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Indicators 2018

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Japanese Science and Technology Indicators 2018 (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, such as R&D Expenditure; R&D Personnel; Higher Education and S&T personnel; Output of R&D; and Science, Technology, and Innovation; and shows the state of Japanese science and technology activities with approximately 160 indicators. The report is published annually and shows the latest results of the analyses of scientific publications and patent applications conducted by the NISTEP.

This edition of "Science and Technology Indicators 2018" includes new indicators such as "the percentage of non-permanent researchers at Japanese universities and colleges," "trial analysis on the trend of papers in social sciences," "relationship between paper-to-paper citations and paper-to-patent family citations," "patent application trends in automobile manufacturing industry." In total, 21 indicators were newly introduced or visualization methods were revised. Also, in the commemoration of the 30th anniversary of NISTEP, a special column on episodes, etc. from the birth to the development stage of science and technology indicators is included (only available in Japanese).

Overviewing the latest Japan's situation from "Science and Technology Indicators 2018," it was found that the R&D expenditure and the number of researchers in Japan are the third largest in major countries (Japan, U.S., Germany, France, U.K., China and Korea). The number of papers in Japan (fraction counting method) is the fourth in the world and the number of papers with high citations is the ninth. Japan continues to be the world first place in the patent family (patent applications to more than two countries). These trends continue from the previous edition. The number of collaborative research between Japanese universities and business enterprises and the amount of research funding received steadily increase. Although the number of papers produced by the business enterprises is decreasing, the proportion of the number of industry-academia collaborative papers among them has increased, and therefore the weight of universities in research activities of business enterprises that produce papers is increasing.

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1. R&D expenditure: circumstances in Japan and the selected countries

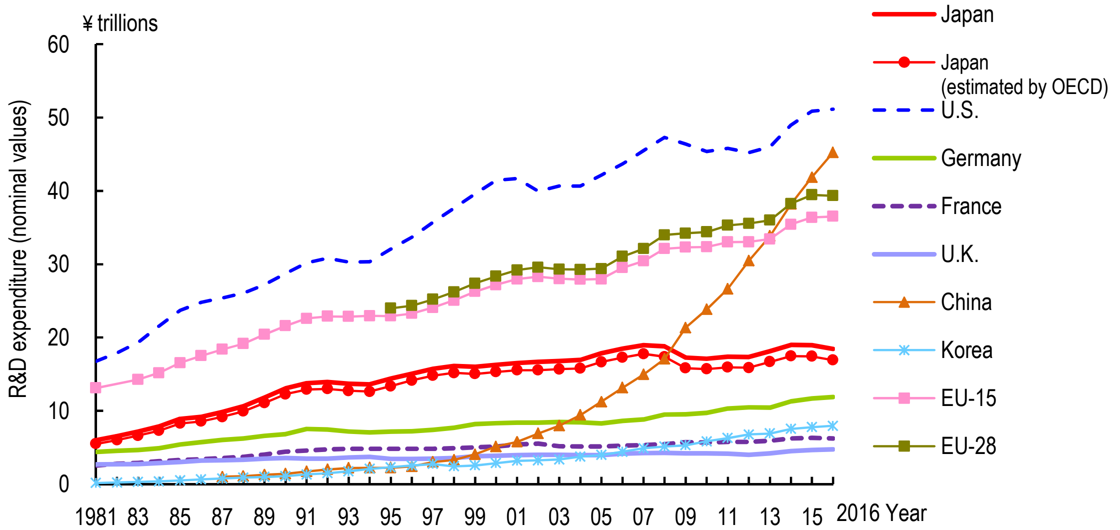
(1) Japan's total R&D expenditure was 18.4 trillion yen in 2016 (OECD-estimate for Japan: 16.9 trillion yen), the world's third largest after the United States and China. The business enterprises accounted for a large part of the total R&D expenditure in all of the selected countries.

Japan's total R&D expenditure was 18.4 trillion yen in 2016 (OECD-estimate for Japan: 16.9 trillion yen), down 2.7% from the previous year (OECD-estimate for Japan: -3.0%). The United States' total R&D expenditure was 51.1 trillion yen in the same year, maintaining the world's largest scale. The R&D expenditure of China reached 45.2 trillion yen in 2016, exceeding that of the EU that shows a long-term growth.

The business enterprises sector accounted for the largest percentage of R&D expenditure in all of the selected countries. This tendency is particularly notable in Asian countries, whereas differences between the business enterprises sector and other sectors are relatively small in major European countries.

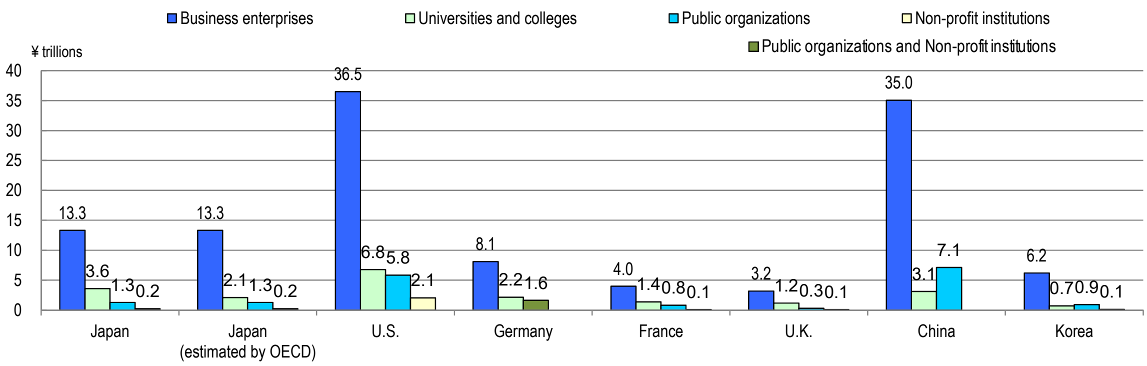
[Summary Chart 1] Changes in total R&D expenditure in the selected countries: nominal values (converted using OECD purchase power parities data)

Attention to international comparison



Reference: Chart 1-1-1, Japanese Science and Technology Indicators 2018 (in Japanese)

[Summary Chart 2] R&D expenditure by sector in the selected countries (2015): nominal values (converted using OECD purchase power parities data)

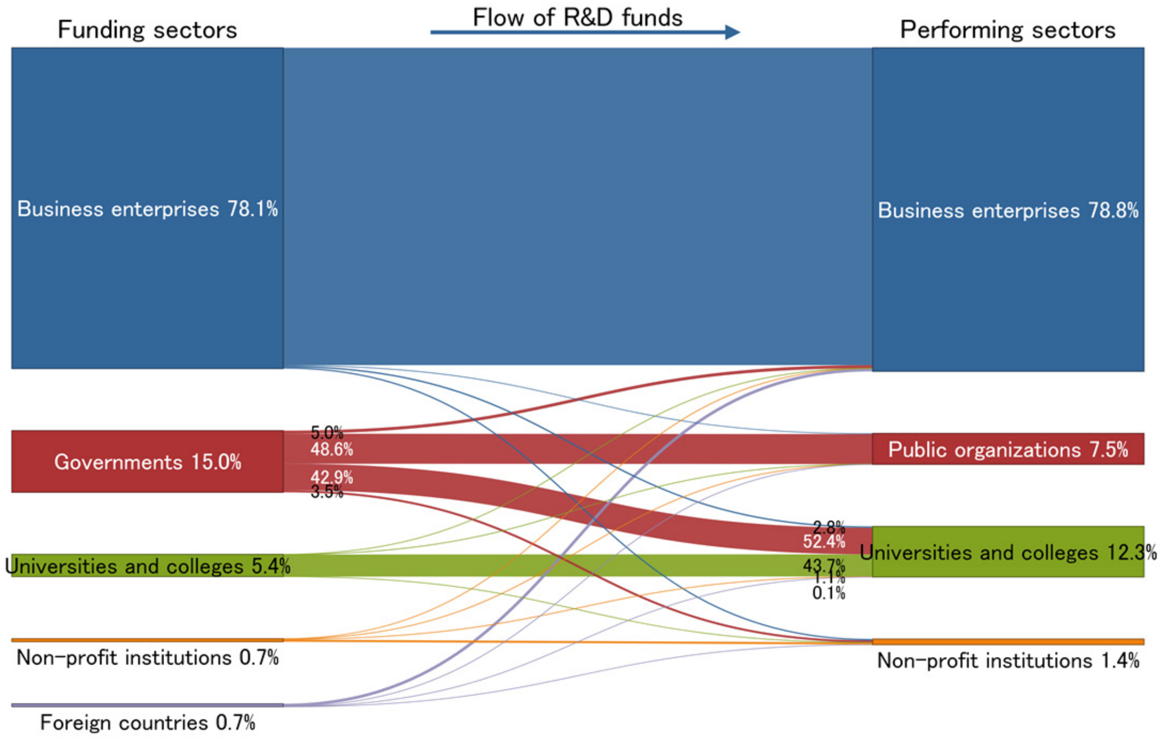


Reference: Chart 1-1-6, Japanese Science and Technology Indicators 2018 (in Japanese)

(2) In Japan, the "business enterprises" is the largest funding sector and is also the largest performing sector. The flow from "business enterprises" to "universities and colleges" is small, accounting only for 2.8% of the entire amount used in the "universities and colleges."

According to the flow of R&D funds from funding sectors to performing sectors in Japan (with reference to OECD estimates), "business enterprises" contribute to the largest proportion of the funds, and most of the funds flow to "business enterprises." The flow from "business enterprises" to "universities and colleges" is small, accounting only for 2.8% of the entire amount used in the "universities and colleges." As for the R&D funds from "governments" to other sectors, the flow of such funds to "public organizations" is the largest with 48.6%, followed by "universities and colleges" with 42.9%.

