Chapter 2 S&T Systems That Mobilize People and Connect Knowledge

In recent years, cross-border activities related to intellectual production have been enhanced and international mobility of science and technology human resources has increased. As a consequence, the competition for recruitment of international talents has intensified. In such circumstances, it is essential to foster and secure talented human resources in the fields of science and technology in order to create innovation by means of science and technology, which are supposed to contribute to providing solutions to certain issues, while enhancing the basic science capability throughout Japan. According to “Public Opinion Poll on S&T and Society” conducted by the Cabinet Office in January 2010, most people, or 76.6% answered that the most necessary measure to be taken for development of science and technology was “education of young scientists and engineers who are to lead the society of next generation,” showing high expectations of the people for science and technology.

In the past, we have focused on fostering and securing researchers and engineers to be the leaders in the scientific and technological fields. However, science and technology have become so sophisticated that the contemporary society, in which the relationship between the society and S&T are more profound and complicated than ever, is now requiring people with more variety in their capacity and talent. In such a society, it is important that a variety of people with more sophisticated expertise and skills but with different knowledge and methodologies should gather in an organic manner applying their individuality as much as possible, while conducting their scientific and technological activities appropriately within their assigned areas to fully utilize their capability as a team.

Such talents necessary for promotion of science and technology include not only researchers and engineers but also competent persons for management, competent persons with knowledge of intellectual property (IP), competent persons for collaboration with industry, university, and government, teachers of math and sciences who are supposed to educate next generation S&T related personnel, and other various personnel. In particular, in countries like Japan, where low birth rates have been accelerating, every one of such talents is requested to enhance their creativity and productivity more than ever. Since such various talents are essential for creation of new values necessary for Japanese people and for all human beings in the future, such people are collectively called “value-creating human resources” in this white paper. Recently, career paths of Doctoral degree holders are sometimes picked up as problems, but these Doctoral degree holders, who have very sophisticated expertise and profound knowledge, are expected to work actively in a variety of scenarios in the society as one of the principal people from the value-creating human resources.

Another important thing, as the basis to provide places for the value-creating human resources to take active roles and to create innovation, is to provide the environment appropriate for the outcomes of the R&D to be connected to innovations and to enhance the functions of R&D institutions, of which the operations comprise of research and development based on the national strategies.

Chapter 2 illustrates the current state and a summary of future prospects of the science and technology systems of Japan mainly in relation to the efforts to foster value-creating human resources and to provide places for creation of innovation.

Section 1 Fostering the Value-creating Human Resources

1 Fostering and Activating Human Resources

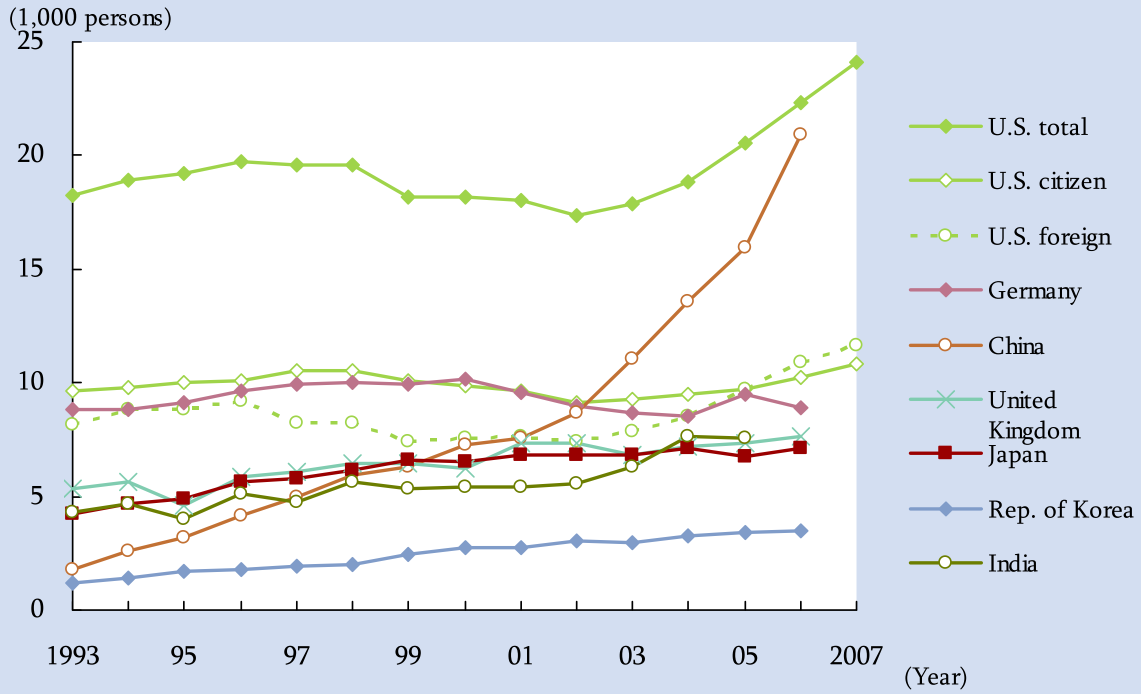
(1) Increasing importance of doctoral degree holders

As global society is becoming more and more competitive, there are expanding demands for those who can create new values required in the society while comprehending the society undergoing rapid changes with many uncertain factors intertwining in complicate manners, and adapting themselves adequately to the changes of the society. Doctoral degree holders are the ones who are expected to stand foremost as such human resources. The following section illustrates such doctoral degree holders who are supposed to play a part as value-creating human resources.

Looking at the trends in the number of doctoral degree holders in natural sciences, it is noted that the number tends to increase in most of the major countries, but the growth in the number is significant particularly in China and some other Asian countries (Figure 1-2-1). Among the doctoral degree holders in the United States, the proportion of foreign population tends to grow in recent years, exceeding 50% in 2006 and thereafter (Figure 1-2-1). Since 1996, in terms of foreign residents who have obtained doctoral degrees in natural sciences in the U.S., China ranked the most (28.2%) followed by India (10.7%) and Rep. of Korea (9.2%), with significant growth in the numbers of China since 2004 (Figure 1-2-2). On the other hand, the number of Japanese people who have obtained doctoral degrees in the same fields in the U.S. is in gradual increase, but the overall share is only 1.8%. Furthermore, when the numbers per million people are compared for doctoral degree holders in natural sciences, Japan is far behind Germany and United Kingdom, and even less Japanese people have obtained doctoral degrees compared to Rep. of Korea[1]. (Figure 1-2-3)

1 Japan is said to have more doctoral degree holders in medical sciences characteristically. When per-million numbers are compared for physical sciences, engineering and technology, and agricultural sciences, excluding medical sciences, Japan has the least doctoral degree holders among the countries.

Figure 1 2 1 Trends in the number of doctoral degree holders in natural sciences and engineering in selected countries



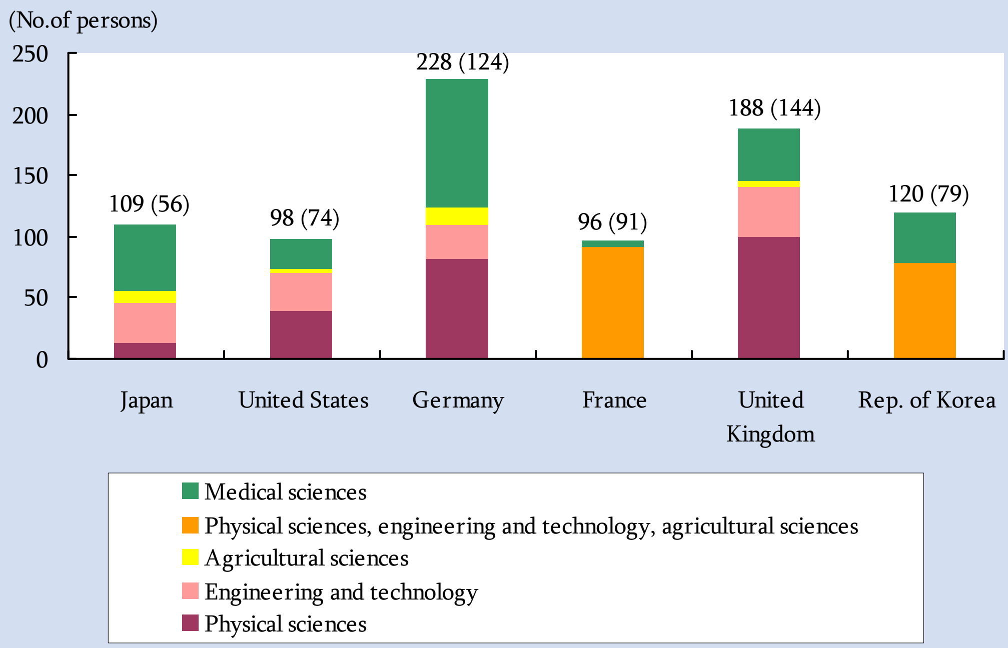
Note: Figures for all countries illustrate the number of students who obtained doctoral degrees in the countries. Medical sciences are not included in these figures.
Source: Prepared by MEXT based on NSF "Science and Engineering Indicators 2010"

Table 1 2 2 Number of foreign doctoral degree recipients in science and engineering in the U.S. (by countries/regions)

Country/Region	Number of S&E doctoral degree recipients				Proportion
	1996-99	2000-03	2004-07	Total of all periods	
Japan	661	751	897	2,309	1.8
China	10,715	10,105	15,533	36,353	28.2
Taiwan	4,128	2,293	1,924	8,345	6.5
Rep. of Korea	3,580	3,541	4,743	11,864	9.2
India	4,798	3,259	5,759	13,816	10.7
Germany	770	856	724	2,350	1.8
France	308	357	460	1,125	0.9
United Kingdom	506	513	459	1,478	1.1
All (Total)	40,756	38,184	49,894	128,834	100.0

Note: Social and behavioral sciences are included in the table.
China includes Hong Kong in the table.
Source: Prepared by MEXT based on NSF "Science and Engineering Indicators 2010"

Figure 1 2 3 Number of doctoral degree holders in natural sciences per million people in selected countries (2005)



Note: 1. France and Rep. of Korea do not statistically distinguish physical sciences, engineering and technology, and agricultural sciences.
2. Figures in parenthesis are the number of doctoral degree holders of physical sciences, engineering and technology, and agricultural sciences per million people.
Source: Prepared by MEXT based on MEXT "International Comparison of Educational Indicators"(2008, 2009) for the number of doctoral degree holders, and on OECD "Main Science and Technology Indicators Volt 2009/2"for the population.

Doctoral degree holders are expected to play important roles as main players in the activities of highly intellectual production, and more people are expected to obtain doctoral degrees in all over the world, including Asian countries, in the future. In particular, some Asian countries, including China and India, may increase the number of doctoral degree holders not only within their own countries but also in the U.S. and other countries. In the future, there may be even more scientific and technological activities conducted by doctoral degree holders in each country in a sort of international network. Therefore, Japan should also enhance both the quantity and quality of doctoral degree holders who can work actively in the world.

(2) Current State and Issues in Relation to Career Paths of Doctoral Degree Holders

1) Trends in the number enrollments in graduate school (doctoral courses) in Japan

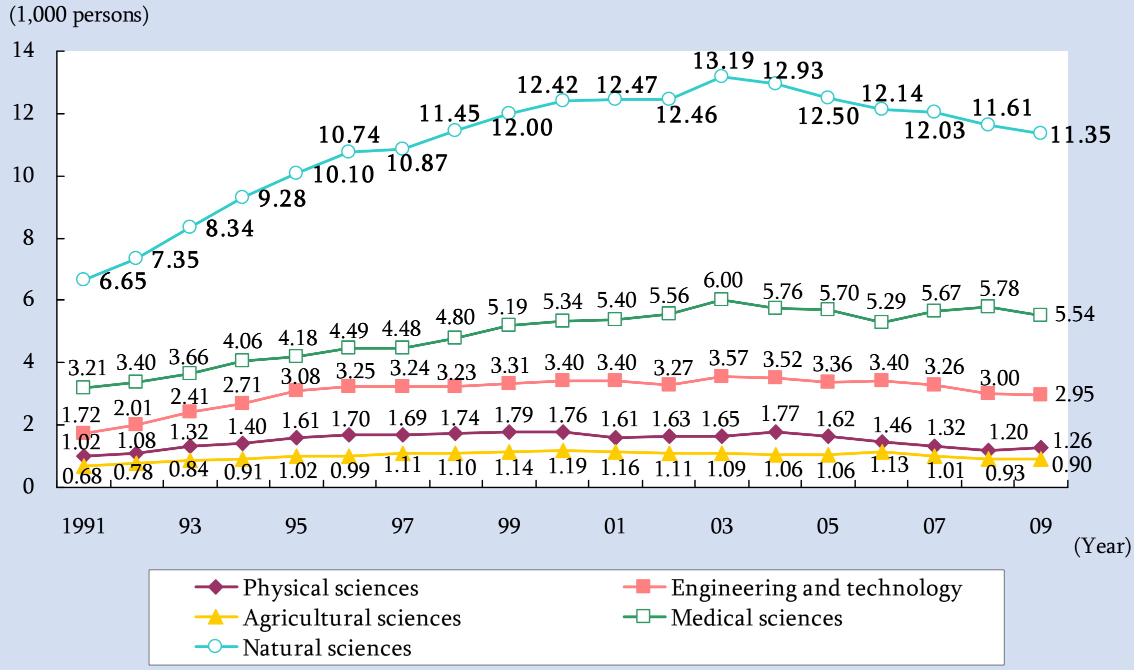
Looking at the trends in the number of enrollments in graduate school (doctoral courses) in natural sciences in Japan, the number increased from1991 as the center of the university education was shifted to the graduate school[1]. However, it turned to decline recently, hitting its peak in 2003

1 Since May 1991, from the decision of the University council, in order to further boost our international contribution, training highly specialized human resources and its researchers and promote academic research, the "Improving facilities in graduate school" state (1) management of educational research organization in graduate school (2) improvement of treatment to graduate students (3) management of educational system for oversea student (4) quantitative improvement of graduate school (5) a recommendation of measures to improving intellectual properties

with 13,190 students entering the universities, while in 2009, it dropped to as low as 11,348. (Figure 1-2-4). Also looking at the trends in the advancement rate from the master's to doctoral course, the statistics proves that the rates are declining recently and, in particular, the declines are significant in physical and agricultural sciences. (Figure 1-2-5)

In addition, according to the expert survey on Japanese S&T system and S&T activities by fields conducted by National Institute of Science and Technology Policy (NISTEP), the number of those who answered that "people with desirable capacity choose to advance to a doctoral course" is in decline lately. (Figure 1-2-6)

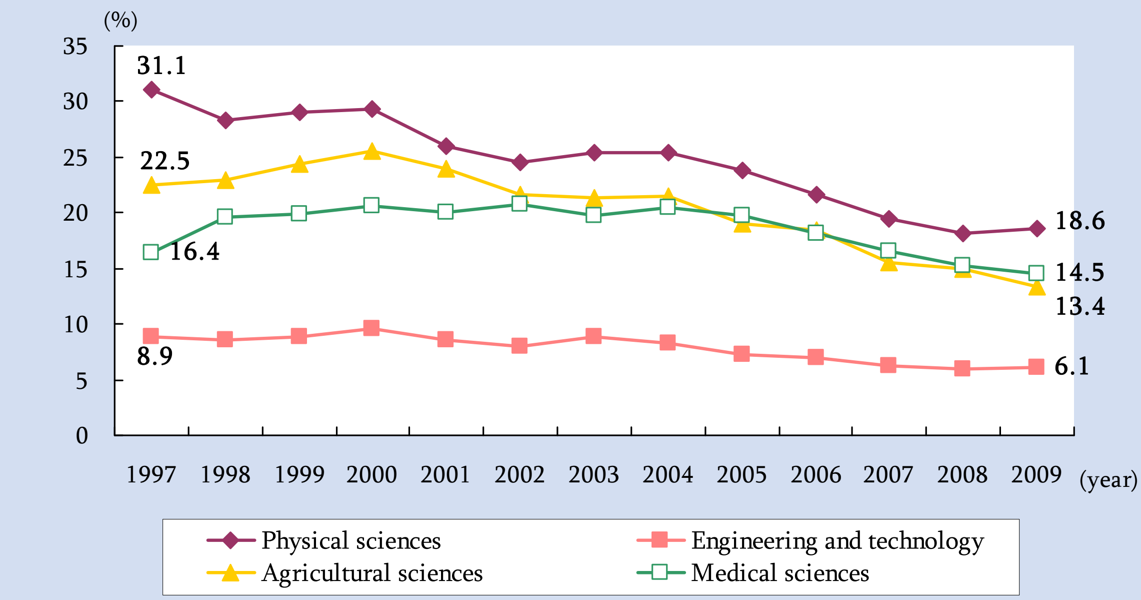
Figure 1 2 4 Trends in the number of students admitted to doctoral courses (Natural sciences)



Note: Natural sciences include physical, engineering and technology, agricultural, medical, and others (related natural sciences).
Source: Prepared by MEXT based on "School Basic Survey"

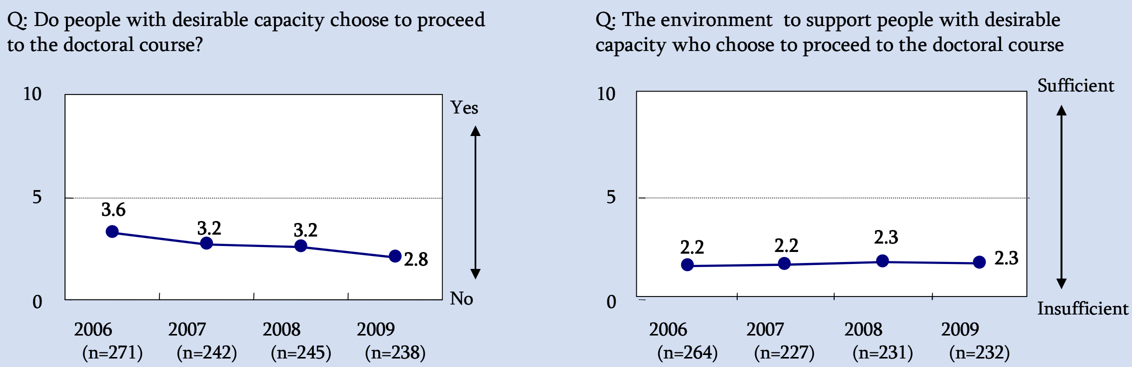
related to graduate school. In addition, from November of the same year, in the same university council, "quantitative facility of graduate school" states that at the point of year 2000, the number of graduate school within Japan needs to be twice its present number. It also states its necessity of rapid improvement in both aspects of quality and quantity which consequently made a progress in quantitative improvement of graduate school.

Figure 1 2 5 Trends in the ratio of students in master's course advancing to doctoral course (Natural sciences)



Source: Prepared by MEXT based on "School Basic Survey"

Figure 1 2 6 Researchers awareness about willingness to advance to doctoral course



Note: Respondents may choose best suitable answer out of 6 different levels. They were also asked if they had experiences on the issue in the question. Indices were calculated based on the responses of the respondents who had experience on the issues in questions.
These charts show indexed figures of the 6-level evaluations converted into 10-point scale.
Source: Prepared by MEXT based on NISTEP "2009 Expert Survey on Japanese S&T System and S&T Activities by Fields (NISTEP REPORT No. 136)"

2) Current state and issues in relation to career paths of doctoral degree graduates

Looking at the career paths of doctoral graduates in natural sciences, there were about 9,000 who got jobs, as far as the universities knew, out of 11,385 doctoral graduates in total. Among the 9,000, 1,468 got jobs as university faculty, 1,654 proceeded to postdoctoral researchers, about 3,200 got jobs at private corporations or public research institutes, etc. (Table 1-2-7) Among doctoral graduates, more people will get jobs spontaneously than those with bachelor's or master's graduates because their job hunting styles are different. There is also a significant number of students who have studies abroad, so in many cases, the universities are not capturing the data sufficiently. Thus, although there might be, in reality, more of those who got part-time jobs or temporary jobs, who have never got jobs, or whose career paths are unknown, but it is true that there are a certain portion of people who have not got any job.

Table 1 2 7 Career paths of doctoral graduates (Completed degree in natural sciences in 2007)

	Number of doctoral graduates	University faculty	Postdoctoral researcher	Private corporation, public research institute, etc. (estimate)	Secondary school teacher, physician, public employee, etc. (estimate)	Physician on training, studying abroad, etc.	Others (temporary employment, etc.)	Unknown
Physical sciences	1,610	128	453	About 630	About 60	44	184	115
Engineering and technology	3,636	405	396	About 1,800	About 110	68	654	231
Agricultural sciences	1,065	98	263	About 350	About 80	24	226	31
Medical sciences	5,074	837	542	About 390	About 2,300	132	607	263
Sub total (Physical, engineering & technology, agricultural sciences)	**6,311**	**631**	**1,112**	**About 2,800**	**About 250**	**136**	**1,064**	**377**
Total (All natural sciences)	**11,385**	**1,468**	**1,654**	**About 3,200**	**About 2,600**	**268**	**1,671**	**640**

Note: 1. Those who are employed for the purpose of obtaining salary, wage, compensation, and others (employed) are counted as either "university faculty," "postdoctoral researchers," "private corporation, public research institute, etc.," or "Secondary school teacher, physician, public employee."
2. Those who are employed to obtain temporary income and who are neither in school nor employed (including housekeeping) are counted as "others (temporary employment, etc.)."
3. Non-traditional students who completed the doctoral course and international students from other countries are included in this table.
4. Of the employed people as "secondary school teacher,"30 are from physical, engineering & technology, agricultural sciences, and 33 were from all natural sciences; whereas of the employed as "national public servant," 92 are from physical, engineering & technology, agricultural services, and 109 are from all natural sciences.
Source: Prepared by MEXT based on MEXT "Fiscal 2008 School Basic Survey" and University Promotion Divisions MEXT "Fiscal 2008 Graduate School Survey" (Partially estimate)

A survey on the career paths of doctoral graduates in Japan conducted by NISTEP illustrates the career paths of those who completed the doctoral courses sorted by their major subjects and by status, i.e. regular student (excluding international students and non-traditional students), international student, and non-traditional student. This survey shows non-traditional students are more likely to be employed at companies in private sector, and international students are more likely to be employed as university faculty except for some categorized as unknown. Among regular students, students in physical sciences and agricultural sciences are more likely to choose to become postdoctoral researchers, whereas students in engineering and technology tend to be employed at companies in private sector. It is possible to conclude that the career paths of doctoral graduates vary not only among different major subjects but also among different student statuses. (Table 1-2-8)

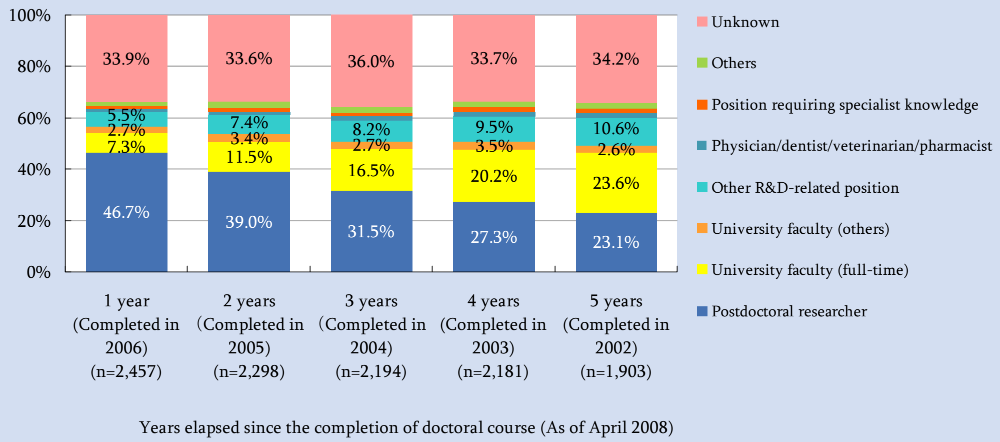
Looking further, in the same survey, at the career paths of those who became postdoctoral researchers after their completion of doctoral courses, the longer they stay as postdoctoral researchers, the more likely they are to be employed as university faculty. However, there are a certain number of students who remain to be postdoctoral researchers after 5 years (Table 1-2-9). Furthermore, according to "Survey on Research Activities and Attitudes of Postdoctoral Fellows" conducted by NISTEP, 16% have experience of 6 years or more as postdoctoral researchers, and the proportion jumps to 25% for the postdoctoral researchers in physical sciences, which proves to be fairly high compared to other major subjects.

