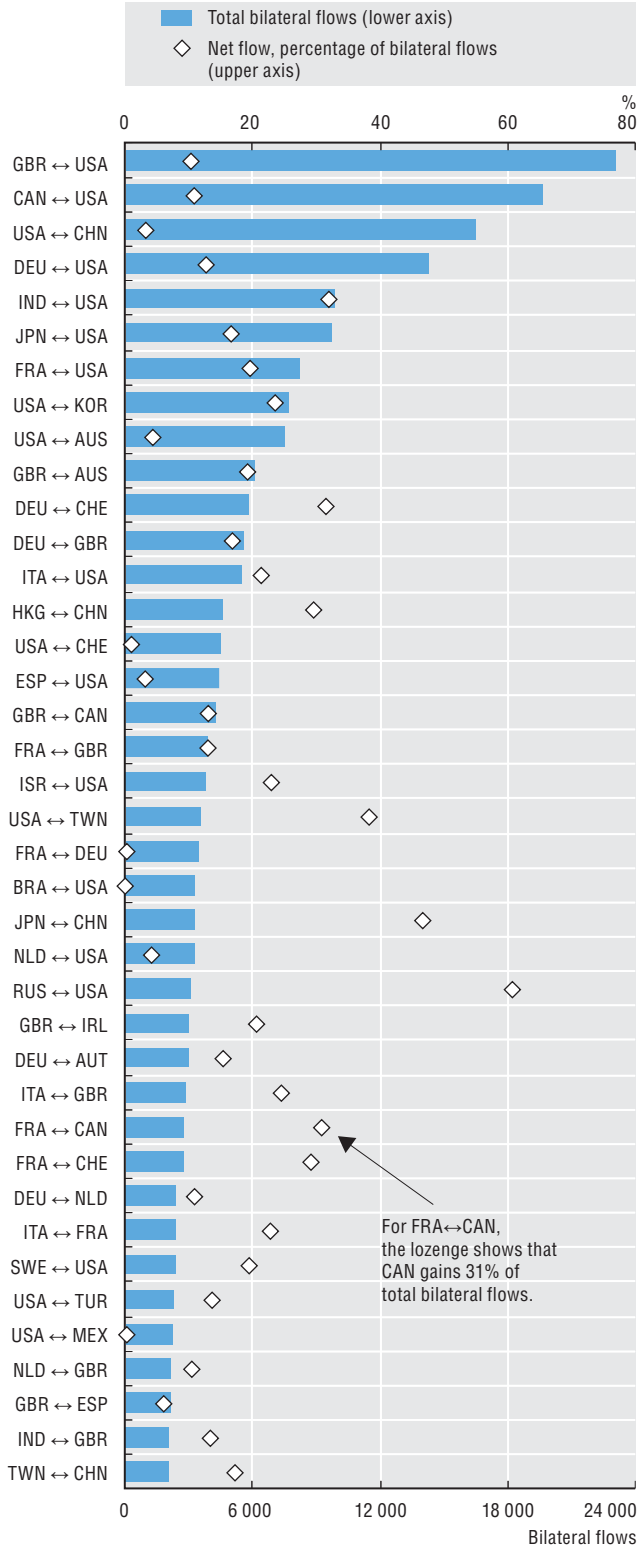
6. Researchers on the move

International flows of scientific authors, 1996-2011

Largest bilateral flows, by first and last affiliation



Source: OECD calculations based on Scopus Custom Data, Elsevier, version 5.2012, May 2013. See chapter notes.

StatLink http://dx.doi.org/10.1787/888932891511

Scientific progress depends significantly on researcher mobility. A new experimental indicator tracks changes in the affiliation of scientists who publish in scholarly journals. The top nine international bilateral flows involve exchanges with the United States. While the total inflow exceeds the outflow, more scientists who start by publishing in the United States move to affiliations in China and Korea than *vice versa*. The United Kingdom is the second most connected economy. German-based researchers moving to Swiss affiliations account for the largest flow in non-English speaking countries. These statistics do not account for the mobility of individuals before their first publication, e.g. as students.

