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Japanese Science and Technology Indicators 2019 (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 180 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 2019" includes new indicators and columns such as "the distribution of doctorate holders by sector in Japan and the United States," "the relation between the percentage of researchers in employees and the percentage of the doctorate holders in researchers by industrial classification," "time series of new doctoral degree recipients in selected countries," "trends of scientific publications in sport sciences," "trends in the amount of trade in selected countries," and "number of unicorn companies by country/region and field" (totally about 20 indicators).

Overviewing the latest Japan's situation from "Science and Technology Indicators 2019," 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 (fraction 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). These trends continue from the previous edition. The percentage of the doctorate holders in researchers differs by industrial classification and the percentage in Japan is lower than the United States. The new doctoral degree recipients per million population have been decreasing only in Japan among the selected countries.

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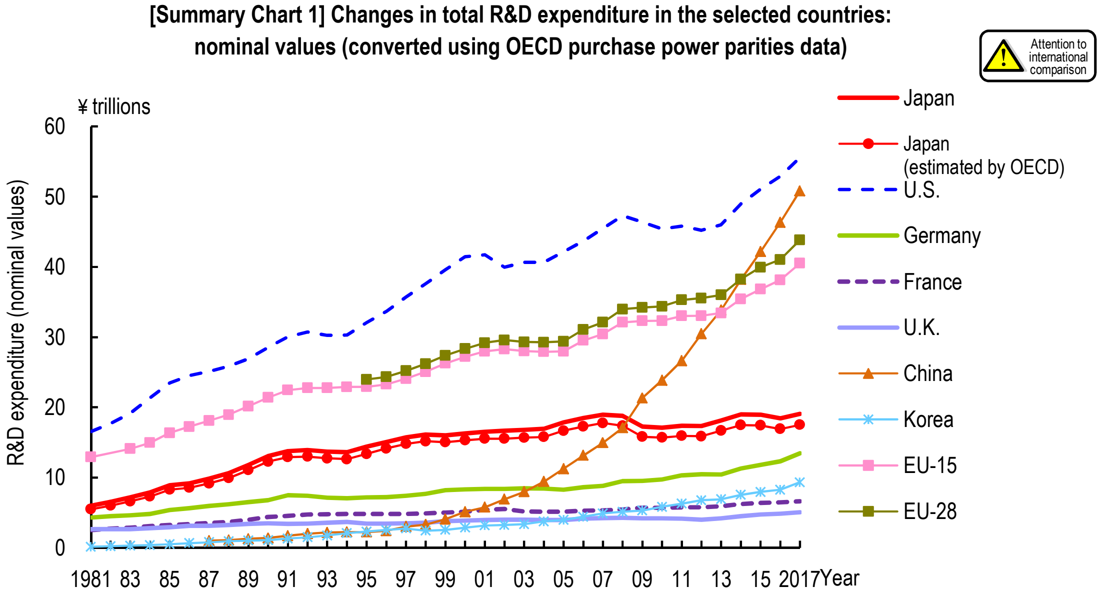
1. R&D expenditure: circumstances in Japan and the selected countries

(1) Japan's total R&D expenditure was 19.1 trillion yen in 2017 (OECD-estimate for Japan: 17.5 trillion yen), the world's third largest after the United States and China.

Japan’s total R&D expenditure (nominal value) was 19.1 trillion yen (OECD-estimate for Japan: 17.5 trillion yen) in 2017, increased by 3.4% from the previous year (OECD-estimate for Japan: +3.6%). The United States maintained the world’s largest scale with its total R&D expenditure being 55.6 trillion yen in the same year and increased by 5.0% from the previous year. The R&D expenditure of China marked 50.8 trillion yen in 2017, increased by 9.7% year on year and approaching the level of the US’s R&D expenditure.

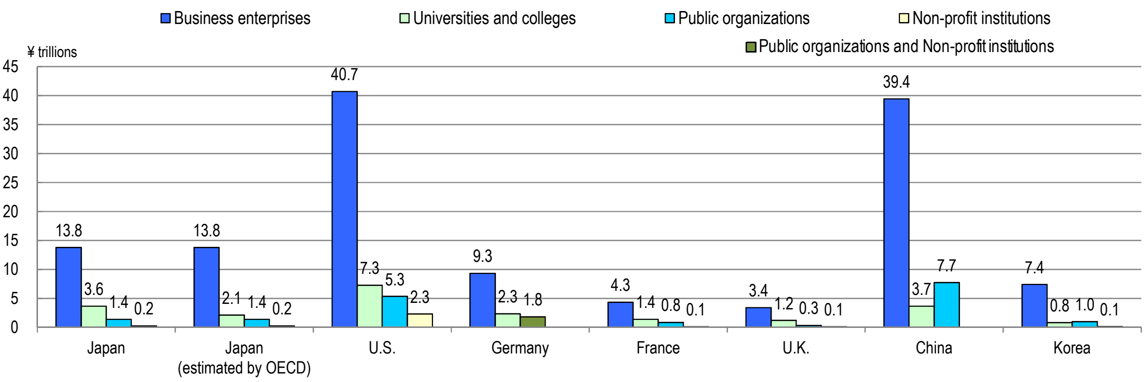
In terms of sectors, the “business enterprises” sector accounted for the largest percentage of R&D expenditure in all of the selected countries. This tendency is particularly notable in Korea, Japan (estimated by OECD) and China, whereas differences between the “business enterprises” sector and other 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)



Reference: Chart 1-1-1, Japanese Science and Technology Indicators 2019 (in Japanese)

[Summary Chart 2] R&D expenditure by sector in the selected countries (2017): nominal values (converted using OECD purchase power parities data)



Reference: Chart 1-1-6, Japanese Science and Technology Indicators 2019 (in Japanese)

(2) 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.

According to the growth of R&D expenditure from 2000 to 2017 by sector, which shows R&D expenditure in 2017 relative to that in 2000, the "business enterprises" sector had the highest growth in Japan, Japan (estimated by OECD), China and Korea, 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 greater. Nonetheless, the scale 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.

[Summary Chart 3] R&D expenditure by sector in the selected countries: the R&D expenditure in 2017 relative to that in 2000

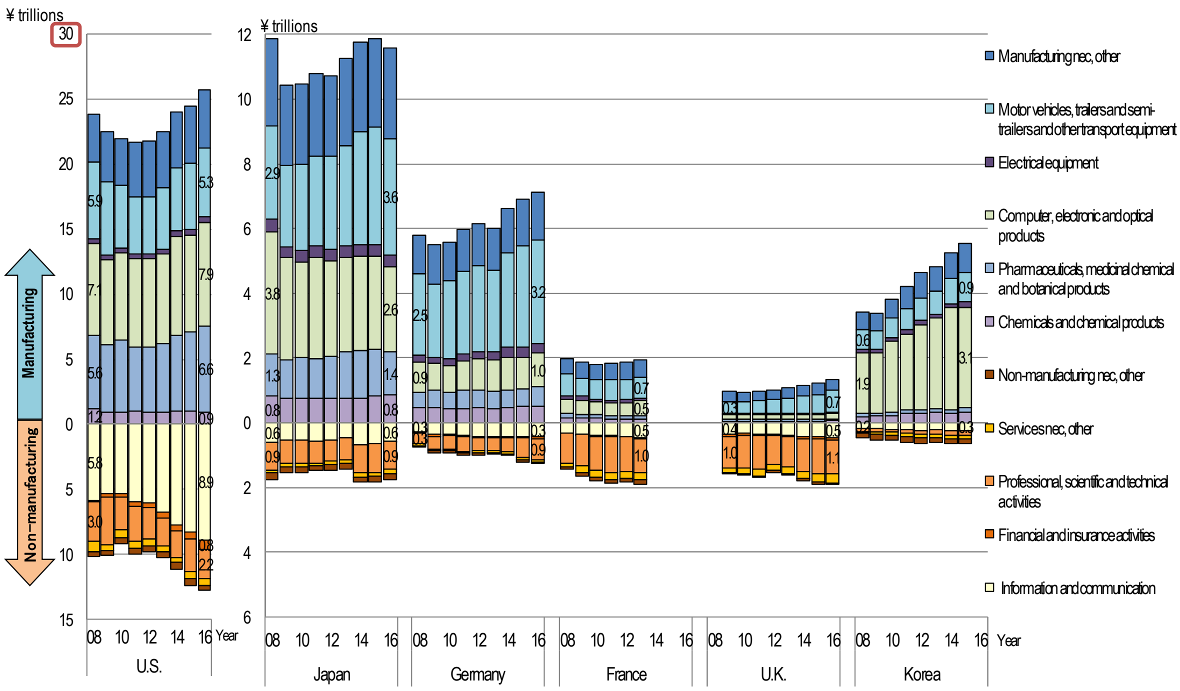
	Nominal values				Real values			
	Business enterprises	Universities and colleges	Public organizations	Non-profit institutions	Business enterprises	Universities and colleges	Public organizations	Non-profit institutions
Japan	1.3	1.1	0.9	0.3	1.4	1.3	1.0	0.4
Japan (estimated by OECD)	1.3	0.9	0.9	0.3	1.4	1.0	1.0	0.4
U.S.	2.0	2.4	1.8	2.3	1.4	1.7	1.3	1.7
Germany	1.9	2.1	1.9	-	1.5	1.7	1.6	-
France	1.7	1.8	1.2	1.9	1.3	1.4	0.9	1.5
U.K.	2.0	2.2	1.0	2.3	1.4	1.6	0.7	1.7
China	25.4	16.5	9.5	-	14.0	9.1	5.2	-
Korea	6.1	4.3	4.6	5.9	4.2	3.0	3.2	4.1

Note: For Germany, public organizations include non-profit institutions.
Reference: Chart 1-1-6, Japanese Science and Technology Indicators 2019 (in Japanese)

(3) In the United States, business enterprises in both manufacturing and non-manufacturing industries have increased their R&D expenditure. In Japan, Germany and Korea, the R&D expenditure in the manufacturing industry tends to be large relative to the expenditure i the non-manufacturing industry. The expenditure of business enterprises in the non-manufacturing industry tends to be greater in France and the United Kingdom than in other countries.