Table 1-2-8 Career paths of doctoral graduates sorted by student status (graduates in natural sciences from FY2002 through FY2006)

		Number of doctoral graduates	University faculty	Postdoctoral researcher	Teacher/ physician/ public employee, etc.	Private corporation	Public research institute	Other employees	Student (incl. students abroad)	Unknown, etc.
Physical sciences (n=9,047)	Regular student (excl. international student and non-traditional student)	7,513	585	2,811	159	1,128	277	543	356	1,654
	International student	901	165	225	10	59	23	92	16	311
	Non-traditional student	523	67	35	35	161	38	78	10	99
	Unknown	110	7	16	2	16	7	17	8	37
Engineering and technology (n=17,896)	Regular student (excl. international student and non-traditional student)	9,498	1,537	1,978	72	2,895	538	595	142	1,741
	International student	4,294	901	777	22	804	135	288	42	1,325
	Non-traditional student	3,945	416	71	84	2,211	255	347	15	546
	Unknown	159	18	6	1	32	7	12	4	79
Agricultural sciences (n=6,055)	Regular student (excl. international student and non-traditional student)	3,787	319	1,407	132	473	332	342	121	661
	International student	1,711	511	352	12	116	116	174	21	409
	Non-traditional student	535	50	31	44	163	109	63	4	71
	Unknown	22	0	3	1	7	0	3	2	6
Medical sciences (n=23,155)	Regular student (excl. international student and non-traditional student)	15,545	3,160	1,309	6,819	585	194	917	599	1,962
	International student	2,311	388	439	256	57	41	268	61	801
	Non-traditional student	4,294	818	95	2,394	280	27	246	31	403
	Unknown	1,005	114	19	522	29	5	71	10	235
Physical sciences, Engineering and technology, Agricultural sciences (n=32,998)	Regular student (excl. international student and non-traditional student)	20,798	2,441	6,196	363	4,496	1,147	1,480	619	4,056
	(Proportion)	(100%)	(11.7%)	(29.8%)	(1.7%)	(21.6%)	(5.5%)	(7.1%)	(3.0%)	(19.5%)
	International student	6,906	1,577	1,354	44	979	274	554	79	2,045
	Non-traditional student	5,003	533	137	163	2,535	402	488	29	716
	Unknown	291	25	25	4	55	14	32	14	122
	All students	32,998	4,576	7,712	574	8,065	1,837	2,554	741	6,939
	(Proportion)	(100%)	(13.9%)	(23.4%)	(1.7%)	(24.4%)	(5.6%)	(7.7%)	(2.2%)	(21.0%)
All natural sciences (n=56,153)	Regular student (excl. international student and non-traditional student)	36,343	5,601	7,505	7,182	5,081	1,341	2,397	1,218	6,018
	(Proportion)	(100%)	(15.4%)	(20.7%)	(19.8%)	(14.0%)	(3.7%)	(6.6%)	(3.4%)	(16.6%)
	International student	9,217	1,965	1,793	300	1,036	315	822	140	2,846
	Non-traditional student	9,297	1,351	232	2,557	2,815	429	734	60	1,119
	Unknown	1,296	139	44	526	84	19	103	24	357
	All students	56,153	9,056	9,574	10,565	9,016	2,104	4,056	1,442	10,340
	(Proportion)	(100%)	(16.1%)	(17.0%)	(18.8%)	(16.1%)	(3.7%)	(7.2%)	(2.6%)	(18.4%)

Note: For "university faculty," "postdoctoral researcher," and "teacher, physician, public employee," the total sum of students employed as each category is shown. For "private corporation" and "public research institute," the number of those who are employed as the categories mentioned in the left is deducted. "Public research institute" includes independent administrative institutions, government-affiliated corporation, national testing and research institutions, and public testing and research institutions.
Source: Prepared by MEXT based on NISTEP: "Career Trends Survey of Recent Doctoral Graduates"

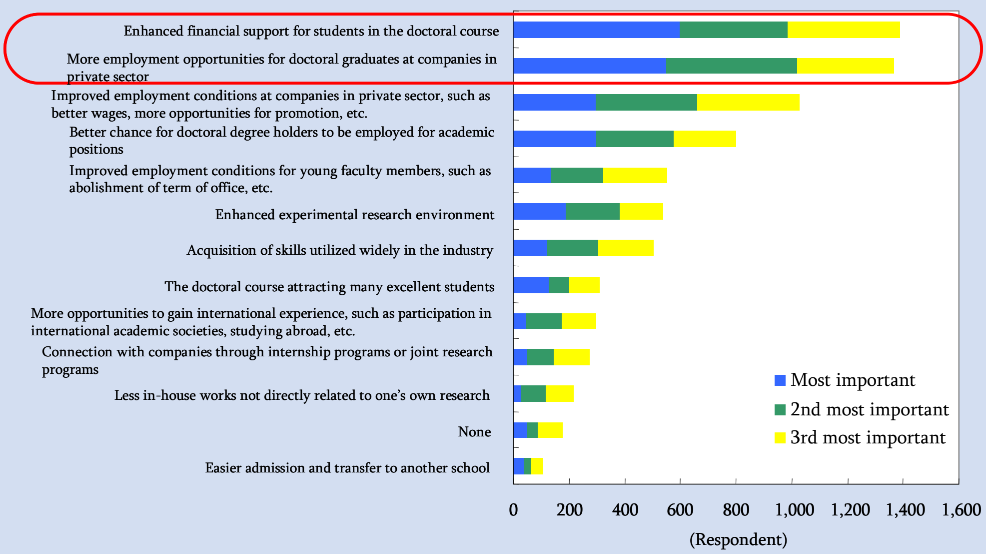
Table 1 2 9 Career paths of doctoral graduates who become postdoctoral researchers immediately after their completion of the courses



Source: NISTEP: “Career Trends Survey of Recent Doctoral Graduates”

The possibility of not being able to find jobs immediately after completing the doctoral course or the tendency of a prolonged postdoctoral period can be the source of concerns for students in the master’s course when considering proceeding to the doctorate. An attitude survey conducted by NISTEP with the students in the master’s course of major graduate schools of sciences and engineering shows that, regarding the important conditions to decide whether or not to proceed to a doctoral course, many people pointed out two things: “sufficient financial support for students in the doctoral course” and “more employment opportunities for doctoral graduates at companies in private sector.” (Table 1-2-10)

Figure 1 2 10 Conditions to be considered when choosing whether or not to proceed to a doctoral course



Source: NISTEP “Attitude Survey on the Career Choices of Students in Master’s Courses of Sciences and Engineering in Japan”

(3) Diversified Career Paths for Doctoral Degree Holders

1) Enhanced functions of graduate schools in relation to human resource development

While there is increasing number of doctoral degree holders in other countries, it is an urgent task for Japan to arrange an environment for students with adequate capability to choose to proceed to a doctoral course with hope. For that purpose, graduate schools (with doctoral courses) are supposed to play important roles to make an attempt to enhance and strengthen their functions developing human resources.

In the report "Graduate School Education in the New Age: Toward the Development of Internationally Attractive Graduate School Education (September 2005)" prepared by Central Council for Education of MEXT, it says that doctoral courses "consist of curricula to provide fostering to enhance their capacity to conduct research important enough to support their own research activities and to provide themselves with opportunities to work actively in various areas of society requiring their superior expertise, and to provide opportunities to acquire abundant knowledge and experience as their foundation." This means that if the students have acquired such knowledge and experience, they should have enough opportunities to work actively in private companies or in other various sectors of society. Nevertheless, in reality, there are doctoral graduates whose evaluations are not high enough in the industrial sector or others that there are requests for further enhancement of graduate education. Expert Panel on Basic Policy of Council for Science and Technology Policy (CSTP) also presented some suggestions in a report entitled "Educational Reform for Graduate Students in Science and Technology Fields to Support the Foundation of the Future Industrialized Society" (January 27, 2010), illustrating several measures to be taken to foster science and technology human resources to be equipped with capability and knowledge with competitive advantage in a wide range of industries.

Doctoral courses will have to improve their curricula for educational research aiming to develop capable personnel with enough skills so that they can work actively in various sectors of society while attempting to maintain the quality of the graduate education by arranging appropriate procedures for admission and certification for the doctoral courses and by enhancing social credibility and evaluation in relation to awarding the doctoral degree.

In order to have the universities proceed with the educational reform for graduate studies, it is essential that the industry clarifies desirable images of doctoral degree holders and provide specific requirements for their capability and skills for the industry. The industry will also need to make contributions to the universities by participating actively in the arrangement of curriculum of educational research from their point of view considering the requests of the universities.

For that purpose, "Industry-Academia Partnership for Fostering Competent Persons" was established to provide the industry and the academia with opportunities to have conversation on a wide range of topics in relation to human resource development and to move to take specific actions. There are also some other efforts to enhance capability and skills of the doctoral degree holders and to diversify their career paths through some projects, including "Fostering Young Researchers for Innovation Creation" (Special Coordination Funds for Promoting Science and Technology) in which universities and private companies inside and outside Japan cooperate to foster young researchers to play the core parts of innovation creation.

In addition to the projects to enhance the graduate education and others, as mentioned above, it is important to enhance the leadership ability of university faculty and to change their recognition about their instructions practically given to the doctoral students. Some point out that many teachers are giving instructions on the assumption that the doctoral students should be involved in activities of the academia in the future, which may be one of the causes narrowing down the diversity in their career choices. It is the university faculty who need to know the needs of the industry and the society through some activities involving industry-academia-government collaboration, and to comprehend the images of human resources that the industry and the society are looking for.

Furthermore, it is also necessary to provide enough financial support for the students in doctoral courses since their worse financial situation compared to those of employed of the same generation should not hinder students in master's courses with adequate capability from proceeding to doctoral courses. In the United States, about 40% of graduate students are receiving financial support of the amount nearly equivalent to their living expenses[1]. The Japanese government is also providing financial aids for JSPS Research Fellowship for Young Scientists (DC), Teaching Assistant (TA), Research Assistant (RA), and others, but only about 15% of doctoral students are granted 1.8 million yen or more per year[2]. "The Third Science and Technology Basic Plan" states that their objective is "we will strive to enable 20 percent of doctoral students to receive an amount equivalent to their living expenses," and thus, the efforts should still be continued to achieve the objective.

The next section argues the possibility of future growth in the employment opportunities for the professions doctoral degree holders in natural sciences may want to find jobs[3]. Before that, however, the current number of employees in these professions should be presented[4] (Table 1-2-11). Here, referring to the professions for which the doctoral degree holders are employed, which were mentioned in the above survey on the career paths of doctoral degree holders in Japan, the professions in which expertise in the natural sciences may be fully utilized are picked up in the following table.

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[1] NSF "Science and Engineering Indicators 2010" Appendix Table 2-21

[2] NISTEP "Survey on Postdoctoral Fellows and Research Assistants.

[3] In this report, while the data related to the career path of doctoral degree holders is apprehended insufficiently, there is a problem of providing accurate estimation since we are still under discussion of possibility of increase in job opportunities in the future. From now on, it is essential to know the career trend of graduating students of each university and graduate schools (doctoral degree holder etc.).

[4] Here, physician, dentist, and pharmacist are excluded although these are typical professions in the medical sciences category. These professionals have to pass national exams (certification), which require them to complete the medical-related university courses (medical, dentistry, pharmaceutical), to obtain national certification (license) before being able to be employed, resulting in not included in the professions expected to enhance students' employment. However, although it is usually required to have a teacher's certificate to be employed as a secondary school teacher, if the university has a teacher-training course (certified university for teacher training), every student can obtain the license no matter what department they belong to. Therefore, secondary school teachers for math and sciences are indicated as the professions expected to enhance employment.

Table 1 2 11 Major professions expected to employ doctoral degree holders (natural sciences) and the number of current employees

	(K: Thousands)
(1) Researcher at the university or the public research institution	
・Full-time faculty member (physical sciences, engineering and technology, agricultural sciences)[a]	About 50 K
・Full-time faculty member (medical sciences)[a]	About 57 K
・Researcher at the public research institution (physical sciences, engineering and technology, agricultural sciences, medical sciences)[a]	About 41 K
・Postdoctoral reseacher (physical sciences, engineering and technology, agricultural sciences, other combined field)[b]	About 13 K
・Postdoctoral reseacher (medical sciences)[b]	About 2 K
(2) R&D-related position in the industrial sector	
・Researcher in the private corporation (physical sciences, engineering and technology, agricultural science, medical sciences)[a]	About 532 K
・Staff with knowledge of intellectual property (IP staff) in the industry[c]	About 43 K
(3) Professions with which doctoral degree holders can newly take active roles	
・Secondary school teacher for math/sciences[d]	About 12 K
・Office workers, technicians, IP or publicity staff at the university or the public research institution[e]	About 10 K
・IP staff[f]/ industry-academia-government cooperation coordinator [g] (national government, local government, public research institution)	About 12 K
・National public employee (on Administrative Service(I) Salary Schedules, Level I & Level II)[h]	About 56 K
・Local public employee (general administrative staff)[i]	(About 95 K)
・Science and technology communicator, entrepreneur (venture, etc.), others	

a FY2009 Report on the Survey of Research and Development
b Survey on Postdoctoral Fellows and Research Assistants (Apr. 2010)
c The number is calculated from the estimated total in the Survey on Intellectual Property Activities in 2008, deducting the numbers of IP staff and individual applicants at the offices that fall under the category "Education, technology transfer institution, public research institution, public servi
d Calculation based on School Teacher Survey in 2007
e Sum (net) of "Assistant research workers," "Technicians," and "Clerical and other supporting personnel at "Universities and colleges, "Public organizations,"and "Non-profit institutions" based on FY2009 Report on the Survey of Research and Development
f Sum of individual applicants from the estimated total in the Survey on Intellectual and Property Activities in 2008 plus registered patent attorneys (excluding those who are assumed to be in-house attorneys) and patent examiner, patent hearing examiner (fixed number)
g Citation from Industry-academia-government Collaboration Support Database
h Citation from FY2008 Survey on Recruitment of National Public Employees in Reguler Service, Reference 1-17 "List of Employee Turnover in FY2008
i Citation from abstract of Survey of the Fixed Number of Local Public Organizations in 2009 (as of Apr. 1, 2009) However, the number of the recruited in the examination for university students or graduate students is unknown.

Note: The figures in this table are calculated based on some of the different statistics mentioned above, so some may be doubling and others may be omitted.
Source: Prepared by MEXT

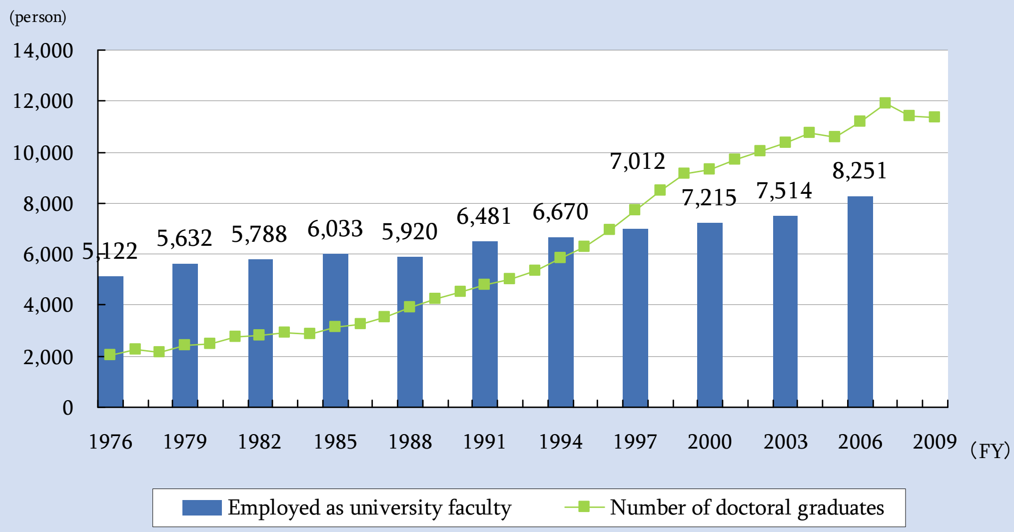
2) Trends in universities and colleges

The transitions of the number of those who have complete the doctoral courses in natural sciences, of the number of those who have been employed as university faculty, and of the age structure of the university faculty demonstrate (1) that the number of doctoral graduates exceeds that of those who have been employed as university faculty (Figure 1-2-12), (2) that the number of postdoctoral researchers tends to increase whereas the ratio of 37-years-or-younger faculty members with respect to full-time faculty members tend to decrease (Figure 1-2-13 and Figure

1-2-14), and thus (3) that it has been difficult to follow the academic career path "from the doctoral courses, via postdoctoral researchers, to university faculty" in recent years.

However, the structure of age distribution of university faculty illustrates that there are more baby boomers than those who were born before or after the baby boomers[1], so considering that these baby boomers may be retiring massively starting from around 2012, it is possible that universities and graduate schools take advantage of this opportunity to increase younger faculty members. Thus, universities may need to take this opportunity to review how they should manage younger researchers and those of advanced age in order to arrange an adequate personnel structure.

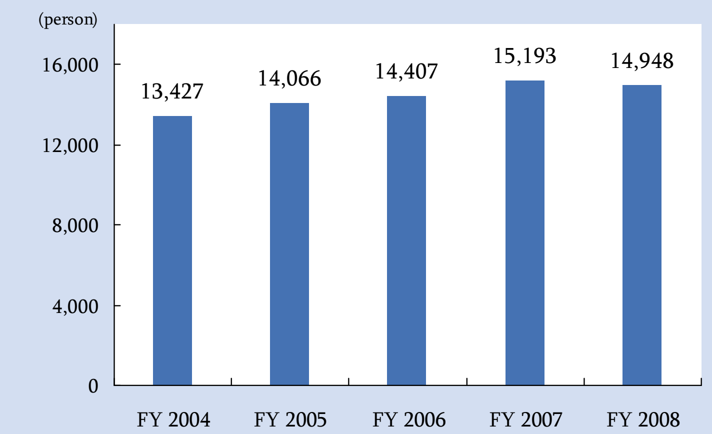
Figure 1 2 12 Trends in the number of employed as university faculty and doctoral graduates (natural sciences)



Source: Prepared by MEXT based on "School Teachers Survey" and " School Basic Survey"

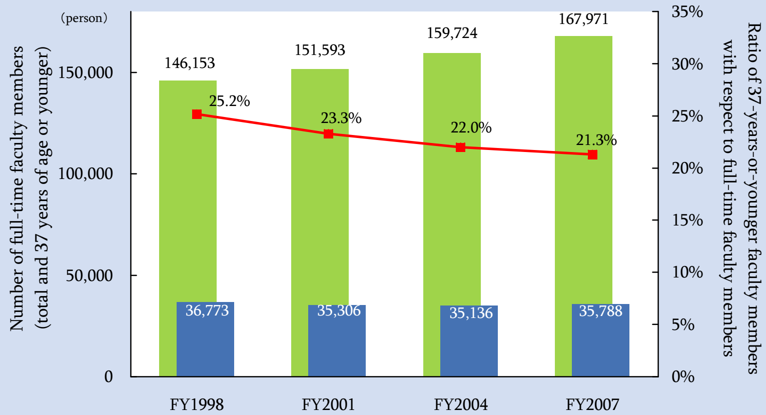
[1] The numbers of full-time university faculty for selected age groups are: 14,519 for ages 46-48, 13,281 for ages 49-51, 12,616 for ages 52-54, 12,661 for ages 55-57, 15,710 for ages 58-60, and 10,703 for ages 61-63, showing that there are more baby boomer university faculty than those who were born before or after the baby-boom generation. (FY 2007 School Teachers Survey)

Figure 1 2 13 Trends in the number of postdoctoral fellows in universities and public research institutions (natural sciences)



Note: The number of postdoctoral fellows in natural sciences is calculated from the total sum of postdoctoral fellows deducting the cultural and social sciences and unknown.
Source: Prepared by MEXT based on NISTEP "Survey on postdoctoral employment and financial support for doctoral enrollment"

Figure 1 2 14 Status of early-career faculty members at universities (all fields)



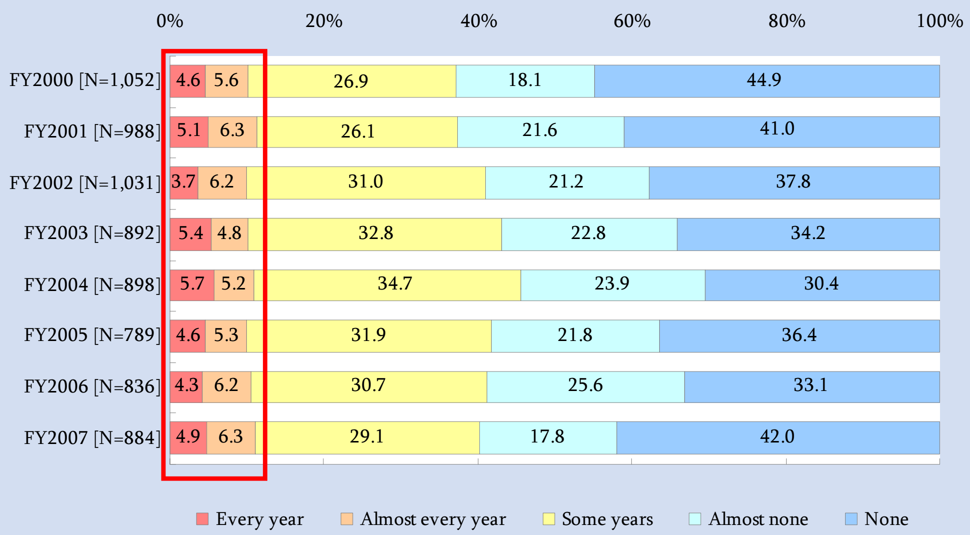
Source: Prepared by MEXT based on "School Teachers Survey"

3) Trend in the private sector

For doctoral degree holders, the corporations in the private sector are the principal places of employment along with universities and other research institutions. Calculation based on Table 1-2-8 shows that those who have found jobs at the private corporations account for about 16% of all the doctoral degree holders in natural sciences. When this calculation is limited to physical sciences, engineering and technology, and agricultural sciences, the figure jumps to about 24%. The proportion of the regular students finding jobs at the private corporations, excluding international and non-traditional students, is about 14% for natural sciences, being about 22% for physical science, engineering and technology, and agricultural sciences. In the United States, on the other hand, about 30% of the doctoral degree holders (mainly in natural sciences) employed as scientists or engineers are working for private for-profit[1].

According to the track record of doctoral degree holders' employment at the private corporations in Japan, the proportion of the companies saying "employing every year" or "employing almost every year" has been shifting around as low as 10%, showing their negative attitudes toward employment of doctoral degree holders (Figure 1-2-15). The proportion of doctoral degree holders among all the researchers in the private sector is as little as 4%. (Figure 1-2-16)

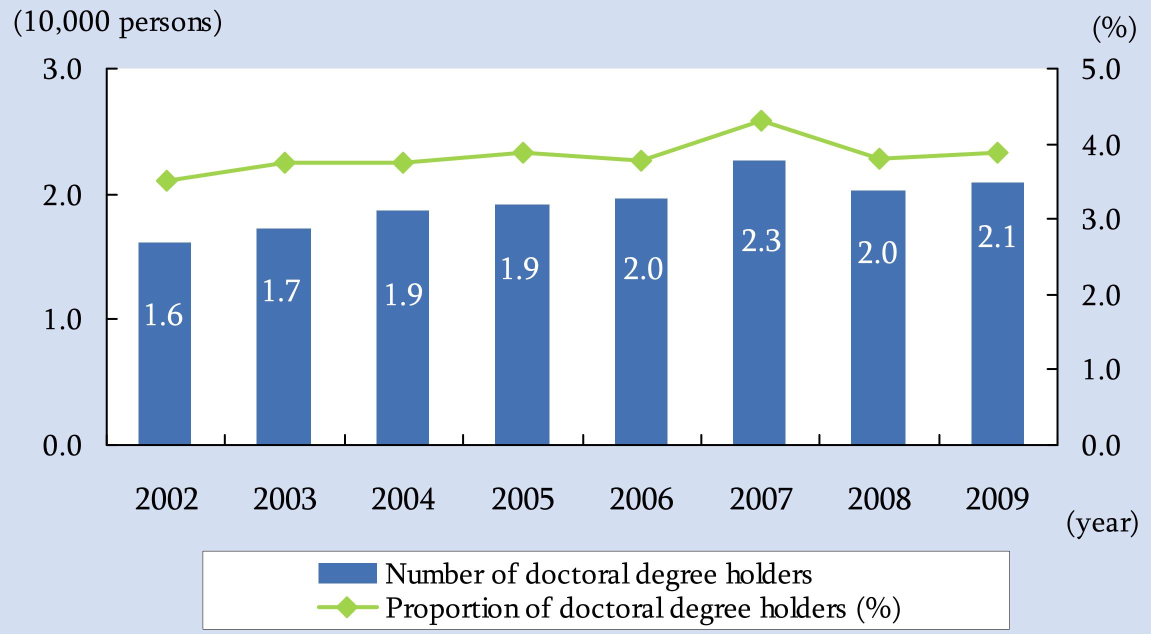
Figure 1 2 15 Record of doctoral degree holders employed as researchers in the private corporations



Source: MEXT "Survey on Research Activities at Private Corporations FY2007" (January 2009)

[1] See Table 12 in NSF "Characteristics of Doctoral Scientists and Engineers in the United States: 2006." The fields of doctorate in this table include psychology and social sciences.

