Chapter 1 Trends and Issues in Science and Technology Policy

The governing party of Japan changed in December 2012. The Abe cabinet has taken measures for required economic policies by promoting an economic revival plan called the "Three Arrows," which is based on the recognition that a "Strong economy is the source of national power. Neither fiscal reconstruction nor the future of Japan can be achieved unless there is a strong economic recovery." The Three Arrows consist of a drastic monetary policy, an agile financial policy, and a stimulus for private investment. Thus, the cabinet has established policies to overcome the prolonged appreciation of the yen and deflation-led recession, and to increase employment and income.

Based on these policies, the government has made new efforts in science, technology and innovation policy programs. Prime Minister Abe declared in his general policy speech that he is determined to recover the economy by creating new values (January 28, 2013). Abe said, "Innovation and system reform will lead to the resolution of social issues, thereby bringing about new values in our daily lives and becoming a driving factor for economic revival. The most important thing will be a spirit of courageously taking up the challenge to explore unknown fields."

In addition, in his speech of policy guidance on February 28, 2013, the Prime Minister said, "Let us build the most innovation-friendly country in the world." While demonstrating his recognition that Japan plays a key role in leading the world in cutting-edge areas, he emphasized the importance of creating a country for creation of innovation.

How is the situation surrounding S&T, which is the source of innovation, observed?

The 4th Science and Technology Basic Plan (hereinafter referred to as "the 4th Basic Plan"), which was approved in a cabinet meeting in August 2011, says that "Under the 3rd Basic Plan, area-focused R&D was promoted in the eight areas designated in the four primary priority areas and four secondary priority areas, leading to the creation of many innovative technologies. However, since it has been indicated that individual achievements did not necessarily lead to the solution of social issues, the government should identify essential issues to address, and then formulate responsive strategies and facilitate effective R&D." In addition, the Plan says that "In the field of basic research, performance has been steadily achieved, as seen by a researcher whose research paper has the world's top class citation, while the total share of Japanese research paper is slightly declining and the country's citation index is low compared to other advanced countries." The plan concludes that the integrated promotion of scientific technology and innovation policies is indispensable.

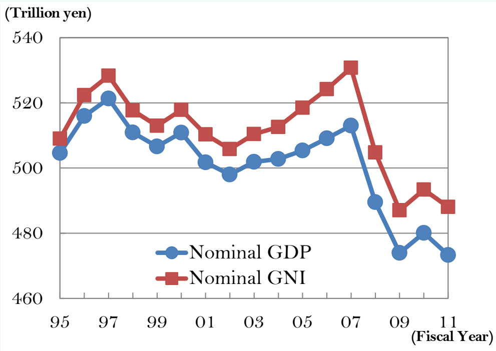
Furthermore, Ryoji Noyori, a chairman of the Council for Science and Technology (CST), which conducts investigations and discussions on critical issues for the comprehensive promotion of S&T and academic promotion, showed his recognition that there has been a decrease of the various S&T indicators in which science and technology play a central role. He also mentioned the decrease in the number, quality, and cost efficiency of scientific papers. He alarmed the current situation of S&T which is the source of innovation in strong terms, and mentioned the necessity of drastic system reformation.

Based on the above, in this chapter, we will overview trends in scientific technological innovation by international comparison and discuss current data analysis and other issues with the goal of building the most innovation-friendly country in the world.

1 Trends in Japan's Economic Growth and Competitiveness

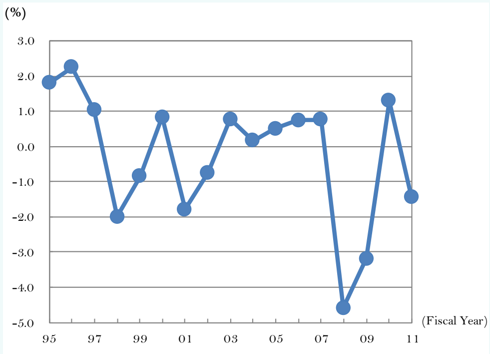
Nominal gross domestic product (Nominal GDP), the total amount of added value produced within a country in a given period of time, has remain restrained during the last 20 years due to protracted deflation and economic stagnation. Nominal gross national income (Nominal GNI), the amount of the "net income from abroad" added in the nominal GDP, indicates higher values than the nominal GDP, yet it remains restrained (Figure 1-1-1, Figure 1-1-2). Japanese nominal GDP (based on market rate) currently ranks third in international comparisons. Japan had remained second in the world during the past 42 years; however, we have given space to China to overtake our position in 2010 (Figure 1-1-3).

Figure 1-1-1 / Trends in Nominal GDP and Nominal GNI of Japan in the Last 20 Years



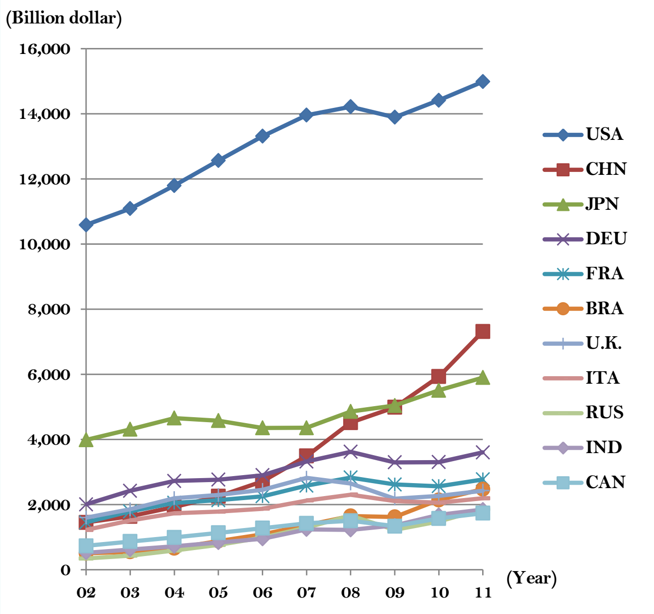
Note: Estimated by 93SNA chain index formula on an annual basis
Oct.-Dec. (The 2nd Preliminary)
Source: National Accounts in Cabinet Office, Government of Japan

Figure 1-1-2 / Trends in Nominal GDP Growth Rate of Japan in the Last 20 Years (a year-to-year comparison)



Note: Estimated by the 93SNA chain index formula on an annual basis
Oct.-Dec. (The 2nd Preliminary)
Source: National Accounts in Cabinet Office, Government of Japan

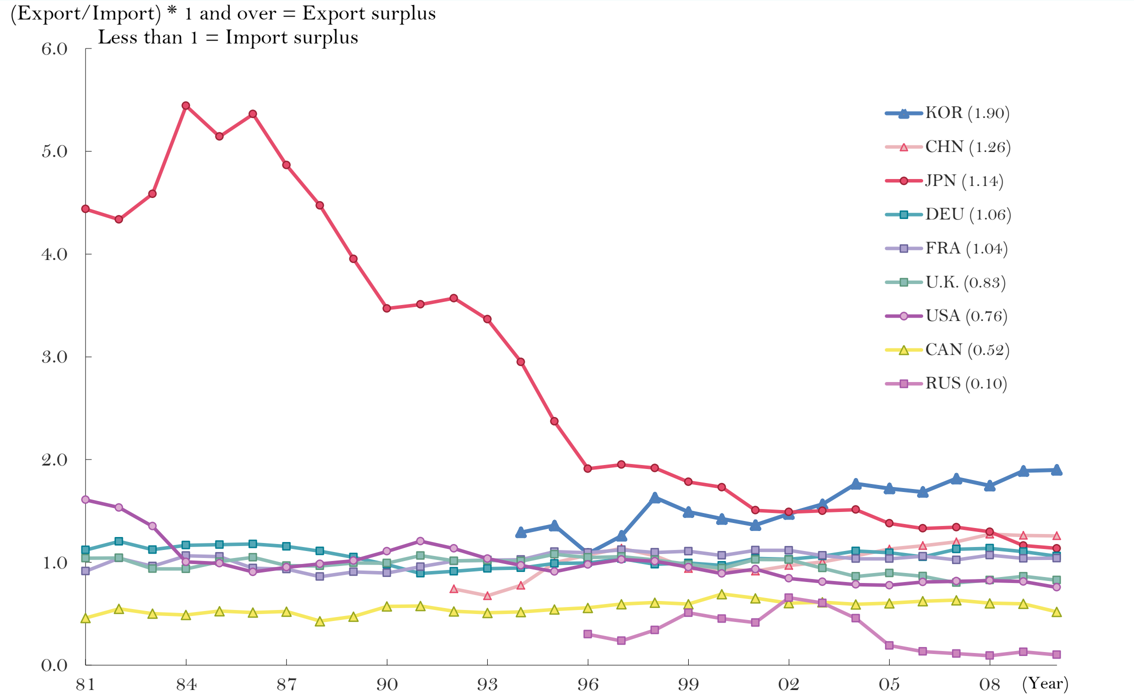
Figure 1-1-3 / Nominal GDP of the Major Countries



Note:
1. Japan: Values estimated by the Economic and Social research Institute, the Cabinet Office, the Government of Japan (Dollar-Yen exchange rate: Simple average per quarter of the monthly averages of Tokyo interbank market offered central spot rates, Nominal GDP (based on Dollar): cumulative values of the same quarter)
China: China Statistical Yearbook 2012 (Exchange rate: IMF "International Financial Statistics")
Russia, Brazil, India : "World Development Indicators database" of the World Bank
OECD affiliate countries other than Japan (Countries other than the above mentioned Japan, Russia, Brazil, China, India) : OECD "Annual National Accounts Database"
2. China excluding Hong Kong and Macau
Source: Created by MEXT based on materials made by the Cabinet Office, Government of Japan.

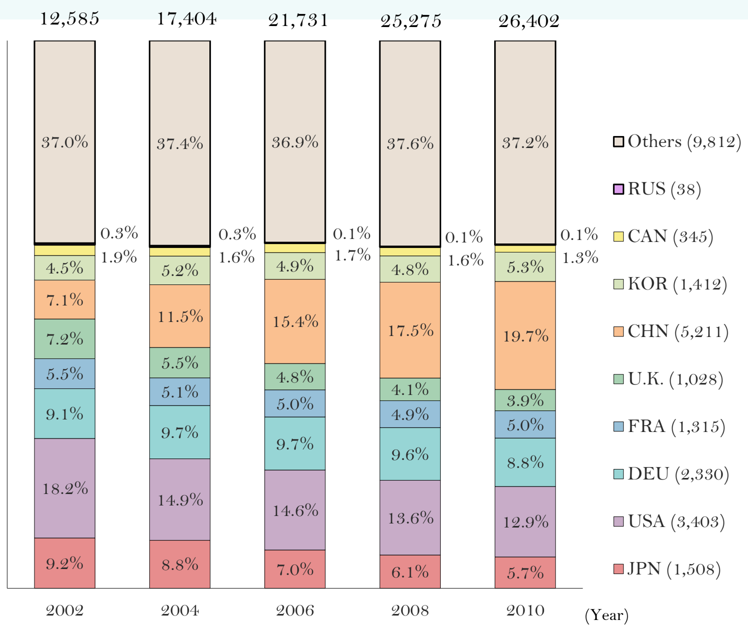
Japan's economic stagnation and the rise of emerging countries have resulted in a decline in the presence of the Japanese economy. We can see the trends in the trade ratio of high-tech industry which has always been something that Japan has excelled at. The ratio of exports to imports in high-tech industry in Japan has been continuously decreasing since the middle of the 1980s. The main reason behind this decrease is due to Japan's downward share of export figures (Figure 1-1-4, Figure 1-1-5).

Figure 1-1-4 / Trends in the Trade Radio of High-tech Industry in Major Countries



Note: Created by MEXT based on "Main Science and Technology Indicators Vol.2012/1"
Source: Indicators of Science and Technology (2012 edition)

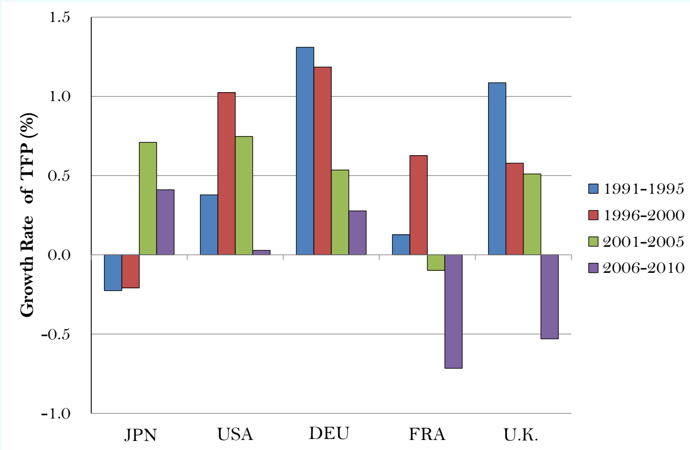
Figure 1-1-5 / Trends in the Export Value of High-tech Industry in Major Countries



Note: 1. Others: Total of Argentina, Romania, Singapore, South Africa, Taiwan, and the OECD affiliate countries except Japan, the United States, Germany, France, the United Kingdom, Korea and Canada.
2. MEXT document based on OECD "Main Science and Technology Indicators Vol. 2012/1"
Source: Indicators of Science and Technology (2012 edition)

Contributions to the growth rate of GDP can be decomposed into 1) the input of production factors such as labor and capital and 2) the increased rate of total factor productivity (TFP), which shows an improved effect on production efficiency. A growth rate of TFP is considered to be associated largely with technological progress. The growth rate of TFP in Japan was the lowest among major advanced countries in the 1990s; after that, it has begun to increase since 2001, and the rate has been as high as that of the United States, the United Kingdom and Germany (Figure 1-1-6). TFP has been influenced by not only technological advancement, but possibly by other effects such as the improvement of operational and organizational progress, the development of division of labor, the achievement of economies of scale, and the influences from excess labor and reserved capital due to recession as well. Therefore, this index does not directly measure technological improvement, but in the long run, it is supposed to comparatively reflect technological advancement.