With regard to the R&D expenditure of the business enterprises sector by industry in the most recent year, the following industries have undertaken large-scale expenditure in the respective countries: the "information and communication industry" in the United States, the "motor vehicles, trailers and semi-trailers and other transport equipment industry" in Japan and Germany, the "professional, scientific and technical activities industry" in France and the United Kingdom, and the "computer, electronic and optical products industry" in Korea.

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

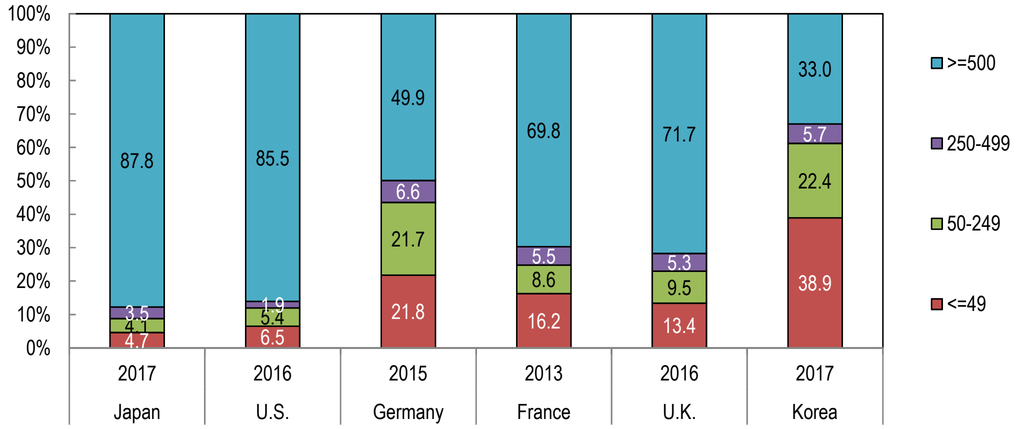


Reference: Chart 1-3-6, Japanese Science and Technology Indicators 2019 (in Japanese)

(4) Direct government contributions to R&D expenditure of business enterprises are concentrated on large-scale business enterprises in Japan and the United States, while such contributions to small- and medium-scale business enterprises have certain significance in Korea and Germany.

Direct government contributions to the R&D expenditure of business enterprises by the number of employees show that more than 80% of the contributions go to the business enterprises with 500 or more employees in Japan and the United States. In contrast, the percentage of business enterprises with 49 or less employees is high in Korea (38.9%) and Germany (21.8%).

[Summary Chart 5] Direct government contributions to the R&D expenditure of business enterprises by the number of employees in the selected countries



	Japan	U.S.	Germany	France	U.K.	Korea
Percentage of government contributions in business enterprises' R&D expenditure	1%	6%	3%	8%	8%	5%
Amount	0.1 trillion yen	2.5 trillion yen	0.3 trillion yen	0.3 trillion yen	0.3 trillion yen	0.3 trillion yen

Reference: Chart 1-3-10, Japanese Science and Technology Indicators 2019 (in Japanese)

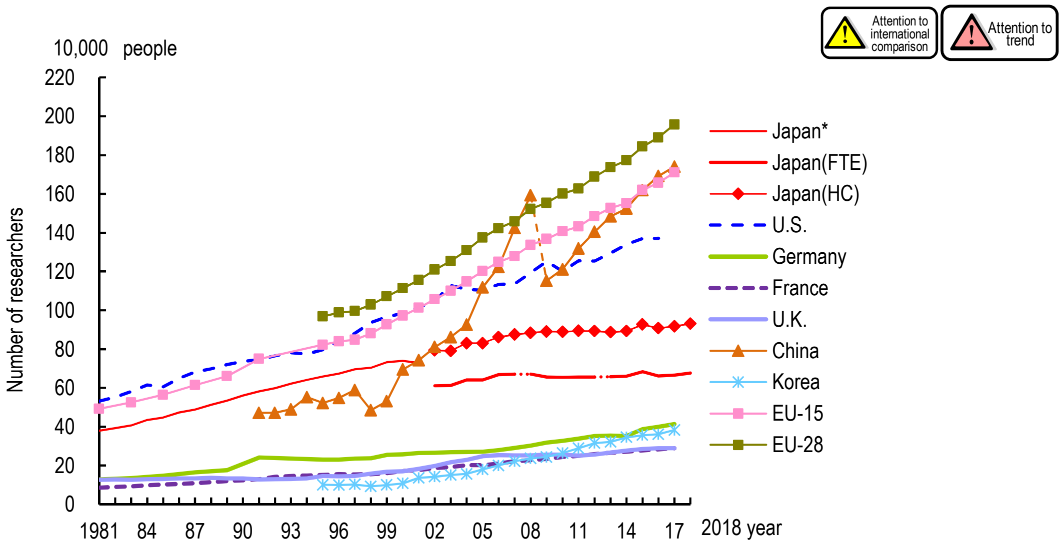
2. R&D personnel: circumstances in Japan and the selected countries

(1) The number of researchers in Japan was 676,000 in 2018, the third largest scale in the world after China and the United States.

The number of researchers is as important as the R&D expenditure in terms of inputs to R&D. The number of researchers in Japan was 676,000 in 2018 (the head count is 931,000), the third largest scale in the world after China and the United States. The number of researchers in Korea has reaching the same level as that of Germany in the most recent year.

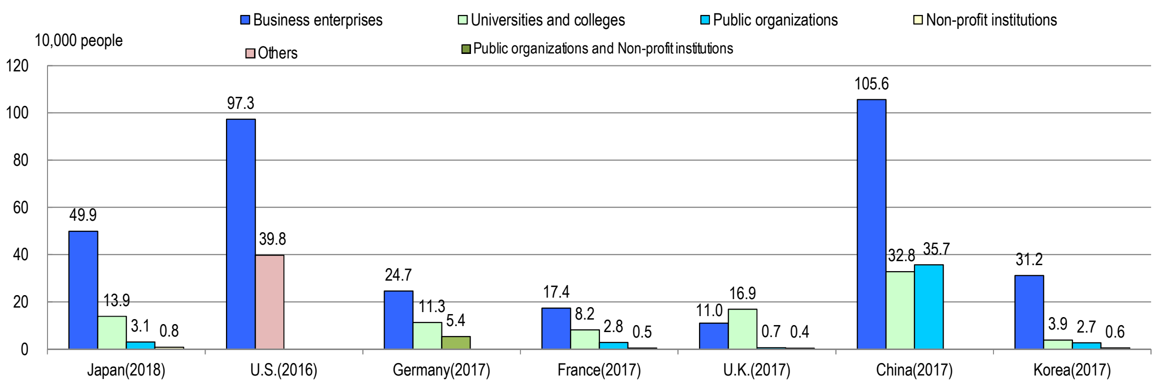
The number of researchers in the business enterprises sector is the highest in most of the selected countries, as is the case for R&D expenditure. However, for the United Kingdom, the largest number of researchers is working in the universities and colleges sector.

[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 2019 (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 2019 (in Japanese)

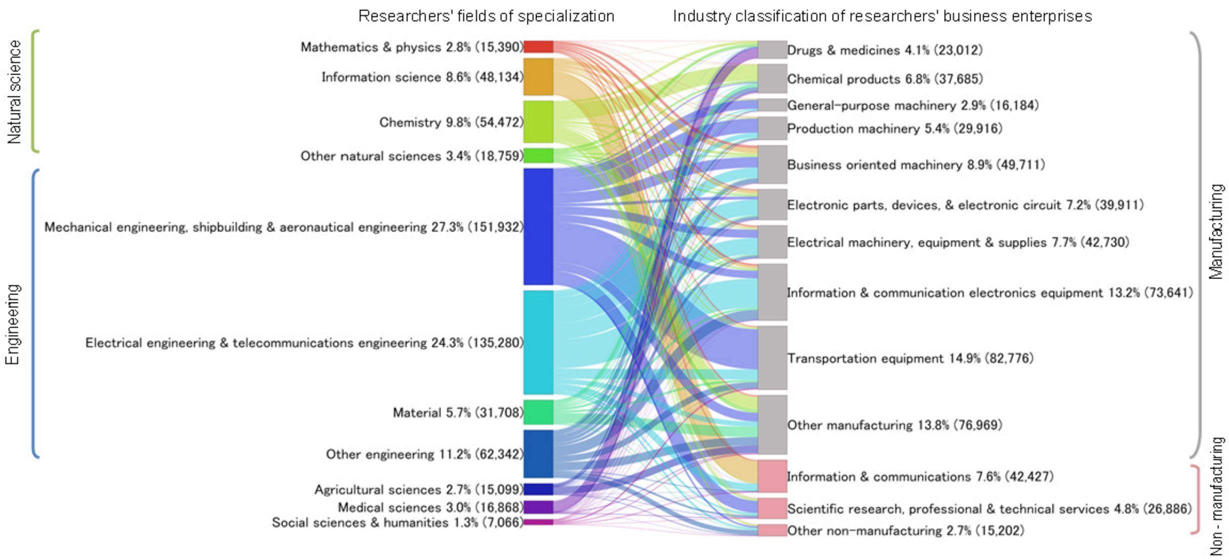
(2) Researchers with engineering-related specialized knowledge account for a large proportion in the manufacturing industry of Japan.