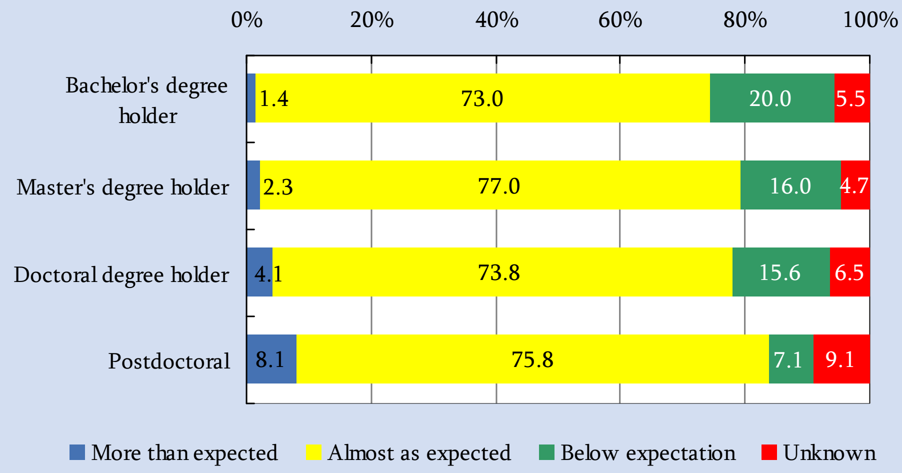
Figure 1 2 16 Number of doctoral degree holders at the private corporations and their proportion among all researchers



Note: "Doctoral degree holders" in this table include those who obtained the degree after being employed by the private corporation.
Source: Prepared by MEXT based on Statistics Bureau, MIC "Report on the Survey of Research and Development

Nevertheless, there should be increasing demand for doctoral degree holders among the corporations, considering the fact that the number of doctoral degree holders at the private corporations increased by about 30% (approximately 5,000 people) in the past seven years (Figure 1-2-16). In addition, the impression of the employed researchers in relation to their capability and skills, excluding that of bachelor's degree holders, was "more than expected" or "almost as expected," which accounted for about 80% of all the responses. The proportion of the answer "more than expected" was the largest among postdoctoral, followed by doctoral degree holder, master's degree holder, and then bachelor's degree holder. On the contrary, the proportion of the answer "below expectations" was the smallest among postdoctoral, followed by doctoral degree holder, master's degree holder, and then bachelor's degree holder (Figure 1-2-17). In sum, many private corporations are giving higher evaluation to doctoral degree holders and postdoctoral researchers whom they employed.

Figure 1 2 17 Impression about the researchers' capability and skills after employment



Source: MEXT "Survey on Research Activities at Private Corporations FY2007" (January 2009)

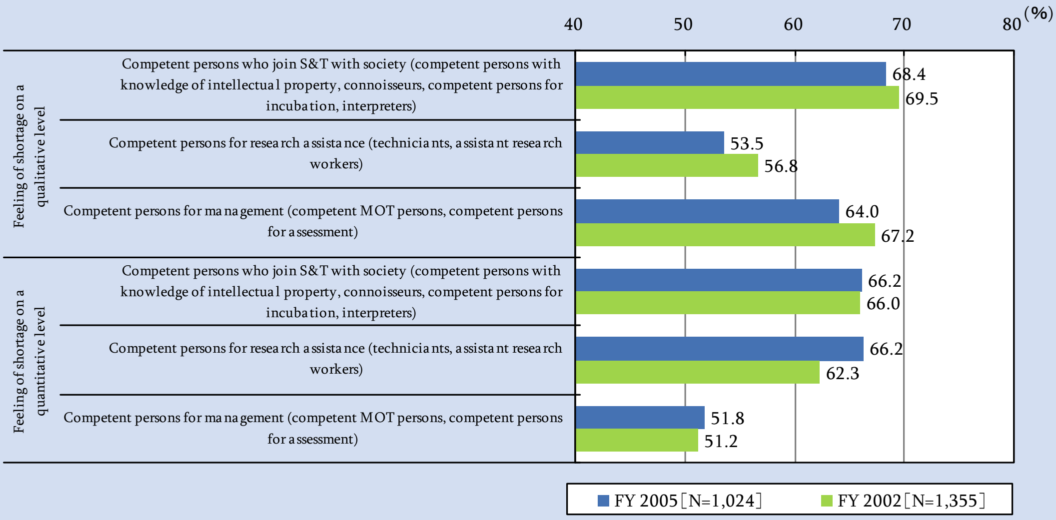
Although it is difficult to predict how the future trend of employment in the private sector will be under the influence of business conditions and fluctuating economy, there is a possibility that the employment of doctoral degree holders in the private sector expands as in the United States in the future considering the facts (1) that further globalization can possibly enhance the needs of the private sector for doctoral degree holders competent for the world's standard, (2) that non-traditional students enrolled in doctoral courses tend to increase in recent years and the number of such students who have obtained a doctoral degree while in the company have increased by approximately 5,000 for the past 7 years, (3) that the number of intellectual property staff in the private sector rose by about 9,000 in four years[1], from 39,024 in 2003 to 47,851 in 2007, and (4) that there are currently approximately 530, 000 researchers (natural sciences) in the private sector, with about 24,000 to 26,000 new employees every year[2].

4) Professions expected to have more active participation of doctoral degree holders

While there are more close and complicated relations between S&T and society, there are needs for new types of personnel in the science and technology fields, or in some interdisciplinary fields, such as competent persons who join S&T and society (competent persons with knowledge of IP, industry-academia-government cooperation coordinator, S&T communicator, etc.), competent persons for management who can control highly sophisticated science and technology (MOT persons, program officer, research administrator, etc.). (Figure 1-2-18)

1 Japan Patent Office "Summary of the Survey on Intellectual Property Activities in 2008"
2 Statistics Bureau, MIC "Report on the Survey of Research and Development"

Figure 1 2 18 Feeling of Shortage for S&T human resources



Note: Researchers' feeling of shortage implies the ratio of researchers who have a feeling of shortage of the relevant persons.
Source: MEXT "Survey of the State of Japan's Research Activities"

More specifically, when managing a competitive research fund, experts are essentially keys to the practical operation of the evaluation system for selection, evaluation, follow-ups, etc. for individual program, and the program officers are usually placed in the funding organizations to manage the issues to be researched. However, in most cases in Japan, researchers at universities and other institutions tend to hold the positions of the program officer at the same time and there are only a few cases of placing a full-time program officer in a funding organization. In the United States, on the other hand, a full-time program officer with a doctoral degree is placed in many cases, and for instance, National Institute of Health (NIH) has about 1,100 program officers, National Science Foundation (NSF) has 520 as of 2008. Comparing to the situation in the United States, it may be possible to conclude that Japan also needs to establish a reliable evaluation system to enhance the competitive research funds, and for that purpose, it is necessary to improve the personnel for the evaluation, meaning that placement of full-time program officers with doctoral degrees should be encouraged.

In addition, in the United States, there are many doctoral degree holders in the university management or administration, who are in charge of organizational management, attempting to enhance the universities' managerial functions[1]. For instance, a position called Research Administrator (RA[2]) is established as an expert to support research activities in terms of application and administration of competitive research funds. The work of such personnel elevates the level of university research in the United States, resulting also in creation of innovation. The personnel

[1] In the United States, about 30% of doctoral degree holders of science and engineering field after acquiring degree 4 to 7 years ago are employed by the university as Full time nontenured nonfacaulty including administrative positions (NSF "Science and Engineering Indicators 2010").

[2] RA's jobs are categorized into two types; the operations related to application for competitive research funds (pre-award) and the operations related to the matters after the fund is awarded. For example, in the United States, Pre-Award operations of an RA includes instructing how to write the application, supporting various application procedures, negotiating and writing contracts, settlement, etc. Post-Award includes accounting to control research expenses, supporting in preparing reports, etc.

capable of adequate management and administration of research activities with understanding of the research itself are the important human resources to take part in R&D and innovative activities in cooperation with researchers. Such personnel have traditionally been called research assistants, but in this White Paper, those who have such expertise are called "administrative and support staff."[1] It is desirable that in the future, doctoral degree holders will play active roles as the administrative and support staff to elevate the managerial functions and to create more specialized management in Japanese universities.

In addition, doctoral degree holders in natural sciences, who are good at mathematics and scientific subjects, are expected to work actively as math and science teachers in secondary schools. For instance, in 2008, Akita prefecture held a teacher recruitment examination targeting especially doctoral degree holders for the first time in the country for the purpose of placing the personnel with highly specialized knowledge and to enhance further the education of natural sciences and mathematics and to activate school education, and as a result, five doctoral degree holders were recruited for the first year.

Furthermore, it is necessary for universities to work on technology transfer to the industry and society and to promote and enhance partnership with the industry, other research institutions, local governments, etc., and for that purpose, the personnel specialized in such fields (industry-academia-government cooperation coordinator) need to be well trained further. In the laboratories of R&D or product development in universities or private corporations, there are needs for more people capable of conducting R&D activities while considering strategic protection and application of intellectual property. Doctoral degree holders in natural sciences are expected to take active roles in this field as the personnel required to have knowledge and experience in relation to the technology management, such as the intellectual property system, technology and management strategies, in addition to the highly specialized knowledge of science and technology. As science and technology are becoming more sophisticated, it has become more important to inform the general public about science and technology in a simple but understandable manner and to enhance accountability and functions of universities as information providers through communication with them. The personnel as science and technology communicators are increasingly needed to play such roles, and it is doctoral degree holders with highly specialized knowledge who are expected to work actively as employees at museums of science and others or as scientific journalists.

As stated above, there are increasing needs for such personnel, and in the future, such positions should be firmly established as stable professions. Currently, estimates show that there are about 120,000 math and science teachers in secondary schools, about 100,000 employees as office workers, technicians, IP or publicity staff in universities and others, about 12,000 IP staffs and industry-academia-government cooperation coordinators in the national and local governments and in public research institutions, accounting about 230,000 employees for these positions in total. (Table 1-2-11). Doctoral degree holders seem to represent only a small percentage of these personnel (Table 1-2-7), but considering the above-mentioned needs for doctoral degree holders, there is a sufficient possibility that their employment opportunities might enhance in the future. In

[1] When citing the existing statistics or survey, the terms equivalent to research assistant used in the respective documents are used.

addition, 2,531 in total national public employees (on Administrative Service (I) Salary Schedule) were recruited through the level I and level II examinations FY 2008[1]. Currently, there are only about 100 national public employees who have doctoral degrees in natural sciences[2]. However, the guidelines for review of the recruitment examination system have been presented and the examination for graduate students will be established in the examination for comprehensive service for the purpose of securing versatile and promising human resources. Therefore, more doctoral degree holders are expected to choose the career path to become national public employees.

It may not an exaggeration to say that in the future, highly capable doctoral degree holders will take active roles in various sectors of society as a whole will be able to benefit from their expertise if the industry, the academia, and the governments work together as a whole.

Such a society will bring up an environment where young people with superior capability will choose to proceed to the doctoral course with hope, so that the scientific and technological capability of the whole country, including universities, will be enhanced. For that purpose, it is obviously important to foster doctoral degree holders with abundant fundamental experience and knowledge and, as a consequence, highly specialized knowledge, who will be able to work actively in various areas of society, but it is also important to create a society in which excellent doctoral degree holders can take prominent roles.

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1 NPA “FY 2008 Survey on Recruitment of National Public Employees in Regular service”

2 This indicates the employees of “national public” under the Japan standard industrial classification. The “national public” includes national organizations such as national diet, courthouses, central government agencies and other regional agencies where offices for legislation, judicial and administrative works are separated.

Column 4 Doctoral Degree Holders Working Actively in the Society

Visiting schools for a lab class (Cutting DNA with an enzyme)
Photo: Mr. Kingo Endo

"When one is awarded a doctoral degree in science, he (or she) will start to work at a university or a research institution devoting oneself in the research while competing with other researchers in the world to find new facts from the research, and then makes contributions to the society. You may have such an image about your future. Obviously, there are many doctoral degree holders who aim to become a leading researcher. However, there are also many young doctoral degree holders who are fully utilizing their knowledge and skills acquired in the doctoral courses and working as a variety of professionals other than as researchers.

Mr. Kingo Endo, a biology teacher at Akita Minami Senior High School (expertise: molecular biology), visits elementary and junior high schools in the prefecture to give lectures. His lectures mainly consists of a variety of experiment, such as experiment of extracting DNA from familiar food (banana), DNA profiling applying the PCR method[1], DNA sequencing[2], experiment of genetic modification, etc., selecting according to the levels of students at elementary or junior high schools. Students who attended his lectures have also given positive feedbacks. "I wasn't interested in biology so much, but the experiment and the teacher's explanation made me want to study the structures of living creatures," said one student. And another said, "I couldn't understand the PCR method in the class of Biology II, but I am happy to have attended this class today because now I understand it." Mr. Endo's visiting classes are based on his research in the graduate school and the lectures in the undergraduate school as a teaching assistant, making arrangement for the students of elementary or junior high schools. The expenses for the experiment in the classes are partially funded by the Grants-in-Aid for Encouragement of Scientists. "I learned how to obtain this competitive research fund in the doctoral course," says Mr. Endo. "Now we are required to find a way to fund our research from outside source or work on outreach activities even in the academic career, so it is necessary to have extra value other than our own expertise."

Mr. Yuki Uchida, also a teacher of physics at Akita Minami Senior High School (expertise: theoretical physics), is trying to be inventive in his classes giving his students enough time to draw figures and think by themselves while checking the progress of students' understanding so that they can actually understand with concrete image of abstract principles when he gives lectures at school. He sometimes goes distracted with a topic of state-of-the-art physics in the class. However, "I don't think the students have to understand everything about the state-of-the-art topics. If a handful of students find it interesting and think they want to study further, that's what I intend to do," he commented. "It's always a pleasure of mine just to teach something new to my students. If possible, I'd like to see an exceptionally excellent student to become a world's first-class researcher who will be awarded the Nobel Prize in the future," he added, and he went to his class room to give his regular lecture as usual. Having an experience of being employed at a private corporation with his doctoral degree before changing his career as a teacher, Mr. Uchida says with a smile, "I believe the attribute to think and structure things logically that doctoral degree holders have as an ability is necessary not only for a researcher but also in every aspect of the society. I would like doctoral students to have courage to step forward."

Mr. Motoyuki Okada, Director of Ueda Textile Science Foundation and Office manager of AREC[3] (expertise: polymer chemistry), is now working as an industry-academia-government cooperation coordinator, fully utilizing his background as a doctor of engineering. In the "Innovation Coordinator Award," founded by Japan Science and Technology Agency (JST) in 2009, he was awarded the 1st innovation coordinator grand prize and the commendation by the Minister of Education, Culture, Sports, Science and Technology. He was awarded

1 Method to identify differences between an individual or the race from the difference in partial DNA sequence.
2 Polymerase chain reaction method. A technique to amplify the specific region of DNA strand in short period of time by using a very small quantity of DNA.
3 ASAMA Research Extension Center

because "he has established 'AREC,' an industry-academia-government collaboration supporting facility in the Nagano region to build a network connecting the industry, the universities, and the governments. He has promoted establishment of many businesses through this facility as the base point, and his leadership has been exceptional." Mr. Okada, who has an experience as an employee at Ueda City Office, commented, "The knowledge of engineering doctor may have nothing to do with the normal job as a public employee of the city office, but it is very meaningful for the job of a coordinator who connects the universities, companies, and city administration."

Ms. Yuko Morita, a science communicator at National Museum of Emerging Science and Innovation (expertise: basic biology), explains, "The problem solving abilities have been very helpful for the job of a communicator, which I acquired in the process of conducting my research. I would like many people to feel close to science and enjoy it, so I think this job requires to be very creative to show difficult science in a way that everybody can understand easily even in some exhibitions and events of very specific topics, and it also requires knowledge or a point of view of completely different fields. I acquired in the graduate school the ability to sense where to find the keys to solve the problems." Ms. Morita was involved with "Doraemon's Scientific Future," an exhibition held in June 2010, from the planning stage. "First of all, we determine the concept of the exhibition while reviewing the Doraemon's world of science fiction from the scientific point of view. Then, we look for any real research similar to the dreams or tools used in the cartoon, visit the researchers and laboratories (companies) with the research related to the subjects selected for the exhibition, and finalize what to display specifically. It requires so many processes to carry out an exhibition," she explained.

Mr. Tetsuo Tomii, science journalist at Nikkan Kogyo Shimbun Ltd. (Business & Technology Daily News) (expertise: biophysics), says, "There are similarities between the job of a journalist to write an article and the research. When there is a problem, it is the job of a researcher to conduct experiment to clarify everything, whereas the job of a journalist is to find out a key word or a key person through internet or other information sources and interview people to find solutions. Although experiment and interview are two different things, but the processes are similar." Mr. Tomii took the opportunity of "Non-research Career-Path Support Program at Nagoya University," which was part of the MEXT's "Project to Promote Diversification of Career Paths for S&T-related Human Resources," to become a journalist after experiencing a period of postdoctoral researcher. He was the first postdoctoral researcher to be employed at this newspaper company. "I acquired during the process of completing a research theme "the ability to frame a hypothesis and to clarify or explain it logically, which is logical thinking," and this can be fully used for various jobs in the society. I believe those who have experienced the postdoctoral researcher should have confidence at least in what they have as an experience that other people don't have when they choose to go outside of the research world," added Mr. Tomii, sending this encouraging message to the students in doctoral courses and the postdoctoral researchers.

(4) Creating an Environment to promote Young Researchers' Independence

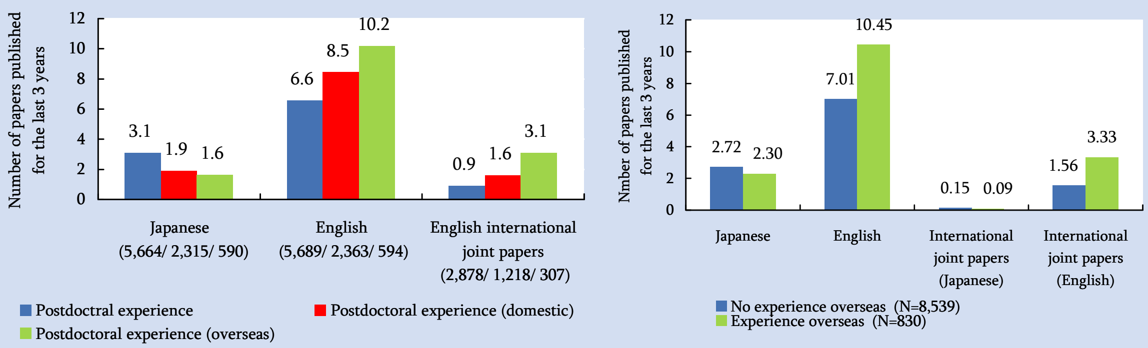
1) Meaning and importance of fostering young researchers

In the world where the intellectual, technological, and economical competition are intensifying internationally, fostering of young researchers with superior capability in science and technology and promotion of their active work are essential to develop science and technology of Japan to the level compatible with that of the rest of the world, and it is necessary to raise young researchers who can make their presence felt in the world.

Researchers with experience of postdoctoral researcher have published more English-language papers on average than researchers without such experience [Figure 1-2-19(1)]. In addition, researchers with experience of overseas full-time job have published more English-language papers on average than researchers without such experience [Figure 1-2-19(2)]. These results show that experience of postdoctoral researchers and overseas full-time jobs are important in fostering young researchers who can fully function internationally. In particular, earlier experience in living overseas at relatively younger ages, including postdoctoral researchers, means increase in opportunities of participating in international researchers' networks at an early stage and of proving their existence in the world. Thus, it may be necessary to enhance the projects to offer opportunities to conduct internationally-compatible research activities at overseas research institutions for excellent young researchers, including postdoctoral researchers.

Figure 1 2 19 Postdoctoral researcher and overseas experience vs. paper productivity

(1) Postdoctoral experience vs. paper productivity (2) Overseas experience vs. paper productivity



Note: Survey of full-time researchers (including postdoctoral researchers) at universities, public research institutions, etc. conducting research on natural sciences
Source: NISTEP "A survey about mobility of researchers and diversity of research organizations"

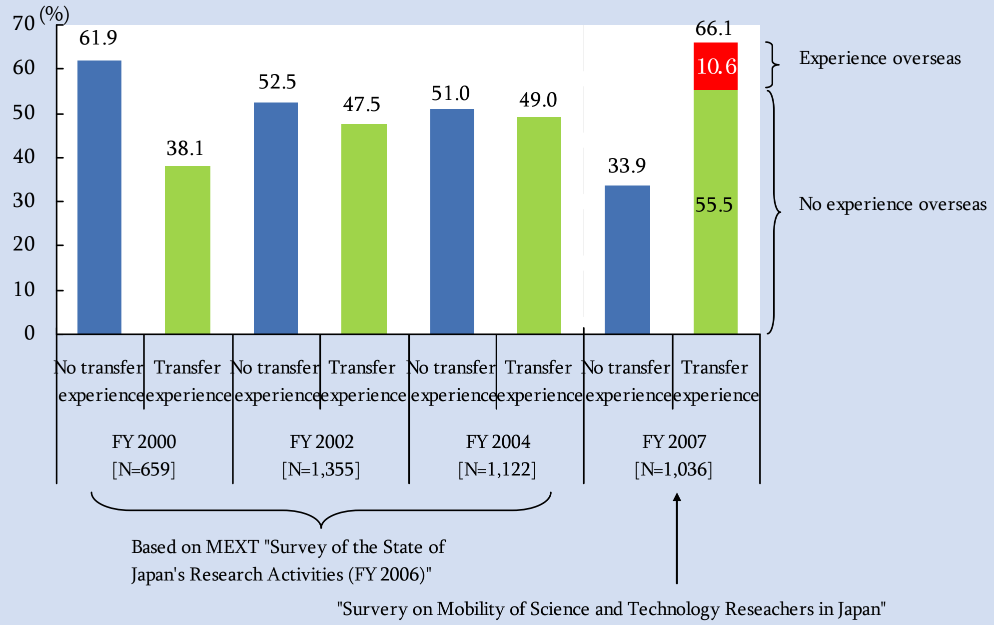
2) Mobility of young researchers

Looking at the statistics of domestic or international mobility of young researchers in Japan, those who have moved before accounted 66.1%, which was an increase compared to the past figures, but among these figures, only 10.6% had an experience of living overseas (Figure 1-2-20). In addition, of all the respondents to this survey, only 2.0% answered that they have a plan to do research overseas in the near future. In an annual report on science and technology promotion (White Paper on Science and Technology 2009), it was pointed out that the Japanese researchers' domestic-oriented attitudes were clearly demonstrated, and the tendency has not changed significantly so far. According to "2008 Expert Survey on Japanese S&T System and S&T Activities by Fields (March 2009)," some of the reasons for not seeking employment or studying at overseas universities or research institutions are concerns about employment when they come back to Japan and no promising prospect of sufficient reward for studying abroad.

In addition to the existing support program of overseas training for young people funded by Japan Society for the Promotion of Science (JSPS), the Japanese government drew up a budget for programs for intensive overseas training for young researchers in the supplementary budget for FY 2009 and the national budget for FY 2010.

In addition to such measure, it is necessary to make an attempt to establish adequate system to secure their positions at universities and other research institutions back in Japan and to consider researchers' overseas experience and others at the time of examination for recruitment.

