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Digest of Japanese Science and Technology

Indicators 2017

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Japanese Science and Technology Indicators 2017 (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; Output of R&D; and Science, Technology, and Innovation, and shows the state of Japanese science and technology activities with approximately 150 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 2017" includes new indicators such as the direct investment from government to business R&D, the graduates' destination after completing master's or doctoral program in social sciences and humanities in Japan, and indicators about linkage between science and technology, i.e., science linkages, using information of scientific publications described in patent applications. Twenty five new indicators or the indicators with modified visualization are introduced in total.

Overviewing the latest Japan's situation from "Science and Technology Indicators 2017," it was found that the R&D expenditure and the number of researchers in Japan is the third largest in major countries (Japan, the United States, Germany, France, the United Kingdom, China and Korea), but the number of new doctoral degree recipients per 1 million population is the sixth place in the major countries. In scientific publications and patent families, 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, the ranking of Japan in the latter has been declining in quicker pace. On the other hand, Japan continues to be the world first place in the patent family (patent applications to more than two countries). Japan's high technology industry trade balance ratio has been declining since the 1990s. After 2011, it experiences a foreign trade deficit and it is the sixth position in the major countries. Meanwhile, the medium high technology industry trade balance ratio is at an exports surplus, keeping the first place among the major countries.

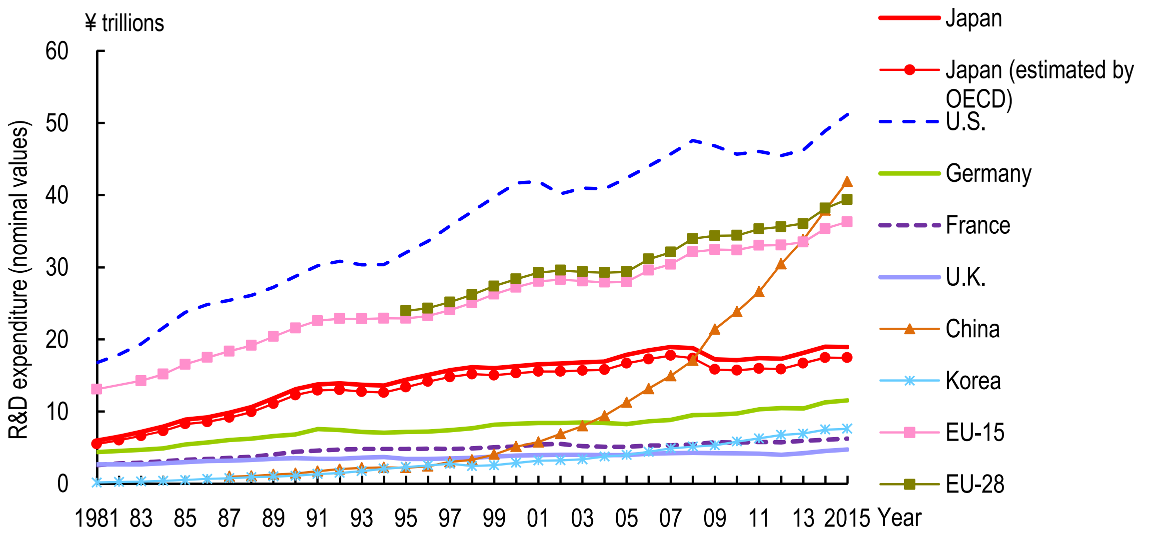
1. Circumstances in Japan and the selected countries in terms of R&D expenditure

(1) Japan's total R&D expenditure was 18.9 trillion yen in 2015 (OECD-estimate Japan: 17.4 trillion yen), the world's third largest after the United States and China. In terms of sectors, the R&D expenditure of business enterprises accounted for a large part of the total R&D expenditure in each of the selected countries.

Japan's total R&D expenditure was 18.9 trillion yen in 2015 (OECD-estimated Japan: 17.4 trillion yen). The United States' total R&D expenditure was 51.2 trillion yen in the same year, maintaining the world's largest scale. With regard to China, its R&D expenditure reached 41.9 trillion yen in 2015, exceeding that of the EU, despite the fact that the latter had been increasing over a long-term period. 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 Asian countries, whereas differences between the business enterprises sector and other sectors are relatively small in major European countries.

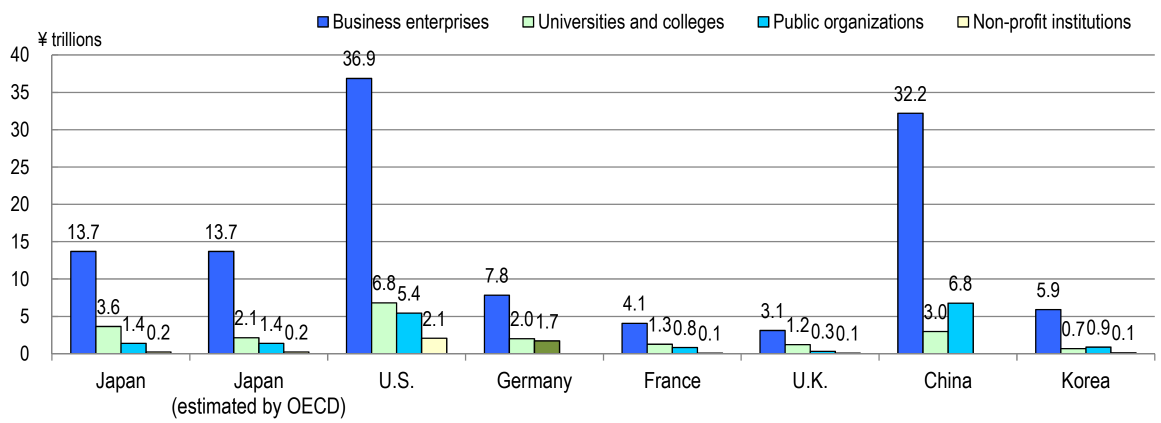
[Summary Chart 1] Changes in total R&D expenditure in the selected countries: nominal values (converted using OECD purchase power parities data)

Attention to international comparison



Reference: Chart 1-1-1, Japanese Science and Technology Indicators 2017 (in Japanese)

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

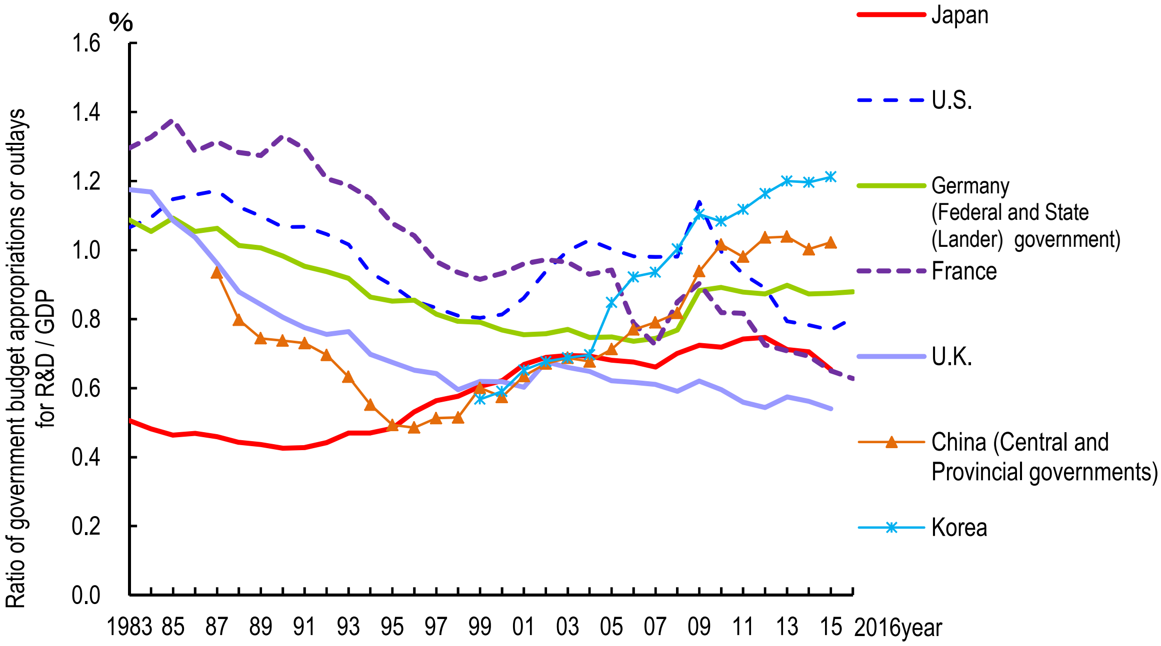


Reference: Chart 1-1-6, Japanese Science and Technology Indicators 2017 (in Japanese)

(2) Japan's science and technology budget as a percentage of GDP is 0.65%, ranked fifth after Korea, China, Germany, and the United States, among the selected countries.

In a comparison of the selected countries' science and technology budgets as percentages of GDP with differences in their economy sizes taken into consideration, Japan's percentage in the most recent year is 0.65%, the United States' is 0.80%, Germany's is 0.88%, France's is 0.63%, the United Kingdom's is 0.54%, and China's is 1.02%. The percentage of Korea marks 1.21%, ranked top among the selected countries.