Figure 1-1-6 / Trend of the Growth Rate of Total Factor Productivity in Major Countries



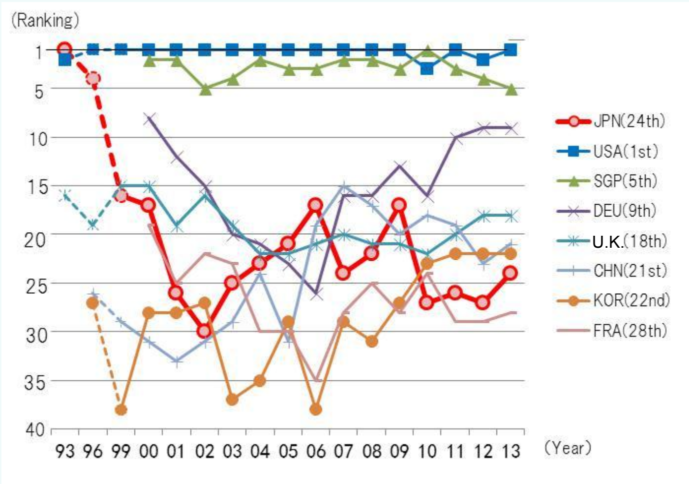
Source: "Japanese Science and Technology Indicators 2012" of the National Institute of Science and Technology Policy (August 2012)

The major indexes that comprehensively evaluate international competitiveness are 1) "World Competitiveness Ranking" issued by the Switzerland-based International Institute for Management Development (IMD) (hereinafter referred to as "IMD index" and 2) the international competitiveness ranking (hereinafter referred to as "WEF index") presented by World Economic Forum (WEF), which is also based in Switzerland. We outline the international competitiveness of Japan by looking into these two indexes.

The comprehensive competitiveness ranking of the IMD index is based on the four main factors of "Economic Performance," "Government Efficiency," "Business Efficiency" and "Infrastructure," as well as on 20 pillars made up of 333 variables (2013), involving a combination of statistical data and an executive opinion survey. The calculated values are supposed to show the "capabilities of creating and sustaining an environment to maintain corporate power (competitiveness)." Japan had been at the top of these ranking since 1989, the year when the IMD index was first published, and remained at the top until 1993; however, in recent years, Japan's ranking has been between 20th and 30th. In 2013, Japan was 24th among 60 countries and regions (Figure 1-1-7). Countries ranked higher than Japan include Europe, the United States, which have been highly competitive for years, Hong Kong, which has recently moved up, Singapore, Taiwan, Qatar and other Asian countries.

When considering individual factors, Japan's best ranking has been in the area of "Infrastructure" among 4 areas, in which Japan ranked 10th. This is because the ranking was contributed to by our "Scientific Infrastructure" (2nd), one of the sub-factors, which consists of R&D expenditure, the number of scientific articles, and the number of patent applications. Japan is not ranked at the top in other factors, such as "Economic Performance" (25th), "Government Efficiency" (45th), and "Business Efficiency" (21st) (Table 1-1-8).

Figure 1-1-7 / Trend in World Competitiveness Ranking



Source: Created by MEXT based on IMD WORLD COMPETITIVENESS YEARBOOK (http://www.imd.org/wcc/)

Figure 1-1-8 / IMD International Competitiveness Ranking Component Factors and Rank (2013)

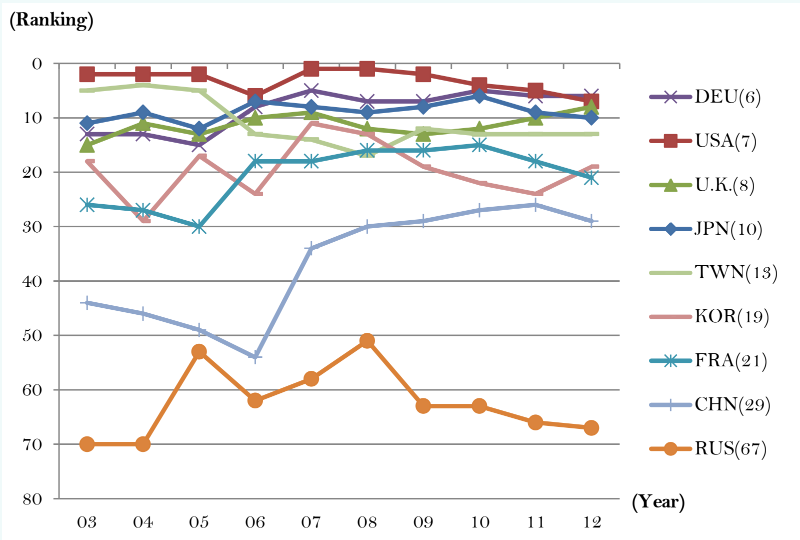
Main factors	Sub-factors	Ranking of Japan	Index
Domestic Economy, International Investment, Employment – growth (25th)	Domestic economy	5	GDP, Household consumption expenditure etc.
	International Trade	56	Current account balance, Balance of trade etc.
	International investment	16	Direct investment, Relocation threats of production etc.
	Employment	12	Employment rate, Unemployment rate etc.
	Prices	53	Consumer price inflation Office rent etc.
Public Finance, Fiscal Policy, Collected total tax revenues, Collected social security contribution, Institutional Framework, Creation of firms (45th)	Public finance	60	Government budget surplus/deficit, Total general government debt etc.
	Fiscal policy	37	Collection total tax revenues, Collected social security contribution etc.
	Institutional framework	17	Transparency, Exchange rate stability etc.
	Business Legislation	29	Competition legislation, Creation of fiems etc.
	Societal Framework	24	Justice, Income distribution etc.
Business Efficiency (21st)	Productivity and Efficiency	28	Overall productivity, Workforce productivity etc.
	Labor Market	39	Working hours, Employee training etc.
	Finance	13	Banking sector assets, Stock market capitalization etc.
	Management Practices	18	Adaptability of companies, Entrepreneurship etc.
	Attitudes and Values	35	Attitudes toward globalization, National culture etc.
Basic Infrastructure (10th)	Basic infrastructure	27	Maintenance and development, Energy infrastructure etc.
	Technological Infrastructure	21	Communication technology,High-tech exports etc.
	Scientific Infrastructure	2	Total expenditure on R&D, Patent applications etc.
	Health and Environment	8	Total health expenditure, Life expectancy at birth, Quality of life etc.
	Educatioin	28	Total public expenditure on education, Management education etc.

Source: Created by MEXT based on IMD WORLD COMPETITIVENESS YEARBOOK 2013 (http://www.imd.org/wcc/)

Comprehensive ranking of the WEF index consists of 12 categories and 111 components, and is based on executive opinion surveys and statistical data. The WEF defines competitiveness as "the set of institutions, policies, and factors that determine the level of productivity of a country." Japan ranked 6th in 2010, which was highest in its history, but has ranked between 6th and 10th place in recent years. In 2012, Japan ranked 10th among 144 countries and regions (Figure 1-1-9). The countries with higher rankings than Japan are Europe and the United States, which has been highly competitive for years, Singapore, (2nd) and Hong Kong (9th).

The 12 categories are grouped into three sub-indexes according to the subject. Japan has placed as high as 2nd in "Innovation and sophistication factors," which is compared to the other two sub-indexes, "Basic requirements" (29th) and "Efficiency enhancers" (11th). "Innovation and sophistication factors" includes both "Innovation" (5th) and "Business sophistication" (Top) (Table 1-1-10). Japan has also attained some highly evaluated indexes, for example, "Production processes sophistication" (Top) in "Business sophistication," in the area in which Japan has strengths, and "Capacity for innovation" (Top) and "Company spending on R&D" (2nd) in "Innovation." However, Japan has also had some poorly evaluated indexes such as "Government procurement of advanced technology products" (48th) in "Innovation."

Figure 1-1-9 / Trend in Rankings in WEF



Source: Created by MEXT based on WEF "The Global Competitiveness Report"

Table 1-1-10 / Japan's WEF International Competitiveness by Criteria

Criteria		Ranking	Index
Basic requirements (29th)	Institutions	22	Wasteful spending by government
	Infrastructure	11	Quality of railway infrastructure
	Macroeconomic environment	124	Government debt
	Health and primary education	10	Attendance rate of primary education
Efficiency enhancers (11th)	Higher education and training	21	Attendance rate of higher education
	Goods market efficiency	20	Sophistication of buyers
	Labor market efficiency	20	Flexibility of wage determination
	Financial market development	36	Accessibility to financial services
	Technological readiness	16	Accessibility to the latest technology
	Market size	4	Index of domestic market size
Innovation and sophistication factors (2nd)	Business sophistication	1	Sophistication of production process
	Innovation	5	

Index	Ranking
Capacity for innovation	1
Quality of scientific research institutions	11
Company spending on R&D	2
University-industry collaboration in R&D	16
Government procurement of advanced technology products	48
Availability of scientists and engineers	2
PCT patent applications	5

Source: Created by MEXT based on WEF "The Global Competitiveness Report 2012-2013"

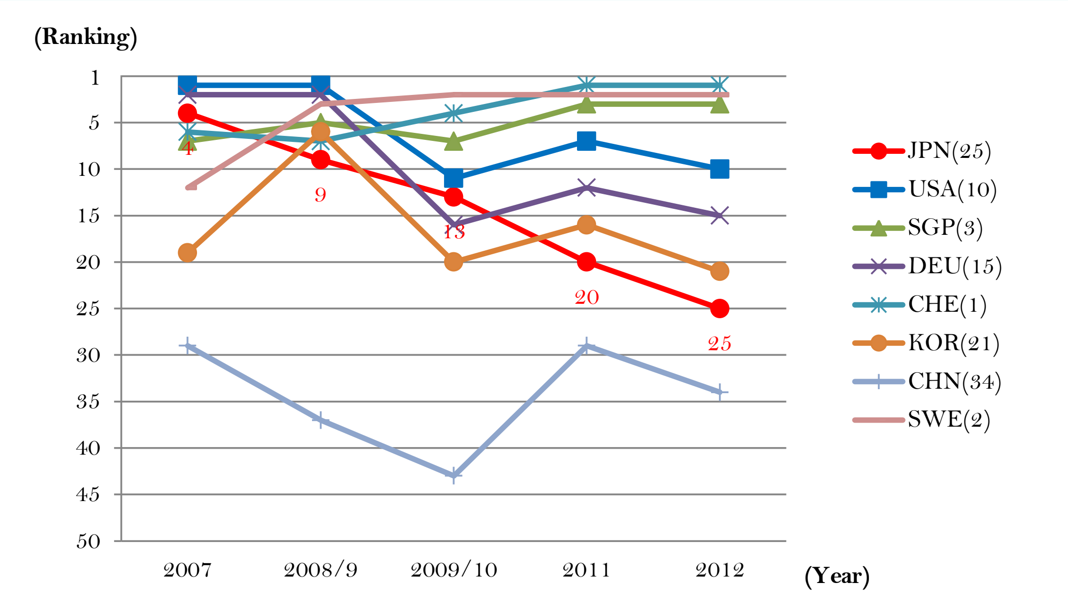
While Japan ranked low in the Economic Performance indexes of the IMD and WEF, Japan was placed high in the S&T innovation related indexes as compared with the other indexes. Here is another index called the Global Innovation Index (GII[1]) (hereinafter referred to as GII index), which is generated and published by INSEAD[2] and is used to show S&T Innovation. This index is designed to more appropriately evaluate innovation levels in a society. Although we need to note that the matters evaluated in the index change every year, Japan has continuously decreased in rank since 2007, and was ranked 25th among 141 countries and regions in 2012. The top 3 countries are Switzerland, Sweden and Singapore, and they have been ranked in this order for 3 consecutive years (Figure 1-1-11).

The ranking of the GII index is determined based on the following seven factors: "Institutions," "Human capital and research," "Infrastructure," "Market sophistication," "Business sophistication," "Knowledge and technology outputs," and "Creative outputs." Japan ranked relatively high in some activities; for example, Japan ranked 7th in "Infrastructure," which includes social infrastructure such as electricity and ICT. Also, with regard to the S&T area, Japan ranks 6th in the sub-index on "Research &development," which indicates the number of researchers and research spending in the field of "Human capital and research"(19th); 8th in the sub-index on "Knowledge workers," which indicates R&D activities by business in the area of "Business sophistication"(21st); 14th in the sub-index on "Knowledge creation" and 14th in the sub-index on "Knowledge diffusion" in the area of "Knowledge and technology outputs" (15th). On the contrary, Japan ranks 112th in a sub-index on "Creative intangibles," which indicates the creation of ICT and business models in the area of "Creative outputs" (69th) (Table 1-1-12).

1 Global Innovation Index. The 2012 edition was established and published jointly with the WIPO (World Intellectual Property Organization).

2 INSEAD : A business school that has campuses in France, Singapore, and Abu Dhabi, and has earned international acclaim. It used to be called the "Europen d'Administration des Affaires (abbreviation: INSEAD)." The name INSEAD was determined to be its official name when it established its campus in Singapore.

Figure 1-1-11 / Rankings of S&T Innovation



Note: Created by Council for Science and Technology Policy (CSTP) based on INSEAD, WIPO "Global Innovation Index"
Source: Material of Expert panels on STI policy promotion at the Council for Science and Technology Policy (CSTP) (November 19, 2012)

Table 1-1-12 / Innovation Index (2012)

the Innovation Input Sub-Index

Pillars	Sub-pillars	Rank
Institutions (23rd)	Political environment	16
	Regulatory environment	18
	Business environment	40
Human capital and research (19th)	Education	52
	Tertiary education	56
	Research & development (R&D)	6
Infrastructure (7th)	Information & communication technologies (ICTs)	10
	General infrastructure	17
	Ecological sustainability	12
Market sophistication (18th)	Credit	9
	Investment	19
	Trade & competition	110
Business sophistication (21st)	Knowledge workers	8
	Innovation linkages	62
	Knowledge absorption	28

the Innovation Output Sub-Index

Pillars	Sub-pillars	Rank
Knowledge and technology outputs (15th)	Knowledge creation	14
	Knowledge impact	57
	Knowledge diffusion	14
Creative outputs (69th)	Creative intangibles	112
	Creative goods and services	26
	Online creativity	43

Source: Created by MEXT based on INSEAD, WIPO Global Innovation Index, materials (November 19, 2012) of Specialist Subcommittee of Council for Science and Technology Policy to Promote Scientific and Technological Innovation Policy

It is apparent that Japan ranks very high in the international competitiveness rankings in an R&D input index related to R&D spending, and in an R&D output index that is related to patent applications. On the other hand, Japan has been on a pronounced yearly decline in the "Global Innovation Index." Because Japan has experienced long-term economic stagnation, it has been said that "Japan wins in Technology but loses in business." Japan's poor ranking in the area of international competitiveness is supposed to be caused by low scores in the international index that is associated with business plans for new technological seeds and with environmental enhancements that support those business plans. This information must be used for better development of the STI policies of Japan.

Also, in recent years, when compared to other countries, Japan's presence has decreased relative to S&T that is the basis of innovation. We summarize this situation as follows:

2 Trends in Japan's Science, Technology and Innovation

In the previous section, we presented an overview of the indexes that showed the economic stagnation of Japan and deterioration in the level of international competitiveness. In this section, we will overview the achievements that have been produced by research activities and current trends in S&T activities.

