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【Contributors】

KANDA Yumiko	Senior Research Fellow, Research Unit for Science and Technology Analysis and Indicators, National Institute of Science and Technology Policy, MEXT
MURAKAMI Akiyoshi	Senior Research Fellow, Research Unit for Science and Technology Analysis and Indicators, National Institute of Science and Technology Policy, MEXT
MATSUMOTO Kuniko	Research Fellow, Research Unit for Science and Technology Analysis and Indicators, National Institute of Science and Technology Policy, MEXT
NISHIKAWA kai	Research Fellow, Research Unit for Science and Technology Analysis and Indicators, National Institute of Science and Technology Policy, MEXT
IGAMI Masatsura	Director, 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 2020 (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 170 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 2020" includes new indicators such as "the number of mature age and non-mature age doctoral students by major" and "doctoral holders among newly hired researchers in Japanese companies by industrial classification." In response to the worldwide pandemic of the COVID-19, the column related to "analyses of scientific publications and patent applications on infectious diseases," "status of immigration of foreign researchers in Japan," and "potential of digital technologies and challenges in promoting their utilization" are included. Compared with the previous edition, there are approximately 20 new or revised indicators in total.

Overviewing the latest Japan's situation from "Science and Technology Indicators 2020," it was found that the R&D expenditure and the number of researchers in Japan are the third largest in selected countries (Japan, U.S., Germany, France, U.K., China and Korea). The number of scientific publications in Japan (fractional counting method) is the fourth in the world and the number of scientific publications 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/regions). These trends continue from the previous two editions. China surpassed the United States for the first time and ranked first among major countries in scientific publications (fractional counting method). The United States holds first place in the number of scientific publications with high citations.

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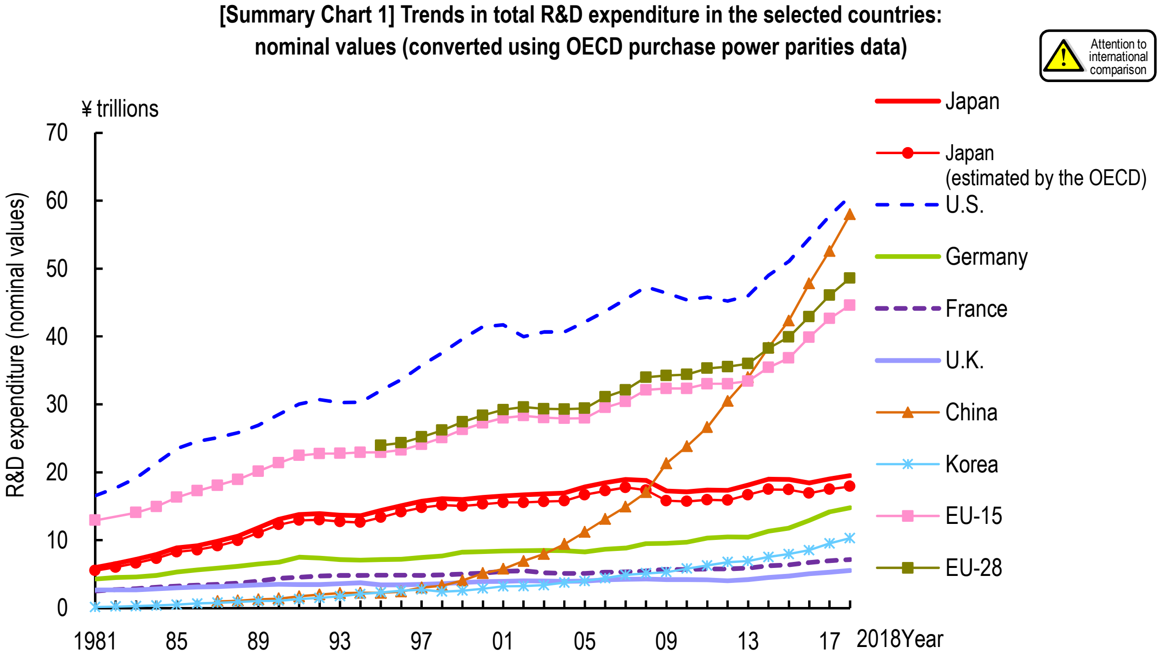
1. R&D expenditure: circumstances in Japan and the selected countries

(1) Japan's total R&D expenditure was 17.9 trillion yen in 2018 (Estimated by the OECD), the world's third largest after the United States and China.

Japan's total R&D expenditure (nominal value) was 17.9 trillion yen (Estimated by OECD) in 2018, increased by 2.3% from the previous year. That of the United States was 60.7 trillion yen in the same year, which was the world's largest and increased by 5.1% from the previous year. The R&D expenditure of China marked 58.0 trillion yen in 2018, increased by 10.3% year on year and approaching the level of the United States.

Germany and Korea also have shown long-term upward trends. In 2018, the R&D expenditure of Germany was 14.8 trillion yen, 4.4% more than the previous year, while that of Korea was 10.3 trillion yen, 8.1% more.

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



Note: The value for Japan was 19.5 trillion yen in 2018 (increased by 2.5% from the previous year), according to the Survey of Research and Development by the Ministry of Internal Affairs and Communications. For comparison with other countries, the OECD-estimated R&D expenditure of universities and colleges, which is adjusted to equivalent is used.
Reference: Chart 1-1-1, Japanese Science and Technology Indicators 2020 (in Japanese)

(2) In terms of sectors, the "business enterprises" sector accounted for the largest percentage of R&D expenditure in all the selected countries.

"Business enterprises" sector accounted for the largest percentage of R&D expenditure in all the selected countries in 2018. It is especially clear in China, Korea, and Japan (estimated by the OECD). China overtook the United States to take the No. 1 spot in R&D expenditure in business enterprises.

The R&D expenditure of Japan (estimated by the OECD) was the third largest in "business enterprises," following China and the United States, the fourth largest in "universities and colleges," following the United States, China, and Germany, and the fourth largest in "public organizations," following China, the United States, and Germany.

[Summary Chart 2] R&D expenditure by sector in the selected countries (2018): nominal values (converted using OECD purchase power parities data)

	Nominal values (¥ trillions)				(%)			
	Business enterprises	Universities and colleges	Public organizations	Non-profit institutions	Business enterprises	Universities and colleges	Public organizations	Non-profit institutions
Japan (estimated by the OECD)	14.2	2.1	1.4	0.2	79.4	11.6	7.8	1.3
U.S.	44.2	7.8	6.2	2.5	72.8	12.9	10.2	4.2
Germany	10.2	2.6	2.0	-	68.8	17.7	13.5	-
France	4.7	1.5	0.9	0.1	65.4	20.5	12.5	1.6
U.K.	3.8	1.3	0.3	0.1	69.1	22.5	6.1	2.2
China	44.9	4.3	8.8	-	77.4	7.4	15.2	-
Korea	8.3	0.8	1.0	0.1	80.3	8.2	10.1	1.4

Reference: Chart 1-1-6, Japanese Science and Technology Indicators 2020 (in Japanese)

(3) The growth of R&D expenditure by sector differs among the selected countries. While the business enterprises sector has had strong growth in Asian countries, the “universities and colleges” sector and “non-profit institutions” sector have risen significantly in European countries and the United States. Among the selected countries, the R&D expenditure growth of China has been the most significant in all sectors, followed by Korea.