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.

However, the percentage of researchers specializing in the field of “information science” has increased by 1.0 percentage point compared to the previous year (8.6%).

The proportion of researchers specializing in the field of “social sciences & humanities” is small (1.3%).

[Summary Chart 8] Fields of specialization of researchers affiliated in business enterprises in Japan (2018)



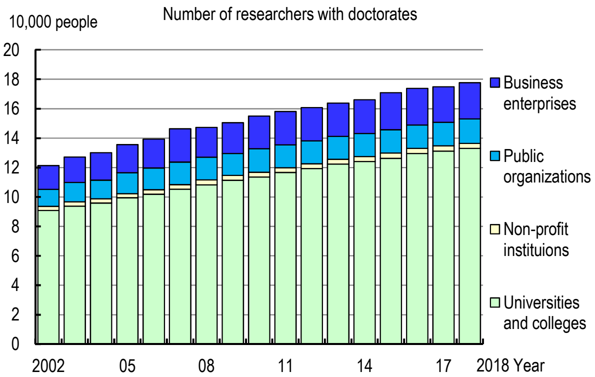
Note: The fields of specialization of researchers are classified according to the contents of their current research (their duties). For the percentage of researchers specializing in the field of “information science” in 2017, the “Japanese Science and Technology Indicators 2018” was used as a reference.
Reference: Chart 2-2-8, Japanese Science and Technology Indicators 2019 (in Japanese)

(3) The number of researchers with doctorate degrees in Japan is large in the “universities and colleges” sector and has been increasing.

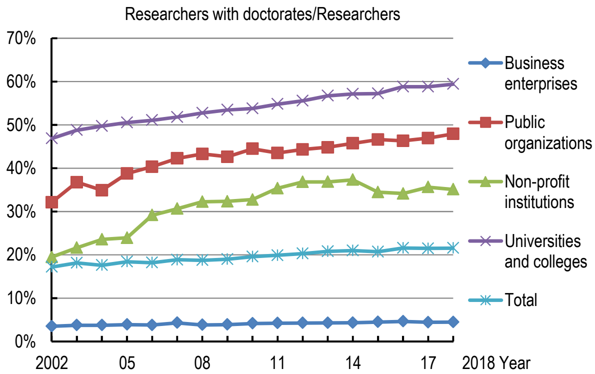
The number of researchers with doctorate degrees in Japan was 178,000 in 2018. The number of researchers with doctorate degrees was largest in “universities and colleges” sector (133,000) and has continuously been increasing. Although the number in “public organizations” sector was small (17,000), it has been on an upward trend over the long term. In “business enterprises” sector, the number continued to increase in the past, but has lost its momentum in recent years, resulting in 25,000 in 2018 (4.4% of all researchers).

[Summary Chart 9] Situation of researchers with doctorate degrees in each sector (HC)

(A) Changes in the number of researchers with doctorate degrees



(B) Percentages of researchers with doctorate degrees among all researchers

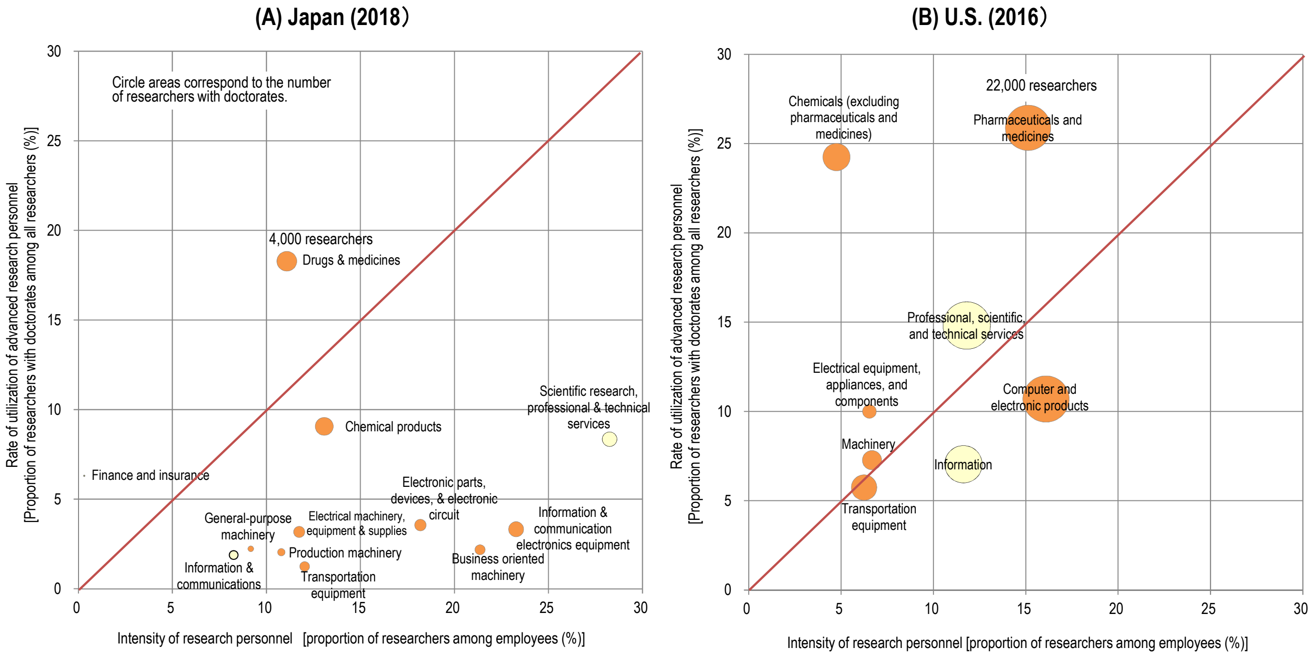


Note: Values are on a head count basis.
Reference: Chart 2-1-8, Japanese Science and Technology Indicators 2019 (in Japanese)

(4) 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.

As for the United State, in all industries shown in the figure, the proportion of researchers with doctorate degrees among all researchers (the rate of utilization of advanced research personnel) accounts for at least 5%. In contrast, the proportion is 5% or less in many industries of Japan, suggesting that Japan tends to have a low rate of utilization of advanced research personnel, compared with the United States.

[Summary Chart 10] Relationship between the intensity of research personnel and the rate of utilization of advanced research personnel by industry

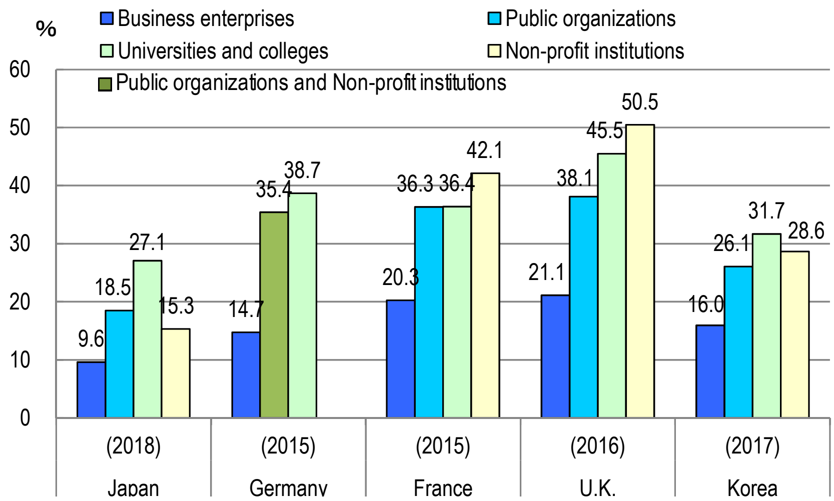


Note: The intensity of research personnel is the proportion of researchers (HC) among employees. The rate of utilization of advanced research personnel is the proportion of researchers with doctorate degrees among all researchers (HC). For both Japan and the United States, this analysis covered business enterprises engaging in R&D.
<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 2-2-10, Japanese Science and Technology Indicators 2019 (in Japanese)

(5) The proportion of female researchers remains low in the business enterprises but tends to be higher in the universities and colleges in the selected countries.

The proportion of female researchers varies by sector. The proportion is the largest in the "universities and colleges" sector in the case of Japan, Germany and Korea, accounting for 27.1%, 38.7% and 31.7%, respectively. In the case of France and the United Kingdom, the proportion is the largest in the "non-profit institutions" sector, although the number of researchers itself is small in this sector. Even for these countries, the proportion in the "universities and colleges" sector is the second largest, accounting for 36.4% and 45.5%, respectively. For all countries, the proportion of female researchers is the lowest in the "business enterprises" sector.