[Summary Chart 3] Changes in government budgets for science and technology as percentages of GDP in the selected countries

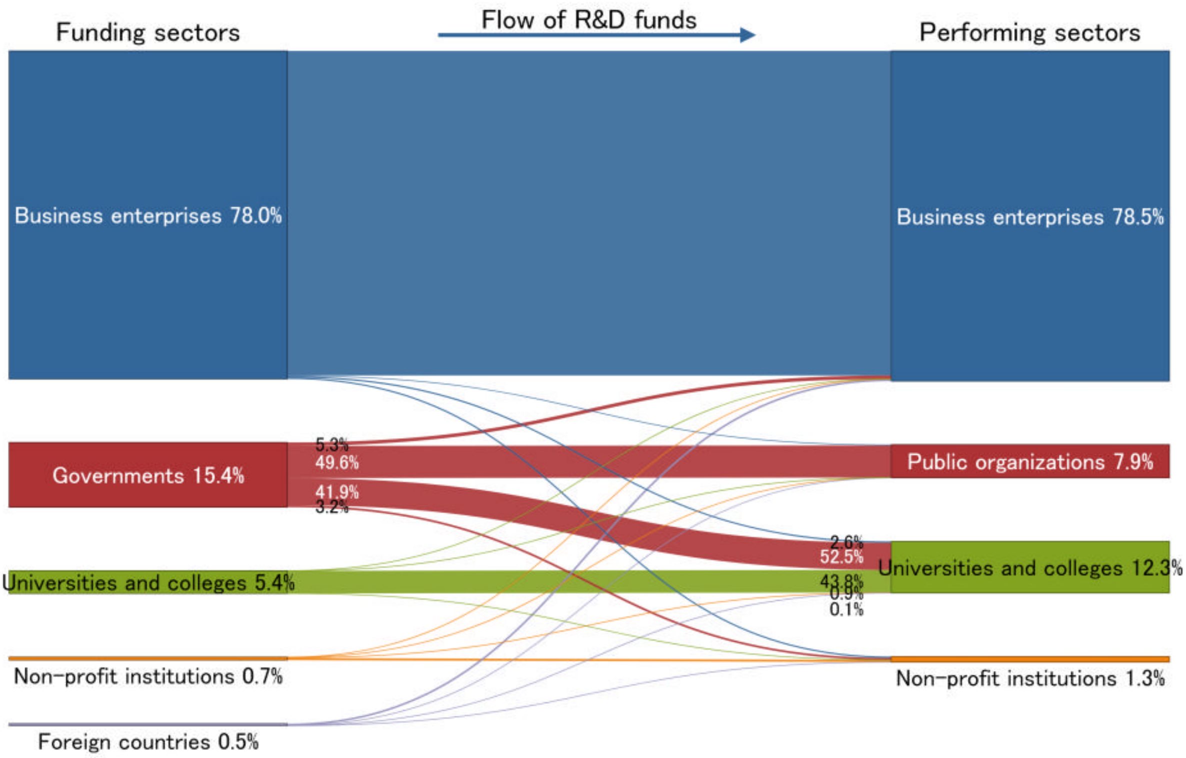


Reference: Chart 1-2-2, Japanese Science and Technology Indicators 2017 (in Japanese)

(3) 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 2.6% of the entire amount used out of R&D funds.

According to the flow of R&D funds from funding sectors to performing sectors with reference to OECD estimates concerning Japan, "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 2.6% of the entire amount used out of R&D funds. With regard to R&D funds from "governments" to other sectors, the flow of such funds to "public organizations" is largest with 49.6%, followed by "universities and colleges" with 41.9%.

[Summary Chart 4] Flow of R&D funds from funding sectors to performing sectors in Japan (estimated by the OECD) (2015)

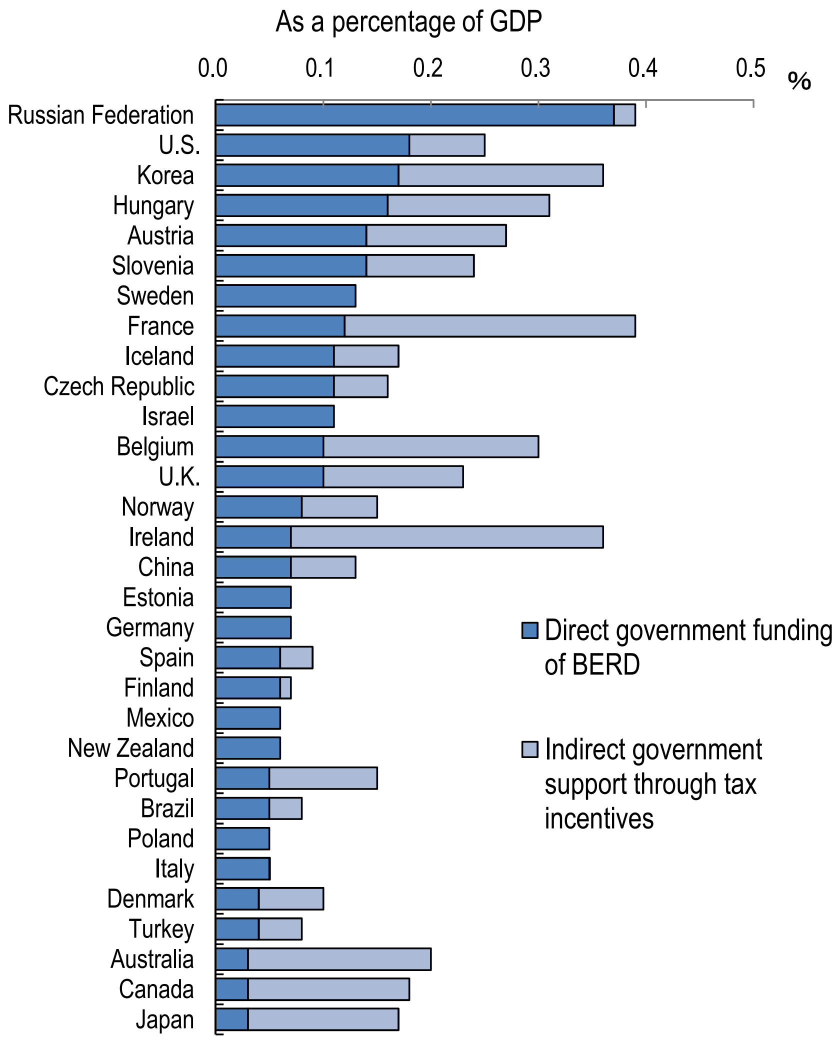


Reference: Chart 1-1-5, Japanese Science and Technology Indicators 2017 (in Japanese)

(4) Compared with other countries, Japan's direct government funding to business enterprises is lowest, while its indirect government support is relatively large.

Direct government funding (the amount funded by the government to support business enterprises' R&D expenditure, which is expressed as a percentage of GDP) in Japan is low, whereas its indirect government support (the amount of deducted corporate tax through R&D tax incentives, which is expressed as a percentage of GDP) is high. For other countries, Russia's direct government funding is highest, followed by the United States, Korea, and Hungary. Indirect government support is high in Ireland, France, Belgium, and Korea. Both direct government funding and indirect government support are high in Korea.

[Summary Chart 5] Direct government funding and indirect government support to help business enterprises with R&D (2014)

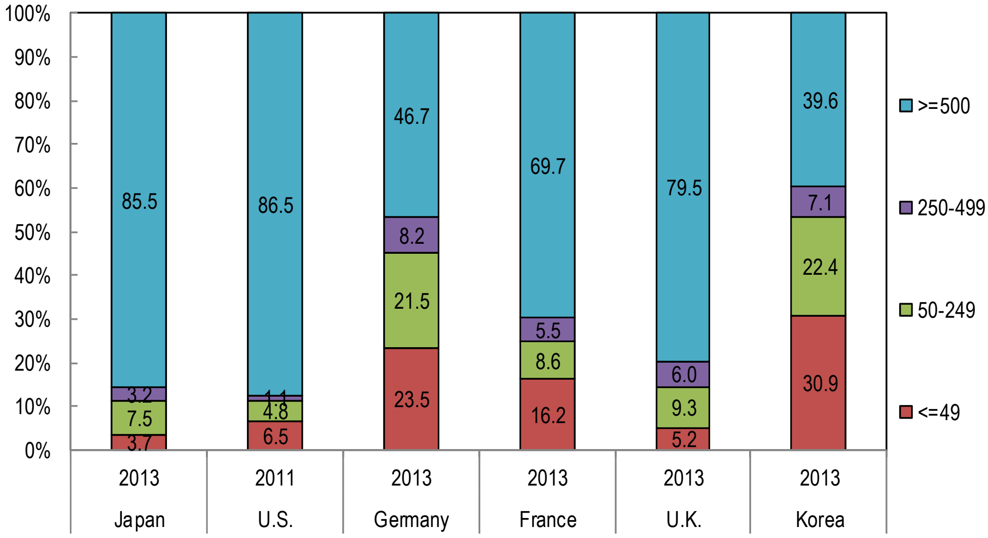


Note: For Russia, its percentages in 2011 are shown; for Belgium, in 2012; and for the U.S., France, China, New Zealand, Brazil, Italy, and Australia, in 2013. For the other countries, their percentages in 2014 are shown. No data on R&D tax incentives (indirect support) in Sweden, Israel, or Poland were provided.
Reference: Chart 1-3-9, Japanese Science and Technology Indicators 2017 (in Japanese)

(5) The direct government funding of Japan and the United States is concentrated on large-scale enterprises, whereas support for small- and medium-scale enterprises also carries a certain weight in Germany and Korea.

With regard to direct government funding for R&D (the amount funded by the government to support business enterprises' R&D expenditure) according to the number of employees in Japan and the United States, business enterprises with at least 500 employees constitute a large part of receiving enterprises, which account for approximately 90% of the total receiving enterprises. On the other hand, in Germany, business enterprises with 249 employees or less account for roughly 50% of enterprises receiving the government's contributions; in Korea, such enterprises account for more than 50%.