Figure 1 2 20 Presence and absence of transfer experience and work experience overseas



Note: Fiscal year is the time investigated. It includes researchers not only at universities and public research institution but also in the private sector.
Source: NISTEP and MEXT "Survey on Mobility of Science and Technology Researchers in Japan"

3) Environment improvement to promote young researchers' independence —implementing and establishing the Tenure-Track System

When fostering young researchers, it is particularly important to provide opportunities for research activities, to promote researcher independence and to build their foundations for their future research. In FY 2006, MEXT implemented the "Promotion of Environmental Improvement to Enhance Young Researchers' Independence" as part of the Special Coordination Funds for Promoting Science and Technology to support research institutions that are implementing the Tenure-Track System[1]. As of the end of FY 2009, 34 universities have implemented the Tenure-Track System, through which 387 young researchers were employed from 2006 through 2008.

At this moment, there are not so many universities implementing the Tenure-Track System and not many young faculty members employed through the System (the number of tenure-track faculty members), but this system has been highly evaluated in the following points[2];

- The system has provided an opportunity to create positions for young researchers and to reexamine the human resource management beyond the boundary of departments, including cultivation of young researchers.
- Generally talented young researchers have been employed through this system, producing

1 A system in which young researchers recruited through a fair and highly transparent selection can accumulate experience as self-supporting researcher during the limited tenure of employment before applying for an examination to obtain more stable job.
2 Committee on Human Resources, Council for Science and Technology "Training and Promotion of Human Resources to Lead the Knowledge Based Society" (Aug. 31, 2009)

positive outcomes in an improved research environment.

-This system provides fair recruitment procedures with high transparency and steadier job supply, offering attractive opportunities for postdoctoral researchers.

As a result of the budget screening in November 2009, Government Revitalization Unit requested to reduce the budget for Special Coordination Funds for Promoting Science and Technology intended for the above-mentioned cultivation of young researchers, but many researchers showed objections regarding this result of the evaluation. One researcher says, "Without permanent implementation of the Tenure-Track System in Japan, talented young researchers will move overseas and they will never come back," and another says, "The Tenure-Track System can resolve problems in relation to postdoctoral researchers, so it should rather be enhanced." Many commented to request implementation of enhancement of the Tenure-Track System.

The Tenure-Track System provides fair evaluation of excellent researchers for selection and can serve as a goal for talented young researchers to be highly motivated if universities attempt to administer the system properly. In fact, four universities (Hokkaido University, Tokyo University of Agriculture and Technology, Shinshu University, and Kyushu University) that received relatively high evaluations in the interim evaluation under the program "Promotion of Environmental Improvement to Enhance Young Researchers' Independence" are planning to offer tenured positions[1] for many tenure-track faculty members with the cooperation of all the universities, utilizing this system as a system "to keep talented personnel" while selecting talented researchers by means of recruitment examination and confirming it during the tenure-track period.

As stated above, this system is necessary to promote activities of talented young researchers, and in the future, it will be necessary to start working on implementation and permanent administration of the system in order to establish the career path, "from a doctoral course, via a postdoctoral researcher, a tenure-track faculty member, and then a tenured faculty member," to function as an important academic career path.

In addition, for the purpose of providing young researchers with opportunities to conduct research independently and to play active roles, it is necessary to enhance research funding for young researchers so that they will be able to devote themselves in the research activities in positive and creative manners and to utilize fully their capability to vie with each other. Thus, in addition to the existing competitive research funds, including Grants-in-Aid for Young Scientists, Council for Science and Technology Policy reviewed all of the Funding Program for World-Leading Innovative R&D on Science and Technology drawn up in the first supplementary budget for FY 2009, and decided to spare 50 billion yen for a new support program for young researchers, "Funding Program for Next Generation World-Leading Researchers." The budget for FY 2010 establishes "Funding Program for Strategic Enhancement or World-Leading Innovative R&D" to enhance the research base for young researchers.

(5) Developing Human Resources for the Next Generation

1) Current academic ability in science and math of human resources for the next generation

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1 For instance, job stability for associate professors who do not have fixed terms.

To develop and secure the high-talent personnel in science and technology in Japan for the future, it is crucial to enhance gradually the curiosity, interest, abundant creativity, and academic grounding in math and science of children and students who will become leaders of the next generation.

From the international evaluation programs of scholastic performance in the primary and secondary education, "OECD Programme for International Student Assessment (PISA)" and "Trends in International Mathematics and Science Study (TIMSS)," it was found that the average score of mathematical literacy[1] of Japanese students in PISA dropped from 534 points to 523 points, demonstrating some problems, in relation to mathematical literacy[1], with ability to apply their knowledge and skills in practical situations. (Figure 1-2-21)

Figure 1 2 21 International academic assessments (PISA and TIMSS)

◇OECD Programme for International Student Assessment (PISA)

: Surveyed by OECD targeting 15 year-old students (1st graders in Japanese high school)

		2000		2003		2006
Mathematical literacy	Among all participating countries	1st/32 countries Mean score:557		6th/41 countries Mean score:534		10th /57 countries Mean score:523
	Among all OECD member countries	1st /28 countries	(※)	4th/30 countries		6th/30 countries
Scientific literacy	Among all participating countries	2nd/32 countries Mean score:550		2nd/41 countries Mean score: 548		6th/57 countries Mean score: 531
	Among all OECD member countries	2nd/28 countries		2nd /30 countries	(※)	3rd/30 countries

(※) Not comparable because testing methods, etc. differ.

◇Trends in International Mathematics and Science Study (TIMSS)

:International Association for the Evaluation of Educational Achievement (IEA) executes it targeting the fourth graders (elementary) and the eighth graders (junior high).

○Elementary

	1995	1999	2003	2007
	(26 countries/regions)		(26 countries/regions)	(26 countries/regions)
Arithmetic	3rd Average: 567	N/A	3rd Average: 565	4th Average: 568
Science	2nd Average: 553	N/A	3rd Average: 543	4th Average: 548

○Junior high school

	1995	1999	2003	2007
	(44 countries/regions)	(38 countries/regions)	(46 countries/regions)	(48 countries/regions)
Math	3rd Average: 581	5th Average: 579	5th Average: 570	5th Average: 570
Science	3rd Average: 554	4th Average: 550	6th Average: 552	3rd Average: 554

Source: Prepared by MEXT based on "2006 Report on the Survey OECD Programme for International Student Assessment (PISA)" and "2007 Report on the Survey Trends in International Mathematics and Science Study (TIMSS)"

[1] PISA defines the "mathematical literacy" as "an individual's capacity to identify and understand the role that mathematics plays in the world, to make well-founded judgments and to use and engage with mathematics in ways that meet the needs of that individual's life as a constructive, concerned and reflective citizen."

Column 5 Japanese Students' Excellent Job at the International Science Olympiads

Every year, secondary students get together from all over the world to compete in the "International Science Olympiads (ISOs)." In 2009, students representing Japan excelled in mathematics, physics, chemistry, biology, and informatics, awarded either gold, silver, or bronze medals.

<Remarkable Performance of Japanese Students in ISOs (2009)>

The International Mathematical Olympiad: 5 gold, 1 bronze (One of them ranked 1st[1], Japan ranked record-high 2nd.)
The International Physics Olympiad: 2 gold, 1 silver, 2 bronze (Japan ranked 11th)
The International Chemistry Olympiad: 2 gold, 1 silver, 1 bronze (Japan ranked record-high 6th)
The International Biology Olympiad: 1 gold, 3 silver (One of them brought first gold medal to Japan, Japan ranked record-high 6th.)
The International Olympiad in Informatics: 2 gold, 1 silver, 1 bronze (One of them ranked 2nd, Japan equaled record-high 6th for the second time.)

Mr. Ryota Otsuki awarded the gold medal at the ceremony of the 20th International Biology Olympiad

Photo: University of Tsukuba

The 20th International Biology Olympiad was held in Japan (Tsukuba) in 2009. Japan has been participating since 2005, sending 4 students each year, and awarded the first gold medal in the fifth trial. In 2010, the 42nd International Chemistry Olympiad will be held in Japan (Tokyo), and 280 students from about 70 countries are expected to participate.

Since 2004, Japan Science and Technology Agency (JST) has been supporting the organization of domestic and international competitions and the participation of Japanese teams in international competitions, and Japanese holding of international competitions. However, we should not forget the facts that there are domestic organizations involved with enormous preparatory works, such as selection of participants, arrangement of conductors, preparation of test problems, etc. as well as many individuals and corporations providing financial support.

The Japan Science Olympiad Committee, presided by Dr. Leo Esaki, conducted an attitude survey on science Olympiads (internet survey) in November 2009, targeting students in secondary schools, parents with children in secondary school, and math and science teachers, and about 50% of the respondents answered, "It is encouraging for children who want to become scientists" and "it will pull up Japan's scientific capability." Also, more than 90% answered, "I am confident about the future of Japanese science," demonstrating high expectations for talented young people.

The excellent performance in the international science Olympiads may provide good opportunities to foster the high-talent personnel in science and technology and can also be a chance to stimulate the interests and curiosity of many students and their parents in relation to sciences. Further efforts to increase participants in the international science Olympiads will be continuously expected in the future.

2) Interest and curiosity in science and technology

Regarding interest and curiosity of children in science and technology, the above-mentioned PISA shows that there are extremely fewer Japanese students who are interested in or having fun with science compared to children in other countries. Those who answered positively to the item, "learning science is fun," accounted 57% on OECD average where for Japan the percentage remains as low as 45%.

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[1] Country rankings were calculated according to the individual scores announced by the organizing body and not official data.

PISA shows that the percentage of positive answer to the item, “I would like to learn a lot in the science classes and make use of it when finding a job,” was 56% on OECD average whereas 39% for Japan, which is an extremely small figure. According to the analysis of National Institute for Educational Policy Research on PISA, the percentage of students who expect to have a job related to science and technology was about 17% for Japan, which is about half of that of the United States or Canada[1]. (Figure 1-2-22)

3) Potential of the talents for the next generation in relation to science and technology

In Japan, it is customary to take general math and science classes in the first year of high school and then to choose other subjects from the following year. Thus, students’ awareness about their career can be an important element, along with their academic capacity in math and science, to predict the future of the talents in science and technology.

With such awareness, National Institute for Educational Policy Research analyzed the result of the PISA survey and tried to compare internationally the indices of the degree of contribution of scientific education to the development of science and technology human resources[2].

First of all, defining the students who are hoping to be employed as S&T professionals at the age of 30 as “students expecting science-related careers” and the students with proficiency levels of scientific literacy[3] scores of level 5 or higher as “top performers in science,” in the United States, the percentage of students expecting science-related careers was larger but the percentage of top performers in science was smaller, on the other hand, in Japan and in Finland, the percentage of the students expecting science-related careers was smaller but the percentage of top performers in science was larger. (Figure 1-2-22)

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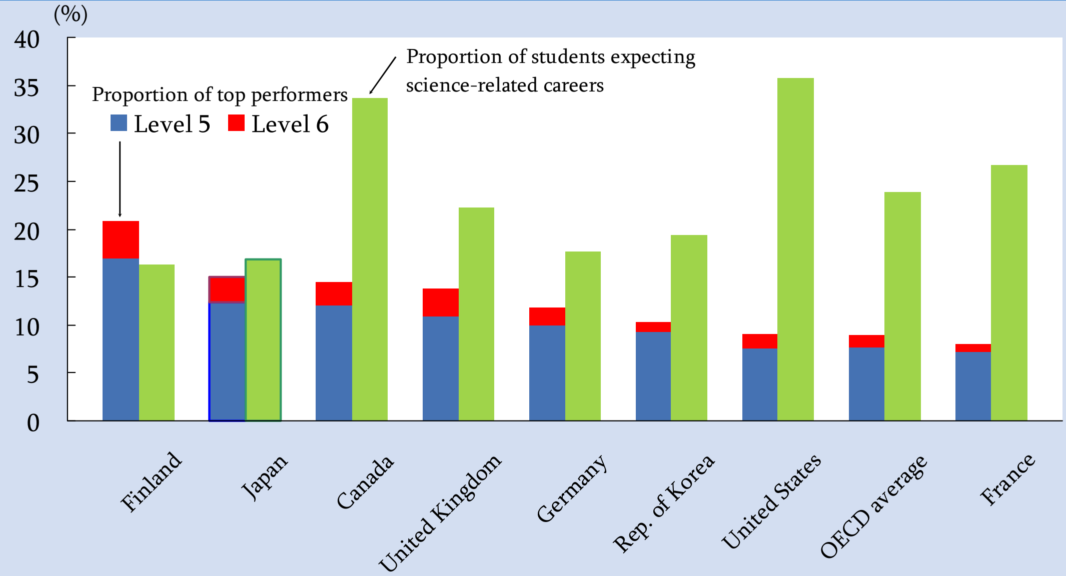
[1] In PISA, regarding one of the questions on the questionnaire targeting students, “What kind of job do you expect to have when you are about 30 years old?,” when an answer in free writing falls in one of the following 4 categories, sorted by the International Standard Classification of Occupations (ISCO88), the respondent is classified as “one who expects to have a job related to science and technology.”
(A) 21 Physical, mathematical and engineering science professionals; (B) 31 Physical and engineering science associate professionals; (C) 22 Life science and health professionals; (D) 32 Life science and health associate professionals.

[2] Regarding development for future human resources for science and technology through science and math education in each country, the following 3 important factors should be considered:
(a) Percentage of students who have career consciousness in science and technology in the country; among whom
(b) Percentage of students showing higher academic capacity in sciences; and
(c) The young population.
However, (c) is determined generally by non-educational factors, such as future birth rates, etc. Thus, when making indicators to measure the S&T human resources developing probability, (a) and (b) were taken into consideration for comparison and analysis among the three factors.

[3] “Scientific literacy” in PISA looks at the following capacities of individual’s:
-Scientific knowledge and use of that knowledge to identify questions, acquire new knowledge, explain scientific phenomena and draw evidence-based conclusions about science-related issues
-Understanding of the characteristic features of science as a form of human knowledge and enquiry
-Awareness of how science and technology shape our material, intellectual, and cultural environments
-Willingness to engage in science-related issues and with the ideas of science, as a reflective citizen
The PISA survey divide students into 7 proficiency levels according to the scores of scientific literacy, and the percentage of the students with this proficiency level of 5 or higher (top performers) of Japan is 15%, highest after Finland and New Zealand among the OECD member countries.

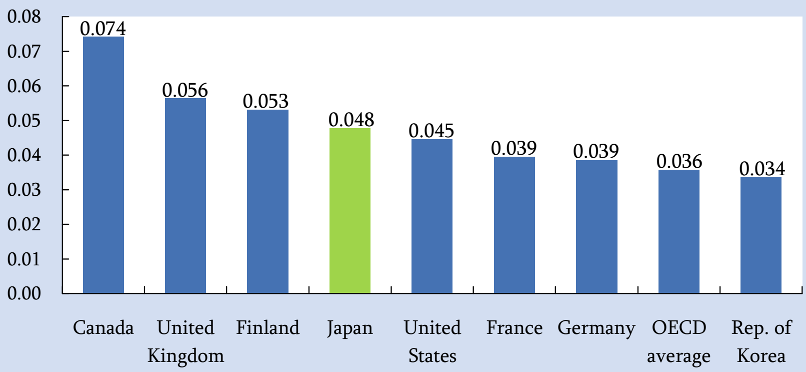
Figure 1-2-22 Proportion of students with career expectation, and with high proficiency in science and technology



Note: Citation of major countries only
Source: Prepared by MEXT based on the analysis of "2006 Report on the Survey OECD Programme for International Student Assessment (PISA)" and the PISA data done by National Institute for Educational Policy Research

According to National Institute for Educational Policy Research, based on the outcomes of the PISA survey, international comparison on "the number of students with high motivation for science and technology career and the students with high proficiency in science" show that the number of Japan (53,000) is the second highest following the United States (159,000). Furthermore, the numbers per capita show that Japan is not as many as Canada (74 per 1,000 persons) but it still shows relatively higher figure (48 per 1,000 persons). (Figure 1-2-23)

Figure 1-2-23 Percentage per population of the students with career expectation and high proficiency in science and technology



Note: Citation of major countries only
Source: Prepared by MEXT based on the analysis of the PISA data done by National Institute for Educational Policy Research

In the midst of rapid decrease in birth rates, it is necessary to make efforts to enhance continuously the interest of children in science and technology and to build systematic human resource development that enables uninterrupted improvement of talents at a developmental stage for the purpose of maintaining sufficient human resources that may lead the next generation in terms of both quality and quantity. MEXT and JST have been supporting the development and implementation of curricula that are not bound by the National Curriculum Standards or the empirical problem-solving learning experiences through promotion of special research or observation and experiment for high schools conducting advanced math and science education through the Super Science High School (SSH) program to increase the number of children who love math and science and to discover children with talents in science and technology while enhancing their extraordinary talents by means of enhancing math and science education at elementary schools and junior high schools, organizing classroom experiments and experiential learning, offering opportunities to communicate with excellent scientists and engineers, and providing support for local science museums, etc., and they also support organizing progressive leaning opportunities, such as “Fostering Next-Generation Scientists” and others.

2 Development of Creative Research Environment

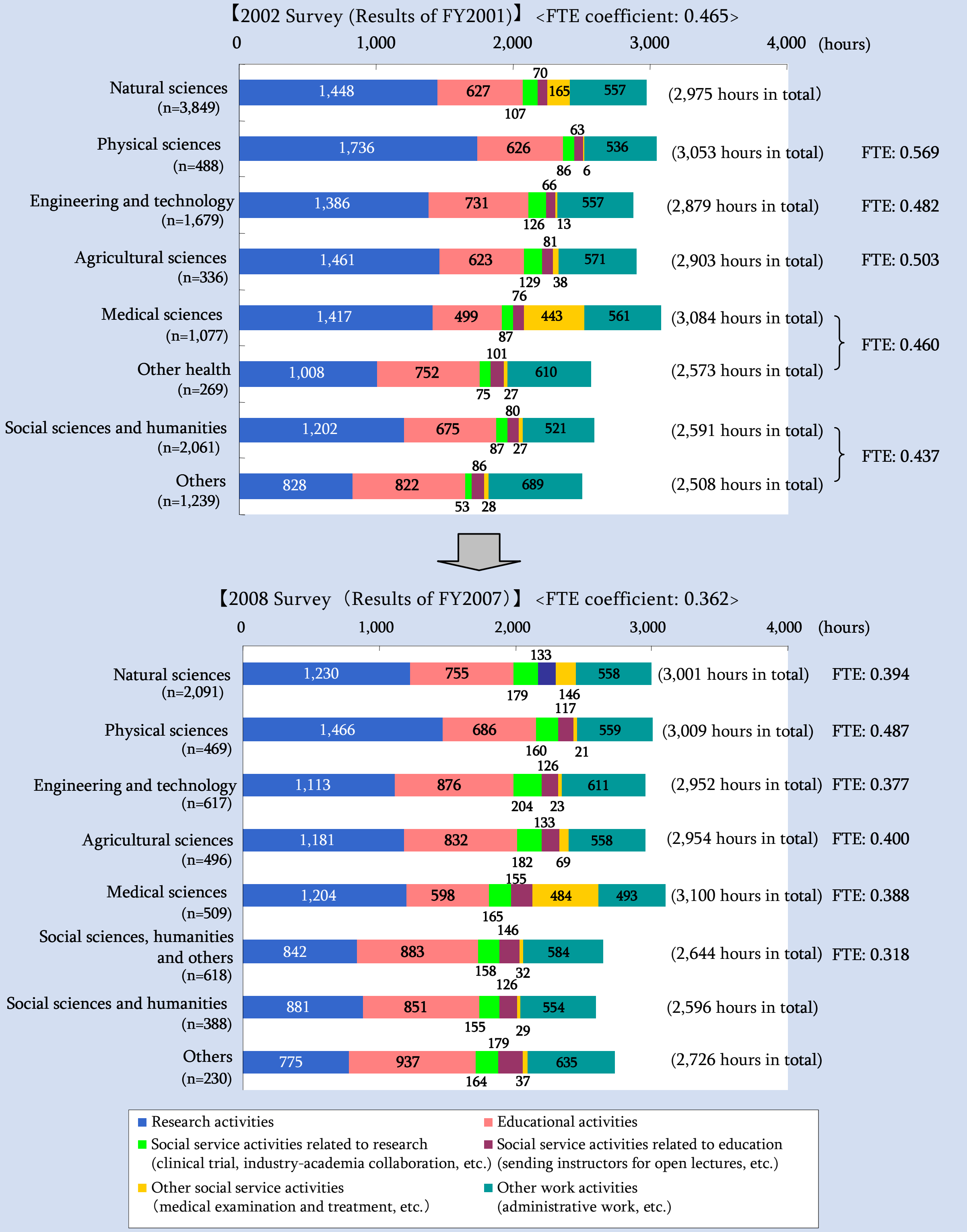
(1) Current State of Research Time

To produce outstanding research outcomes in the universities, it is essential to secure the time for research.

According to the outcomes of “Survey on Full Time Equivalent data for Research Staff members in Higher Education Organization” conducted by MEXT and looking at the change in full-time equivalent (FTE[1]) of the university faculty members, the average of all fields dropped from 0.465 to 0.362 in 6 years, from 2001 to 2007. Total working hours did not change so much in both natural sciences and social sciences and humanities compared to 2001, the hours for educational and social service activities increased although the hours for research activities decreased (Figure 1-2-24). Looking at the data by fields, the physical sciences show the longest hours of research activities whereas the engineer and technology show the longest hours of educational activities.

1 Abbreviation for Full Time Equivalent. FTE is the coefficient to indicate the ratio of researchers’ actual hours spent on research activity within total work hours. The value achieve from this revision is called FTE value. For instance, if the FTE coefficient is 0.4 and when the number of researchers (actual number) in universities is 100,000, the number of researchers can be revised to 40,000. Similarly, the research funds can be revised.

Figure 1 2 24 Change in total working hours and activities of university faculty (from FY2001 to FY2007)



Source: MEXT "Survey on Full Time Equivalent data for Research Staff members in Higher Education Organization" (September 2009)

In addition, from the expert survey on Japanese S&T system and S&T activities by field conducted by National Institute of Science and Technology Policy (NISTEP) in FY2009, it was found that many respondents pointed out that the obstacles to arranging an environment to focus on research at universities and others was decrease in time for research while evaluation, organizational management, and other works increased.

The same survey summarizes opinions related to measures to develop an environment to devote oneself to research in universities and public research institutions (Table 1-2-25). In the report, more efficient office work, enhancement of R&D and managerial functions, and further improvement of work share between university faculty and administrative staff were pointed out, and there are many needs especially for enhancement of office staff. Thus, it is necessary to improve their labor conditions and career paths (full-time employee or other position improvement) in order to recruit talented personnel. Cooperation with other researchers and change in their awareness are also required to improve the management of such organizations.

In the future, it will be necessary to develop a research environment by enhancing R&D support and managerial functions for researcher so that they will be able to use their time for research activities effectively and efficiently and to produce excellent research outcomes.