[Summary Chart 11] 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 2-1-11, Japanese Science and Technology Indicators 2019 (in Japanese)

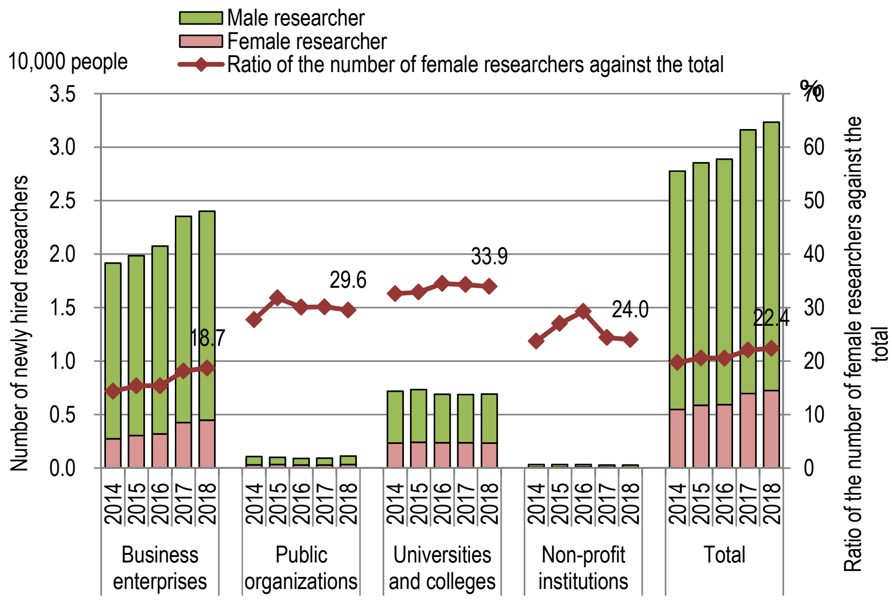
(6) In Japan, the proportion of females among newly hired researchers is higher than the proportion of females among all researchers.

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.

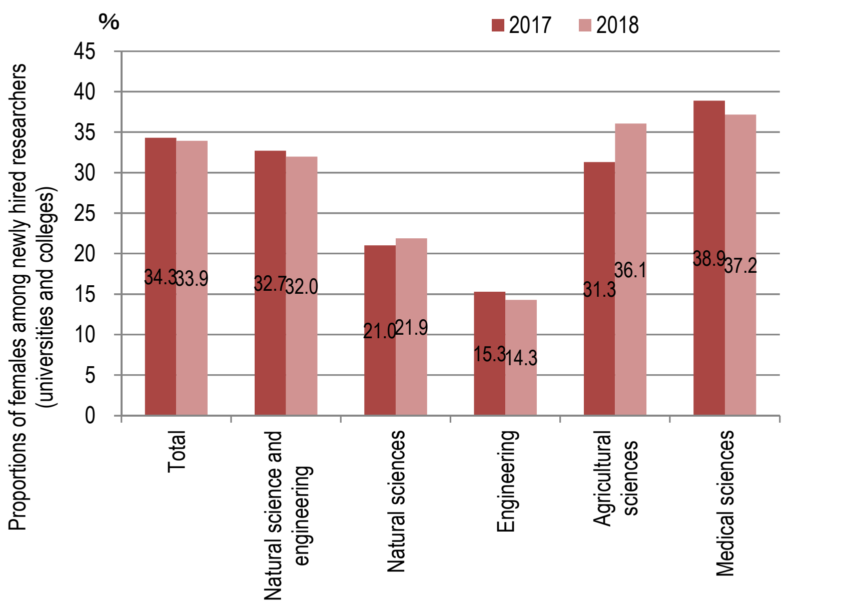
At universities and colleges, the proportion of females among newly hired researchers in "natural sciences" accounts for 32.0% (2018). The same proportion is large in "medical sciences" (37.2%) and small in "engineering" (14.3%).

[Summary Chart 12] Newly hired researchers in Japan

(A) Newly hired researchers by gender



(B) Proportions of females among newly hired researchers by field (universities and colleges)



Reference: Chart 2-1-21, Japanese Science and Technology Indicators 2019 (in Japanese)

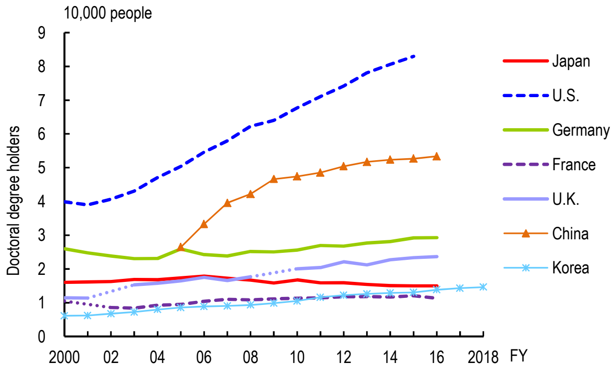
3. Graduates of universities and colleges: the situation in Japan

(1) Among the selected countries, Japan is the only country that continues to show a decline in the number of new doctoral degree recipients per million population.

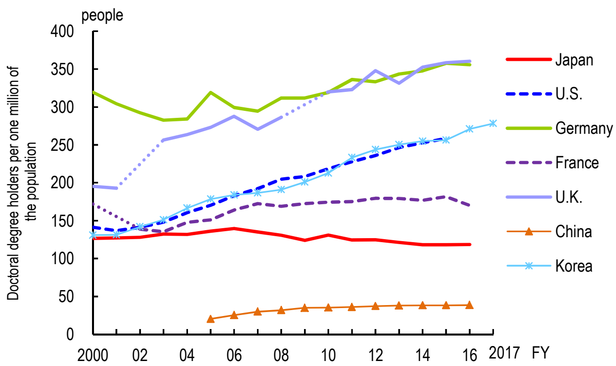
In the number of new doctoral degree recipients per million population, Germany has continued to have the largest number among the selected countries since FY2000. The United Kingdom caught up with the German level around FY 2010, and thereafter both countries have remained at around the same level. In FY2000, the levels of the United States and Korea were roughly the same as that of Japan. Subsequently, the numbers of these countries grew steadily, reaching nearly double Japan's number in the most recent data. The number of new doctoral degree recipients per million population in Japan is lower than in many of the selected countries, and Japan is the only country that continues to show a long-term decline.

[Summary Chart 13] Changes in the number of new doctoral degree recipients in the selected countries

(A) New doctoral degree recipients



(B) New doctoral degree recipients per one million of population



Note: The number of new doctoral degree recipients in the United States is the value calculated by subtracting all the figures for "Professional fields" (formerly referred to as "First-professional degrees") from the figures for "Doctor's degrees" stated in the "Digest of Education Statistics."
Reference: Chart 3-4-4, Japanese Science and Technology Indicators 2019 (in Japanese)

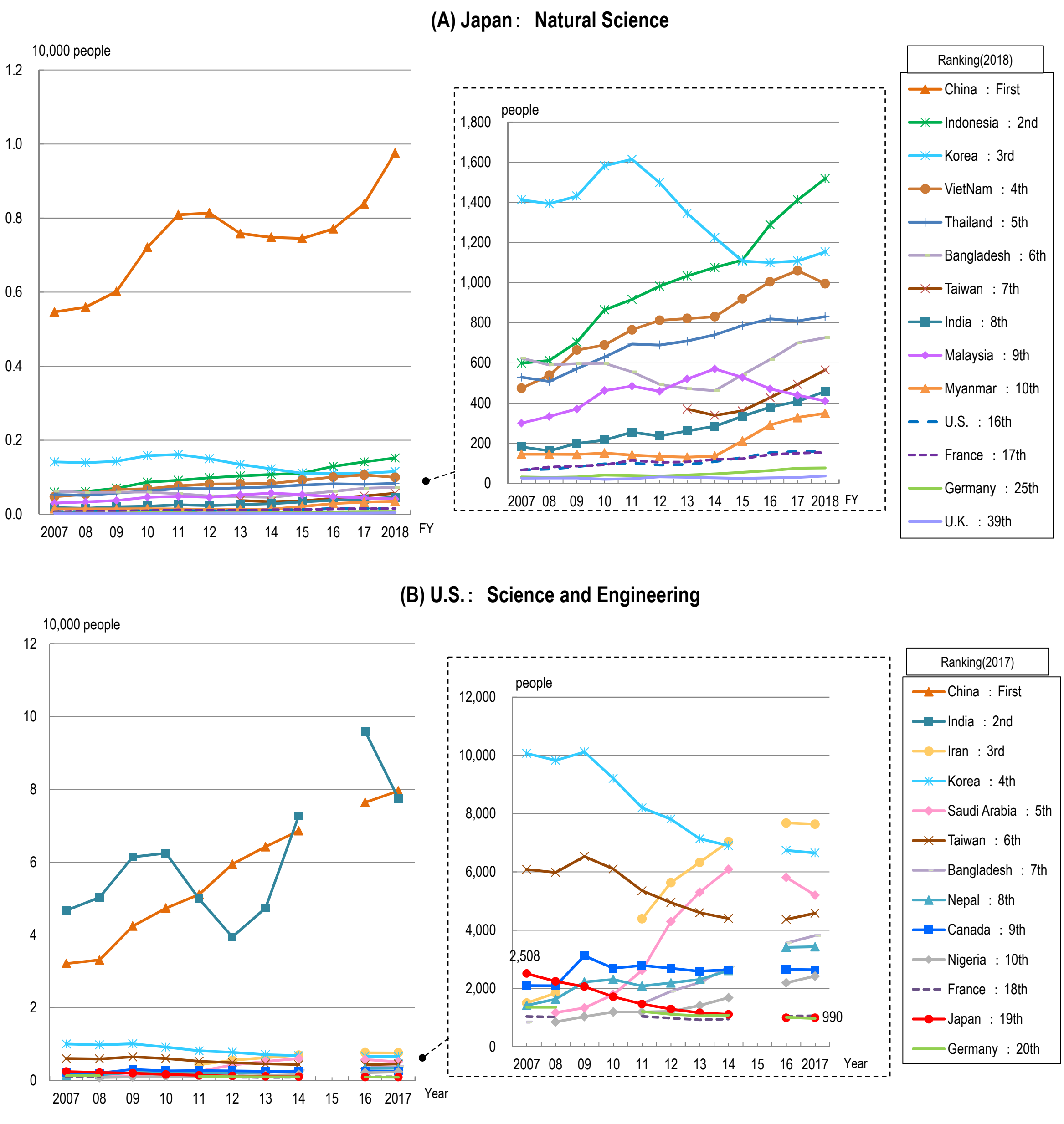
(2) In terms of overseas postgraduate students in Japan, the number of Indonesian postgraduate students has increased. The number of Japanese postgraduate students in the United States decreased from 2,508 in 2007 to 990 in 2017. The share of Japanese postgraduate students in the whole number of overseas postgraduate students has dropped from 1.8% (2007) to 0.4% (2017).