[Summary Chart 6] Government contributions to the R&D expenditure of business enterprises by the number of employees in the selected countries



Government contribution to business enterprises' R&D expenditure	0.1 trillions ¥	3.4 trillions ¥	0.2 trillions ¥	0.3 trillions ¥	0.2 trillions ¥	0.3 trillions ¥

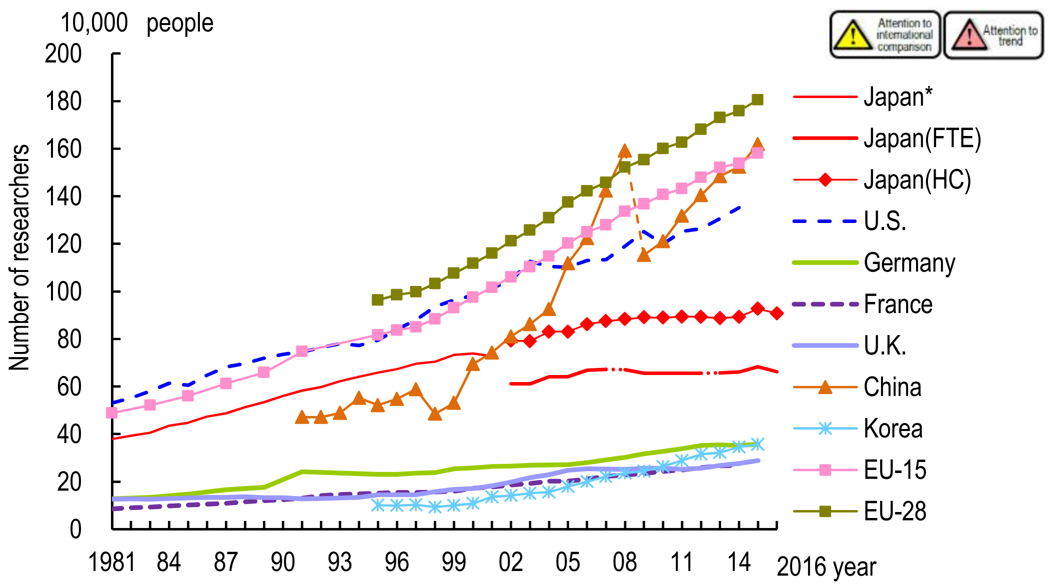
Reference: Chart 1-3-10, Japanese Science and Technology Indicators 2017 (in Japanese)

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

(1) The number of researchers in Japan was 662,000 in 2016, the third largest scale in the world after China and the United States.

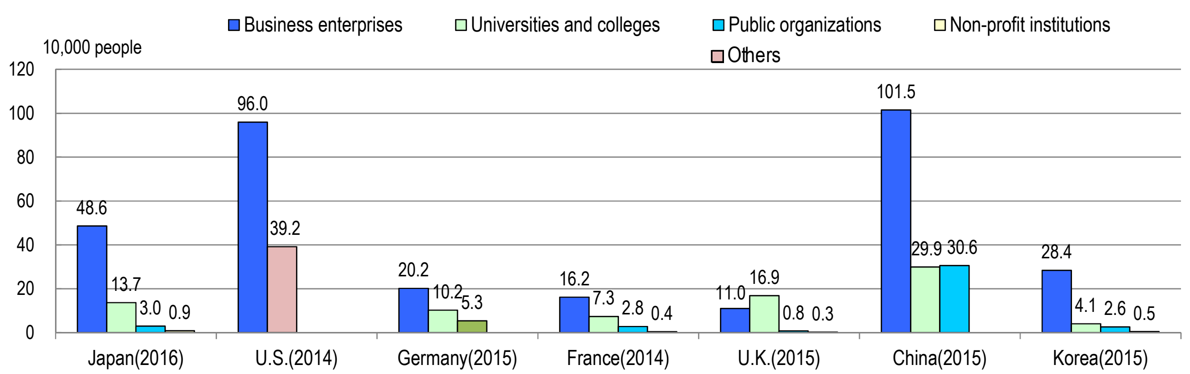
As one of the key indicators, the number of researchers is as important as the amount of R&D funds. The number of researchers in Japan was 662,000 in 2016 (the actual number (head count [HC]) is 907,000), the third largest scale in the world after China and the United States. The number of researchers 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. By sector, 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 7] 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 2017 (in Japanese)

[Summary Chart 8] The number of researchers by sector in the selected countries

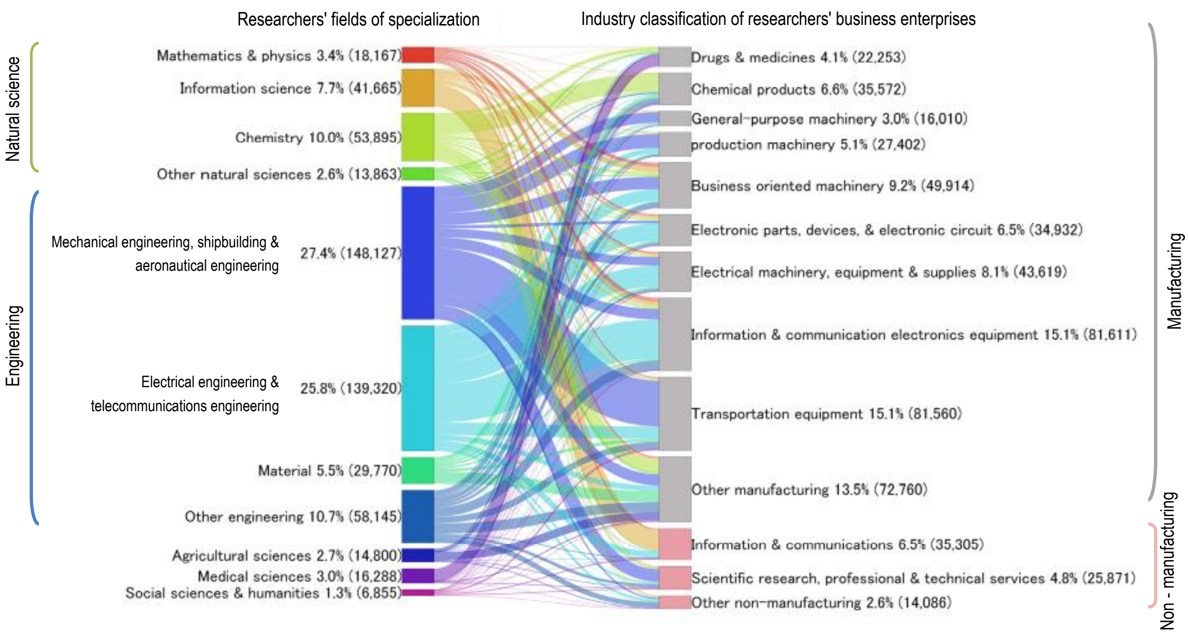


Note: 1) All the countries are based on FTE values.
2) The values of the U.S. are those estimated by the OECD. Since no value for recent years is available aside from those for the business enterprise sector, the values shown pertain to business enterprises and other sectors.
Reference: Chart 2-1-7, Japanese Science and Technology Indicators 2017 (in Japanese)

(2) In the manufacturing industry of Japan, researchers with engineering-related specialized knowledge account for a large proportion of the total number of researchers.

With regard to the fields of specialization of researchers in each industry classification, the number of researchers specializing in the "electrical engineering & telecommunications engineering" field is large in the "information & communication electronics equipment manufacturing industry," which is an area of the manufacturing industry and holds a large number of researchers. In the "transportation equipment manufacturing industry," a large number of researchers specialize in the field of "mechanical engineering, shipbuilding & aeronautical 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." In other industry classifications, the number of researchers in "information science" is low. Furthermore, the total number of researchers specializing the field of "social sciences & humanities" is very low compared with other fields of specialization.

[Summary Chart 9] Fields of specialization of researchers belonging to business enterprises in Japan (2016)

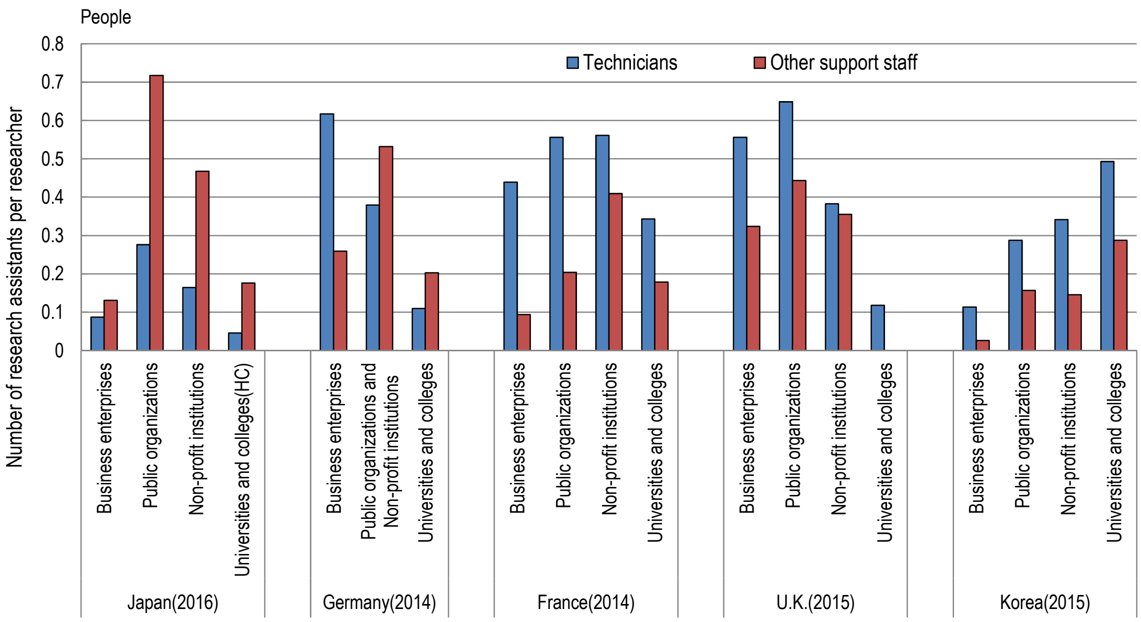


Note: The values shown are HC values. Parentheses indicate the numbers of researchers.
Reference: Chart 2-2-8, Japanese Science and Technology Indicators 2017 (in Japanese)

(3) In an international comparison of research assistants according to their operations, the number of "other support staff" is higher than that of "technicians" in Japan, whereas the number of "technicians" tends to be higher in other countries.

The number of research assistants per researcher by sector and by operation indicates that the number of "other support staff" is higher than that of "technicians" in Japan, whereas the number of "technicians" tends to be higher in other countries.

[Summary Chart 10] Operation-specific number of research assistants for each researcher by sector in the selected countries



Note: 1) Technicians (skilled workers and staff equivalent thereto) mean those whose primary tasks require technical knowledge and experience in one or more of the fields of engineering, physics, life sciences, social sciences, and/or humanities. Normally, technicians are those who participate in R&D by engaging in scientific/technical tasks associated with the application of concepts or actual methods, or with the use of research devices, under the instructions of researchers.