Regarding the growth of R&D expenditure from 2000 to 2018 by sector, which shows R&D expenditure in 2018 relative to that in 2000, the “business enterprises” sector had the highest growth in China, Korea and Japan (estimated by the OECD), while the “universities and colleges” sector grew the most in the United States and Germany. Although the “universities and colleges” sector saw growth in France and the United Kingdom, the growth of their “non-profit institutions” sector was even greater. Nonetheless, the R&D expenditure of the “non-profit institutions” sector is rather small in all the selected countries. Furthermore, among the selected countries, the R&D expenditure growth of China was the most significant in all sectors, followed by Korea.

The growth of Japan’s R&D expenditure was the smallest among the selected countries in the sectors of “universities and colleges” and “non-profit institutions,” and was relatively low in “public organizations”.

[Summary Chart 3] R&D expenditure by sector in the selected countries: the R&D expenditure in 2018 relative to that in 2000

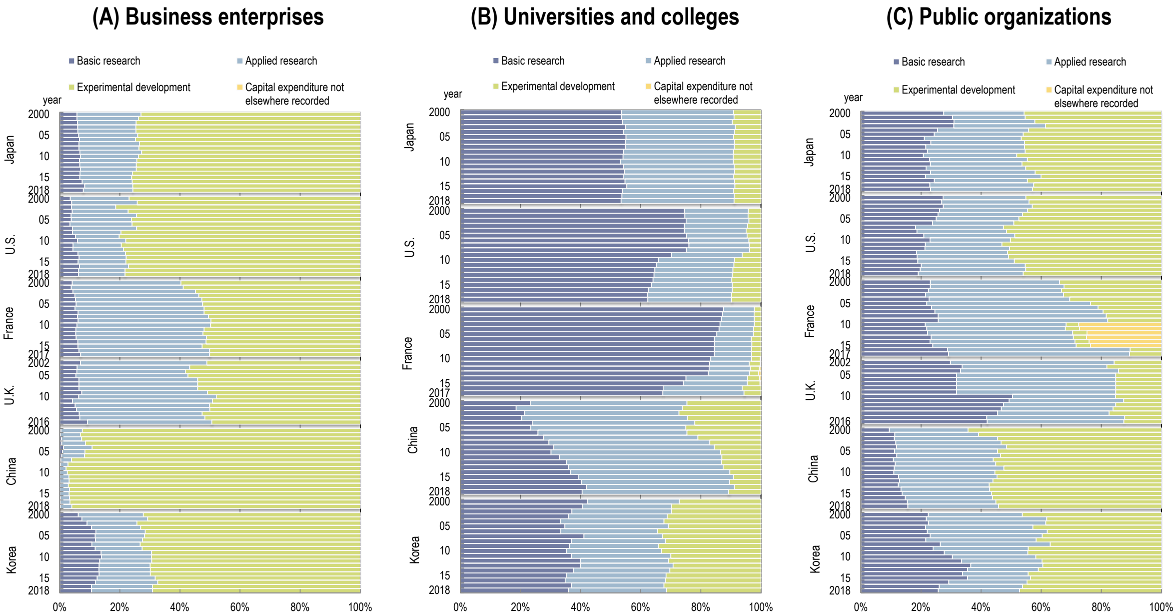
	Real values (Index: Growth from 2000)			
	Business enterprises	Universities and colleges	Public organizations	Non-profit institutions
Japan (estimated by the OECD)	1.5	1.0	1.0	0.4
U.S.	1.5	1.8	1.5	1.8
Germany	1.6	1.8	1.6	-
France	1.4	1.4	1.0	1.5
U.K.	1.5	1.6	0.7	1.8
China	15.3	10.2	5.7	-
Korea	4.6	3.1	3.2	4.4

Note: For Germany, public organizations include non-profit institutions.
Reference: Chart 1-1-6, Japanese Science and Technology Indicators 2020 (in Japanese)

(4) The proportion of R&D expenditure type in "universities and colleges" sector has been stable in Japan, whereas not in other selected countries.

R&D expenditure in the "business enterprises" sector is the largest in "experimental development" whereas much smaller in "basic research" in all the countries. In the "universities and colleges" sector, "basic research" accounts for the largest part in most countries except for China, where "applied research" accounts for the largest; "basic research" has been stable in Japan whereas it has declined in the United States and France and increased in China. In the "public organizations" sector, "experimental development" is the largest in many countries except for France and the United Kingdom, where "applied research" accounts for the largest part.

[Summary Chart 4] Breakdown of sector-specific R&D expenditure of selected countries by type

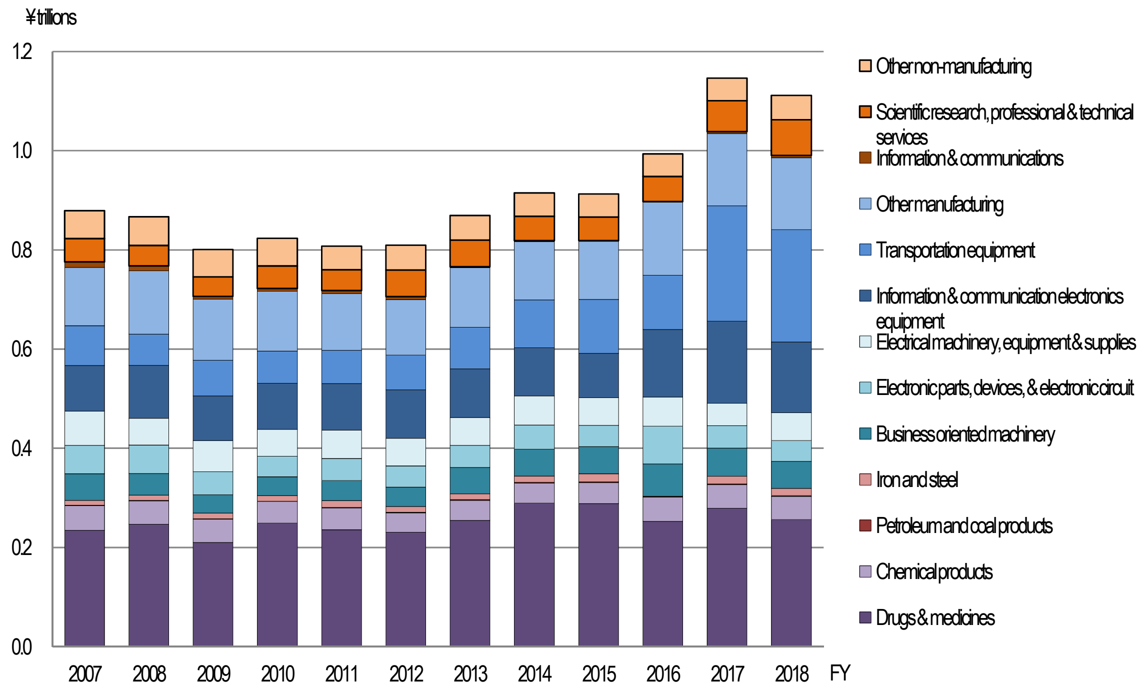


Note: Universities and colleges in the United Kingdom are excluded as the data are estimations.
Reference: Chart 1-4-2, Japanese Science and Technology Indicators 2020 (in Japanese)

(5) R&D expenditure by Japanese business enterprises in “basic research” is the largest in “drugs and medicines” industry and is growing in “transportation equipment” industry.

Regarding the R&D expenditure by Japanese business enterprises in “basic research” by industry, “drugs & medicines” was the largest (256 billion yen) in FY2018, followed by “transportation equipment” (226.3 billion yen) and “information & communication electronics equipment” (142.4 billion yen). The largest growth from FY2007 to FY2018 was in “transportation equipment” (2.8 times).

