiliated to an institution in a given economy in his/her last publication in 2016 was previously affiliated to an institution in another economy. Authors are assigned a mobility status from the perspective of the last destination in 2016: The "stayers" status is assigned if the main affiliation for both 2016 and pre-2016 correspond to the reference economy. The "returnee" status is assigned to those who move affiliation into the reference economy, but were affiliated to it in his/her first recorded publication. From the perspective of the previous economy of author affiliation, individuals can be computed as outflows, and the count incorporated in the data presentation.

The indicator is represented as the average SJR2015 among authors in the relevant category and economy.

3.5. The globalisation of R&D

Business R&D funded from abroad, by source of funds, 2015

When a breakdown by source of funds is not available, the share of BERD funded by the Rest of the World (abroad) is presented.

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

For Australia, Belgium, Denmark, Germany, Sweden and South Africa, data refer to 2013.

For Denmark and Estonia, BERD funded by international organisations only includes European commission funding.

For the EU 28 zone, France, Israel, Italy, the Netherlands, the OECD zone, Poland, Portugal, Slovenia and the United Kingdom, data refer to 2014.

For Austria, data refer to 2004 and 2013.

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

For Mexico, only funds from foreign business enterprises are available.

For Switzerland, data refer to 2004 and 2015.

Business R&D expenditures by foreign-controlled affiliates, selected countries, 2005 and 2015 or latest available year

For the Netherlands, Poland, Slovenia and Spain, only sections B to F of ISIC Revision 4 are covered.

For Estonia and Finland, only sections B to E of ISIC Revision 4 are covered.

For Austria and the Netherlands, figures refer to 2004.

For Australia and Israel, figures refer to 2006.

For Switzerland, figures refer to 2008.

For Israel and Slovenia, figures refer to 2011.

For Norway, figures refer to 2012.

For Australia, Austria, Belgium, Canada, Estonia, Finland, Germany, Poland and Spain, figures refer to 2013.

For France, Italy, Japan, the Netherlands and the United States, figures refer to 2014.

European Commission funding of government and higher education R&D in Europe, 2015

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

A breakdown is not available for the Netherlands.

For Austria, the data refer to 2013 and 2006.

For Belgium, Denmark and Sweden, data refer to 2013.

For Bulgaria, Croatia, Cyprus, Germany, France, Italy, Lithuania, Luxembourg, the Netherlands, Poland, Portugal, Romania, and Slovenia, data refer to 2014.

For the Czech Republic, the earlier period data refer to 2007.

For the Slovak Republic, the earlier period data refer to 2006.

3.6. Inventions across borders

International co-inventions in ICT, 2012-15

International co-inventions are measured as the share of IP5 patent families featuring inventors located in at least two economies, out of the total number of IP5 patent families having inventors located in the economy considered. Data refer to IP5 families, by filing date, according to the inventors' residence using fractional counts. Patents in ICT are identified using the list of IPC codes in Inaba and Squicciarini (2017). Only economies with more than 100 families in total and at least 50 families in ICT in 2012-15 are included. 2014 and 2015 figures are estimated based on available data for those years.

Number of economies in which inventors are located, by technology, 2012-15

Data refer to the average number of inventors' economies in IP5 families, by technology fields and filing date, according to the location of the patent assignee. Patent families are allocated to technology fields on the basis of their International Patent Classification (IPC) codes, following the concordance provided by WIPO (2013). IP5 patent families in ICT are identified using the list of IPC codes in Inaba and Squicciarini (2017). Only economies with more than 100 families by technology are included.

Domestic ownership of ICT inventions from abroad, 2012-15

Foreign inventions owned by economies relate to the number of IP5 patent families owned by a resident of an economy for which no inventors reside in the given economy, as a share of total IP5 patent families owned by that economy. Data refer to IP5 families, by filing date, according to the applicant's residence using fractional counts. IP5 patent families in ICT are identified using the list of IPC codes in Inaba and Squicciarini (2017). Only economies with more than 100 families in total and at least 50 families in ICT in 2012-15 are included. 2014 and 2015 figures are estimated based on available data for those years.

3.7. Collaboration on innovation

Businesses collaborating on innovation with higher education or research institutions, by size, 2012-14

International comparability may be limited due to differences in innovation survey methodologies and country-specific response patterns. European countries follow harmonised survey guidelines with the Community Innovation Survey. Please see *www.oecd.org/sti/inno-stats.htm*.

Size is calculated on the basis of numbers of persons employed. SMEs are defined as businesses with 10 to 249 employees and large firms as businesses with 250 employees or more.

For countries following the Eurostat CIS 2014, data on innovation collaboration include product process, and ongoing and abandoned innovative firms. The Industry core coverage includes ISIC Rev.4 Sections and Divisions B, C, D, E, G46, H, J, K and M71-72-73. Only enterprises with 10 or more employees are covered.

For Australia, data come from the Business Characteristics Survey (BCS) and refer to the financial year 2014/15. Data on innovation collaboration with higher education or research institutions are calculated by including enterprises who collaborated with (f) Universities or other higher education institutions, (g) Other research institutions (all options) or (h) Government agencies. Data include product, process, marketing or organisational innovative firms (including ongoing or abandoned innovation activities). Marketing and organisational innovators are less likely to be involved in collaboration. The sectoral and size coverage of enterprises matches the CIS scope.

