

Main Science and Technology Indicators 2018-2

1. STATISTICAL CONTENT

1.1. General description

This publication is prepared by the Economic Analysis and Statistics (EAS) Division of the OECD Directorate for Science, Technology, and Innovation in collaboration with the Working Party of National Experts on Science and Technology Indicators (NESTI). It contains key data series selected from the OECD Scientific and Technological Indicators database. 109 series concern resources devoted to research and experimental development, and an additional 17 are measures of output and the impact of scientific and technological activities. Included also are 10 economic series used to calculate indicators such as growth rates at fixed prices, R&D expenditures as a percentage of GDP or industrial value added, and to convert data into a common currency using comparisons at purchasing power parities. These 136 series are grouped according to subject (see the list indicators in section 2)

There are series for 36 OECD Member countries and three zones (EU-28, EU-15 and Total OECD). Also available are series for seven non-member economies.

The OECD has been collecting R&D data on a regular basis since the early 1960s. During the 1990s, the collection was widened to include selected non-Member economies. This publication presents various indicators of the level and trends in total national R&D efforts. The flagship measure is the Gross Domestic Expenditure on Research and Experimental Development (GERD), which captures all spending on R&D carried out within each economy each year. The sources of financing and of performance of GERD is also presented.

Further information is given on R&D performed in the Business Enterprise sector – the main R&D performing sector. This includes tables showing the most intensive industries carrying out Business enterprise Expenditure on R&D (BERD). Indicators are also provided for R&D carried out in the Higher Education and Government sectors. All such tables are mainly based on retrospective surveys of the units carrying out the R&D.

The database includes tables on the R&D expenditure of foreign-controlled affiliates. These data come from the OECD database on foreign affiliates and in some cases are not directly comparable with Business Enterprise R&D figures. They do, however, provide useful supplementary information.

This publication contains two types of proxy indicators for outputs of Scientific and Technological activities: patent data and international trade in R&D-intensive industries.

Patent data can be considered as a proxy for the output of R&D in the form of inventions. The data presented show the total number and national percentages of triadic patent families, as well as the number of patent applications to the European Patent Office (EPO) in two specific sectors of interest: Information and Communications Technology (ICT) and biotechnology.

Indicators of trade performance in R&D intensive industries can be used as proxy measures of the industrial and economic impact of scientific and technological activity. The tables concerned give trade balances and export market shares for three selected groups of R&D intensive industries: “pharmaceuticals”, “computer, electronic, and optical industry”, and “aerospace”.

Prior MSTI editions also included Technology Balance of Payments (TBP) series with the aim of measuring the flow of technological know-how and services into and out of the economy concerned. The production of TBP indicators has been discontinued since MSTI 2018/2, pending decisions on the statistical reporting framework to be used in this area.

1.2. R&D data

1.2.1. Definitions and Coverage

OECD Standards

The R&D data used in this publication have been collected and presented in line with the standard OECD methodology for R&D statistics as laid out in the OECD "Frascati Manual" (see <http://oe.cd/frascati>). The 2002 edition of the manual has now been superseded by the 2015 edition. The revised guidelines and definitions are in the course of being implemented and are not expected to change the main indicators significantly although some terminology changes will occur. This edition of MSTI has been compiled in accordance with the 2015 Frascati Manual, some countries may still be following the 2002 edition for certain series or data points.

The Two Types of R&D Data

Most R&D data are derived from retrospective surveys of the units actually carrying out or "performing" R&D tasks. Thus, the indicators on (or derived from) Gross Domestic Expenditure on R&D (GERD) and R&D personnel are based on the sum of performers' reported R&D expenditures and personnel on national territory (*i.e.* excluding payments to international organisations and other performers abroad). Personnel data are expressed as full-time equivalent (FTE) spent working on R&D (*i.e.* a person working half-time on R&D is counted as 0.5 person-years) and headcount.

Because of the time such surveys take to undertake, it is difficult to obtain very up to date series; some recent data are provisional figures, national estimates, or projections (these data are annotated).

More up to date information on government support for R&D can be derived from budgetary sources. The indicators based on Government Budget Allocations for R&D (GBARD) as reported by the funding ministry or agency and include payments to international organisations and other performers abroad.

The specifications of these two sets of R&D data vary significantly and, while they can be used in complement to one-another, they should not be combined.

Fields of Science

In general, the tables cover R&D in both Natural Sciences and Engineering (NSE, including agricultural and medical sciences) and Social Sciences and Humanities (SSH). A large number of countries collect data on R&D activities in the Business Enterprise sector for NSE only.

Sectors of Performance and Sources of Funds

Domestic R&D efforts (expenditure or personnel) are divided into four *sectors of performance* for statistical purposes, Business Enterprise, Higher Education, Government, and Private Non-Profit institutions (PNP).

R&D expenditure is also classified by sources of funds, including: funds from Business Enterprises, from Government, from Higher Education, from PNPs, and from the rest of the world. By convention and for international comparison purposes, public general university funds (GUF) are recorded as funds originating from the government sector. Since the amounts financed by the Higher Education and PNP sectors are small, they have been combined as "other national sources".

R&D in the Business Enterprise Sector

The Business Enterprise sector covers private and public enterprises and institutes serving such enterprises. The industry breakdown is made according to the main activity of the enterprises. National

Main Science and Technology Indicators

statistical regulations prevent publication of results where there are very few firms in a given category, hence there are many gaps in the tables broken down by industry.

The industrial classification used is the International Standard Industrial Classification, Revision 4 (ISIC Rev.4). The indicators on BERD by industry concern R&D-intensive manufacturing industries and services:

	ISIC Rev.4
Pharmaceutical industry	21
Computer, electronic and optical industry	26
Aerospace industry	303
Services industry	45-99

The above mentioned indicators were calculated primarily using the Analytical Business Enterprise R&D database (ANBERD) for OECD Member countries and those selected non-member economies covered by the database. For further information on this database see <http://oe.cd/anberd>.

Government Budget Allocations for R&D (GBARD)

These statistics are assembled by national authorities using data collected for budgeting purposes. This essentially consists of identifying all the budget items involving R&D and measuring or estimating their R&D content. These estimates, based on funders' reports, have a different conceptual basis from the "performer reported" data but as they are derived from the budget, they can be linked back to policy issues by means of a classification by "objectives" or "goals". Data are allocated to socio economic objectives on the basis of intentions at the time the funds are committed and not the actual content of the projects concerned. These breakdowns reflect policies at a given moment in time.

The classification used is the European Commission's Nomenclature for the Analysis and Comparison of Scientific Programmes and Budgets - (NABS) 2007, specially developed for R&D analysis (see "Frascati Manual 2015", section 12.4).

The breakdown is as follows:

Defence	All defence R&D financed by government, including military nuclear and space but excluding civilian R&D financed by ministries of defence (e.g. meteorology).
Civil	Total GBARD less Defence.
Economic	R&D programmes financed for the purpose of transport, telecommunication and other infrastructures; energy; industrial production and technology; and agriculture (NABS chapters 04, 05, 06 and 08 respectively).
Health and Environment	R&D programmes funded for the purpose of the exploration and exploitation of the earth; environment; and health (NABS chapters 01, 02 and 07 respectively).
Education and Society	R&D programmes funded for the purpose of education; culture, recreation, religion and mass media; and political and social systems, structure and processes (NABS chapters 09, 10 and 11 respectively).
Space	Civil space R&D programmes (NABS chapter 03).
Non-oriented Research	Research programmes financed in view of the general advancement of knowledge., except General University Funds (NABS chapter 13).
General University Funds	The estimated R&D content of "block grants" paid by government to the Higher Education sector. This category (NABS chapter 12) is generally absent or underestimated for countries where only federal government is included.

Main Science and Technology Indicators

Budget data can be more timely than those derived from performer surveys. Readers are warned that GBARD data vary in coverage from government-financed GERD series and that these two types of data should not be combined.

