Research Material-229

Digest of Japanese Science and Technology

Indicators 2014

Feb. 2015

Research Unit for Science and Technology Analysis and Indicators
National Institute of Science and Technology Policy, MEXT

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Japanese Science and Technology Indicators 2014

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Research Unit for Science and

Technology Analysis and Indicators

National Institute of Science and Technology Policy

(NISTEP)

Ministry of Education, Culture, Sports,

Science and Technology(MEXT), Japan

Japanese Science and Technology Indicators 2014（ABSTRACT）

"Science and Technology Indicators" is a basic resource for understanding Japanese science and technology activities based on objective and quantitative data. It classifies science and technology activities into five categories, R&D Expenditure; R&D Personnel; Higher Education; The Output of R&D; and Science, Technology, and Innovation. The multiple relevant indicators (approximately 150 indicators) show the state of Japanese science and technology activities.

"Japanese Science and Technology Indicators 2014" adds a new indicator that utilizes the results of the Japanese National Innovation Survey in time-series comparison. In indicators related to human resources development, data representation has been improved to more clearly show the status of women and international students. Additionally, seven column-style articles use indicators to focus on timely issues and specific themes from today's society.

Using "Japanese Science and Technology Indicators 2014" to look at conditions in Japan, total Japanese R&D expenditure has changed little since 2009. The percentage of researchers who are female is especially small in the business enterprise sector. The number of female students enrolling in Japanese higher education institutions is rising. Japan ranked number one in the world in share of patents (patent families) during the 2000s. Japan's competitive superiority of its high-technology industries is falling, but the competitiveness in medium high-technology industries is maintained high level.

Characteristics of the Japanese Science and Technology Indicators

The Japanese Science and Technology Indicators is published each year to present the most recent values at the time of publication. It is a collection of items that allow time-series comparisons as well as comparisons among the selected countries based on data that are updated each year in principle.

Use of statistical data announced by each country

Wherever possible, statistical data announced by each country are used as the sources of data for indicators appearing in Japanese Science and Technology Indicators. Every effort has been made to clarify each country's method of collecting statistics and how it differs from other countries' methods.

Independent NISTEP analysis of paper and patent databases

Paper data were independently aggregated and analyzed by NISTEP using Thomson Reuters Web of Science. The aggregation method is provided and explained in detail.

Of indicators pertaining to patents, patent family data were independently aggregated and analyzed by NISTEP using PATSTAT (the patent database of the European Patent Office). The aggregation method is provided and explained in detail.

Presentation of topical indicators in "columns"

In addition to base indicators, those indicators having topicality or are expected to have particular importance in the future are presented in the form of "columns."

Use of "reminder marks" for international comparisons and time-series comparisons

The reminder marks "attention to international comparison" (Attention to international comparison) and "attention to trend" (Attention to trend) have been attached to graphs where they are required. Generally, the data for each country conform to OECD manuals and other materials. However, differences in methods of collecting data or scope of focus do in fact exist, and therefore attention is necessary when making comparisons in some cases. Such cases are marked "attention to international comparison." Likewise, for some time series data, data could not be continuously collected under the same conditions due to changes in statistical standards. Cases where special attention is required when reading trends of increases and decreases are marked "attention to trend." Specifics for such points requiring attention are provided in the notes of individual charts.

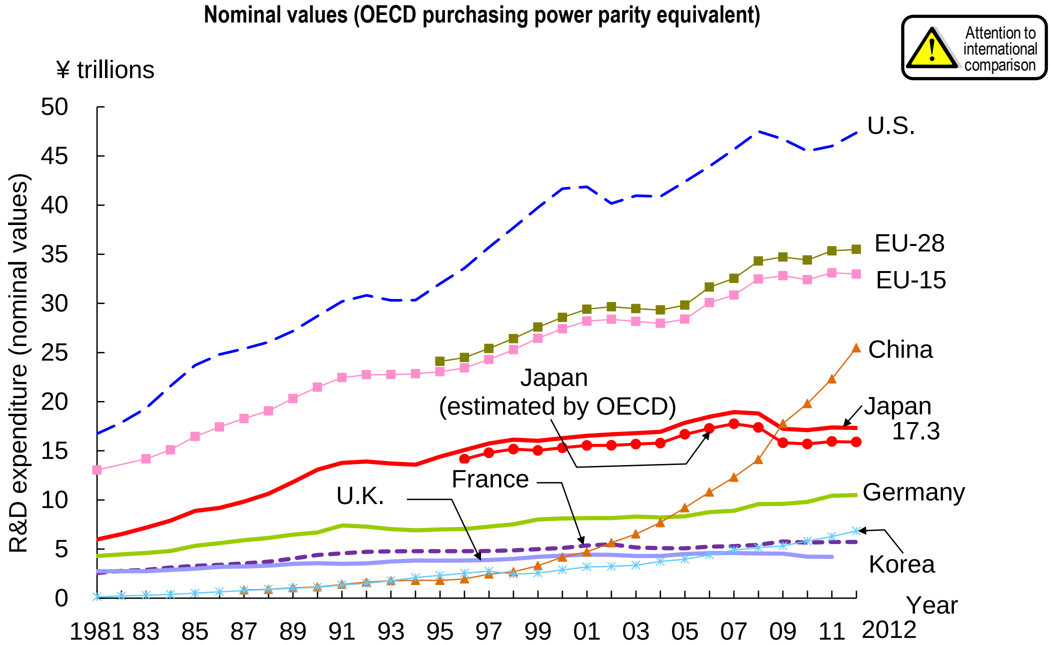
1. Circumstances in Japan and the selected countries in terms of R&D expenditure

(1) Japan's total R&D expenditure has remained mostly unchanged since 2009.

Looking at the total R&D expenditure of the selected countries as an indicator of the scale of Japan's R&D, in 2012 Japan's expenditure amounted to 17.3 trillion yen (OECD estimate: 15.9 trillion yen), a figure that has remained mostly unchanged since 2009. Looking at the other countries, the U.S. has a much larger expenditure compared to the others. China's expenditure surpassed Japan's in 2009 and is continuing to grow.