[Summary Chart 5] Trends in “basic research” R&D expenditure of Japanese business enterprises by industry



Reference: Chart 1-4-3, Japanese Science and Technology Indicators 2020 (in Japanese)

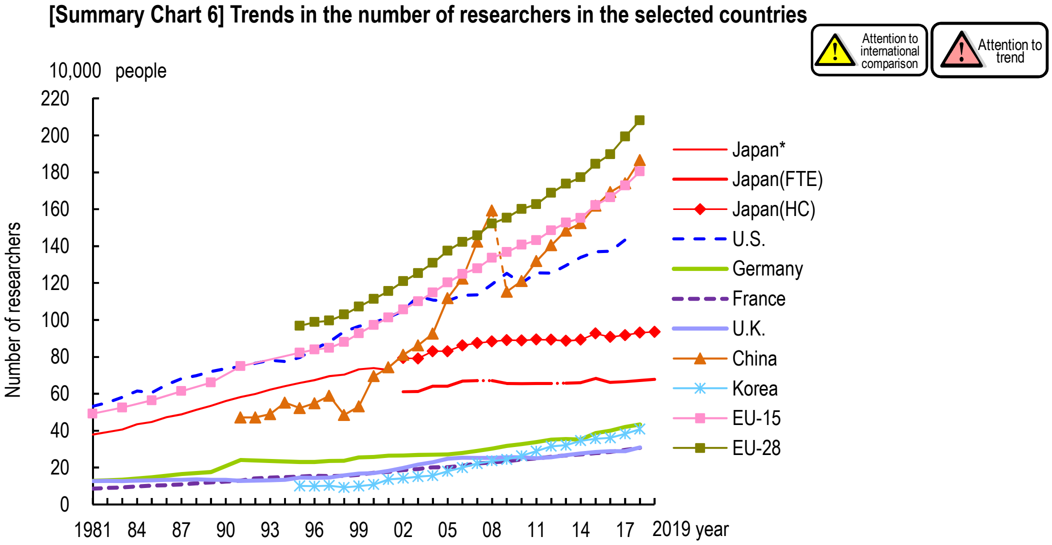
2. R&D personnel: circumstances in Japan and the selected countries

(1) The number of researchers in Japan was 678,000 in 2019, which is the third largest in the world after China and the United States. "Business enterprises" sector has the largest number of researchers in most countries.

The number of researchers in Japan is 678,000 (in FTE: Full-time equivalent) in 2019, which is the third largest following China and the United States. The number of researchers in Korea has continued to rise, becoming on a par with Germany in the latest year.

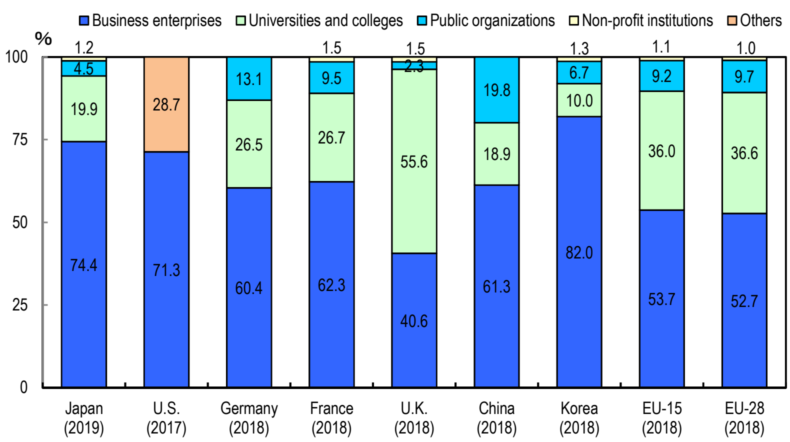
Like R&D expenditure, the "business enterprises" sector accounts for the largest part in terms of number of researchers in most countries, except for the United Kingdom, where "universities and colleges" has the largest number of researchers.

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



Note: 1)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.
2) Japan (HC) denotes the headcount of researchers in Japan.
Reference: Chart 2-1-3, Japanese Science and Technology Indicators 2020 (in Japanese)

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



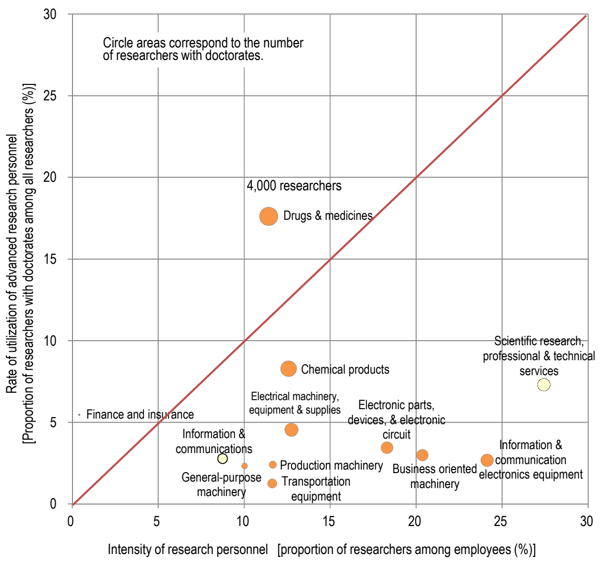
Note: 1) All the countries are based on FTE values.
2) The values of the U.S. are those estimated by the OECD. Since no value for recent years is available aside from those for the business enterprise sector, the values shown pertain to business enterprises and other sectors.
3) The figure of public organizations in Germany includes non-profit institutions.
Reference: Chart 2-1-7, Japanese Science and Technology Indicators 2020 (in Japanese)

(2) The rate of utilization of advanced research personnel (the proportion of researchers with doctorate degrees among all researchers) is low in Japan, compared with the United States.

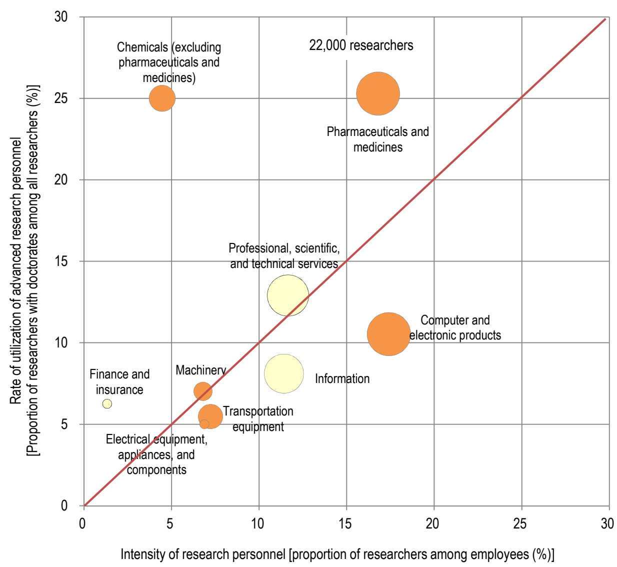
The proportion of researchers with doctorate degrees among all researchers is at least 5% in all the industries shown in the figure in the United Stetes, while the proportion is less than 5% in many industries in Japan. It suggests that Japan tends to be low in utilization of advanced research personnel compared with the United States.

[Summary Chart 8] Relationship between the intensity of research personnel and the rate of utilization of advanced research personnel by industry

(A) Japan (2019)



(B) U.S. (2017)



Note: The intensity of research personnel is the proportion of researchers (HC) among employees. The rate of utilization of advanced research personnel is the proportion of researchers with doctorate degrees among all researchers (HC). For both Japan and the United States, this analysis covered business enterprises engaging in R&D. Orange circles denote manufacturing sectors, yellow circles non-manufacturing sectors.