International Comparability

Though all OECD countries generally collect and report R&D in line with the Frascati Manual, some detailed national specifications may vary from OECD standards. These differences are generally too minor to materially affect the general indicators quoted in this publication. The main exceptions are shown in Annex 1.

Expenditure in Current Dollars

National currency data have been converted to USD using purchasing power parity (PPP) series from the OECD National Accounts Division (see <http://www.oecd.org/std/prices-ppp>). Due to lags in availability, the PPP series are estimated in the most recent years by comparing the growth in prices (implicit GDP deflator) in each country with that in the United States. These estimated parities are footnoted "b" in the tables as are any data converted to current dollars using them.

Expenditure in Constant Dollars

R&D expenditure series have been deflated using the implicit GDP deflator taken from the OECD National Accounts database. This is estimated for the most recent years based upon projections published in the biannual *OECD Economic Outlook* (except in the case of Norway where a deflator excluding trends in petroleum prices has been used). Any expenditure series calculated on the basis of these estimated rates are footnoted "b".

Compound Annual Growth Rates

Average annual growth is calculated at compound rates when the intervals are not annual. Expenditure growth is calculated at constant prices.

Comparisons with Economic Indicators

R&D expenditures are shown as a percentage of selected indicators drawn from the OECD National Accounts database where available and estimated for the most recent years on the basis of the projections published in the *OECD Economic Outlook*. Any ratios where such estimated economic series are the denominator are footnoted "b" in the tables concerned. R&D personnel are expressed "per thousand" in relation to selected indicators from the OECD National Accounts and Labour Force databases. The main indicators used are also presented.

R&D data are typically expressed as a percentage of GDP to allow cross-country comparisons. When compiling such indicators for the business enterprise sector, one may wish to exclude from GDP measures, economic activities for which BERD is null or negligible by definition. By doing so, the adjusted denominator (GDP, or Value Added, excluding non-relevant industries) better corresponds to the numerator (BERD) with which it is compared to. The MSTI variable "Value added in industry" is used to this end; it is calculated as the total Gross Value Added (GVA) excluding "real estate activities" (ISIC rev.4 68) where the "imputed rent of owner-occupied dwellings", specific to the framework of the System of National Accounts, represents a significant share of total GVA and has no R&D counterpart. Moreover, the R&D performed by the community, social and personal services is mainly driven by R&D performers other than businesses. Consequently, the following service industries are also excluded: ISIC rev.4 84 to 88 and 97 to 98.

In the same way, some indicators on R&D personnel in the business sector are expressed as a percentage of industrial employment. The latter corresponds to total employment excluding ISIC rev.4 68, 84 to 88 and 97 to 98.

Main Science and Technology Indicators

Data on GVA and employment in industry are mainly taken from the SStructural ANalysis (STAN) Database, complemented by the OECD and Eurostat National Accounts databases, as well as national sources.

Impact of changes to the measurement of GDP on R&D to GDP ratios: the 2008 update to the System of National Accounts (SNA) implemented various accounting changes which impacted the level of GDP, one key change was recognising the role of R&D as an activity leading to the creation of knowledge assets. One implication of recognising R&D as an asset-creating activity is that the level of GDP was, in many countries, revised upwards by a magnitude close to the value of domestic business investment in R&D. This reduced the R&D to GDP ratio, as the numerator stayed constant while the denominator increased to incorporate an element that was previously missing from the GDP estimate.

When possible, economic indicators for the non-member economies are also drawn from OECD databases. Alternatively, other international databases are used, such as the Eurostat National Accounts database (in the case of Romania, Bulgaria, Croatia, Cyprus, and Malta for the EU zone totals), the International Monetary Fund, and World Bank databases, as well as various national data sources.

Zone Totals

Zone totals have been calculated for the OECD and the EU-28 for most tables. The OECD zone includes all Member countries of the OECD i.e. Australia, Austria, Belgium, Canada, Chile, the Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Israel, Italy, Japan, Korea, Latvia, Lithuania, Luxembourg, Mexico, the Netherlands, New Zealand, Norway, Poland, Portugal, Slovak Republic, Slovenia, Spain, Sweden, Switzerland, Turkey, the United Kingdom, and the United States.

The EU-28 includes Austria, Belgium, Bulgaria, Croatia, Cyprus, the Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, the Netherlands, Poland, Portugal, Romania, Slovak Republic, Slovenia, Spain, Sweden and the United Kingdom. Zone totals for EU-15 (the first 15 countries of the EU-28) are also available.

In order to obtain a full set of figures for the OECD countries the Secretariat has made a number of estimates to fill gaps and to bring series up-to-date. These estimates were computed using simple statistical routines or information from national publications and observations of trends. Data points where such estimates would exceed 25% of the zone total have been suppressed. Israel, Korea, and Mexico are included in the OECD total as of 1991. The Czech Republic, Estonia, Hungary, Latvia, Poland, the Slovak Republic and Slovenia are likewise included as of 1995; Luxembourg is included in zone totals beginning 2000; Croatia and Malta are included in the EU-28 total beginning 2002; Chile is in the OECD total from 2007.

Data for non-OECD countries used to calculate EU-28 have been provided by Eurostat.

OECD estimates for the EU-15 and the EU-28 zones may slightly differ from those published by Eurostat. In this publication, in line with standard OECD practice, national estimates are aggregated using USD Purchasing Power Parity (PPP) indices instead of EUR exchange rates applied by Eurostat. For example, the EU-28 measure of GERD to GDP ratio will be an average of EU countries' GERD intensities, weighted by the share of countries' GDP to EU GDP expressed in USD by applying PPP conversion as opposed to EUR-based GDP shares.

1.2.2. Sources

The data are derived from national R&D surveys and budgets and are supplied by national statistical agencies to the Secretariat via an OECD/Eurostat co-ordinated collection.

1.3. R&D Expenditures of Foreign Affiliates

1.3.1. Definitions and Coverage

These data are collected as part of the OECD effort to measure globalisation through the role of multinationals. A “foreign controlled affiliate” (FCA) is a company located inside the country/economy of interest and in which a controlling stake (over 50% of voting shares) is owned by a company outside the country/economy of interest. These figures thus present the amounts spent on R&D by FCAs based in the domestic economy. For further information on methodological and conceptual aspects of globalisation statistics, see Handbook on Economic Globalisation Indicators (OECD, 2005). Data, in some cases, are not directly comparable with standard BERD figures.

1.3.2. Sources

OECD database on Activities of Multinational Enterprises (AMNE), February 2019,

<http://oe.cd/amne>.

1.4. Patents

1.4.1. Definitions and Coverage

Patents and Patent Families

A patent family is defined as a set of patents protecting a single invention across various jurisdictions. Inventors seeking protection file a first application (priority), often in their country of residence. Following this, there is a period where protection may also be applied for in other jurisdictions. Patent families, as opposed to patents, are provided with the intention of improving international comparability (the “home advantage” is suppressed; the patent data are more homogeneous).

The patent families presented in this publication refer to triadic families: i.e. a patent is included if and only if it is filed at the European Patent Office (EPO), the Japan Patent Office (JPO), and the US Patent & Trademark Office (USPTO).

In addition, the number of patent applications filed under the Patent Co-operation Treaty (PCT) is provided for two specific sectors of interest: the ICT and biotechnology sectors, alongside the total number of applications filed across all sectors. These sectors are defined according to selected classes of the International Patent Classification (IPC), www.wipo.int/classifications/ipc/en/index.html. From the 2018-2 MSTI edition onwards, the definition of biotechnology-related patents has been modified to better align with the evolution of the ICT sector, affecting the whole time-series. The PCT procedure offers the possibility to seek patent rights in a large number of countries by filing a single international application with a single patent office, and then to enter the national stage in the desired countries at a later date.

Presentation and availability

For patent counts, the choice of the country and date of reference among the set of information included in patent documents is important. Patents are presented here according to the country (or countries) of residence of the inventor(s), giving an indication of technological innovativeness of researchers and laboratories located in a country.