Among overseas postgraduate students in Japan who specialize in the field of natural science, Chinese postgraduate students account for the largest proportion, reaching approximately 10,000 students in FY2018. Indonesian postgraduate students occupy the second rank, consisting of about 1,500 students. Despite a large gap between the first and second rankings, the number of Indonesian postgraduate students has steadily risen.

In relation to overseas postgraduate students in the United States, postgraduate students from India and China account for a large proportion of the whole number. Although the gap between the first and second rankings is not wide, the gap between them and the third-ranked country, Iran, is huge. The number of

Japanese postgraduate students in the United States decreased from 2,508 in 2007 to 990 in 2017. The share of Japanese postgraduate students in the whole number of overseas postgraduate students in the country has dropped from 1.8% (2007) to 0.4% (2017).

[Summary Chart 14] Situation of overseas postgraduate students in Japan and the United States



Reference: Chart 3-5-1 Japanese Science and Technology Indicators 2019 (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 remarkable in 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 outputs, the number of Japanese papers (the average of PY2015–2017) 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, Italy, France, 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, Australia, Canada, France, 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 15] 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	1995 — 1997 (PY) (Average)		
	The number of papers		
Country/Region	Fractional counting		
	Papers	Share	World rank
U.S.	196,528	29.6	1
Japan	56,203	8.5	2
U.K.	48,036	7.2	3
Germany	45,730	6.9	4
France	34,698	5.2	5
Canada	24,618	3.7	6
Russia	22,881	3.4	7
Italy	21,963	3.3	8
China	14,621	2.2	9
Australia	14,122	2.1	10

All fields	2005 — 2007(PY) (Average)		
	The number of papers		
Country/Region	Fractional counting		
	Papers	Share	World rank
U.S.	234,153	25.0	1
China	73,956	7.9	2
Japan	67,026	7.2	3
Germany	54,749	5.8	4
U.K.	53,059	5.7	5
France	39,252	4.2	6
Italy	32,938	3.5	7
Canada	31,269	3.3	8
India	25,311	2.7	9
Spain	24,736	2.6	10

All fields	2015 — 2017 (PY) (Average)		
	The number of papers		
Country/Region	Fractional counting		
	Papers	Share	World rank
U.S.	276,638	18.8	1
China	272,698	18.6	2
Germany	66,110	4.5	3
Japan	63,725	4.3	4
U.K.	61,003	4.2	5
India	55,707	3.8	6
Korea	47,642	3.2	7
France	45,520	3.1	8
Italy	45,207	3.1	9
Canada	40,108	2.7	10

All fields	1995 — 1997 (PY) (Average)		
	The number of adjusted top 10% papers		
Country/Region	Fractional counting		
	Papers	Share	World rank
U.S.	29,957	45.1	1
U.K.	5,556	8.4	2
Germany	4,231	6.4	3
Japan	3,939	5.9	4
France	3,188	4.8	5
Canada	2,879	4.3	6
Italy	1,787	2.7	7
Netherlands	1,655	2.5	8
Australia	1,440	2.2	9
Sweden	1,194	1.8	10

All fields	2005 — 2007(PY) (Average)		
	The number of adjusted top 10% papers		
Country/Region	Fractional counting		
	Papers	Share	World rank
U.S.	34,775	37.2	1
U.K.	6,773	7.2	2
Germany	5,849	6.3	3
China	5,487	5.9	4
Japan	4,506	4.8	5
France	4,028	4.3	6
Canada	3,592	3.8	7
Italy	2,887	3.1	8
Spain	2,287	2.4	9
Netherlands	2,241	2.4	10

All fields	2015 — 2017 (PY) (Average)		
	The number of adjusted top 10% papers		
Country/Region	Fractional counting		
	Papers	Share	World rank
U.S.	38,347	26.1	1
China	28,386	19.3	2
U.K.	8,718	5.9	3
Germany	7,591	5.2	4
Italy	5,014	3.4	5
France	4,716	3.2	6
Australia	4,530	3.1	7
Canada	4,455	3.0	8
Japan	3,927	2.7	9
Spain	3,542	2.4	10

All fields	1995 — 1997 (PY) (Average)		
	The number of adjusted top 1% papers		
Country/Region	Fractional counting		
	Papers	Share	World rank
U.S.	3,576	53.9	1
U.K.	551	8.3	2
Germany	365	5.5	3
Japan	311	4.7	4
France	285	4.3	5
Canada	272	4.1	6
Netherlands	161	2.4	7
Italy	137	2.1	8
Australia	126	1.9	9
Switzerland	120	1.8	10

All fields	2005 — 2007(PY) (Average)		
	The number of adjusted top 1% papers		
Country/Region	Fractional counting		
	Papers	Share	World rank
U.S.	4,140	44.3	1
U.K.	730	7.8	2
Germany	564	6.0	3
China	400	4.3	4
France	358	3.8	5
Japan	355	3.8	6
Canada	350	3.7	7
Italy	249	2.7	8
Netherlands	243	2.6	9
Australia	210	2.2	10

All fields	2015 — 2017 (PY) (Average)		
	The number of adjusted top 1% papers		
Country/Region	Fractional counting		
	Papers	Share	World rank
U.S.	4,601	31.3	1
China	2,692	18.3	2
U.K.	985	6.7	3
Germany	766	5.2	4
Australia	478	3.3	5
Canada	438	3.0	6
France	437	3.0	7
Italy	389	2.6	8
Japan	328	2.2	9
Netherlands	294	2.0	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 2018.
Reference: Chart 4-1-6, Japanese Science and Technology Indicators 2019 (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) 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 1992 and 1994, the United States was ranked first and Japan second. Between 2002 and 2004 and between 2012 and 2014, Japan was ranked first and the United States 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 2012 and 2014.

[Summary Chart 16] The number of patent families by selected country/region: top 10 countries/regions

1992 - 1994(Average)			
Country/Region	Number of patent families (Whole counting)		
	Patent Families	Share	World rank
U.S.	25,060	29.3	1
Japan	22,332	26.1	2
Germany	14,486	16.9	3
France	5,647	6.6	4
U.K.	4,672	5.5	5
Italy	2,577	3.0	6
Switzerland	2,199	2.6	7
Canada	1,797	2.1	8
Netherlands	1,744	2.0	9
Korea	1,653	1.9	10

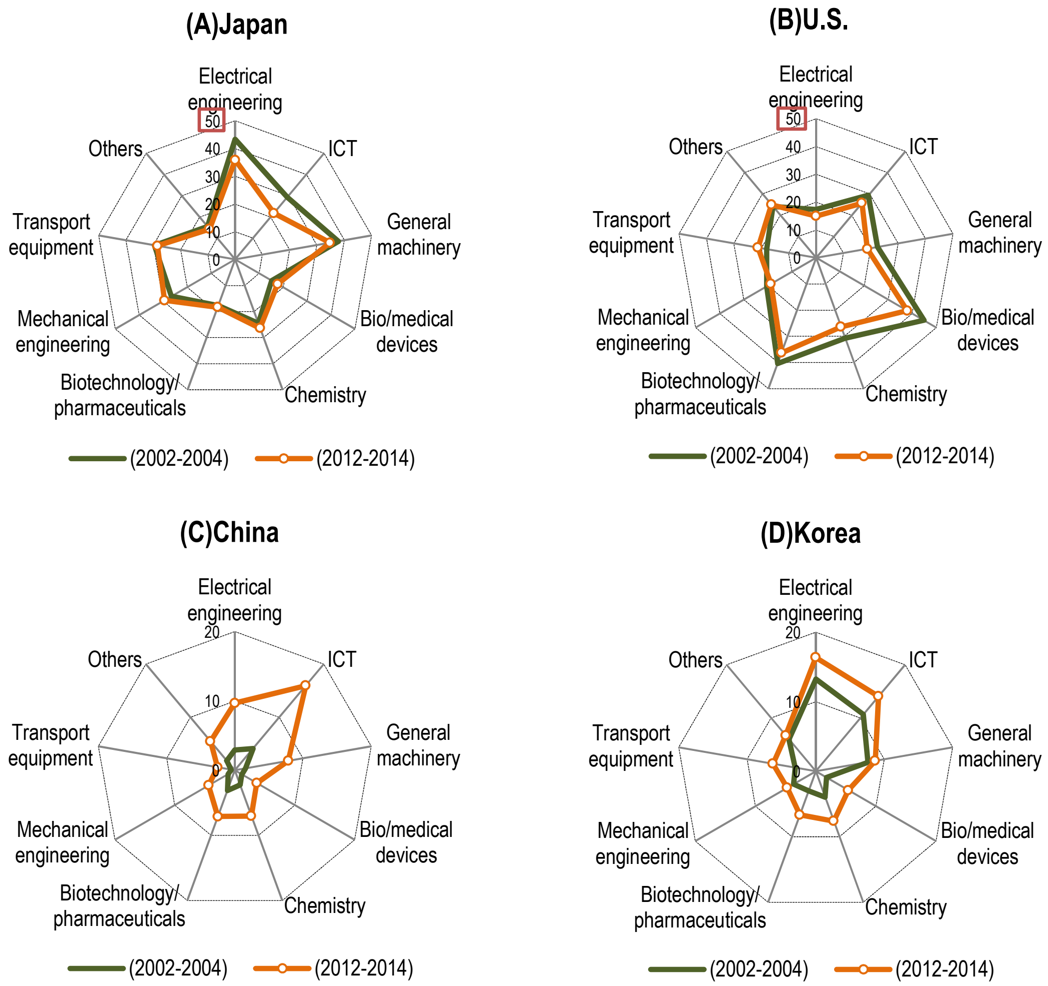
2002 - 2004(Average)			
Country/Region	Number of patent families (Whole counting)		
	Patent Families	Share	World rank
Japan	52,514	29.4	1
U.S.	45,793	25.6	2
Germany	26,629	14.9	3
Korea	12,686	7.1	4
France	9,724	5.4	5
U.K.	8,490	4.8	6
Taiwan	5,546	3.1	7
Netherlands	4,745	2.7	8
Italy	4,694	2.6	9
Canada	4,681	2.6	10