<Japan> For the industrial classification of Japan, an industrial classification system for scientific and technological research and surveys based on the Japan Standard Industry Classification was used.

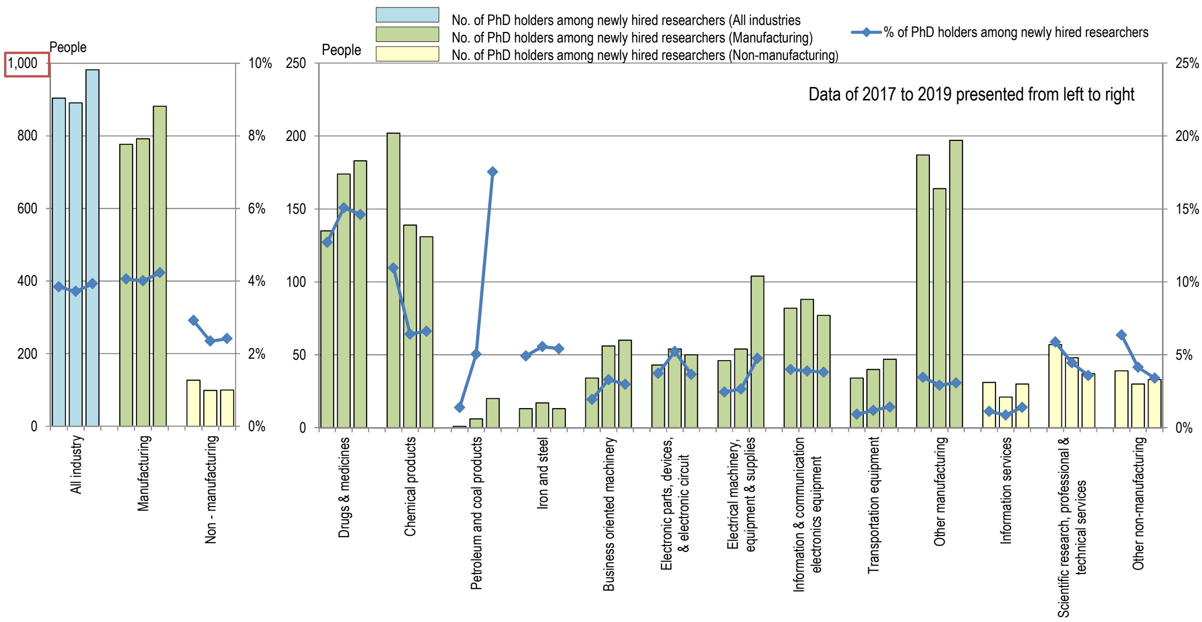
<U.S.> For the industrial classification of the United States, the North American Industry Classification System (NAICS) was used.

Reference: Chart 2-2-9, Japanese Science and Technology Indicators 2020 (in Japanese)

(3) Fresh hiring of PhD holders is increasing in manufacturing industries in Japan while stagnating in non-manufacturing industries.

The number of PhD holders newly hired and their share in all newly hired researchers vary depending on the industries. The number is increasing in manufacturing insudtries whereas stagnating in non-manufacturing ones. The figures tend to be high in “drugs and medicines” and “chemical products.” The number of newly hired PhD holders grew significantly between 2017 and 2019 in “petroleum and coal products” and “electrical machinery, equipment & supplies.”

[Summary Chart 9] PhD holders among newly hired researchers of business enterprises (by industry)

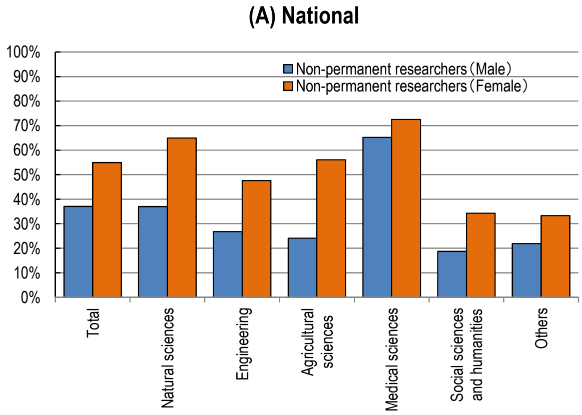


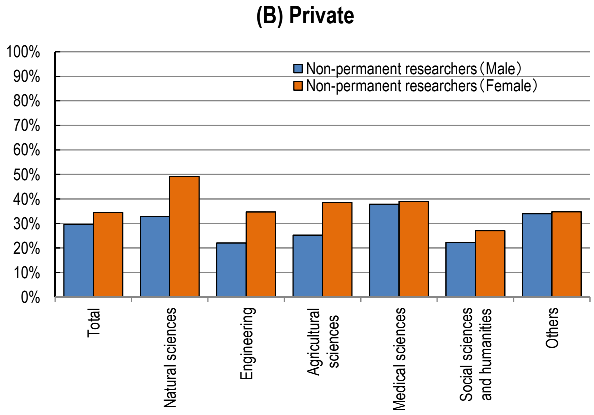
Reference: Chart 2-1-19, Japanese Science and Technology Indicators 2020 (in Japanese)

(4) The percentage of non-permanent female researchers tends to be higher than that of non-permanent male researchers in universities and colleges in Japan, which mostly applies to national and private universities and colleges regardless of fields of study.

The percentage of non-permanent female researchers in universities and colleges tends to be higher than that of non-permanent male researchers both in national and private. Similar trends can be observed in almost all fields of study. The percentage of non-permanent researchers is especially high in medical sciences. While the difference between male and female is relatively small in medical sciences, it is significant in natural sciences, engineering, and agricultural sciences. This trend is particularly evident in national universities and colleges.

[Summary Chart 10] The situation of non-permanent researchers in universities and colleges in Japan (2019)





Reference: Chart 2-2-14 Japanese Science and Technology Indicators 2020 (in Japanese)

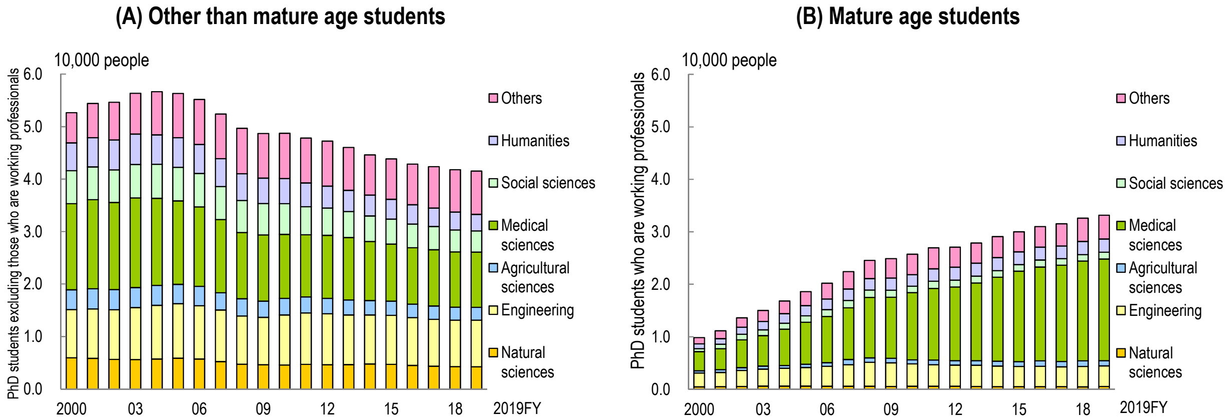
3. Students and graduate students: situations in Japan and selected countries

(1) The number of PhD students excluding mature age students is decreasing while the number of mature age PhD students is growing.