[Summary Chart 3] Flow of R&D funds from funding sectors to performing sectors in Japan (estimated by the OECD) (2016)

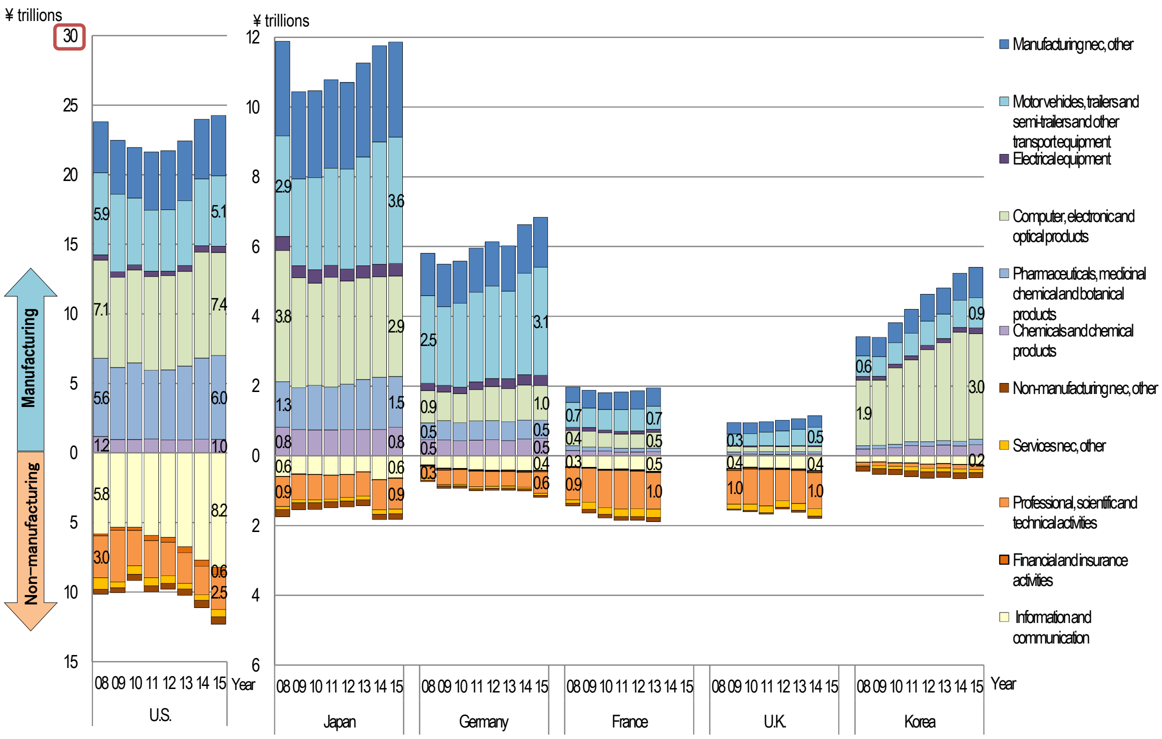


Reference: Chart 1-1-5, Japanese Science and Technology Indicators 2018 (in Japanese)

(3) In the manufacturing industry of Japan, R&D expenditure in the “motor vehicles, trailers and semi-trailers and other transport equipment” has been growing, reaching 3.6 trillion yen in 2015, in contrast to a decline in the “computer, electronic and optical products.”

In the United States, R&D expenditure in both manufacturing and non-manufacturing industries shows the steady growth, with a marked increase in the “information & communication.” In Japan, Germany and Korea, the volume of R&D expenditure of the non-manufacturing industry tends to be small relative to the manufacturing industry. Germany saw growths in both the manufacturing and non-manufacturing industries, although not by as much as in the United States. The volume of the non-manufacturing industry tends to be greater in France and United Kingdom than in other countries.

[Summary Chart 4] Business enterprise R&D expenditure by industry in the selected countries



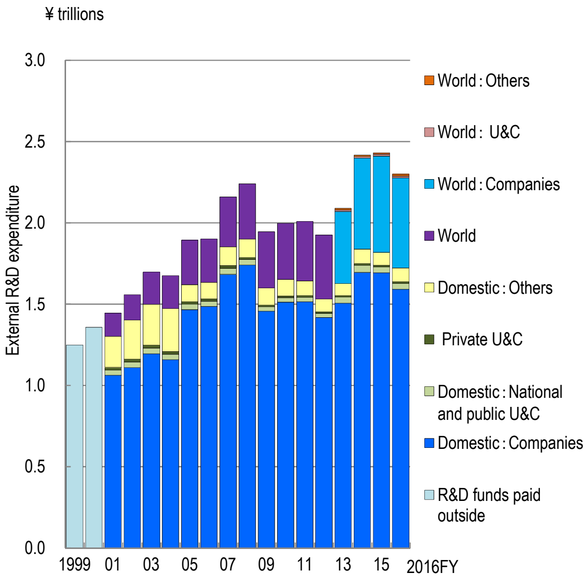
Note: 1) The chart complies with the International Standard Industrial Classification Rev. 4 (ISIC Rev. 4).
2) The figures in individual countries are classified according to the main economic activities of business enterprises engaged in R&D.
3) The figures for the United States do not include amounts in the “agriculture, forestry, fishing and hunting” or “public administration” category, which makes the country’s non-manufacturing statistics different from those of other countries. For this reason, care is needed when making international comparisons.
Reference: Chart 1-3-6, Japanese Science and Technology Indicators 2018 (in Japanese)

(4) The external R&D expenditure of Japanese enterprises has been rising over the long term; the degree of rise is relatively large in the overseas spending. Much of the external R&D funding to universities is directed toward national and public universities and colleges in Japan.

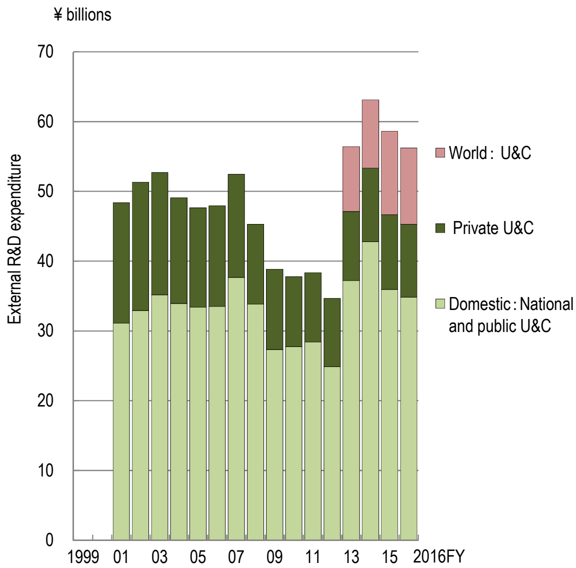
The R&D expenditure spent outside by Japanese enterprises has been expanding over the long term. The growth rate is large in overseas spending rather than in domestic spending. For both overseas and domestic expenditure, external funding to business enterprises accounts for the largest segment, according to its breakdown. For R&D expenditure directed toward universities, funding to national and public universities and colleges in Japan accounted for the largest share in FY2016, followed by universities and colleges in abroad and private universities and colleges in Japan.

[Summary Chart 5] Changes in the external R&D expenditure of Japanese business enterprise

(A) Breakdown of external R&D expenditure



(B) Breakdown of external R&D expenditure spent on universities and colleges



Note: 1) Aggregated values are available only for FY1999 and FY2000. The recording of external R&D expenditure outside Japan broken down by business enterprises, universities and colleges and others began in FY2013.
2) Data on universities and colleges in the world prior to FY2012 are not shown in Summary Chart 5 (B).
3) Please note that some of the R&D expenditure paid to a parent company and its subsidiaries outside Japan may have been spent on local universities and colleges as part of R&D efforts by the parent company or subsidiary concerned.
Reference: Chart 1-3-11, Japanese Science and Technology Indicators 2018 (in Japanese)

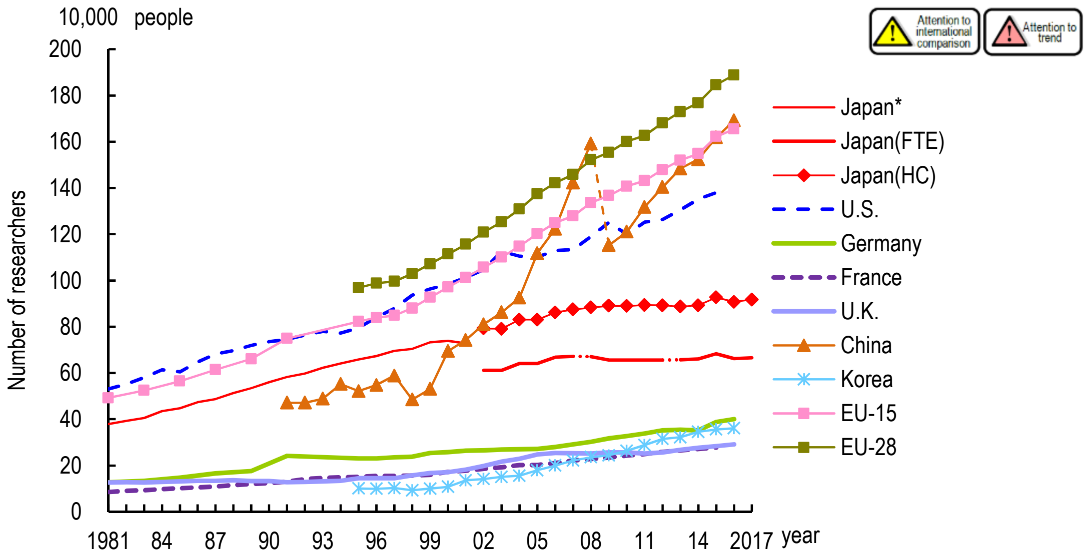
2. R&D personnel: circumstances in Japan and the selected countries

(1) The number of researchers in Japan was 666,000 in 2016, the third largest scale in the world after China and the United States.

The number of researchers is as important as the amount of R&D funds. The number of researchers in Japan was 666,000 in 2017 (the head count is 918,000), the third largest scale in the world after China and the United States. The number of researchers in Korea has exceeded those of France and the United Kingdom since 2010, reaching the same level as that of Germany in the most recent year.