Summary chart 1: Trends in total R&D expenditure in selected countries

Nominal values (OECD purchasing power parity equivalent)



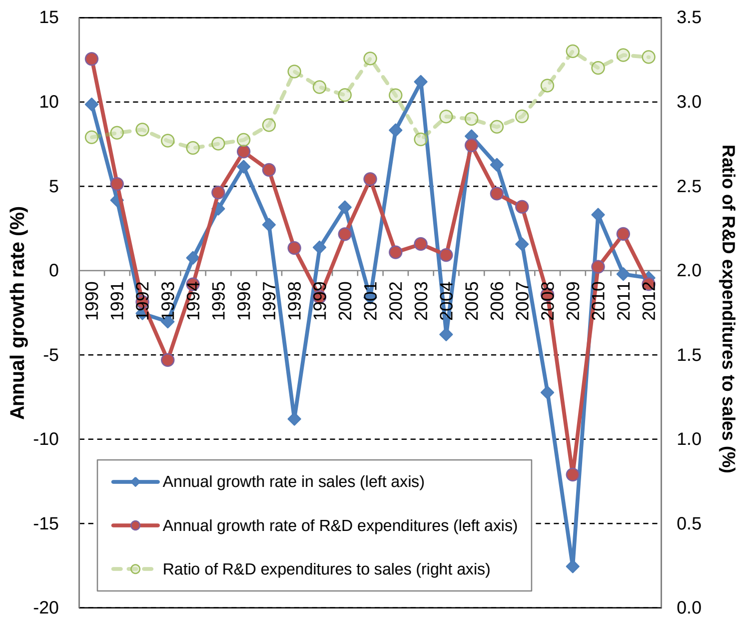
Note: 1) The total R&D expenditure is the sum of each sector's expenditure, and the definition of each sector occasionally differs depending on the country. Therefore it is necessary to be careful when making international comparisons. Refer to Chart 1-1-4 for the definition of sectors in each selected country.
2) R&D expenditure includes the field of social sciences and humanities (for Korea, only natural sciences until 2006)
3) The former West Germany until 1990, and the unified Germany since 1991, respectively.
4) Reference statistics E were used for the conversion to obtain purchasing power parity equivalent.
5) Real values were obtained by calculations with a GDP deflator (reference statistics D were used).
6) Value for Japan (estimated by the OECD) represents the total R&D expenditure in which the labor cost comprising a part of R&D expenditure in the university and college sector was converted to FTE. The value was corrected and estimated by the OECD.
7) Regarding the 2012 values, those for the U.S. are preliminary values, while those for Germany are national projections or estimated values that have been corrected by the Secretariat to accord, where necessary, with OECD standards. The values for France are provisional, while those for Japan (OECD) and the EU are OECD Secretariat estimates/projections based on each country's materials.

Source: <Japan> Ministry of Internal Affairs and Communications, "Report on the Survey of Research and Development"
<U.S.> NSF, "National Patterns of R&D Resources 2011–12 Data Update"
<Germany> Bundesministerium für Bildung und Forschung, "Bundesbericht Forschung 2004, 2006," "Bundesbericht Forschung und In-novation 2010, 2012"; from 2010: OECD, "Main Science and Technology Indicators 2013/2"
<Japan (estimated by the OECD), France and EU> OECD, "Main Science and Technology Indicators 2013/2"
<U.K> National Statistics website: www.statistics.gov.uk
<China> Ministry of Science and Technology of the People's Republic of China, S&T Statistics Data Book 2013 (website)
<Korea> National Science and Technology Information Service (website)

(2) Japan's business enterprises continue to emphasize R&D.

Looking at the general conditions of business enterprises, which account for approximately 70% of Japan's total R&D expenditure, the year-on-year R&D expenditure and sales growth rates of Japanese business enterprises show a roughly linked trend. In 2009, the year in which the global economic crisis (Lehman Shock) affected Japanese business enterprises, R&D expenditure and the year-on-year sales growth rate were on the negative side by a large margin. However, the ratio of R&D expenditure to sales, which is an indicator showing the degree of focus that business enterprises place on R&D, has remained at a high level since 2009. It is therefore thought that business enterprises are continuing to emphasize R&D.

Summary chart 2: Year-on-year growth rate in sales and R&D expenditures in the Japanese business enterprise sector, and ratio of R&D expenditures to sales

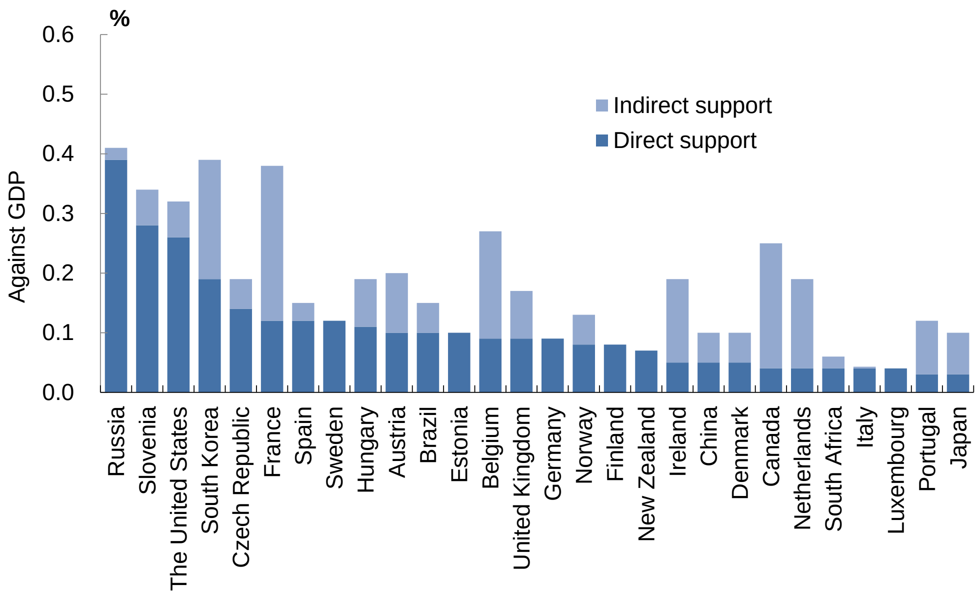


Note: R&D expenditures and sales are both nominal values and based on figures of businesses engaged in R&D (excluding finance and insurance industries),
Sources: Ministry of Internal Affairs and Communications, "Report on the Survey of Research and Development"

(3) Indirect support forms the major part of government support for R&D by Japanese business enterprises.