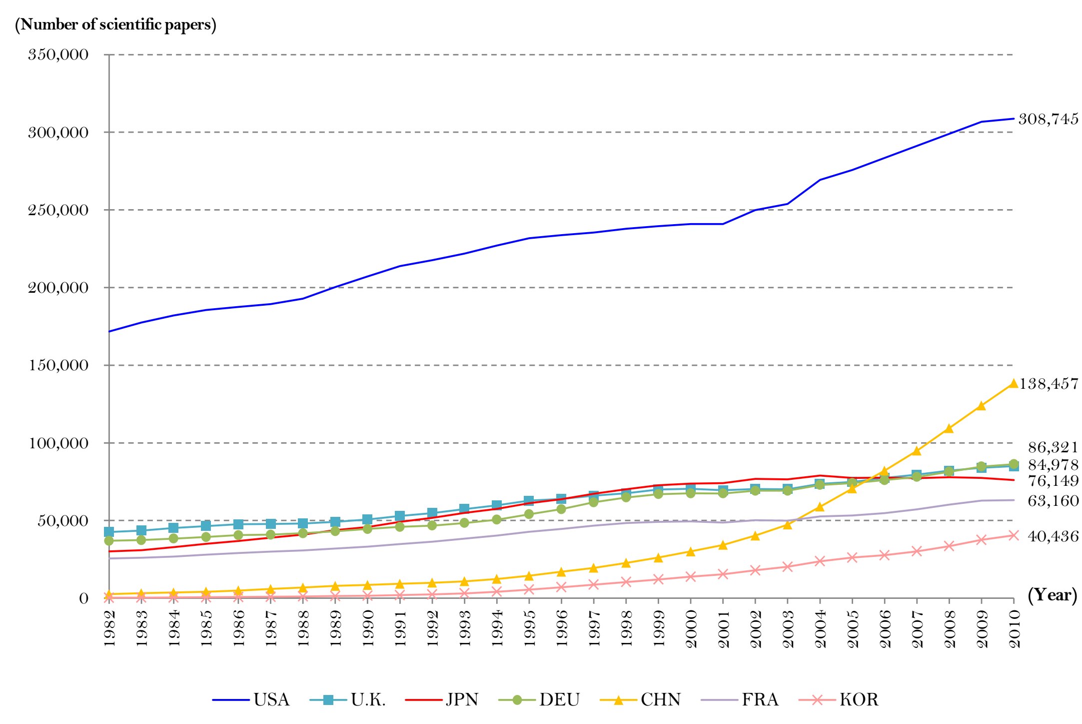
(1)Trends in achievements by research activities

1) Trends of all research activities revealed by the analysis of scientific papers

Major indexes used to quantify research activities are the number of scientific papers (a quantitative index) and the number of scientific paper citations (a qualitative index). Regarding the number of scientific papers (the quantitative index), when comparing the average number from 1999 to 2001 and the average number from 2009 to 2011 (Figure 1-1-14), we can see that Japan has slightly increased its number; however, other countries such as China have exponentially increased its number. As a result, Japan has decreased its share in the world, and the relative ranking has considerably dropped (Figure 1-1-13, Figure 1-1-14). As for the number of scientific paper citations (the qualitative index), the downward trend in the share in the world is shown, including the high-visible scientific papers whose frequency of citations ranked in the top 10% (the number of adjusted Top 10% highly cited papers) and the very high-visible scientific papers whose frequency of citations ranked in the top 1% (the number of adjusted top 1% highly cited papers) (Figure 1-1-14).

Thus, the number of scientific papers and the number of highly cited papers have steadily increased; however, the share and the rank of Japan have gone down due to the substantial rise of other countries. This implies a decrease in Japan's presence in research activities throughout the world.

Figure 1-1-13 / Trends in the Number of Scientific Papers in Major Countries



Notes: 1. Article, Article & Proceedings (count as an article), Letter, Note and Review were counted on an integral count-based analysis. 3-year moving average.
2. 3-year moving average. For example, the figure for 2010 is an average of 2009, 2010 and 2011.
3. Estimated by NISTEP based on the "Web of Science," Thomson Reuters

Source: NISTEP "Scientific Research Benchmarking 2012" (March 2013)

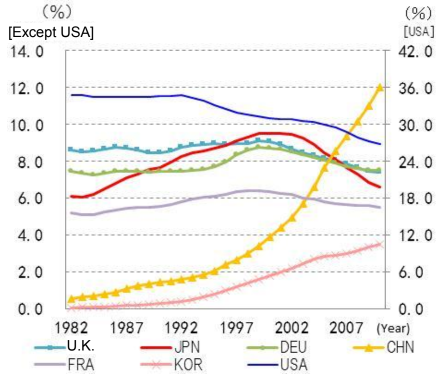
Figure 1-1-14 / Number and Share of Scientific Papers by Country/Region

Number and share of publications by country/region

(Number of Scientific Papers)

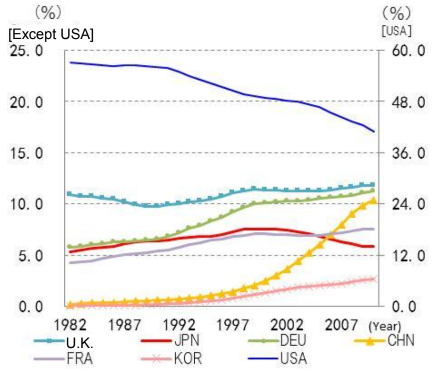
Left: Annual average for 2009-2011
Right (in parentheses): Annual average for 1999-2001

Country	Number of Scientific Papers		Share		Rank	
United States	308,745	(240,912)	26.8	(31.0)	1	(1)
China	138,457	(30,125)	12.0	(3.9)	2	(8)
Germany	86,321	(67,484)	7.5	(8.7)	3	(4)
United Kingdom	84,978	(70,411)	7.4	(9.1)	4	(3)
Japan	76,149	(73,844)	6.6	(9.5)	5	(2)
France	63,160	(49,395)	5.5	(6.4)	6	(5)
Italy	52,100	(32,738)	4.5	(4.2)	7	(6)
Canada	50,798	(32,101)	4.4	(4.1)	8	(7)
Spain	43,773	(23,149)	3.8	(3.0)	9	(10)
India	43,144	(17,863)	3.7	(2.3)	10	(13)



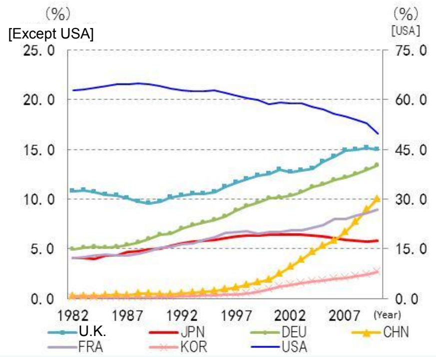
(Number of adjusted Top 10% highly cited papers)

Country	Number of Scientific Papers		Share		Rank	
United States	46,972	(37,168)	41.0	(48.9)	1	(1)
United Kingdom	13,540	(8,644)	11.8	(11.4)	2	(2)
Germany	12,942	(7,685)	11.3	(10.1)	3	(3)
China	11,873	(1,911)	10.4	(2.5)	4	(13)
France	8,673	(5,380)	7.6	(7.1)	5	(5)
Canada	7,060	(4,099)	6.2	(5.4)	6	(6)
Japan	6,691	(5,764)	5.8	(7.6)	7	(4)
Italy	6,524	(3,336)	5.7	(4.4)	8	(7)
Spain	5,444	(2,098)	4.7	(2.8)	9	(11)
Australia	5,178	(2,413)	4.5	(3.2)	10	(9)



(Number of adjusted Top 1% highly cited papers)

Country	Number of Scientific Papers		Share		Rank	
United States	5,705	(4,464)	49.7	(58.7)	1	(1)
United Kingdom	1,715	(956)	15.0	(12.6)	2	(2)
Germany	1,532	(768)	13.4	(10.1)	3	(3)
China	1,148	(145)	10.0	(1.9)	4	(13)
France	1,021	(512)	8.9	(6.7)	5	(4)
Canada	884	(429)	7.7	(5.6)	6	(6)
Italy	767	(305)	6.7	(4.0)	7	(7)
Japan	671	(484)	5.8	(6.4)	8	(5)
Netherlands	668	(302)	5.8	(4.0)	9	(8)
Australia	628	(239)	5.5	(3.1)	10	(10)



Notes: 1. Analysis based on whole count of Article, Article & Proceedings (use of article), letters, notes, and reviews
2. 3-year average
3. Adjusted Top 10% highly cited papers indicate the number of scientific papers adjusted such that the actual number is 1/10 of the number of publications after selection of the articles in the top 10% in terms of citations in each year and in each field.
4. Adjusted Top 1% highly cited papers indicate the number of articles adjusted such that the actual number is 1/100 of the number of publications after selection of the articles in the top 1% in terms of citations by round down method in each year and in each field.
5. NISTEP calculated based on "Web of Science," Thomson Reuters

Source: NISTEP "Scientific Research Benchmarking 2012" (March 2013)

2) Trends in notable research achievements

As described in the previous section, both qualitative and quantitative data indicate declining trends in Japanese S&T. On the other hand, there is a large amount of notable research that has captured the attention worldwide in recent years.

For example, in the field of natural science, in the 21st century, Japan boasts nine Nobel laureates; Professor Shinya Yamanaka, who was awarded the Nobel Prize in Physiology or Medicine in 2012, Akira Suzuki and Ei-ichi Negishi (2010), Makoto Kobayashi, Toshihide Masukawa and Osamu Shimomura (2008), Masatoshi Koshiba and Koichi Tanaka (2002) and Ryoji Noyori (2001). Thus, when it comes to Nobel laureates, Japan is the second only to 47 from the United States during this time period (Table 1-1-15).

Also, almost every year, "Ten Breakthroughs of the Year," a list of the prominent research achievements of the year introduced in "Science," a scientific journal published in the United States, includes the research achievements of Japanese scientists. For example, the research articles, "Eggs from mouse iPS cells" in 2012 and "Discovery of the Higgs," in which many Japanese researchers were involved, were selected in the magazine. Last year, a research achievement that was related to the asteroid explorer "Hayabusa" was also selected.

As shown with these examples above, the fact of prominent research achievements of Japan being highly evaluated in recent years represents the achievements of the science and technology policies of Japan.

Table 1-1-15 / Nobel Laureates (Natural Science)

Japanese Nobel Laureates

Year awarded	Name		Subject of Research
1949	Hideki Yukawa	Physics	The prediction of the existence of mesons on the basis of theoretical work
1965	Sin-Itiro Tomonaga	Physics	The fundamental work in quantum electrodynamics
1973	Leo Esaki	Physics	The experimental discoveries regarding tunneling phenomena in semiconductors
1981	Kenichi Fukui	Chemistry	Theories, developed independently, concerning the course of chemical reactions
1987	Susumu Tonegawa	Physiology or Medicine	The discovery of the genetic principle for generation of antibody diversity
2000	Hideki Shirakawa	Chemistry	The discovery and development of conductive polymers
2001	Ryoji Noyori	Chemistry	The work on chirally catalyzed hydrogenation reactions
2002	Masatoshi Koshiba	Physics	Pioneering contributions to astrophysics, in particular for the detection of cosmic neutrinos
2002	Koichi Tanaka	Chemistry	The development of methods for identification and structure analyses of biological macromolecules
2008	Yoichiro Nambu	Physics	Discovery of the mechanism of spontaneous broken symmetry in subatomic physics
2008	Makoto Kobayashi	Physics	The Kobayashi-Masukawa theory and its contribution to particle physics through discovery of the origin of the CP Violation
2008	Toshihide Masukawa	Physics	
2008	Osamu Shimomura	Chemistry	The discovery and development of the green fluorescent protein (GFP)
2010	Akira Suzuki	Chemistry	Palladium-catalyzed cross couplings in organic synthesis
2010	Ei-ichi Negishi	Chemistry	
2012	Shinya Yamanaka	Physiology or Medicine	The discovery that mature cells can be reprogrammed to become pluripotent

Number of Nobel Laureates in major countries

	1901 - 1950	1951 - 1960	1961 - 1970	1971 - 1980	1981 - 1990	1991 - 2000	2001 - 2012	Total
U. S.	28	27	27	39	35	39	47	242
Germany	38	3	5	3	9	5	5	68
U. K.	30	9	11	12	3	3	9	77
France	15	0	5	1	1	3	6	31
Japan	1	0	1	1	2	1	9	15

Notes: 1 Counted the number of Nobel laureates in Physics, Chemistry and Physiology or Medicine in Natural Science.
2. Counted per nationality. Applied country of origin for those who own dual nationality (In cases where the nationalities and the country of origin differ, the country of his/her then main research base is counted.).
3. Yoichiro Nambu, Ph.D., the laureate in Physics in 2008 is counted in the United States because of his nationality.

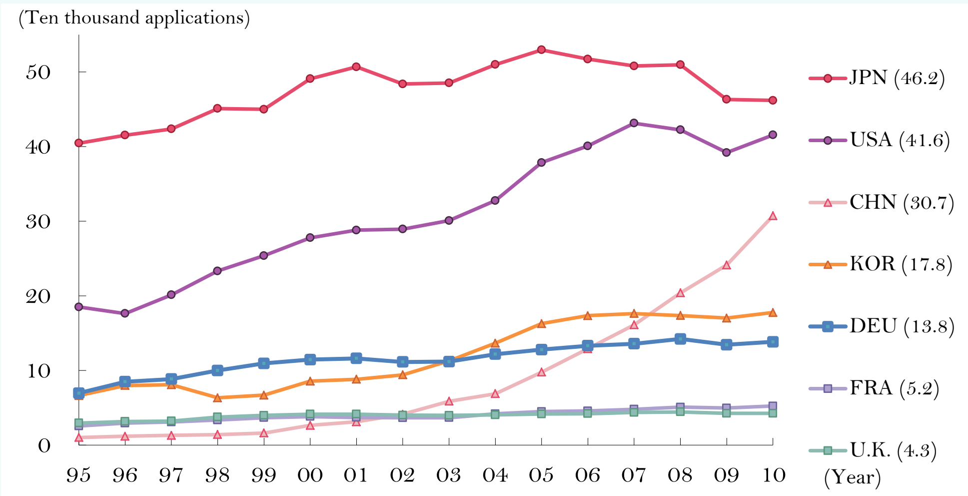
Source: Created by MEXT

3) The number of patent applications

The number of patent applications is one of the indexes, along with the number of scientific papers and the number of scientific paper citations, that measures achievements through research activities. The number of patent applications in Japan is more than 450 thousands; however, it has been decreasing since the middle of 2000 (Figure 1-1-16). It is believed that the decrease is due to companies' selection of patent applications because the budget for R&D has been flat. In addition, it is because they have instead been focusing on international applications. The Japan Patent Office accelerates procedures by improving the patent examination system, including recruiting fixed-term examiners, in order to strengthen the intellectual property strategy of Japan through the early adoption of R&D achievements and the acquisition of rights based on a global perspective.