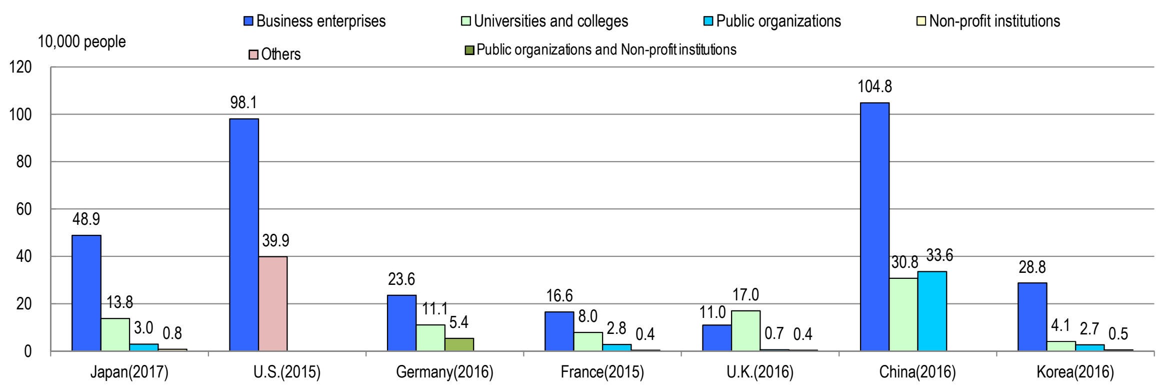
The number of researchers in the business enterprises sector is the highest in most of the selected countries, as is the case for R&D expenditure. However, for the United Kingdom, the largest number of researchers is found in the university and college sector.

[Summary Chart 6] Changes in the number of researchers in the selected countries



Note: China's definition of a researcher up to 2008 was not fully compatible with the OECD's definition, and consequently its method of measurement was changed in 2009. For that reason, there is a break between the years leading up to 2008 and 2009 onward.
Reference: Chart 2-1-3, Japanese Science and Technology Indicators 2018 (in Japanese)

[Summary Chart 7] The number of researchers by sector in the selected countries

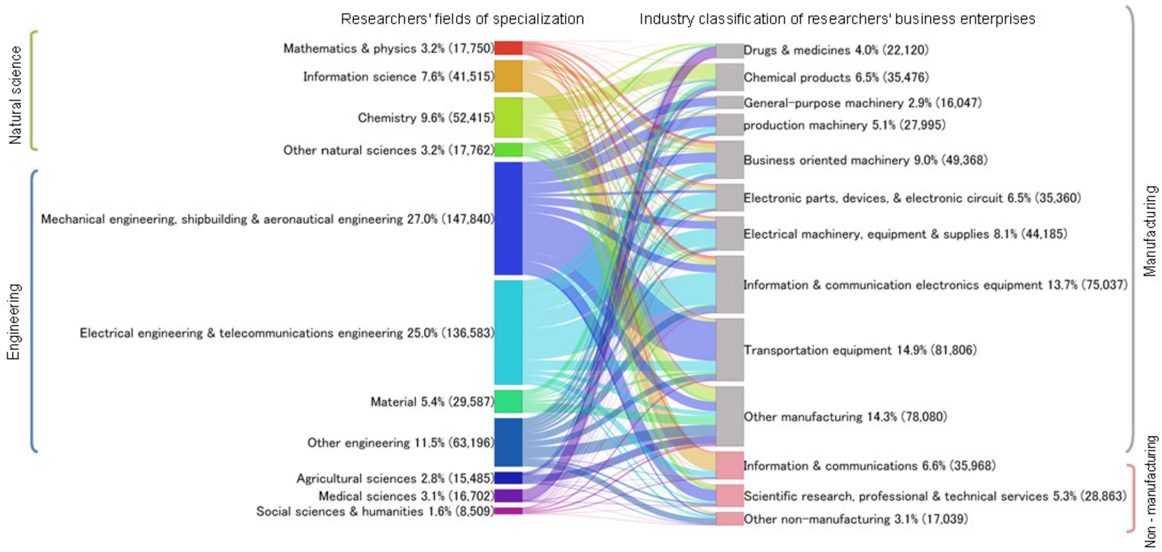


Note: 1) All the countries are based on FTE values.
2) The values of the U.S. are those estimated by the OECD. Since no value for recent years is available aside from those for the business enterprise sector, the values shown pertain to business enterprises and other sectors.
Reference: Chart 2-1-7, Japanese Science and Technology Indicators 2018 (in Japanese)

(2) Researchers with engineering-related specialized knowledge account for a large proportion in the manufacturing industry of Japan.

As for the fields of specialization of researchers in each industry classification, the number of researchers specializing in the "mechanical engineering, shipbuilding & aeronautical engineering" field is large in the "transportation equipment manufacturing industry," which holds the largest number of researchers in the manufacturing industry. In the "information & communication electronics equipment manufacturing industry," a large number of researchers specialize in the field of "electrical engineering & telecommunications engineering." Meanwhile, in the non-manufacturing industry, the number of researchers specializing in the field of "information science" is large in the "information & communication industry." The number of researchers specializing in "information science" is small in other industry classifications.

[Summary Chart 8] Fields of specialization of researchers affiliated in business enterprises in Japan (2017)

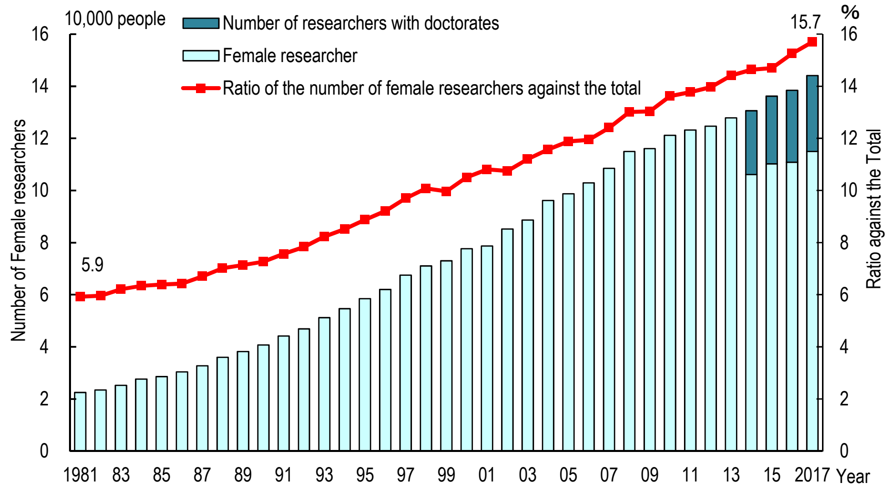


Note: Parentheses indicate the numbers of researchers in the head count.
Reference: Chart 2-2-8, Japanese Science and Technology Indicators 2018 (in Japanese)

(3) In Japan, the number of female researchers, which totaled to 144,126 in 2017, is increasing steadily. In all countries, the proportion of female researchers remains low in the business enterprises but tends to be higher in the universities and colleges.

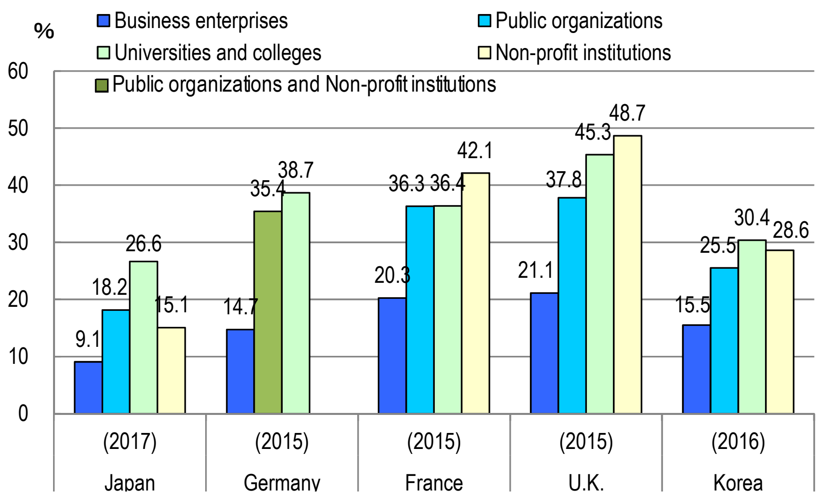
The number of female researchers, which totaled to 144,126 in 2017, is increasing and their proportion is also growing steadily in Japan. The number of female researchers with doctorates was 29,114 in 2017. This is an increase of 5.6% from 2016, which is greater than the overall increase rate of female researchers in number, at 4.1%. Status by sector shows that, in all countries, the proportion of female researchers tends to be lower in the business enterprises and higher in the universities and colleges.

[Summary Chart 9] The number of female researchers and their ratio against the total number of researchers (HC)



Note: The numbers of researchers until 2001 were regular researchers. The numbers of researchers since 2002 were head count basis.
Reference: Chart 2-1-11, Japanese Science and Technology Indicators 2018 (in Japanese)

[Summary Chart 10] Shares of female researchers of the selected countries by sector



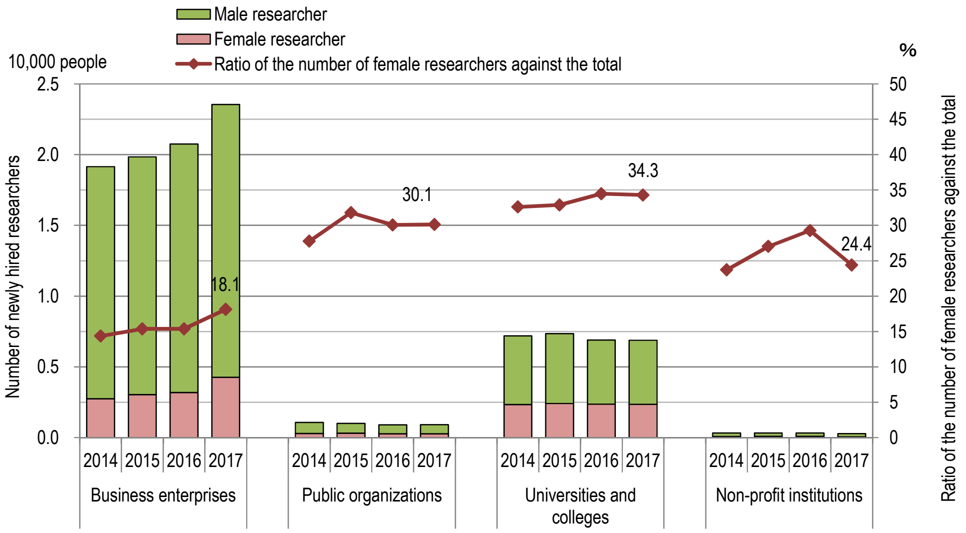
Note: 1) The numbers of researchers were head count basis.
2) For the non-profit institutions sectors of France, the U.K., and Korea, the number of researchers was obtained by subtracting the numbers of researchers in the business enterprises sector, the universities and colleges sector, and public organizations sector from the total.
Reference: Chart 2-1-10, Japanese Science and Technology Indicators 2018 (in Japanese)

(4) In Japan, the proportion of females among newly hired researchers is higher than the proportion of females among all researchers.