The priority date, the date of the first international filing of a patent, is chosen as the reference date. It is the earliest available date and therefore the closest to the invention date. Although the application date may provide more recent series, counts by application date introduce a bias between residents and foreigners for a selected patent office with respect to the priority date. Residents usually first file a patent application at their domestic office, the extension of application to other countries takes one year following the traditional procedure, and up to two and a half years for the PCT procedure.

Main Science and Technology Indicators

However, counting patent families according to the earliest priority date exacerbate one drawback of traditional patent counts: timeliness. The time lag between the priority date and the availability of information on patent applications could be up to 4 years. From 2013 onwards, patent families for individual countries are Secretariat estimates, based on the latest trends in patent filings observed at the three patent offices. Furthermore, because of changes in the rules and regulations at the USPTO, triadic patent families before 2001 are based on USPTO granted patents.

The PCT procedure expanded after 1990 and is increasingly used by applicants from all signatory states: since the early 2000s, most countries are well represented. For the transition period (1990-2000), cross-country comparisons and time series should be interpreted with care.

A broader set of patent-related indicators is available on-line at <http://oe.cd/ipstats>, along with methodological notes. These present patents by main technology classes and by region, as well as indicators on international co-operation in patenting. For further details on patent data, refer to the OECD Patent Statistics Manual, 2009, www.oecd.org/science/inno/oecdpatentstatisticsmanual.htm.

1.4.2. Sources

The data on patents filed at intellectual property offices (EPO, JPO, USPTO) are mainly derived from EPO's Worldwide Statistical Patent Database (PATSTAT, Autumn 2018). Triadic patent families series have been compiled by the Secretariat. PCT applications series are based on data published by the EPO.

1.5. Trade Balance and Export Market Shares for R&D-Intensive Industries

1.5.1. Definitions and Coverage

These tables present indicators concerning the international trade in goods of selected R&D intensive industries. Data are categorized in accordance with the International Standard Industrial Classification, Revision 4 (ISIC Rev.4). In general, prior to 1988 underlying source data are based on ISIC Revision 2.

These series are taken from the OECD's Bilateral Trade in Goods by Industry and End-use Category database (BTDIXE), derived from the OECD International Trade Statistics and United Nations Statistics Division COMTRADE databases, which have been converted from the Harmonised System (HS) to International Standard Industrial Classification (ISIC).

Industries covered are as follows:

	ISIC Rev.4
Pharmaceutical industry	21
Computer, electronic and optical industry	26
Aerospace industry	303

A note indicating a break in series is assigned to the first available year of ISIC Revision 4 data. Prior to 1993, the data for Belgium include Luxembourg.

The zone total for EU-15 excludes intra-EU trade. The OECD total has not been adjusted to exclude trade between member countries.

From 1996, calculation of the Export market shares is relative to total aggregate exports of the declaring countries available in the OECD BTDIXE database. Prior to 1996, Export market shares are based on the share of OECD total exports.

Main Science and Technology Indicators

1.5.2. Sources

OECD Bilateral Trade in Goods by Industry and End-use Category database (BTDIxE), November 2018 (<http://oe.cd/btd>).

1.6. Notes

Information on the quality and international comparability of the data are included. As concerns the standard footnotes, the following cases are noted in the data file:

- b) Time series break
- c) Confidential statistical information
- d) Definition differs
- e) Estimated value
- k) Data included in another category
- l) Overestimated or based on overestimated data
- m) Underestimated or based on underestimated data
- p) Provisional value
- s) Unrevised breakdown not adding to the revised total
- v) The sum of the breakdown does not add to the total
- w) Includes data from another category

The latest data for EU countries, as well as Iceland, Norway, the Russian Federation, Switzerland and Turkey, were collected by Eurostat. From 2017, Eurostat follows slightly different, but generally compatible, conventions with regard to footnotes:

- Countries only use flags 'b', 'c', 'd', 'e' and 'p'.
- Only one flag may be submitted per data item (cell).
- The flags follow a hierarchy: p>b>d>e. As an example, an estimated (e) and provisional (p) data will be annotated with a 'p'.
- Estimated (e), overestimated (l) and underestimated (m) data are all annotated with an 'e' flag.
- 'd', 'k', 's', 'v' and 'w' flags are grouped as 'd' (definition differs).

In this publication, flags for these countries are published as they were received by the OECD from Eurostat, except in the following cases:

- The single-flag rule is not applied when this would lead to suppress 'b' flags indicating breaks in series.
- 's' flags are not replaced with 'd'.

1.7. Abbreviations

R&D Terminology

BERD	Business enterprise Expenditure on R&D (intramural)
FTE	Full Time Equivalent (on R&D)
GBARD	Government Budget Allocations for R&D
GERD	Gross Domestic Expenditure on R&D (intramural)
GOVERD	Government Expenditure on R&D (intramural)
GUF	General University Funds
HERD	Higher Education Expenditure on R&D (intramural)
NSE	Natural Sciences and Engineering
PNP	Private Non Profit Institutions
R&D	Research and Experimental Development
SSH	Social Sciences and Humanities

For further explanations of the above terms, please see the OECD Frascati Manual 2015 <http://oe.cd/frascati>, which includes in particular a glossary of key terms (www.oecd.org/sti/inno/Frascati-2015-Glossary.pdf).

Other

GDP	Gross Domestic Product
ISIC	International Standard Industrial Classification
PCT	Patent Co-operation Treaty
PPP	Purchasing Power Parity

2. LIST OF INDICATORS

1. Gross Domestic Expenditure on R&D (GERD) at current PPP \$
2. GERD in national currency (for euro area: pre-EMU euro or EUR)
3. GERD as a percentage of GDP
4. GERD at constant prices and PPP \$
5. GERD, compound annual growth rate (constant prices)
6. GERD per capita population (current PPP \$)
7. Estimated Civil GERD as a percentage of GDP
8. Basic research expenditure as a percentage of GDP
9. Total researchers (FTE)
10. Total researchers, compound annual growth rate
11. Total researchers per thousand labour force
12. Total researchers per thousand total employment
13. Total R&D personnel (FTE)
14. Total R&D personnel, compound annual growth rate
15. Total R&D personnel per thousand labour force
16. Total R&D personnel per thousand total employment
17. Business-financed GERD as a percentage of GDP
18. Government-financed GERD as a percentage of GDP
19. Percentage of GERD financed by the business enterprise sector
20. Percentage of GERD financed by government
21. Percentage of GERD financed by other national sources
22. Percentage of GERD financed by the rest of the world
23. Percentage of GERD performed by the Business Enterprise sector
24. Percentage of GERD performed by the Higher Education sector
25. Percentage of GERD performed by the Government sector
26. Percentage of GERD performed by the Private Non-Profit sector
27. Total researchers (headcount)
28. Woman researchers (headcount)
29. Women researchers as a percentage of total researchers (headcount)
30. Business enterprise sector: Total researchers (headcount)
31. Business enterprise sector: Woman researchers (headcount)
32. Business enterprise sector: Women researchers as a percentage of total researchers (headcount)
33. Government sector: Total researchers (headcount)
34. Government sector: Woman researchers (headcount)
35. Government sector: Women researchers as a percentage of total researchers (headcount)
36. Higher education sector: Total researchers (headcount)
37. Higher education sector: Woman researchers (headcount)
38. Higher education sector: Women researchers as a percentage of total researchers (headcount)
39. Business Enterprise Expenditure on R&D (BERD) at current PPP \$
40. BERD in national currency (for euro area: pre-EMU euro or EUR)
41. BERD as a percentage of GDP
42. BERD at constant prices and PPP \$
43. BERD, compound annual growth rate (constant prices)
44. BERD as a percentage of value added in industry
45. Business Enterprise researchers (FTE)
46. Business Enterprise researchers, compound annual growth rate
47. Business Enterprise researchers as a percentage of national total
48. Business Enterprise researchers per thousand employment in industry
49. Total Business Enterprise R&D personnel (FTE)
50. Total Business Enterprise R&D personnel, compound annual growth rate
51. Total Business Enterprise R&D personnel as a percentage of national total
52. Total Business Enterprise personnel per thousand employment in industry
53. Business-financed BERD at constant prices and PPP \$