Swiss-based authors have the largest mobility rates; nearly 20% have a previous affiliation abroad. In Japan, Brazil and China, researcher mobility stands at less than 5%. Mobility patterns vary across economies. In Italy, a majority of inflows are returnees (researchers who had an Italian affiliation for their initial recorded publication(s)); in Switzerland and Singapore the majority of researchers with an international mobility record are new inflows.

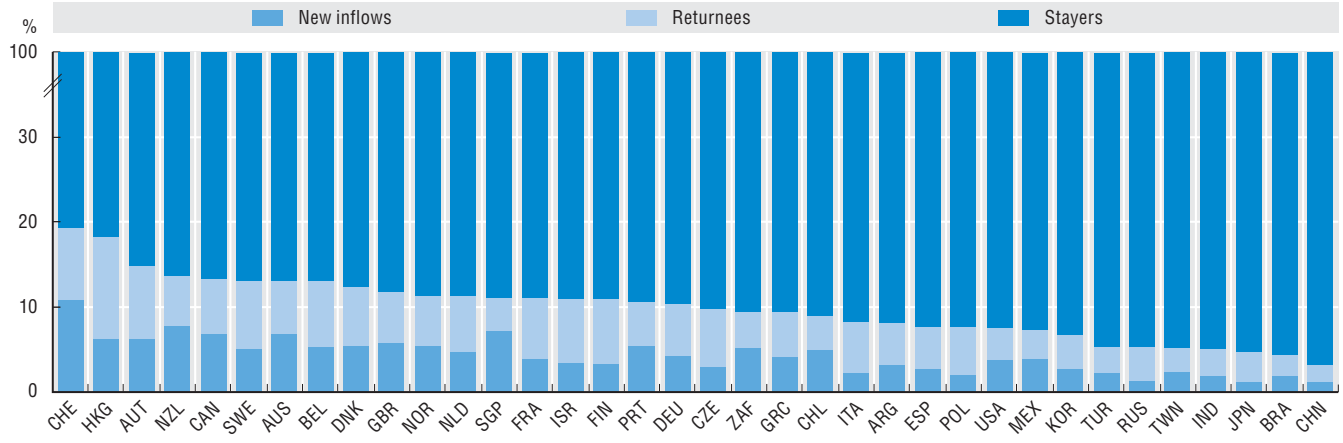
With few exceptions, stayers are more likely to publish in journals of lower quality. In economies with lower average research quality, outflows tend to have the largest impact factors. Returnees help to increase quality scores, as do new inflows. For many economies, raising the performance of stayers to the level of returnees would allow them to catch up with leading research nations.

Definitions

Scientific authors are listed in the Scopus database of peer-reviewed scientific publications and identified by the unique author ID assigned by Elsevier. International mobility is inferred from authors with at least two publications over the reference period and is based on changes in institutional affiliation and sequence of publications. *Stayers* maintain the same country of affiliation over their entire record. *Returnees* begin in the final country but "move" before returning, while *new inflows* are not first affiliated to institutions in their last recorded country. *Outflows* concern those who do not return to their first affiliation. A proxy of scientific impact is estimated by calculating, for each author and mobility profile, the median across journals' source-normalised impact per paper (SNIP). SNIP measures citation impact by calculating the ratio of a journal's citation count per paper and the citation potential in its subject field.

International mobility of scientific authors, 1996-2011

As a percentage of authors with two or more publications, by last reported affiliation