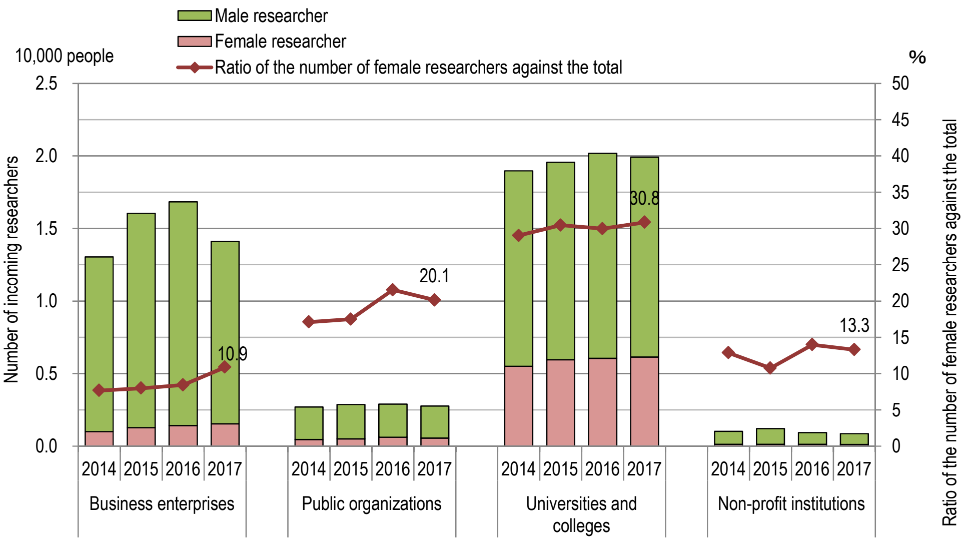
Male researchers account for a larger proportion of newly hired researchers than their female counterparts in all sectors. The proportion of female researchers among newly hired researchers is higher than that of female researchers among all researchers. The number of researchers newly hired by business enterprises is on the rise for both males and females. In all sectors, male researchers account for a larger segment of incoming researchers than female researchers. Females account for a large segment of incoming researchers at universities and colleges, at around 30%.

[Summary Chart 11] Newly hired and incoming researchers by gender in Japan

(A) Newly hired researchers



(B)Incoming researchers



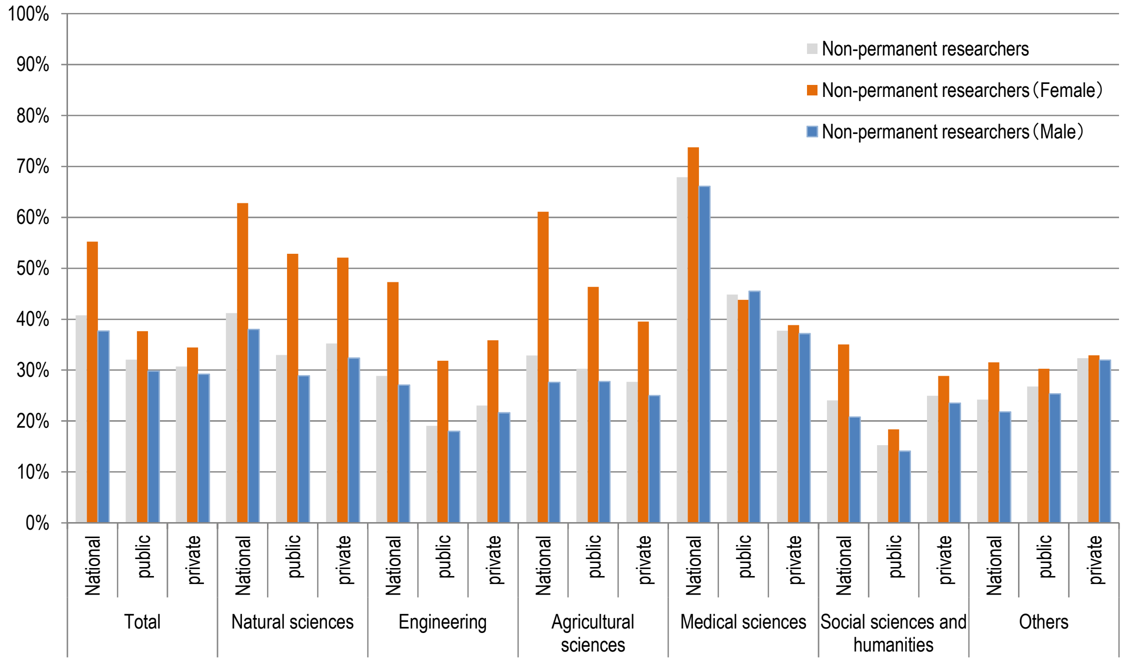
Reference: Chart 2-1-20, Japanese Science and Technology Indicators 2018 (in Japanese)

(5) The proportion of non-permanent researchers at Japanese universities and colleges is high in the medical science. The proportion of non-permanent researchers tends to be higher among female researchers than among male researchers.

Female researchers tend to account for a greater proportion of non-permanent researchers at universities and colleges than their male counterparts. It is true for most attributes such as academic fields and the type of universities and colleges, i.e., national, public and private.

By academic field, a high proportion of non-permanent researchers can be found in the medical science and in national universities among national, public and private universities and colleges. The gender differential among non-permanent researchers tends to be narrower in the medical science and more prominent in natural sciences, engineering, and agricultural sciences.

[Summary Chart 12] The percentage of non-permanent researchers at Japanese universities and colleges (2017)



Note: 1) The survey covers teaching and other research staff.
2) Permanent researchers here refer to teaching and other research staff with no prescribed term of employment contract (including terms that last until the retirement age). Non-permanent researches refer to all researchers other than permanent researchers.
Reference: Chart 2-2-14, Japanese Science and Technology Indicators 2018 (in Japanese)

3. Graduates of universities and colleges: the situation in Japan

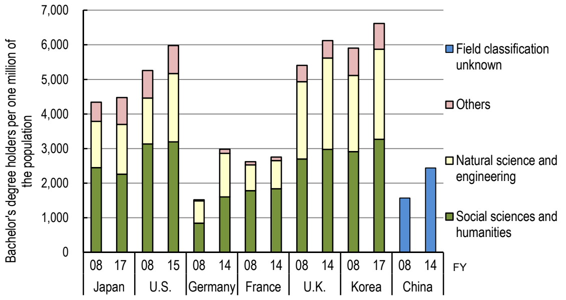
(1) Among the selected countries, Japan is the only country that shows a decline in the number of new master’s degree and doctoral degree recipients per one million of population. Compared with other selected countries, the number of master’s degree and doctoral degree recipients in humanities and social sciences is small in Japan.

Regarding the balance of fields among bachelor's degree recipients, master's degree recipients, and doctoral degree recipients per one million of population, the number of bachelor's degree recipients in “social sciences and humanities” is large in many of the countries. In Japan, the number of graduates in “natural science and engineering” tends to be high as the academic stage advances, specifically among master's degree recipients and doctoral degree recipients. In contrast, in the other selected countries, the number of graduates in “social sciences and humanities” is largest even among master's degree recipients, and the number of graduates in “natural science and engineering” tends to be largest among doctoral degree recipients.

Other than Japan, the numbers of academic degree recipients per one million of population have increased at all degree levels. In Japan, the number of master’s degree recipients dropped slightly and that of doctoral degree recipients declined.

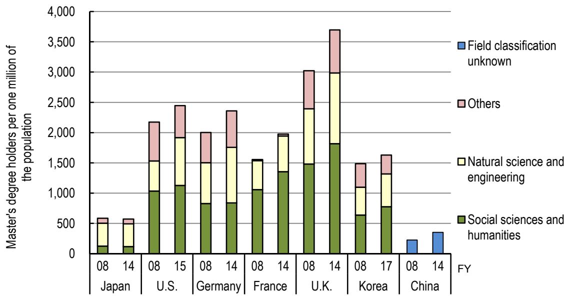
[Summary Chart 13] International comparison of academic degree recipients per one million of population

(A) New bachelor's degree recipients



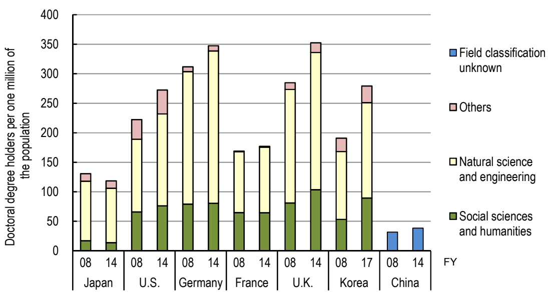
Reference: Chart 3-4-1, Japanese Science and Technology Indicators 2018 (in Japanese)

(B) New master's degree recipients



Reference: Chart 3-4-2, Japanese Science and Technology Indicators 2018 (in Japanese)

(C) New doctoral degree recipients



Reference: Chart 3-4-3, Japanese Science and Technology Indicators 2018 (in Japanese)

Note: 1) The number of doctoral degree recipients in the U.S. is the figures calculated by subtracting the figures for “law and economics,” “medicine, dentistry, pharmacy, and health care,” and “other” among the figures for first-professional degrees from the figures for the “doctoral degrees” noted in the “Digest of Education Statistics.”
2) The figures for individual fields are not known for China.
3) Each field classification includes the following:
Social sciences and humanities: humanities, art, law, economics, etc.
Natural science and engineering: science, engineering, agriculture, medicine, dentistry, pharmacy, and health care
Others: education, teacher training, domestic economy, etc.

