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Knowledge Creation Process in Science: Basic findings from a large-scale survey of researchers in Japan

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Summary

This paper reports the initial findings from a large scale survey of Japanese researchers on the knowledge creation process in science. The survey was jointly conducted by the Institute of Innovation Research of Hitotsubashi University and the National Institute of Science and Technology Policy[1]. It collected 2,100 responses on research projects, one third of the sample are from highly cited papers (top 1% in the world, H papers hereafter) in each science field by year and the rest of are from the other randomly selected papers (N papers hereafter). We call the research projects that yielded H (N) papers by H (N) projects. The survey covered all scientific fields, including social sciences, and characterized the motivations of the research projects, the knowledge sources which inspired the projects, uncertainty in the knowledge creation process, research competition, composition of the research team, sources of research money, and the research outputs, including the papers, the patents, the collaborative research projects.

Major findings are as follow:

1. A significant part of the research project are very importantly motivated both by "Pursuit of fundamental principles/understandings" and by "Solving specific issues in real life". Thus, even if we define "Pasteur's quadrant" narrowly (both motivations are very important), it is quantitatively important in scientific research. The level of motivation is stronger in H projects than in N projects for both objectives, but especially on "Pursuit of fundamental principles/understandings".
2. A large majority of the focal papers involved surprise in either research process or in research outcome. A majority of research projects generated serendipitous output (The research output found answers to questions not originally posed). H papers involve more surprises and serendipity.
3. Most researchers recognize the extent of research competition ex-ante (only a minority chose "don't know answer"). A significant part of researchers were concerned with priority loss (around 50% in H projects and around 30% in N projects).Competition is global in most fields.
4. There are significant differences in research management in terms of setting the research goal and the design of the research team across H projects and N projects.
5. Research teams with more diversity in terms of disciplines and nationalities seem to perform better.
6. Young scholars are important contributors for research efforts. Post-doctoral students and doctoral students are often the first authors of H papers (around 40%) when the order of the authors is according to their contributions.
7. Majority of research projects use more than one funding sources. While H projects use more external funding source, only a minority of projects use only external funding.
8. The distribution of the number of refereed papers produced from a project is highly skewed.

[1] There is a corresponding Japanese report with detailed statistical tables, published in November 2010 on which this paper is based (available from http://www.nistep.go.jp/achiev/ftx/jpn/mat191j/idx191j.html).

9. Research projects generate not only research papers, but also outputs useful for industrial innovation, including patent applications, licensing/assignment, collaborative research, startups and standard. This is more so for H projects. For an example, more than 40% (23%) of the H projects (N projects) involved at least one patent application. 3 % (2%) of the H projects (N projects) resulted in startups. 5% (3%) of H (N) projects led to standards.
10. A majority of licensing and assignment (70 to 80%) were associated with the provision of know-how.
11. Educational outputs of the research projects are also important. 74% (65%) of H projects produce doctoral degrees. The research projects also often produced materials and the other research tools.

The paper also discusses the implications of these research findings on research on research and on science policy.

1 BACKGROUND AND PURPOSE OF THE RESEARCH

Developing systematic and objective data on the knowledge creation process in science at project level has become very important, given that science is expected to play an important role in the innovation process of a nation and the knowledge creation process in science has become more complex in recent years. Science has increasing become teamwork, requiring variety of skills, knowledge and research equipments have become more expensive, while scientific competition has become more global. Active researches based on the bibliographic information have been being conducted in recent years (see for an example, Wuchty, Jones, and Uzzi (2007) and Jones, Wuchty and Uzzi (2008)). However, the information one can retrieve from the bibliographic information is limited. The bibliographic information does not provide the information about motivation for the research project, external knowledge sources that inspired the research project, the history of the research project, research funding, and research outputs and impacts. As one will later see, authors are often not researchers and researchers are often not authors.