Main Science and Technology Indicators

54. Business-financed BERD - compound annual growth rate (constant prices)
55. Business-financed BERD as a percentage of value added in industry
56. Percentage of BERD financed by the business sector
57. Percentage of BERD financed by government
58. Percentage of BERD financed by other national sources
59. Percentage of BERD financed by the rest of the world
60. BERD performed in the pharmaceutical industry (current PPP \$)
61. Percentage of BERD performed in the pharmaceutical industry
62. BERD performed in the computer, electronic and optical industry (current PPP \$)
63. Percentage of BERD performed in the computer, electronic and optical industry
64. BERD performed in the aerospace industry (current PPP \$)
65. Percentage of BERD performed in the aerospace industry
66. BERD performed in service industries (current PPP \$)
67. Percentage of BERD performed in service industries
68. Higher Education Expenditure on R&D (HERD) at current PPP \$
69. HERD in national currency (for euro area: pre-EMU euro or EUR)
70. HERD as a percentage of GDP
71. HERD at constant prices and PPP \$
72. HERD, compound annual growth rate (constant prices)
73. Percentage of HERD financed by the business sector
74. Higher Education researchers (FTE)
75. Higher Education researchers, compound annual growth rate
76. Higher Education researchers as a percentage of national total
77. Higher Education Total R&D personnel (FTE)
78. Higher Education Total R&D personnel, compound annual growth rate
79. Government Intramural Expenditure on R&D (GOVERD) at current PPP \$
80. GOVERD in national currency (for euro area: pre-EMU euro or EUR)
81. GOVERD as a percentage of GDP
82. GOVERD at constant prices and PPP \$
83. GOVERD, compound annual growth rate (constant prices)
84. Percentage of GOVERD financed by the business sector
85. Government researchers (FTE)
86. Government researchers, compound annual growth rate
87. Government researchers as a percentage of national total
88. Government Total R&D personnel (FTE)
89. Government Total R&D personnel, compound annual growth rate
90. Total Government Allocations for R&D (GBARD) at current PPP \$
91. Total GBARD in national currency (for euro area: pre-EMU euro or EUR)
92. Total GBARD at constant prices and PPP \$
93. Defence Budget R&D as a percentage of Total GBARD
94. Civil Budget R&D as a percentage of Total GBARD
95. Civil GBARD for Economic Development programmes (current PPP\$)
96. Economic Development programmes as a percentage of Civil GBARD
97. Civil GBARD for Health and Environment programmes (current PPP\$)
98. Health and Environment programmes as a percentage of Civil GBARD
99. Civil GBARD for Education and Social programmes (current PPP\$)
100. Education and Social programmes as a percentage of Civil GBARD
101. Civil GBARD for Space programmes (current PPP\$)
102. Space programmes as a percentage of Civil GBARD
103. Civil GBARD for Non-oriented Research programmes (current PPP\$)
104. Non-oriented Research programmes as a percentage of Civil GBARD
105. Civil GBARD for General University Funds (GUF) (current PPP\$)
106. General University Funds (GUF) as a percentage of Civil GBARD
107. R&D expenditure of foreign affiliates (current PPP \$)

Main Science and Technology Indicators

108. R&D expenditure of foreign affiliates in national currency (for euro area: pre-EMU euro or EUR)
109. R&D expenditure of foreign affiliates as a percentage of R&D expenditures of enterprises
110. Number of "triadic" patent families (priority year)
111. Number of patent applications filed under the PCT(priority year)
112. Share of countries in "triadic" patent families (priority year)
113. Number of patents in the ICT sector - applications filed under the PCT (priority year)
114. Number of patents in the biotechnology sector - applications filed under the PCT (priority year)
115. Export market share: Pharmaceutical industry
116. Total imports: Pharmaceutical industry (current prices)
117. Total exports: Pharmaceutical industry (current prices)
118. Trade Balance: Pharmaceutical industry (current prices)
119. Export market share: Computer, electronic and optical industry
120. Total imports: Computer, electronic and optical industry (current prices)
121. Total exports: Computer, electronic and optical industry (current prices)
122. Trade Balance: Computer, electronic and optical industry (current prices)
123. Export market share: Aerospace industry
124. Total imports: Aerospace industry (current prices)
125. Total exports: Aerospace industry (current prices)
126. Trade Balance: Aerospace industry (current prices)
127. Implicit GDP Price Indices
128. Purchasing Power Parity
129. Gross Domestic Product (national currency)
130. Gross Domestic Product (current PPP\$)
131. Value Added of Industry (national currency)
132. Value Added of Industry (current PPP\$)
133. Population
134. Labour Force
135. Total Employment
136. Industrial Employment

ANNEX NATIONAL SPECIFICATIONS

OECD Member Countries

- From 2011, Australia has included submission from agencies that have previously not submitted R&D expenditure data. The agencies have been asked to provide retrospective time series and this results in a break in series in 2002 in GBARD data. From 1999, Australia has prepared its Federal Budget details according to the principles of accrual accounting, leading to a break in the series for GBARD data.

Since 2006, a definition of foreign ownership has not been provided in the national survey and R&D data on foreign affiliates have been accepted (by the Australian Bureau of Statistics) as reported.

- In **Austria**, three large units were reclassified in the Government sector in 2016 (previously included in the business and the Higher education sectors). From 2016, government R&D support through tax incentives is reported as funds from the business sector. Beforehand, it was included in the government funding.

Since 2009, a large unit previously omitted has been included as an R&D performer in the PNP sector.

From 2007 onwards, the former "post-secondary colleges for teacher training" ("Paedagogische Akademien") have become "Universities of Education" and are, consequently surveyed as units of the Higher education sector (up to 2006 these units were covered in the Government sector).

In the BE sector, the "research premium" is included in "funds from government" beginning 2006. This measure was introduced for the first time for the calendar year 2002, and for the 2002 and 2004 data, government funding for R&D via the "research premium" was subsumed under "funds from enterprises".

In 2004, Statistics Austria's regular annual updating procedure of the R&D expenditure data resulted in revisions showing a significant increase compared to previous estimates, mainly due to the inclusion of results from the 2002 survey of the business enterprise sector.

- In **Belgium**: the personnel data increased markedly in 2015 due to the introduction of a new government incentive scheme for hiring researchers. However, this was not matched by a counterpart increase in R&D expenditure, which grew only slightly. It is therefore likely that labour costs are being underreported in relation to the number of R&D personnel employed.

Some institutions were reallocated from the PNP sector to the Government sector in 2012.

Beginning with the 1998 data, two large non-profit organisations, formerly included in the higher education sector, were reclassified in the government sector.

As of 1993 (1992 for the Business enterprise sector), data are based on full surveys and no longer on a combination of budget figures and survey findings.

Total national R&D expenditures are underestimated in 1987 and 1988, as is the contribution of government as R&D financed by federative authorities (about 2-4 % of GERD and 7-15 % of government-financed GERD) is excluded. As a breakdown of this sum by sector of performance is not available, the impact on the other R&D expenditure tables cannot be estimated, though it probably affects R&D in the Government and Higher Education sectors.

- In **Canada**, new sampling method (weighted sample survey supplemented by administrative tax data) and conceptual changes in the business R&D survey caused a break in series in 2014. From 2012 the coefficients used for estimating R&D expenditure in the Higher Education sector have been

Main Science and Technology Indicators

revised, as well as the distribution of HERD between funds directly from government for R&D, GUF, and from institutions' own funds. From 1988, the estimated values for R&D in hospitals not covered by university reports are included in the R&D expenditure of the higher education sector (not previously included). From 2010, the federal government R&D expenditures are better measured.