Countries, including Japan, have increased the number of patent applications to non-resident countries (Figure 1-1-17).

Figure 1-1-16 / Trends in the Number of Patent Applications in Major Countries

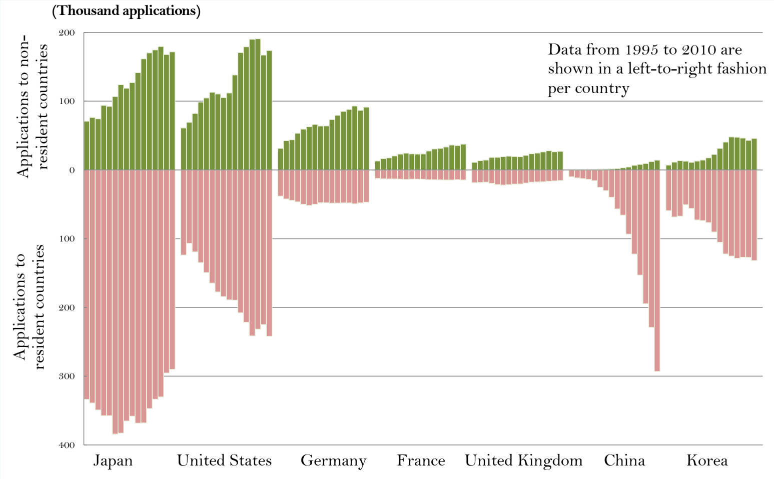


Notes: 1. Sum of the number of applications to the applicant's domestic country and/or overseas and the number of PCT international applications which are transferred into the national phase as per the applicant's nationality

2. WIPO Statistics Database, December 2011, "Patent applications by country of origin and patent office (1995-2010)"

Source: Indicators of Science and Technology (2012 edition)

Figure 1-1-17 / Trends in the Number of Patent Applications from Major Countries (1995 – 2010)



Notes: 1. Breakdowns of applications are as follows (Applications from Japan as an example):
"Applications to resident countries" - An applicant who lives in Japan directly applies to the Japan Patent Office.
"Applications to non-resident countries" - An applicant who lives in Japan applies to a country other than Japan (For example, to United States Patent and Trademark Office).
2. This includes the applications to EPO for all countries.
3. This includes the applications to PCT that are transferred into the national phase.

Source: NISTEP "Japanese Science and Technology Indicators 2012" (August 2012)

The number of corporate international patent applications made by the top-10 corporations of 2011 has increased as compared to 2006, and the international patent applications have accelerated; for example, the number of Japanese corporations increased from two to three among top-10 corporations. On the other hand, although no corporations from China or Korea were listed among top-10 corporations in 2006, three corporations from these countries appeared in 2011. Thus, China and Korea have made a leap in the domain of patent applications (Figure 1-1-18).

Figure 1-1-18 / Changes in the Number of International Patent Applications by Corporations (2006 – 2011)

[Ranking of International Patent Applications in 2006]

	Applicant	Nationality	Number of applications
1	Philips	The Netherlands	2,495
2	**Matsushita Electric**	**Japan**	2,344
3	Siemens	Germany	1,480
4	Nokia	Finland	1,036
5	Bosch	Germany	962
6	3M	USA	727
7	BASF	Germany	714
8	**Toyota Motor**	**Japan**	704
9	Intel	USA	690
10	Motorola	USA	637

[Ranking of International Patent Applications in 2011]

	Applicant	Nationality	Number of applications
1	ZTE	China	2,826
2	**Panasonic**	**Japan**	2,483
3	Huawei Technologies	China	1,831
4	**Sharp**	**Japan**	1,755
5	Bosch	Germany	1,518
6	Qualcomm	USA	1,494
7	**Toyota Motor**	**Japan**	1,417
8	LG Electronics	Korea	1,336
9	Philips	The Netherlands	1,148
10	Ericsson	Sweden	1,116

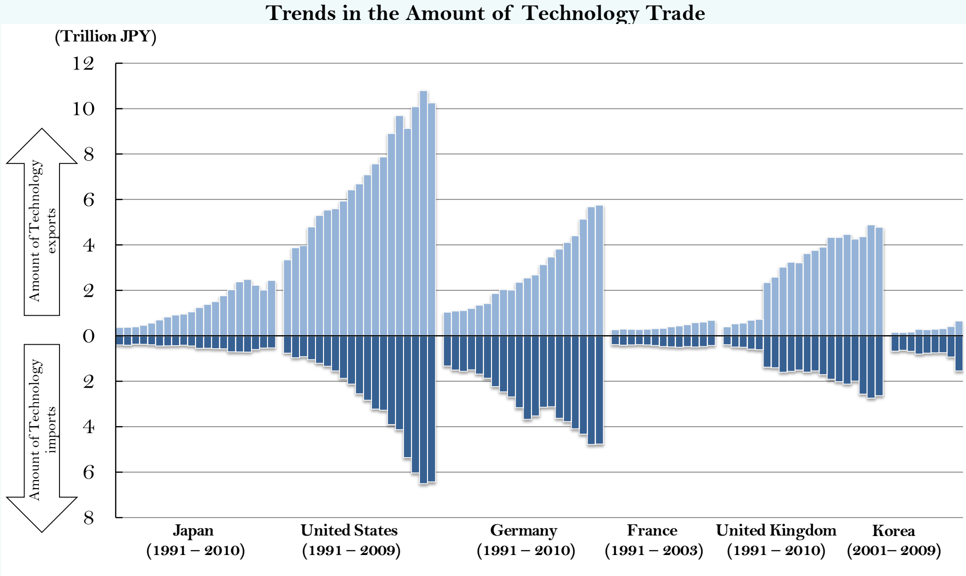
Source: Created by MEXT based on WIPO "World Intellectual Property Indicators - 2012 Edition" and "The International Patent System In 2006 PCT Yearly Review."

4) Technology Trade

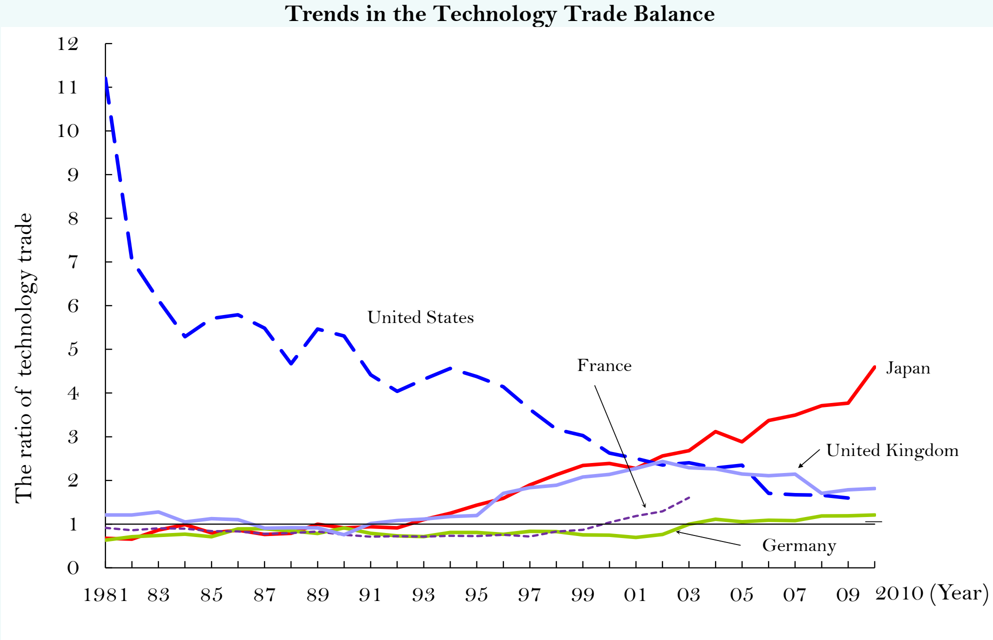
The "Technology Trade" is used as an indicator to measure international competitiveness in technology. It is a combination of "Technology Exports" and "Technology Imports" .The former means the rights of using technology provided to an overseas corporation or individual in return for reasonable remuneration. The latter means the rights of using technology received from an overseas corporation or individual. Since 1991, the technology trade of both imports and exports has increased in some Western countries and Korea, as well as in Japan. In terms of the technology trade balance (amount of technology export/amount of technology import), Japan exceeded 1.0 in 1993, and has continued to rise reaching as high as 4.6 in 2010 (Figure 1-1-19).

Figure 1-1-19 / Trends in the Amount of Technology Trade and the Technology Trade Balance

Trends in the Amount of Technology Trade



Trends in the Technology Trade Balance



Note: <Japan> Fiscal year data. Types of technological trade are as follows (trademark excluded):
1. Patent property, Utility model rights, Copyrights, 2. Design rights, 3. Offer of technological know-how and technical guidance (excluding what is provided for free of charge), 4. Technological support for developing countries (including a support delegated by the government).
<USA> Royalties and licenses only until 2000. Research, development and inspection services are added in 2001 to 2005. Computer, data processing services, etc. are added after 2006. Provisional figure in 2009.
<Germany> West Germany until 1990. Patents, licenses, trademarks and design rights are included until 1985. Technical services, computer services, and R&D in industrial fields are included after 1986. Provisional figure in 2010.
<U. K.> Figures of oil corporations are included after 1984. Patents, inventions, licensees, trademarks, design rights, technology-related services and R&D are included after 1996. Data in 2009 lacks consistency with the data of the previous year. Provisional figure for 2010.
<Korea> Provisional figure for 2009

Source: "S&T Indicators 2012" of National Institute of Science and Technology Policy (August 2012)

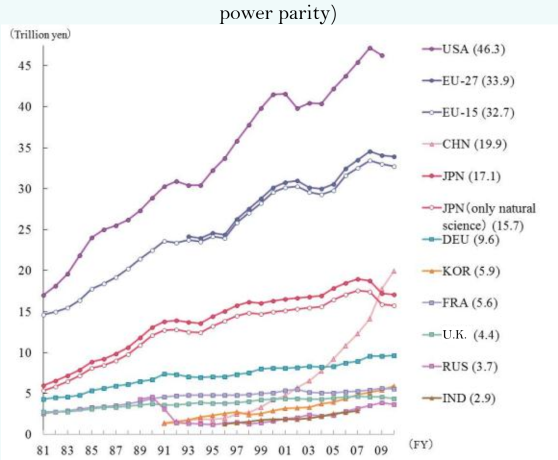
(2) Trends in research activities

1) Trends in R&D expenditure

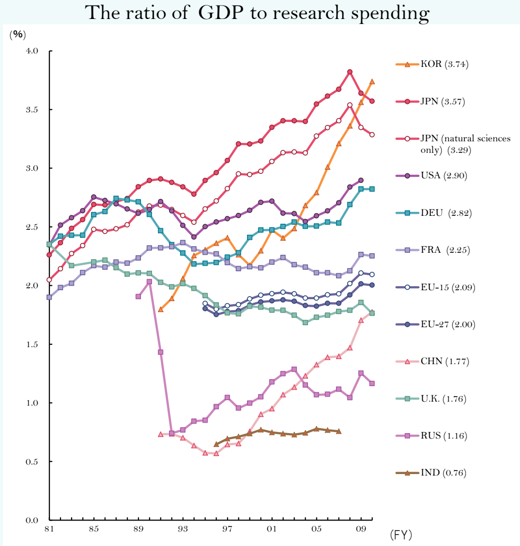
In the comparison of research spending among the major countries based on the OECD purchasing power parity conversion, the United States has the largest amount of research spending, at 46.3 trillion yen; EU- 27 member states have 33.9 trillion yen, and Japan has 17.1 trillion yen, which is just behind China at 19.9 trillion yen. In terms of the changes in research spending, Japan's has increased since 1980, but was overtaken in 2009 by China, which has increased its expenditure sharply. Regarding the ratio of research spending to GDP, Japan had maintained the highest standards among the major countries since 1989, but it decreased in two consecutive years from 2008-2009, resulting in Japan's falling behind Korea in 2010, which has grown sharply since 2000. China's increase is remarkable as shown in the figure (Figure 1-1-20).

Figure 1-1-20 / Trends in OECD purchasing Power Parity Conversion in Major Countries (Indicated by OECD Purchasing Power Parity) and the Ratio of R&D Expenditure to GDP

Trend in research spending by major countries (by OECD purchasing power parity)



The ratio of GDP to research spending



Notes: 1. The ratio of GDP to research spending is estimated by MEXT based on research spending and GDP.
2. Academic and Social Sciences are included in all countries. Academic and Social Sciences are not included in Korea until 2006.
For Japan, Research spending in the natural sciences, is also indicated.
3. For Germany, figures for 1982, 1984, 1986, 1988, 1990, 1992, 1994-96, 1998 and 2010 are preliminary.
4. For France, the figure for 2010 is provisional.
5. For the U. K., the figure for 2008-2009 is preliminary, and the figure for 2010 is provisional.
6. For EU, figures are estimated by Eurostat.
7. For India, the figures for 2006 and 2007 are preliminary.
8. (Research spending and GDP)
Japan: (Research spending) "Survey of Research and Development" by Statistics Japan, (GDP) "Annual Report on National Accounts" by the Cabinet Office
EU: Eurostat database
India: UNESCO Institute for Statistics S&T database
Other countries: OECD "Main Science and Technology Indicators Vol. 2012/1"
(Purchasing Power Parity)
India: The World Bank "World Development Indicators"
Other countries: OECD "Main Science and Technology Indicators Vol. 2012/1"

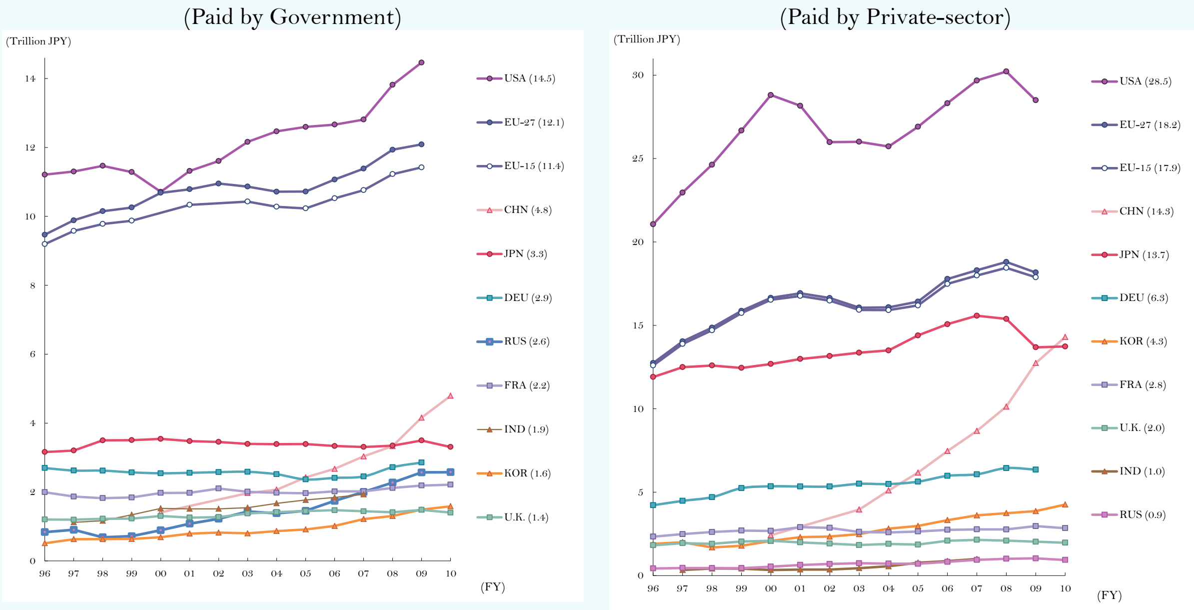
Source: Indicators of Science and Technology (2012 edition)

In terms of research spending paid by governments, Japan pays out 3.3 trillion yen following the

United States, the EU's 27 member states and China. Japan's increase has been stagnant in recent years while the United States, the EU's 27 member states and China have all increased their governmental research spending (Figure 1-1-21).

