Research Material-238

Digest of Japanese Science and Technology

Indicators 2015

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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 2015

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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 2015（ABSTRACT）

"Japanese Science and Technology Indicators" is a basic resource for systematically understanding Japan's S&T activities based on objective and quantitative data. It presents S&T activities in Japan using approximately 150 indicators by classifying the activities into five categories; namely, "R&D expenditure," "R&D personnel," "higher education," "the output of R&D," and "science, technology and innovation." This summary presents indicators that have shown changes as well as indicators that deserve attention in "Science and Technology Indicators 2015".

"Japanese Science and Technology Indicators 2015" adds new indicators that show the number of doctorate holders working as a researcher in various sectors and the number of adult learners in a graduate school. Indicators related to research expenditures of universities in major countries has been improved to show the structure of the source of funding more clearly.

The key findings are the following: The level of Japan's gross domestic expenditure on R&D (GERD) as a percentage of GDP is high compared to the benchmarking countries; however Japan is only country that shows the decrease of GDP in the past decade. The percentage of adult learners in the enrollment of a graduate school has been increasing and that causes the changes of composition of students in a graduate school. Scientific papers from Japan remains at the same level in number, however the Japan moves down in rank due to the growth of other countries. Japan keeps large share in the number of patent families, but Korea and China are catching-up in some technology fields.

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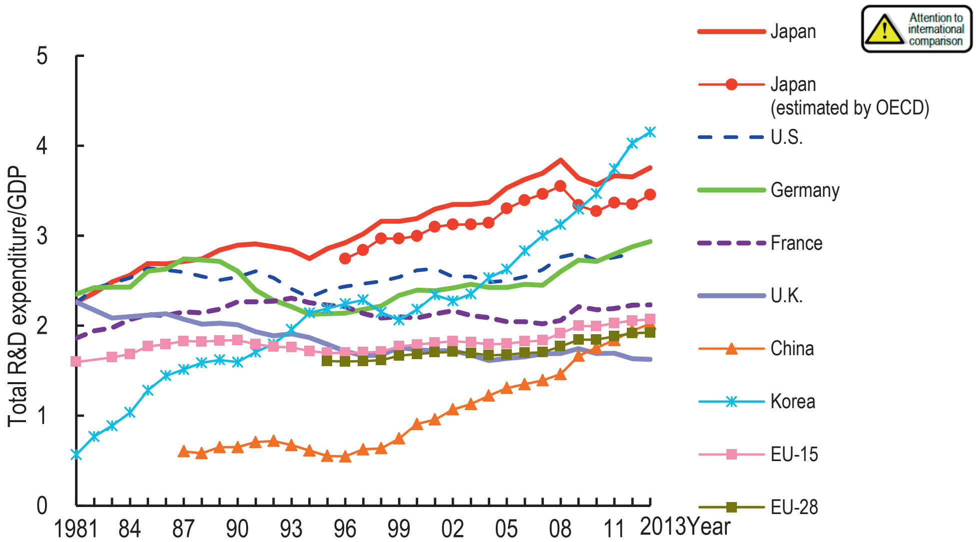
1. Circumstances in Japan and the selected countries in terms of R&D expenditure

(1) Japan's total R&D expenditure/GDP is at a relatively high level among the selected countries. However, the amount of increase in the ratio/GDP compared with 10 years ago included the effects of decline in the GDP.

In the most recent year of 2013, the ratio of Japan's total R&D expenditure/GDP is 3.75% (OECD estimate: 3.45%), which is at a relatively high level among the selected countries. Looking at changes in the last 10 years, the ratios of the total R&D expenditure/GDP in the selected countries have been on an upward trend, except for the U.K. and France. However, during this period, the GDP of Japan has declined, whereas the GDPs of the other countries have been on the increase. For this reason, a certain amount of increase in the ratio of Japan's total R&D expenditure/GDP is attributable to the decline in its GDP. On the other hand, for the United States, Germany, China and Korea, the ratios of their R&D expenditure/GDP have risen, as their economic scales have expanded.

[Summary Chart 1] Trend in the total R&D expenditure/GDP in each selected countries



Reference: Chart 1-1-3, Science and Technology Indicators 2015 (in Japanese)

[Reference] Gross Domestic Products (GDPs) of the selected countries

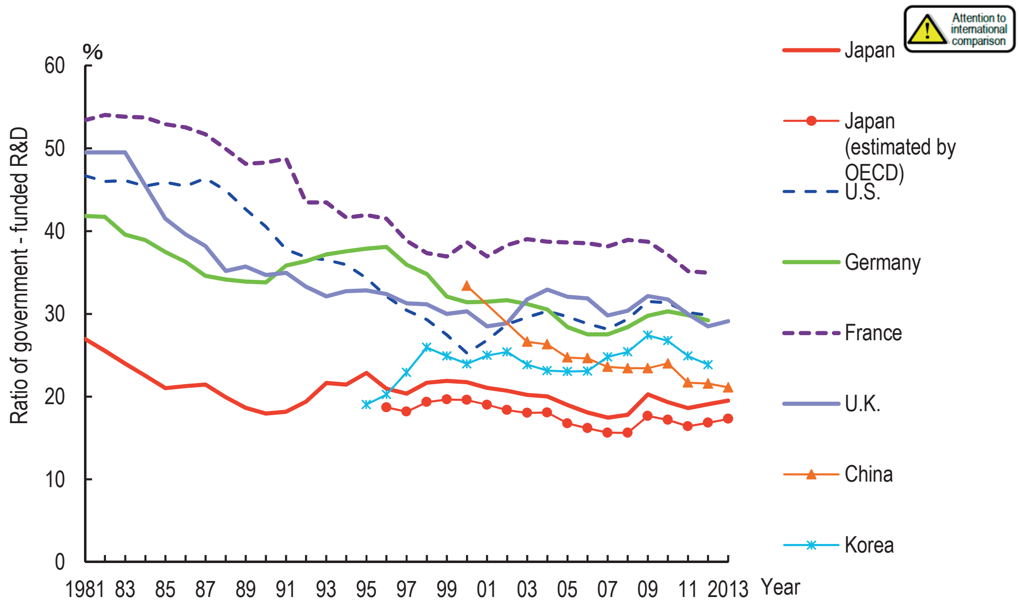
Year	Japan (Billion yen)	U.S. (Billion dollar)	Germany (Billion euro)	France (Billion euro)	U.K. (Billion pound)	China (Billion yuan)	Korea (Billion won)	EU-15 (Billion dollar)	EU-28 (Billion dollar)
2005	505,349.4	13,093.7	2,297.8	1,772.0	1,326.7	18,742.3	919,797.3	12,198.5	13,745.7
2006	509,106.3	13,855.9	2,390.2	1,853.3	1,403.7	22,271.3	966,054.6	13,237.0	14,959.2
2007	513,023.3	14,477.6	2,510.1	1,945.7	1,481.0	26,659.9	1,043,257.8	13,990.3	15,899.7
2008	489,520.1	14,718.6	2,558.0	1,995.9	1,518.7	31,597.5	1,104,492.2	14,551.2	16,623.5
2009	473,933.9	14,418.7	2,456.7	1,939.0	1,482.1	34,877.5	1,151,707.8	14,203.1	16,283.2
2010	480,232.5	14,964.4	2,576.2	1,998.5	1,558.4	40,281.6	1,265,308.0	14,581.3	16,752.4
2011	473,904.8	15,517.9	2,699.1	2,059.3	1,617.7	47,261.9	1,332,681.0	15,153.6	17,461.2
2012	474,474.9	16,163.2	2,749.9	2,091.1	1,655.4	52,939.9	1,377,456.7	15,310.4	17,670.9
2013	483,110.3	16,768.1	2,809.5	2,113.7	1,713.3	58,667.3	1,428,294.6	15,481.6	17,915.6