4. R&D outputs circumstances in Japan and the selected countries

(1) Compared with ten years ago, the number of papers from Japan slightly declined (counted by the fractional counting method). Due to the growth of other countries, the position of Japan in the world rankings has moved down. The decline of Japan's ranking is remarkable in relation to highly cited papers (the number of adjusted top 10% papers and adjusted top 1% papers).

As for the number of scientific papers, which is one form of R&D output, the number of Japanese papers (the average of PY2013–2015) is ranked 4th after the United States, China, and Germany, when counted by the fractional counting method that measures the degree of contribution to paper production. As to the number of adjusted top 10% papers, Japan is ranked 9th after the United States, China, the United Kingdom, Germany, France, Italy, Canada, and Australia. As to the number of adjusted top 1% papers, Japan is ranked 9th after the United States, China, the United Kingdom, Germany, France, Australia, Canada, and Italy.

Compared with ten years ago, the number of Japanese papers has slightly declined. It is clear that Japan's ranking has moved down because of the growth of other countries in terms of the number of papers. The decline of Japan's ranking is particularly remarkable in highly cited papers such as adjusted top 10% papers and adjusted top 1% papers.

[Summary Chart 14] Top 10 countries/regions in terms of the number of papers, the number of adjusted top 10% papers, and the number of adjusted top 1% papers (based on the fractional counting method)

All fields	1994 — 1996 (PY) (Average)		
	The number of papers		
	Fractional counting		
Country/Region	Papers	Share	World rank
U.S.	189,879	30.4	1
Japan	52,061	8.3	2
U.K.	45,619	7.3	3
Germany	42,089	6.7	4
France	32,571	5.2	5
Canada	24,195	3.9	6
Russia	21,912	3.5	7
Italy	20,122	3.2	8
Australia	13,117	2.1	9
India	12,620	2.0	10

All fields	2004 — 2006(PY) (Average)		
	The number of papers		
	Fractional counting		
Country/Region	Papers	Share	World rank
U.S.	228,849	25.7	1
Japan	67,696	7.6	2
China	63,296	7.1	3
Germany	53,648	6.0	4
U.K.	51,976	5.8	5
France	38,337	4.3	6
Italy	31,573	3.5	7
Canada	29,676	3.3	8
Spain	23,056	2.6	9
Korea	22,584	2.5	10

All fields	2014 — 2016 (PY) (Average)		
	The number of papers		
	Fractional counting		
Country/Region	Papers	Share	World rank
U.S.	273,858	19.3	1
China	246,099	17.4	2
Germany	65,115	4.6	3
Japan	63,330	4.5	4
U.K.	59,688	4.2	5
India	52,875	3.7	6
France	46,522	3.3	7
korea	45,337	3.2	8
Italy	44,450	3.1	9
Canada	39,674	2.8	10

All fields	1994 — 1996 (PY) (Average)		
	The number of adjusted top 10% papers		
	Fractional counting		
Country/Region	Papers	Share	World rank
U.S.	29,000	46.5	1
U.K.	5,175	8.3	2
Germany	3,873	6.2	3
Japan	3,631	5.8	4
France	2,984	4.8	5
Canada	2,754	4.4	6
Italy	1,604	2.6	7
Netherlands	1,562	2.5	8
Australia	1,340	2.1	9
Sweden	1,127	1.8	10

All fields	2004 — 2006(PY) (Average)		
	The number of adjusted top 10% papers		
	Fractional counting		
Country/Region	Papers	Share	World rank
U.S.	34,127	38.4	1
U.K.	6,503	7.3	2
Germany	5,642	6.4	3
Japan	4,559	5.1	4
China	4,453	5.0	5
France	3,833	4.3	6
Canada	3,392	3.8	7
Italy	2,731	3.1	8
Netherlands	2,146	2.4	9
Spain	2,093	2.4	10

All fields	2014 — 2016 (PY) (Average)		
	The number of adjusted top 10% papers		
	Fractional counting		
Country/Region	Papers	Share	World rank
U.S.	38,736	27.4	1
China	24,136	17.0	2
U.K.	8,613	6.1	3
Germany	7,755	5.5	4
Italy	4,912	3.5	5
France	4,862	3.4	6
Australia	4,453	3.1	7
Canada	4,452	3.1	8
Japan	4,081	2.9	9
Spain	3,609	2.5	10

All fields	1994 — 1996 (PY) (Average)		
	The number of adjusted top 1% papers		
	Fractional counting		
Country/Region	Papers	Share	World rank
U.S.	3,425	54.9	1
U.K.	511	8.2	2
Germany	343	5.5	3
Japan	289	4.6	4
France	261	4.2	5
Canada	260	4.2	6
Netherlands	145	2.3	7
Italy	124	2.0	8
Australia	115	1.9	9
Switzerland	112	1.8	10

All fields	2004 — 2006(PY) (Average)		
	The number of adjusted top 1% papers		
	Fractional counting		
Country/Region	Papers	Share	World rank
U.S.	4,088	46.0	1
U.K.	695	7.8	2
Germany	524	5.9	3
Japan	356	4.0	4
France	337	3.8	5
China	332	3.7	6
Canada	318	3.6	7
Netherlands	231	2.6	8
Italy	223	2.5	9
Australia	182	2.1	10

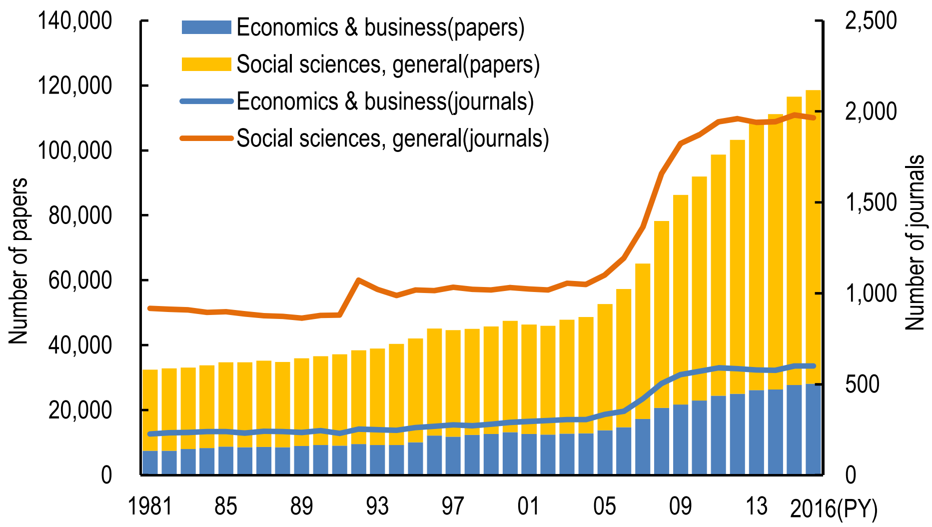
All fields	2014 — 2016 (PY) (Average)		
	The number of adjusted top 1% papers		
	Fractional counting		
Country/Region	Papers	Share	World rank
U.S.	4,686	33.1	1
China	2,214	15.6	2
U.K.	973	6.9	3
Germany	764	5.4	4
Australia	456	3.2	5
France	445	3.1	6
Canada	432	3.1	7
Italy	398	2.8	8
Japan	333	2.4	9
Spain	302	2.1	10

Note: The number of Articles and Reviews was counted. Papers were sorted by publication year (PY). The number of citations was as of the end of 2017.
Reference: Chart 4-1-6, Japanese Science and Technology Indicators 2018 (in Japanese)

(2) The number of papers (whole counting method) in "economics and business" and "social sciences, general" in Japan has grown faster than the world average in the past two decades. Japan's rank, however, fell from the 10th to 15th place in "economics and business" and from 14th to 24th in "social sciences, general."

Regarding the number of journals and papers on "economics and business" and "social sciences, general" in the world (those indexed in SSCI: Social Sciences Citation Index), the numbers have grown rapidly in both fields since 2005.

[Summary Chart 15] Number of journals and papers on "economics and business" and "social sciences, general" (Worldwide, whole counting)



Note: 1) Social sciences, general: education, sociology, law, political science, etc.
2) The number of articles and reviews was counted based on the whole counting method. Publication year was applied for the counting.
Reference: Chart 4-1-11, Japanese Science and Technology Indicators 2018 (in Japanese)

The number of Japanese papers on "economics and business" increased 4.2 times in the past two decades, from 136 to 565. While Japan's share rose from 1.3% to 2.1%, its ranking in the world dropped from the 10th to 15th place. Likewise, the number of Japanese papers on "social sciences, general" grew 4.6 times during the same period, from 188 to 868. Japan's share increased from 0.6% to 1.0%, but its ranking fell from the 14th to 24th place. Regarding the number of papers by country/region, differences in ranking trends can be observed between English-speaking and non-English-speaking countries. The difference is large between "economics and business" and "social sciences, general" that include education, law, political science and other disciplines that deal with research subjects that are dependent on legal/social framework or language.

The analysis presented here was conducted using SSCI, which indexes papers primarily in the English language. In social sciences, emphasis is sometimes placed on research output in forms other than papers, including books, which makes it difficult to gauge the status of activities in overall social sciences using the SSCI. However, the number of papers has increased worldwide over the long term, and English-language papers have come to play a certain role in the presentation of research outcomes. For these reasons, the index can serve as a tool to measure some research activities in social sciences in forms that enable international comparisons.