Meanwhile, 70% of the world's R&D spending is paid by companies. Research spending paid by the private sector has continuously increased; however, it started to decrease after the financial crisis in 2008 (Figure 1-1-21). In terms of research activities conducted by Japanese companies, the research period has been shortened in recent years (Figure 1-1-22), and the portion of outsourced research has been increasing in recent years as shown in the figure (Figure 1-1-23).

Figure 1-1-21 / Trends in Spending by Payer in Major Countries (Indicated by OECD Purchasing Power Parity)



Notes: 1. Figures are estimated by MEXT based upon research spending and the ratio of research spending paid by the government or the ratio of research spending paid by the private sector (excluding Japan).

2. Academic and Social Sciences are included for all countries. Academic and Social Sciences are not included for Korea until 2006.

3. For the U. K., figures for 1981 and 1983 are estimated by the OECD, figures for 2008-2009 are preliminary, and the figure for 2010 is provisional.

4. For Germany, figures for 1982, 1984, 1986, 1988, 1990, 1992, 1994-96, 1998, 2000 and 2002 are preliminary.

5. For France, the figure for 2010 is provisional.

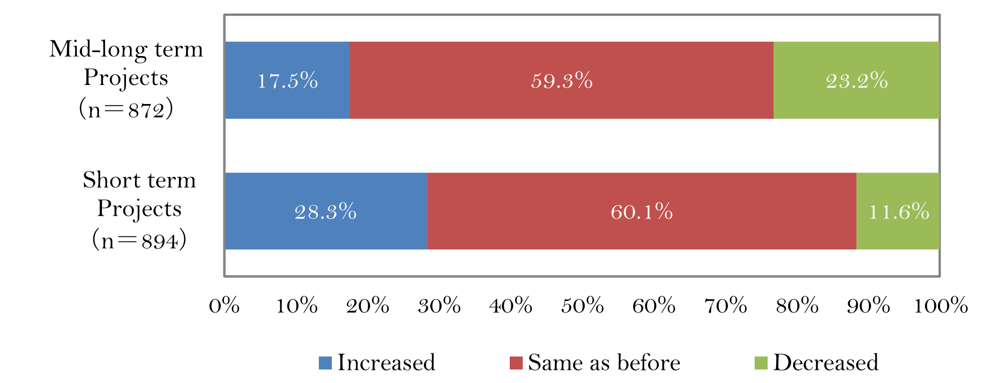
6. For the EU, figures until 2008 are estimated by Eurostat and OECD. The figure for 2009 is estimated from a provisional figure and the estimation by Eurostat and OECD.

7. For India, figures for 2006 and 2007 are preliminary.

8. Japan: "Survey of Research and Development" by Statistics Japan
EU: (Research spending) Eurostat database
(the ratio of research spending paid by the government) OECD "Main Science and Technology Indicators Vol. 2012/1"
India: (Research spending, the ratio of research spending paid by the government) UNESCO Institute for Statistics S&T database
(Purchasing power parity) The World Bank "World Development Indicators"
Other countries: OECD "Main Science and Technology Indicators Vol. 2012/1"

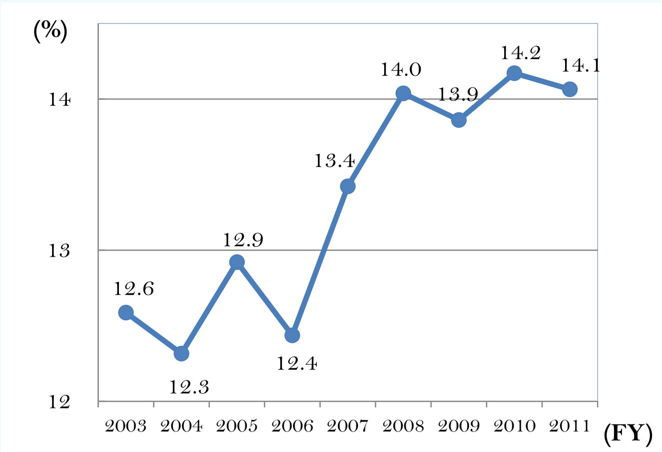
Source: Created by MEXT based on Indicators of Science and Technology (2012 edition).

Figure 1-1-22 / The Change of Term for R&D Projects in Private Companies (Compared with the situation 10 years ago.)



Notes: 1. Based on a questionnaire survey about "How things were as compared to ten years ago" (in FY2011).
2. A short term is defined as a term of one to four years, and a long term is defined as five years or longer.
Source: Created by MEXT based on METI's Industrial Technology Survey "Survey of Medium- and Long-Term R&D by Japanese Companies Contributing to Innovation Creation" (February 2012).

Figure 1-1-23 / The Ratio of Outsourced Research by Private Companies



Source: "Survey of Research and Development 2012" by Statistics Japan (December 2012)

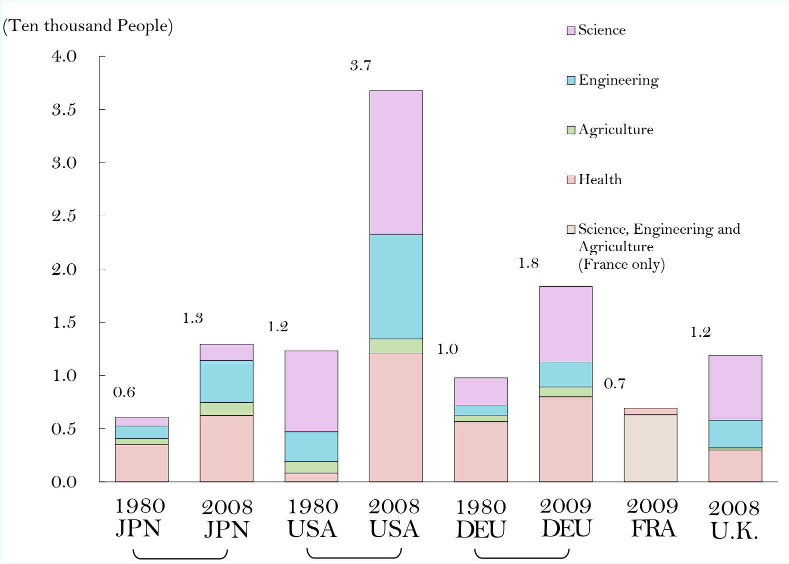
As described above, the research spending of Japan has steadily increased; however, that of other countries such as China and the United States has increased more rapidly. Also, Japan's entire amount of research spending has increased due to the research activities of companies, but those companies have reduced the allocation of their research spending since the financial crisis of 2008. This is the opposite of what has occurred in China and Korea where R&D investments have increased. Also, in recent years, we can see a downward trend in spending by the private business sector in the area of long-term research, which takes time to obtain results. Instead, they have increased the outsourcing of their research. From this trend, we can see that companies are looking toward external sources of research.

2) Trends in research personnel

(Number of doctoral degrees awarded)

Regarding the number of people in major countries obtaining degrees in the natural sciences, Japan has increased its number to twice as many as it was about 30 years ago, while the United States has people obtaining degrees at a rate that is slightly less than three times that of Japan, and Germany also has more people obtaining degrees than does Japan (Figure 1-1-24). Regarding the number of people obtaining doctorate degrees per million population, Japan has the fewest number of people obtaining doctorate degrees. For example, the number of people obtaining doctorate degrees in Japan is approximately half that of Germany, which is ranked the highest (Figure 1-1-25).

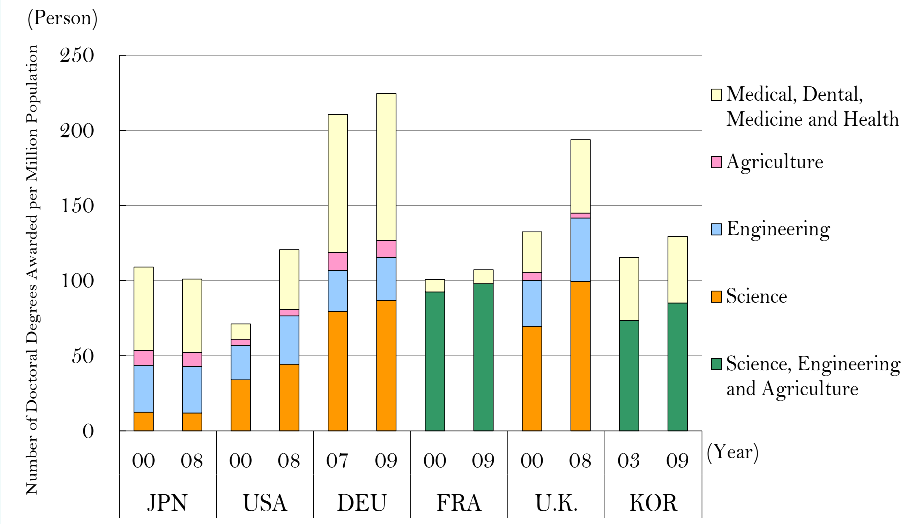
Figure 1-1-24 / Number of Doctoral Degrees Awarded (in the Natural Sciences)



Notes: 1. For Germany, figures for 1980 are for the former West Germany.
2. For France, Science, Engineering and Agriculture are not statistically classified. Figures include metropolitan France and its overseas department.
3. MEXT "International comparison of educational index (Ver. 2003 and Ver. 2012)"

Source: Indicators of Science and Technology (2012 edition)

Figure 1-1-25 / Number of Doctoral Degrees Awarded per Million Population



Notes: <Japan> Records the number of people obtaining doctorate degrees during the period from April of the specified year through March of the following year.
<USA> Records the number of people obtaining doctorate degrees during the year beginning September.
<Germany> Records the number of people who pass doctorate tests given during the winter of the specified year and summer of the next year.
<France> The number of people who obtain doctoral degrees during the specified calendar year after an 8-year program. Sum of science, engineering and agriculture is recorded simultaneously.
<U.K. > Records the number of people who obtain higher level degrees from university or higher education colleges during the specified calendar year.
<Korea> Records the number of people who obtain doctorate degrees during the period from March of the specified fiscal year through February of the following year. Sum of science, engineering and agriculture is recorded simultaneously.
The notation the country in accordance with ISO3166-1

Source: National Institute of Science and Technology Policy “S&T Indicators”(August 2012)

(Young researchers and their career paths)

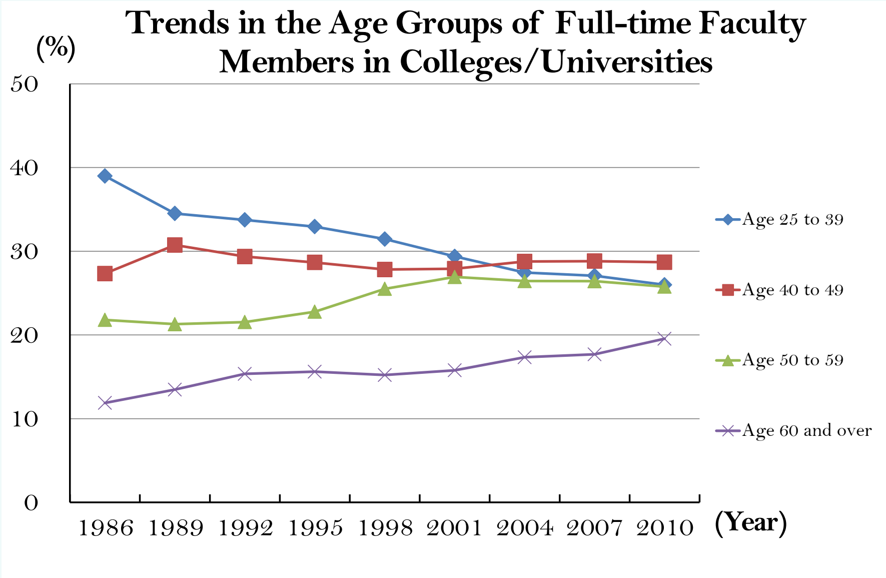
We will observe changes in rate of young teachers who act as full-time faculty members in colleges/universities. Full-time faculty members are defined as full-time teachers who belong to such colleges/universities. Fixed term and/or specially appointed teachers are also included in full-time faculty members in colleges/universities if they work at such institutions but concurrently posted teachers are not included. In 1986, the rate of teachers in the 25 to 39 age group was 39%; however, it decreased to 26% in 2010. The rate of the higher age group increased, and the age of those 60 and over was 19.6% in 2010, increasing from 11.9% in 1986 (Figure 1-1-26). In terms of the situation regarding young researchers who have independence, the number of researchers who undertake research independently as independent investigators in the 35 to 40 age group (PI[1]) stayed at 14.1%, which suggests that many researchers who are age 40 or younger are not in the position to take leadership as independent investigators in research activities (Figure 1-1-27).

It is expected that people obtaining doctorate degrees will play active roles not only in universities but also in business. However, we can see that the ratio of the people obtaining doctorate degrees in business

1 Principal Investigator (PI): In this survey, it is indicated as PI who satisfies the following 5 points: 1. Owns an independent laboratory, 2. Is a substantial leader in budget-making and execution of the research group, 3. Is a substantial leader in budget making and execution of the project, 4. Is a supervisor of the specified subordinates (graduate students) and 5. Is a representative of a published scientific paper.