2012 - 2014(Average)			
Country/Region	Number of patent families (Whole counting)		
	Patent Families	Share	World rank
Japan	62,585	27.1	1
U.S.	52,797	22.9	2
Germany	26,949	11.7	3
Korea	23,023	10.0	4
China	19,574	8.5	5
Taiwan	11,600	5.0	6
France	11,114	4.8	7
U.K.	8,615	3.7	8
Canada	5,403	2.3	9
Netherlands	4,097	1.8	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 2019 (in Japanese)

As for the shares of patent families by technological field between 2012 and 2014, Japan's share exceeds 30% 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 "electrical engineering" and "information & communication technology" have both fallen by around 8 percentage points, which is attributable to rapid growth in the global shares of China and Korea.

[Summary Chart 17] Comparison of the shares of patent families by technological fields in the selected countries (%, 2002-2004 and 2012-2014, whole counting)



Note: Same as Summary Chart 16. The items "ICT" in Summary Chart 17 stand for "Information and communication technology."
Reference: Chart 4-2-10, Japanese Science and Technology Indicators 2019 (in Japanese)

(3) 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 (the total in the 2007-2014 period) 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 9.1% 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 number of Japanese papers cited by patent families during the 2007-2014 period (the total in the 1981-2014 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 18] The number of patent families that are citing papers: top 10 countries/regions

Whole counting		2007–2014 (Total)		
		(A) Patent families citing papers	(B) Total number of patent families	
No.	Country / Region		No. of patent families	Percentage of patent families citing papers (A) / (B)
1	U.S.	104,121	385,307	27.0
2	Japan	44,395	487,764	9.1
3	Germany	38,415	218,430	17.6
4	France	22,339	86,402	25.9
5	China	19,235	118,596	16.2
6	U.K.	18,950	66,823	28.4
7	Korea	14,042	158,298	8.9
8	Canada	11,422	43,207	26.4
9	Netherlands	10,018	33,016	30.3
10	India	9,159	27,139	33.7

Reference: Chart 4-3-2, Japanese Science and Technology Indicators 2019 (in Japanese)

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

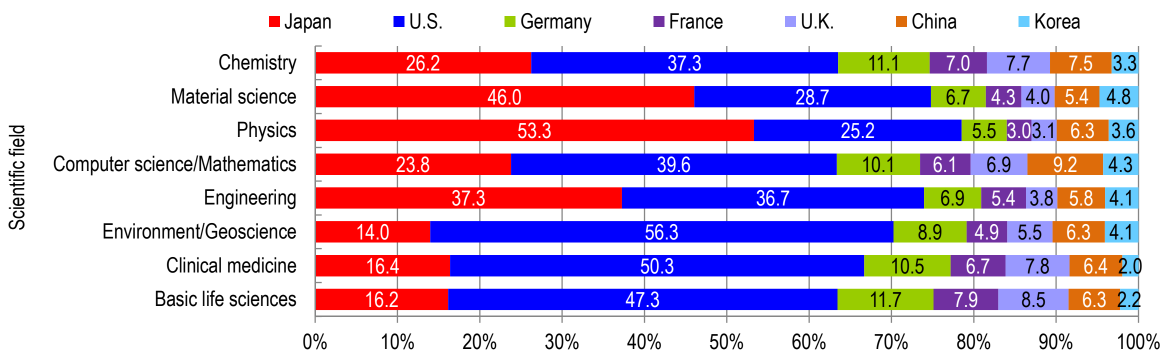
Whole counting		1981–2014 (Total)		
		(A) Papers cited by patent families	(B) Total number of papers	
No.	Country / Region		No. of papers	Percentage of papers cited by patent families (A) / (B)
1	U.S.	386,655	7,773,669	5.0
2	Japan	80,785	1,977,900	4.1
3	Germany	76,259	2,021,362	3.8
4	U.K.	75,755	2,014,621	3.8
5	France	49,942	1,473,247	3.4
6	China	42,482	1,823,178	2.3
7	Canada	40,565	1,123,128	3.6
8	Italy	32,793	1,021,471	3.2
9	Netherlands	26,419	600,059	4.4
10	Switzerland	22,646	454,920	5.0

Reference: Chart 4-3-3, Japanese Science and Technology Indicators 2019 (in Japanese)

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

The most cited fields are "physics (53.3%)" and "material science (46.0%)" in Japanese papers cited by Japanese patent families. On the other hand, the fields of "environment/geoscience (14.0%)," "clinical medicine (16.4%)" and "basic life sciences (16.2%)" are relatively less cited by Japanese patent families.

[Summary Chart 20] Connection between Japanese papers and the selected countries' patent families



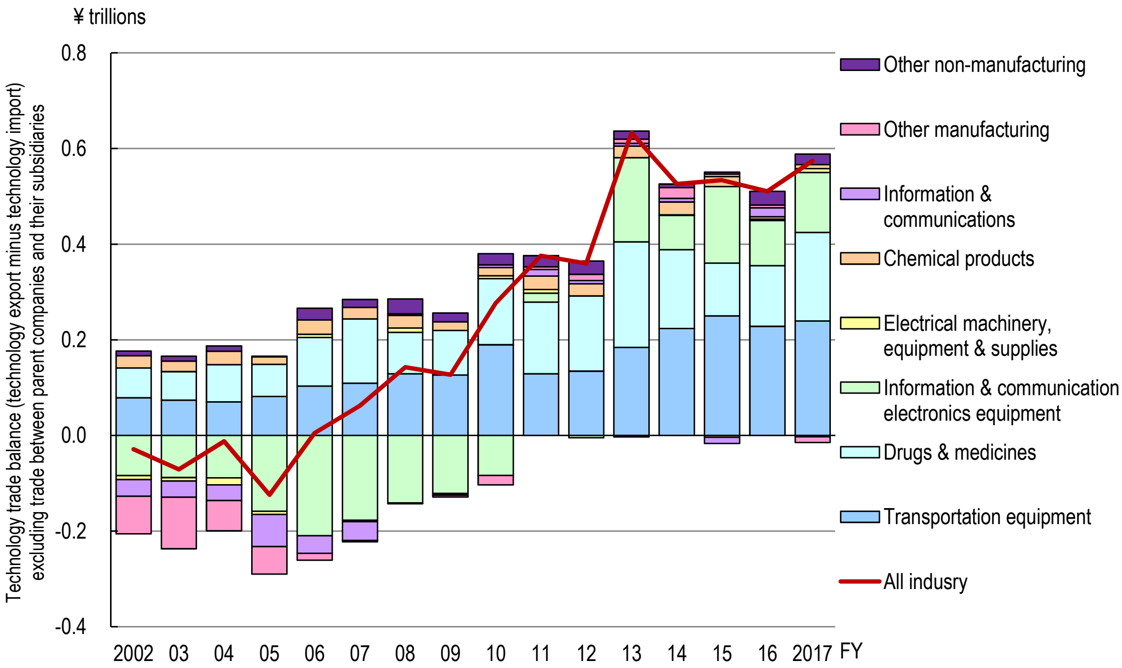
Reference: Chart 4-3-7, Japanese Science and Technology Indicators 2019 (in Japanese)

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

(1) The technology trade balance of Japan excluding trade between parent companies and their subsidiaries has continuously achieved surpluses since FY2006.

In Japan's technology trade balance by industry (technology export minus technology import; excluding trade between parent companies and their subsidiaries), which is regarded as an indicator of international technological competitiveness, the industries of "transportation equipment" and "drugs & medicines" account for a large amount of technology trade and have recorded surpluses throughout the relevant period.