[Summary Chart 16] Number of papers by country/region in "economics and business" and "social sciences, general" (Worldwide, whole counting)

Economics & business	1994 — 1996 (PY) (Average)			Economics & business	2014 — 2016 (PY) (Average)			Social sciences, general	1994 — 1996 (PY) (Average)			Social sciences, general	2014 — 2016 (PY) (Average)		
Country/Region	Papers	Share	World rank	Country/Region	Papers	Share	World rank	Country/Region	Papers	Share	World rank	Country/Region	Papers	Share	World rank
U.S.	5,662	53.7%	1	U.S.	9,625	35.1%	1	U.S.	16,677	52.1%	1	U.S.	33,655	38.2%	1
U.K.	1,133	10.8%	2	U.K.	3,894	14.2%	2	U.K.	3,346	10.4%	2	U.K.	11,833	13.4%	2
Canada	646	6.1%	3	Germany	2,451	8.9%	3	Canada	1,631	5.1%	3	Australia	6,467	7.3%	3
Australia	295	2.8%	4	China	2,229	8.1%	4	Australia	1,064	3.3%	4	Canada	5,235	5.9%	4
France	292	2.8%	5	Australia	1,983	7.2%	5	Germany	764	2.4%	5	Germany	4,008	4.6%	5
Netherlands	252	2.4%	6	France	1,511	5.5%	6	Netherlands	514	1.6%	6	Netherlands	3,593	4.1%	6
Germany	233	2.2%	7	Canada	1,492	5.4%	7	France	414	1.3%	7	China	3,503	4.0%	7
Israel	146	1.4%	8	Spain	1,413	5.2%	8	Israel	331	1.0%	8	Spain	3,298	3.7%	8
Italy	141	1.3%	9	Italy	1,286	4.7%	9	Sweden	288	0.9%	9	Sweden	2,194	2.5%	9
Japan	136	1.3%	10	Netherlands	1,127	4.1%	10	Russia	288	0.9%	10	Italy	1,966	2.2%	10
Sweden	115	1.1%	11	Taiwan	754	2.7%	11	China	206	0.6%	11	France	1,863	2.1%	11
China	113	1.1%	12	Korea	734	2.7%	12	India	197	0.6%	12	South Africa	1,750	2.0%	12
Belgium	110	1.0%	13	Sweden	661	2.4%	13	New Zealand	194	0.6%	13	Brazil	1,688	1.9%	13
Spain	91	0.9%	14	Switzerland	657	2.4%	14	Japan	188	0.6%	14	Belgium	1,472	1.7%	14
Switzerland	85	0.8%	15	Japan	565	2.1%	15	Norway	187	0.6%	15	Korea	1,372	1.6%	15
Denmark	71	0.7%	16	Belgium	509	1.9%	16	Italy	178	0.6%	16	⋮	⋮	⋮	⋮
New Zealand	65	0.6%	17	Denmark	465	1.7%	17	South Africa	171	0.5%	17	Japan	868	1.0%	24

Note: Same as Summary Chart 15.
Reference: Chart 4-1-12, Japanese Science and Technology Indicators 2018 (in Japanese)

(3) Japan has maintained the 1st position in the world in the number of patent families (patents filed in two or more countries) in the past ten years. However, Japan's shares in "information & communication technology" and "electrical engineering" have declined in parallel to the rise of Korea and China.

This section examines the status of patent applications by analyzing the number of patent families, which is the number of inventions created in each country/region and measured in an internationally comparable manner.

Between 1991 and 1993, the United States was ranked first and Japan second. Between 2001 and 2003 and between 2011 and 2013, Japan was ranked first and the United States second. The increase in the number of Japanese patent families is attributable to the increase in its patent applications in multiple countries instead of any single country. China's number of patent families has been steadily increasing although it was ranked fifth between 2011 and 2013.

[Summary Chart 17] The number of patent families by selected country/region: top 10 countries/regions

1991 - 1993(Average)			
Country/Region	Number of patent families (Whole counting)		
	Patent Families	Share	World rank
U.S.	24,204	28.8	1
Japan	21,927	26.1	2
Germany	14,280	17.0	3
France	5,614	6.7	4
U.K.	4,631	5.5	5
Italy	2,613	3.1	6
Switzerland	2,194	2.6	7
Canada	1,714	2.0	8
Netherlands	1,668	2.0	9
Sweden	1,349	1.6	10

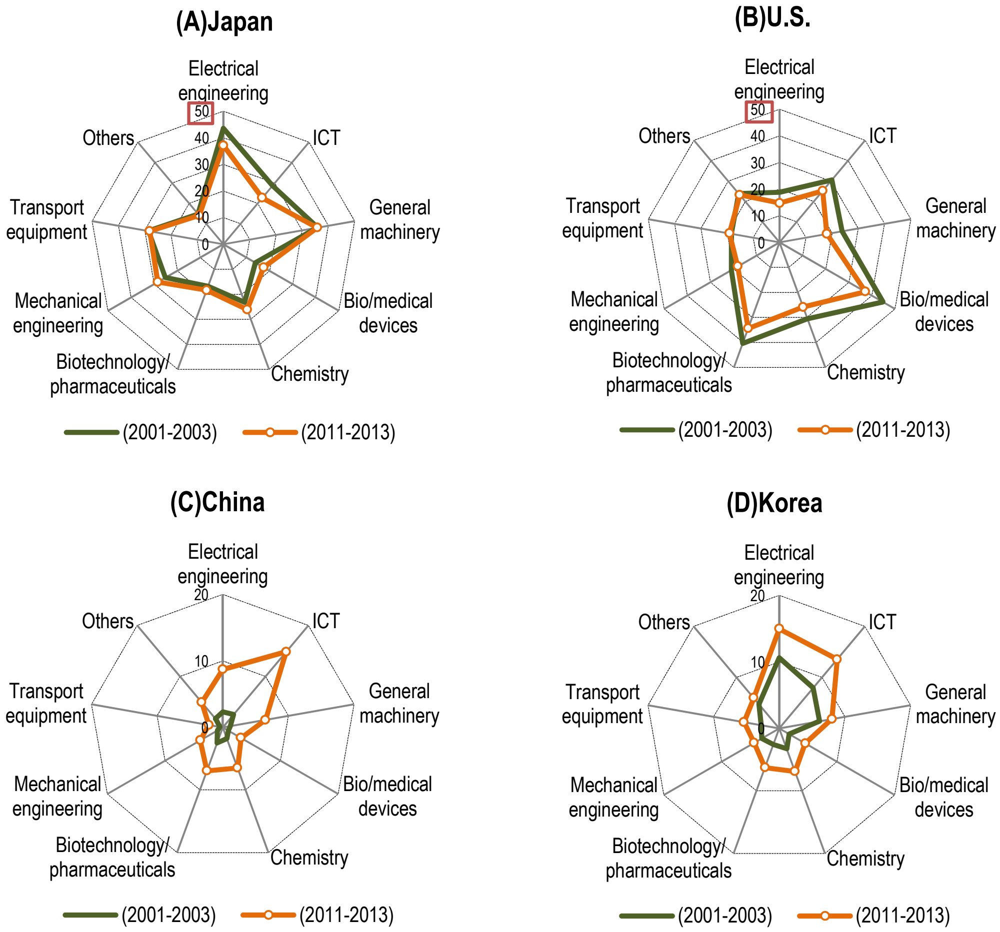
2001 - 2003(Average)			
Country/Region	Number of patent families (Whole counting)		
	Patent Families	Share	World rank
Japan	48,717	28.2	1
U.S.	45,644	26.4	2
Germany	27,408	15.9	3
Korea	9,606	5.6	4
France	9,509	5.5	5
U.K.	8,663	5.0	6
Canada	4,796	2.8	7
Italy	4,756	2.8	8
Netherlands	4,634	2.7	9
Taiwan	4,299	2.5	10

2011 - 2013(Average)			
Country/Region	Number of patent families (Whole counting)		
	Patent Families	Share	World rank
Japan	64,804	27.4	1
U.S.	52,073	22.0	2
Germany	29,819	12.6	3
Korea	21,806	9.2	4
China	18,202	7.7	5
Taiwan	12,281	5.2	6
France	11,588	4.9	7
U.K.	8,935	3.8	8
Canada	5,943	2.5	9
Italy	5,466	2.3	10

Note: A patent family is a group of patents filed in two or more countries, directly or indirectly related to each other by priority rights. In many cases, the same patents filed in multiple countries belong to the same patent family.
Reference: Chart 4-2-5, Japanese Science and Technology Indicators 2018 (in Japanese)

As for the shares of patent families between 2011 and 2013, Japan's share exceeds 35% for "electrical engineering" and "general machinery," while Japan has relatively small shares for "bio/medical devices" and "biotechnology/pharmaceuticals." The global shares of Japan in the "information & communication technology" and "electrical engineering" have both fallen by around 6 percentage points, which is attributable to rapid growth in the global shares of China and Korea.

[Summary Chart 18] Comparison of the shares of patent families by technological fields in the selected countries (%, 2001-2003 and 2011-2013, whole counting)



Note: Same as Summary Chart 17. The items "ICT" in Summary Chart 18 stand for "Information and communication technology."
Reference: Chart 4-2-10, Japanese Science and Technology Indicators 2018 (in Japanese)

(4) Although the number of Japanese patent families that are citing papers is the world's second largest, these patent families account for only a small proportion of the total patent families of Japan.

In order to examine the linkage between science and technology, information on papers cited by patent families was analyzed. Japan ranks second in the world in terms of the number of patent families that are citing papers. However, the number of Japanese patent families that are citing papers accounts for only 9.4% of its total patent families, suggesting that Japan's technologies do not cite scientific output as much as other countries' technologies do. On the other hand, the volume of Japanese papers that are cited by patent families is second largest after the United States.