2) Other support staff are operating, administrative, secretarial and office work staff who are skilled or unskilled and participate in an R&D project or are directly involved in a similar project.

3) Numerical values pertaining to "other support staff" at UK universities and colleges are not specified in the relevant reference material ("R&D Statistics" by the OECD), which is used as the source of the above-shown values.

Reference: Chart 2-3-2, Japanese Science and Technology Indicators 2017 (in Japanese)

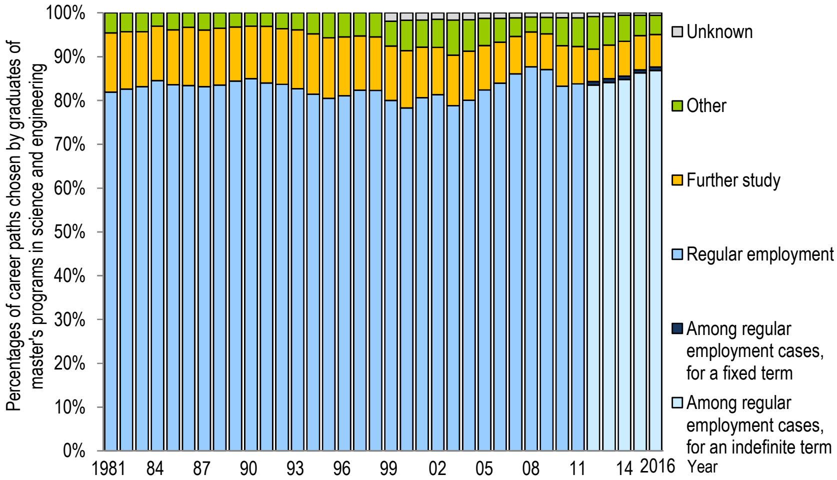
3. The situation in Japan in terms of graduates of universities and colleges

(1) Approximately 90% of graduates of master's programs in "science and engineering" find "regular employment," and most of such graduates are employed for "indefinite terms." Approximately 70% of graduates of doctoral programs in "science and engineering" find "regular employment," and only roughly 50% of such graduates are employed for "indefinite terms."

With regard to career paths chosen by graduates of master's programs in "science and engineering" in 2016 (37,128 graduates), the percentage of those who found "regular employment" was 87.6%. The percentage of those who found "regular employment" for "indefinite terms" was 86.8% of the total graduates concerned, and those employed for "fixed terms" accounted for 0.8% of the total. With regard to career paths chosen by graduates of doctoral programs in "science and engineering" in 2016 (4,809 graduates), the percentage of those who found "regular employment" was 68.6%. The percentage of those who found "regular employment" for "indefinite terms" was 51.4% of the total graduates concerned, and those employed for "fixed terms" accounted for 17.2% of the total.

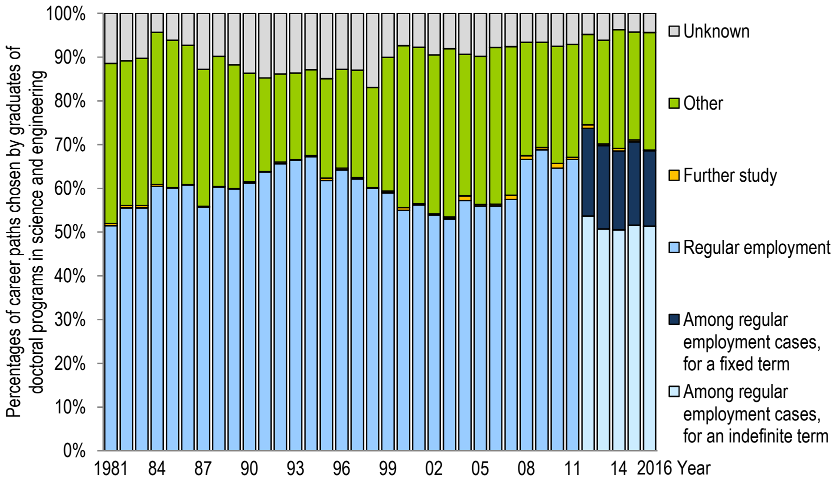
[Summary Chart 11] Career paths of graduates in science and engineering

(A) Career paths of graduates of master's programs in science and engineering



Reference: Chart 3-3-2, Japanese Science and Technology Indicators 2017 (in Japanese)

(B) Career paths of graduates of doctoral programs in science and engineering



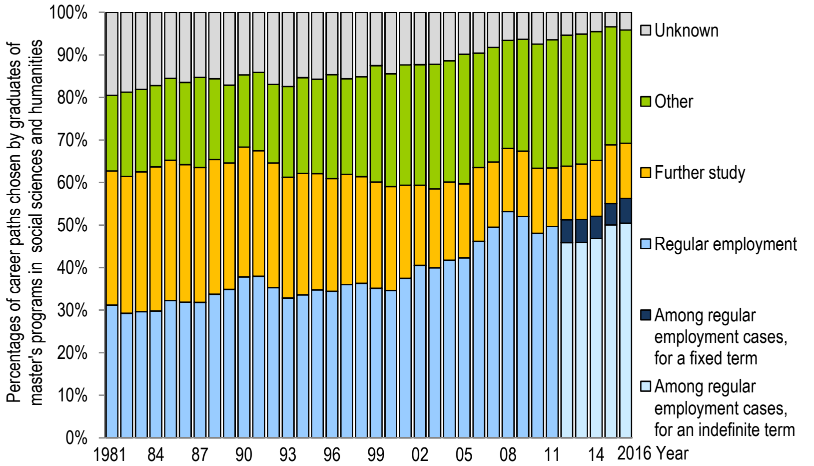
Reference: Chart 3-3-3, Japanese Science and Technology Indicators 2017 (in Japanese)

(2) The percentage of graduates of master's programs in "social sciences and humanities" who find "regular employment" has increased, and approximately 60% of the total graduates concerned are employed. With respect to graduates of doctoral programs in "social sciences and humanities," although approximately 50% of the total graduates find employment, only roughly 30% of the total are employed for "indefinite terms."

With regard to career paths chosen by graduates of master's programs in "social sciences and humanities," the percentages of those who found "regular employment" and those who went on to "further study" were both approximately 30% during the 1980s. Later, the percentage of those who found "regular employment" increased, reaching 56.3% among graduates of master's programs in "social sciences and humanities" (11,458 graduates) in 2016. With regard to career paths chosen by graduates of doctoral programs in "social sciences and humanities" in 2016 (2,135 graduates), the percentage of those who found "regular employment" was 45.1%. However, only 29.8% of the total doctoral graduates were employed for "indefinite terms," and 15.3% were employed for "fixed terms."

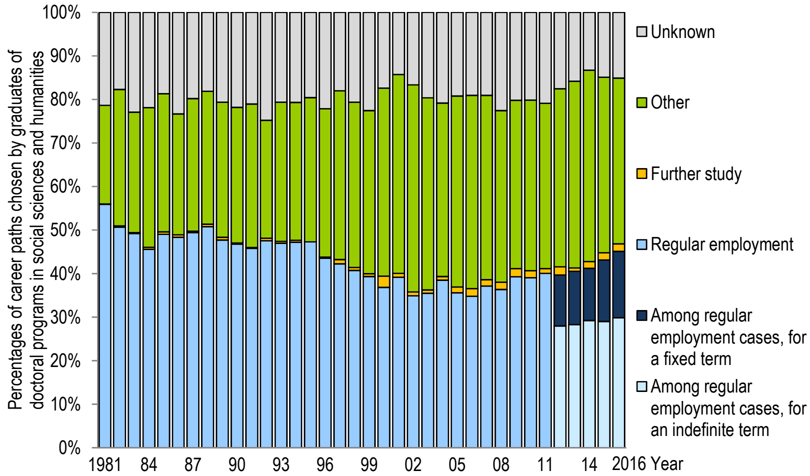
[Summary Chart 12] Career paths of graduates in social sciences and humanities

(A) Career paths of graduates of master's programs in social sciences and humanities



Reference: Chart 3-3-10, Japanese Science and Technology Indicators 2017 (in Japanese)

(B) Career paths of graduates of doctoral programs in social sciences and humanities



Reference: Chart 3-3-11, Japanese Science and Technology Indicators 2017 (in Japanese)

Note: Graduates employed for indefinite terms mean those who are employed without a specific term of employment.
Graduates employed for fixed terms mean those whose terms of employment are stipulated as at least one year, and also whose prescribed weekly working hours are around 30 to 40 hours.
"Other" means those who are in temporary employment, who work on a part-time basis, etc.

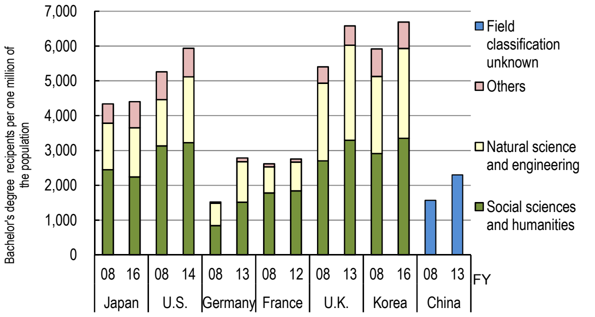
(3) In Japan, the number of graduates in "natural science and engineering" tends to be high as the academic stage advances, specifically among master's degree recipients and doctoral degree recipients. In the selected countries other than Japan, the number of graduates in "social sciences and humanities" 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.

According to 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.

In the countries concerned other than Japan, the numbers of bachelor's degree recipients, master's degree recipients, and doctoral degree recipients per one million of population have increased at all degree levels.