The number of PhD students excluding mature age students is decreasing. Looking into the majors, the number of “engineering” students had been gently fluctuating up to FY2010 and has been slightly decreasing since FY2011. The numbers of students in many other fields have been on downtrends.

The number of mature age PhD students is growing, especially in “medical sciences”.

[Summary Chart 11] Trends in the number of PhD students by major who are or are not mature age students



Notes: 1) Others include “merchant marine,” “domestic science,” “education,” “fine arts,” and “others.”
2) “Mature age students” include 1) people who are employed (those who are currently working to earn salaries, wages, remunerations or other regular income), 2) those who are retired from positions in which they earned salaries, wages, remunerations or other regular income, and 3) housewives/househusbands.

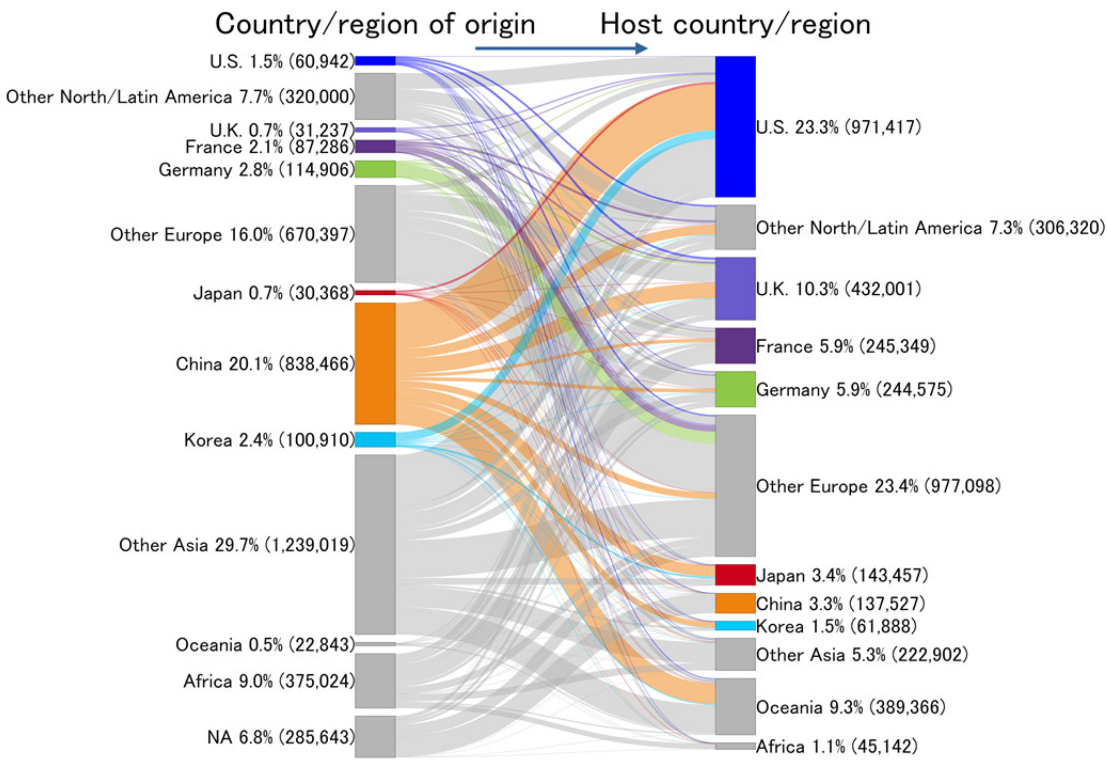
Reference: Chart 3-2-10, Japanese Science and Technology Indicators 2020 (in Japanese)

(2) Around 4.2 million students in the world receive higher education in countries or regions different from those of their origin (as of 2016).

China sends the highest proportion of students abroad among all the selected countries, accounting for 20.1% of all students studying abroad. The United States is the largest country receiving the highest proportion of such Chinese students. In terms of the receiving countries/regions, the United States receives the largest number of foreign students, 23.3% of all students studying abroad, followed by the United Kingdom, receiving 10.3%.

The data of foreign students in the selected countries show that China and Korea send more students abroad than what they receive from abroad. On the other hand, the United States and the United Kingdom receive more than what they send. Japan relatively does not send or receive many students.

[Summary Chart 12] Countries/regions of origin and host countries/regions of foreign students with higher education (ISCED2011 level 5–8) (2016)



Notes:1) Students with education level equivalent to ISCED 2011 level 5–8 (such as Japanese colleges including two-year colleges and technical colleges)
2) Foreign students refer to students who do not hold nationality of their host countries/regions.
3) China includes Hong Kong.
4) As information is not available for the countries/regions of origin of foreign students studying in China, those students are all included in "NA." Therefore, Japanese students who study in China are also included in "NA." According to the announcement by the Ministry of Education of the People's Republic of China as of April 12, 2019 (http://www.moe.gov.cn/jyb_xwfb/gzdt_gzdt/s5987/201904/t20190412_377692.html, accessed on June 12, 2019), the number of Japanese students studying in China's higher-education institutions (1,004 institutions), not including those in Hong Kong, Macao, or Taiwan, was 14,230 (2018).

Reference: Chart 3-5-2, Japanese Science and Technology Indicators 2020 (in Japanese)

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 noticeable in highly cited papers (the number of adjusted top 10% papers and adjusted top 1% papers). China overtook the United States to become the world's top in terms of number of papers.

In terms of number of scientific papers, which is one measure of R&D outputs, the number of Japanese papers (the average of PY2016–2018) is ranked 4th after China, the United States, and Germany, when counted by the fractional counting method that measures the degree of contribution to paper production. China overtook the United States to take the top in the world. Japan is ranked 9th both in the number of adjusted top 10% papers and the number of adjusted top 1% papers.

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 noticeable in highly cited papers such as adjusted top 10% papers and adjusted top 1% papers.

[Summary Chart 13] 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	1996 — 1998 (PY) (Average)		
	The number of papers		
Country/Region	Fractional counting		
	Papers	Share	World rank
U.S.	202,530	28.9	1
Japan	60,704	8.7	2
U.K.	49,920	7.1	3
Germany	49,305	7.0	4
France	36,668	5.2	5
Canada	24,799	3.5	6
Italy	23,508	3.4	7
Russia	23,061	3.3	8
China	17,034	2.4	9
Spain	15,509	2.2	10

All fields	2006 — 2008(PY) (Average)		
	The number of papers		
Country/Region	Fractional counting		
	Papers	Share	World rank
U.S.	238,912	24.2	1
China	84,587	8.6	2
Japan	66,460	6.7	3
Germany	55,674	5.6	4
U.K.	53,735	5.4	5
France	40,733	4.1	6
Italy	34,517	3.5	7
Canada	32,718	3.3	8
India	29,110	2.9	9
Spain	26,447	2.7	10

All fields	2016 — 2018 (PY) (Average)		
	The number of papers		
Country/Region	Fractional counting		
	Papers	Share	World rank
China	305,927	19.9	1
U.S.	281,487	18.3	2
Germany	67,041	4.4	3
Japan	64,874	4.2	4
U.K.	62,443	4.1	5
India	59,207	3.9	6
Korea	48,649	3.2	7
Italy	46,322	3.0	8
France	45,387	3.0	9
Canada	41,071	2.7	10