[Summary Chart 19] The number of patent families that are citing papers: top 10 countries/regions

Whole counting		2006–2013 (Total)		
			(B) Total number of patent families	
No.	Country / Region	(A) Patent families citing papers	Number of patent families	Percentage of patent families citing papers (A) / (B)
1	U.S.	105,576	389,823	27.1
2	Japan	46,826	497,991	9.4
3	Germany	41,870	242,031	17.3
4	France	23,233	90,202	25.8
5	U.K.	20,079	70,009	28.7
6	China	19,088	108,828	17.5
7	Korea	14,022	156,546	9.0
8	Canada	12,366	46,321	26.7
9	Netherlands	10,639	35,595	29.9
10	India	9,716	28,608	34.0

Reference: Chart 4-3-2, Japanese Science and Technology Indicators 2018(in Japanese)

[Summary Chart 20] The number of papers that are cited by patent families: top 10 countries/regions

Whole counting		1981–2013 (Total)		
			(B) Total number of papers	
No.	Country / Region	(A) Papers cited by patent families	Number of papers	Percentage of papers cited by patent families (A) / (B)
1	U.S.	381,502	7,425,218	5.1
2	Japan	82,002	1,900,522	4.3
3	Germany	75,148	1,924,036	3.9
4	U.K.	74,823	1,919,295	3.9
5	France	49,417	1,403,206	3.5
6	Canada	39,982	1,064,191	3.8
7	China	37,996	1,571,419	2.4
8	Italy	32,535	959,700	3.4
9	Netherlands	25,403	565,878	4.5
10	Switzerland	22,275	427,917	5.2

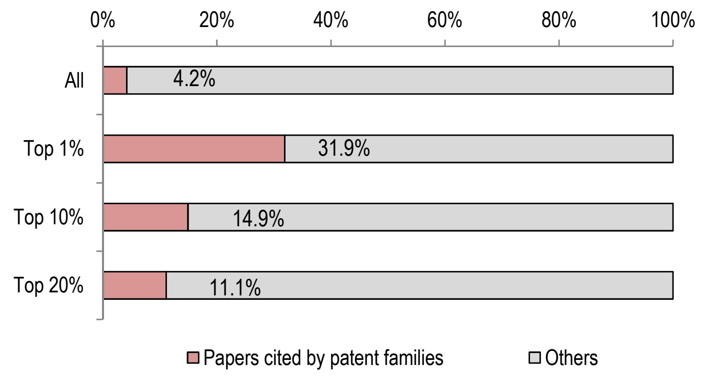
Reference: Chart 4-3-3, Japanese Science and Technology Indicators 2018 (in Japanese)

(5) Scientific papers that get more paper-to-paper citations tend to get higher paper-to-patent family citations. In other words, papers that attract wide recognition of science also attract wide recognition of technology.

To explore whether the frequency of paper-to-paper citations impacts on the degree of citation by patent families, the proportion of papers that are cited by patent families was examined controlling for the frequency of paper-to-paper citations.

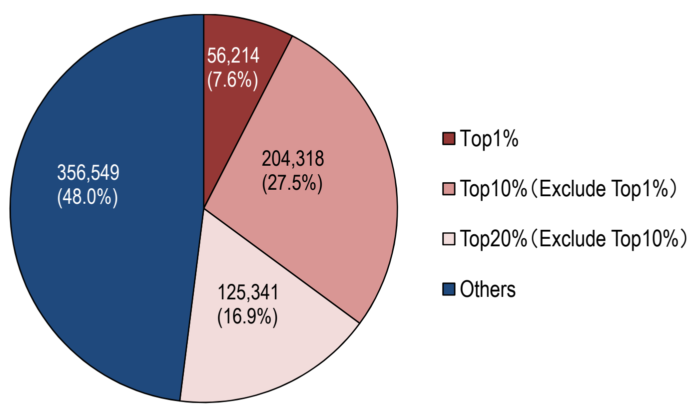
Of all the papers published globally since 1994, some 4.2% were cited by patent families between 2006 and 2013. Controlling for the frequency of paper-to-paper citations, papers in the top 1%, top 10% and top 20% categories were cited at the rates of 31.9%, 14.9% and 11.1%, respectively, indicating that scientific papers that get more paper-to-paper citations tend to get higher paper-to-patent family citations. Papers within the top 20% paper-to-paper citations occupy about a half of all papers cited by patent families.

[Summary Chart 21] Percentage of papers cited by patent families according to frequency of citation



Note: Calculations based on papers published after 1994 (in the past 20 years) that were cited by patent families among those filed between 2006 and 2013.
Reference: Chart 4-3-9, Japanese Science and Technology Indicators 2018

[Summary Chart 22] Number and percentage of papers by frequency of citation among papers cited by patent families



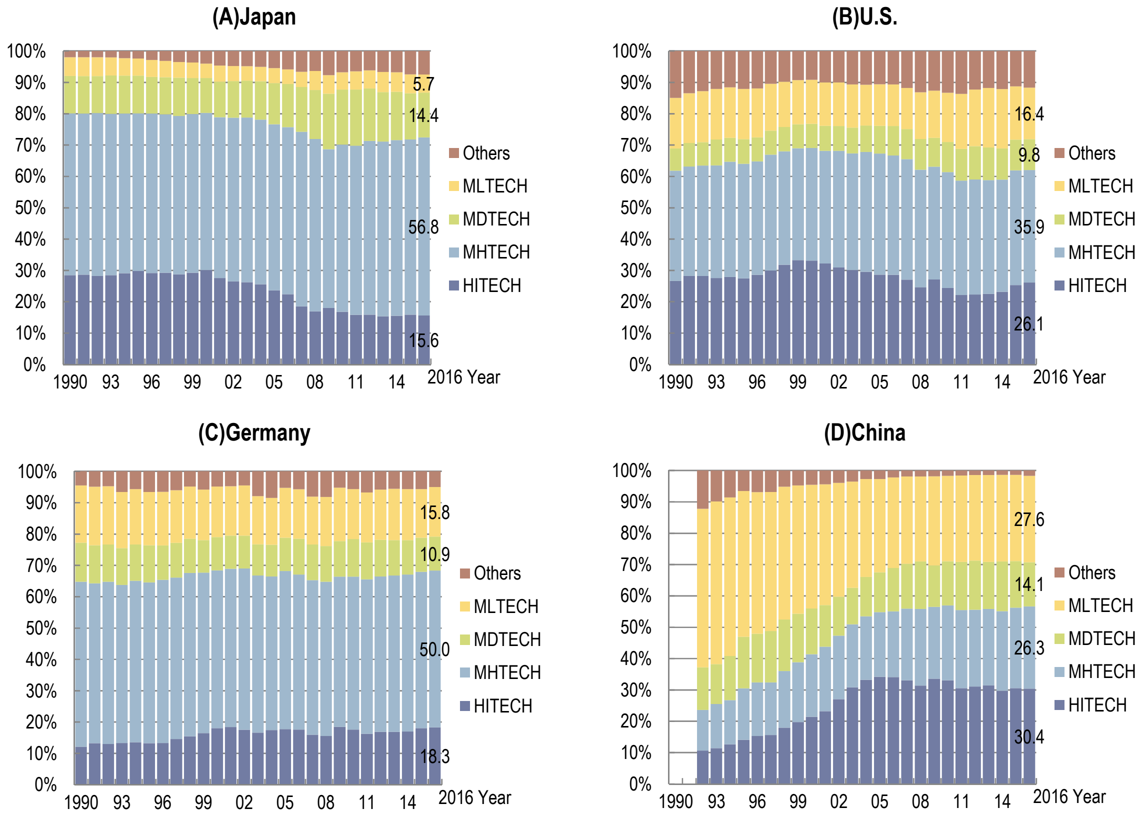
Note: Same as Summary chart 21.
Reference: Chart 4-3-8, Japanese Science and Technology Indicators 2018

5. Science, technology, and innovation: circumstances in Japan and the selected countries

(1) An examination of the structure of industrial trade exports in the selected countries reveals that medium-high-technology industries account for the largest segment in many countries. In Japan, medium-high-technology industries constitute approximately 60% of its exports.

The country that had the most substantial share of medium-high-technologies in 2016 was Japan (56.8%), followed by Germany (50.0%). High-technology industries had the largest share in China (30.4%), where medium-low-technology industries accounted for 27.6% of the total, with different industries carrying certain weightages.

[Summary Chart 23] Percentage of industrial trade exports in the selected countries



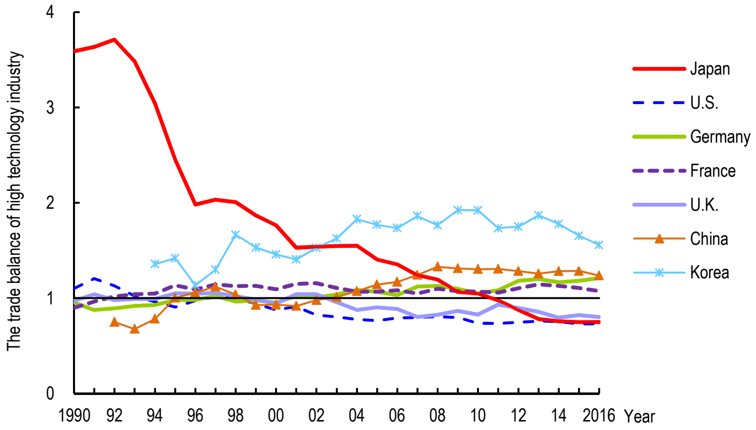
Reference: Chart 5-2-1, Japanese Science and Technology Indicators 2018 (in Japanese)

Industry	Breakdown
HITECH: High R&D intensive industries	pharmaceutical, computer, electronic and optical, and aerospace.
MHTECH: Medium-high R&D intensive industries	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.
MDTECH: Medium technology industries	Rubber/plastic products, metals, shipbuilding, others
MLTECH: Medium-low technology industries	Textiles, food/beverage/tobacco, metal fabrication products (except machinery and equipment), others
Others	Industries other than the above

(2) Japan's trade balance ratio for high-technology industries is the lowest among the selected countries. However, in medium high-technology industries, Japan maintains highest position among the selected countries.