Note: The GDP of each country is based on 2008SNA (except for Japan and China).
Reference: Statistical Reference C, Science and Technology Indicators 2015 (in Japanese)

(2) The proportion of R&D expenditure that the Japanese Government bears is relatively low among the selected countries.

This section examines the role of governments in terms of R&D expenditure (proportion of government-funding). The country with the largest percentage of government-funded R&D expenditure is France, with 35.0% in 2012. Japan has the lowest percentage among the seven countries shown in the summary chart; in 2013, the percentage of the expenditure funded by the government was 19.5% (OECD estimate: 17.3%). This is due to the fact that the proportion funded by private universities (9.6%, which is considered to be sourced mainly from tuition fees) as well as the proportion funded by business enterprises (69.6%) are high in Japan comparing to the other countries.

[Summary Chart 2] Trend in the ratios of government-funded R&D expenditure in the selected countries

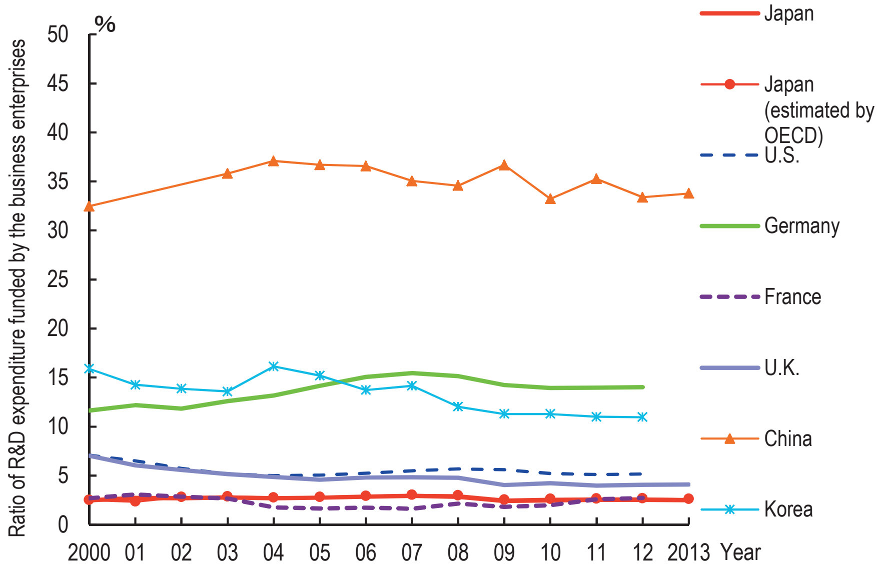


Reference: Chart 1-2-4, Science and Technology Indicators 2015 (in Japanese)

(3) With regard to the R&D expenditure of universities and colleges in Japan, there has not been a significant change in the proportion of the expenditure funded by business enterprises.

The portion of R&D expenditure of universities and colleges that is funded by business enterprises shows no significant change in most of the countries, despite some increase in Germany and some decline in Korea. The situation in the most recent year shows that China is the highest (33.8%), followed by Germany (14.0%), Korea (11.0%), the U.S. (5.2%), the U.K. (4.1%), France (2.7%), and Japan (2.5%; OECD estimate: 2.6%).

[Summary Chart 3] Trend in the ratio of the R&D expenditure of universities and colleges funded by business enterprises



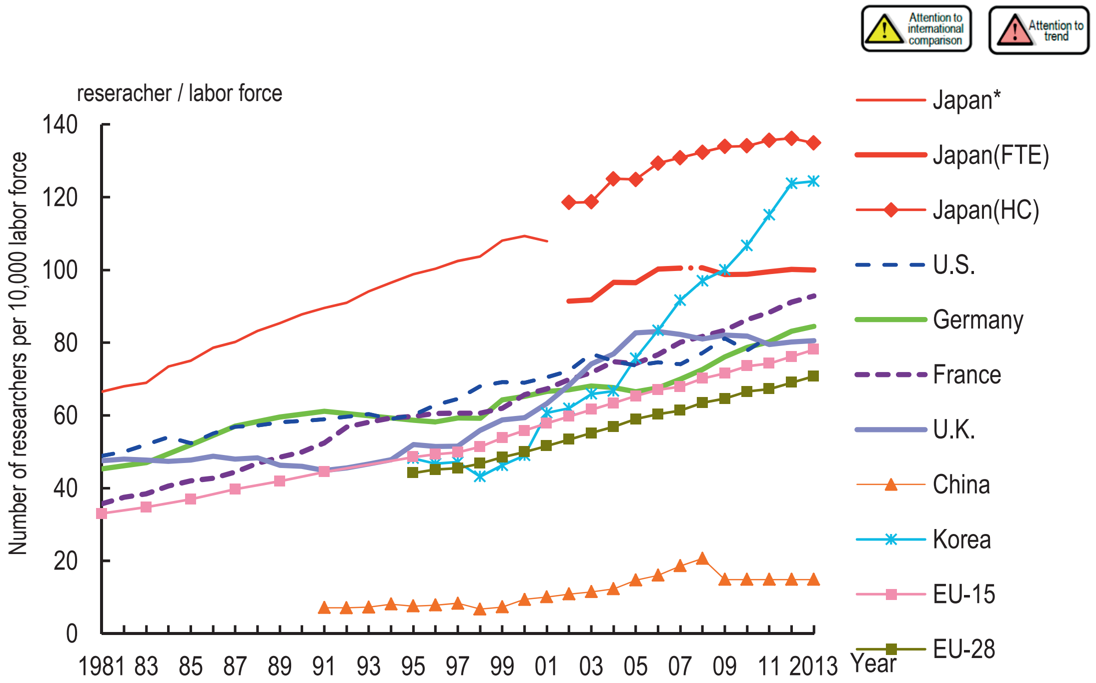
Reference: Chart 1-3-11, Science and Technology Indicators 2015 (in Japanese)

2. The situation in Japan in terms of R&D personnel

(1) The number of researchers per ten thousand labor force in Japan is relatively high among the selected countries. However, the growth of this number has been small in the last 10 years, in comparison with many of the selected countries.