All fields	1996 — 1998 (PY) (Average)		
	The number of adjusted top 10% papers		
Country/Region	Fractional counting		
	Papers	Share	World rank
U.S.	30,791	44.0	1
U.K.	5,880	8.4	2
Germany	4,619	6.6	3
Japan	4,237	6.1	4
France	3,432	4.9	5
Canada	2,939	4.2	6
Italy	1,955	2.8	7
Netherlands	1,755	2.5	8
Australia	1,539	2.2	9
Switzerland	1,247	1.8	10

All fields	2006 — 2008(PY) (Average)		
	The number of adjusted top 10% papers		
Country/Region	Fractional counting		
	Papers	Share	World rank
U.S.	35,516	36.0	1
U.K.	7,086	7.2	2
China	6,598	6.7	3
Germany	6,079	6.2	4
Japan	4,461	4.5	5
France	4,220	4.3	6
Canada	3,802	3.9	7
Italy	3,100	3.1	8
Spain	2,503	2.5	9
Australia	2,493	2.5	10

All fields	2016 — 2018 (PY) (Average)		
	The number of adjusted top 10% papers		
Country/Region	Fractional counting		
	Papers	Share	World rank
U.S.	37,871	24.7	1
China	33,831	22.0	2
U.K.	8,811	5.7	3
Germany	7,460	4.9	4
Italy	5,148	3.4	5
Australia	4,686	3.1	6
France	4,515	2.9	7
Canada	4,423	2.9	8
Japan	3,865	2.5	9
India	3,672	2.4	10

All fields	1996 — 1998 (PY) (Average)		
	The number of adjusted top 1% papers		
Country/Region	Fractional counting		
	Papers	Share	World rank
U.S.	3,669	52.5	1
U.K.	585	8.4	2
Germany	392	5.6	3
Japan	338	4.8	4
France	298	4.3	5
Canada	274	3.9	6
Netherlands	175	2.5	7
Italy	154	2.2	8
Australia	146	2.1	9
Switzerland	134	1.9	10

All fields	2006 — 2008(PY) (Average)		
	The number of adjusted top 1% papers		
Country/Region	Fractional counting		
	Papers	Share	World rank
U.S.	4,251	43.1	1
U.K.	765	7.8	2
Germany	600	6.1	3
China	470	4.8	4
France	385	3.9	5
Canada	383	3.9	6
Japan	351	3.6	7
Netherlands	259	2.6	8
Italy	255	2.6	9
Australia	249	2.5	10

All fields	2016 — 2018 (PY) (Average)		
	The number of adjusted top 1% papers		
Country/Region	Fractional counting		
	Papers	Share	World rank
U.S.	4,501	29.3	1
China	3,358	21.9	2
U.K.	976	6.4	3
Germany	731	4.8	4
Australia	507	3.3	5
Canada	434	2.8	6
France	427	2.8	7
Italy	390	2.5	8
Japan	305	2.0	9
Netherlands	288	1.9	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 2019.
Reference: Chart 4-1-6, Japanese Science and Technology Indicators 2020 (in Japanese)

(2) Japan has maintained the 1st position in the world in the number of patent families (patents filed in two or more countries/regions) in the past ten years.

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 measured in an internationally comparable manner.

Between 1993 and 1995, the United States was ranked the first and Japan the second. Between 2003 and 2005 and between 2013 and 2015, Japan was ranked the first and the United States the second. The increase in the number of Japanese patent families is attributable to the increase of patent applications to multiple countries instead of any single country. China's number of patent families has been steadily increasing although it was ranked fifth between 2013 and 2015.

[Summary Chart 14] The number of patent families by selected country/region: top 10 countries/regions

1993 - 1995(Average)			
Country/Region	Number of patent families (Whole counting)		
	Patent Families	Share	World rank
U.S.	26,066	28.7	1
Japan	24,470	26.9	2
Germany	15,147	16.7	3
France	5,839	6.4	4
U.K.	4,894	5.4	5
Italy	2,658	2.9	6
Korea	2,582	2.8	7
Switzerland	2,254	2.5	8
Netherlands	1,914	2.1	9
Canada	1,904	2.1	10

2003 - 2005(Average)			
Country/Region	Number of patent families (Whole counting)		
	Patent Families	Share	World rank
Japan	57,034	29.6	1
U.S.	48,219	25.0	2
Germany	27,678	14.4	3
Korea	15,979	8.3	4
France	10,210	5.3	5
U.K.	8,569	4.4	6
Taiwan	6,890	3.6	7
China	5,921	3.1	8
Netherlands	5,034	2.6	9
Canada	4,924	2.6	10

2013 - 2015(Average)			
Country/Region	Number of patent families (Whole counting)		
	Patent Families	Share	World rank
Japan	61,753	26.3	1
U.S.	54,150	23.0	2
Germany	26,895	11.4	3
Korea	23,963	10.2	4
China	21,191	9.0	5
France	11,167	4.8	6
Taiwan	10,760	4.6	7
U.K.	8,754	3.7	8
Canada	5,253	2.2	9
Italy	4,232	1.8	10

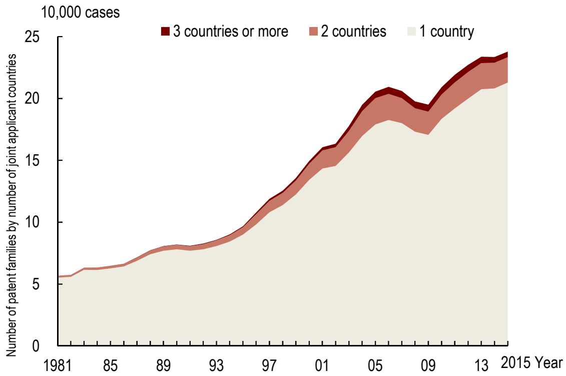
Note: A patent family is a group of patents filed in two or more countries/regions, directly or indirectly related to each other by priority rights. In many cases, the same patents filed in multiple countries belong to the same patent family.
Reference: Chart 4-2-5, Japanese Science and Technology Indicators 2020 (in Japanese)

(3) While international collaboration is being strengthened concerning patent families, Japan ranks the lowest among the selected countries in the percentage of patent families filed through joint international applications.

Regarding the state of international cooperation in patent families in the world, the number of patent families filed through joint international applications (by inventors from two, three or more different countries/regions, hereinafter these countries are referred to as joint applicant countries), is growing, and it is clear that international collaboration is strengthening concerning patent families.

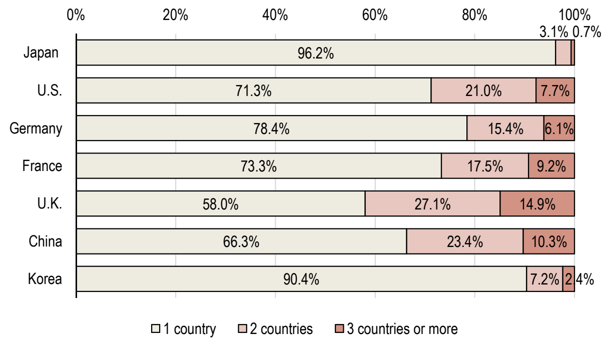
Looking at the breakdown of patent families of selected countries by number of joint applicant countries, Japan had only 3.8% of patent families jointly applied with other countries, the lowest among the selected countries. Compared to other selected countries, Japan stands particularly low at 0.7% in terms of patent families jointly applied by three or more countries.