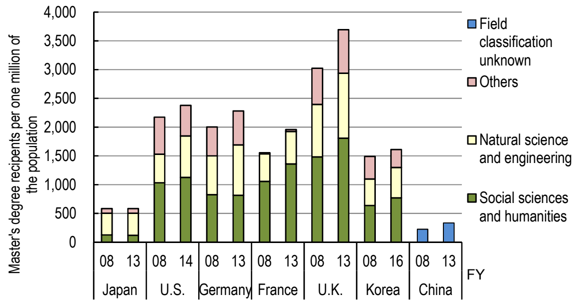
[Summary Chart 13] International comparison of academic degree recipients per one million of population

(A) New bachelor's degree recipients



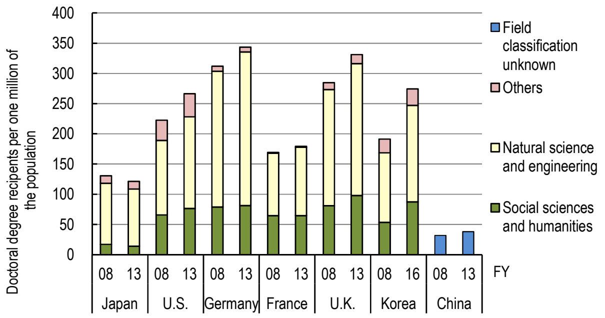
Reference: Chart 3-4-1, Japanese Science and Technology Indicators 2017 (in Japanese)

(B) New master's degree recipients



Reference: Chart 3-4-2, Japanese Science and Technology Indicators 2017 (in Japanese)

(C) New doctoral degree recipients



Reference: Chart 3-4-3, Japanese Science and Technology Indicators 2017 (in Japanese)

Note: 1) The numbers of doctoral degree recipients in the U.S are 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 (such as the bachelor of medicine and the bachelor of law) from the figures for the "doctor's degrees" noted in the "Digest of Education Statistics."
2) With regard to China, the figures for individual fields are not known.
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. Circumstances in Japan and the selected countries in terms of R&D output

(1) Compared with ten years ago, the number of Japanese papers has slightly declined (counted by the fractional counting method). With other countries expanding their shares, 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).

With regard to 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 relation to 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	1993 — 1995 (PY) (Average)		
	The number of papers		
Country/Region	Fractional counting		
	Papers	Share	World rank
U.S.	182,135	31.4	1
Japan	47,588	8.2	2
U.K.	42,583	7.3	3
Germany	38,890	6.7	4
France	30,361	5.2	5
Canada	23,243	4.0	6
Russia	20,924	3.6	7
Italy	18,140	3.1	8
Australia	11,982	2.1	9
Netherlands	11,639	2.0	10

All fields	2003— 2005 (PY) (Average)		
	The number of papers		
Country/Region	Fractional counting		
	Papers	Share	World rank
U.S.	221,367	26.1	1
Japan	67,888	8.0	2
Germany	52,315	6.2	3
China	51,930	6.1	4
U.K.	50,862	6.0	5
France	37,392	4.4	6
Italy	30,358	3.6	7
Canada	27,847	3.3	8
Spain	21,527	2.5	9
India	20,319	2.4	10

All fields	2013 — 2015 (PY) (Average)		
	The number of papers		
Country/Region	Fractional counting		
	Papers	Share	World rank
U.S.	272,233	19.9	1
China	219,608	16.0	2
Germany	64,747	4.7	3
Japan	64,013	4.7	4
U.K.	59,097	4.3	5
India	49,976	3.7	6
France	45,315	3.3	7
korea	44,822	3.3	8
Italy	43,804	3.2	9
Canada	39,473	2.9	10

All fields	1993 — 1995 (PY) (Average)		
	The number of adjusted top 10% papers		
Country/Region	Fractional counting		
	Papers	Share	World rank
U.S.	27,664	47.8	1
U.K.	4,800	8.3	2
Germany	3,481	6.0	3
Japan	3,348	5.8	4
France	2,740	4.7	5
Canada	2,564	4.4	6
Netherlands	1,453	2.5	7
Italy	1,406	2.4	8
Australia	1,224	2.1	9
Sweden	1,039	1.8	10

All fields	2003— 2005 (PY) (Average)		
	The number of adjusted top 10% papers		
Country/Region	Fractional counting		
	Papers	Share	World rank
U.S.	33,242	39.4	1
U.K.	6,288	7.5	2
Germany	5,458	6.5	3
Japan	4,601	5.5	4
France	3,696	4.4	5
China	3,599	4.3	6
Canada	3,155	3.7	7
Italy	2,588	3.1	8
Netherlands	2,056	2.4	9
Australia	1,903	2.3	10

All fields	2013 — 2015 (PY) (Average)		
	The number of adjusted top 10% papers		
Country/Region	Fractional counting		
	Papers	Share	World rank
U.S.	39,011	28.5	1
China	21,016	15.4	2
U.K.	8,426	6.2	3
Germany	7,857	5.7	4
France	4,941	3.6	5
Italy	4,739	3.5	6
Canada	4,442	3.2	7
Australia	4,249	3.1	8
Japan	4,242	3.1	9
Spain	3,634	2.7	10

All fields	1993 — 1995 (PY) (Average)		
	The number of adjusted top 1% papers		
Country/Region	Fractional counting		
	Papers	Share	World rank
U.S.	3,223	55.7	1
U.K.	471	8.1	2
Germany	321	5.5	3
Japan	271	4.7	4
Canada	241	4.2	5
France	231	4.0	6
Netherlands	137	2.4	7
Italy	113	1.9	8
Switzerland	108	1.9	9
Australia	100	1.7	10

All fields	2003— 2005 (PY) (Average)		
	The number of adjusted top 1% papers		
Country/Region	Fractional counting		
	Papers	Share	World rank
U.S.	3,983	47.2	1
U.K.	673	8.0	2
Germany	503	6.0	3
Japan	365	4.3	4
France	311	3.7	5
Canada	295	3.5	6
China	283	3.4	7
Netherlands	211	2.5	8
Italy	200	2.4	9
Switzerland	178	2.1	10

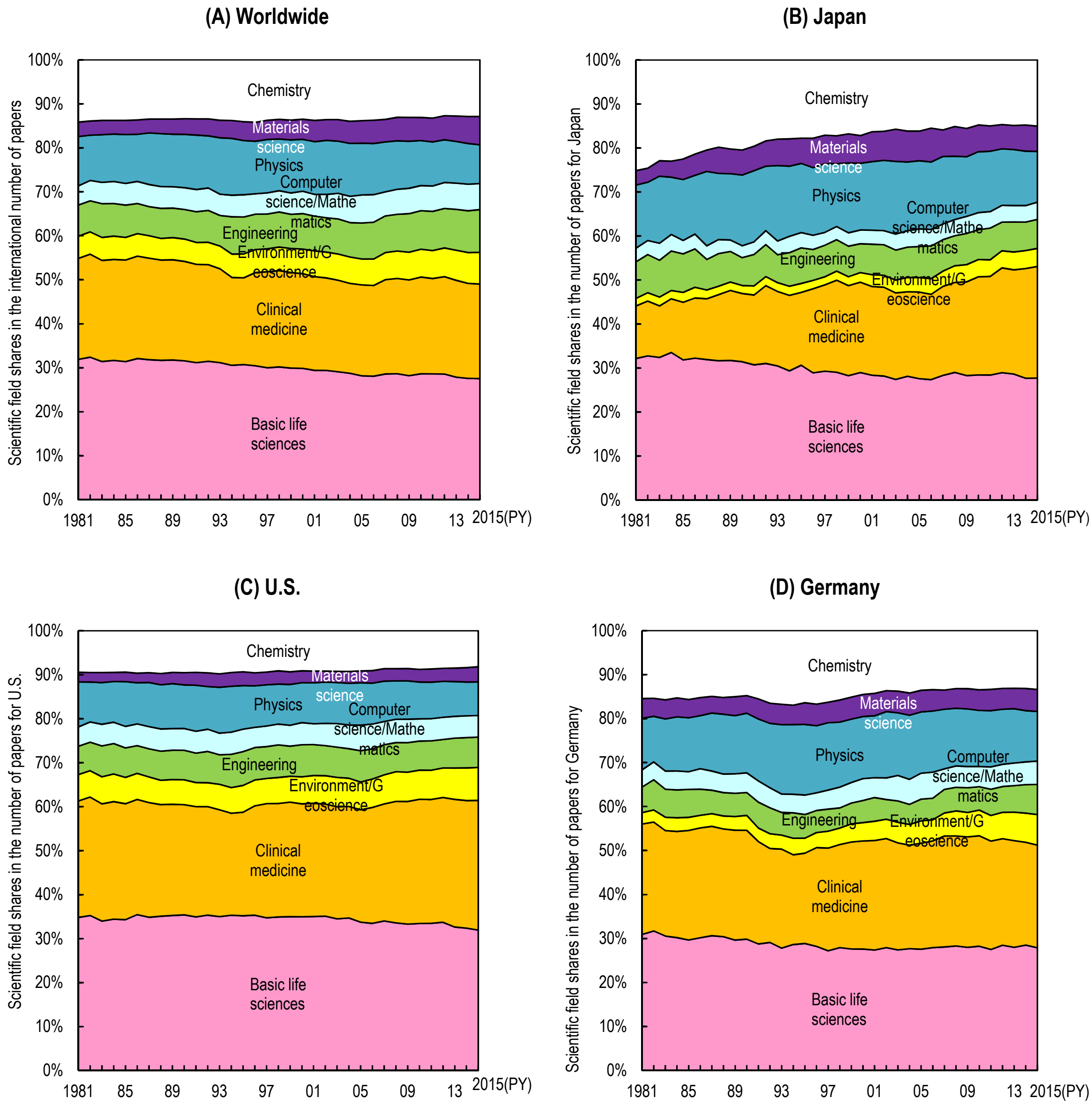
All fields	2013 — 2015 (PY) (Average)		
	The number of adjusted top 1% papers		
Country/Region	Fractional counting		
	Papers	Share	World rank
U.S.	4,700	34.3	1
China	1,954	14.3	2
U.K.	961	7.0	3
Germany	763	5.6	4
France	476	3.5	5
Australia	433	3.2	6
Canada	419	3.1	7
Italy	384	2.8	8
Japan	335	2.4	9
Spain	299	2.2	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 2015.
Reference: Chart 4-1-6, Japanese Science and Technology Indicators 2017 (in Japanese)

(2) With regard to scientific field shares in the number of Japanese papers, the shares of "basic life sciences," "chemistry," and "physics" were large in the first half of the 1980s. Over time, "basic life sciences" and "chemistry" have lowered, while "clinical medicine" has risen.