Table 1 2 25 Examples of views on measures to create an environment to devoted oneself to research

<Enhancing efficiency of office work, etc.>
-We should make efforts to carry out activities that were not frequently conducted, such as outreach activities, in a more effective way, considering the energy necessary for the activities. (Male, university dean level)
-It is not sufficient to streamline the office work, but the personnel system should be renewed to hire more talented people at the discretion of each institution so that these people can be placed in important positions. (Male, university director level)

<Increasing and enhancing research assistants>
-Necessary to streamline office works, to enhance personnel, and to simplify conference and paper work. It is also necessary to increase employees to reduce the workload of each worker. (Male, university director level)
-Research associates tend to be placed. We would like to have the personnel to be in charge of chores in each department. Otherwise, we would want allowance for the various office works. (Female, university chief level)
-Enhancement of research assistants. Program managers, talented secretaries, maintenance and machinery operators, English translation, drawing charts and tables, collecting information on research, the status of strategic assistants, their career paths. (Male, university dean level)
-Support system is too weak for faculty to devote themselves in educational research. It is necessary not only to simplify various procedures other than educational research and to enhance employees' capability, but also to train research assistants and to improve their status. (Male, university dean level)
-When we say we need more funding and assistants for research, they impatiently try to cut back some other budget to make up for it. It is not the matter of money but about the status of assistants and the problems of education and training system. No talented people would come to get the unsecured position, in which they don't know whey they will be fired. Assistants should be full-time employees. (Male, university director level)

<Division of functions among teachers and universities>
-For universities, education is also extremely important, so how about hiring faculty for educational purpose and for research purpose separately? (Male, university director level)
-It is better to separate the personnel for research and for management. Managers' job is management and it is impossible to spare time to do the both, so these should be separated and research personnel should be able to secure their time while arranging sufficient number of workers. (Female, university chief level)

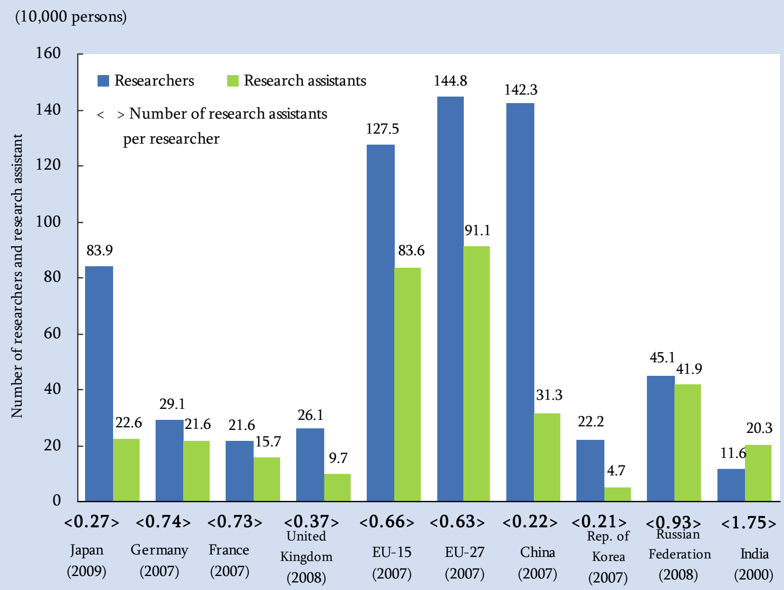
Source: Prepared by MEXT based on NISTEP "2009 Expert Survey on Japanese S&T System and S&T Activities by Fields"

(2) Current State of Administrative and Support Personnel

To produce creative research and to create innovation in university and other institutions, not only researcher but also various staff specialized in management of whole educational activities, intellectual property management, and maintenance and management of state-of-the-art facilities and equipment should work together to develop a structure in which all can promote their educational research activities in an effective manner. Educational research and innovation activities will produce maximal outcomes by combining such various human resources to work together as a united team utilizing fully their professional skills under the appropriate division of roles. To this end, it is important to secure and develop administrative and support staff so that they will be able to take part in the educational research activities while cooperating with researchers.

Looking at the number of research assistants per researcher in selected countries[1], however, Japan shows a lower level than the United States and Europe (Figure 1-2-26). In addition, the situation of such people in Japanese universities (natural Sciences), it is noted that "assistant research workers" and "technicians" have remained virtually unchanged whereas "clerical and other supporting personnel" has increased since 1998 (Figure 1-2-27). The background story is that the roles of university instructors have expanded outside of educational research activities while there is increasing demand for administrative staff in addition to increase in fixed-term employment of administrative staff utilizing competitive funds.

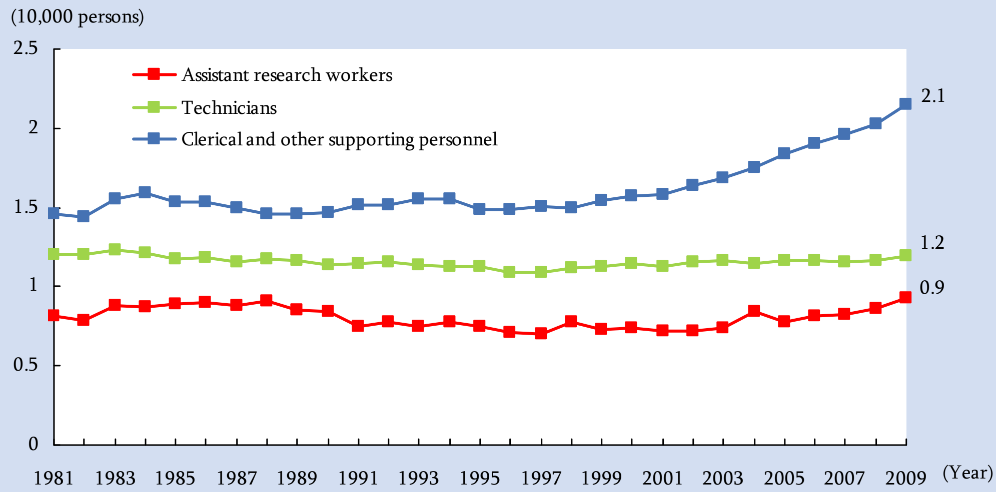
Figure 1-2-26 Number of research assistants per researcher in selected countries



Note:
1. The number of research assistants per researcher is estimated from the number of researchers and research assistants by MEXT.
2. Figures for all countries include social sciences and humanities.
3. Research assistants are those who assist researchers, provide technical services associated with research, or perform research-related clerical duties. In Japan, it refers to "assistant research workers", "technicians", or "clerical and other supporting personnel".
4. UK figures are provisional, and the number of research assistants may be underestimated or based on underestimated data. EU figures are estimated by OECD. China figures don't correspond exactly to the Frascti Manual recommendations.
Source: Japan: MIC Statistics Bureau "Report on the Survey of Research and Development "
India: UNESCO Institute for Statistics S&T database
Others: OECD "Main Science and Technology Indicators vol. 2009/2"

[1] The range of researchers and research assistants may vary from country to country, so it is important to note that it is not easily compared.

Figure 1-2-27 Trends in the number of research assistants in universities (natural sciences)

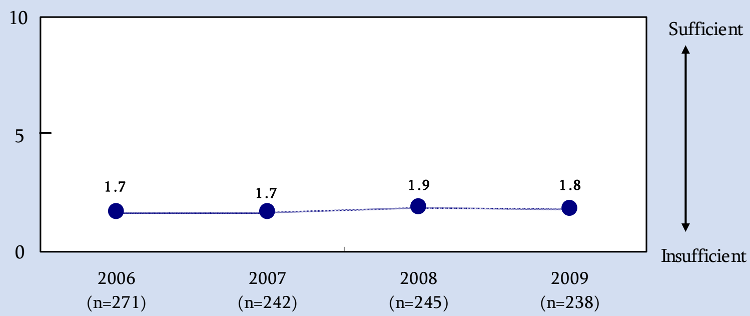


Source: Prepared by MEXT based on MIC Statistics Bureau "Report on the Survey of Research and Development"

However, the number of technical personnel (research assistants and technicians) has remained consistently low and the expert survey on Japanese S&T system and S&T activities by field shows, continuously since the survey in 2006, that the situation of the research assistants at universities have been significantly insufficient (Figure 1-2-28). In addition, many pointed out the increased administrative burden on researchers in the survey. Thus, although "clerical and other supporting personnel" tend to increasing in recent years, that is not sufficient to decrease the routine office works of university faculty. Furthermore, there are opinions to point out the deterioration in the structures of R&D support and management compared to earlier and to call for increase and enhancement of talented research assistants and other staff. (Table 1-2-25)

Figure 1-2-28 Awareness on the situation of university research assistants

Q: Do you think the university has a sufficient research environment (research assistant) to conduct basic research?



Note: Respondents may choose best suitable answer out of 6 different levels. They were also asked if they had experiences on the issue in the question. Indices were calculated based on the responses of the respondents who had experience on the issues in questions. The chart shows indexed figures of the 6-level evaluations converted into 10-point scale.
Source: Prepared by MEXT based on NISTEP "2009 Expert Survey on Japanese S&T System and S&T Activities by Fields"

However, as stated above, in the U.S. universities, professional staff in management and administration department is fully arranged, providing an environment that can promote effective educational and research activities. [See Chapter 2, section 1, 1, (3), 4)] In Japan, too, some R&D programs utilizing various competitive funding declare enhancement of supporting administrative system for R&D[1], but it is essential to enhance further the managerial functions in universities. Therefore, it is necessary to acquire doctoral degree holders, who have experienced in research activities, as the professional staff (research administrator, etc.) in the university managerial and administrative departments in order to enhance highly professional administrative and support staff, while it is strongly desired to establish their labor conditions and career paths.

(3) Current State of Improvement of University Research Facilities

University facilities and equipment constitute an essential foundation for the development of creative human resources and creative and cutting-edge academic R&D, so some of the prioritized systematic improvement has been carried out so far. In addition, universities are playing principal roles to promote improvement of educational and research facilities, industry-academia collaboration facilities, and others, while going into partnership with the industry, local governments, and other ministries and utilizing their own income from donation, etc. However, about 30% of all the facilities of National Universities are unrenovated deteriorating facilities, so the safety and the functionality of these facilities are the major issues (Figure 1-2-29). Meanwhile, budget for improvement of the facilities of National Universities tends to be reduced in recent years.

Over 60% of the directors of organizations in the universities of natural sciences answered that “they are not providing independent research spaces for postdoctoral researchers and other researcher-class workers who were newly employed or transferred,” revealing the fact that the space is not sufficiently provided for young researchers[2]. Furthermore, universities are also required to address various policy program and social request, including internationalization, community healthcare, and advanced medical care.

In the future, while considering such policy program, universities are required to improve strategically a highly complex, diversified educational and research environment while utilizing various funding.

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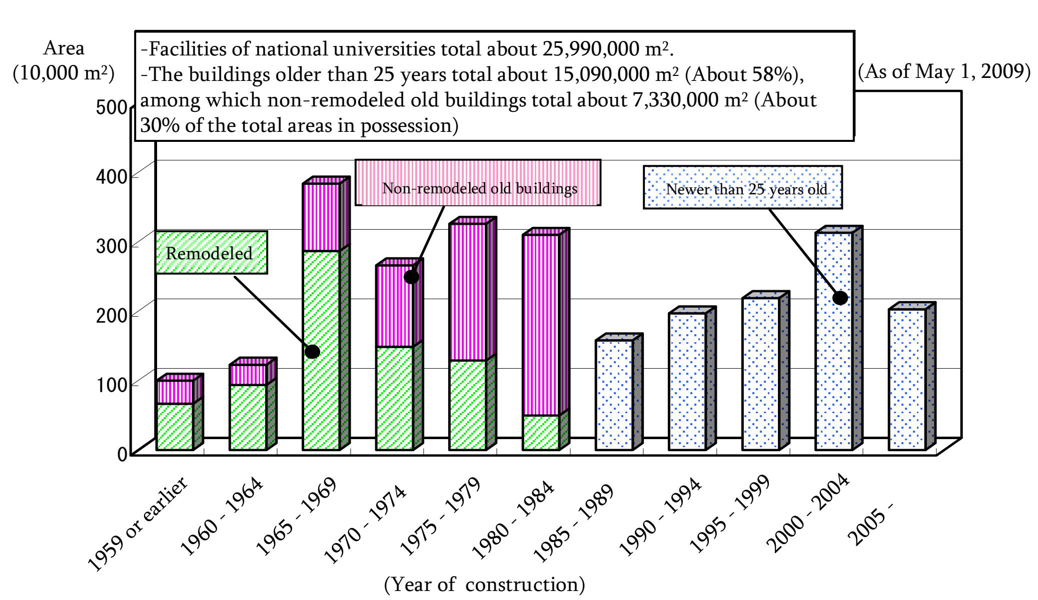
[1] For example, the “Funding Program for World-Leading Innovative R&D on Science and Technology,” which was started in FY2009, has established a brand new system, which never existed in the past, to support researchers;
-to establish a system in which researchers can concentrate on their research by organizing a research support team; and
-to secure funding with more freedom for researchers and for multi-year research;
placing “the most priority on researchers” so that they can fully utilize their capacity.

[2] NISTEP “A survey about mobility of researchers and diversity of research organizations” (NISTEP REPORT No.123)

Figure 1 2 29 Areas held by National University Corporations, etc. in selected years



Source: Prepared by MEXT

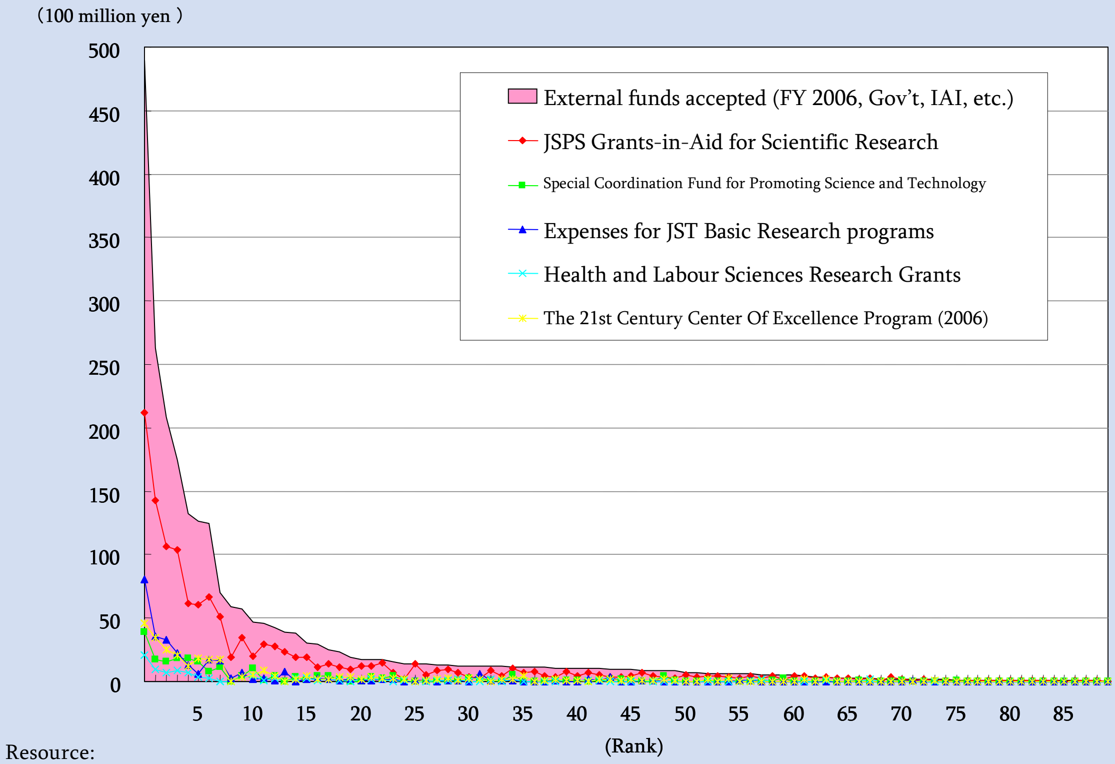
(4) Circumstances of Research Funds

1) Reform of the competitive funding programs and allocation

There is a variety of competitive funding programs depending on their objectives and characteristics, such as programs targeting the research based on free conception of researchers, R&D that follows political issues, basic or exit-oriented research, etc., for which budget has been enhanced in recent years. Other efforts are being made to arrange unified and flexible rules or to reform the programs in order to make the funds more convenient and outcome producing for researchers. As of FY 2009, 44 programs allow multi-year contracts or renewable annual contracts, while with Grants-in-Aid for Scientific Research, the percentage of diversion between sub categories not requiring the approval of the granter was raised from 30% to 50% of the total direct expenses. It also allows the fund to be practically available from the beginning of the fiscal year, by unofficially determining the expenses in April.

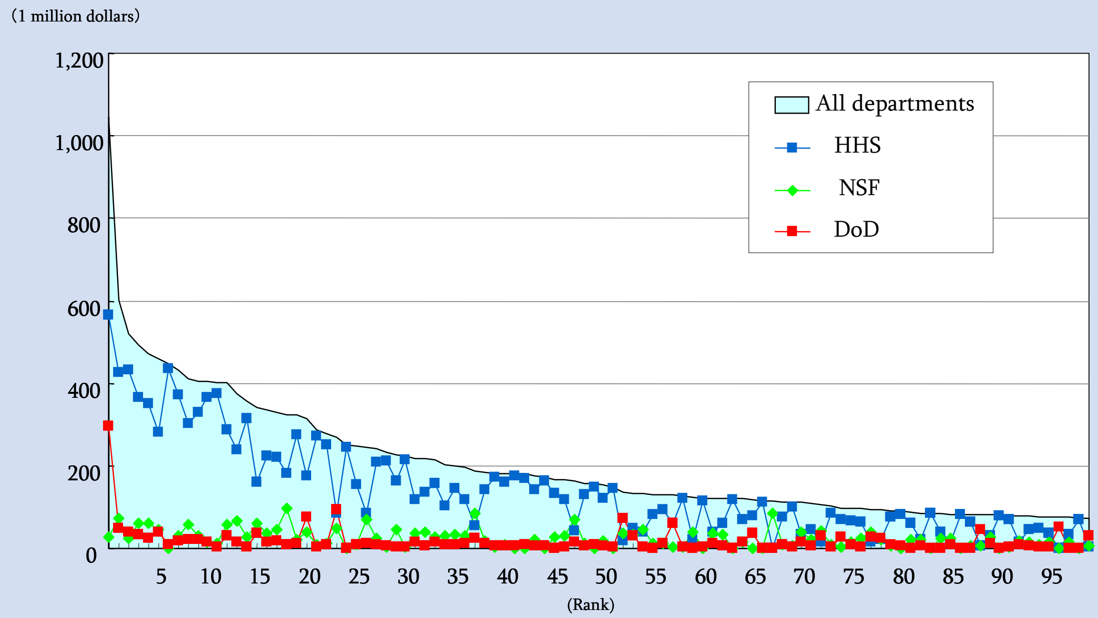
In relation to the allocation of funds, however, the allocation in Japan drops significantly after the top institution whereas that of the United States declines moderately from the top, among the universities receiving the allocation in higher ranks. It also illustrates that the funds are also allocated in the universities even in the middle ranks. (Figure 1-2-30, 31)

Figure 1 2 30 Allocation of competitive research funds to the National University Corporations from the government of Japan (FY 2007)



Resource:
MEXT "2007 Grants-in-Aid for Scientific Research; List of selected institutions and allocated sum (new + continuing)"
Cabinet Office "Survey on Scientific and Technical Activities of IAI National Universities and colleges (FY 2007)" (Oct. 2008)
NISTEP "Survey on Current Situation of Scientific, Technological, and Academic Activities in universities (University Survey 2008)" (Apr. 2009)

Figure 1 2 31 Allocation of science and engineering R&D funds from government agencies to universities in the United States (FY2005)



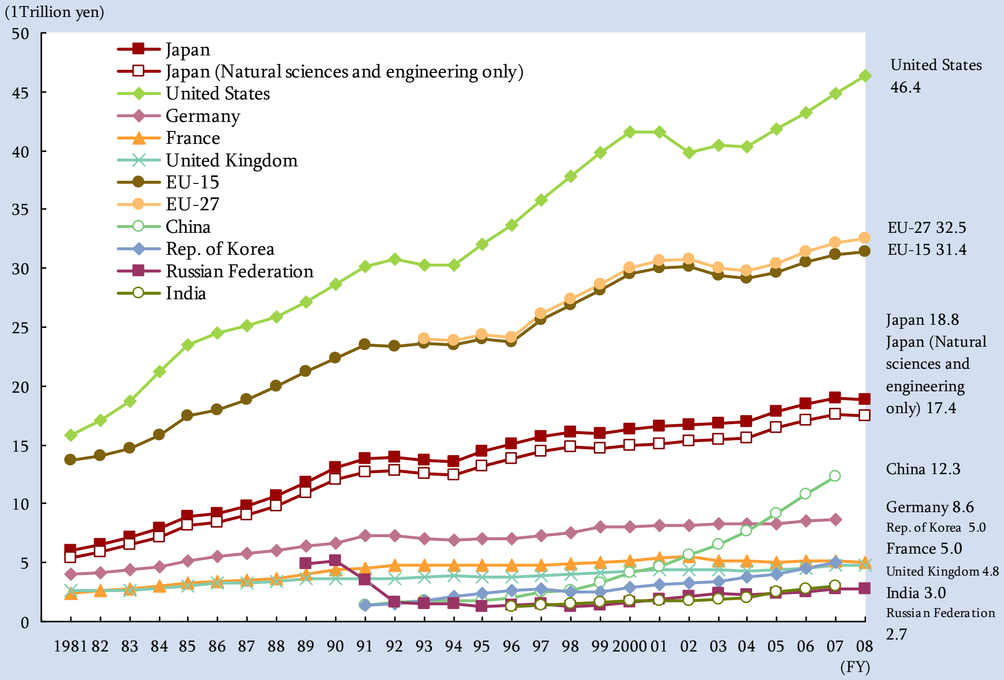
Source: Prepared by MEXT based on NSF survey

2) R&D Expenditures in selected countries

Looking at the trends in R&D expenditures in selected countries/regions, while growing in China and in the United States, the expenditures of Japan decreased in 2008 for the first time in 9 years, due to the decrease in R&D expenditures in the private sector, which pays about 80% of the R&D expenditures of Japan (Figure 1-2-32). In such a situation, the rate of government expenditures, which should play the main role in basic research assistance, is lower than that of the other countries. (Figure 1-2-33)

In addition, the rate of R&D expenditures against the Gross Domestic Product (GDP) of 2008 was 3.80%, whereas that of R&D expenditures paid by the government against GDP is 0.68%.

Figure 1 2 32 Trends in R&D Expenditures in Selected Countries/Regions (On PPP-basis)



Notes:

1. R&D expenditures of all countries include those of Humanities and social sciences. Japan's R&D expenditures for the natural sciences are also shown.
2. The U.S. figure for FY 2008 is provisional.
3. The Germany figures for FY 1982, 1984, 1986, 1988, 1990, 1992, 1994-96, 1998, 2000, and 2002 are estimated values.
4. The France figures for FY 2006 and 2008 are provisional.
5. The EU figures are estimates by Eurostat.
6. EU-15 (following 15 EU countries: Belgium, Germany, France, Italy, Luxembourg, the Netherlands, Denmark, Ireland, United Kingdom, Greece, Portugal, Spain, Austria, Finland, and Sweden)
7. EU-27 (EU-15 plus the following 12 countries: Cyprus, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Malta, Poland, Slovakia, Slovenia, Bulgaria, and Romania)
8. The India figures for FY 2003 and 2004 are estimated.

Sources:

Japan: Statistics Bureau, Ministry of Internal Affairs and Communications *Report on the Survey of Research and Development*

EU: Eurostat

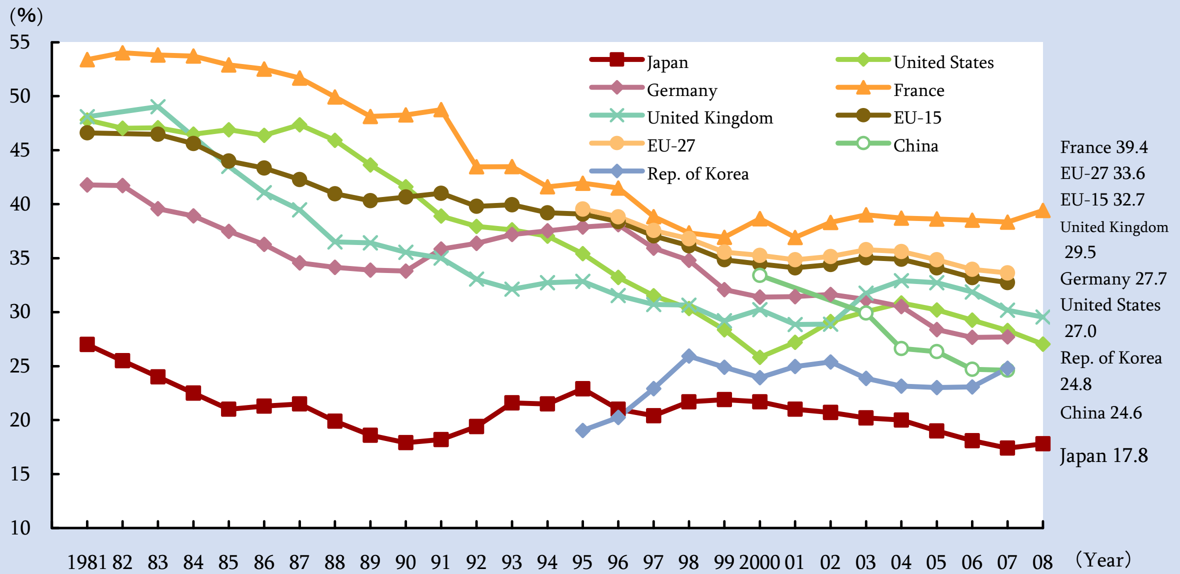
India: [R&D expenditures] UNESCO Institute for Statistics S&T database

[PPP] The World Bank *World Development Indicators CR-ROM-2009*

Other countries: OECD *Main Science and Technology Indicators Vol. 2009/2*

OECD-PPP: OECD *Main Science and Technology Indicators Vol. 2009/2*

Figure 1 2 33 Trends in Ratio of Government-financed R&D Expenditures in Selected Countries/Regions



Notes:

1. For international comparison, R&D expenditures of all countries other than South Korea include those of Humanities and social sciences.
2. The United States figure for FY 2007 and France figure for FY 2006 are provisional.
3. The Germany figures for FY 1982, 1984, 1986, 1988, 1990, 1992, 1994-96, 1998, 2000, and 2007 are estimated values.
4. The United Kingdom figures for FY 1981 and 1983 and EU figures are estimated values.
5. EU-15 (following 15 EU countries: Belgium, Germany, France, Italy, Luxembourg, the Netherlands, Denmark, Ireland, United Kingdom, Greece, Portugal, Spain, Austria, Finland, and Sweden)
6. EU-27 (EU-15 plus the following 12 countries: Cyprus, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Malta, Poland, Slovakia, Slovenia, Bulgaria, and Romania).