A look at "direct support" (amount of business enterprises' R&D expenditures borne by the government) and "indirect support" (amount of business enterprises' corporate taxes to be paid to the government that is exempted through R&D tax incentives) on a ratio to GDP basis in order to view government support for business enterprises' R&D shows that the share of indirect support is larger in Japan. Looking at other countries, those in which direct government support to business enterprises is large include Russia, Slovenia and the U.S. Countries in which indirect support is large include France, Canada, and Belgium.

Summary chart 3: Direct support and indirect support by governments for R&D by business enterprises



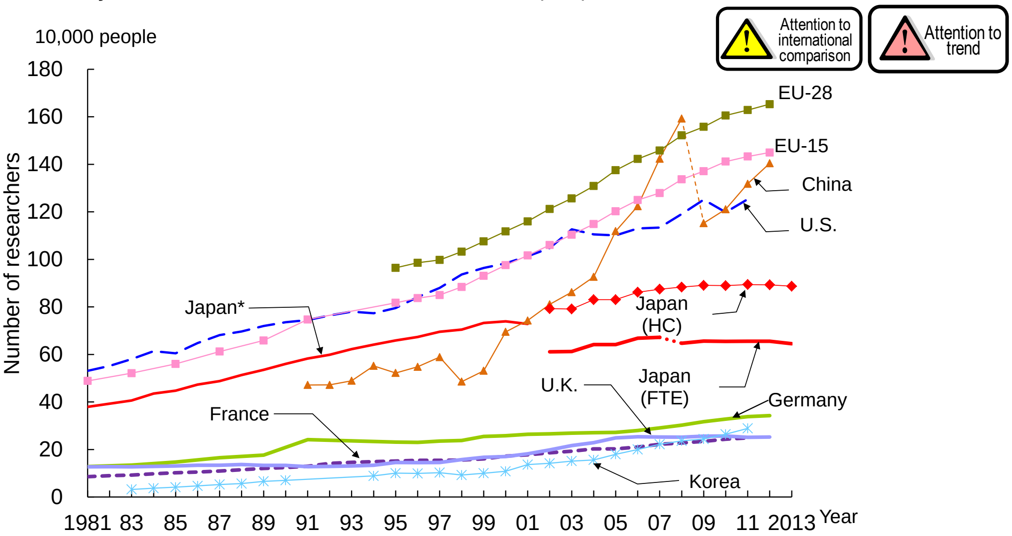
Note: 1) Values estimated by each country (in accordance with the survey for R&D tax incentives by NESTI). Preliminary budget values are also included.
2) Values for China, South Africa, and Luxembourg are for 2009; values for Spain, Brazil, Belgium, and Ireland are for 2010.
3) Data on indirect support was not provided for Estonia, Finland, Germany, Luxembourg, Mexico, New Zealand, Sweden, and Switzerland.
Source: OECD, “STI Scoreboard 2013"

2. The situations in Japan and the selected countries in terms of R&D personnel

(1) Japan ranks third behind China and the U.S. in the number of researchers.

In regards to the numbers of researchers in the selected countries, in 2013, Japan had 660,000 researchers in terms of FTE value (full-time equivalent) and 890,000 in terms of HC value (actual value). A comparison of FTE values shows that Japan ranks third behind China and the U.S. It should be noted that Japan's numbers have remained roughly the same since the second half of the 2000s.

Summary chart 4: Trends in the number of researchers (FTE) in selected countries



Note: 1) The number of researchers in a country represents the total value of researchers in every sector, and the definition and measurement method for researchers in each sector is occasionally different depending on the country. Therefore it is necessary to be careful when international comparisons are being made.

2) Values for each country are FTE, except Japan, which showed both FTE and HC values.

3) The values include the number of researchers in the field of social sciences and humanities (until 2006, only that of the field of natural science and engineering for Korea).

<Japan> (1) Values until 2001 represent the numbers of researchers measured on Apr.1 and since 2002 represent the numbers of researchers measured on Mar.31 in the corresponding year, respectively.

(2) “Japan ∗ ”: The number of “people mainly engaged in research” without being converted on FTE basis. External non-regular researchers are not measured.

(3) “Japan (HC)”: The total of “people mainly engaged in research” and “people engaged in research under non-regular conditions”. The number of researchers in the universities and colleges sector includes the above mentioned “external non-regular researchers”.

(4) The FTE values of “Japan” through 2007 : The measurement for the universities and colleges sector is made with the conversion in accordance with the results of the “Survey on the data for full-time equivalents in universities and colleges” in 2002. With regard to the business enterprises sector, the public organizations sector and the non-profit institutions sector, “people mainly engaged in research” and “people engaged in research under non-regular condition whose values are converted on FTE basis” are measured.

(5) FTE values for “Japan” from 2008 : The value for the ““universities and colleges” calculated using the 2008 “Survey on the data for full-time equivalents in universities and colleges,” and for ““business enterprises” and “public organizations and non-profit institutions” count ““people mainly engaged in research” and “people engaged in research under non-regular condition whose values are converted on FTE basis.”

<U.S.> OECD Secretariat estimate/projection based on each country's materials.

<Germany> Until 1990, data is for the former West Germany. After 1991, data is for the unified Germany. For 2010 and 2012, OECD Secretariat estimate/projection based on each country's materials. Figures for 2012 are provisional.

<U.K.> OECD secretariat estimate or projection based on national sources has been used since 1999. In 2005, the measurement method was changed to use of national projections or estimated values Figures for 2012 are provisional.

<China> Through 2008, the definition of researcher used was not in complete accordance with the OECD. The measurement method was changed in 2009. Caution is therefore necessary when observing changes over time.

<EU> OECD Secretariat estimate/projection based on each country's materials.

Source: <Japan> Ministry of Internal Affairs and Communications, “Report on the Survey of Research and Development “; MEXT, “Survey on the data for full-time equivalents in universities and colleges” (2002 and 2008)

<U.S., France, U.K., China, and EU> OECD, “Main Science and Technology Indicators 2013/2”

<Germany> Bundesministerium für Bildung und Forschung, “Bundesbericht Forschung 1996, 2000, 2004”; “Forschung und Innovation in Deutschland 2007” “Bundesbericht Forschung und Innovation, 2008, 2010, 2012”; OECD, “Main Science and Technology Indicators 2013/2” since 2010.