The number of researchers is a key input, along with R&D funds. The number of researchers per ten thousand labor force (FTE[1]) in Japan had been the highest among the selected countries in the early 2000s. However, Korea overtook Japan in 2009. Still, the number in Japan (FTE) remained at a high level among the selected countries as of 2013. However, changes in the number of researchers during the past 10 years show that the number rose in the selected countries except for the U.K. In contrast, the number in Japan (FTE) remained mostly flat. Close observation shows that there has been a particularly significant increase in the number of university and college researchers in Germany, and in the number of corporate researchers in France and Korea.

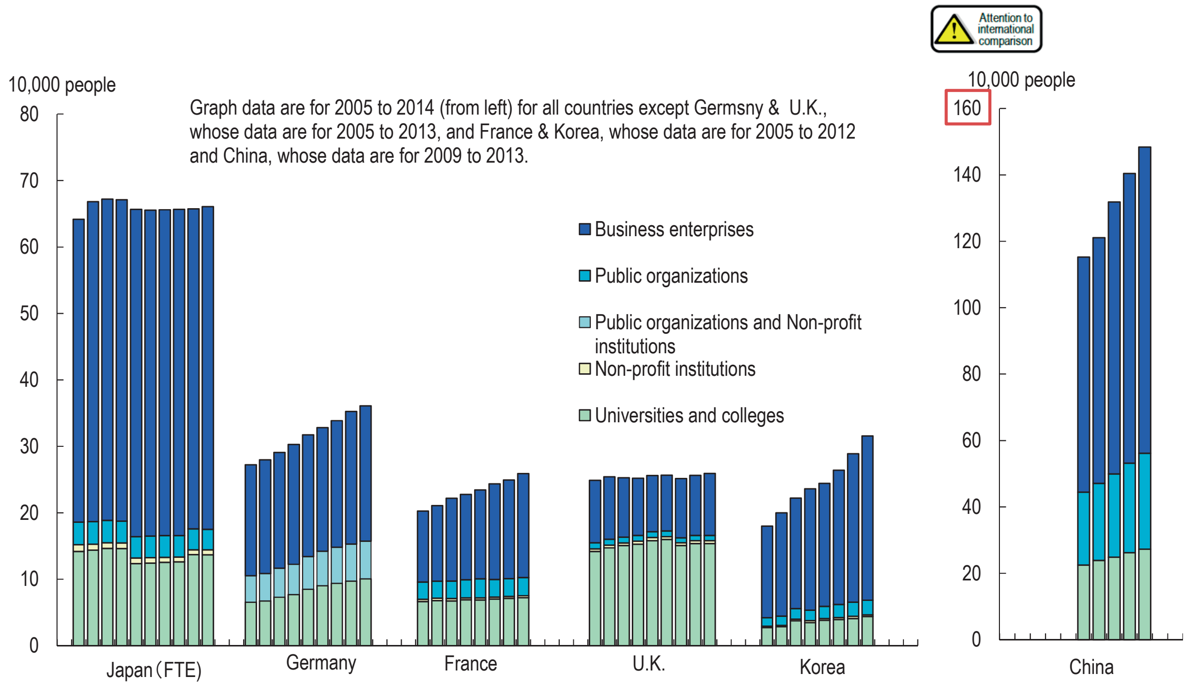
[Summary Chart 4] Trend in the number of researchers per ten thousand labor force



Reference: Chart 2-1-5, Science and Technology Indicators 2015 (in Japanese)

[1]There are two types of methods for counting the number of researchers: by counting the actual number (HC: Head Count) and by taking account of the degree of engagement in research (FTE: full-time conversion). Since the number of researchers is counted on the basis of FTE in the selected countries, it is appropriate that the number in Japan (FTE) be used when comparing it with other countries.

[Summary Chart 5] Trend in the number of researchers by sector

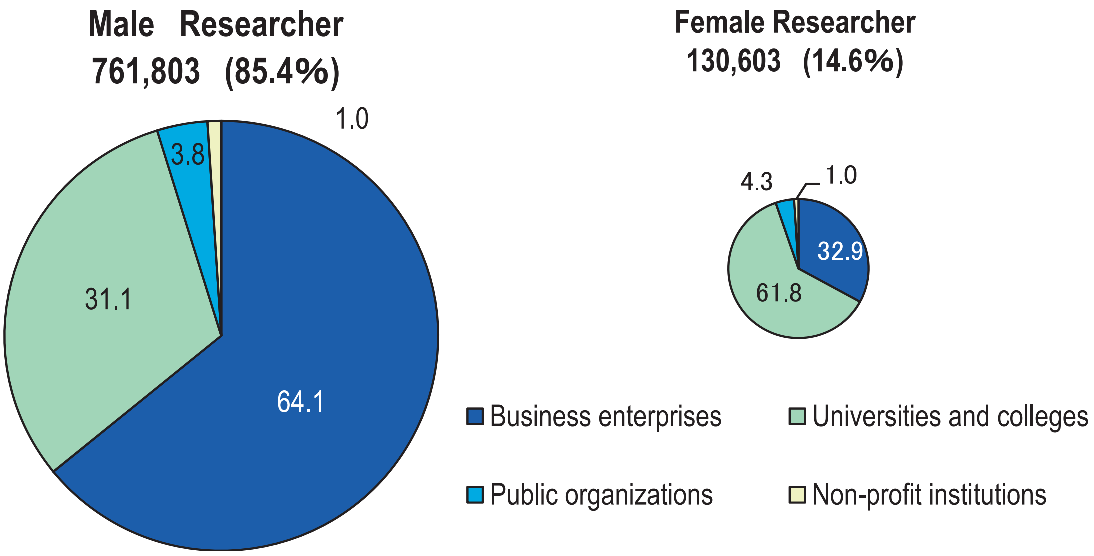


Note: Since the figures of business enterprise sector are only available for the U.S., the trend is not shown.
Reference: Chart 2-1-7, Science and Technology Indicators 2015 (in Japanese)

(2) With regard to Japanese researchers, while many male researchers belong to “business enterprises,” a large number of female researchers belong to “universities and colleges.”

The percentage of female researchers in Japan as of 2014 is 14.6%. On the basis of the percentage of the number of researchers by gender in each sector, the largest number of male researchers belong to “business enterprises” (64.1%), followed by “universities and colleges” (31.1%). On the other hand, the largest number of female researchers belong to “universities and colleges” (61.8%), followed by “business enterprises” (32.9%).