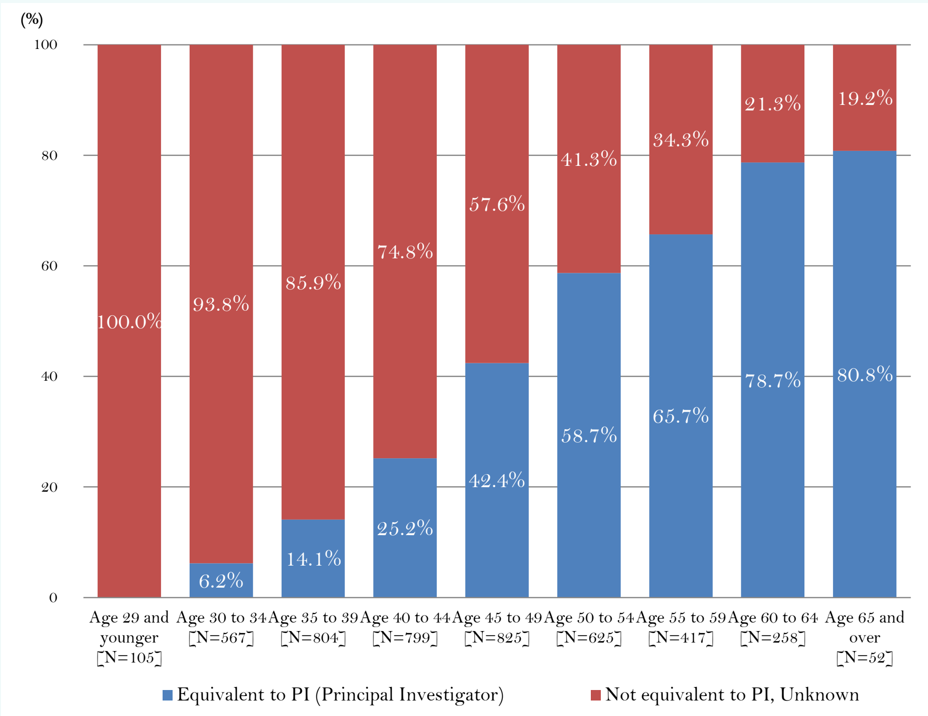
is low as compared to other countries (Figure 1-1-28).

Figure 1-1-26 / Trends in the Age Groups of Full-time Faculty Members in Colleges/Universities



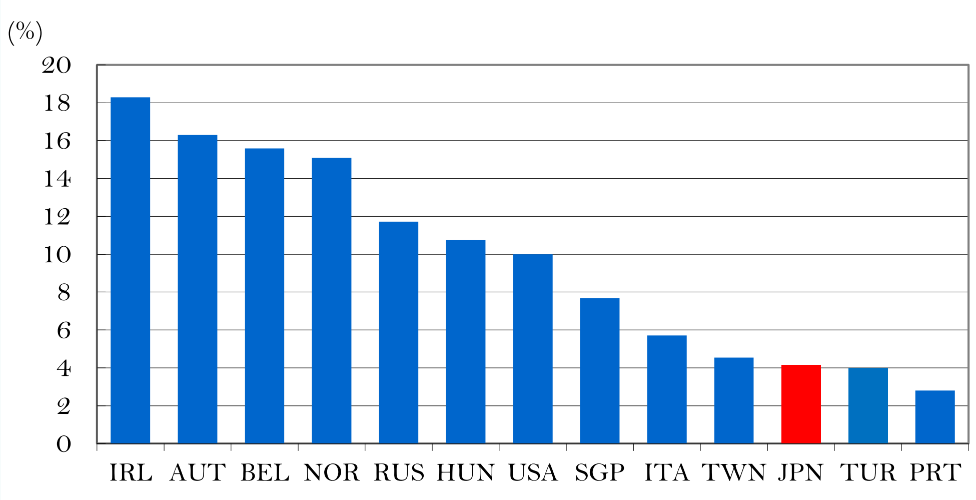
Note: Full-time faculty members suggest full time teachers who belong to such colleges/universities.
Source: National Institute of Science and Technology Policy "S&T Indicators" (August 2012)

Figure 1-1-27 / Ratio of Principal Investigators per Age Group



Source: NISTEP "Independence Processes of Researchers in Japan - Large-scale Survey of Job History and Authority for Research - " (August 2012)

Figure 1-1-28 / Ratio of People Obtaining Doctorate Degrees Among Corporate Researchers (2010)

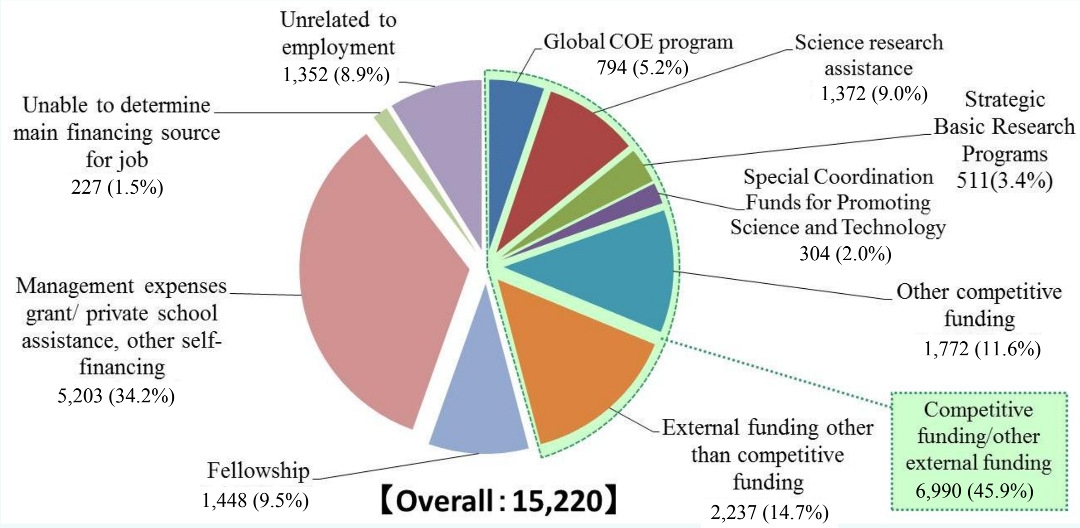


Source: Japan: "Survey of Research and Development," Statistics Japan
USA: "SESTATT," NSF
Other countries: Created by MEXT based on "Science, Technology and R&D Statistics," OECD
* Data of Austria, Belgium and Taiwan are 2009 data.

Nearly 50% of postdoctorals[1] (hereinafter referred to as "postdocs") are employed with competitive funds (Figure 1-1-29). The status of those who are employed with competitive funds can vary, and the terms of their employment are limited. Among those who were employed under fixed-term contracts immediately after having graduated from doctoral programs, the number of those under fixed-term contracts after five years is 1) more than half of those whose career is known, and 2) more than one third of the total number of those who were employed under fixed-term contracts immediately after graduation (Figure 1-1-30).

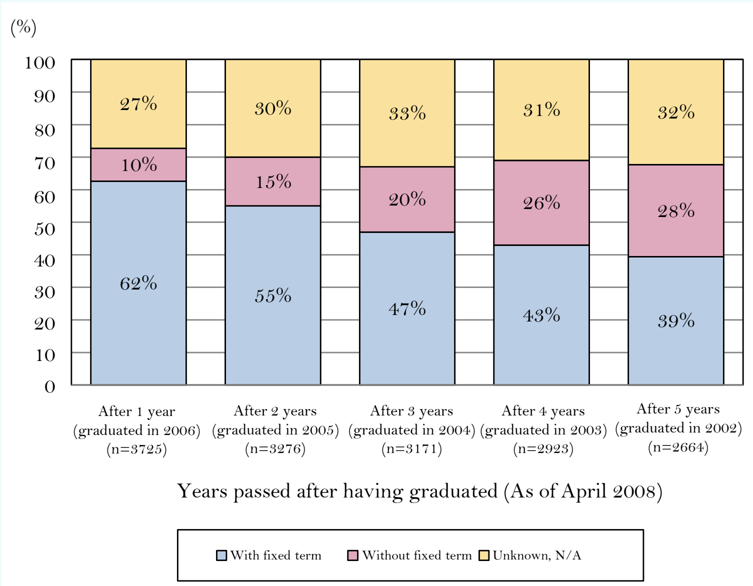
1 After obtaining doctorate degrees, 1. those who are engaged in research at a research institution such as a university and are not professors, associate professors or assistants, and 2. those who are engaged in research at a research institution such as an independent administrative agency, who are appointed for a fixed period, and who are not leaders or chief scientists of the research groups to which they belong. This includes those who study at school for a standard course term or who were out of college after having obtained the recognized credits (so called "Full-term school leavers").

Figure 1-1-29 / Breakdown of Financing for Postdoctoral Employment



Source:　NISTEP "Postdoctoral Employment/Career Path Study; Comprehensive Study of Universities and Public Research Institutions (Results from FY 2009) (December 2011)

Figure 1-1-30 / Current Employment Status for Those Who Were Employed under Fixed-term Contracts Immediately after Having Graduated from Doctoral Programs

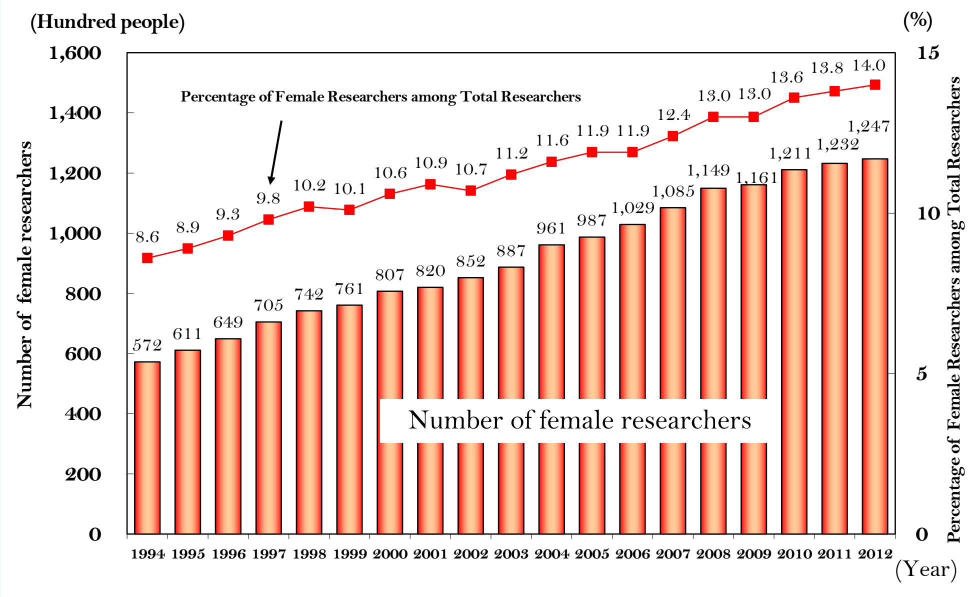


Source:　NISTEP "Career Trends Survey of Recent Doctoral Graduates" (March 2009)

(Female researchers)

Both the number of female researchers and their percentage of the total number of researchers in Japan are increasing. In 2012, there were 120,000 female researchers, and they accounted for 14.0% of total researchers (Figure 1-1-31). However, this number is considered as low compared with other countries (Figure 1-1-32).

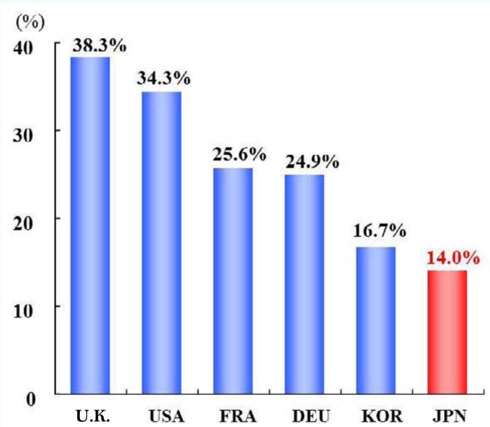
Figure 1-1-31 / Trends in Number of Female Researchers and the Percentage of Female Researchers among Total Researchers



Note: As for the number of researchers, until 2001, both the number of key researchers for businesses and non-profit organizations, and the number of researchers that include concurrently serving researchers for colleges/universities and institutions are counted. Headcount-based number of researchers per gender after 2002.

Source: Created by MEXT based on "Survey of Research and Development" by MIC

Figure 1-1-32 / Percentage of Female Researchers in Each Country



Notes: 1. MIC "Report on the Survey of Research and Development in Japan" (Japan: As of 2012)
OECD "Main Science and Technology Indicators" (U.K.: As of 2012; France: as of 2010; Germany: as of 2009; Korea: as of 2010); NSF "Science and Engineering Indicators 2006" (U.S. : as of 2003)
2. For the U.S. the figure covers science professionals rather than researchers (those holding a bachelor's or above in science or engineering and have specialist jobs related to science. Note that science includes social sciences.).
3. The notation the country in accordance with ISO3166-1

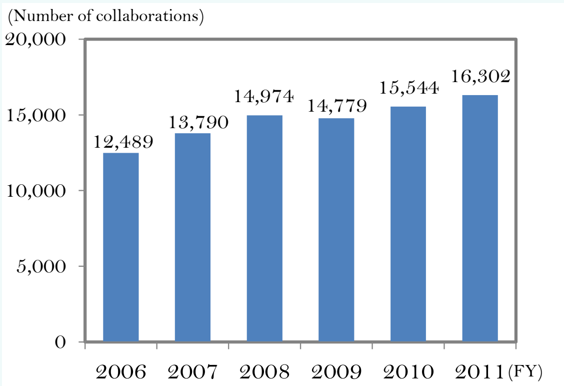
Source: Created by MEXT

The trends in research personnel described above indicate that Japan is not yet able to make full use of the capabilities of young researchers and female researchers. They also suggest the need to further promote the development, recruitment, and number of opportunities available for young researchers and female researchers.

3) Trends in university-industry collaboration

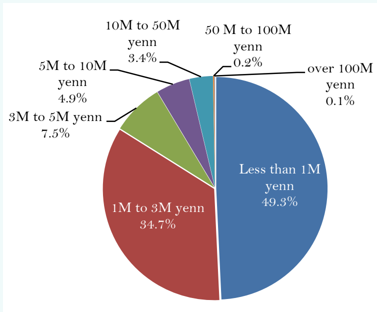
The amount of collaborative research between universities and private companies has increased despite the impacts of the economic downturn (Figure 1-1-33). However, approximately 50% of collaborative researches are those in which the accepted amount of spending per collaborative research project is less than one million yen, and approximately 3.7% of collaborative researches have been allowed spending of 10 million yen or more (Figure 1-1-34). Income from patent rights has been increasing, and it reached 1.09 billion yen in FY2012 (Figure 1-1-35). The cumulative number of university-launched venture companies was 47 in 1994, and increased to 2,143 in 2011, although there has been a downturn in growth (the number of new venture companies established per year) in recent years (Figure 1-1-36). As described above, the trends for university-industry collaboration have quantitatively expanded.