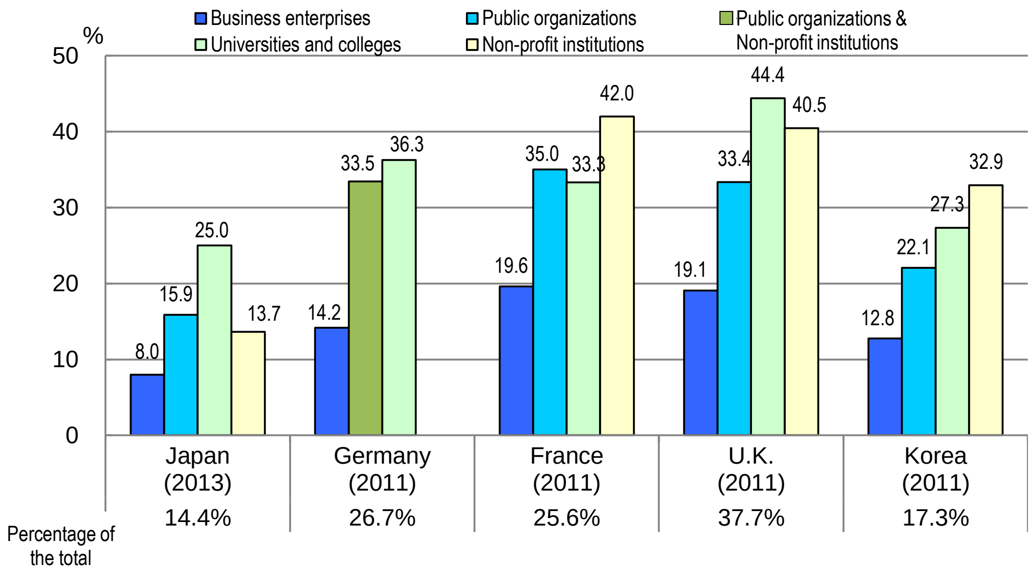
<Korea>KISTEP, Statistical DB (website)

(2) The ratio of female researchers in Japan is large in the "universities and colleges" sector but low in the "business enterprises" sector.

Looking at female researchers in the selected countries by sector, in each country, the ratio of female researchers was smallest in the business enterprises sector. The ratio was relatively large in the universities and colleges sector in each country.

In the case of Japan, the share of female researchers in the universities and colleges sector was large at 25.0%. On the other hand, the share of female researchers in the business enterprises sector was smallest, accounting for 8.0% of the total. Additionally, Japan's share of female researches in the non-profit institutions sector is small compared to the selected countries.

Summary chart 5: Shares of female researchers of the selected countries by sector



Notes: 1) Values for France's public organizations sector are underestimated or based on underestimated data.
2) For the non-profit institutions sectors of France, the U.K., and Korea, the number of researchers was obtained by subtracting the numbers of researchers in the business enterprises sector, the universities and colleges sector, and public organizations sector from the total.

Sources: <Japan> Ministry of Internal Affairs and Communications, "Report on the Survey of Research and Development"
<Other countries> OECD "Main Science and Technology Indicators 2013/2"

3. The situation in Japan in terms of university and graduate students

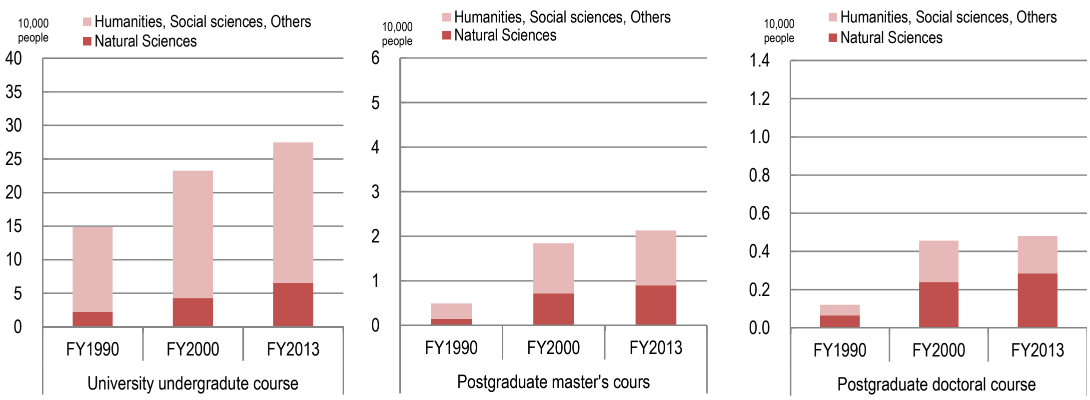
(1) The number of female students enrolling in Japanese universities is growing.

Looking at the numbers of students enrolling in Japan's undergraduate departments, master's programs, and doctoral programs, the number of enrolling female students is increasing. On the other hand, the number of enrolling male students is decreasing.

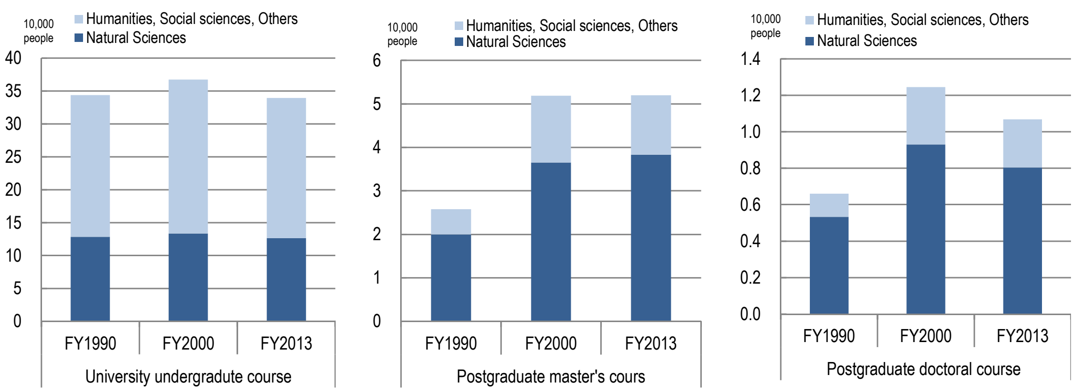
Looking at the numbers of newly enrolled students in Japan's universities and graduate schools, that for doctoral courses began decreasing in 2003 and that for master's programs began decreasing after peaking in 2010, while that for undergraduate departments has remained flat since around 2000. Thus, human resources development in institutions of higher education is improving from the standpoint of diversity due to increasing numbers of female enrollees. However, it is also shrinking in size when viewed in terms of the total number of enrolling students. This situation may have an impact on the supply of R&D personnel and advanced human resources in the future.