From 1989, non-federal sources are no longer excluded from GUF in GBARD.

- For **Chile**, the method for reporting international observatories' R&D expenditure has been revised in 2016, leading to a break in series in the PNP sector. Prior to 2014, higher education data was obtained from the research departments of each institution (in a centralised way). Thereafter, it is obtained from the units directly (research centres of universities, scientific centres, etc). In 2013, some institutions, previously classified in the PNP sector, were included in the government sector. BERD funded by the business and the rest of the world sectors has also significantly increased as a result of better reporting in the R&D surveys starting with reference year 2013. From reference year 2009 in the business sector innovation and R&D surveys were separated and the survey sampling modified. Astronomical observatories are surveyed and included in the PNP sector from 2009; this may include some observatories operated by international organisations.
- For the **Czech Republic**: beginning in 2005, there is a change in methodology for the collection of R&D personnel data in FTE. Data are provided in FTE by the reporting units, and based on new, more precise guidelines. From 2005 onward, certain institutional units previously classified in the business sector have been reallocated to the Government sector to comply with the new System of National Accounts (SNA) 2008.
- In **Denmark**: from reference year 2007, the surveys are conducted by Statistics Denmark (previously by the Danish Centre for Studies in Research and Research Policy). Modifications in the questionnaires have increased the response rate; this is particularly noticeable in the Business enterprise sector where survey response is now mandatory. Additionally, due to changes in the administrative structure, a number of institutes, previously classified in the Government sector, were merged with universities.

Until 2002, the HE-sector R&D expenditure was underestimated as R&D carried out in hospital departments at the university-hospitals was included in the Government sector.

As of 2002, the business enterprise survey specifically requests data on researchers, technicians and other personnel. Earlier data for R&D personnel by occupation are based on qualification.

In 2017, unit reclassification led to a break in series in the “industrial production and technology” socio-economic objective (increase) and the “general advancement of knowledge, other than GUF” (decrease). From 2002, GBARD data include government-financed R&D on renewable energy. In 2001, a new principle concerning budgeting of commitments was introduced: commitments of grants are carried to the debit side at the time of entering the commitment, where previously commitment of grants was carried to the debit side at maturity.

From 1999, provincial and local government funding is included in the GBARD data (in particular funding in provincial hospitals), as well as funding from the Danish National Research Foundation and the Danish Investment Fund. In 1983, 1988, and 1993, the method for breaking down GBARD data by socio-economic objectives changed, leading to breaks in series.

Main Science and Technology Indicators

- In **Estonia**, GBARD figures come from budget data from 2016 onward, whereas they were previously estimated from R&D survey data.
- In **Finland**: a new methodology for calculating the time spent on R&D by personnel in the Higher Education sector was implemented in 2011. As a consequence, R&D personnel (measured in FTE) in the Higher Education sector decreased.

From 2004, R&D personnel data are available according to occupation. Previous breakdown was by formal qualification.

From 1998 to 2004, due to a greater number of responses to the BE survey on the group level, the questionnaire category funds from other foreign enterprises of the group was merged with business enterprise funds (own funds) thus reducing the share of funds coming from the rest of the world.

From 1997, the Higher Education sector includes central university hospitals.

From 1997 and the implementation of ISCED-97, “Researchers” also includes holders of engineering degrees and graduates of vocational polytechnics, degrees which are now classified in First Stage Tertiary Education (ISCED 5A).

In 1991, the method for measuring R&D expenditures in the Government and the Higher Education sectors changed. Since 1994, PNP institutions are included in the Government sector in non-survey years.

Data on GBARD have been revised back to 1991 because of changes in R&D coefficients for certain research institutes. In 1991, there was an upward adjustment in the total due to the inclusion of pension costs. From 1995, funds received by the State research institutes from external sources are excluded from Government allocations. As of 1997, the data covers allocations for central university hospitals.

- In **France**, from 2014 onwards, the better identification of R&D personnel in the university hospitals caused a break in series in the higher education sector; moreover, from that year, university hospitals collect R&D personnel data by gender whereas these figures were previously estimated. The National Centre for Scientific Research (CNRS) is included in the Higher Education sector, whereas in other countries such as Italy for example, this type of organisation is classified in the Government sector. This affects comparisons of the breakdown of R&D efforts by sector of performance.

The methodology of the public administrations survey was changed in 2010: the method for measuring the resources devoted to R&D in ministries and some public organisations has been modified, leading to a better identification of their financing activities. The impact is notably a 900 million fall in GOVERD and a 3 200 drop in FTE personnel.

From 2004 onwards, a new methodology was introduced to correct for some double-counting of funds for universities. In 2007, the sampling method in the BE sector was modified and the 2004 data revised according to the new methodology.

Beginning with the 2006 survey, in order to better take into account SMEs, there is no longer a cut-off point in the business enterprise sector of one Full-time-equivalent on R&D for an enterprise to be included in the survey population.

Main Science and Technology Indicators

From 2001, coverage of the BE sector was expanded. Data communicated by the Ministry of Defence were also extended to cover research that was not considered R&D in earlier years. This also affected GBARD data.

In 2000, several methodological changes which improved the quality of the public sector data resulted in a break in series for that year: social charges and civil pensions are better captured in universities' research expenses; modification of responses from some institutes to better harmonise with the corresponding multi-annual programme; and implementation of a redesigned questionnaire. National sources estimate that the previous method would have produced a 1.6% increase in GERD, where the current method resulted in 4%.

Due to changes in the methods used to evaluate domestic expenditure on defence, the results of the 1998 surveys revealed significant modifications requiring new estimates for 1997. This break in series relates also to the GBARD data.

In 1997, the method used to measure R&D personnel in administrations has changed.

Between 1991 and 1992 France Télécom and GIAT Industries were transferred from the Government to the Business Enterprise sector following a change in their legal status.

In 2006 and 2007, following the implementation of the Constitutional Bylaw on Budget Acts (LOLF act: "loi organique relative aux lois de finances"), some departments are no longer recorded in the GBARD data. Consequently, total GBARD is underestimated for both years.

- The data in this publication for **Germany** cover unified Germany from 1991 and western Germany only until 1990.

In 2016, the method for calculating R&D coefficients was revised, introducing a break in series in the Higher Education sector. In particular, coefficients are thereafter based on time-use surveys.

From reference year 2014, the distribution of R&D personnel by occupation is requested in the government survey whereas it was previously estimated from data by qualification.

The method for calculating public-financed R&D in the business enterprise sector was reviewed, resulting in the revision of business enterprise R&D and the national total back to 1991.

In 1992 the methodology of the survey on resources devoted to R&D in the Government sector was changed.

From 1991, the data for the Private Non-Profit sector have been included in the Government sector.

For 1997, the methodology for allocating GBARD by socio-economic objective changed. For 1997 and from 2001 to 2015, the global budget reduction was not distributed proportionally across SEO by the Federal Ministry of Education and Research. Therefore, the sum of the breakdown for those years does not add to the total. From 2016 onwards the global reduction is distributed across SEO proportionally.

- In **Greece**, in 2011, methodological improvements and a better coverage resulted in breaks in series: in the business enterprise sector, a new population frame was defined to cover all R&D-performing

Main Science and Technology Indicators

firms; in the government sector, the coverage was extended to also cover public hospitals as well as all institutions administered by the Ministry of Culture; in the higher education sector, all Technological Educational Institutes (TEI) and post-secondary establishments were included. These methodological changes were also applied to estimate the total GERD, BERD, GOVERD, and HERD between 2008 and 2010.

The methods for estimating R&D in the Higher Education sector changed in 1983, 1989, and 1995.

From 2008, GBARD data are exclusively based on R&D funders. Part of the increase in 2008 is also explained by a better identification of GBARD for cultural and archaeological activities.