In the first half of the 1980s, "basic life sciences," "chemistry," and "physics" accounted for a large share of the number of Japanese papers. However, a comparison between 1981 and 2015 shows that the shares of "chemistry" and "basic life sciences" have lowered by 9.3 points and 3.5 points, respectively. On the other hand, the share of "clinical medicine" has risen by 13.7 points. In comparison between life sciences ("clinical medicine" and "basic life sciences") and other fields, the share of life sciences has increased by nearly 10 points in Japan.

[Summary Chart 15] Changes in scientific field shares in the worldwide number of papers and the selected countries' numbers of papers (fractional counting)



Note: The number of articles and reviews was counted. Papers were sorted by publication year (PY).
Reference: Charts 4-1-8 and 4-1-9, Japanese Science and Technology Indicators 2017 (in Japanese)

(3) Japan has maintained its position as the world's highest in terms of the number of patent families (patents filed in two or more countries) for the last ten years.

This section looks at 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 1990 and 1992, the United States was ranked first and Japan second. Between 2000 and 2002, and between 2010 and 2012, 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. With regard to China in terms of the number of patent families, although it was ranked fifth between 2010 and 2012, its number has been steadily increasing.

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

1990 - 1992(Average)			
Number of patent families			
Country/Region	Whole counting		
	Patent Families	Share	World rank
U.S.	23,537	28.7	1
Japan	22,051	26.9	2
Germany	14,111	17.2	3
France	5,601	6.8	4
U.K.	4,611	5.6	5
Italy	2,618	3.2	6
Switzerland	2,175	2.6	7
Netherlands	1,619	2.0	8
Canada	1,593	1.9	9
Switzerland	1,254	1.5	10

2000 - 2002(Average)			
Number of patent families			
Country/Region	Whole counting		
	Patent Families	Share	World rank
Japan	46,332	30.2	1
U.S.	43,501	28.3	2
Germany	26,933	17.5	3
France	9,153	6.0	4
U.K.	8,633	5.6	5
Korea	7,326	4.8	6
Italy	4,592	3.0	7
Canada	4,376	2.9	8
Netherlands	4,283	2.8	9
Switzerland	3,521	2.3	10

2010 - 2012(Average)			
Number of patent families			
Country/Region	Whole counting		
	Patent Families	Share	World rank
Japan	64,273	29.8	1
U.S.	48,847	22.6	2
Germany	30,097	13.9	3
Korea	20,094	9.3	4
China	16,144	7.5	5
Taiwan	11,932	5.5	6
France	11,393	5.3	7
U.K.	8,647	4.0	8
Canada	5,990	2.8	9
Italy	5,557	2.6	10

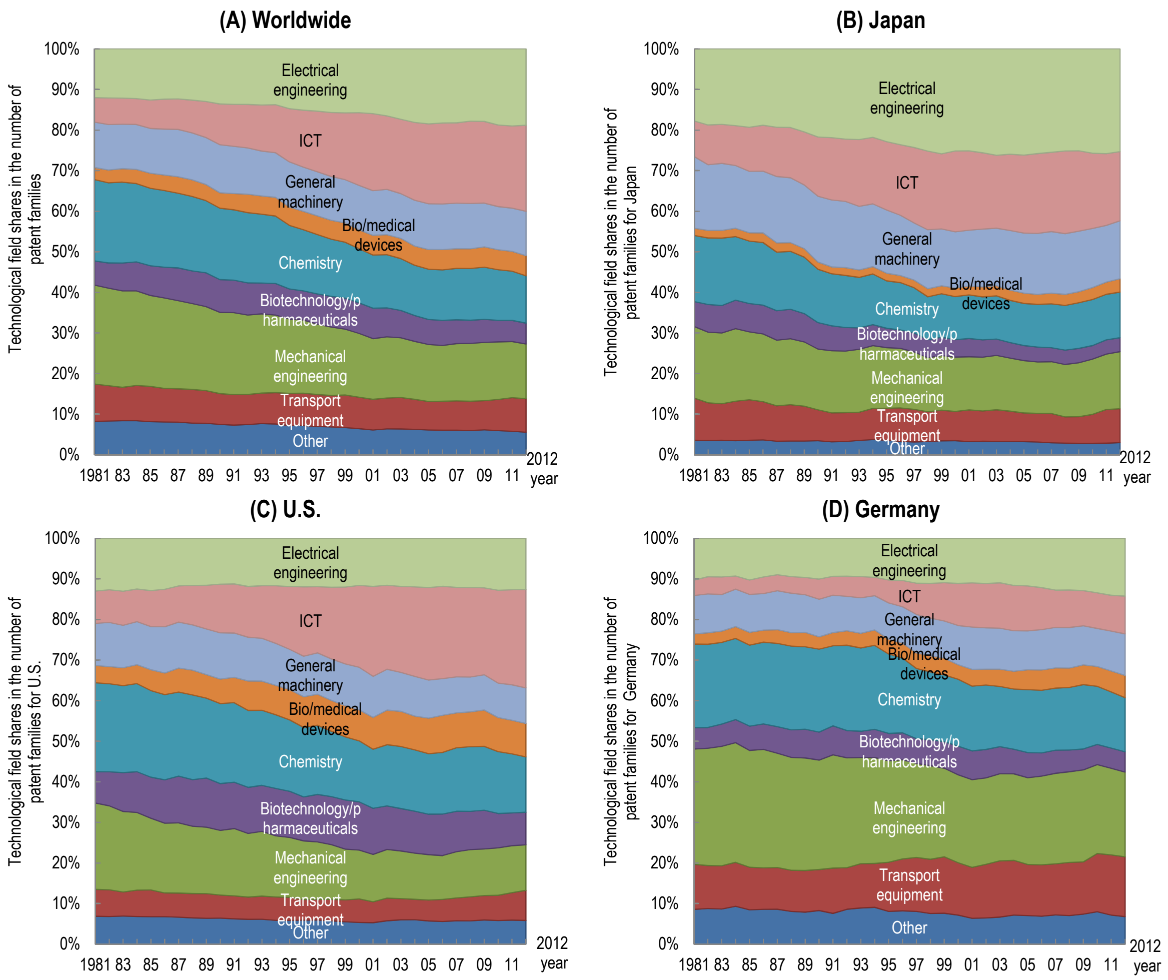
Note: A patent family is a group of patents filed in two or more countries, directly or indirectly related to each other by priority rights. In many cases, the same patents filed in multiple countries belong to the same patent family.
Reference: Chart 4-2-5, Japanese Science and Technology Indicators 2017 (in Japanese)

(4) The balance of technological fields in Japan as of 2012 showed that the shares of "electrical engineering" and "general machinery" were high, compared with the corresponding worldwide shares. On the other hand, the shares of "biotechnology/pharmaceuticals" and "bio/medical devices" were low, compared with the corresponding worldwide shares.

The balance of technological fields in Japan as of 2012 showed that the shares of "electrical engineering" and "general machinery" were high, compared with the corresponding worldwide shares (the worldwide shares of 18.8% and 10.9%, respectively; and Japan's shares of 25.3% and 14.3%, respectively). On the other hand, Japan's shares of "biotechnology/pharmaceuticals" and "bio/medical devices" were low, compared with the corresponding worldwide shares (the worldwide shares of 5.1% and 5.0%, respectively; and Japan's shares of 3.4% and 3.3%, respectively).

According to changes in the shares of Japan's technological fields, although the share of "ICT" increased over a long period of time from 1981, reaching 20.4% in 2008, it has declined in recent years. The share of "electrical engineering" rose by 7.5 points between 1981 and 2012. Furthermore, the share of "transport equipment" has increased in recent years.

[Summary Chart 17] Changes in technological field shares in the worldwide number of patent families and the selected countries' numbers of patent families



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: Charts 4-2-8 and 4-2-9, Japanese Science and Technology Indicators 2017 (in Japanese)

(5) With regard to the linkage between science and technology (science linkage), a large number of Japanese papers are cited by patent families around the world (second most in the world). Although the number of Japanese patent families citing papers is also 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 (science linkage), information on papers cited by patent families was analyzed. Japan ranks second in the world in terms of the number of patent families citing papers by country/region. However, the number of Japanese patent families citing papers accounts for only 9.0% 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 cited by patent families is second largest after the United States.

[Summary Chart 18] The number of patent families citing papers: top 10 countries/regions

Whole counting		2005–2012 (Total)		
			(B) Total number of patent families	
No.	Country / Region	(A) Patent families citing papers	No. of patent families	Percentage of patent families citing papers (A) / (B)
1	U.S.	94,249	383,812	24.6%
2	Japan	44,622	494,925	9.0%
3	Germany	39,488	242,606	16.3%
4	France	21,316	89,106	23.9%
5	U.K.	18,311	69,304	26.4%
6	China	16,056	96,432	16.7%
7	Korea	11,874	151,249	7.9%
8	Canada	11,224	45,748	24.5%
9	Netherlands	9,964	36,434	27.3%
10	India	8,318	26,194	31.8%

Reference: Chart 4-3-2, Japanese Science and Technology Indicators 2017}
(in Japanese)

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

Whole counting		1981–2012 (Total)		
			(B) Total number of papers	
No.	Country / Region	(A) Papers cited by patent families	No. of papers	Percentage of papers cited by patent families (A) / (B)
1	U.S.	106,593	7,079,917	1.5%
2	Japan	26,890	1,821,236	1.5%
3	Germany	22,415	1,826,813	1.2%
4	U.K.	20,456	1,824,576	1.1%
5	France	14,409	1,333,730	1.1%
6	China	11,335	1,353,245	0.8%
7	Canada	10,885	1,006,284	1.1%
8	Italy	9,235	898,805	1.0%
9	Korea	7,306	438,284	1.7%
10	Netherlands	7,226	531,922	1.4%

Reference: Chart 4-3-3, Japanese Science and Technology Indicators 2017
(in Japanese)

(6) In the technological fields of "electrical engineering" and "general machinery," which account for a large part of the composition of technological fields in Japan compared with the worldwide levels of these fields, Japan's share of patent families citing papers tends to be low, in comparison with the corresponding shares of the United States and European countries.