[Summary Chart 6] Percentage of the number of researchers by gender for each sector in Japan (2014)

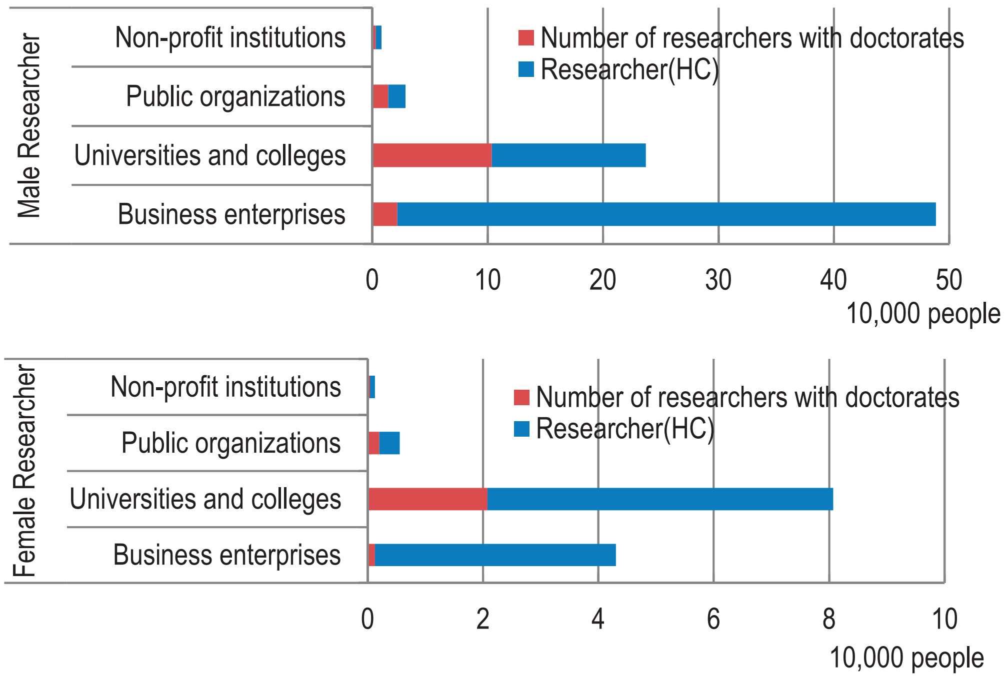


Note: The values are on a head count basis (actual number).
Reference: Chart 2-1-12, Science and Technology Indicators 2015 (in Japanese)

(3) A large number of both male and female researchers with doctorates in Japan belong to "universities and colleges."

Among both male and female researchers in "universities and colleges," the proportion of doctorate holders is high (43.6% for male and 25.7% for female). Meanwhile, the proportion of researchers with doctorates in "business enterprises" is small, with 4.4% for male and 3.0% for female.

[Summary Chart 7] The situation of doctorate holders in each sector by gender (2014)



Note: The values are on a head count basis (actual number).
Reference: Chart 2-1-12, Science and Technology Indicators 2015 (in Japanese)

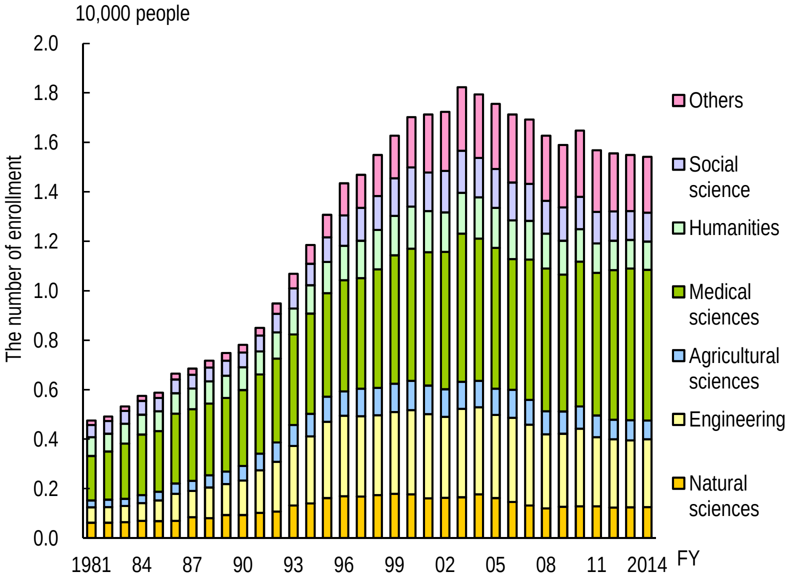
3. The situation in Japan in terms of graduate students

(1) The proportion of adults who aspire to enter doctoral programs at graduate schools is growing.

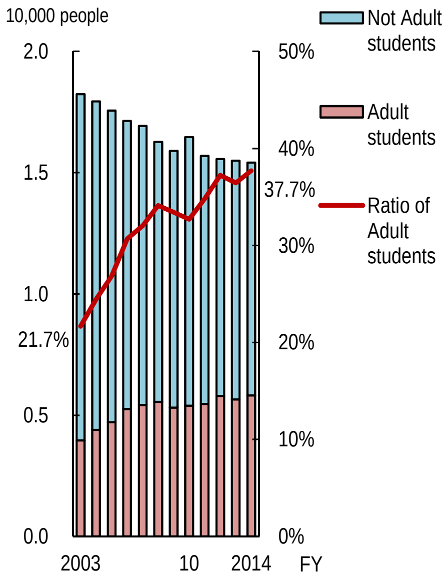
The numbers of students newly enrolled in graduate schools for doctoral programs in Japan began decreasing after having reached a peak in 2003, down to 15 thousand enrollments in 2014. In contrast, the number of adult students newly enrolled in doctoral programs has continued to increase, reaching six thousand enrollments in 2014. The ratio of the total number of adult students newly enrolled in doctoral programs against the total was 21.7% in 2003, and increased roughly twofold to 37.7% in 2014.