Figure 1-1-33 / Number of University-industry Collaborations



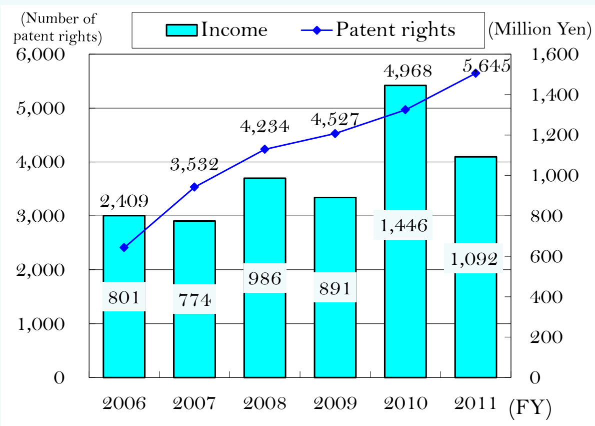
Source: MEXT "FY 2011 University Industry-Academia Partnership Survey" (October 2012)

Figure 1-1-34 / The Distribution of Investment for Collaborative Projects between Universities and Private Companies.



Source: MEXT "FY 2011 University Industry-Academia Partnership Survey" (October 2012)

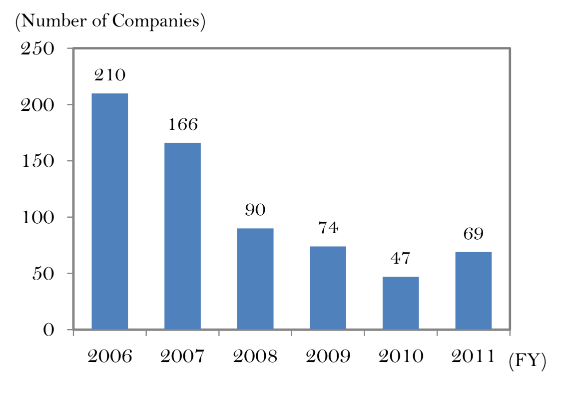
Figure 1-1-35 / Trends in the Number of Patent Rights and their Income



Notes: 1. "Number of patent rights" is the number of licensed patents or transferred patents (including those in the phase of "the right to accept").
2. Rounded to the nearest million yen

Source: MEXT "FY 2011 University Industry-Academia Partnership Survey" (October 2012)

Figure 1-1-36 / Number of University-launched Venture Companies



Note: 1. Numbers until 2009 are based on the survey carried out by MEXT's Institute of Science and Technology Policy; numbers after 2010 are based on this survey.
2. Numbers after 2010 are the results of the survey that covered only the number of university-launched venture companies established in those years, and these numbers are accumulated in the data through 2009 provided by the Institute of Science and Technology Policy.
3. An established year is based on a fiscal year that starts in April and ends in next March. Companies whose established year is unknown are considered to have been established after April.
4. The data through 2009 included nine companies whose established years were unknown; these companies are excluded in this data.

Source: MEXT "FY 2011 University Industry-Academia Partnership Survey" (October 2012)

(3) Trends in the basis for research activities

1) Trends in educational research at universities

(University rankings)

Not only the international competitiveness of each country, but also the quality of its universities is internationally ranked using an index of research activities. In this section, we overview the international rankings of universities in Japan by focusing on the index that indicates research activities in universities.

Times Higher Education, a magazine in the United Kingdom, has its World University Rankings published every year, and they are based on information about "Teaching," "International outlook," "Industry income," "Research," and "Citations." According to the rankings, many highly rated universities are in the United States and the United Kingdom. The University of Tokyo was ranked the highest among Japanese universities, at 27th in the world. It is followed by Kyoto University (54th) and the Tokyo Institute of Technology (128th). Thus, there is a large gap in the rankings of Japanese universities when compared with universities in the United States and the United Kingdom (Table 1-1-37).

In terms of "Research" and "Citations," however, the University of Tokyo and Kyoto University are ranked near the top in both Asia and the world; although, universities/colleges in Japan are not highly ranked in general. In the index on "Industry income," while universities in Korea and China are rated near the top level in the world, universities in Japan are inferior to them. In terms of the index on "International outlook," regarding universities in Asia, the universities in English-speaking countries such as Singapore and Hong Kong ranked very high. Universities in China, such as Peking University ranked relatively high, even though China is not an English speaking country. Overall, the universities in Japan are declining in regard to these trends.

Times Higher Education also publishes rankings in other subject areas, such as "Clinical," "Pre-Clinical & Health," "Engineering & Technology" and "Life Sciences." Universities in the United States and Europe ranked high in all of these subjects, but only three universities in Japan: the University of Tokyo, Kyoto University and the Tokyo Institute of Technology are ranked among the Top 50 universities. As shown, the universities in Japan do not have much of a presence.

Also, universities in Europe and the United States rank high in the rankings issued by Quacquarelli Symonds[1], a British company which is well-known for its World University Rankings. The University of Hong Kong has the top ranking in Asia and is 23rd in the world. As for the world rankings of Japanese universities, the University of Tokyo ranks 30th, Kyoto University ranks 35th, and Osaka University ranks 50th. In this ranking, universities are evaluated and ranked by subjects that are categorized in detail. Thus, we can see how the universities in Japan are recognized within these rankings. For example, the University of Tokyo and Kyoto University rank within the top 20 in Chemistry, Mechanical engineering, and Biology, but no Japanese universities rank high in Medicine, Mathematics, Statistics and Material.

As shown above, while universities in the United States and the United Kingdom are still highly evaluated by these university rankings in regard to the areas of research and activities, universities in Japan do not have much of a presence. Also, Japanese universities are exposed to fierce international competition with universities in other Asian countries having relatively similar rankings as Japan.

1 World University Rankings by Quacquarelli Symonds are created based on "Scopus" that is provided by Elsevier Co., an academic publishing company in the Netherlands. The rankings are calculated based on the six evaluation results: 1. Academic reputation by worldwide academics (40%), 2. Employer reputation by research initiatives (10%), 3. Citations per faculty member (20%), 4. Faculty-student ratio (20%), 5. Ratio of international to domestic students (5%) and 6. Ratio of international to domestic staff (5%).

Table 1-1-37 / "Times Higher Education" University Rankings throughout the World

	Country	Ranking within Japan	Ranking within Asia	World Ranking	Overall score (contribution to overall score)	Teaching 30.00%	International outlook 7.50%	University-industry collaboration 2.50%	Research 30.00%	Citations 30.00%
Top 10 universities in the World										
California Institute of Technology	United States			1	95.5	96.3	59.8	95.6	99.4	99.7
Stanford University	United States			2	93.7	95.0	56.6	62.4	98.8	99.3
University of Oxford	United Kingdom			2	93.7	89.7	88.7	79.8	98.1	95.6
Harvard University	United States			4	93.6	94.9	63.7	39.9	98.6	99.2
Massachusetts Institute of Technology	United States			5	93.1	92.9	81.6	92.9	89.2	99.9
Princeton University	United States			6	92.7	89.5	54.5	79.5	99.4	99.8
University of Cambridge	United Kingdom			7	92.6	91.2	83.6	59.1	95.6	96.2
Imperial College London	United Kingdom			8	90.6	88.0	91.4	87.5	90.9	93.0
University of California, Berkeley	United States			9	90.5	85.1	49.7	65.4	99.3	99.3
University of Chicago	United States			10	90.4	89.6	55.3	(undisclosed)	92.9	98.7
Top 10 universities in Asia										
The University of Tokyo	Japan		1	27	78.3	87.9	27.6	59.0	89.9	71.3
National University of Singapore	Singapore		2	29	77.5	74.4	92.3	77.4	87.2	67.2
The University of Hong Kong	Hong Kong		3	35	75.6	78.4	81.7	62.5	85.9	62.1
Peking University	China		4	46	70.7	81.5	54.1	99.9	67.9	64.3
Pohang University of Science and Technology	Korea		5	50	69.4	63.9	28.8	100.0	63.9	88.2
Tsinghua University	China		6	52	67.1	74.5	37.2	99.2	76.4	55.2
Kyoto University	Japan		7	54	66.8	77.1	26.3	76.4	74.8	57.8
Seoul National University	Korea		8	59	65.9	76.7	27.0	81.7	81.4	48.0
Hong Kong University of Science and Technology	Hong Kong		9	65	64.4	56.9	78.1	55.6	64.6	68.9
Korea Advanced Institute of Science and Technology	Korea		10	68	64.0	69.9	31.1	100.0	68.9	58.4
Top 10 universities in Japan										
The University of Tokyo	Japan	1	1	27	78.3	87.9	27.6	59.0	89.9	71.3
Kyoto University	Japan	2	7	54	66.8	77.1	26.3	76.4	74.8	57.8
Tokyo Institute of Technology	Japan	3	13	128	53.7	58.0	29.6	65.3	56.1	52.0
Tohoku University	Japan	4	15	137	53.1	57.7	32.0	80.7	55.6	48.9
Osaka University	Japan	5	17	147	52.0	59.5	23.6	69.6	55.7	46.4
Nagoya University	Japan	6	26	201-225	43.8	44.2	25.3	35.5	39.2	53.3
Tokyo Metropolitan University	Japan	7	36	251-275	40.0	19.0	19.6	31.1	9.8	97.1
Tokyo Medical and Dental University	Japan	8	39	276-300	37.7	47.5	21.9	45.4	21.6	47.1
University of Tsukuba	Japan	9	42	301-350	36.5	39.9	30.7	33.0	26.2	45.3
Hokkaido University	Japan	10	44	301-350	36.4	45.1	24.9	41.3	34.2	32.3

Note: 1. The universities are assessed based on the following five evaluation indexes:
1) Teaching (30%): evaluation by researchers (15%), staff-to-student ratio (4.5%), PhD awards/bachelor's awards (2.25%), PhD awards per faculty member (6%), Income per faculty member (2.25%),
2) International outlook (7.5%): proportion of foreign staff over domestic staff (2.5%), proportion of foreign students over domestic students (2.5%) and the proportion of internationally co-authored papers (2.5%)
3) University-industry collaboration (2.5%): research income from industry per academic staff member (2.5%)
4) Research (30%): evaluation by researchers (18%), research income per faculty member (6%), papers per faculty and research staff members (6%)
5) Citations (30%): Degree of citation impact (average number of citations per paper) (30%)

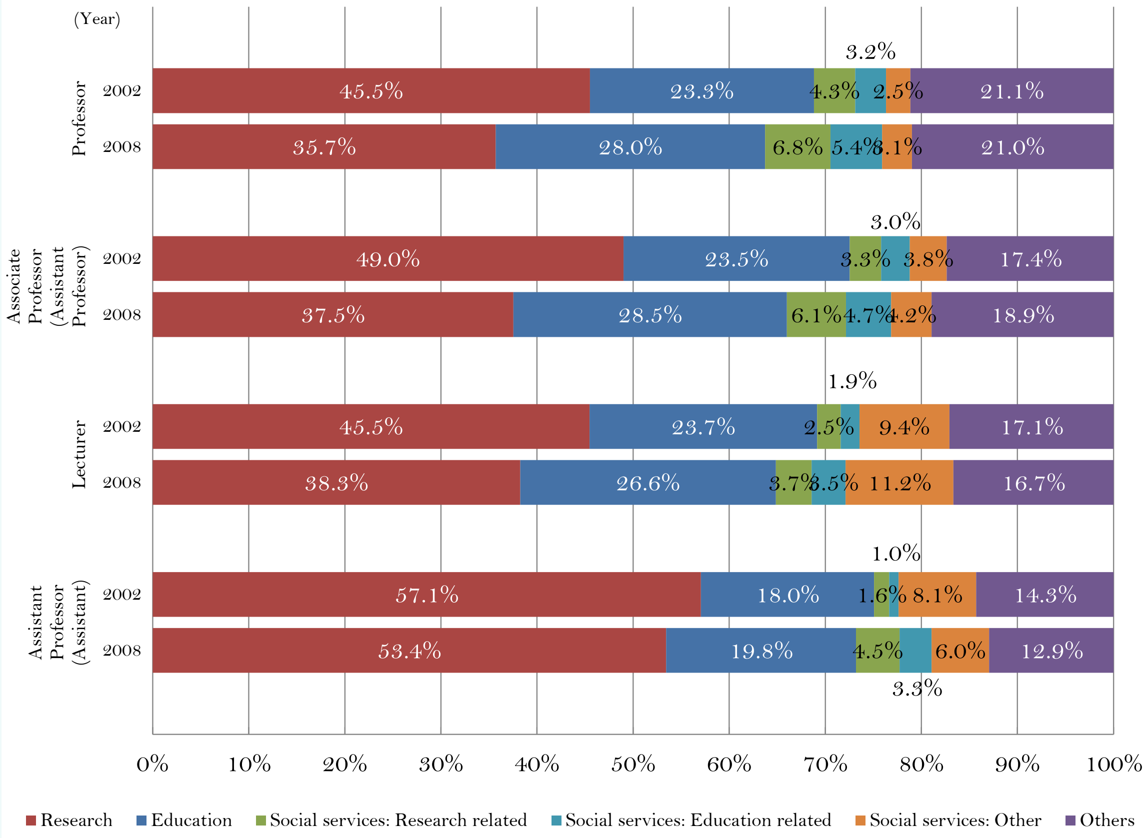
2. World rankings of 201 or lower show the range of the rankings only and have no particular ranking.

Source: Created by MEXT based on The Times Higher Education, "World University Rankings 2012-2013 powered by Thomson Reuters," "Asia University Rankings 2013"

(R&D environment)

In this section, we overview the environments of research and development in universities. The time allocated to research decreased in 2008 as compared with the survey conducted in 2002 for faculty members in any position. Other than lecturers, most faculty members have less than 40% of their total work hours available for research (Figure 1-1-38).

Figure 1-1-38 / Rate of Average Working Hours by Position/Activity



Note: Departments of universities (including graduate schools). Titles shown in parentheses are the names at the time the survey was conducted in 2002.

Source: NISTEP "Shrinking Research Time for University Faculty Members Comparison" in 2002, and 2008 in the "Survey on Full-time Equivalents at Universities" (December 2011)

It is shown that there has been a deterioration of the environments of research and development as a result of decreasing of the time for research in universities. Environments where researchers are unable to engage themselves fully in their research are considered to be the cause of universities in Japan's decline in the university rankings.

2) Trends in the S&T personnel base

In order to broaden the base of S&T experts, increase public S&T literacy, and spread understanding and awareness of S&T and its social context, it is important to approach goals at elementary and secondary education stage. Thus, we examine the following trends as based on the results of the "Trends in International Mathematics and Science Study (TIMSS)."