[Summary Chart 21] Japan's technology trade by industry and its balance, excluding trade between parent companies and their subsidiaries



Note: 1) The sorts of technology trade are as follows (excluding trademark rights): (1) Patent rights, utility model rights and copy rights, (2) Design rights, (3) Each kind of technological know-how provision and technical guidance (excluding free provision),(4) Technological aid for developing countries. (including govern-ment-commissioned works)

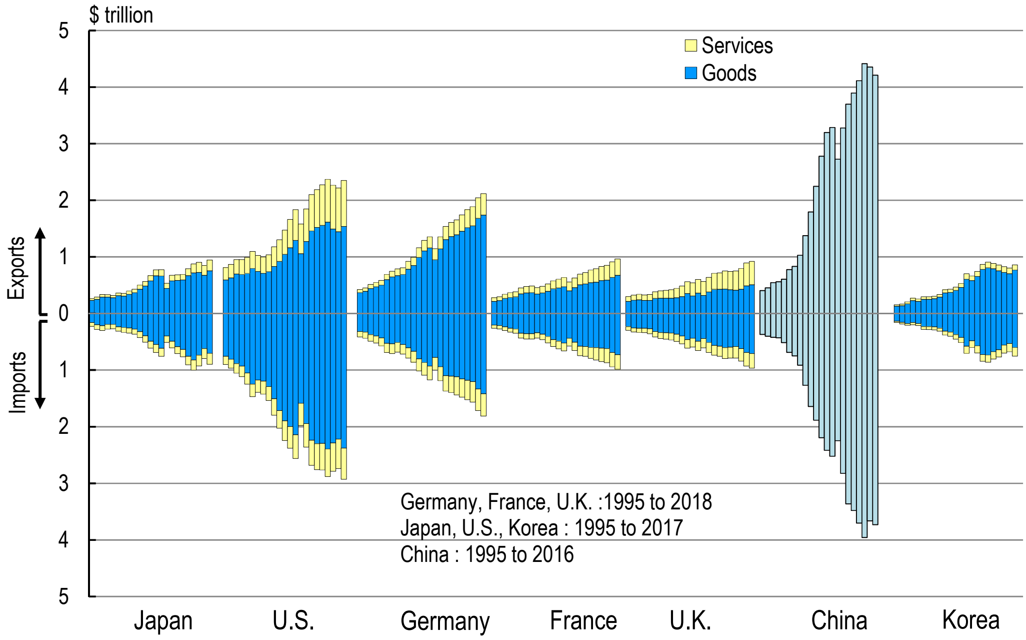
2) Japan's parent companies and subsidiaries are companies whose controlling share is over 50%.

Reference: Chart 5-1-4, Japanese Science and Technology Indicators 2019 (in Japanese)

(2) In the amount of trade (export value), services account for a small proportion in Korea (11.0%), Germany (17.8%) and Japan (20.2%), in contrast with the United Kingdom (44.7%), the United States (34.6%) and France (29.8%) for which the proportion of services is large.

The total value of imports and exports in the selected countries showed an upward trend until 2008. After a temporary decline in 2009, it turned upward. In all countries, the volume of trade in goods is more than in services (export value), but in the United Kingdom (44.7%), the United States (34.6%), and France (29.8%), services account for a larger share.

[Summary Chart 22] Changes in the trade amounts of the selected countries

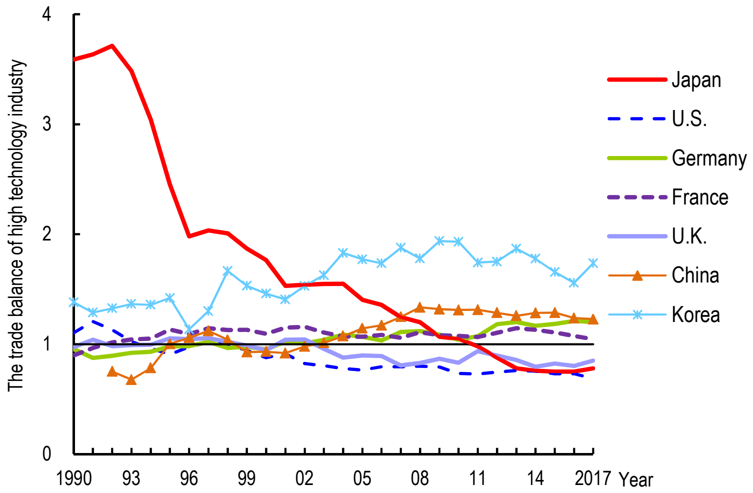


Note: For China, available data did not classify its amount of trade into “goods” and “services.”
Reference: Chart 5-2-1, Japanese Science and Technology Indicators 2019 (in Japanese)

(3) 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.

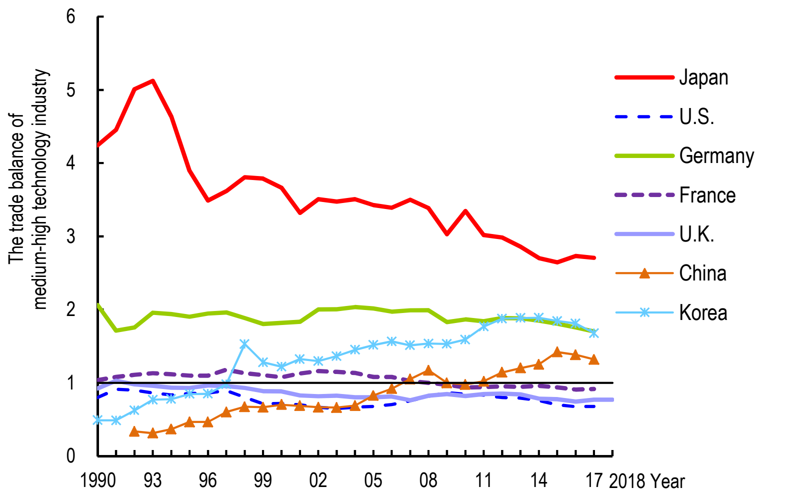
Japan's trade balance ratio in high-technology industries showed a continuous decline and it marked 0.78 in 2017. Japan ranked first among the selected countries in trade balance ratio for medium high-technology industries at 2.71. The trade balance ratio shows a gradual decline following a rapid drop in the mid-1990s.

[Summary Chart 23] 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 5-2-4, Japanese Science and Technology Indicators 2019 (in Japanese)

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



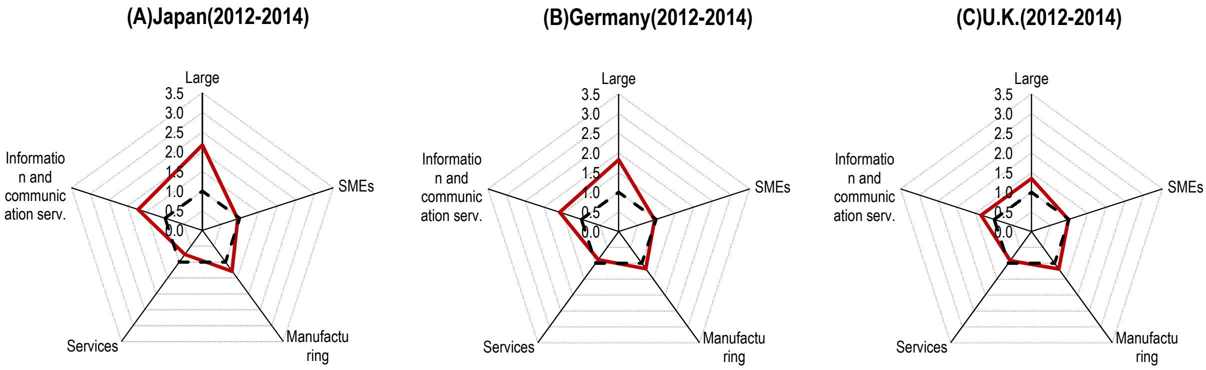
Note: 1) Medium high-technology industries refer to "chemicals and chemical products," "electrical equipment," "machinery and equipment n.e.c.," "motor vehicles, trailers and semi-trailers," "railroad equipment and transport equipment n.e.c.," and "other."
2) Trade balance ratio = export value / import value
Reference: Chart 5-2-6, Japanese Science and Technology Indicators 2019 (in Japanese)

(4) The rate of product innovation realization in the information and communication service industry is higher than that in the manufacturing industry, suggesting that the information and communication service industry has actively engaged in realizing innovations.

Proportion of business enterprises that realized product innovation in Japan, Germany and the United Kingdom were examined by company size (large-sized enterprises and small- and medium-sized enterprises) and the type of industry ("manufacturing industry," "service industry" and "information and communication service industry"), where the percentage of companies that realized product innovation relative to the country mean were shown. According to the results of this examination, figures associated with "large-sized enterprises" tend to be large in all the three countries.

In all of these countries, the rate of product innovation realization in the service industry is below "1" and the rate is smaller than that in the "manufacturing industry." However, the rate of product innovation realization by the "information and communication service industry" is higher than the manufacturing industry's rate, showing that the "information and communication service industry" has actively engaged in realizing innovations.

[Summary Chart 25] Proportion of business enterprises that realized product innovation in Japan, Germany and the United Kingdom (by company size and type of industry, where the percentage of companies that realized product innovation relative to the country mean were shown)



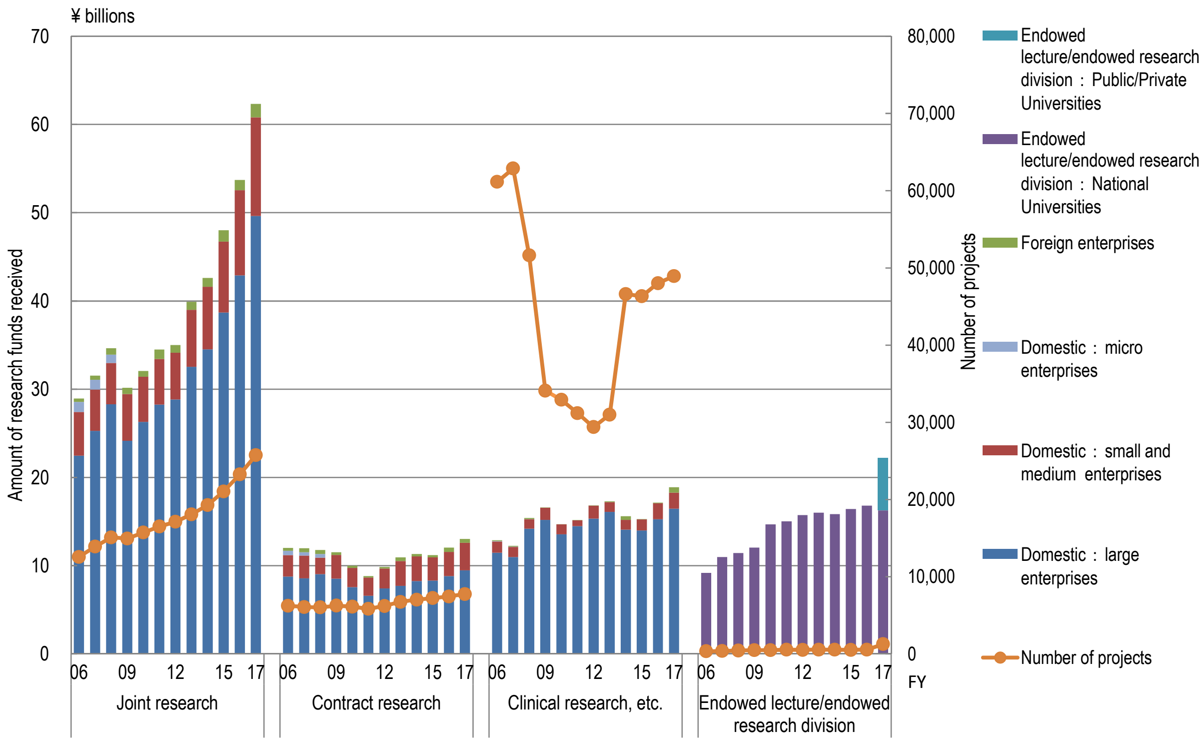
Reference: Chart 5-4-3, Japanese Science and Technology Indicators 2019 (in Japanese)