[Summary Chart 8] The numbers of new enrollments in graduate schools (doctoral programs)

(A) Trend in the number of new enrollments by major subject (doctoral programs)



(B) Trend in the number of newly enrolled adult students (doctoral programs)



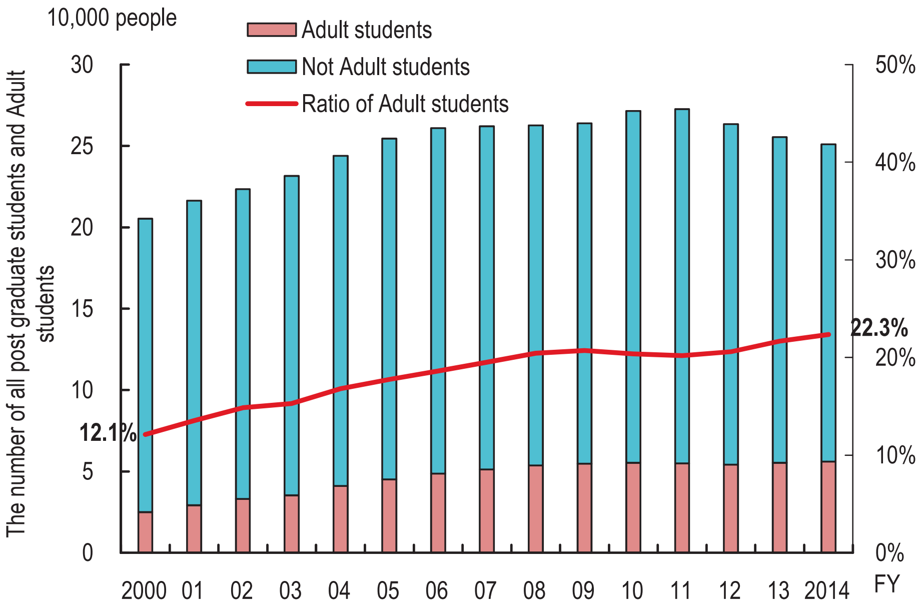
Note: "Adult" refers to persons who have entered into employment to receive routine income such as pay, wage or remuneration as of May 1 of each year; it includes retired employees and housewives.
Reference: Chart 3-2-4, Science and Technology Indicators 2015 (in Japanese)

(2) The composition of students in graduate schools has gone through changes.

In Japan, the proportion of adult graduate students among all the graduate students (currently enrolled in) was 12.1% in 2000, but increased roughly twofold to 22.3% in 2014.

The total number of graduate students had been rising until 2010, along with the number of adult graduate students. However, the former number started declining after having reached a peak in 2011, and the degree of increase in the latter number started shrinking. By field, the number of adult graduate students in master's and doctoral programs in natural sciences has been on a downward trend since around 2005.

[Summary Chart 9] The situation of adult graduate students (enrolled in programs) in Japan



Note: 1) Graduate students in this section mean those persons who are registered in a master's program or the preliminary term of a doctoral program, a doctoral program or the latter term of a doctoral program, or a professional graduate program.
2) "Adult" refers to persons who have entered into employment to receive routine income such as pay, wage or remuneration as of May 1 of each year; it includes retired employees and housewives.
Reference: Charts 3-2-7 and 3-2-5, Science and Technology Indicators 2015 (in Japanese)

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

(1) Despite the fact that the volume of papers produced in Japan has remained at the same level in last 10 years, Japan has dropped in rank due to increase in the volume of papers produced by other countries.

The number of papers produced in Japan (the average from 2011-2013 [PY]) ranks Japan third behind the U.S. and China on the basis of fractional counting that takes account of the degree of contribution to the production of papers. In terms of the number of adjusted top 10% papers in citations, Japan ranked sixth behind the U.S., China, the U.K., Germany, and France. In terms of the number of adjusted top 1% papers, Japan ranked seventh behind the U.S., China, the U.K., Germany, France, and Canada.

Despite the fact that the volume of papers produced in Japan has remained at the same level in last 10 years, it is clear that Japan has dropped in rank due to increase in the volume of papers produced by other countries. This trend is particularly notable in adjusted top 10% papers and adjusted top 1% papers.

[Summary Chart 10] Number of papers by country/region, and number of hot papers (top 10% and top 1%): top 10 countries/regions (fractional counting)

All fields	1991 — 1993年 (PY) (Average)		
	The number of papers		
	Fractional counting		
Country/Region	The number of papers	Share	World rank
U.S.	178,302	32.7	1
Japan	43,652	8.0	2
U.K.	39,755	7.3	3
Germany	36,843	6.8	4
France	28,058	5.1	5
Russia	26,834	4.9	6
Canada	22,532	4.1	7
Italy	16,150	3.0	8
India	11,364	2.1	9
Netherlands	10,768	2.0	10

All fields	2001— 2003年 (PY) (Average)		
	The number of papers		
	Fractional counting		
Country/Region	The number of papers	Share	World rank
U.S.	206,916	26.8	1
Japan	66,635	8.6	2
Germany	50,859	6.6	3
U.K.	49,560	6.4	4
France	36,604	4.7	5
China	35,147	4.5	6
Italy	27,530	3.6	7
Canada	24,763	3.2	8
Russia	20,253	2.6	9
Spain	19,341	2.5	10

All fields	2011 — 2013年 (PY) (Average)		
	The number of papers		
	Fractional counting		
Country/Region	The number of papers	Share	World rank
U.S.	263,133	21.0	1
China	163,891	13.1	2
Japan	64,843	5.2	3
Germany	63,087	5.0	4
U.K.	57,433	4.6	5
France	44,455	3.5	6
India	43,034	3.4	7
Italy	40,763	3.3	8
South Korea	40,323	3.2	9
Canada	37,809	3.0	10

All fields	1991 — 1993年 (PY) (Average)		
	The number of adjusted top 10% papers		
	Fractional counting		
Country/Region	The number of papers	Share	World rank
U.S.	27,545	50.6	1
U.K.	4,494	8.2	2
Japan	3,141	5.8	3
Germany	3,034	5.6	4
Canada	2,494	4.6	5
France	2,428	4.5	6
Netherlands	1,325	2.4	7
Italy	1,196	2.2	8
Australia	1,062	1.9	9
Sweden	998	1.8	10

All fields	2001— 2003年 (PY) (Average)		
	The number of adjusted top 10% papers		
	Fractional counting		
Country/Region	The number of papers	Share	World rank
U.S.	31,430	40.8	1
U.K.	6,042	7.8	2
Germany	5,196	6.7	3
Japan	4,561	5.9	4
France	3,549	4.6	5
Canada	2,816	3.7	6
Italy	2,337	3.0	7
China	2,313	3.0	8
Netherlands	1,858	2.4	9
Australia	1,722	2.2	10

All fields	2011 — 2013年 (PY) (Average)		
	The number of adjusted top 10% papers		
	Fractional counting		
Country/Region	The number of papers	Share	World rank
U.S.	38,509	30.8	1
China	15,062	12.0	2
U.K.	7,983	6.4	3
Germany	7,711	6.2	4
France	4,932	3.9	5
Japan	4,471	3.6	6
Italy	4,270	3.4	7
Canada	4,230	3.4	8
Australia	3,612	2.9	9
Spain	3,518	2.8	10