Summary chart 6: Numbers of students enrolling in undergraduate departments, master's programs, and doctoral programs

(A) Female enrollees



(B) Male enrollees



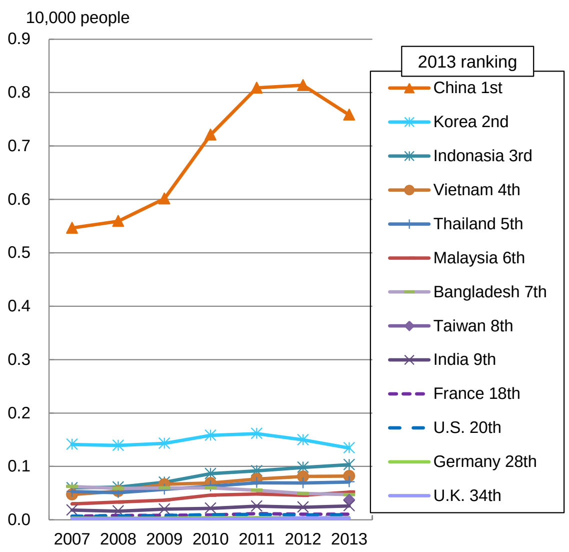
Source: MEXT, “Report on School Basic Survey”

(2) The number of Chinese graduate school students among foreign graduate students in Japan is extremely high.

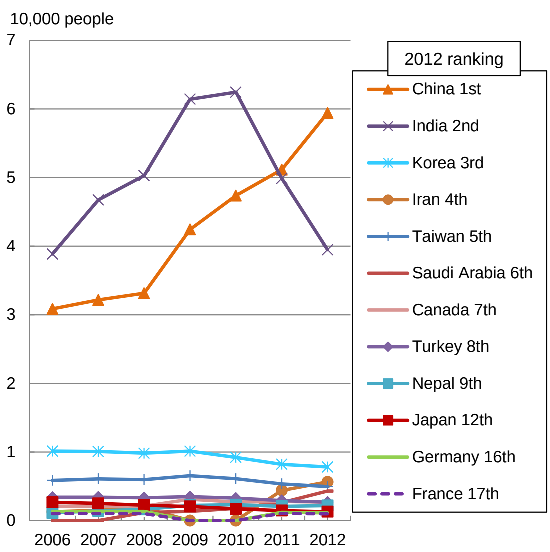
Concerning the state of foreign graduate students in Japan and the U.S., Japan had 16,000 foreign graduate students in the natural sciences field (2013). Chinese graduate students accounted for the largest share of this number with 8,000, which was half the total. On the other hand, in the U.S. had 163,000 foreign graduate students in the science and engineering field (2012). Chinese and Indian graduate students had the largest shares of this number, accounting for a combined total of 60%.

Summary chart 7: Foreign graduate students in Japan and the U.S.

(A) Japan: Natural sciences and engineering



(B) U.S.: Science and engineering



Note: For Japan, foreign students are those without Japanese citizenship. For the U.S., foreign students are those without U.S. citizenship.
Sources: <Japan> MEXT, "Report on School Basic Survey"
<U.S.> NSF, "Science and Engineering Indicators 2006, 2008, 2010, 2012"

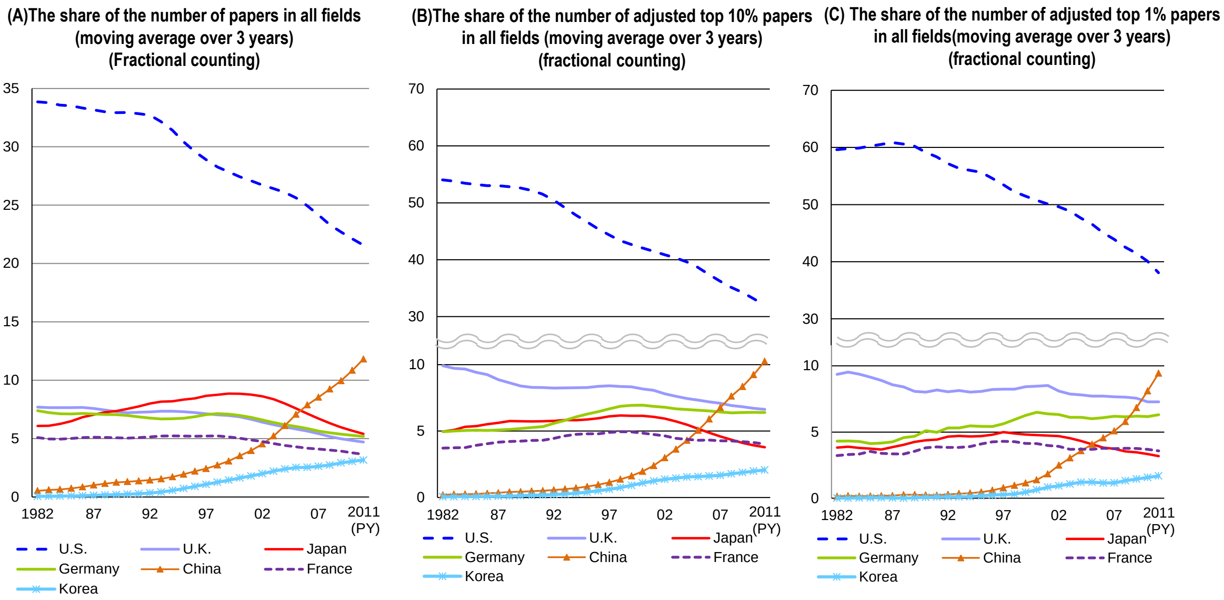
4. Circumstances in Japan and the selected countries in terms of R&D output

(1) Japan continues to have a declining presence in terms of its share of the number of scientific papers published.