Sources:

Japan: Statistics Bureau, Ministry of Internal Affairs and Communications *Report on the Survey of Research and Development*

India: UNESCO Institute for Statistics S&T database

Other countries: OECD *Main Science and Technology Indicators Vol. 2009/2*

3) Flow of R&D expenditures between sectors

Comparing the international flow of R&D expenditures between sectors, Japan's rate of expenditures from government to the business enterprises is low (Table 1-2-34, Figure 1-2-35). It seems that the governments of other countries are utilizing more capacity of companies compared to Japan. In addition, the rate of expenditures from business enterprises to higher education is relatively small. (Table 1-2-34, Figure 1-2-36)

Figure 1 2 34 Flow of research expenses in Japan

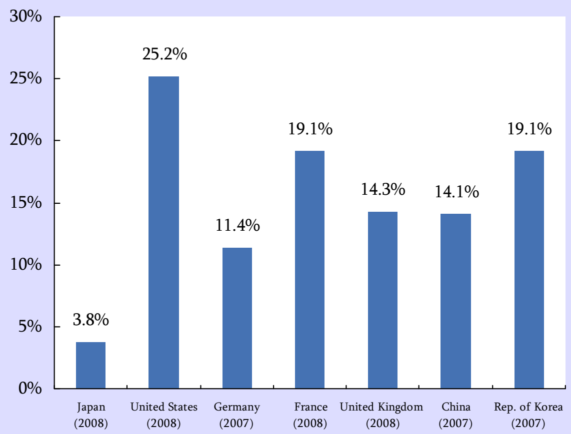
Japan [Fiscal year 2008] (Unit: 100 thousand yen)

Source \ Performer	Business enterprises (Industry)	%	Public organizations	%	Universities and colleges	%	Non-profit institutions	%	Total	%
Total	136,345	72.5%	14,474	7.7%	34,450	18.3%	2,732	1.5%	188,001	100%
Government	1,261	3.8%	14,304	42.8%	16,768	50.1%	1,123	3.4%	33,456	100%
Business enterprises (Industry)	134,362	98.6%	103	0.1%	972	0.7%	773	0.6%	136,209	100%
Private universities and colleges	6	0.0%	1	0.0%	16,337	99.9%	1	0.0%	16,345	100%
Non-profit institutions	108	8.2%	47	3.6%	351	26.5%	819	61.8%	1,325	100%
Foreign countries	607	91.2%	19	2.9%	23	3.4%	17	2.5%	666	100%

Note:
1. Cultural and social sciences are included.
2. "Business enterprises" includes companies and government-affiliated corporations, independent administrative institutions (IAI) in the private sector whose main constituent of production is categorized as "industrial" in the "Input-Output Table."
3. "Government" includes national and local governments, national and public universities, national and public research institutions, government-affiliated corporations and IAI conducting tests and survey related to science and technology (related to national, local governments), etc.
4. "Private universities and colleges" includes junior colleges, technical colleges, etc. "Universities and colleges" includes national, public, and private universities, university-affiliated research institutions, Inter-University Research Institute Corporations, etc.
5. "Non-profit institutions" includes corporations not intended for profit-making.

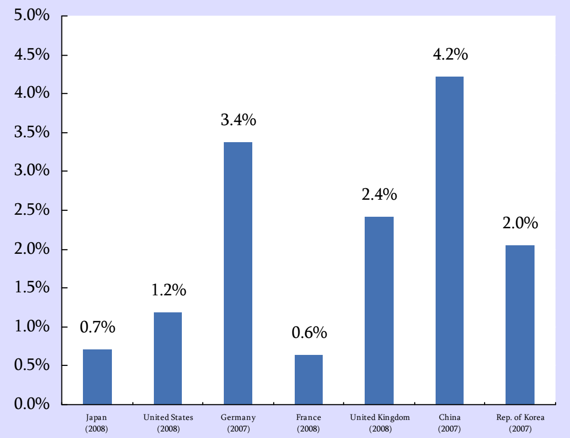
Source:
Prepared by MEXT based on Statistics Bureau, Ministry of Internal Affairs and Communications *Report on the Survey of Research and Development*

Figure 1 2 35 Percentage of research expense paid to the industry by government



Source:
Japan: Statistics Bureau, Ministry of Internal Affairs and Communications Report on the Survey of Research and Development Communications Report on the Survey of Research and Development
Others: Prepared by MEXT based on OECD "Research and Development Statistics Vol 2009/1

Figure 1 2 36 Percentage of research expenses paid to universities by industry



Source:
Japan: Statistics Bureau, Ministry of Internal Affairs and Communications Report on the Survey of Research and Development Communications Report on the Survey of Research and Development
Others: Prepared by MEXT based on OECD "Research and Development Statistics Vol 2009/1

4) Circumstances of Basic research fundings

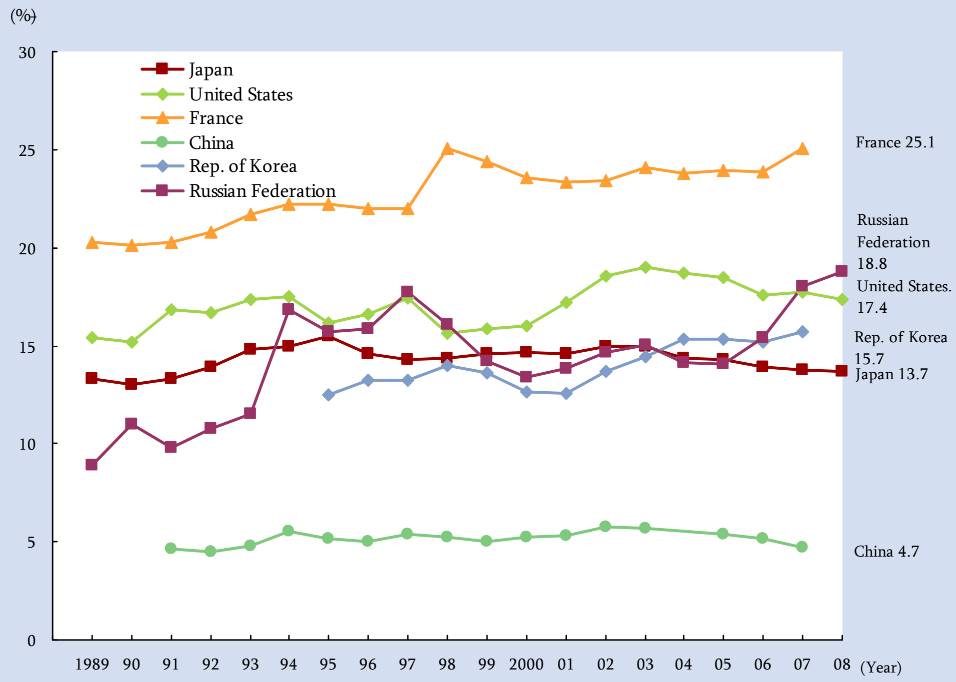
Looking at trends in the percentage of basic research fundings in selected countries, the percentage of Japan is much lower than that of other countries, showing trends of declining in recent years in Japan (Figure 1-2-37). Basic research is conducted primarily in higher education, but Japan's government spending for public institutions of higher education against GDP ranks the smallest among OECD member countries. (Figure 1-2-38)

In relation to the Grants-in-Aid for Scientific Research, which plays a principal role in basic research in Japan, the sum of the budget of direct and indirect expenses is increasing, but the aid should be enhanced since the rate of newly adopted projects remains between 20 and 25% while the recent number of applications for grant for R&D expenditures is increasing.

In addition, in terms of international comparison of the R&D expenditures in a quantitative manner, it is not easy to make a simple comparison since each country has different statistical contents and different methods of survey. The NISTEP has conducted a survey on R&D expenditures in the higher education sector in selected countries with more accuracy in terms of international comparison. According to this survey, in terms of spending in research of natural sciences, the growth of the United States and that of United Kingdom is larger than that of Japan, which remains only a slight increase. (Figure 1-2-39)

These situations are some of the issues in strengthening basic research, which is considered to be the source of innovation brought into the economy and the society.

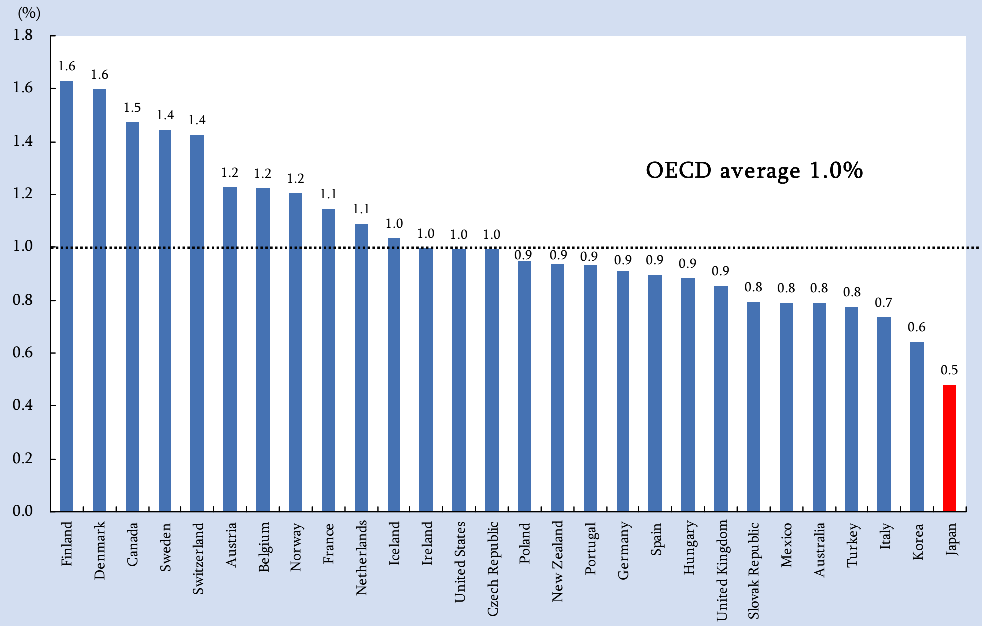
Figure 1 2 37 Trends in percentage of basic research fundings in selected countries



Note:
1. Excluding Japan, cultural and social sciences are included in each country.
2. United States 2008 and French 2007 are preliminary values.

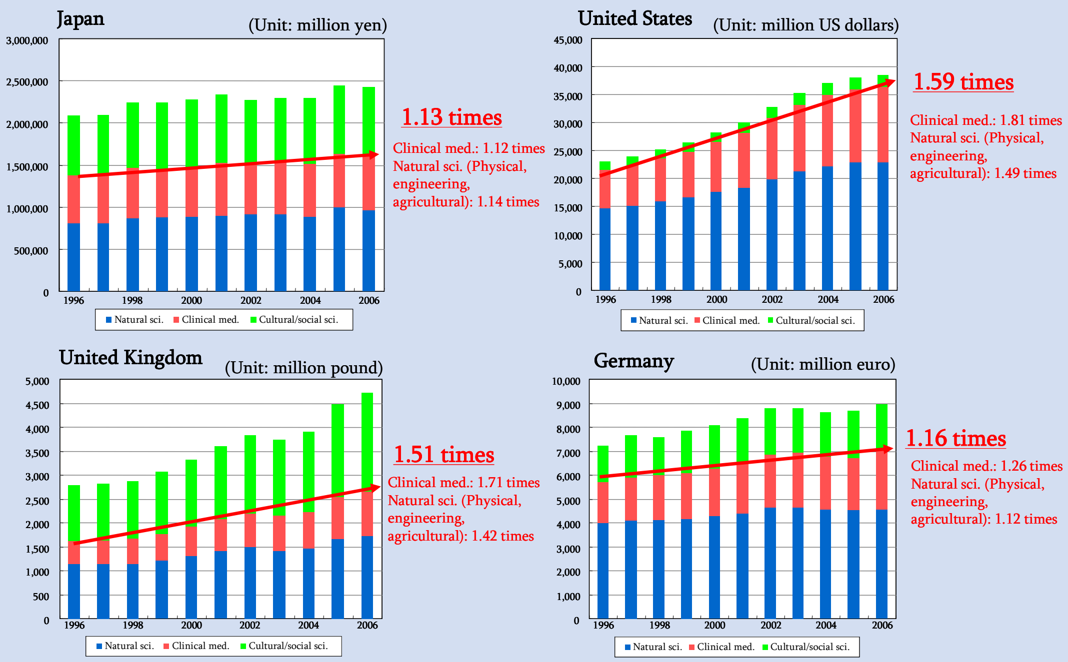
Source:
Japan : Statistics Bureau, Ministry of Internal Affairs and Communications *Report on the Survey of Research and Development*
Other countries: OECD "Research and Development Statistics Vol 2009/1"

Figure 1-2-38 Ratio of public spending for higher education against GDP (2006)



Source: Prepared by MEXT based on OECD "Education at a Glance 2009"

Figure 1-2-39 Growth in research funding in higher education



Note:

1. The figures are inflation adjusted by GDP deflator. (base year 1996)
2. Calculated from the growth of research costs, labor costs were corrected taking into account the percentage of full-time research activities in real time the FTE (full-time estimation using a conversion factor described above)

Source:

NISTEP "Comparative Analysis of R&D inputs and outputs between Japan and major countries" (March 2009)

Section 2 Creation of Opportunities to Connect Knowledge with Innovation

1 Current State of Innovative Activities

(1) Efforts of each country for creation of innovation

Innovation is a socio-economical transformation caused by the creation of new values and it is recognized as an important element for development of a country of a society and for economic recovery. Therefore, every country is implementing efforts in relation to the creation of innovation.

In the United States, “A Strategy for American Innovation: Driving towards Sustainable Growth and Quality Jobs” was announced in September 2009 as a joint statement of the Executive Office of the President (EOP), Office of Science and Technology Policy (OSTP), and National Economic Council (NEC). In the statement it says, “History should be our guide. The United States led the world’s economies in the 20th century because we led the world in innovation. Today, the competition is keener; the challenge is tougher; and that is why innovation is more important than ever. It is the key to good, new jobs for the 21st century. That’s how we will ensure a high quality of life for this generation and future generations. With these investments, we’re planting the seeds of progress for our country, and good-paying, private-sector jobs for the American people.” And government subsidies and regulations to the science and technology are directed that way.

In United Kingdom, the Department for Business, Enterprise and Regulatory Reform (BERR) and the Department of Innovation, Universities and Skills (DIUS) were merged into a new department called the Department for Business, Innovation and Skills (BIS). The BIS announced “Going for Growth” in January 2010. Similar to the innovation strategy of the United States, the UK strategy has set forth the measures with objectives of economic recovery, creation of employment, improvement of quality of life, etc.

In Germany, “The High-Tech Strategy for Germany” was announced. This is a comprehensive strategy for research and innovation across multiple ministries in the German federal government, for the purpose of promoting the development of new products and innovative services, and stimulating employment and economic growth by creation and spread of knowledge. To do so, the government says that they are enhancing investment to research areas beyond the boundary of academic disciplines and reinforcing industry-university collaboration.

In France, for the purpose of supporting the enhancement of higher education, R&D, and SME in the areas with priority, under the leadership of President Nicolas Sarkozy, the government will start to sell government bonds in 2010 to promote creation of innovation.

EU announced a new strategy setting the 10-year objectives in relation to economy and society, “EUROPE 2020” in March 2010. It refers to three points to be addressed for growth with priority; “Smart growth: developing an economy based on knowledge and innovation,” “Sustainable growth: promoting a more resource efficient, greener and more competitive economy,” and “Inclusive growth: fostering a high-employment economy delivering social and territorial cohesion.” It sets out an objective to raise the ratio of R&D investments against GDP from the current 1.9% to 3% while stimulating investment from the industry. OECD is also working on development of “OECD Innovation Strategy.” (published in May 2010)

China is implementing "National Plan for Scientific and Technology Development (2006-2020) to resolve contradictions in the economy and society by means of scientific thought, aiming at sustainable growth. The plan illustrates some objectives, including raising the number of patent for invention and citation of papers by Chinese people to rank within 5th, while focusing on creation of China's original innovation, rather than introduction from other countries.

As mentioned above, each country considers that the objectives of innovation are economic recovery and creation of employment, and promotes political measures focusing on science and technology. Japan is also reinforcing measures focusing on innovation recently.

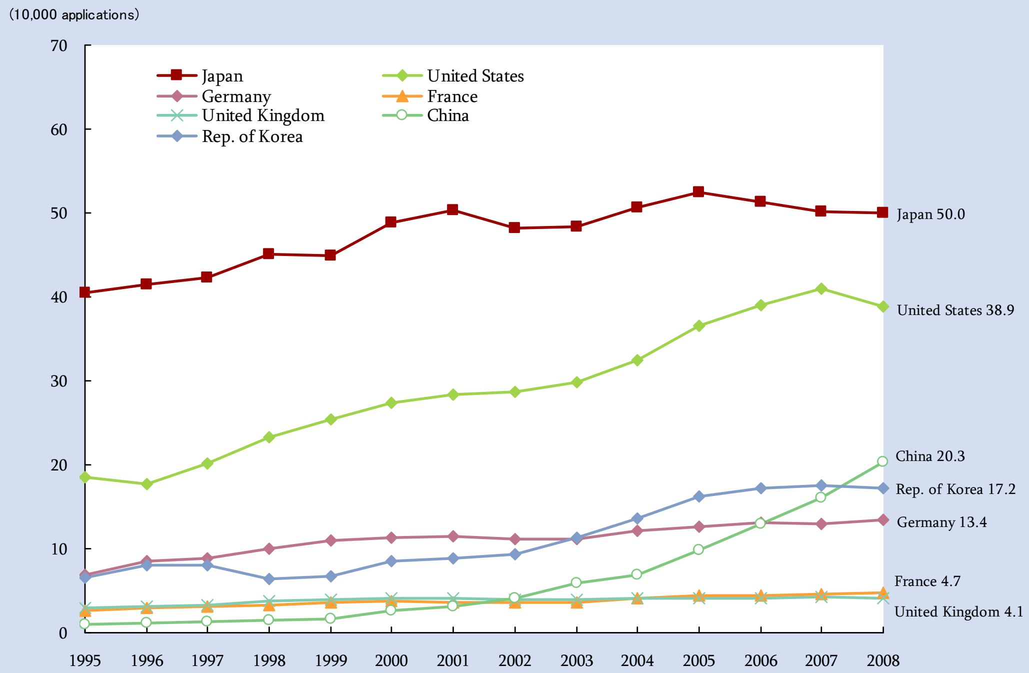
(2) Innovation Activities in Companies

1) International comparison of patent applications

In terms of nationality of the applicants for patent, although Japanese people have been in decline since 2005, they are still world's No.1. While the United States showed increase until 2007 but turned to decline in 2008 and other major countries tend to be unchanged, China, maintaining constant growth, ranked No.3, going ahead of Republic of Korea. (Figure 1-2-40)

The number of patent registration has been increasing steadily in Japan, maintaining World's No.1 position in addition to the number of applications.

Figure 1 2 40 Trends in the number of patent applications in major countries (by applicants' nationality)



Note: Added up the number of applications within the country or in other countries and the number of patents being transferred into the country based on PCT international application.

Source: WIPO Statistics Database, December 2009 "Patent applications by patent office and country of origin (1995-2008) "

2) Export market shares for high-tech products

High-tech products apply advanced science and technology in its principles and in the production processes, and are considered to be products with high added value, possibly to create innovation impacting the society. Thus, export value of high-tech products can be viewed as an indicator that illustrates one aspect of the industry's international competitiveness while utilizing science and technology. Therefore, the export values and the state of shares of high-tech products based on the OECD data are provided for international comparisons.

Comparing the trends in the shares of high-tech products[1] (Aerospace, Electronics, Office machinery and computers, Pharmaceuticals, Medical, precision and optical instruments) in the world of the major exporting countries between 2000 and 2008, United Kingdom, United States, and Japan were proved to have dropped their shares significantly (Figure 1-2-41). Meanwhile, China's share has increased considerably from 2000 to 2008.

Also, looking at the shares of exports sorted by high-tech products, Japan's share of electronics exports is as much as 9.9%, China's share was 25.0%, and the United States had 10.7%, showing the world's largest share (Figure 1-2-42). In addition, China demonstrates the share of 36.3%, which is the largest share in the world, of office equipment and computer, showing its significant presence in high-tech export.