In December 2012, the trends in international mathematics and science as conducted in a 2011 study (TIMSS 2011) were reported. This assessment is to measure the degree of mathematics and science achievement among elementary and secondary school students on an international scale. The first assessment was conducted in 1995 and every four years thereafter. The latest one was the 5th such assessment. At the elementary level, there were 50 countries and regions participating (approx. 260,000 students) and, at the junior high level, there were 42 countries and regions participating (approx. 240,000 students). In Japan, approximately 4,000 elementary school fourth graders and about the same amount of second grade junior high school students participated.

The assessment revealed that the average scores of fourth graders in mathematics and science to be 585 (5th among 50 participating countries) and 559 (4th among 50 participating countries) respectively, and the average scores of 2nd grade in mathematics and science were 570 (5th among 42 participating countries) and 558 (4th among 42 participating countries) respectively. Ever since the first assessment was conducted in 1995, Japan has ranked relatively high as compared with other nations (Table 1-1-39). The average scores in mathematics and science in elementary school showed a significant increase as compared to the assessment conducted in 2007, with the number of students with low proficiency has decreasing and the number of students with high proficiency increasing. Regarding junior high school students, the average scores remained at about the same level as compared to the previous assessment; however, the number of students with high proficiency has increased.

In terms of student attitudes toward mathematics and science, students who answered "I like studying." and "I enjoy studying" numbered below the international average. This tendency is particularly shown in junior high school students (Table 1-1-40). We can see a similar tendency in the Programme for International Student Assessment (PISA) conducted by the Organization for Economic Co-operation and Development (OECD) as reported in the FY 2010 White Paper on Science and Technology.

In the national surveys on academic ability and learning conditions, conducted in FY 2012, science had room to improve its interpretation, review and explanations based on organized, analyzed results from observations and experiments. It was also pointed out that in response to the item "I understand science class very well," there was a bigger difference (21%) between the number of elementary school students (86%) and junior high school students (65%), as compared to other subjects (Table 1-1-41).

From these results, students of both elementary school and junior high school in Japan earn high international ranks and acquire basic accomplishments in S&T; however, they tend to lose interest in S&T as they move on to higher grades. This tendency has remained the same as found in previous results. It is believed that improvement is necessary to expand the S&T personnel base and to foster S&T literacy.

Table 1-1-39 / Average Scores Observed in the Data about Trends in Mathematics and Science (TIMSS) (Top 10 Countries)

	Ranking	1995		1999		2003		2007		2011	
		Country/Region (26)	Average scores			Country/Region (25)	Average scores	Country/Region (36)	Average scores	Country/Region (50)	Average scores
Elementary School Mathematics	1	Singapore	625	No tests conducted		Singapore	594	Hong Kong	607	Singapore	606
	2	Korea	611			Hong Kong	575	Singapore	599	Korea	605
	3	Japan	597			Japan	565	Taiwan	576	Hong Kong	602
	4	Hong Kong	587			Taiwan	564	Japan	568	Taiwan	591
	5	The Netherlands	577			Belgium (Flemish speaking areas)	551	Kazakhstan	549	Japan	585
	6	Czech	567			The Netherlands	540	Russia	544	North Ireland	562
	7	Austria	559			Latvia	536	England	541	Belgium	549
	8	Slovenia	552			Lithuania	534	Latvia	537	Finland	545
	9	Ireland	550			Russia	532	The Netherlands	535	England	542
	10	Hungary	548			England	531	Lithuania	530	Russia	542

	Ranking	1995		1999		2003		2007		2011	
		Country/Region (26)	Average scores			Country/Region (25)	Average scores	Country/Region (36)	Average scores	Country/Region (50)	Average scores
Elementary School Science	1	Korea	597	No tests conducted		Singapore	565	Singapore	587	Korea	587
	2	Japan	574			Taiwan	551	Taiwan	557	Singapore	583
	3	United States	565			Japan	543	Hong Kong	554	Finland	570
	4	Austria	565			Hong Kong	542	Japan	548	Japan	559
	5	Australia	562			England	540	Russia	546	Russia	552
	6	The Netherlands	557			United States	536	Latvia	542	Taiwan	552
	7	Czech	557			Latvia	532	England	542	United States	544
	8	England	551			Hungary	530	United States	539	Czech	536
	9	Canada	549			Russia	526	Hungary	536	Hong Kong	535
	10	Singapore	547			The Netherlands	525	Italy	535	Hungary	534

	Ranking	1995		1999		2003		2007		2011	
		Country/Region (41)	Average scores	Country/Region (38)	Average scores	Country/Region (45)	Average scores	Country/Region (48)	Average scores	Country/Region (42)	Average scores
Junior high Mathematics	1	Singapore	643	Singapore	604	Singapore	605	Taiwan	598	Korea	613
	2	Korea	607	Korea	587	Korea	589	Korea	597	Singapore	611
	3	Japan	605	Taiwan	585	Hong Kong	586	Singapore	593	Taiwan	609
	4	Hong Kong	588	Hong Kong	582	Taiwan	585	Hong Kong	572	Hong Kong	586
	5	Belgium (Flemish speaking areas)	565	Japan	579	Japan	570	Japan	570	Japan	570
	6	Czech	564	Belgium (Flemish speaking areas)	558	Belgium (Flemish speaking areas)	537	Hungary	517	Russia	539
	7	Slovakia	547	The Netherlands	540	The Netherlands	536	England	513	Israel	516
	8	Switzerland	545	Slovakia	534	Estonia	531	Russia	512	Finland	514
	9	The Netherlands	541	Hungary	532	Hungary	529	United States	508	United States	509
	10	Slovenia	541	Canada	531	Malaysia	508	Lithuania	506	England	507

	Ranking	1995		1999		2003		2007		2011	
		Country/Region (41)	Average scores	Country/Region (38)	Average scores	Country/Region (45)	Average scores	Country/Region (48)	Average scores	Country/Region (42)	Average scores
Junior high Science	1	Singapore	607	Taiwan	569	Singapore	578	Singapore	567	Singapore	590
	2	Czech	574	Singapore	568	Taiwan	571	Taiwan	561	Taiwan	564
	3	Japan	571	Hungary	552	Korea	558	Japan	554	Korea	560
	4	Korea	565	Japan	550	Hong Kong	556	Korea	553	Japan	558
	5	Bulgaria	565	Korea	549	Estonia	552	England	542	Finland	552
	6	The Netherlands	560	The Netherlands	545	Japan	552	Hungary	539	Slovenia	543
	7	Slovenia	560	Australia	540	Hungary	543	Czech	539	Russia	542
	8	Austria	558	Czech	539	The Netherlands	536	Slovenia	538	Hong Kong	535
	9	Hungary	554	England	538	United States	527	Hong Kong	530	England	533
	10	England	552	Finland	535	Australia	527	Russia	530	United States	525

Notes: 1. Scores suggest the figures that show change from the reference point, which was 500 points (value adjusted so that two thirds of students will receive scores ranging from 400 to 600 points) in the assessment in 1995.

2. Subjects of the assessment conducted in 1995 are 3rd grade elementary students and 1st grade junior-high students. Scores of elementary 3rd and 4th graders or 1st and 2nd grade junior-high students are adjusted so that the average and standard deviation become 500 and 100, respectively.

Source: Created by MEXT based on TIMSS 2011 - Trends in International Mathematics and Science Study - International Results in Mathematics.

Table 1-1-40 / Opinion Poll on Students' Sense Trends in International Mathematics and Science Study (TIMSS)

○ Summary of those who answered "I like studying"

[4th grade in elementary school (Mathematics)]

Country/Region	Agree a lot	Agree a little	Disagree a little	Disagree a lot
Japan	31.1	34.8	21.9	12.2
Australia	52.4	25.0	10.3	12.3
Taiwan	35.4	27.0	18.0	19.6
England	51.5	27.8	10.2	10.6
Finland	37.1	28.3	17.8	16.8
Germany	47.5	28.5	13.6	10.4
Hong Kong	52.7	26.9	12.7	7.7
Hungary	56.4	23.9	9.7	9.9
Italy	56.8	26.1	8.2	8.8
Korea	27.9	36.9	24.5	10.7
Russia	67.2	22.4	6.9	3.5
Singapore	51.2	27.9	11.5	9.3
Sweden	44.5	30.4	15.9	9.3
United States	52.5	24.9	10.0	12.5
International average scores	58.7	22.7	9.5	9.0

[2nd grade in elementary school (Science)]

Country/Region	Agree a lot	Agree a little	□isagree a little	Disagree a lot
Japan	52.0	31.2	12.0	4.9
Australia	62.1	22.0	8.3	7.6
Taiwan	63.4	21.3	9.0	6.3
England	47.1	28.7	11.9	12.2
Finland	36.7	33.5	17.6	12.2
Germany	58.0	27.5	8.6	6.0
Hong Kong	59.5	23.5	9.5	7.6
Hungary	57.4	24.0	9.4	9.2
Italy	56.9	28.7	8.1	6.4
Korea	38.9	39.1	16.0	6.0
Russia	71.4	20.2	6.3	2.2
Singapore	59.3	26.1	8.9	5.6
Sweden	46.8	34.3	11.9	7.0
United States	61.7	20.7	9.1	8.6
International average scores	63.7	22.0	8.0	6.4

[2nd grade in junior high school (Mathematics)]

Country/Region	Agree a lot	Agree a little	Disagree a little	Disagree a lot
Japan	12.7	26.4	38.1	22.7
Australia	19.9	37.3	23.7	19.2
Taiwan	15.5	28.9	30.7	24.9
England	17.9	40.6	24.6	17.0
Finland	11.5	32.1	32.2	24.3
Hong Kong	23.3	39.4	22.7	14.6
Hungary	17.9	27.5	29.7	24.9
Italy	22.0	35.8	24.7	17.4
Korea	9.9	31.1	39.2	19.8
Russia	32.7	39.0	21.3	7.0
Singapore	37.8	39.8	14.8	7.5
Sweden	13.9	36.4	32.5	17.2
United States	26.9	34.9	19.1	19.2
International average scores	32.2	34.0	18.4	15.3

[2nd grade in junior high school (Science)]

Country/Region	Agree a lot	Agree a little	Disagree a little	Disagree a lot
Japan	18.2	34.3	31.8	15.7
Australia	27.5	37.2	20.0	15.2
Taiwan	17.9	34.6	31.1	16.4
England	34.6	38.9	17.0	9.5
Hong Kong	30.6	46.1	16.9	6.4
Italy	27.9	45.3	18.6	8.2
Korea	12.4	35.5	38.8	13.3
Singapore	39.7	42.7	12.8	4.7
United States	36.4	35.5	15.5	12.7
International average scores	42.5	33.0	15.2	9.3

○ Summary of those who answered "I enjoy studying"

[4th grade in elementary school (Mathematics)]

Country/Region	Agree a lot	Agree a little	Disagree a little	Disagree a lot
Japan	29.2	44.1	19.1	7.7
Australia	51.1	28.8	10.4	9.7
Taiwan	33.4	32.3	18.3	16.1
England	49.9	33.2	9.8	7.2
Finland	33.8	39.2	16.3	10.6
Germany	41.2	33.4	17.0	8.5
Hong Kong	51.3	32.6	10.8	5.3
Hungary	55.5	27.1	9.2	8.2
Italy	48.2	34.5	8.8	8.5
Korea	26.2	45.3	20.7	7.8
Russia	57.8	29.4	9.6	3.2
Singapore	51.1	31.7	10.3	6.9
Sweden	50.7	36.0	9.7	3.7
United States	51.1	28.9	9.8	10.2
International average scores	57.8	26.4	8.8	6.9

[4th grade in elementary school (Science)]

Country/Region	Agree a lot	Agree a little	Disagree a little	Disagree a lot
Japan	56.4	33.7	7.3	2.5
Australia	62.6	25.7	7.0	4.7
Taiwan	64.5	23.0	7.3	5.2
England	45.9	32.6	12.5	9.1
Finland	36.9	38.9	15.9	8.4
Germany	57.0	30.1	8.3	4.6
Hong Kong	59.1	26.4	8.1	6.5
Hungary	57.0	25.9	8.7	8.5
Italy	51.3	34.0	8.3	6.4
Korea	40.8	41.7	12.8	4.7
Russia	64.3	25.4	7.6	2.6
Singapore	60.3	28.5	7.2	4.1
Sweden	49.6	38.7	8.4	3.3
United States	61.7	22.8	8.3	7.2
International average scores	64.3	23.7	6.7	5.2

[2nd grade in junior high school (Mathematics)]

Country/Region	Agree a lot	Agree a little	Disagree a little	Disagree a lot
Japan	13.3	34.3	36.4	16.0
Australia	21.2	40.5	22.2	16.1
Taiwan	15.1	31.5	30.0	23.5
England	18.2	45.3	22.2	14.2
Finland	10.3	35.9	34.3	19.5
Hong Kong	27.3	40.7	19.4	12.6
Hungary	18.7	32.4	28.4	20.4
Italy	19.0	39.8	26.4	14.8
Korea	10.3	35.3	38.5	15.9
Russia	29.7	42.3	22.8	5.1
Singapore	43.1	40.1	10.5	6.3
Sweden	19.9	43.9	25.2	11.0
United States	27.3	37.3	18.7	16.6
International average scores	33.1	37.6	17.2	12.1

[2nd grade in junior high school (Science)]

Country/Region	Agree a lot	Agree a little	Disagree a little	Disagree a lot
Japan	20.3	42.4	28.2	9.1
Australia	28.8	41.3	18.1	11.9
Taiwan	16.7	38.9	31.4	13.0
England	36.5	42.4	13.7	7.4
Hong Kong	32.7	46.5	15.1	5.7
Italy	25.8	47.5	20.2	6.5
Korea	12.0	39.1	38.1	10.8
Singapore	42.3	44.6	9.2	3.9
United States	37.0	37.2	14.8	11.0
International average scores	45.1	35.0	12.8	7.1

Source: Created by MEXT based on TIMSS 2011 - Trends in International Mathematics and Science Study - International Results in Mathematics.

Table 1-1-41 / Results Obtained from the National Surveys on Academic Ability and Learning Conditions in FY 2012 (Interest, Motivation and Attitude)

	Science			Japanese			Mathematics		
	Elementary school (%)	Junior high school (%)	Variance	Elementary school (%)	Junior high school (%)	Variance	Elementary school (%)	Junior high school (%)	Variance
I like studying.	82	62	20	63	58	5	65	53	12
Study is important.	86	69	17	93	90	3	93	82	11
What I study will be of good use after getting out of school in the future.	73	53	20	89	83	6	90	71	19
I understand the class very well.	86	65	21	83	72	11	79	66	13

Note: Ratio of students answered as “Strongly Agree” and “Somewhat Agree”
Source: Created by MEXT