The following looks at scientific papers published, which is a measure of R&D output. Looking first at share of the number of papers, between the 1980s and the early 2000s, Japan's share grew to surpass those of the U.K. and Germany, and for a while ranked number two in the world; however, its share has been declining in recent years. However, this tendency toward a declining share is not limited to Japan, as it is also seen for the U.K., Germany, and France.

Moreover, looking at shares of the numbers of adjusted top 10% papers and adjusted top 1% papers as qualitative indicators, Japan saw its shares increase gradually from the 1980s into to the early 2000s; however, these shares have been decreasing rapidly since then.

Summary chart 8: Changes in the shares of papers, number of adjusted top 10% papers, and number of adjusted top 1% papers of the selected countries (All fields, fractional counting, three-year moving average)

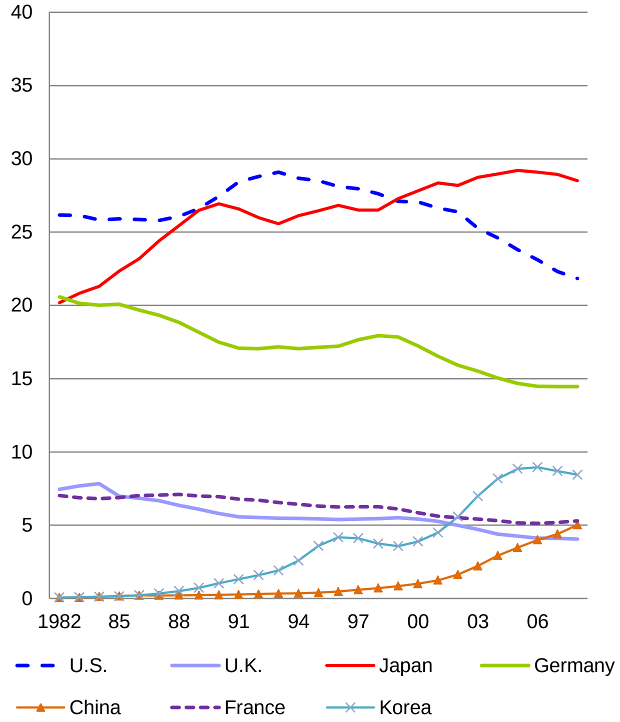


Note: The analysis targeted articles and reviews. Publication year (PY) was used in annual aggregation. Three-year moving averages of share of papers in all fields (if 2011, average of PY 2010, PY 2011, and PY 2012). Fractional counting used. Numbers of times cited are values as of the end of 2013.
Source: Compiled by NISTEP based on Thomson Reuters, "Web of Science (SCIE, CPCI: Science)"

(2) Japan ranked first in terms of share of patents (number of patent families) in 2000.

Next, looking at numbers of patent families, which are measured by the number of inventions produced by each country and region in an internationally comparable form, with particular attention to patents, Japan and the U.S. traded places during the second half of the 1990s before Japan took the top share in the 2000s. This reflects the fact that the number of patent applications submitted from Japan to multiple countries increased.

Summary chart 9: Changes in shares in the number of patent families in the selected countries
(All technical fields, whole counting, three-year moving average)



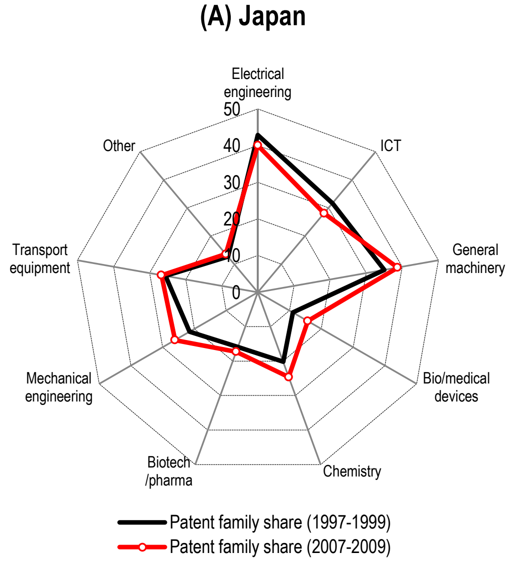
Notes: Three-year moving averages of share of number of patent families in all technical fields (if 2008, the average of 2007, 2008, and 2009); see the Technical Notes for details concerning the method used for patent family analysis.
Source: Compiled by NISTEP based on PATSTAT (October 2013 version) of the European Patent Office

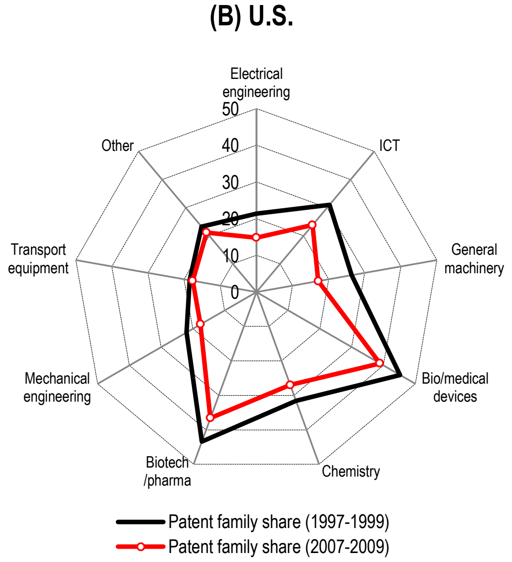
(3) Japan has high shares of the number of patents (number of patent families) in the electrical engineering, general machinery, and information and communication technology fields.

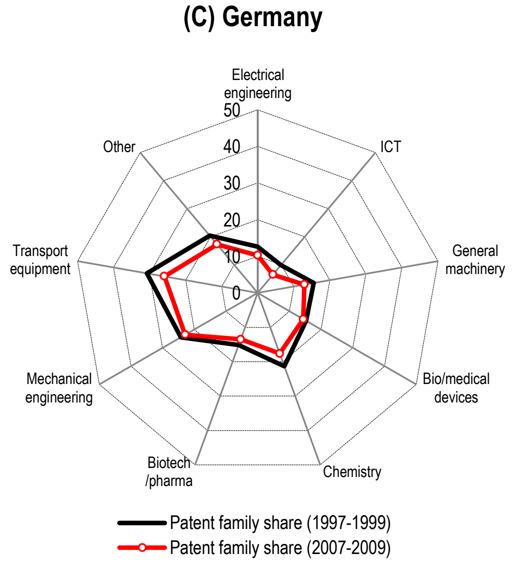
Looking at Japan's technology field balance among patent families, Japan has a portfolio with high shares for electrical engineering, general machinery, and information and communication technology and low shares for biotechnology/pharmaceuticals and bio/medical devices.