All fields	1991 — 1993年 (PY) (Average)		
	The number of adjusted top 1% papers		
	Fractional counting		
Country/Region	The number of papers	Share	World rank
U.S.	3,113	57.1	1
U.K.	440	8.1	2
Germany	294	5.4	3
Japan	257	4.7	4
Canada	230	4.2	5
France	213	3.9	6
Netherlands	120	2.2	7
Switzerland	100	1.8	8
Australia	96	1.8	9
Italy	90	1.6	10

All fields	2001— 2003年 (PY) (Average)		
	The number of adjusted top 1% papers		
	Fractional counting		
Country/Region	The number of papers	Share	World rank
U.S.	3,802	49.3	1
U.K.	633	8.2	2
Germany	485	6.3	3
Japan	363	4.7	4
France	296	3.8	5
Canada	254	3.3	6
China	190	2.5	7
Italy	179	2.3	8
Netherlands	176	2.3	9
Switzerland	150	1.9	10

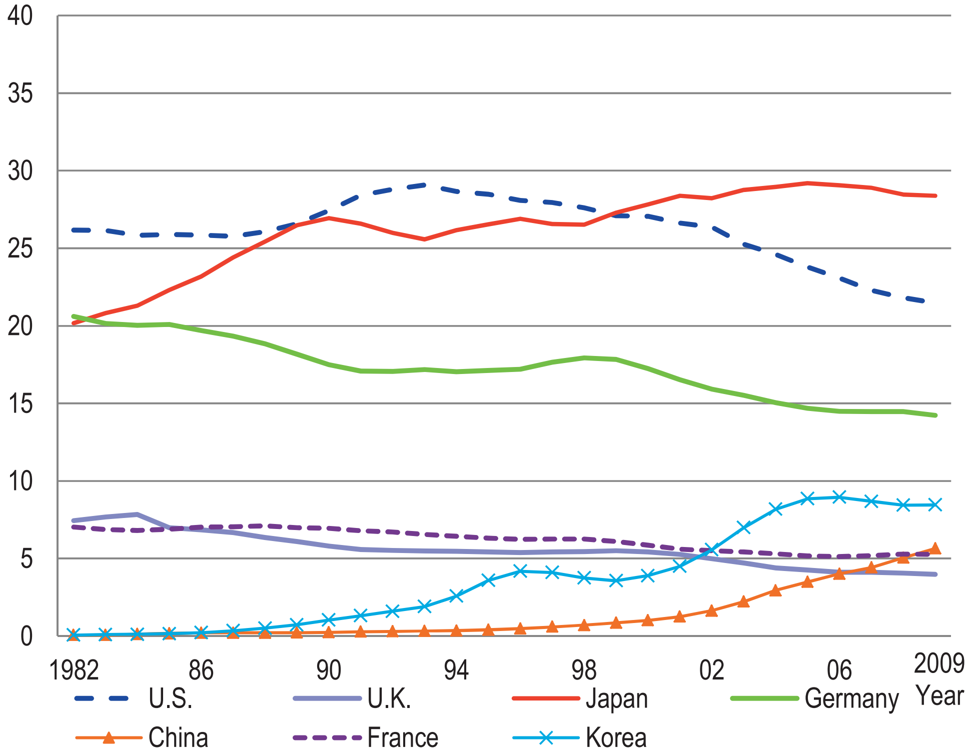
All fields	2011 — 2013年 (PY) (Average)		
	The number of adjusted top 1% papers		
	Fractional counting		
Country/Region	The number of papers	Share	World rank
U.S.	4,613	36.8	1
China	1,405	11.2	2
U.K.	880	7.0	3
Germany	749	6.0	4
France	459	3.7	5
Canada	419	3.3	6
Japan	367	2.9	7
Australia	365	2.9	8
Italy	311	2.5	9
Spain	310	2.5	10

Note: The analysis targeted articles and reviews. Publication years (PYs) were used for annual aggregation. For the number of times cited, the values as of the end of 2014 were used.
Reference: Chart 4-1-6, Science and Technology Indicators 2015 (in Japanese)

(2) While Japan has maintained a high share of the number of patents (the number of patent families) for the last 10 years, Korea and China are catching up with Japan in some technological fields.

The number of patents is examined based on the counting of patent families, which is measured with the number of inventions produced by each country and region in an internationally comparable form. Looking at shares of the number patent families, Japan overtook the U.S. during the second half of the 1990s and Japan maintained the top share in the 2000s. This reflects the fact that the number of patent applications submitted from Japan to multiple countries increased. China's share has continued to increase, moving up to fifth place in 2009.

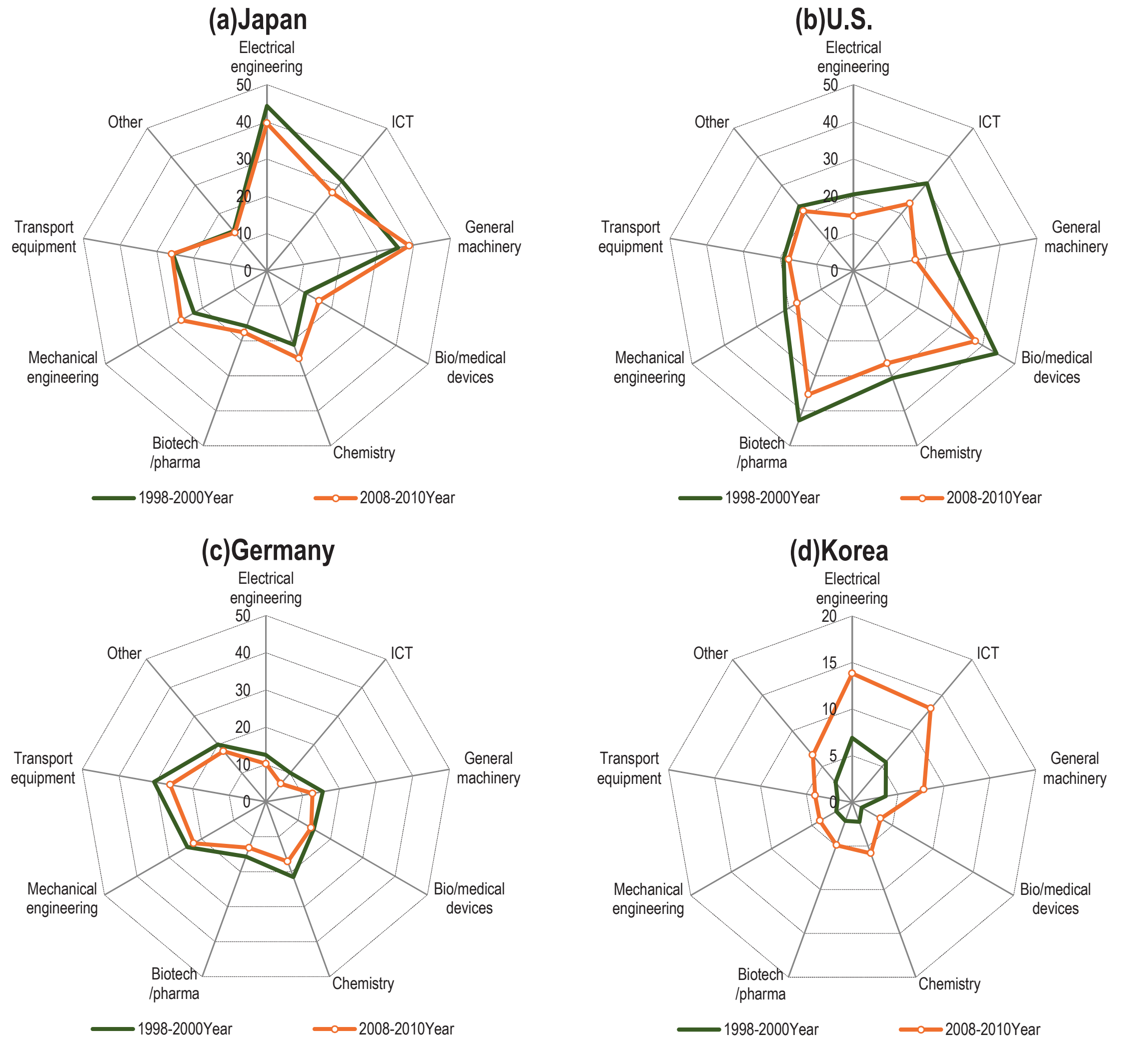
[Summary Chart 11] Shares of the number of patent families in the selected countries (whole counting)