- In **Hungary** the breakdown of R&D expenditure data by sector of performance and by source of funds is not complete. Beginning in 2006, government-financed R&D, some of which was not allocated to the appropriate sector, is now allocated, in particular to the Business enterprise sector. Prior to 2004, only defence R&D performed in the civil sector is covered. Up until 1993, Business Enterprise expenditure includes purchases of licenses and know-how. As of 1994, the Central Technology Fund has been reclassified from the Business Enterprise sector to the Government sector.

2013 GBARD data include multi-annual R&D projects which are not allocated to the year in which they were budgeted.

- In **Iceland**, in 2015, the implementation of the 2015 Frascati Manual edition has affected the distribution of personnel data by occupation. From reference year 2013, the R&D data collection methodology has been changed resulting in breaks in series. The main differences concern the redesign of the questionnaire, use of business registers in the sample selection mechanism, the legal obligation for firms to respond, the definition of key R&D concepts in the questionnaire, and changes in the allocation of institutions into the business or government sectors. New sampling methods caused a break in series in 2010 (or in 2011 for sectors with no 2010 data).

From 2014 onward, GBARD data are provided by Statistics Iceland and are compiled according to the Frascati Manual guidelines. From 2006, GBARD data make better use of R&D information from the state budget and are based on a better coverage of relevant R&D funding in major recipients organizations. From 1993, new methods for collecting and processing budget data for GBARD result in a break in series.

- In **Ireland**, from 2012, data on researchers in the higher education sector include PhD students. As of 2000, personnel data in the government sector were surveyed in FTE. Prior to 2000, data were collected for human resources devoted to S&T in FTE, and the R&D expenditure to total S&T expenditure ratio was applied.

The government data were revised back to 1992, as some government expenditures are no longer classified as R&D.

Prior to 2004, EU funds were included in GBARD data.

- In **Israel**, from 2000 onwards, hospitals were re-classified to the business sector from the government and PNP sectors. Both the business enterprise and higher education surveys were improved in 2009, causing a break in series for the BERD financed by the rest of the world and by the Business Enterprise sector, as well as a break in 2007 for the HERD financed by the rest of the world and by the Higher Education sector. Since 2001, the government sector is covered by a survey; beforehand government R&D was estimated through financial reports and interviews of accountants.

Main Science and Technology Indicators

Data for the higher education sector are partly based on universities' financial reports. Before 2008, humanities and law are only partially covered in the higher education sector.

The 2009 BERD survey has given more options to businesses to break down the data by sources of funds. Using the results of the 2009 survey, BERD and GERD financed by Business Enterprises and by the rest of the world were revised back to 1993.

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.

- For **Italy**, the population frame was improved in 2016 (+18% of units compared to the 2015 frame) and for the first time, an imputation procedure was applied for handling non responses. In 2005 and 1997, new methods for estimating R&D in universities were introduced, resulting in breaks in series in the higher education sector.

Up until 1990, the total expenditure on R&D is overestimated by more than 10% as extramural R&D expenditures is included. From 1991, data on extramural R&D expenditure is available separately.

2010 GBARD data are calculated with a new set of coefficients especially affecting the data on non-oriented research programmes.

- For **Japan** in 2008 and 2013, the FTE coefficients for researchers in the higher education sector were revised, producing an increase (in 2013) and a decrease (in 2008) in both R&D expenditure and personnel for this sector and the national total.

Beginning with the 2002/2003 survey (OECD data 2002), the coefficients supplied by the Ministry of Education, Culture, Sports, Science and Technology were applied to doctoral level students as well as teachers when calculating FTE for the HE sector, resulting in a break in series in that year.

Before 1996, Higher Education expenditure and personnel data in FTE are OECD estimates derived from official headcount-based data.

GBARD data represent the budget for S&T and cover central government only. Since 2018, the aggregation method of S&T budgets has changed. From 2011 onwards, GBARD for the "Education and Society" socio-economic objective include a more accurate measure of the budget of the National Institute for Cultural Heritage. Military procurement contracts are excluded from defence GBARD. Before 2010, GUF excludes SSH.

- In **Korea**, SSH are excluded from the R&D data prior to 2007. From 2013, GBARD data on the education objective are available separately, having previously been included in non-oriented research. Since 2008, GBARD has been broken down to fit NABS 2007 using estimation techniques.
- In **Luxembourg**, a better identification of R&D in software-related activities resulted in a break in series in 2012 for BERD (and GERD). From 2009, some budgetary items of the Ministry of Research

Main Science and Technology Indicators

and other ministries are no longer included in the government's own R&D funds. The impact on GOVERD is a drop of less than 7 million.

The significant increase in R&D performed in the higher education sector in 2004 is due to the re-defined role of higher education in the national system of innovation and research, in particular the newly created University of Luxembourg.

Government budget allocations for space programs and GUF are included from 2006.

The Luxembourg balance of payments was based on an International Transactions Reporting System (ITRS) up until 2011. From 2012 onwards, this has been replaced by direct reporting from companies. Banks are still reporting their own Balance of Payments transactions.

- In **Mexico**, post-graduate students are included in R&D expenditure data from 2007. Beginning with the 2004 data, the Business enterprise survey register was increased to include large firms not previously identified as R&D performers. The first R&D surveys based on the Frascati Manual covered the period 1992-93. Earlier data for R&D performed in the Government sector are based on national estimates and do not exactly correspond to the recommendations of the Frascati Manual.
- In the **Netherlands**, in 2012, the method for sampling enterprises included in ISIC industries 84 to 99 (community, social, and personal services) as well as the breakdown of personnel data by occupation were modified leading to breaks in series in the business and government sectors. In 2011, the method for producing business enterprise data changed: all observed enterprises are included whereas before 2011, only enterprises with substantial R&D activities (*i.e.* with a minimum number of R&D personnel) were incorporated. Subsequent changes affected the higher education sector: before 1999, a large number of PhD candidates were formally employed by research institutes (in the government sector) financing their research. From 1999, universities became the formal employer of PhD candidates and their research activities moved from the Government sector to the Higher Education sector. Besides this, the R&D activities of the Universities of Applied Sciences (HBO) were taken into account for the first time. Finally the R&D activities of the Academic hospitals were increasingly underestimated due to the merging of the Academic hospitals and (parts) of the Faculties of Medicine of the universities into so-called University Medical Centers (UMC's). This started in 1998 and meant for instance that staff of the Faculty of Medicine of the university became employees of the UMC. As a result, data on R&D in the field of medical sciences were also revised. As of 2000, newly-recruited researchers on the payroll of the Netherlands Organisation for Scientific Research (NOW), previously included in the Government sector, were included with personnel in the higher education sector. In 1982 and 1990, the methodology of the survey on R&D expenditure changed.

In 2003, Statistics Netherlands revised the panel of the R&D survey for the Government and PNP sectors, resulting in breaks in series for both. Also beginning in 2003, R&D personnel in the PNP sector are grouped with Government sector R&D personnel.

In 1994 and 1996 there were major expansions of the scope of the Business Enterprise sector survey; R&D expenditure and personnel data in the latter sector and in the whole economy are thus not comparable with those for the previous years.

In 1990 and 1999, new methods for calculating GUF are introduced for GBARD series.

- **New Zealand** revised the methods of collection and estimation of R&D data respectively in 1984 (for the Higher Education sector), 1992 (for GUF), and 2001 (BERD and national total and HE personnel).

Main Science and Technology Indicators

In 2016, part of R&D budgets previously reported in the “R&D financed from other sources than GUF” objective was reallocated to “economic development programmes” (more precisely to the “industrial production and technology” objective). GBARD figures have been revised back to 2007 resulting in a break in series. From 2006 onwards, GBARD data are collected from all government agencies, together with analysis of selected budgetary information. Prior to that year, data were derived from the budget estimate of the pool for science funding, together with figures on government departments’ operational research.

- In **Norway**, in 2007, a break in series occurs because of a change in compilation methods for health institutions. This affects both the Higher education sector (university hospitals) and Government sector (other hospitals).