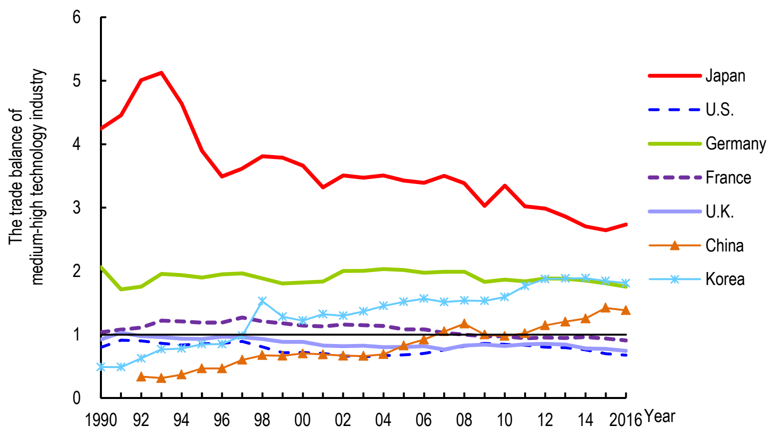
Japan's trade balance ratio in high-technology industries showed a continuous decline and it marked 0.75 in 2016. Japan ranked first among the selected countries in trade balance ratio for medium-high-technology industries at 2.73. The trade balance ratio shows a gradual decline following a rapid drop in the mid-1990s.

[Summary Chart 24] Changes in the trade balance ratios for high-technology industries in the selected countries



Note: 1) High-technology industries refer to "pharmaceutical," "computer, electronic and optical," and "aerospace."
2) Trade balance ratio = export value / import value
Reference: Chart 5-2-3, Japanese Science and Technology Indicators 2018 (in Japanese)

[Summary Chart 25] Changes in the trade balance ratios for medium high-technology industries in the selected countries

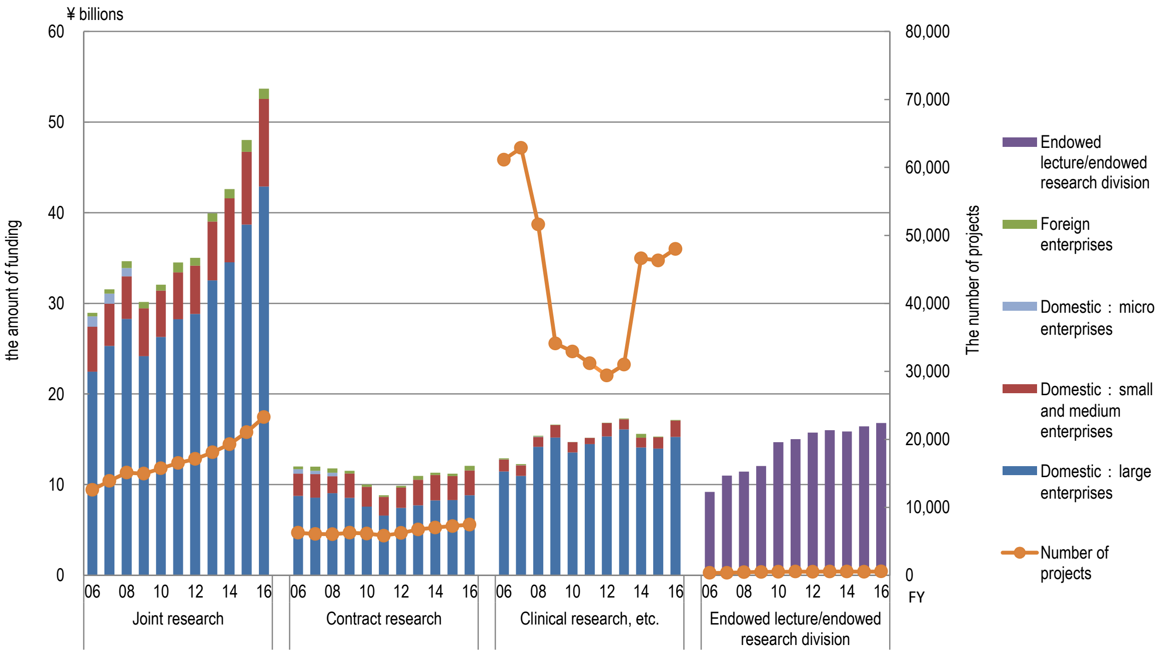


Note: 1) Medium high-technology industries refer to "chemicals and chemical products," "electrical equipment," "machinery and equipment n.e.c.," "motor vehicles, trailers and semi-trailers," "railroad equipment and transport equipment n.e.c.," and "other."
2) Trade balance ratio = export value / import value
Reference: Chart 5-2-5, Japanese Science and Technology Indicators 2018 (in Japanese)

(3) The number of joint research projects conducted by Japanese universities and the private sector, as well as the amount of research funds received, has grown steadily.

Changes in the funding and number of research projects with business enterprises shows that "joint research" received the largest amount of funds at 53.7 billion yen with the implementation of some 23,000 projects. Most of the funds, 42.9 billion yen that year, came from large corporations. This was followed by funds for "clinical trials, etc." at 17.1 billion yen.

[Summary Chart 26] Changes in the funds received (breakdown) and number of projects implemented for joint research, etc., by Japanese universities and private businesses, etc



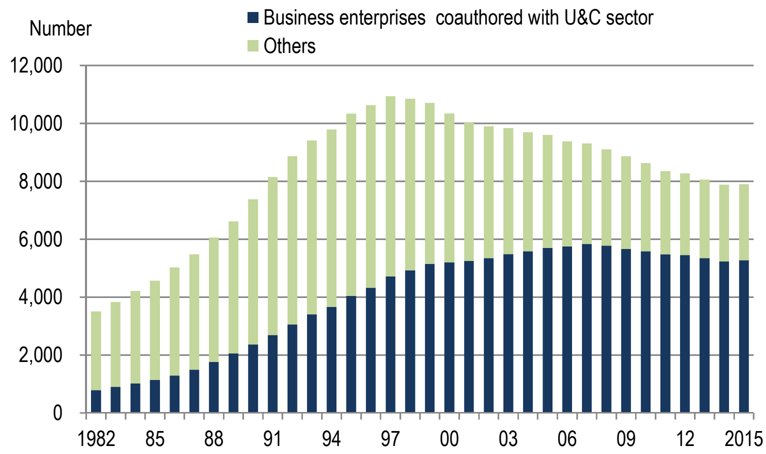
Note: Joint research: Joint research and development by institutions and private business, etc., in which the other party bears the expenses. Until FY2008, the amount of funding and the number of projects were classified according to the size of the enterprises - small and medium, micro and large enterprises.
Contract research: R&D conducted primarily by universities, etc., under a commission from private enterprises, etc., the costs of which are paid for by the private enterprises, etc.
Clinical research, etc.: Clinical research on pharmaceuticals and medical equipment, etc., conducted primarily and independently by universities, etc., based on a contract with outside parties, the costs of which are paid for by the consignee. Clinical research includes histopathological examination outside the range of clinical research as well as similar tests and surveys.
Endowed lecture/endowed research division: Values shown are only for national universities.
Reference: Chart 5-4-6, Japanese Science and Technology Indicators 2018

(4) The number of papers produced by Japanese business enterprises has been declining. Among such papers, the share of papers authored jointly by industry and academia has been on the rise.

The number of papers produced by Japanese business enterprises has been declining. Among such papers, the percentage of papers authored jointly by industry and academia has been on the rise. The proportion of such jointly authored papers increased from 22% of the total in 1982 to 67% in 2015, illustrating the growing weightage of universities and colleges, in research activities that result in papers at the corporate level.

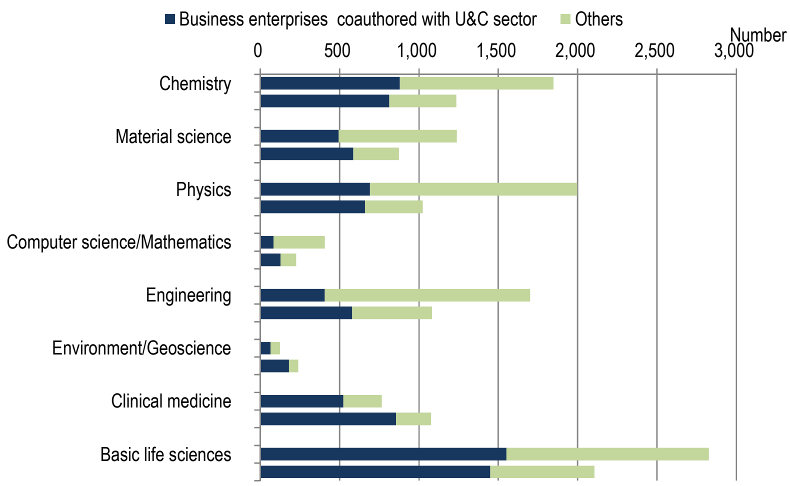
The number of papers produced by business enterprises has fallen in many fields of science. The decline in the number of papers produced by business enterprises in physics, basic life sciences, etc., can be attributed to a decline in the number of papers that are not co-authored by industry and academia. The number of papers produced by business enterprises has increased in clinical medicine and environment/geoscience, in which a rise in the number of papers jointly produced by businesses and academic institutions contributed greatly.

[Summary Chart 27] Status of papers co-authored by industry and academia in Japanese business enterprises



Note: The analysis, which covers articles and reviews, used the whole counting method for a 3-year moving average.
Reference: Chart 5-5-1, Japanese Science and Technology Indicators 2018 (in Japanese)

[Summary Chart 8] Status of papers co-authored by industry and academia among Japanese businesses by field



Note : Same as Summary chart 27.
Reference: Chart 5-5-2, Japanese Science and Technology Indicators 2018 (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. The statistics/indicators are selected considering the following two conditions: 1) the indicators should allow either of the time-series comparison or the comparison among the selected countries and 2) the indicators should be possible to update annually in principle.

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 aggregated and analyzed by NISTEP using Web of Science provided by Clarivate Analytics. Patents family data were 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 are collected in line with the OECD's manuals. However, differences in methods or scope of collecting data 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 chronological trends are marked "attention to trend." Specifics for such points requiring attention are provided in the notes of individual charts.

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