Note: Three-year moving averages of shares of the number of patent families in all technological fields (for 2009, the average of 2008, 2009 and 2010)
Reference: Chart 4-2-6 (B), Science and Technology Indicators 2015
(in Japanese)

Japan's technology field balance among patent families shows that 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. Changes over time indicate that Japan's shares of electrical engineering and information and communication technology have been on a downward trend, with increase in the number of Korea's and China's patent families. With regard to transport equipment, mechanical engineering, and chemistry, although Japan's shares do not stand out much, they are roughly at the same level as Germany's and the U.S.'s shares. Similarly, in comparison with the shares 10 years ago, Japan's shares have been at the same level or slightly higher.

[Summary Chart 12] Comparison of shares of the number of patent families for each technological field (%, 1998-2000 and 2008-2010, whole counting)



Note: "Patent family" refers to a group of patent applications made to two or more countries that are tied directly or indirectly by priority rights. Ordinarily, patents for which applications with the same content are made to multiple countries belong to the same patent family.
Reference: Chart 4-2-10, Science and Technology Indicators 2015 (in Japanese)

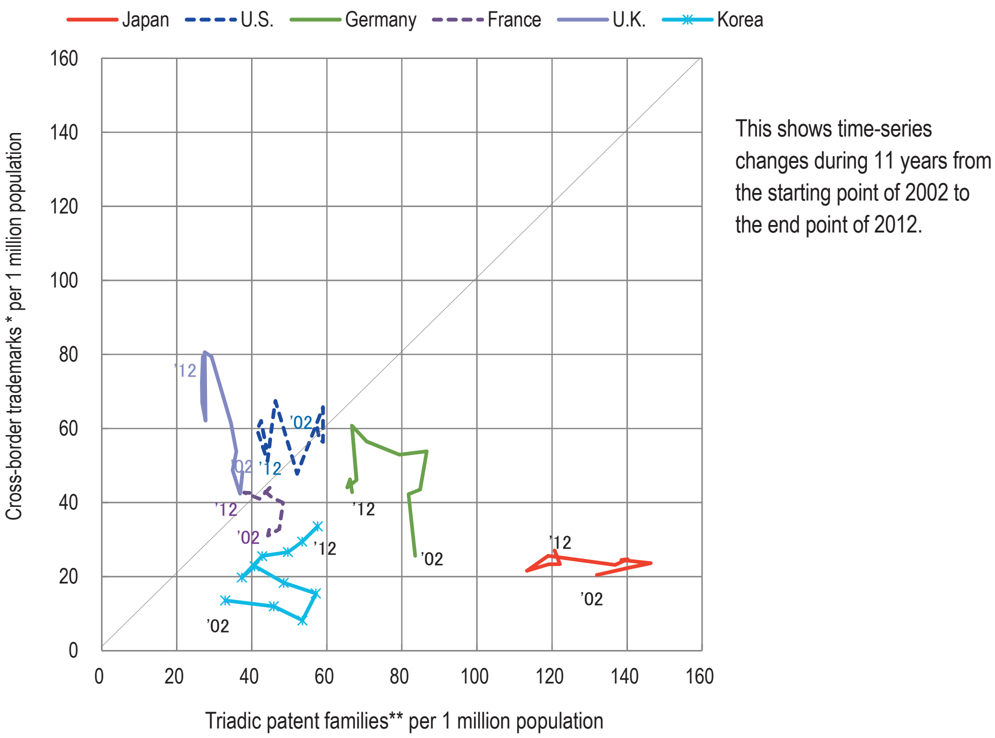
5. Circumstances in Japan and the selected countries in terms of science, technology, and innovation

(1) Although Japan's strength lies in technology, it has not expanded such technology in the form of introducing new products and services on an international scale, as much as the other selected countries have.

Although the analysis of patents indicates that technology is Japan's strength, it is not clear whether such strength has led to new products and the like. To ascertain this, the number of transnational trademark applications and the number of patent applications (triadic patent families) is analyzed. In this analysis, the number of trademark applications is used as an indicator relating to the situation of the introduction of new products and services overseas, and the number of patent applications as an indicator to measure technological levels of countries.

The balance between the number of trademark applications and the number of patent applications indicates that Japan, Germany and Korea have a larger number of patent applications than their respective numbers of trademark applications. Notably, Japan shows a strong trend of this kind with no significant change for 11 years from 2002 to 2012. Therefore, although Japan's strength lies in technology, it has not, as a whole, expanded such technology in the form of introducing new products and services on an international scale, as much as the other selected countries have.

[Summary Chart 13] Cross-border trademark applications* and patent applications (per 1 million population)**



Note: 1)* For the definition of cross-border trademarks, "Measuring Innovation: A New Perspective" released by the OECD was followed. The specific definition is as follows.

・The number of trademarks in Japan, Germany, France, the U.K. and Korea is the number filed with the U.S. Patent and Trademark Office (USPTO).

・The number of trademarks for the U.S. is the average of (i) and (ii).