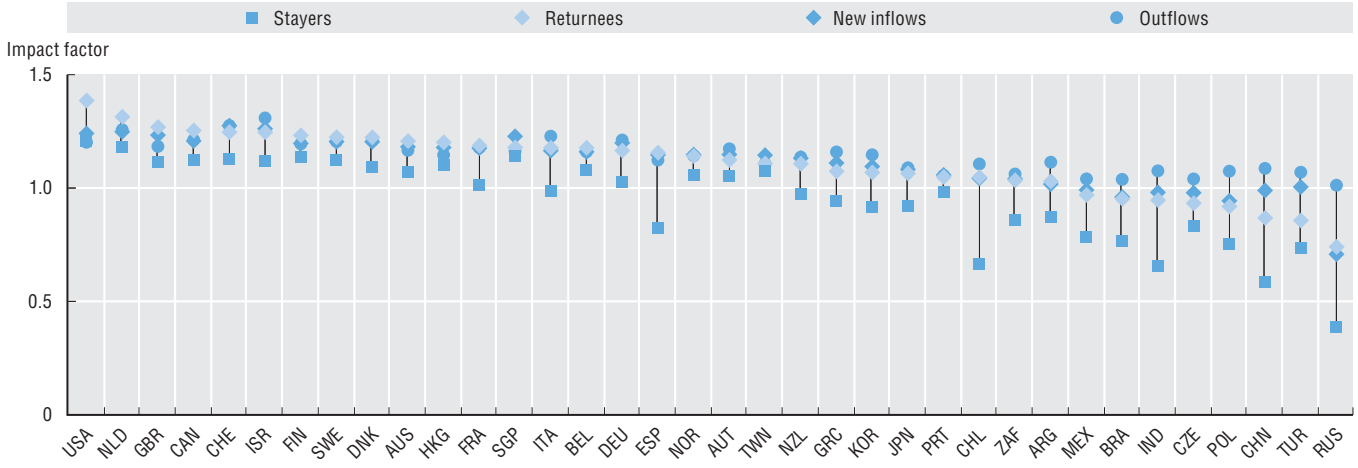


Source: OECD calculations based on Scopus Custom Data, Elsevier, version 5.2012, May 2013. See chapter notes.

StatLink http://dx.doi.org/10.1787/888932891530

Impact of scientific authors, by category of mobility, 1996-2011

Based on the median source-normalized impact per paper (SNIP)



Source: OECD calculations based on Scopus Custom Data, Elsevier, version 5.2012, and SNIP2 Database, *www.journalmetrics.com*, Elsevier, Scimago and University of Leiden. May 2013. See chapter notes.

StatLink http://dx.doi.org/10.1787/888932891549

Measurability

Bibliometric indicators provide a complementary picture of researcher mobility at a global level. First developed by Elsevier (2011), these are experimental and require careful interpretation (Moed et al., 2013). Mobility records are less accurate for less prolific authors and for those who move from and into roles for which disclosure in scholarly journals is not the norm. Expanding the reference period can help capture more complex mobility patterns (e.g., to show that an individual returns to an initial affiliation requires at least three observations) but can introduce other biases. Institutional affiliations are often recorded with a lag and may not reflect where the research took place. Affiliations may also be multiple and require disambiguation. Failure to assign author IDs consistently can also distort mobility estimates by understating mobility when an individual has multiple IDs or overstating it for individuals with common names. A global initiative – the open researcher and contributor ID (ORCID) – seeks to deal with this problem by assigning unique identifiers linkable to an individual's research output.

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 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."

3.1. R&D and knowledge flows

Business enterprise R&D funded by other companies, 2010

Data refer to 2010 except for Austria (2009), Brazil (2009), the Czech Republic (2011), Denmark (2009), Iceland (2009), New Zealand (2009), Norway (2011), South Africa (2009), Sweden (2009), Switzerland (2008) and the United States (2009).

Reported funding by other firms includes funding from other domestic enterprises that are part of the same group, except for Finland and New Zealand.

For Brazil, data on the share of BERD funded by industry are not available.

Business funding of extramural R&D, by type of performer, 2010

Data refer to 2010 except for Austria (2009), Belgium (2009), the Czech Republic (2011), Germany (2009), New Zealand (2009), Norway (2011), Sweden (2009), Switzerland (2008) and the United States (2009).

"Other" includes funding to non-business institutions, both domestic and abroad. For Germany and Japan, it also includes funding to enterprises abroad.

For the Czech Republic, Estonia, Italy, Korea, the Slovak Republic, Spain and Turkey, reported data exclude funding by non-R&D performers.

Business-funded R&D in the higher education and government sectors, 2001 and 2011

For Australia, data refer to 2000 and 2008 instead of 2001 and 2011.

For Austria, data refer to 2002 and 2009 instead of 2001 and 2011.

For Belgium, Iceland, Israel, the Netherlands and South Africa, data refer to 2009 instead of 2011.

For Chile, EU28, France, Germany, Italy, OECD, Portugal and Spain, data refer to 2010 instead of 2011.