Summary chart 10: Comparison of shares in the number of patent families for each technology field in the selected countries

(%, 1997-1999 and 2007-2009, whole counting)







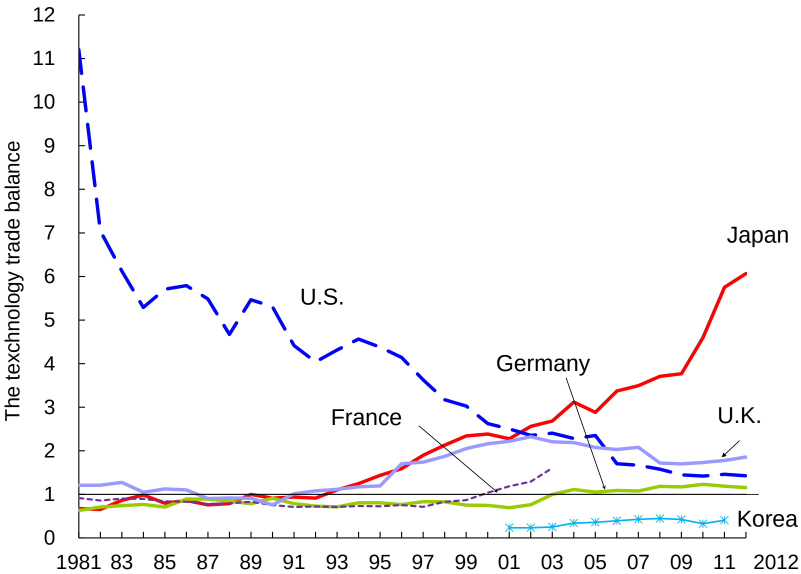
Note: Biotechnology/pharmaceuticals: Biotech/pharma
Information and communication technology: CT
Source: Compiled by NISTEP based on PATSTAT (October 2013 version) of the European Patent Office

5. Circumstances in Japan and the selected countries in terms of science, technology, and innovation

(1) Japan's technical strength is rising in the world in terms of its technology trade balance.

Looking at technology trade, which illustrates international trade of technical knowledge as an indicator of each country's technical strength, Japan's technology trade balance has been rising continuously since surpassing 1 in 1993. In 2012, it reached a high level of 6.1. This is primarily due to a decline in technology imports, most noteworthy of which is a decline in imports from the U.S. Looking at technology trade exclusive of that between parent companies and subsidiaries, Japan's technical trade balance in 2012 was 2.0. It has had an export surplus since 2006. On the other hand, the U.S.'s technical trade balance was 4.0 (reference: main text chart 5-1-2 B).

Summary chart 11: Technology trade balance ratios of the selected countries



Note :<Japan> Data are for fiscal years.

The sorts of technology trade are as follows (excluding trademark rights):

1) Patent rights, utility model rights and copy rights
2) Design rights
3) Each kind of technological know-how provision and technical guidance (excluding free provision)
4) Technological aid for developing countries (including government-commissioned works)

<U.S.> Through 2000, only royalties and licenses. For 2001–2005, research, development and testing services were added. Since 2006, intangible assets (excluding books, records, television, films, etc), computers, data processing services, etc., have been included. Figures for 2011 are provisional.

<Germany> West Germany until 1990. Until 1985 includes patents, licenses, know-how, trademarks, and design. From 1986, additionally included technical services, computer services and R&D in industrial fields. Figures for 2011 are provisional.

<U.K.>From 1996, includes patents, inventions, licenses, trademarks, design and services and R&D related to technology. Data continuity with the previous year is impaired for 2009. Figures for 2011 are provisional.

<Korea> Figures for 2009 are provisional.Statistical reference E was used for purchasing power parity conversion.

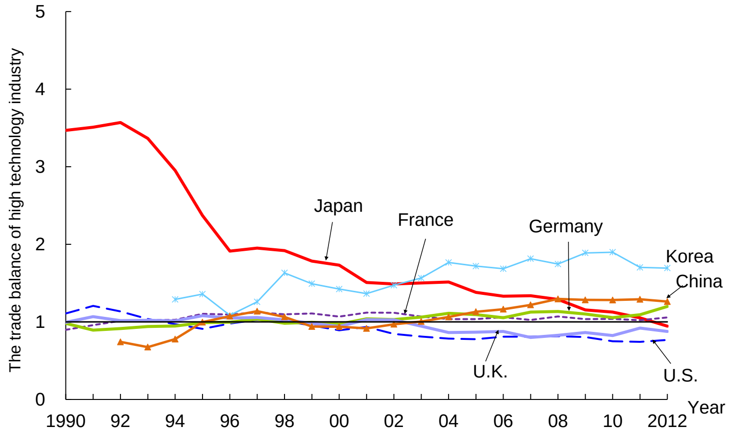
Source :<Japan> Ministry of Internal Affairs and Communications, "Report on the Survey of Research and Development."
<U.S., Germany, France, U.K. and Korea>OECD, "Main Science and Technology Indicators 2013/2."

(2) Japan's superior competitiveness in high-technology industries is eroding; however, it maintains high competitiveness in medium-high technology industries.

Looking at high-technology industrial competitiveness from the standpoint of products and services trade balance, Japan's balance ratio was 0.9 in 2012, a figure that fell below 1 and marked Japan's first import surplus. This is primarily due to an increase in technology imports, most noteworthy of which is an increase in imports from radio, television, and communication equipment industries.