(i) The corrected number of the U.S. applications, based on the ratio of Japanese and the U.S. applications to the Office for Harmonization in the Internal Market (OHIM) = (number of the U.S. applications to the OHIM / number of Japanese applications to the OHIM) × number of Japanese applications to the USTPO

(ii) The corrected number of the U.S. applications, based on the ratio of European and the U.S. applications to the Japan Patent Office (JPO) = (number of the U.S. applications to the JPO / number of EU-15 applications to the JPO) × number of EU-15 applications to the USTPO

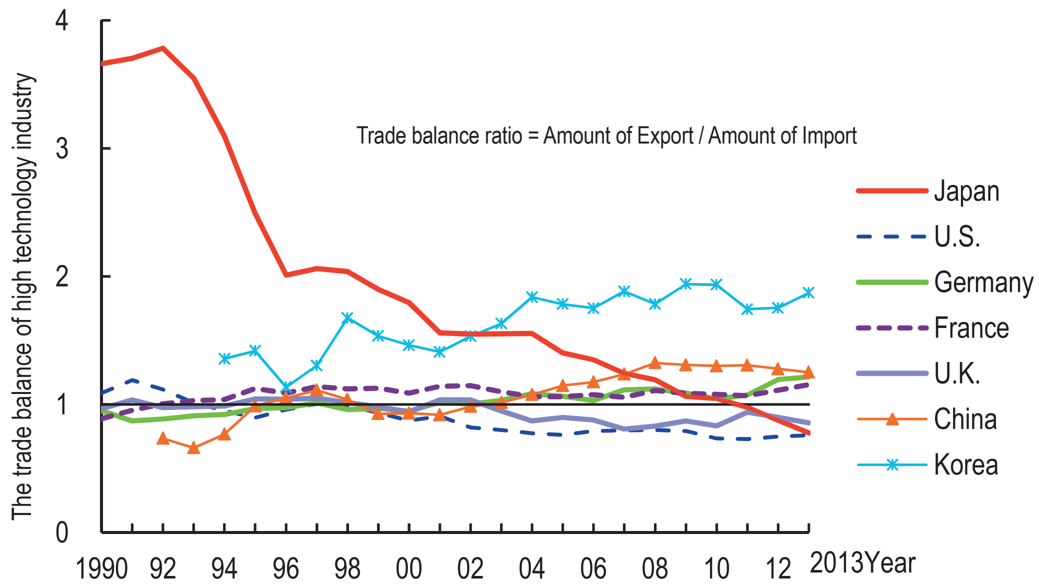
2)**Cross-border patent applications mean the number of triadic patent families (patents with the same content submitted to Japan, the U.S. and Europe).

Reference: Chart 5-3, Science and Technology Indicators 2015 (in Japanese)

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

Last of all, looking at high-technology industrial competitiveness from the standpoint of products and services trade balance, Japan's trade balance continues to fall. Its balance ratio has been below 1 since 2011 and it has had an import surplus. Its balance ratio in 2013 was 0.78. By industry, Japan's Computer, electronic and optical had its first import surplus of approximately nine billion US dollars in 2013, despite continuous export surplus until then. Further, its pharmaceuticals continue to have an import surplus; in 2013, this industry had an import surplus of approximately 18 billion US dollars.

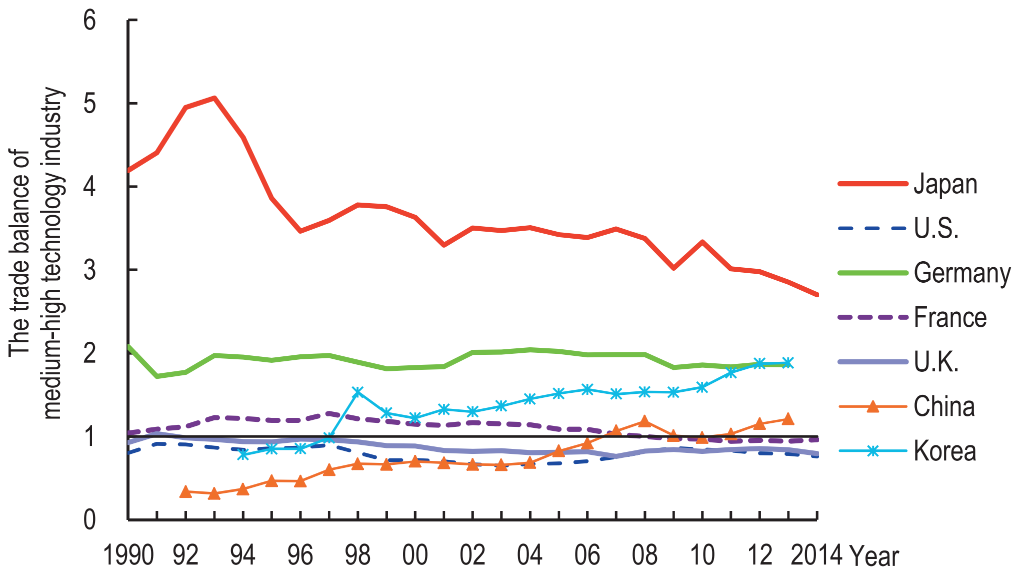
[Summary Chart 14] Changes in the trade balance ratios for high-technology industries in the selected countries



Note: High-technology industries refer to "Pharmaceutical," "Computer, electronic and optical," and "Aerospace,"
Reference: Chart 5-2-3, Science and Technology Indicators 2015 (in Japanese)

On the other hand, Japan's medium high-technology trade balance ratio in 2014 was 2.70, ranking 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. By industry, as of 2014, Japan had an export surplus of approximately 120 billion US dollars in the industry of motor vehicles, trailers and semi-trailers, and an export surplus of approximately 81 billion US dollars in the industry of machinery and equipment n.e.c.

[Summary Chart 15] Changes in the trade balance ratios for medium high-technology industries in the selected countries



Note: Medium high-technology industries refer to “Chemicals and chemical products,” “Electrical equipment,” “Machinery and equipment n.e.c.,” “Motor vehicles, trailers and semi-trailers,” “Railroad equipment and transport equipment n.e.c.,” and “Other.”
Reference: Chart 5-2-5, Science and Technology Indicators 2015 (in Japanese)

Characteristics of the Japanese Science and Technology Indicators

The Japanese Science and Technology Indicators is published annually to present the most recent statistics/indicators at the time of publication. Items that allow time-series comparisons as well as comparisons among the selected countries based on data that are updated each year in principle are collected.

Use of original statistical data published by authorities in each country

Wherever possible, statistical data published by authorities in 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.

NISTEP conducted analysis of paper and patent databases

Paper data were independently aggregated and analyzed by NISTEP using Thomson Reuters Web of Science.

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).

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

The reminder marks "attention to international comparison" 

and "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.

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