For China, data refer to 2000 instead of 2001.

For Switzerland, data refer to 2000 and 2010 instead of 2001 and 2011.

3.2. Open innovation

General notes for all figures:

For Australia, data refer to financial year 2010/11 and include product, process, marketing and organisational innovating firms (including ongoing or abandoned innovation activities).

For Brazil, data refer to 2006-08. Only the following activities are included in the services sector: ISIC Rev.4 Divisions 58, 61, 62 and 72.

For Chile, data refer to 2009-10 and to firms with more than UF 2 400 in annual revenue. Data include product, process, organisational and marketing innovating firms. Ongoing or abandoned innovative activities are not identified. The industries covered are based on ISIC Rev.3.1 and include a wider range of activities than the CIS, such as agriculture, forestry, fishing, construction and some services.

For Israel, data refer to 2006-08.

For Japan, data refer to financial years 2009/10 and 2010/11. Data are provisional estimates.

For Korea, data refer to 2005-07 and to firms with more than 10 employees in the manufacturing sector.

For Mexico, data refer to 2008-09 and to firms with 20 or more employees. The industries covered are based on ISIC Rev.3.1 and include a wider range of activities, such as agriculture, construction and some services.

For New Zealand, data refer to financial years 2009/10 and 2010/11, and to firms with six or more employees with an annual goods and services tax (GST) turnover figure greater than NZD 30 000. Data refer to product, process, organisational and marketing innovating firms (including ongoing or abandoned innovation activities).

For the Russian Federation, data refer to 2009-11 and to firms with 15 or more employees. The industries covered are based on NACE Rev.1.1 and include manufacturing (D), and services (64, 72, 73, 74).

For South Africa, data refer to 2005-07 and to firms with 20 or more employees, with a minimum turnover of between ZAR 3 million and ZAR 6 million depending on the industry. Data also include the retail trade sector.

For Switzerland, data refer to 2009-11. Collaboration only refers to collaboration on R&D.

Additional notes:

External sources of knowledge for innovation, by type, 2008-10

In the Australian questionnaire it is only asked whether the relevant source was used, not the degree of importance of the source.

For Germany, Israel, Luxembourg, the Netherlands and Switzerland, data refer to 2006-08.

In the New Zealand questionnaire, sources of information are defined as important, rather than highly important.

3.3. Collaboration on innovation

General notes for all figures:

See under 3.2.

Additional notes:

Firms engaging in collaboration on innovation, by R&D status, 2008-10

For Luxembourg, data refer to 2006-08.

For Spain, R&D status corresponds to 2010 only.

Firms collaborating on innovation with higher education or public research institutions, by firm size, 2008-10

For Ireland, Israel and Luxembourg, data refer to 2006-08.

For Mexico, data refer to collaboration with higher education institutions only.

3.4. International collaboration

General notes for all figures:

See under 3.2.

Additional notes:

National and international collaboration on innovation by firms, 2008-10 and Firms engaged in international co-operation, by firm size, 2008-10

For Ireland and Luxembourg, data refer to 2006-08.

International collaboration on patents, 2007-11 and innovation, 2008-10

International co-inventions are measured as the share of patent applications filed under the Patent Cooperation Treaty (PCT) with at least one co-inventor located in a different country in total patents invented domestically. Patent counts are based on the priority date, the inventor's country of residence and whole counts.

3.5. Skills mobility

International and foreign students enrolled in tertiary education, 2011

Data refer to foreign students for the Czech Republic, France, Israel, Italy, Poland, 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 chart.

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

Data for Austria, Finland, Germany and Switzerland exclude tertiary-type B programmes.

Data for Canada and Luxembourg refer to 2010.

Data for the Netherlands exclude programmes in private education.

Labour turnover, by educational attainment, 2011

With the exception of the United States, the indicator for all employed individuals is computed on the basis of the OECD Job Tenure Database as a share of declared figures for total employed (dependent employees and self-employed) of all age groups. Estimates by level of educational attainment are based on an *ad hoc* tabulation of European Labour Force Survey data and computed on a similar basis.

For the United States, data refer to the share of all wage and salary workers aged 16 and over with a year or less of tenure with their current employer in January 2012.