According to the share of patent families citing papers in total patent families by technological field, the share of "biotechnology/pharmaceuticals" is high and the shares of "mechanical engineering" and "transport equipment" are low in all the selected countries. As for the other technological fields relative to each country's "biotechnology/pharmaceuticals", each of the United States, Germany, France, and the United Kingdom has a high share of patent families citing papers in the fields of "ICT," "general machinery," and "electrical engineering," in comparison with Japan.

In the technological fields of "electrical engineering" and "general machinery," which account for a large part of the composition of technological fields in Japan compared with the worldwide levels of these fields (see Summary Chart 17), Japan's share of patent families citing papers tends to be low, compared with the corresponding shares of the United States and European countries.

[Summary Chart 20] Technological field shares in the selected countries' numbers of patent families citing papers (Relative value to "biotechnology/pharmaceuticals" in each country)

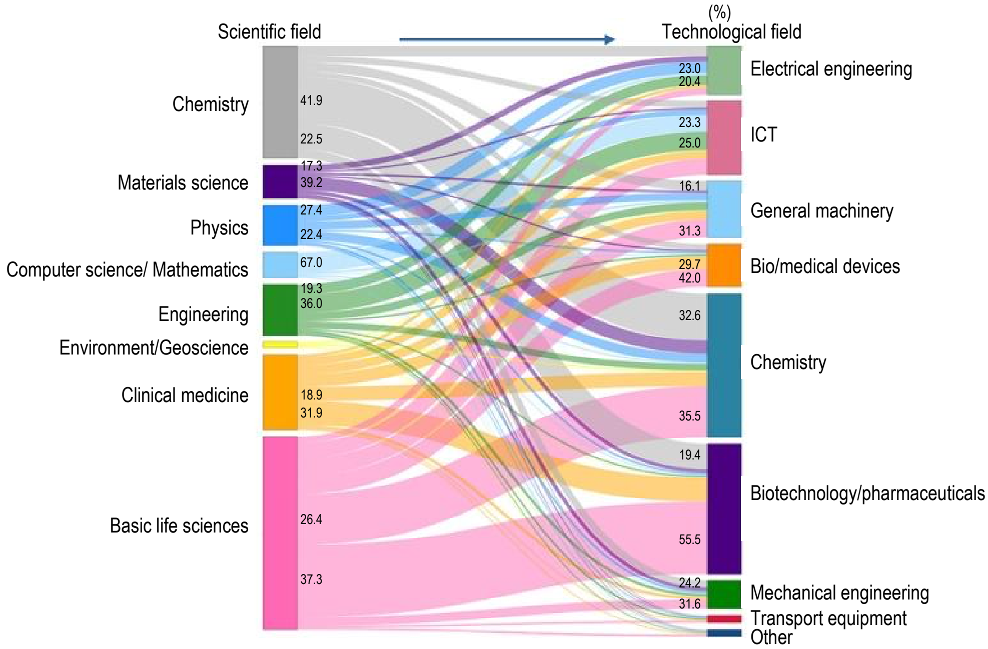
Technological field	Japan	U.S.	Germany	France	U.K.	China	Korea
Biotechnology/pharmaceuticals	1	1	1	1	1	1	1
Chemistry	0.48	0.58	0.50	0.59	0.60	0.61	0.44
Bio/medical devices	0.37	0.42	0.37	0.40	0.41	0.37	0.32
ICT	0.21	0.33	0.38	0.38	0.34	0.25	0.16
General machinery	0.18	0.39	0.32	0.41	0.42	0.19	0.13
Electrical engineering	0.16	0.28	0.21	0.30	0.31	0.17	0.12
Mechanical engineering	0.09	0.15	0.09	0.11	0.13	0.11	0.08
Other	0.08	0.11	0.06	0.06	0.09	0.06	0.05
Transport equipment	0.07	0.08	0.06	0.07	0.07	0.08	0.04

Reference: Chart 4-3-5, Japanese Science and Technology Indicators 2017 (in Japanese)

(7) Japanese papers in the fields of "clinical medicine" and "basic life sciences" account for a small proportion of papers cited by Japan's own patent families, compared with "physics" and "materials science"; such papers are instead cited by other countries' patent families.

The linkage between scientific fields and technological fields in the world shows that a large number of papers cited by patent families fall within the scientific fields of "basic life sciences," "chemistry," and "clinical medicine."

[Summary Chart 21] Linkage between scientific fields and technological fields in the world

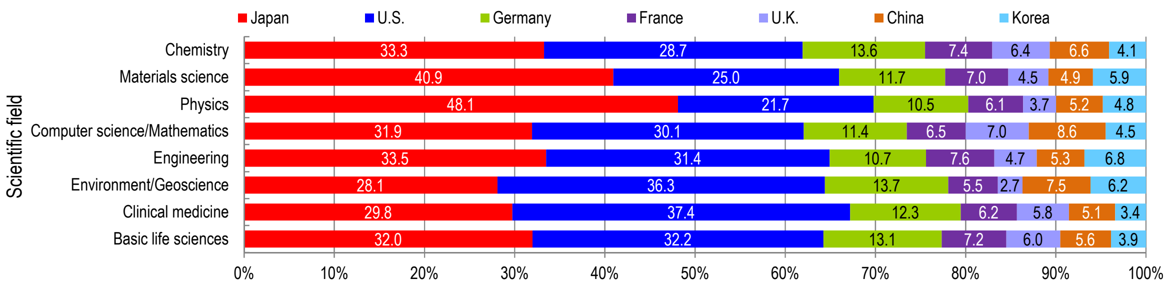


Reference: Chart 4-3-6, Japanese Science and Technology Indicators 2017 (in Japanese)

With regard to which countries' patent families cite Japanese papers in each scientific field, a large number of papers in "physics" and "materials science" are cited by Japan's own patent families (48.1% and 40.9%, respectively). On the other hand, Japan's papers in "clinical medicine" and "basic life sciences" account for a relatively small proportion of papers cited by Japan's own patent families (29.8% and 32.0%, respectively); such papers are instead cited by countries other than Japan.

While the number of papers in "clinical medicine" has been increasing (see Summary Chart 15), the share of "biotechnology/pharmaceuticals" in the number of patent families is low despite the fact it is the technological field that cites such papers the most (see Summary Chart 17). For that reason, the current situation suggests that Japan's scientific knowledge is possibly not being sufficiently utilized by its own technologies.

[Summary Chart 22] Countries whose patent families cite Japanese papers



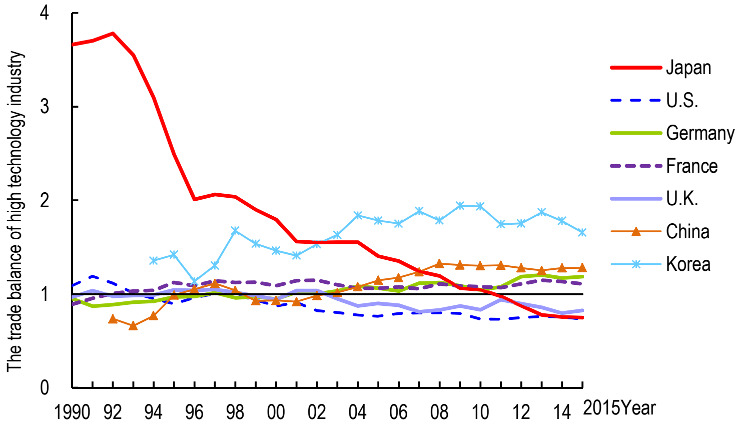
Reference: Chart 4-3-7, Japanese Science and Technology Indicators 2017 (in Japanese)

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

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

In high-technology industries, Japan's trade balance ratio has continuously been on the decline, having hit below 1 and having run import surpluses since 2011. The trade balance ratio of Japan in 2015 was 0.75, which was at the same level as the United Kingdom and the United States whose ratios had originally been low. Meanwhile, China and Korea have raised their balance ratios over a long period of time; the balance ratio of the latter was highest (1.66) among the selected countries.

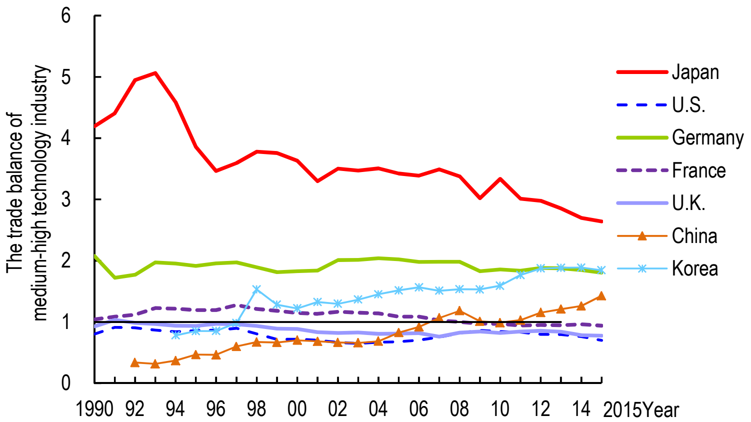
[Summary Chart 23] Changes in the trade balance ratios for high-technology industries in the selected countries



Note: 1) High-technology industries refer to "pharmaceutical," "computer, electronic and optical," and "aerospace."
2) Trade balance ratio = export value / import value
Reference: Chart 5-2-3, Japanese Science and Technology Indicators 2017 (in Japanese)

Japan's trade balance ratio for medium high-technology industries in 2015 was 2.64, which ranked it number one among the selected countries. Changes in the trade balance indicate that it showed large drop during the middle of the 1990s, and since then has kept declining gradually. While the trade balance ratios of the United States, Germany, France, and the United Kingdom remain at the same level, only those of Korea (1.84) and China (1.43) have increased.