For Brazil, data come from the Brazil Innovation Survey 2014 (PINTEC) and refer to 2012-14. Data on innovation collaboration include product or process innovative firms (including ongoing or abandoned innovation activities). The industries surveyed differ from the CIS core coverage. ISIC Rev.4 Section E is not included and only a selection of services is covered (Divisions and groups: 592, 61, 62, 631, 71 and 72).

For Chile, data come from the 9th Chilean Innovation Survey and refer to 2013-14. The data on innovation collaboration include product, process, marketing or organisational innovative firms. Ongoing or abandoned innovative activities are not identified. Marketing and organisational innovators are less likely to be involved in collaboration. The survey covers firms with more than UF 2 400 in annual revenue; no cut-off by size is applied. Sectoral coverage is larger for the industrial sector and in addition to CIS core activities includes: ISIC Rev.3 Section A, Agriculture, hunting and forestry; B, Fishing and F, Construction. The services covered are ISIC Rev.3 (G, I, J and K).

For Estonia, CIS-2014 data were the subject of a methodological review. This caused a break in series when comparing with previous CIS editions.

For Japan, data come from the Japanese National Innovation Survey (J-NIS 2015). Data refer to the financial years 2012/13, 2013/14 and 2014/15. Data on innovation collaboration include product or process innovative firms (including ongoing or abandoned innovation activities). The sectoral and size coverage of enterprises matches the CIS scope.

For Korea, data come from the Korean Innovation Survey. The survey is carried out separately for manufacturing and services, but all data refer to the period 2013-15. Data on innovation collaboration include product or process innovative firms (including ongoing or abandoned innovation activities). The sectoral coverage is smaller than CIS for the industrial sector and includes ISIC Rev.4 Section C Manufacturing only. All services are covered except for Section (O) Public administration and defence; compulsory social security.

For New Zealand, data refer to the financial years 2012/13 and 2013/14, and firms with six or more employees and with an annual Goods and Services Tax (GST) turnover figure greater than NZD 30 000. Data refer to enterprises that collaborated with universities or polytechnics or crown research institutes, other research institutes or research associations, including Callaghan Innovation. Data refer to product, process, organisational and marketing innovating firms (including ongoing or abandoned innovation activities).

For Switzerland, data come from the Survey of Innovation Activities in the Swiss Economy, and refer to the period 2012-14. Data on collaboration only refer to collaboration on R&D.

Businesses collaborating on innovation with suppliers and clients, by size, 2012-14

International comparability may be limited due to differences in innovation survey methodologies and country-specific response patterns. European countries follow harmonised survey guidelines with the Community Innovation Survey. Please see *www.oecd.org/sti/inno-stats.htm* for more details.

Size is calculated on the basis of numbers of persons employed. SMEs are defined as businesses with 10 to 249 employees and large firms as businesses with 250 employees or more.

For countries following the Eurostat CIS 2014, data on innovation collaboration include product or process innovative firms (including ongoing or abandoned innovation activities). The Industry core coverage includes ISIC Rev.4 Sections and Divisions B, C, D, E, G46, H, J, K and M71-72-73. Only enterprises with 10 or more employees are covered.

For Australia, data come from the Business Characteristics Survey (BCS) and refer to financial year 2014/15. Data on innovation collaboration with higher education or research institutions are calculated by including enterprises who collaborated with (f) Universities or other higher education institutions, (g) Other research institutions (all options) or (h) Government agencies. Data include product, process, marketing or organisational innovative firms (including ongoing or abandoned innovation activities). Marketing and organisational innovators are less likely to be involved in collaboration. The sectoral and size coverage of enterprises matches the CIS scope.

For Brazil, data come from the Brazil Innovation Survey 2014 (PINTEC) and refer to 2012-14. Data on innovation collaboration include product or process innovative firms (including ongoing or abandoned innovation activities). The industries surveyed differ from the CIS core coverage. ISIC Rev.4 Section E is not included and only selections of services are covered (Divisions and groups: 592, 61, 62, 631, 71 and 72).

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For New Zealand, data refer to the financial years 2012/13 and 2013/14, and firms with six or more employees and with an annual Goods and Services Tax (GST) turnover figure greater than NZD 30 000. Data on innovation collaboration with higher education or research institutions are calculated by including enterprises that collaborated with universities or polytechnics or crown research institutes, other research institutes or research associations, including Callaghan Innovation. Data refer to product, process, organisational and marketing innovating firms (including ongoing or abandoned innovation activities).

For Switzerland, data come from the Survey of Innovation Activities in the Swiss Economy, and refer to the period 2012-14. Data on collaboration only refer to collaboration on R&D.

Businesses engaged in international collaboration for innovation, by size, 2012-14

International comparability may be limited due to differences in innovation survey methodologies and country-specific response patterns. European countries follow harmonised survey guidelines with the Community Innovation Survey. Please see *www.oecd.org/sti/inno-stats.htm* for more details.

Size is calculated on the basis of numbers of persons employed. SMEs are defined as businesses with 10 to 250 employees and large firms as businesses with more than 250 employees.

For countries following the Eurostat CIS 2014, data on innovation collaboration include product or process innovative firms (including ongoing or abandoned innovation activities). The Industry core coverage includes ISIC Rev.4 Sections and Divisions B, C, D, E, G46, H, J, K and M71-72-73. Only enterprises with 10 or more employees are covered.

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For Switzerland, data come from the Survey of Innovation Activities in the Swiss Economy, and refer to the period 2012-14. Data on collaboration only refer to collaboration on R&D.

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