(5) 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.

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

Among various types of university-industry collaborations, the amount of funds received for "joint research" was the largest, reaching 62.3 billion yen as a whole, with 26,000 joint research projects implemented. A large amount of such funds was provided by large enterprises, amounting to 49.7 billion yen in the latest year. The amount of funds received for "joint research" in total has increased by 10% or more each year since FY2015.

[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.

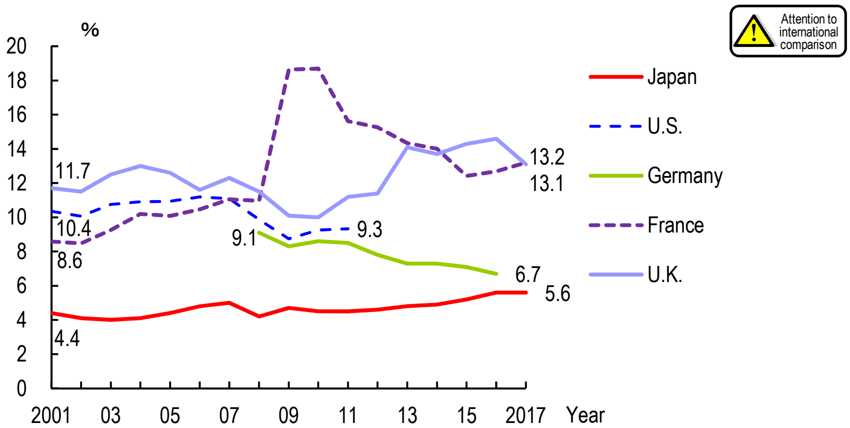


Note: Joint research: Joint research and development by institutions and private business, etc., in which the other party bears the expenses. Until FY2008, the amount of funding and the number of projects were classified according to the size of the enterprises - small and medium, micro and large enterprises.
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 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 5-4-8, Japanese Science and Technology Indicators 2019 (in Japanese)

(6) The entry rate in Japan has been on a gradual increase, it still remains at lower level compared to other countries. Furthermore, the proportion of individuals indifferent to business startup is high in Japan.

The entry rate of Japan was 5.6% in the latest data, which was the lowest compared with the rates of other countries. France and the United Kingdom had the highest rates at 13.2% and 13.1%, respectively. In comparison with 2001, the rate of entrepreneurship in Japan has been on a gradual increase, though it still remains at a level lower than other countries.

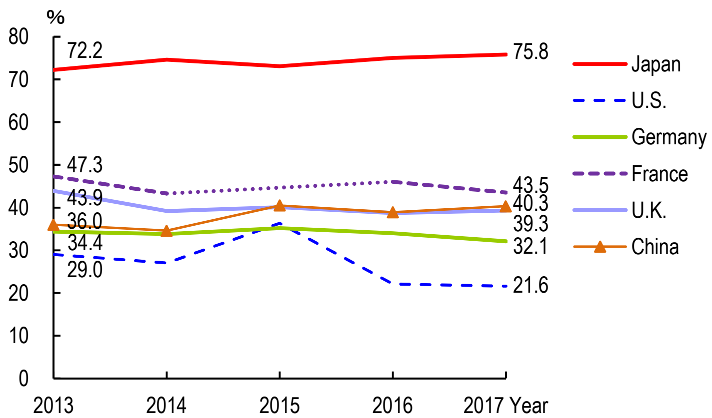
[Summary Chart 27] Changes in the entry rates in the selected countries



Reference: Chart 5-4-11, Japanese Science and Technology Indicators 2019 (in Japanese)

Changes in the proportions of individuals indifferent to business startup show that Japan's proportion in 2017 was 75.8%, which was the highest among the selected countries and 32 percentage points away from France that had the second highest proportion. The United States had the lowest proportion at 21.6%.

[Summary Chart 28] Changes in proportions of individuals indifferent to business startup in the selected countries



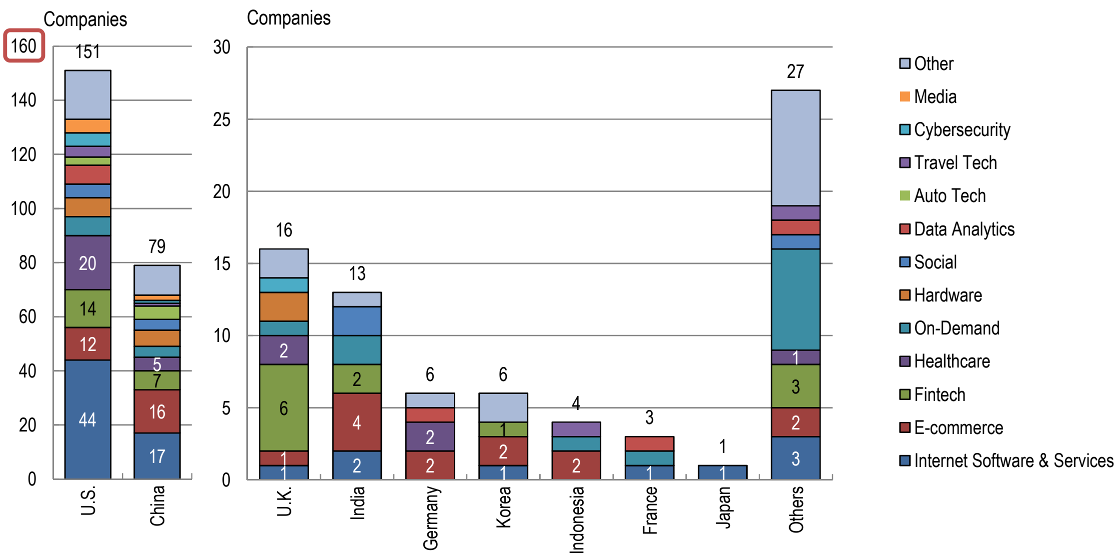
Note 1) Based on the results of Global Entrepreneurship Monitor (GEM) surveys.
2) "Individuals indifferent to business startup" here mean those individuals who answered "No" to all the three questions of "I know a person who started up a business over the past 2 years," "A chance useful for stating up a business will come in my area of residence within the next 6 months," and "I have the knowledge, abilities and experience necessary for starting up a new business."
3) The aggregation excluded individuals who answered "I don't know" to the three questions and those who did not answer the questions.
4) With regard to France, there are no data for 2015.

Reference: Chart 5-4-12, Japanese Science and Technology Indicators 2019 (in Japanese)

(7) Unicorn companies (privately held companies with a current valuation of US$1 billion or more) have emerged in diverse categories; the majority of such unicorn companies are associated with information and communication services.

By using data (as of January 18, 2019) on unicorn companies on the basis of surveys conducted by CB Insights of the United States, the situations of those unicorn companies in the world were examined. A unicorn company means a privately held company with a valuation of US$1 billion or more. The United States has the largest number of unicorn companies, 151 companies, followed by China with 79 companies. There is a significant gap between these two countries and the third-ranked country is the United Kingdom (16 companies). The number of unicorn companies in Japan is one, which is less than the number in other countries. According to the categorization by CB Insights, unicorn companies categorized into "Internet software and services" account for the largest proportion in the United States. In China, the proportion of unicorn companies in "Internet software and services" and that in "e-commerce" are equally high. In the United Kingdom and India, the largest proportion is found in "fintech" and "e-commerce," respectively.

[Summary Chart 29] Number of unicorn companies by category/country （2010 to 2018）



Note: 1) Prepared by NISTEP using data (as of January 18, 2019) on unicorn companies on the basis of surveys conducted by CB Insights of the United States.
2) With regard to the categories, the items specified by CB Insights were tentatively translated by NISTEP.
3) The years were those during which each company was judged as having a valuation of US$1 billion or more.
4) CB Insights, "Global Unicorn Club: Private Companies Valued at $1B+ (as of January 18, 2019) (obtained from its website on 2019/04/23).
5) According to the list published on the website of CB Insights as of July 1, 2019, there are two Japanese companies, and the worldwide total is 362 companies.
https://www.cbinsights.com/reports/CB-Insights-Global-Unicorn-Club_2019.xlsx
Reference: Chart 5-4-14, Japanese Science and Technology Indicators 2019 (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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