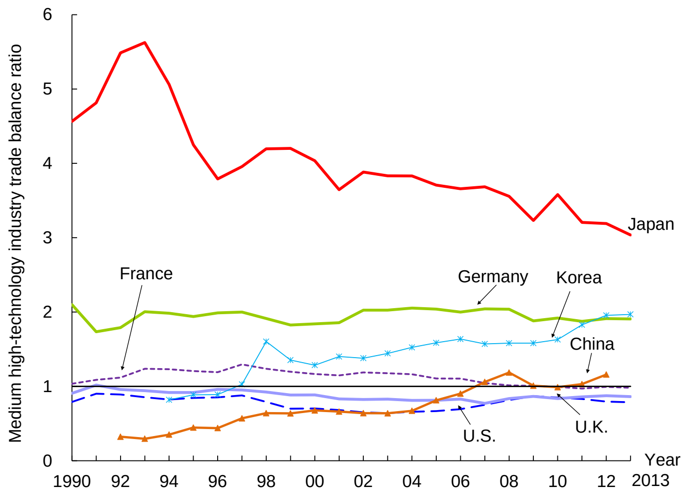
On the other hand, Japan's industry trade balance ratio in medium high-technology industries was 3.0 in 2013. This ranked number one among the selected countries. Japan showed a rapid decline in the mid-1990s followed by a gradual decrease; however, its export surplus is still larger than the other countries.

Summary chart 12: Changes in the high-technology industry trade balance ratios of the selected countries



Note: High-technology industries: "Pharmaceuticals," "Radio, Television and Communication Equipment," and "Aircraft and Spacecraft"
Sources: OECD, "Main Science and Technology Indicators 2013/2"

Summary chart 13: Changes in the medium high-technology industry trade balance ratios of the selected countries



Note: Medium high-technology industries: "Chemicals (excluding Pharmaceuticals)," "Machinery & Equipment," "Electrical Machinery and Apparatus (excluding Telecommunications Equipment)," "Motor Vehicles, Trailers and Semi-Trailers," and "Railroad Equipment and Transport Equipment."
Source: OECD, "STAN Bilateral Trade in Goods by Industry and End-use (BTDIxE), ISIC Rev. 3"

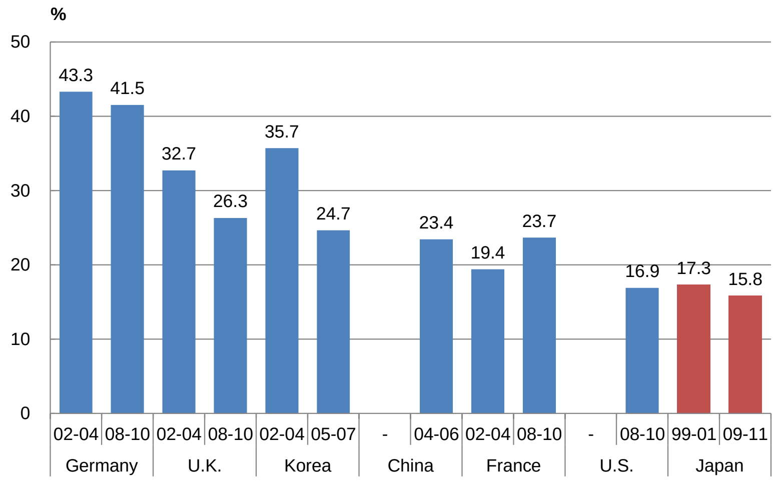
(3) Japan's share of companies that achieved process innovation is low compared to the selected countries but growing.

Looking at the shares of companies that achieved innovation of the selected countries in terms of product and process innovation, Japan's share of companies that achieved product innovation is low compared to the selected countries and decreasing. However, the shares of Germany, the U.K., and Korea are also decreasing. On the other hand, looking at shares of companies that achieved process innovation, Japan's share is low compared to the selected countries but only Japan's share is growing.

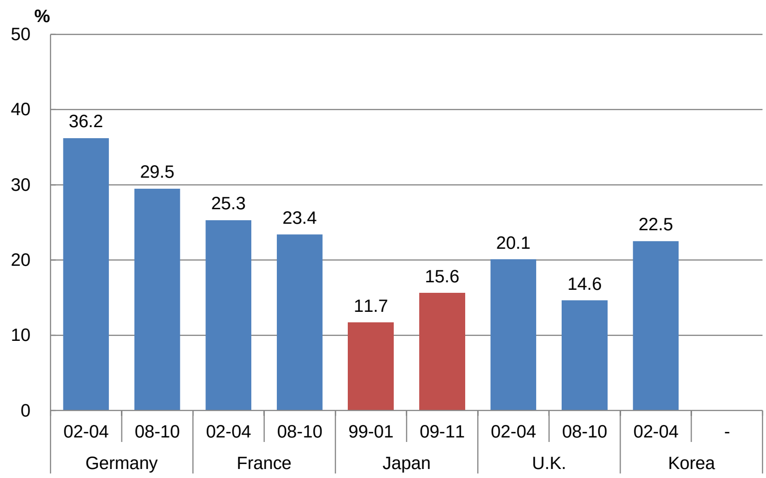
It should be noted that the shares of companies that achieved innovation that are presented here are the results of aggregation based on numbers of companies without consideration for company size. It is therefore thought that the circumstances of small and medium-size enterprises, which make up the majority of the number of companies, are more strongly expressed in the data.

Summary chart 14: Shares of companies that achieved innovation of the selected countries

(A) Shares of companies that achieved product innovation



(B) Shares of companies that achieved process innovation



Notes: 1) "Fiscal year" is used for Japan; "year" is used for other countries.
2) Only the latest data are provided for China and the U.S.

3) Figures are estimates of share among all companies of the survey population. The figures for Japan are estimates of all industries (core) that include only core industries of CIS 2010, thereby matching them to other countries and similar standards for the purpose of international comparison. The figures for Korea are for manufacturing industries, and product innovation refers to manufactured goods only.

Sources: 1) National Institute of Science and Technology Policy, " A report on the Japanese National Innovation Survey 2012 "

2) 2002-2004 figures for Germany, France, the U.K., and Korea and 1999-2001 figures for Japan are quoted from OECD, "Innovation in Firms."

3) Figures for the U.S., China, and Korea are quoted from OECD Science, Technology, and Industry Scoreboard 2013. It should be noted that figures for the U.S. are the results of the 2010 Business R&D and Innovation Survey (BRDIS; survey years 2008-2010); figures for China are results of the Industrial Enterprises Innovation Survey (survey years: 2004-2006); and figures for Korea are results of the 2008 Korean Innovation Survey (survey years: 2005-2007).

4) Figures for the U.K., France, and Germany are quoted from results of CIS 2010 (survey years: 2008 to 2010) that are recorded in the Eurostat database.

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