[Summary Chart 15] Number of patent families by number of joint applicant countries



Note: Figures in "3 countries or more" and "2 countries" correspond to patent families through joint international patent appcilations.
Reference: Chart 4-2-7, Japanese Science and Technology Indicators 2020 (in Japanese)

[Summary Chart 16] Breakdown of patent families of selected countries by number of joint applicant countries (2006-2015)



Note: Figures in "3 countries or more" and "2 countries" correspond to patent families through joint international patent appcilation.
Reference: Chart 4-2-8, Japanese Science and Technology Indicators 2020 (in Japanese)

(4) Although the number of Japanese patent families that cite 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 (the total in the 2008-2015 period) was analyzed. Japan ranks second in the world in terms of the number of patent families that cite papers. However, the number of Japanese patent families that cite papers accounts for only 8.5% of its total patent families, suggesting that Japan's technologies do not cite scientific output as much as other countries' technologies do.

While, the number of Japanese papers cited by patent families during the 2008-2015 period (the total in the 1981-2015 period) is the world's second largest after the United States, meaning that many Japanese papers are cited by technologies around the world.

[Summary Chart 17] The number of patent families that are citing papers: top 10 countries/regions

Whole counting		2008–2015 (Total)			
		(A) Patent families citing papers		(B) Total number of patent families	
No.	Country/ Region	No. of patent families	Global share of (A)	No. of patent families	Percentage of patent families citing papers (A) / (B)
1	U.S.	101,435	28.4	393,094	25.8
2	Japan	41,272	11.6	487,497	8.5
3	Germany	36,366	10.2	217,229	16.7
4	France	21,711	6.1	86,933	25.0
5	China	18,764	5.3	132,457	14.2
6	U.K.	18,141	5.1	67,353	26.9
7	Korea	13,844	3.9	163,638	8.5
8	Canada	10,819	3.0	43,219	25.0
9	Netherlands	9,569	2.7	32,707	29.3
10	India	8,832	2.5	28,201	31.3

Reference: Chart 4-3-2, Japanese Science and Technology Indicators 2020 (in Japanese)

[Summary Chart 18] The number of papers that are cited by patent families: top 10 countries/regions

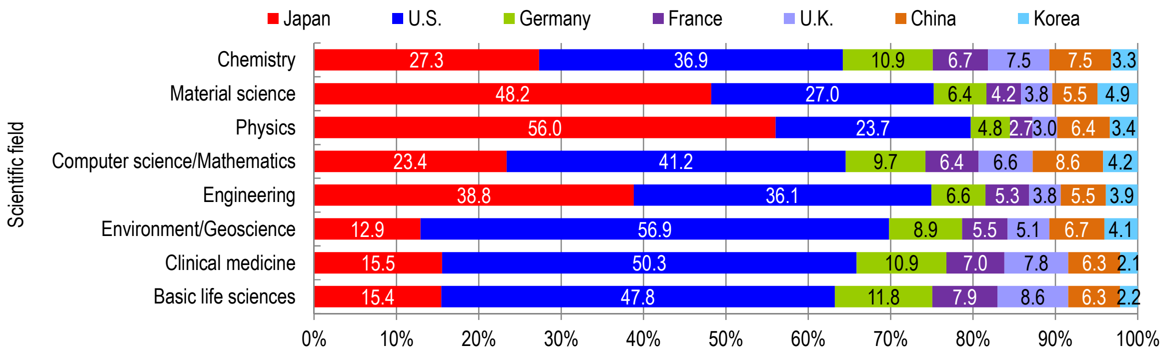
Whole counting		1981-2015 (Total)			
		(A) Papers cited by patent families		(B) Total number of papers	
No.	Country/ Region	No. of papers	Global share of (A)	No. of papers	Percentage of papers cited by patent families (A) / (B)
1	U.S.	380,078	35.2	8,129,640	4.7
2	Japan	77,471	7.2	2,054,783	3.8
3	Germany	75,039	7.0	2,122,707	3.5
4	U.K.	74,553	6.9	2,115,855	3.5
5	France	49,247	4.6	1,545,747	3.2
6	China	45,217	4.2	2,105,866	2.1
7	Canada	40,154	3.7	1,183,810	3.4
8	Italy	32,620	3.0	1,085,464	3.0
9	Netherlands	26,383	2.4	635,482	4.2
10	Korea	23,003	2.1	598,185	3.8

Reference: Chart 4-3-3, Japanese Science and Technology Indicators 2020 (in Japanese)

(5) Japanese scientific knowledge may not sufficiently be utilized from Japanese technologies

Regarding Japanese papers cited by Japanese patent families, the most cited fields are "physics (56.0%)" and "material science (48.2%)". While, the fields of "environment/geoscience (12.9%)," "basic life sciences (15.4%)" and "clinical medicine (15.5%)" are relatively less cited by Japanese patent families.

[Summary Chart 19] Connection between Japanese papers and the selected countries' patent families



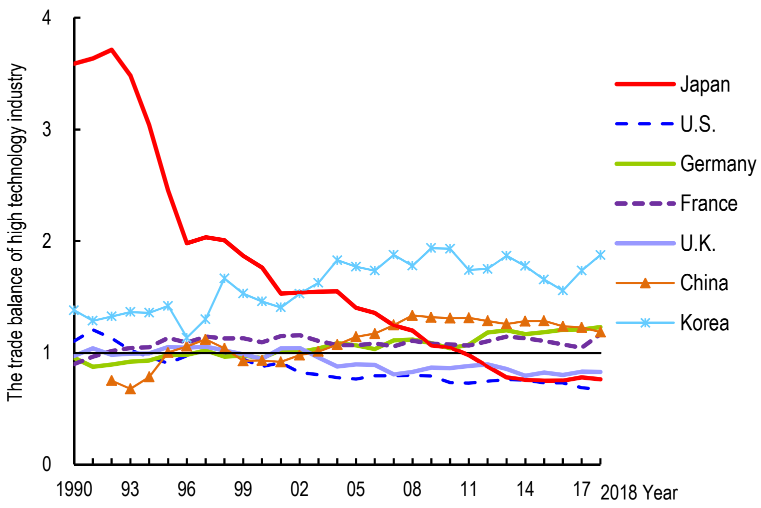
Reference: Chart 4-3-7, Japanese Science and Technology Indicators 2020 (in Japanese)

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

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

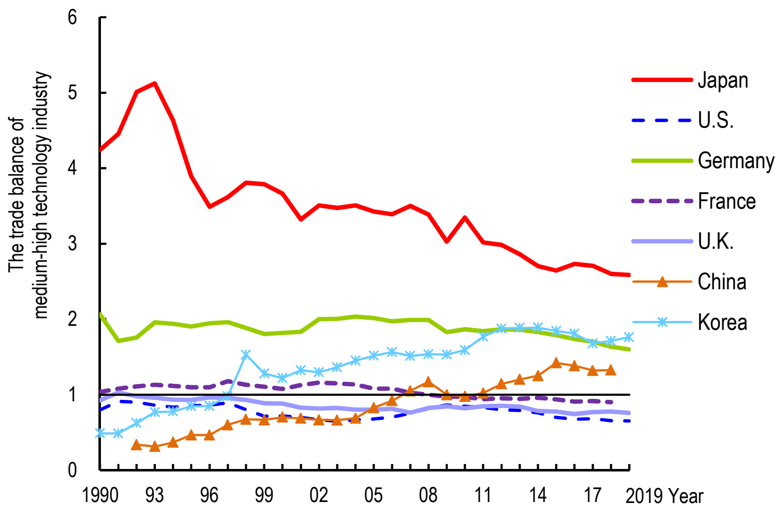
The latest trade balance ratio in Japan's high-technology industry is 0.76 (trade deficit). That of Japan's medium high-technology industry is 2.59 (trade surplus), the highest among the selected countries. The trade balance ratio shows a gradual decline following a rapid drop in the mid-1990s.