Tertiary education refers to individuals who have graduated from tertiary education (ISCED 5 and 6 levels); low or no formal education refers to individuals with at most lower secondary education (ISCED 0, 1 and 2 levels).

For Australia and Canada, data refer to 2010.

For Brazil, data refer to 2009.

For Mexico, data refer to 2008.

Doctorate holders who changed jobs in the last ten years, 2009

For Belgium, Hungary, the Netherlands and Spain, data refer to graduates only from 1990 onwards.

For the Russian Federation, data refer only to those doctoral graduates employed as researchers and teachers.

For Spain, there is limited coverage of graduates who received their doctorate between 2007 and 2009.

EU15 total employment mobility is computed on the basis of the OECD Job Tenure Database and corresponds to the share of 25-69 year-old employed individuals who have changed jobs in the last ten years.

3.6. Researchers on the move

International flows of scientific authors, 1996-2011

The minimum threshold for inclusion is over 2 000 bilateral flows.

General note:

International mobility of scientific authors, 1996-2011 and;

Impact of scientific authors, by category of mobility, 1996-2011

The minimum threshold per economy is over 25 000 scientific authors in the stayer category.

Additional note:

Impact of scientific authors, by category of mobility, 1996-2011

International mobility of scientific researchers is inferred from authors listed in the Scopus Custom database of peer-reviewed scientific publications, with at least two documents over the reference period, based on changes in the location of their institutional affiliation. Stayers maintain an affiliation in a given reference country over the period. Outflows are defined on the basis of the first affiliation. New inflows are defined on the basis of the final affiliation and exclude individuals who "return" to their original country of affiliation. The latter group are defined as "returnees".

A proxy measure of scientific impact for researchers with different mobility patterns is estimated by calculating, for each author and mobility profile, the median across the relevant journals' source-normalised impact per paper (SNIP) over the entire period. A SNIP impact value that is higher than one means that the median attributed SNIP for authors of that country/category is above average.

3.7. Research excellence

General note for all figures:

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

3.8. Science for innovation

General notes for all figures:

The link between patents and scientific literature is based on the non-patent literature (NPL) listed as relevant references in patent documents in the Thomson Reuters Derwent World Patents Index and Derwent Patents Citation Index databases. It is applied to patents in selected technology areas, based on the International Patent Classification (IPC) codes in the patent document.

In order to identify whether NPL corresponds to a scientific document, NPL references were matched to the Thomson Reuters Web of Science Database, an index of scientific literature. For matched references, scientific domains correspond to the Thomson Reuters Essential Science Indicators 22-field classification (*http://archive.sciencewatch.com/about/met/fielddef/*). Geographical attribution of scientific documents is based on the document's author's affiliation, using a "whole counts" approach.

Only the main scientific domains accounting for 90% of total patent citations to the scientific literature are reported.

Additional notes:

Main sources of scientific documents cited in patents, selected technology areas, 2001-11

Patents in health-related technologies comprise medical technologies and pharmaceuticals. The list of environment-related patent codes is available at *www.oecd.org/env/consumption-innovation/indicator.htm*. The list of biotechnology and ICT-related patent codes is available at *www.oecd.org/sti/inno/40807441.pdf*. Nanotechnology-related patents are defined as those with IPC codes B82B and B82Y.

Main scientific sources of biotechnology, nanotechnology and ICT patents, 2001-11

The list of biotechnology and ICT-related patent codes is available at *www.oecd.org/sti/inno/40807441.pdf*. Nanotechnology-related patents are defined as those with IPC codes B82B and B82Y.

Main scientific sources of health and environment-related patents, 2001-11

The link between health-related patents and scientific literature is applied to patents in medical technologies and pharmaceuticals following the classification presented in Schmoch (WIPO, 2008, revised in 2013).

The list of environment-related patent codes is available at *www.oecd.org/env/consumption-innovation/indicator.htm*.

3.9. From knowledge to inventions

General notes:

Patents citing non-patent literature by technology field, 1997-2002 and 2007-12 and;

Patents citing non-patent literature, selected technologies, 1997-2002 and 2007-12

Data refer to the citations made in patent applications filed at the European Patent Office (EPO), according to the publication date of the citing patent, the applicant's residence and fractional counts.