[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 5-2-5, Japanese Science and Technology Indicators 2017 (in Japanese)

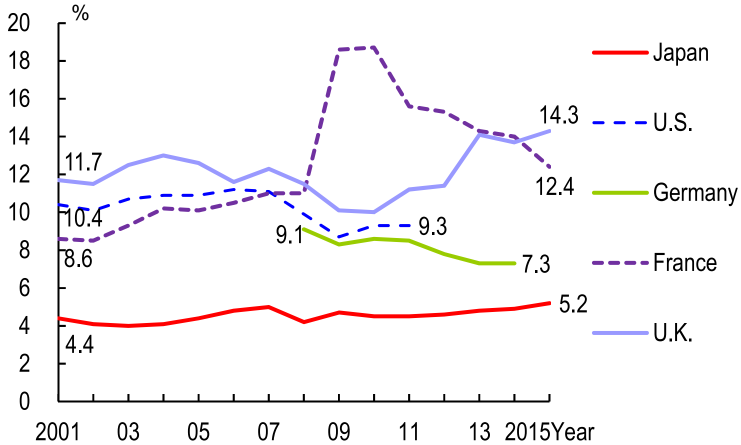
(2) In Japan, both the business startup rate and business discontinuance rate are low, compared with those rates of the other selected countries, while the proportion of people without entrepreneurial motivation is high in Japan. However, Japan's business survival rate after business startup is high.

In Japan, the business startup rate is higher than its business discontinuance rate. However, both of these rates remain at low levels, compared with those rates of the other selected countries, and have not changed much over time. With regard to the other selected countries, the business startup rate is higher than the business discontinuance rate in the United Kingdom and France, while the business discontinuance rate is higher than the business startup rate in the United States and Germany.

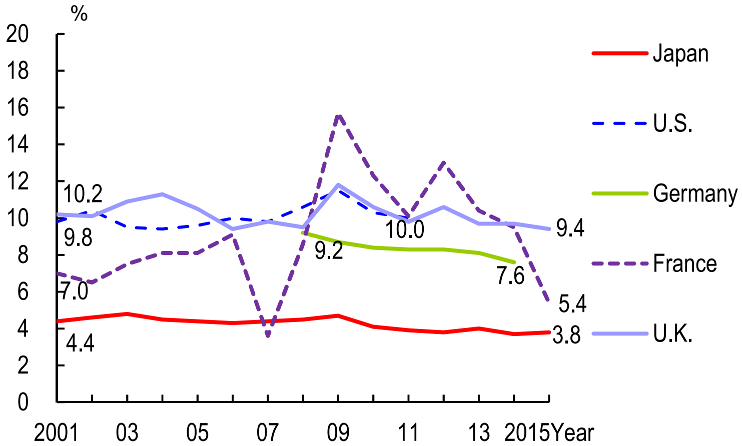
[Summary Chart 25] Changes in the business startup rates and business discontinuance rates of the selected countries

Attention to international comparison

(A) Business startup rate



(B) Business discontinuance rate



Note: It is necessary to pay attention to international comparisons in this regard since the method of calculating a business startup rate and a business discontinuance rate differs from country to country.

<Japan> The business startup and discontinuance rates are calculated on the basis of the formation and extinguishing of business establishments in respect of which necessary insurance relations have been established (applicable places of business). Specifically, the business startup rate is calculated by dividing the number of business establishments that newly establish employment relationships during the year concerned by the number of applicable places of business at the end of the previous year. The business discontinuance rate is calculated by dividing the number of business establishments whose employment relationships extinguish during the year concerned by the number of applicable places of business at the end of the previous year. Applicable places of business mean the number of business establishments that have established labor insurance relations pertaining to employment insurance.

<U.S.> The business startup and discontinuance rates are calculated on the basis of the generation and extinguishing of employers.

<U.K.> The business startup and discontinuance rates are calculated on the basis of the number of business enterprises registered for VAT (value-added tax) and PAYE (withholding income tax).

<Germany> The business startup and discontinuance rates are calculated on the basis of the number of business enterprises that have submitted the notifications of business commencement/discontinuance.

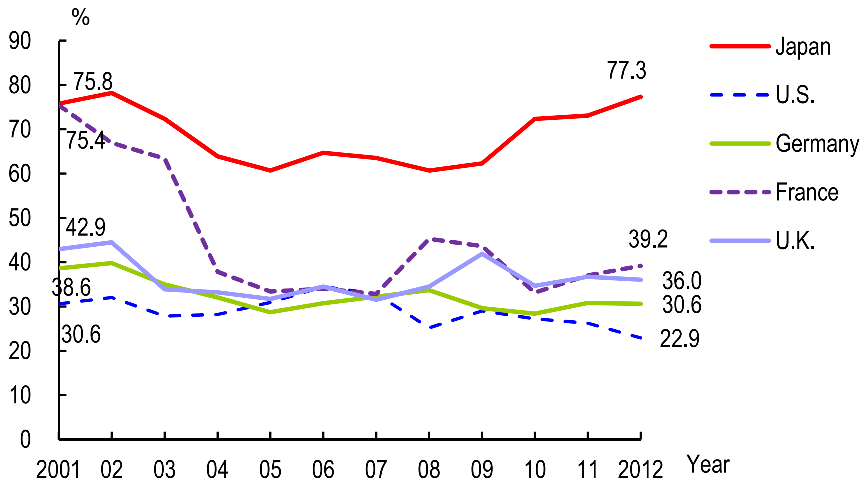
<France> The business startup rate is calculated on the basis of the number of business startup cases registered with/deleted from the SIRENRE database (the list of business enterprises and offices).

Reference: Chart 5-4-9, Japanese Science and Technology Indicators 2017 (in Japanese) (with data provided by the Small and Medium Enterprise Agency)

Regarding changes in the selected countries' percentages of people without entrepreneurial motivation, Japan's percentage in the most recent year is 77.3%, the highest level among the countries concerned. The difference between Japan and the other selected countries in this regard is as big as approximately 40 points.

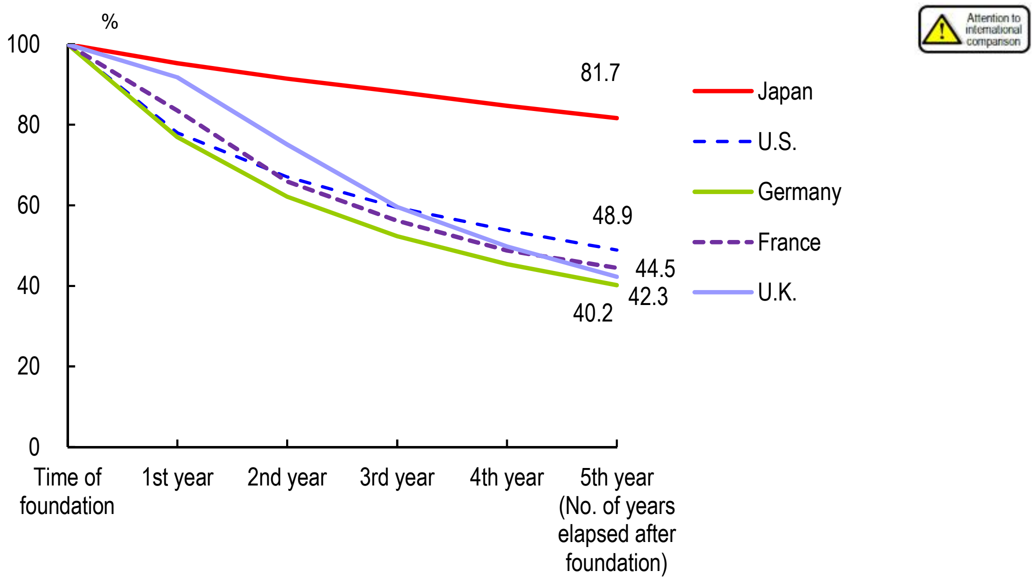
The business survival rate in Japan is relatively high, compared with the other selected countries. Even after five years, 81.7% of business enterprises in Japan continue their businesses. On the other hand, the business survival rates of the other selected countries after five years of business startup are 50% or less.

[Summary Chart 26] Changes in the percentages of people without entrepreneurial motivation in the selected countries



Note: 1) Research results produced by Global Entrepreneurship Monitor ("GEM") are shown.
2) The percentage of "people without entrepreneurial motivation" is a percentage calculated by counting people to whom none of the three indicators, "the indicator of entrepreneurial activity penetration," "the indicator of business opportunity perception" and "the indicator of knowledge, ability and experience," applies.
Reference: Chart 5-4-10, Japanese Science and Technology Indicators 2017 (in Japanese) (with data provided by the Small and Medium Enterprise Agency)

[Summary Chart 26] Changes in the post-startup business survival rates in the selected countries



Note: 1) The business survival rate in Japan is calculated only on the basis of business enterprises whose company information is recorded on the database "COSMOS2 (corporate profile database)" of Teikoku Databank, Ltd. In addition, since it takes a certain period of time until information is recorded on the database, the calculated rate may be higher than the actual survival rate.
2) The business survival rate in each of the U.S., the U.K., Germany, and France is acquired from its average of the number of business enterprises that newly started business during the period from 2007 to 2013.
Reference: Chart 5-4-11, Japanese Science and Technology Indicators 2017 (in Japanese) (with data provided by the Small and Medium Enterprise Agency)

Characteristics of the Japanese Science and Technology Indicators

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

Use of original statistical data published by authorities in each country

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

NISTEP conducted analysis of paper and patent databases

Paper data were 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" [Attention to international comparison] and "attention to trend" [Attention to trend] have been attached to graphs where they are required. Generally, the data for each country conform to OECD manuals and other materials. However, differences in methods of collecting data or scope of focus do in fact exist, and therefore attention is necessary when making comparisons in some cases. Such cases are marked "attention to international comparison." Likewise, for some time series data, data could not be continuously collected under the same conditions due to changes in statistical standards. Cases where special attention is required when reading 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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