In 1995, the survey sample was revised to improve coverage of small firms (10 to 50 employees) and non-manufacturing industries.

As of 1991, personnel in central administration units of higher education are not included, however the cost of such personnel is included in other current R&D expenditure (in line with the Frascati Manual).

In 1987, own funds from Public enterprises were reclassified from funds from Government to the funds from the Business Enterprise sector. As of 1989, R&D performed by PNP institutes has been included in the government sector.

The growth in resources devoted to R&D in 1984 is due to the expansion of the scope of the Business Enterprise sector survey.

The method for compiling GBARD data changed in 1996. The series have been revised retrospectively to exclude contract research, state enterprises and payments to the European Commission.

- In **Poland**, in 2016, some units previously classified in the Government sector were reallocated to the Business sector. From 2013, improvements in R&D surveys enable the distribution of all expenditure by type of R&D, leading to a break in basic research series.

GBARD data exclude European Commission funds since 2012.

- In **Portugal**, a significant number of entities previously classified in the PNP sector were reclassified to the higher education sector in 2013. Besides, R&D personnel occupation categories have been reviewed: researchers, technicians and other support staff have been defined according to the main functions performed by each individual as part of R&D activities and according to criteria based on the ISCO classification, rather than being defined only by the level of academic qualification. In 2008, the number of R&D personnel increased because of methodological improvements: the results of the individual survey forms were combined with information from other internal databases resulting notably in the inclusion of all permanent academic staff and all researchers funded by the Ministry of science, technology and higher education in 2008.

Due to methodological improvements in the 2008 R&D survey as well as complementary information collected from internal databases, there is now a more complete and accurate measure of R&D resources - both expenditure and personnel - in the Higher education sector. In particular, the large increase in higher education funded R&D is due to the inclusion of more accurate data related to private higher education institutions.

Main Science and Technology Indicators

Beginning with the 2007 survey, the following measures resulted in a significant increase in Business enterprise R&D: the reintroduction of the fiscal incentive, SIFIDE; an increase in the number of the firms performing R&D activities; and an updating of the Business Enterprise register.

New methodological procedures have been adopted for the 1997 survey so that only R&D activities are covered in the survey. The classification of BERD by NACE (Rev 1) was introduced and the data have been revised back to 1995. Some of the PNP units have been re-classified to the Business Enterprise and Higher Education sectors.

In 1997, due to a new accounting method for structural funds from the European Commission, funds from the Rest of the World and direct Government financing are not comparable with those of earlier years.

Before 2002, GBARD figures include EU funding programs. Thereafter, they are excluded, as set out in the 2015 Frascati Manual.

- For the **Slovak Republic**, data before 1994 refer to the Research and Development Base (RDB) and cover the whole activity of institutions and not only R&D. Defence R&D was totally excluded until 1997 and only partially included thereafter.

Since 2002, a new budget classification compatible with COFOG enables the identification of government budget allocations for defence R&D. The defence category includes R&D allocations for defence, safety, and security of the country. For earlier years, defence R&D was included in the GBARD total.

- In **Slovenia**, before 2014, the GERD allocation by type of R&D was estimated from the number of projects recorded in each type of R&D, and not from the actual amount of R&D expenditure (as it is the case from 2014). In 2011, the increase in R&D personnel and expenditure is notably explained by both the improvement of non-response analysis and new administrative sources to better identify R&D performers. Beginning reference year 2008, survey coverage was expanded to include some innovative companies that were not previously recognized as R&D performers.
- For **Spain**, beginning in 2008, the R&D questionnaire includes a specific category for on-site consultants undertaking R&D projects in the enterprise; as well as a specific category within the breakdown of current costs.

Since 2004, loans for R&D that are returnable are not included in GBARD, in order to ensure international comparability.

From 2002, R&D expenditure and personnel data for the business enterprise sector include both occasional and regular R&D.

Prior to 1989 R&D personnel data for the Higher Education sector only include researchers. In consequence, total R&D personnel may be underestimated in these years by between 10 and 15 %.

In 1992 there was an upward reestimation of General University Funds causing a break in series in the financing of HERD and GERD. In 1995, the sources of funds for R&D in the Higher Education sector were reviewed; own funds are now separated from the General University Funds, where they were previously included.

Main Science and Technology Indicators

In 1997, the defence objective in GBARD almost doubled in magnitude due to an exceptional contribution by the Ministry for Industry and Energy. The incorporation in 1997 of the Spanish contribution to CERN has involved substantial changes in the “Energy” category.

- In **Sweden**, the organisation of the police force was changed in 2015 and this has altered the coverage of the R&D personnel figures (in the government sector) received through survey responses. Part of personnel data were reallocated from the category “technicians” to the category “researchers” in 2013. In 2011 and 2009, the PNP sector decreased due to a new sampling method. In 2011, for personnel data, the institutional coverage of the Government sector was improved. Beginning 2007, researchers in the Business enterprise, Government and PNP sectors are now surveyed by occupation; prior to that year, data correspond to university graduates instead of researchers.

Until 2005, R&D data for Sweden were underestimated: R&D in the Government sector covered central government units only and companies between 10-49 employees were excluded from the coverage. Moreover, prior to 1993 the surveys in the Business Enterprise, Government and Private Non-Profit sectors excluded R&D in the SSH. Also beginning 2005, FTE on R&D in the Higher education sector reflects a change in survey method. Concerning the Government sector, beginning 2005, the data exclude R&D personnel from the County councils, resulting in the personnel data being underestimated.

From 1997, funding from the Public Research Foundations, previously classified in the PNP sector, is considered as funding from the government sector, due to their re-classification.

In 1995, some institutions from the PNP sector were reclassified to the Business Enterprise or Government sectors; in the Higher Education sector, capital expenditures are excluded.

From 1998, GBARD series refer to the calendar year (January-December) instead of the period July-June which had been used until 1994. Budget allocations for 1995 and 1996 are estimates based on the period July 1995-December 1996. Also from 1998, funding by Public Research Foundations is excluded from the GBARD data.

- In **Switzerland**, the Business Enterprise sector comprises private enterprises only. Public enterprises are included in the Government sector. From 2000, the Government sector no longer includes the telecommunications companies that have been privatised (Swisscom).

The Swiss contribution to the European Space Agency is allocated to the space objective in GBARD as of 2006, while it was before included in non-oriented research programmes. From 1998, the Federal Office of Agriculture and its research institutes no longer break down their R&D by socio-economic objective but group all under "Agriculture". For GBARD this results in a break in series for both Agriculture and Health objectives, where half of the funds previously declared under Health are now declared under Agriculture. Also in 1998, the telecommunications field of the Federal Post office has become the private enterprise Swisscom which is no longer included under the Infrastructure objective in GBARD. Before 1994, GBARD did not include the public sector financed R&D mandates.

Main Science and Technology Indicators

- Before 2016, total R&D personnel data for **Turkey** are underestimated because personnel data for the Higher Education sector only include researchers. From 2008, universities' own R&D funds are included in funding from the Higher education whereas they were previously distributed into the other funding categories.

- In the **United Kingdom**, the methodology for distributing GOVERD by type of R&D was improved in 2010, resulting in a break in series. Beginning in 2005, numbers of researchers in FTE incorporate a more accurate measure of post-graduate students. Estimates are based on the sum of student time allocated to different research activities (some students may be involved in several research projects). Students who spend 50% or more of their time on research activities are counted as one FTE; those for whom it is less than 50% are not counted.

In 2001, the government research agency, the Defence Evaluation and Research Agency (DERA) was disbanded and two new organisations were created. Around one quarter of DERA remained within the Ministry of Defence as a government agency, whilst the remaining three quarters became a private limited company, resulting in a break in series in both the Government and business enterprise sectors as well as GBARD.

In 1996, following work to enhance the estimates of R&D by PNP, estimates of PNP R&D were substantially revised downwards. The data for previous years were revised accordingly.

Until 1994 BERD funding by business includes funds that may have been from other national sources such as higher education or PNPs.