Additional notes:

Patents citing non-patent literature by technology field, 1997-2002 and 2007-12

Only economies with more than 500 patents in 2007-12 are included in the figure. Patents are allocated to technology fields using International Patent Classification (IPC) codes, following the classification presented in Schmoch (2008, revised in 2013).

Patents citing non-patent literature, selected technologies, 1997-2002 and 2007-12

Patents are allocated to technological fields using the International Patent Classification (IPC) or the European Patent Classification (ECLA).

Citations to patents that include non-patent literature, by technology fields, 2007-12

Data refer to the citations made in patent applications filed at the European Patent Office (EPO), according to the publication date of the citing patent. Forward citations of patents refer to patents with NPL backward citations that are cited as particularly relevant documents (I, X, Y) by EPO patents up to five years after the first publication. Patents are allocated to technology fields using International Patent Classification (IPC) codes, following the classification presented in Schmoch (2008, revised in 2013).

3.10. Inventions across borders

International co-inventions in patents, 1999-2001 and 2009-11

International co-inventions are measured as the share of patent applications filed under the Patent Cooperation Treaty (PCT) with at least one co-inventor located in a different economy in the total patents invented domestically. Patent counts are based on the priority date, the inventor's residence and fractional counts. Only economies with more than 250 patents in 2009-11 are included.

International co-inventions by technology fields, 1999-2001 and 2009-11

International co-inventions are measured as the share of patent applications filed under the Patent Cooperation Treaty (PCT) with at least one co-inventor located in a different country in total patents. Patents are allocated to technology fields using International Patent Classification (IPC) codes, following the classification presented in Schmoch (2008, revised in 2013). Patent counts are based on the priority date and fractional counts by technology fields.

Foreign inventions owned by economies, 2009-11

Data refer to counts of patent applications filed under the Patent Cooperation Treaty, by priority date, applicant's residence and fractional counts. Foreign inventions owned by economies relate to the share of patents owned by a resident of an economy for which no inventors reside in the given economy, as a share of total patents owned by that economy. Only economies that applied for more than 250 patents over the period are included.

3.11. Technology flows and markets

International technology flows of royalties and licence fees, 2000-11

For Belgium and the Russian Federation, data refer to 2003-11.

For Denmark and Indonesia, data refer to 2005-11.

For the Netherlands, data refer to 2004-11.

For Norway, data refer to 2000-10.

For Italy, data refer to 2000-07.

OECD excludes Iceland, Mexico and Turkey.

Revenues of specialist intellectual property leasing firms, 2010

For European countries, revenue estimates correspond to firms in NACE Rev.2 sector 774 ("Leasing of intellectual property and similar products, except copyrighted works"). For the United States, estimates correspond to NAICS sector 533 ("Lessors of nonfinancial intangible assets – excluding copyrights"). Revenue estimates are divided by INTAN-Invest estimates of business sector investment in "new intangible assets" (R&D, design, new financial products, advertising, market research, training and organisational capital). This category approximately corresponds to the products within the scope of the IP leasing sector.

Royalty income by industry, United States, 1999 and 2009

Data on royalties and revenues (receipts) from the United States Internal Revenue Service's Statistics of Income (SOI), Table 6 – Returns of Active Corporations, Form 1120, *www.irs.gov/uac/SOI-Tax-Stats-Returns-of-Active-Corporations-Table-6*, "Balance Sheet, Income Statement, Tax, and Selected Other Items, by Major Industry". Figures are estimates based on samples. Last accessed June 2013.

Only the 23 industries with the highest royalty income are reported. For 2009, Broadcasting and telecommunication is calculated as the sum of Broadcasting except Internet and Telecommunication (including paging, cellular, satellite, cable, internet, service providers, etc.). For 2009, Information and data processing services were calculated as the sum of Data processing services and Other information services.

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Squicciarini, M., H. Dernis and C. Criscuolo (2013), "Measuring Patent Quality: Indicators of Technological and Economic Value", *OECD Science, Technology and Industry Working Papers*, No. 2013/03, OECD Publishing. Doi: *http://dx.doi.org/10.1787/5k4522wkw1r8-en*.