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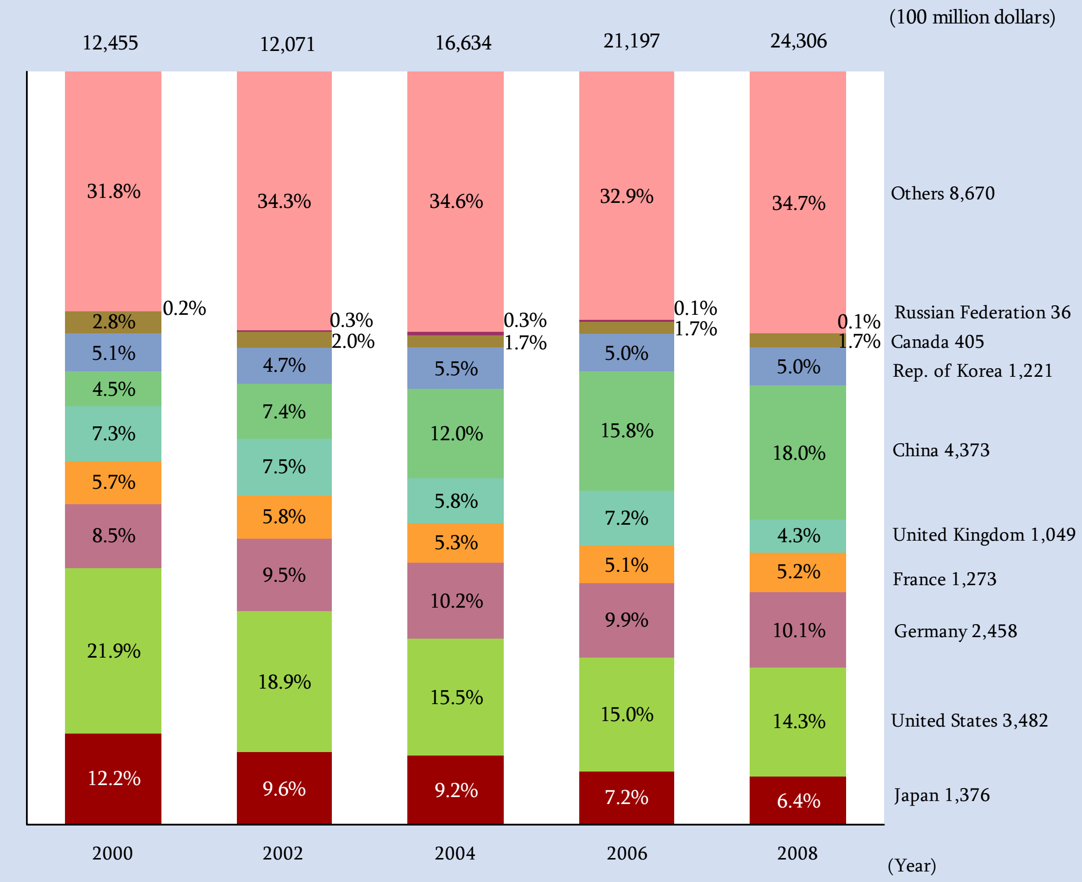
[1] OECD calculates the percentage of R&D expenses against total manufactured value for each sector, defining the high-tech industry with the largest number as the high-tech industry (Aerospace, Electronics, computer, office machinery and computers , Pharmaceuticals, Medical precision and optical instruments).
(Revision of the high-technology sector and product classification, STI Working Papers, OECD, 1997/2)

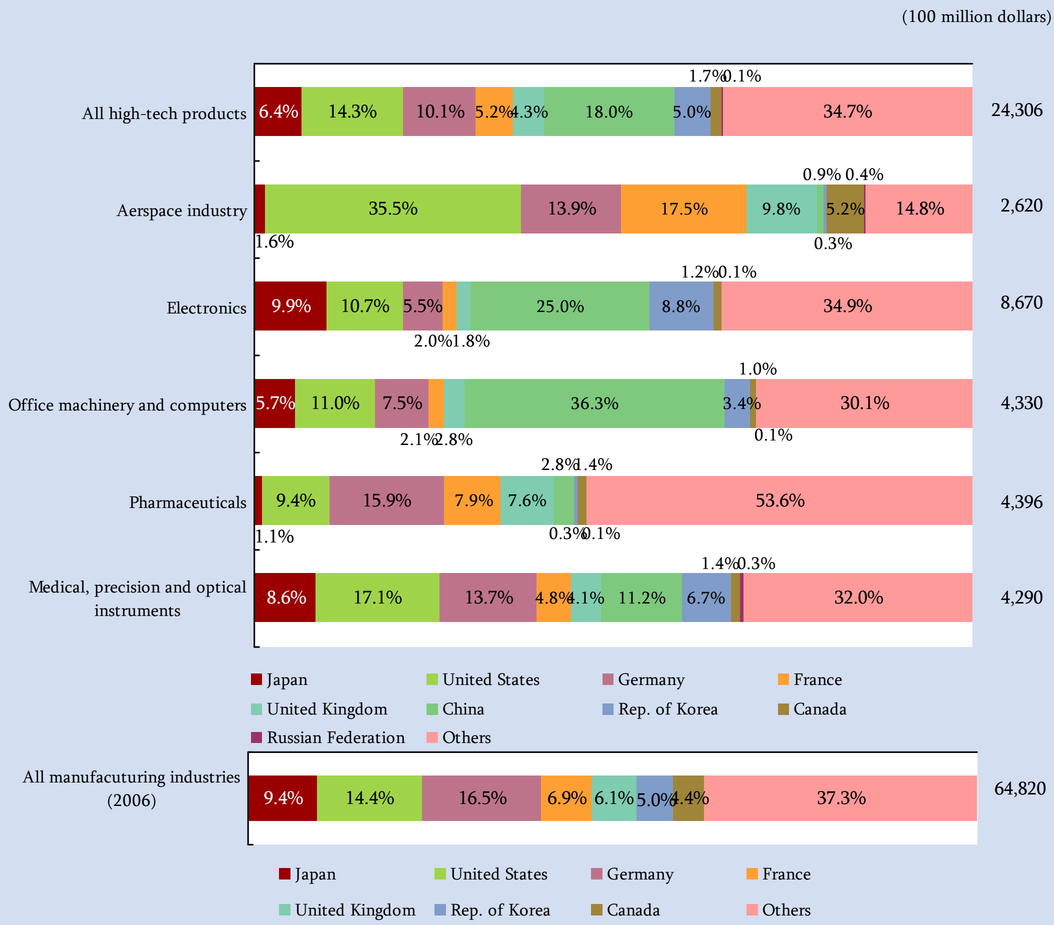
Figure 1 2 41 Export market share for high-tech products in selected countries



Note: "Others" are the sum of the OECD member countries plus Argentina, Israel, Singapore, Slovenia, and South Africa, excluding Japan, U.S.A., Germany, France, U.K., South Korea, and Canada.

Source: OECD "Main Science and Technology Indicators Vol.2009/2"

Figure 1 2 42 Share of high-tech products by country manufactured in selected countries (2008)



Note:
1. China, Mexico, and Turkey are not included in "All manufacturing industries."
2. "Others" in "All high-tech products" represent the sum of all OECD members excluding Japan, United States, Germany, France, United Kingdom, Rep. of Korea, and Canada, and Argentina, Israel, Singapore, Slovenia, and South Africa.
Resource:
Total and individual high-tech industry: OECD "Main Science and Technology Indicators Vol 2009/2"
All manufacturing industries: OECD "STAN Database for Structural Analysis (As of Feb. 2010)"

3) Innovative activities in companies (Citation from 2nd National Innovation Survey[1])

NISTEP conducted the second survey on innovation activities in Japanese companies in 2009[2], following the first National Innovation Survey conducted in 2003.

As a result of the surveys with two different categories; "Product innovation as the input of a new product or a new service in the market[3]" and "Process innovation as the introduction of a new process or the improvement of the existing process in relation to manufacturing of products and

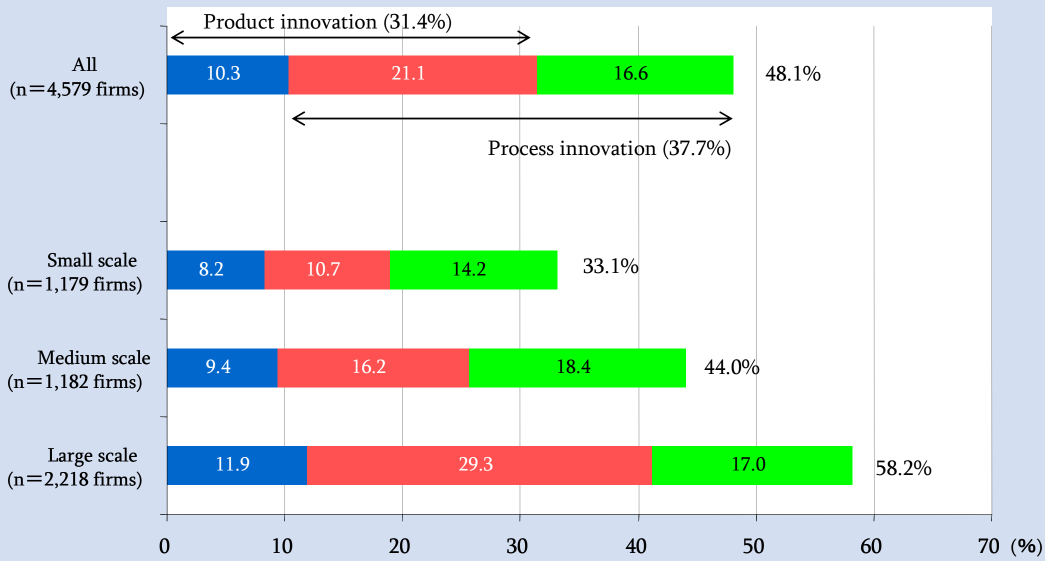
1 The figures shown here is a simple summary of survey results collected.
2 NISTEP "1st National Innovation Research and Statistics Report (Conducted in 2003, reported in 2004)," "2nd National Innovation Survey (Conducted in 2009)"
3 Product innovation includes not only renewed functions, performance, designs, materials, components, and features in new products or new services, but also combination of existing technologies and advanced technology of existing products or services. However, simple change in design with no change in functionality or in purposes as existing ones, and sales or offer of products and services of other companies are not included.

services[1]," the outcomes of product innovation and process innovation in the companies for three years, from 2006 though 2008, were as following: the companies with successful product innovation only accounted 10.3%, the companies with successful process innovation only accounted 16.6%, and the companies with both successes accounted 21.1%, resulting in 48.1% of the companies were successful in innovation (Figure 1-2-43). In addition, it was proven that the greater the sizes of the companies, the more companies were successful in innovation. With large-scale companies, it was 58.2%, with medium-scale companies, it was 44.0%, and with small-scale companies, it was 33.1%.

In addition, those who answered that they have achieved innovation, which accounted for 2,201 corporations, were asked what obstacles they had. "Lack of technical know-how," "lack of capable employees," and "lack of information about the market" were some of the answers that showed higher percentage (Figure 1-2-44). Furthermore, more small corporations answered that "lack of funding" was an obstacle than larger or middle-sized corporations.

In summary, it can be concluded that it is important to enhance human resources with sophisticated knowledge, information, and skills in innovation activities in companies.

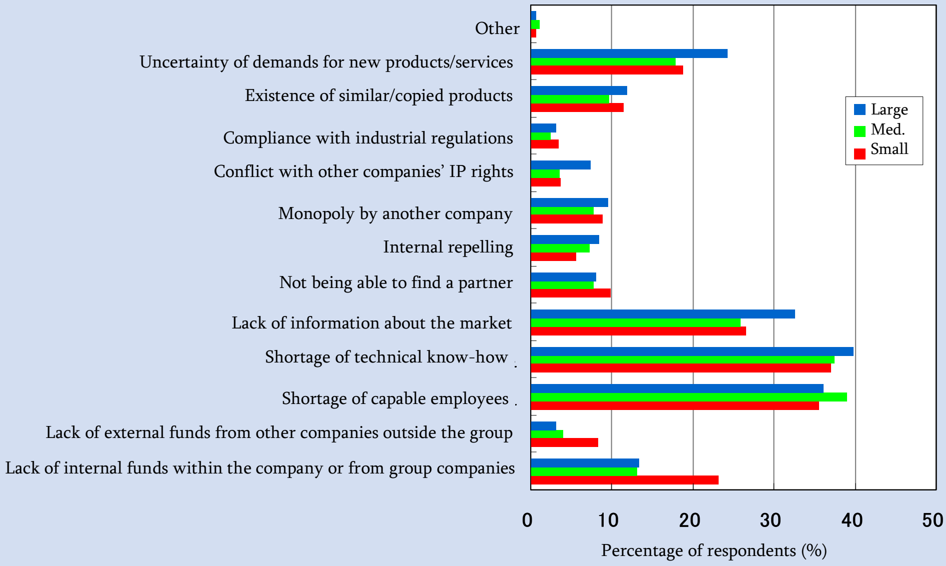
Figure 1 2 43 Percentage of companies that realized innovations



Note: Fewer than 49 small businesses of 10 or more employees, medium companies with less than 249 over 50 is more than
250 large enterprises. Blue shows only product innovation, yellow shows process innovation, and green shows both.
Source: Prepared by MEXT based on NISTEP "2nd National Innovation Survey"

1 The process innovation includes not only newly introduced or improved manufacturing or production methods of products or services, but also newly introduced or improved maintenance systems or computing systems that support manufacturing/production, transportation, and distribution.

Figure 1 2 44 Impediments to innovation with the companies that realized innovation (Multiple answers)



Source: Prepared by MEXT based on NISTEP "2nd National Innovation Survey"

(3) Industry-academia Collaboration

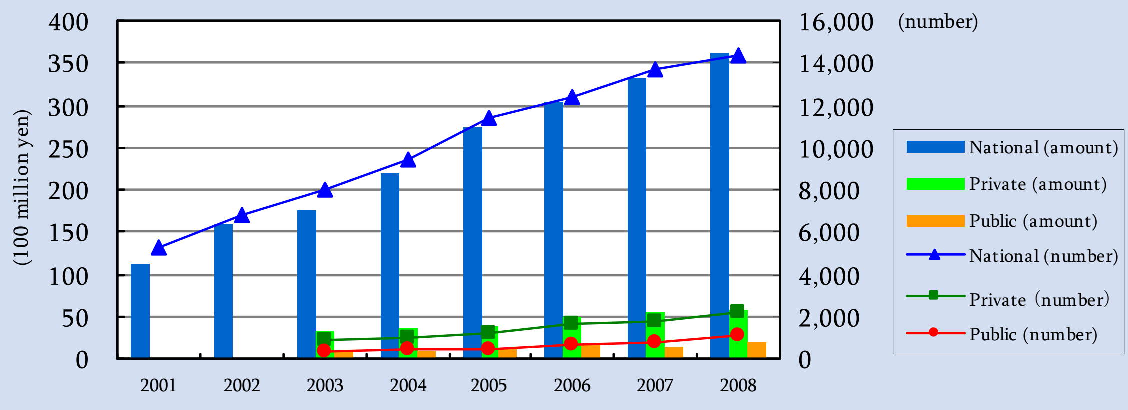
1) Subcontracted R&D and joint R&D of industry and universities

The total amount of research expenses funded by the companies (excluding government-affiliated corporations and independent administrative institutions) reached 14.5 trillion yen, among which the research expenses paid out to the outside of them, such as universities and other companies was 2.2 trillion yen[1].

The number of joint research of national, public, and private universities with companies in the private sector increased to 17,638 cases in FY 2008, adding 1,427 cases (9%) compared to the previous year (Figure 1-2-45). Similarly, the number of subcontracted research increased to 19,201 cases in FY 2008, adding 676 cases (4%) from the previous year (Figure 1-2-46). In addition, the amount of spending increased both in joint research and subcontracted research. Comparing among national, public, and private universities, national universities outperformed in the number of cases and the amount of spending.

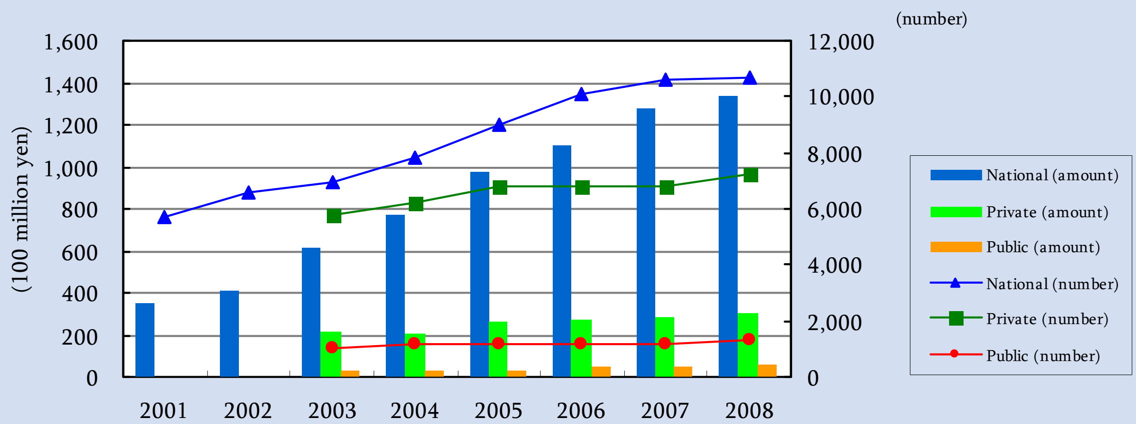
[1] MIC "Report on the Survey of Research and Development" (2009)

Figure 1 2 45 Number and amount of spending of joint research of universities with companies



Source: MEXT " Collaboration in research universities and the implementation FY2008"

Figure 1 2 46 Number and amount of money of subcontracted research of universities with companies



Source: MEXT "Collaboration in research universities and the implementation FY2008"

2) Current State of University Ventures

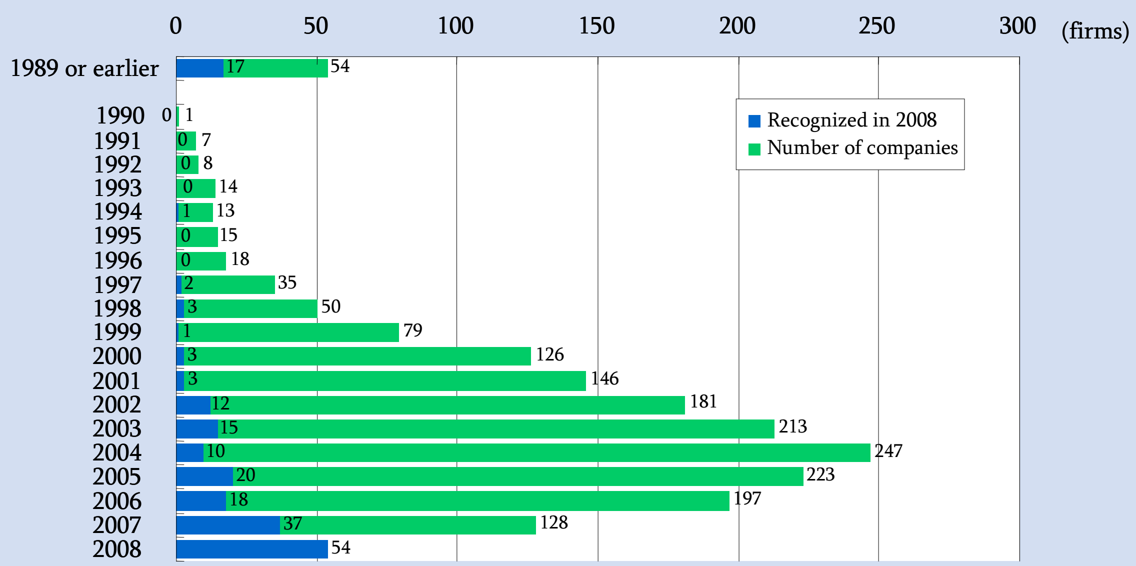
According to the report of a survey subcontracted by METI in 2008, "Basic Survey on University Ventures" (Japan Economic Research Institute) (March 2009), a university venture is defined as "an enterprise newly founded for the purpose of commercialize the patent, new technologies, and business methods based on the research outcomes achieved in the university," with an additional condition, "a venture closely related to the university (a venture having conducted joint research, etc. with the university within 5 years before the foundation, a venture with technologies transferred from the university within 5 years before the foundation, a venture founded by the students closely related to the university, a venture closely related to the university, such as university's investment, etc.).

According to the report, there are 1,809 university ventures running business at the end of FY 2008. In the past decade, increasing number of university ventures was founded. However, the number of university venture founded each year has been decreasing since around 2005 (Figure 1-2-47). Looking at the figures of each university, the greatest number of the university ventures was 125 of the University of Tokyo (active ventures as of March 2009), in terms of cumulative number, followed by University of Tsukuba's 76, Osaka University's 75, Waseda University's 74, Kyoto University's 64, Tohoku University's 57, Tokyo Institute of Technology's 57, Kyushu University's 55, Keio University's 51, Kyushu Institute of Technology's 45, and so on.

In addition, about 10% of the university ventures (about 150 companies) are utilizing "technology seeds" of several universities, and these ventures have pointed out some advantages in running their business, such as "better accessibility with the funds providers," "better coordination with related people outside the company," etc.

Furthermore, 20 university ventures expected to grow were selected in the above-mentioned survey[1] based on the information provided by the university venture support institutions, venture capitals, etc. and the interview with university ventures. These ventures were selected with the criteria that the venture has not publicly offered their stocks (IPO, Initial Public Offerings) until the previous year, that it has an excellent technology, appropriate managerial organization, and that it has received investment or financing of a venture capital or other financial institutions, in addition to their historical earnings (Figure 1-2-48). Most of their businesses are related to life science, followed by the fields related to environmental issues. 20% of the university ventures are involved with multiple universities.

Figure 1 2 47 Trends in the number of university ventures founded each year



Source: FY 2008 survey subcontracted by METI "Report on Basic Survey on University-initiated venture"(Japan Economic Research Institute) (March 2009)

[1] Report on "Basic Survey on University Ventures" (Japan Economic Research Institute), a survey subcontracted by METI in 2008 (March 2009)

Table 1 2 48 The selected 20 University Ventures

Company name	Related university	Business
EVEC Inc. (Sapporo, Hokkaido)	Hokkaido University	Sales of fully human antibody completely developed by its original technology
Soundpower corporation (Fujisawa, Kanagawa)	Keio University	Development of power generation products using sound and vibration power generation, manufacturing and marketing, etc.
Clean venture 21 Corporation (Kyoto)	Osaka Univ. Ritsumeikan Univ., Univ. of Tokyo	Commercialization and practical application of condensed-type spherical micro solar cell
Contig-I Ink. (Gifu)	Gifu University	Bioethanol production and non-food raw materials and soil remediation using microbial
Genaris, Inc. (Yokohama, Kanagawa)	Nara Institute of Science and Technology, Univ. of Tokyo, etc.	Genome Technology development, etc.
Spiber Inc. (Tsuruoka, Yamagata)	Keio University	(1) Research and development of high-protein fiber materials that can be non-oil recycling system, (2) Development of microbiological monitoring
CellSeed Inc. (Shinjuku, Tokyo)	Tokyo Women's Medial University	Regenerative medicine, regenerative medicine support
SOSHO, Inc. (Osaka)	Osaka University	Subcontractor of crystallization processing of pharmaceutical compound and protein
SoftEther Corporation (Tsukuba, Ibaraki)	University of Tsukuba	Research and development of network communication security software products and hardware products, such as providing network services
Tella Inc. (Shinjuku, Tokyo)	Univ. of Tokyo, Osaka Univ., Univ. of Tokushima, Chiba Univ., etc.	Practical application of dendritic cell vaccine therapy and cancer
NANOEGG Research Laboratories, Inc. (Kawasaki, Kanagawa)	St. Marianna University School of Medicine	Drug discovery based on nano egg, nano-cube, which are DDS (Drug delivery system) technology, commercialization of quasi-drugs and cosmetics
Biomaker Science (Osaka)	Kyoto Prefectural University of Medicine	Support for developing functional foods for preventive disease biomarker, support for personal medical care by searching drug response biomarker
PaptiDream (Chiyoda, Tokyo)	University of Tokyo, etc.	Search for drug candidates
Optical Comb, Inc. (Chiyoda, Tokyo)	Tokyo Institute of Technology	Optical comb generator and its application
Human Metabolome Technologies (Tsuruoka, Yamagata)	Keio University	Metabolome analysis using CE-MS and related business
Brookman Laboratory (Hamamatsu, Shizuoka)	Shizuoka University	CMOS integrated circuits, development and design of image sensor
MechaTrax (Fukuoka)	Kyushu University	Development and sales of amusement equipment for Biped Robot Commercial
MECARO Co. Ltd. (Katagami, Akita)	Univ. Of Tokyo, Akita Prefectural Univ., Ashikaga Institute of Technology, Akita National College of Technology, Kogakuin Univ., etc.	Development and design of wind turbine generator systems, development and design of control software, sales of electronics and machine parts

MedGEL Corporation (Kyoto)	Kyoto University	Development of biomedical research tools, bioabsorbable sustained release DDS substrate
Morpho, Inc. (Bunkyo, Tokyo)	University of Tokyo	Research and development of image processing technology, product development and licensing

Source: Prepared by MEXT based on Report on FY 2008 METI subcontracted survey "Basic Research on University Venture"(Japan Economic Research Institute) (March 2009)

3) Current state of TLO (Technology Licensing Organization)

Based on "Act on the Promotion of Technology Transfer from Universities to Private Business Operators" (Law No. 52 of 1998), 47 TLOs (Technology Licensing Organization) have been approved by METI and MEXT as of March 1, 2010. Among the 47 institutions, 30 are corporations and foundations outside the universities (including universities' subsidiaries), and 17 are campus organizations. Since FY 2005, 10 TLOs have been added on campus in national universities, but no wide-area TLO has been established since FY 2005.

The operations of TLO include licensing of patents, intermediation of technical training, and management of intellectual properties obtained as a result of research, including consulting and marketing.

In relation to the earnings of approved TLOs, excluding campus organizations, 11 companies, or 34%, were in deficit in FY 2007[1], and approved TLOs are in a difficult business conditions while the number of organizations in deficit is increasing.

4) Regional innovation system[2]

In relation to the promotion of science and technology in the region, the MEXT started the "Knowledge Cluster Initiative" and "City Area Program" in FY 2002, promoting development of an industry-academia-government network the area around the university. Consequently, as a concrete outcome, in the Iizuka region in Kitakyushu, Fukuoka, the integration of the enterprises related to system LSI is further in progress, with the number of related companies increased from 21 in FY 2000, before starting the system LSI business, to 189 as of the end of FY 2009, due to business expansion from outside of the prefecture and to foundation of university ventures. In Toyama/Ishikawa region, the joint research of University of Toyama and Toyama Industrial Technology Center developed a system that mass produces antibodies affective in preventing infection in a short period of time in August 2009, and this was commercialized by a bio-venture corporation in the region. A business cycle utilizing the research outcomes has started.

On the other hand, the science and technology-related spending in prefectures and in ordinance-designated cities has decreased by about 15% in FY 2008, compared to FY 2001, and in particular, the budget for public examination research institution has decreased about 32%, but each region is actively working on deploying the outcomes of research, utilizing "Knowledge Cluster Initiative" and other national measures to stimulate local activities by creating innovation.

The financial conditions in the local government are difficult, but it is important that the national

1 Academic Council Special Committee on Science and Technology Basic Plan (6th) "Resources for Promoting Collaboration" (Oct.1, 2009)
2 Interim Report for the existence of regional science and technology development policies in the future (Sep. 2009) (Regional Science and Technology Policy Committee)

and local governments work together to create a business cycle of R&D, technical verification, and outcome, development of social infrastructure, deregulations, enlightenment of citizens, and others in the region, for the purpose of improving people's quality of life, realization of sustainable socio-economic growth.