[Summary Chart 20] Trends 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 5-2-4, Japanese Science and Technology Indicators 2020 (in Japanese)

[Summary Chart 21] Trends in the trade balance ratios for medium high-technology industries in the selected countries



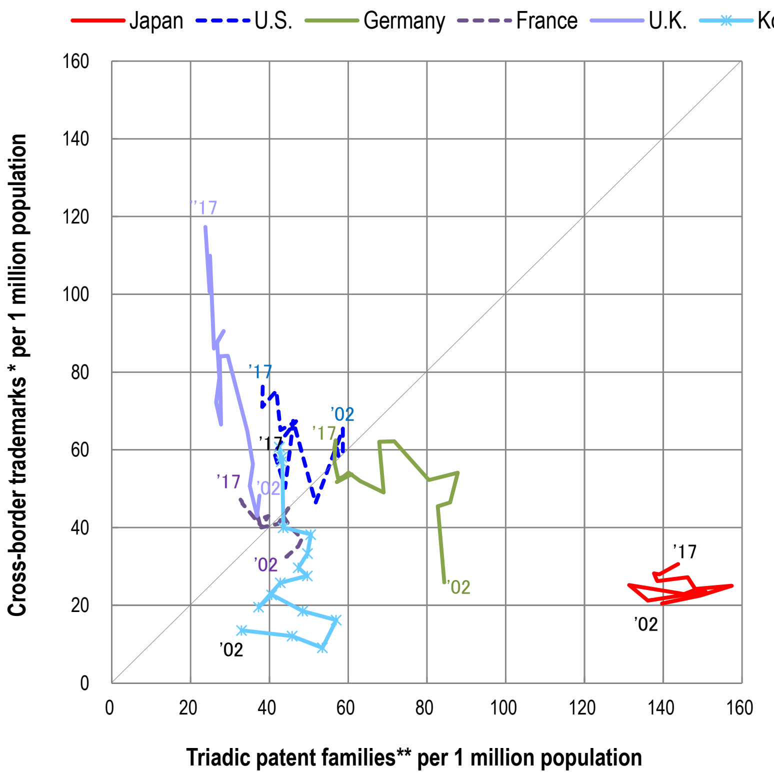
Note: 1) Medium high-technology industries refer to "chemicals and chemical products," "electrical equipment," "machinery and equipment n.e.c.," "motor vehicles, trailers and semi-trailers," "railroad equipment and transport equipment n.e.c.," and "other."
2) Trade balance ratio = export value / import value
Reference: Chart 5-2-6, Japanese Science and Technology Indicators 2020 (in Japanese)

(2) Japan has strength in technology yet with a possibility of lagging other selected countries in terms of international launching of new products or services based on their technologies

When comparing the numbers of cross-border applications for trademarks and patent families per million populations, Japan is the only country with fewer trademark applications than patent family applications in the latest year.

Countries with more trademark applications than patent family applications in the latest year are the United Kingdom, the United States, France, Korea, and Germany. In Korea, the United Kingdom, and Germany, the number of trademark applications surged in the period between 2002 and 2017.

[Summary Chart 22] Cross-border trademark applications and patent applications (per 1 million population)



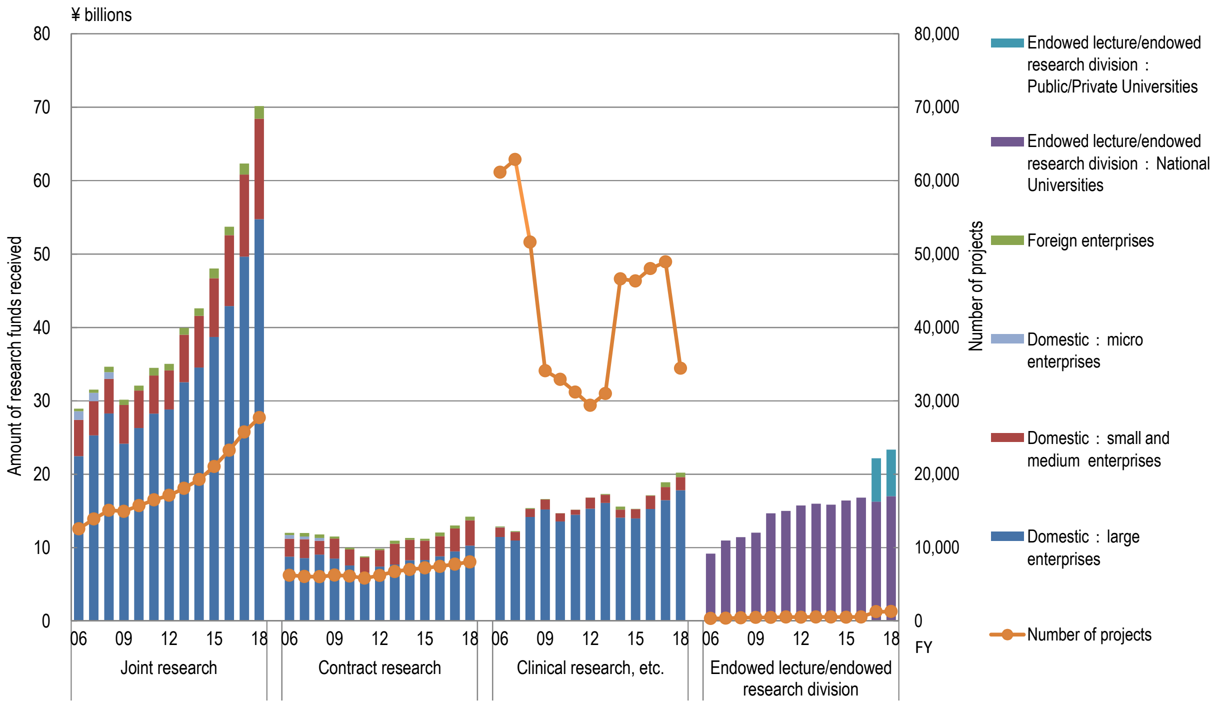
[Meaning of the number of trademark applications as an indicator]
The number of trademark applications is related to concretizations of innovations in the forms of new product or service introductions, or marketing activities thereof. In this sense, the number of trademark applications is considered as data that reflect the relationship between innovations and markets.

Note: 1)* For the definition of cross-border trademarks, "Measuring Innovation: A New Perspective" released by the OECD is 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, Japanese Science and Technology Indicators 2020 (in Japanese)

(3) The number of joint research projects implemented by Japanese universities and private businesses, and the amount of research funds that Japanese universities received, are rapidly increasing.

In Japan, among various types of university-industry collaborations, the amount of funds received for "joint research" was the largest, reaching 70.1 billion yen, with 28,000 joint research projects implemented in 2018. A large amount of such funds was provided by large enterprises, amounting to 54.7 billion yen in the latest year. The total amount of funds received for "joint research" has increased by 10% or more each year since FY2015.

[Summary Chart 23] Trends 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 universities and private business, etc., in which the other party (i.e. other than universities) 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 only for national universities up until FY2016. The measurement of values for public/private universities started in FY2017.
Recalculation by NISTEP using the individual data of the "Status of Industry-Academic Collaboration at Universities, etc." published by the Ministry of Education, Culture, Sports, Science and Technology
Reference: Chart 5-4-7, Japanese Science and Technology Indicators 2020 (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.

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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