A new method for estimating government-financed R&D in the Higher Education sector was applied from 1993.

Reclassification of institutes explains most of the growth of the R&D personnel in the Government sector between 1991 and 1992 and the decline in the following year.

From 1991 the data for the Government sector include an estimate for R&D expenditures in the public health services.

Between 1985 and 1986 the "United Kingdom Atomic Energy Authority" was transferred from the Government sector to the Business Enterprise sector. Expenditure revisions have been made back to 1985.

Due to lack of official data for the higher education sector, the OECD Secretariat has made estimates for total researchers beginning 1999 and total R&D personnel beginning 1994.

As of 1995, the Health objective in GBARD has been broadened to include the total net costs to National Health Service trusts of their involvement in R&D.

- For the **United States**, in the business sector, the funds from the rest of the world previously included in the business-financed BERD, are available separately from 2009. In the higher education sector all fields of SSH are included from 2003 onwards.

Following a survey of federally-funded research and development centers (FFRDCs) in 2005, it was concluded that FFRDC R&D belongs in the government sector - rather than the sector of the FFRDC administrator, as had been reported in the past. R&D expenditures by FFRDCs were reclassified from the other three R&D performing sectors to the Government sector; previously published data were revised accordingly. Between 2003 and 2004, the method used to classify data

Main Science and Technology Indicators

by industry has been revised. This particularly affects the ISIC category “wholesale trade” and consequently the BERD for total services.

U.S. R&D data are generally comparable, but there are some areas of underestimation:

- i) Up to 2008, Government sector R&D performance covers only federal government activities. That by State and local government establishments is excluded;
- ii) Except for the Government sector, the R&D data exclude capital expenditures. For the Business Enterprise sector, depreciation is reported in place of gross capital expenditures.

Higher education (and national total) data were revised back to 1998 due to an improved methodology that corrects for double-counting of R&D funds passed between institutions.

Breakdown by type of R&D (basic research, applied research, etc.) was also revised back to 1998 in the business enterprise and higher education sectors due to improved estimation procedures.

The methodology for estimating researchers was changed as of 1985. In the Government, Higher Education and PNP sectors the data since then refer to employed doctoral scientists and engineers who report their primary work activity as research, development or the management of R&D, plus, for the Higher Education sector, the number of full-time equivalent graduate students with research assistantships averaging an estimated 50 % of their time engaged in R&D activities. As of 1985 researchers in the Government sector exclude military personnel. As of 1987, Higher education R&D personnel also include those who report their primary work activity as design.

Due to lack of official data for the different employment sectors, the total researchers figure is an OECD estimate.

Pre-production development is excluded from GBARD (in accordance with the Frascati Manual) as of 2000 for “Defence” and 2017 for “Exploration and exploitation of space”. 2009 GBARD data also includes the one time incremental R&D funding legislated in the American Recovery and Reinvestment Act of 2009. Beginning with the 2000 GBARD data, budgets for capital expenditure – “R&D plant” in national terminology - are included. GBARD data for earlier years relate to budgets for current costs only.

Non-Member Economies

- For **Argentina**, from 2009, business R&D data are derived from a new survey covering an expanded sample of enterprises. The following national report gives further information about the impact of the new methodology on BERD estimates: http://indicadorescti.mincyt.gob.ar/documentos/Informe_Encuesta%20I+D.pdf (in Spanish).

Since 1997, data for human resources relate to R&D. Before that, human resources data were expressed in terms of Science and Technology Activities (STA), involving R&D and diffusion activities of S&T (library services, training services, conferences, etc.). These have not been transferred to the OECD database. Since 2002, the source of funds data for private non-profit organisations, universities and S&T public organisations are requested for R&D. Before 2002, these sources of funds data were requested in terms of STA. These data were converted into R&D by means of a coefficient for each sector of performance. The main source of funds for science and technology activities in Argentina is the National Budget.

- In **China**, the national breakdown by source of funds does not fully match with the classification defined in the Frascati Manual. The R&D financed by the government, business enterprises, and by the rest of the world can be retrieved but part of the expenditure has no specific source of financing, i.e. self-raised funding (in particular for independent research institutions), the funds from the higher education sector and left-over government grants from previous years.

The government and higher education sectors cover all fields of NSE and SSH while the business enterprise sector only covers the fields of NSE. There are only few organisations in the private non-profit sector, hence no R&D survey has been carried out in this sector and the data are not available.

From 2009, researcher data are collected according to the Frascati Manual definition of researcher. Beforehand, this was only the case for independent research institutions, while for the other sectors data were collected according to the UNESCO concept of “scientist and engineer”.

In 2009, the survey coverage in the business and the government sectors has been expanded.

Before 2000, all of the personnel data and 95% of the expenditure data in the business enterprise sector are for large and medium-sized enterprises only. Since 2000 however, the survey covers almost all industries and all enterprises above a certain threshold. In 2000 and 2004, a census of all enterprises was held, while in the intermediate years data for small enterprises are estimated.

Due to the reform of the S&T system some government institutions have become enterprises, and their R&D data have been reflected in the Business Enterprise sector since 2000.

- In **Romania**, in 2011, R&D questionnaires have been redesigned for all sectors (and merged with the Community Innovation Survey in the case of the business enterprise sector). This has had an impact on the number of researchers in both the higher education and business enterprise sectors. A substantial proportion of R&D expenditure and R&D personnel reported in the data for the business enterprise sector are performed/employed in public enterprises (57.4% and 62% respectively for the year 2003).

The higher education sector includes faculty hospitals. For some of these hospitals, as well as for other types of medical centres, there are problems of delimitation between R&D activities and

Main Science and Technology Indicators

health activities and in these cases no data is available on R&D expenditures and personnel. The higher education sector does not include experimental stations: given the specific nature of their activity, these are directly co-ordinated by the Ministry of Agriculture, and therefore included in the business enterprise sector.

In 2013, a change in methodology for the allocation of GBARD data by socio-economic objectives has resulted in a break in series.

- In the **Russian Federation**, the business enterprise sector includes all organisations and enterprises whose main activity is connected with the production of goods and services for sale, including those owned by the state, and private non-profit institutions serving the above-mentioned organisations. In practice however, R&D performed in this sector is carried out mostly by industrial research institutes other than enterprises. This particularity reflects the traditional organisation of Russian R&D.

Headcount data include full-time personnel only, and hence are underestimated, while data in full-time equivalents (FTE) are calculated on the basis of both full-time and part-time personnel. This explains why the FTE data are greater than the headcount data.

New budgetary procedures introduced in 2005 have resulted in items previously classified as GBARD being attributed to other headings and have affected the coverage and breakdown by socio-economic objective.

- In **Singapore**, the Public Research Centres are located within the universities and draw upon university expertise. They are closely linked with the universities and several have ‘spun off’ from university research groups. However they are administratively separate from the universities and funded by the Agency for Science, Technology and Research (A*STAR) and industry. The centres have been included in the ‘Public Research Institutes and Centres’ category in the R&D survey since 1995. Until 1995 they were subsumed in the Higher Education sector. This leads to a discontinuity in the statistics for the Government/Public and Higher Education sectors between 1994 and 1995.
- For the 2001/02 R&D survey in **South Africa**, no comprehensive business register was available, nor was there any official register of the specific subset of those entities that actually conduct R&D. However, lists of firms surveyed in previous R&D surveys, those covered in previous technology audits, public listings of the top 200 companies in the economy, as well as lists of firms that participate in public innovation and R&D support programmes were available to the survey agency. These lists provided the basis for a purposive sample of all firms known to have R&D activities. There may however be an underestimation of R&D expenditure by 10% to 15%.
- In **Chinese Taipei**, since 2003, the business sector includes R&D data of private enterprises in the sectors of electricity, gas and water supply; construction; and services, which were not surveyed before.

Postgraduate students engaged in R&D were not included in the higher education sector until 2002.

Researchers must have a university degree or above.