In addition, universities, which are playing key roles in education and research activities, are expected to make contributions to the community in terms of creation of "knowledge" and deployment of research outcomes. Thus, in the future, it is necessary to promote not only industry-academia-government collaboration research but also a sharing system and a network of intellectual properties that the community possesses, including development of a program of fostering human resource by promoting shared use of research facilities and partnership among universities in the same regions.

Column 6 Collaborative Activities of Academic Society and Banks

The survey conducted by the Industry-Academia Collaborative Academic Society in 2009 targeting mainly regional banks showed that the financial institutions implementing collaborative activities with universities accounted 72% of all the banks responded to the survey, and 46% for credit unions[1].

Most collaborative activities are "technical consultations at universities," "needs-seeds matching," "co-hosting/hosting a seminar." Financial institutions, as the experts of economy and management, introduce corporations or research institutions to provide opportunities to obtain technologies required by the corporations. Through consultation, they are bridging the local industry and universities. Financial institutions are taking this activity as part of customer service.

Meanwhile, many respondents said what universities are focusing on for the purpose of collaboration of academia and banks are "needs-seeds matching" and "expansion of the range of collaboration of industry and academy." These activities proved that local banks and other financial institutions are functioning as a type of coordinators of industry-academia collaboration.

Furthermore, in relation to the collaboration of academy and banks, over 90% of banks and credit unions are hoping for collaboration, if including "further expansion" and "maintain status quo."

In relation to problems, universities chose the most and banks chose the second most the answer "human resource is not sufficient to utilize the collaboration." Banks pointed out "university technologies and seeds were difficult to understand" the most.

Highly professional talented people capable of understand university technologies and seeds are requested.

(4) Issues and Efforts in Relation to Innovation System

1) Current awareness of companies and universities in relation to industry-academia collaboration

Some of the most frequently quoted reasons for implementing joint research are "enhancement of R&D and technological capability" and "utilization of technical knowledge and ideas that do not exist in the company[2]." On the other hand, the reasons for not implementing it are "research partners compatible with the company's technical areas do not exist" and "gaps in the objectives of R&D" (Figure 1-2-49). This fact reveals that there are many cases of companies passing up the opportunities to collaborate in research activities due to incompatibility with the needs between industry and academia.

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1 Survey to understand the implementation of academia-bank collaboration (Conducted in April 2009) (Koji Ono, chairman of NPO Industry-academia Collaborative Academic Society and NPO Academia-bank Collaboration System Research Institute, Deputy Director of International Business Studies, Yamagata University)

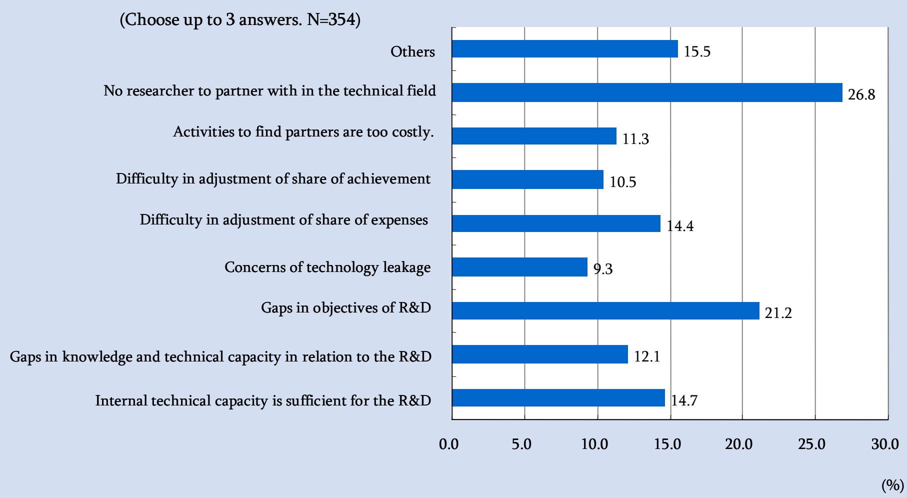
2 NISTEP "Survey on private enterprises research and development 2008"

Meanwhile, according to a survey conducted for universities actively implementing industry-academia collaboration[1], the activities that universities are focusing on in joint research were found to change between 2003 and 2008. The activities focused on by the universities that showed significant increases were "needs and seeds matching activities between industry and academia" and "understanding cooperate needs" (Figure 1-2-50). In addition, the answers focusing on "promoting consortium-type joint research participated in by several institutions" and "promotion of comprehensive/organizational collaboration" increased significantly, which were not focused in 2003.

Recently, such experts in different fields and organizations are working together to form a network to link a variety of expertise and to build a platform for innovation (Platform of Knowledge) to create new methodologies and breakthroughs, examining strategies under the collaboration of industry, academia, and governments (industry, universities, R&D type IAI, etc.) to promote R&D activities.

One of case studies of that kind is the global nanotechnology research center "Tsukuba Innovation Arena." In Tsukuba City, Ibaraki, in which world-class nanotechnology research facilities and human resources are concentrated, with the National Institute of Advanced Industrial Science and Technology (AIST), the National Institute for Materials Science (NIMS), and the University of Tsukuba, as three centers of the project, Nippon Keidanren (Japan Business Federation) announced jointly in June 2009 that they would be united to promote industrialization of nanotechnology and training of human resources. This would be an R&D center as a fusion of industry, academia, and government, opened internationally to support development of research environments with the cooperation of METI and MEXT and to expand the network of major corporations and universities.

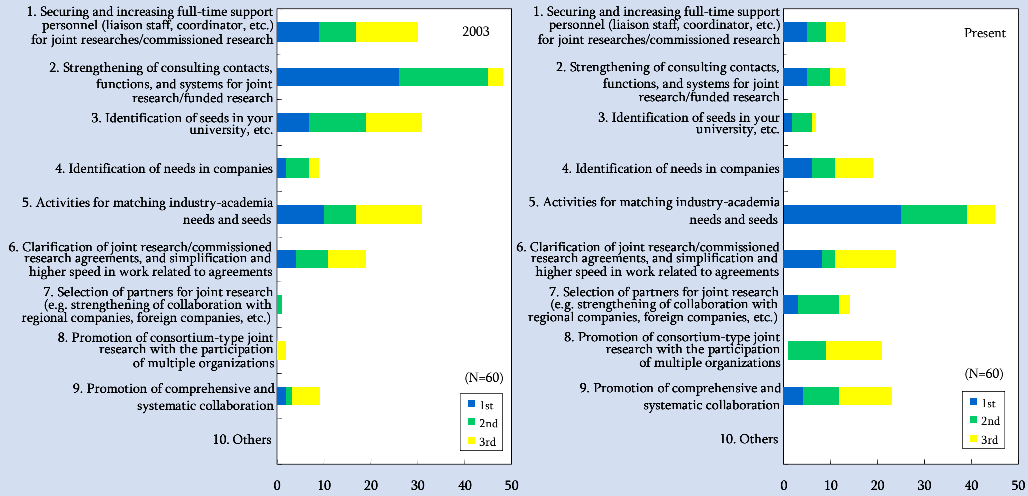
Figure 1 2 49 Reasons for non-implementation of joint research by companies and universities



Source: NISTEP "Report on FY 2008 Research Activities of the Private Sector"

[1] NISTEP Survey on Innovation Systems: Part I, Creation and Utilization of Industry-academia-government Collaboration and Intellectual Properties" (2009)

Figure 1 2 50 Change in activities focused on by universities in joint and subcontracted research



Source: NISTEP Survey on Innovation Systems: Part I, Creation and Utilization of Industry-academia-government Collaboration and Intellectual Properties" (2009)

2) Development of a structure to promote new industry-academia collaboration

Poor capacity in basic research in industry has been pointed out recently, and it is predicted that the importance of basic research will be further highlighted in the future in the context of industry-academia collaboration. To extend the target range of industry-academy collaboration to basic research encourages creating a new range of basic research areas in the universities by providing feedback with the views and knowledge of industry into the field of basic research for industry-university collaboration. Therefore, basic research for finding solutions to industrial issues is conducted at universities and other institutions.

In industry-academia collaboration targeting basic research, excessive promotion of patent applications from the outcomes of research may work contrary to free research activities and the active application of research outcomes may sometimes be impeded. Thus, it is necessary to construct a scheme that enables free use of patents with a limitation on the purposes of the research. (Research Patent Commons[1])

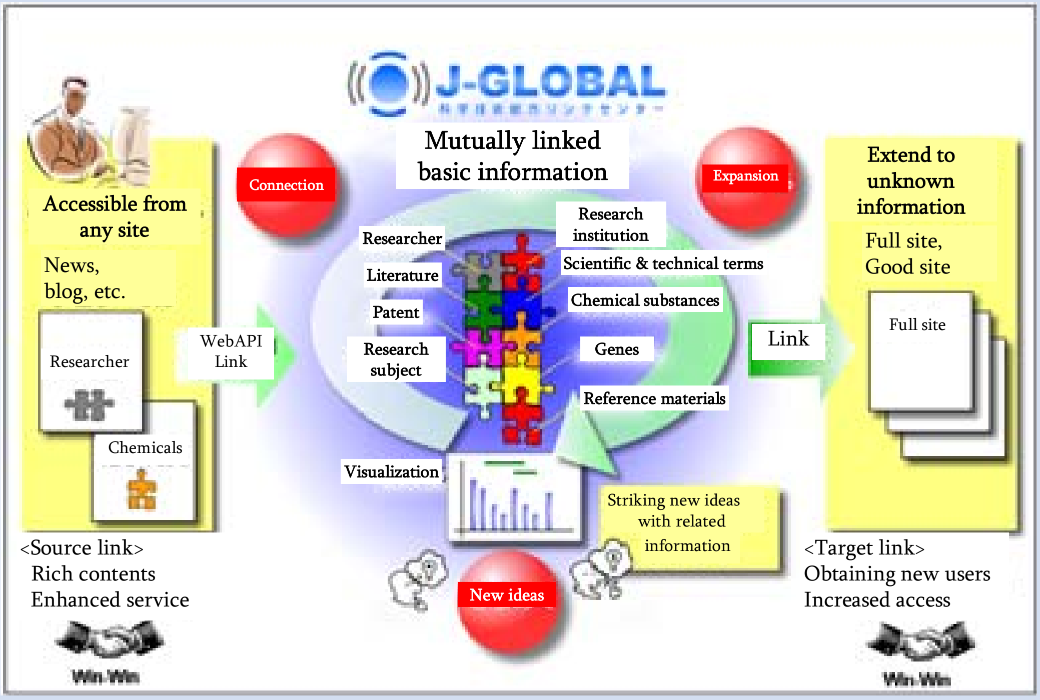
In advanced integrated fields, in which creation of innovation is especially expected, it is important to construct an industry-academia collaboration system that can consistently cover a wide range of research activities, from basic research to exit-oriented R&D activities, in close cooperation with corporations based on the seeds provided by universities. The Special Coordination Funds for Promoting Science and Technology, "Formation of Foundation for Creation of Innovation in Advanced Interdisciplinary Fields," which was founded in fiscal year 2006, is intended to support the formation of the centers to conduct R&D to produce outcomes that can have a significant impact on society and the economy, by means of matching funds with

[1] It is likened to the shared land "commons" for patents in basic research. (MEXT "Connecting Research Outcomes to Innovation" published in the Journal of Industry-Academia-Government Collaboration, vol. 6, No.3, 2010.

corporations, and the reports of Council on Competitiveness-Nippon[1] indicates their high expectation, saying “its function as the ‘place’ to achieve breakthroughs is promising.” This means the expectations are very high in the industry as a whole.

In addition, to use effectively information related to intellectual properties, it is important to promote networking of the information related to intellectual properties, including development of an integrated search system enabling analysis while linking a variety of information, such as related patents, documents, etc. J-GLOBAL (Science and Technology Agency), which the Japan Science and Technology Agency (JST) started in 2009, connects basic information in relation to R&D (researchers, universities, research institutions, papers, patents, research projects, scientific and technological terms, etc.). It is a new service that assists in obtaining knowledge in other fields or encountering surprising discoveries (Figure 1-2-51). With such an information network, many new innovations are expected to be born since anybody can obtain new information so easily that new partnerships between industry and academia or between different fields will be promoted.

Figure 1-2-51 Concept image of J-GLOBAL



Source: JST J-GLOBAL

[1] Industrial Competitiveness Group Report “Industry expectations and responsibilities for basic research” (March 6, 2009)

Column 7 Lessons from Past Industry-Academia Collaboration Activities

Not all projects will be successful even if they are implemented under industry-academia collaboration. There are some lessons learned from the analysis of past cases.

Hokkaido University created the "Analytical Report on the 'Conception of Research & Business Park of Hokkaido University,'" a project to enhance the strategic research center on the Special Coordination Funds for Promoting Science and Technology, analyzing the past large-scale projects of industry-academia collaboration, while adding some perspectives of business management of the university, and was published in December 2009. The report summarizes "10 points to be noted when implementing a large-scale research project," taking into consideration the reflections from the past cases, to be the guidelines for large future projects.

In particular, one of the often-seen background issues was the "contradiction of recognition and sense of values in relation to implementing a new managerial method in an existing organization," according to their analysis. In other words, although it was necessary to implement the industry-academia collaboration project with a theory different from the one based on past experiences accumulated in the university, it was not possible to do so due to the conflict of values.

-Conflict of the theory of continuous implementation based on a long-term perspective in the university and that of achieving outcomes in a relatively short period of time in the project
-Conflict of the bottom-up method or consensus method, which is a traditional decision-making process in the university and the top-down method with which a leader clearly indicates the mission
-Conflict of the custom of allocating equally resources, such as research funds and human resources, in the university and the necessity of distributing the funds with an inclination or intensively into the projects with clear missions
-Conflict of the theory of managers who manage the project with premise of keeping the existing order and the theory of leaders who doubt the existing order and break from it if necessary

The report suggests the necessity of clarifying the rules of which theory is to be prioritized and of incorporating hybrid mechanisms in the project in advance.

(http://mm.general.hokudai.ac.jp/information/info_548/HURBP-followup09-all_Jpn.pdf)

2 New System in Relation to R&D Institution

(1) Roles of independent administrative agencies related to R&D, as "R&D institution"

R&D institutions comprise major research institutions, private companies and universities. In the "Research and Development Enhancement Act[1]," enacted in 2008, it is defined as the important IAIs with the operations of R&D, R&D on public calls, enlightenment and dissemination of knowledge in relation to science and technology. Although the purposes, background, and functions may vary, each R&D corporation conducts R&D based on the national Science and Technology Basic Plan, which is difficult to be carried out only by universities and institutions in the private sector, and it plays an important role in promoting innovations while, at the same time, enhancing Japan's scientific and technological capability.

Specifically, as a huge ripple effect is expected in Japan's society and economy, with long-term

1 "Law Concerning the Promotion of effective capacity building and research and development and R & D R & D system reforms" (Law No.63 of June 11, 2008): Allocation of research funds from other national R & D system reforms ranging from the development of research, public research institutions, universities and to strengthen national research and development, including the private sector to promote Innovation with the aim to strengthen our competitiveness. It defines (1) Strengthening the foundation for the promotion of research and development, (2) Promotion of competition, (3) Effective promotion of research and development carried out by public funds, and (4) Promotion of commercialization of research and development.

risks, the difficulties of R&D should not be left in the hands of the non-profit private sector. Therefore, institutions have been established to address policy issues for the allocation of research funding; advanced research facilities, equipment, maintenance, and operation; human resources; science and technology information, material collection and storage; and dissemination of research results or communication activities related to science and technology. As of April 2010, 38 institutions have been established[1].

The promotion of R&D for Key Technologies of National Importance is an example of such efforts of R&D institutions. Key Technologies of National Importance is described in the 3rd Science and Technology Basic Plan, in order to maximize the economic and social effects in terms of security. It includes a comprehensive national plan that focuses on basic large-scale national projects and invests in core technology, such as the Space Transportation System (Japan Aerospace Exploration Agency), Earth Observation and Ocean Exploration System (JAMSTEC), FBR Cycle Technology (Japan Atomic Energy Agency), Next-generation Supercomputer (RIKEN), and X-ray Free Electron Laser (RIKEN).

Such interests will lead to competitiveness, strengthening national sovereignty, and developing long-term studies in order to ensure national security and is intended to contribute to broader security measures which will become more and more vital in the future.

The implementation of these R&D institutions has mainly been for the specific allocation of funds and manpower of research, and now has been expanded to include the collaboration of universities and industry for long-term R&D goals.

In FY2009, for example, Japan was in the spotlight for its contribution to the International Space Station (ISS) Program. The Japanese Experiment Module, known as "Kibo" which Japan Aerospace Exploration Agency (JAXA) had developed was completed by Japanese astronauts assembling it. Thereafter, H-II Transfer Vehicle (HTV), an unmanned cargo transfer spacecraft launched by a new rocket (H-IIB), both of which JAXA had developed, accomplished its mission to deliver indispensable supplies to the ISS. For the last 20 or more years, despite some failures and revisions to the program, we have finally assembled expert knowledge and created cutting-edge technology (Table 1-2-52)

The Earth Observation and Ocean Exploration System, the principle technology under the control of JAMSTEC, is being applied to full-scale operation of the Earth Simulator and the deep sea drilling vessel "Chikyu". The main goal for use of this technology is to elucidate the Earth's system, furthering the progress in research areas of global environment observation, research for Earth evolution, and biogeosciences.

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1 Scientific and Technical Research Organization, Okinawa Infrastructure, NICT, National Institute of Alcohol, National Science Museum, NIMS, NIED, National Institute of Radiological Sciences, JST, RIKEN, JAXA, JAMSTEC, JAEA, National Institute of Health and Nutrition, JNIOSH, NIBIO, National Cancer Center, National Cerebral and Cardiovascular Center, NCNP, NCGM, National Center for Child Health and Development, Research Institute, National Center for Geriatrics and Gerontology, NARO, National Institute of Agrobiological Sciences, National Institute for Agro-environment Sciences, Forestry and Forest Products Research Institute, FRA, AIST, Japan Oil, Gas and Metals National Corporation, NEDO, PWRI, BRI, National Traffic safety and Environment Laboratory, PARI, ENRI, National Institute for Environmental Studies

Figure 1 2 52 History of development of space transportation systems and related International Space Station Program (until FY 2009)

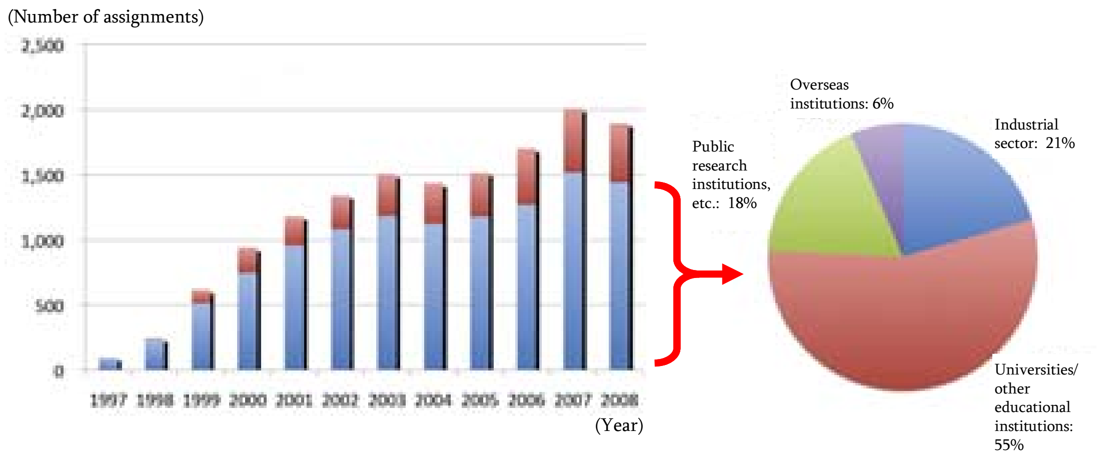
Month, year	History
June 1982	<National Aeronautical and Space Administration (NASA) requested participation of the Japanese government to the Space Station Program.> National Space Development Agency of Japan (then) began a study with focusing on the technicality.
January 1984	<The U.S government officially announced Space Station Program.>
March	The Japanese government expressed an interest in the announcement of Space Station Program by the US government.
August 1985	Japanese first 3 astronauts (Payload specialists) were selected. (Mohri, Mukai, Doi)
January 1986	<Space Shuttle Challenger accident>
June 1989	The Space Station Inter Governmental Agreement (IGA) was approved by the Diet. Development of Japanese Experiment Module (JEM) began.
September 1992	Astronaut Mohri became the first Japanese to be on board the Space Shuttle.
January 1994	Indigenous large scale rocket H-II Launch vehicle No.1 was launched.
March	NASDA began constructing the flight model of JEM.
April 1998	The new Space Station Inter Government Agreement was approved by the Diet.
November	<Construction of International Space Station (ISS) commenced.>
April 1999	Nickname for JEM was announced as “Kibo.”
November	Launch of H-II Launch vehicle No. 8 failed.
November 2000	<Long duration expedition to the ISS began.>
August 2001	The main large scale rocket, H-II A Launch vehicle No.1 was launched.
December	<NASA announced scale down of ISS program.>
February 2003	<Space Shuttle Columbia accident>
October	Japan Aerospace Exploration Agency (JAXA) was inaugurated. (Institute of Space and Astronautical Science (ISAS), National Aerospace Laboratory of Japan (NAL), and National Space Development Agency of Japan (NASDA) were joined).
November	Launch of H-II A Launch vehicle No.6 failed.
July 2005	<Recommence of the Space Shuttle flights>
September	Development of Japan’s “Centrifuge” was suspended.
March 2008	Experiment logistic module- pressurized section of “Kibo” was launched (Astronaut Doi on board)
June	Pressurized Module of “Kibo” was launched (Astronaut Hoshide on board)
March 2009	Astronaut Wakata became the first Japanese to stay in the ISS for long duration expedition.
July	Exposed facility of “Kibo” was launched.
September	An unmanned cargo transfer spacecraft H-II Transfer Vehicle (HTV) was launched by new type Rocket H-II B experimental Launch vehicle.
December	Astronaut Noguchi began long duration expedition to the ISS.

Source: Prepared by MEXT

In addition, R&D institutions are responsible for the development maintenance and operation of world-leading research facilities and equipments, which they are equally responsible for promoting widely shared use of. The large synchrotron radiation facility, SPring-8, and Japan Proton

Accelerator Research Complex (J-PARC) , which are the leading large research facilities and require large amount of budget, have been developed and operated by R&D institutions based on the "Act on Promotion of shared use of Specified Large-Scale High Technology Research Facility" (Act No. 78 of 1994). These large facilities are used for various domestic and international researchers and produced for excellent results in wide fields of science and technology. Future efforts will continue to promoted advanced and basic research facilities and equipment appropriate for shared use by multiple institutions.

Figure 1 2 53 Trends in the number of research projects at SPring-8 and the breakdown of user institutions



Use of shared beam line (blue) and exclusive beam line (red) (Total)

Breakdown of institutions using shared beam line (blue) (FY2008)

Note: "Breakdown of the institutes" is a representative institution in the breakdown of each task.
Source: Provided by Japan Synchrotron Radiation Research Institute (JASRI)

(2) Implementation of the New System in Relation to R&D Institutions

As stated above, R&D institutions play a vital role in promoting science and technology in Japan. For implementation of the system, the Research and Development Enhancement Act and its affiliated acts have imposed necessary measures within the next three years (until Oct. 2011) for appropriate systems for R&D institutions, acquisition of talented human resources and international competitiveness.

Currently, there is a new system in place for R&D institutions that is under evaluation of the each corresponding ministry. Due to international competition, R&D institutions require policies that meet global standards for management based on characteristics of R&D (i.e., competitiveness, fluctuation, unforeseeable uncertainties, long-lifetime, high specialization, versatility and cross-competitiveness). More specifically, the new system established by "Organization of National Institute of Research and Development" recommended some governance reforms including for basing human resource payroll structure on global standards, having flexible budget allocation to accommodate for the characteristics of R&D; acquiring external funding or promoting common facilities; reforming management of promotional efforts beyond the ministries; encouraging external opinions or auditing; and assessing incorporation of global perspectives[1].

[1] The interim report of the task force for the functional enhancement of Research and Development (April 2010)