The Institute of Innovation Research of Hitotsubashi University and the National Institute of Science and Technology Policy of the Ministry of Education, Culture, Sports, Science and Technology have decided to jointly carry out the "Survey on the Knowledge Creation Process in Science". The purpose of this survey is to collect the objective data that show structural characteristics in the knowledge creation process in science and the process of creating innovation from scientific knowledge based on comprehensive questionnaire surveys for researchers in all fields of science both in Japan and in the United States (more than seven thousand researchers each in the two countries). Japanese survey was conducted from the end of 2009 to the early summer of 2010 and totally 2,100 researchers responded to the survey. The survey in the United States in collaboration with Georgina Institute of Technology has been implemented since the autumn of 2010. This report covers the initial findings from the Japanese survey.

The survey tries to answer the following basic questions about scientific research. The structural understandings of these issues will be valuable for designing of science policy, too.

1. What percentage of research projects conducted by researchers is in pure basic research ("Bohr's quadrant" in the classification of Stokes), use-inspired basic research (Pasteur's quadrant), and pure applied research (Edison's quadrant)?
2. How long does it take from the conceiving of the research projects to internationally recognized research outputs? What kind of research funds do researchers rely on in the research project?
3. To what extent do researchers recognize *ex ante* the status of global competition in research and how seriously are concerned over priority loss?
4. How important is the serendipity in research and which kind of research is more likely to spawn the serendipity?
5. To what extent research teams are interdisciplinary and international? How frequent do researcher move across the organizations?
6. What kind of research management was implemented in research projects?

7. What percentage of the research outputs result in patents and how frequently the provision of knowhow is involved? What about the production of the research tools.

What kinds of commercialization paths are pursued in the innovation processes based on the outputs of scientific research? So far, comprehensive micro-data set, covering the research projects, the composition of the research team, research funding used in the research projects, external knowledge sources that inspired the research project, serendipities in the research projects, outputs yielded by the research projects have been constructed and basic analysis has been conducted. This report summarizes the basic findings of the survey based on this.

The rest of the paper consists of the following 9 sections. Section 2 provides an overview of the survey method. More details are provided in the Appendix. Section 3 provides the characteristics of the focal papers. Section 4 provides the results of the survey on the motivations for the research and uncertainty in research both in the process and in the output. Section 5 discusses the results on research competition. Section 6 discusses the results on knowledge sources and research management. Section 7 discusses the characteristics of research teams, based on the survey results on the authors of the focal paper. Section 8 discusses the results on the labor and the other inputs for research projects. Section 9 discusses the outputs and the channels of impacts of the research projects on industrial innovation. Section 10 concludes.

ACKNOWLEDGEMENT

This research has been being conducted in collaboration between Institute of Innovation Research (IIR) of Hitotsubashi University and National Institute of Science and Technology Policy (NISTEP) as a part of "Industry-university-government joint research on the innovation process" with support of Special Funds for Education and Research of The Ministry of Education, Culture, Sports, Science and Technology. This work has also been supported by JSPS KAKENHI 21243020.

US-Japan Workshop on Scientific Collaboration and Productivity was held in March 2010 in collaboration with Georgia Institute of Technology, with support of the National Science Foundation of the United States. The interim results of Japanese survey; various studies related to the knowledge creation process; and experiences of researchers on the knowledge creation process were presented. Workshop on the knowledge creation process in science was held in October 2010. Basic findings of the survey were presented and productive discussions were held about research management; challenges in science and technology policy; and research on research. We would like to thank for the supports from the funding Ministry and organizations as well as individuals who provided comments and suggestions to the project at various stages of the research. In particular, we would like to thank the researchers who kindly became subject to pre-testing and provided very useful comments to the design of questionnaires and Terutaka Kuwahara, the director of the NISTEP, who provided strong supports to the project. The research team of this project consists of the following and the survey in Japan was mainly designed, developed and implemented by the first four members of the team (four authors of this paper), with helpful comments from the rest of the members .

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Hiroshi SHIMIZU	Assistant Professor, Institute of Innovation Research, Hitotsubashi University
Paula E. STEPHAN	Professor, Georgia State University
John WALSH	Associate Professor, Georgia Institute of Technology International Affiliated Fellow, National Institute of Science and Technology Policy, Ministry of Education, Culture, Sports, Science and Technology

2 OVERVIEW OF THE SURVEY METHOD

2－1 SELECTION OF THE SURVEY TARGETS

The survey targets were selected through the following procedures. Details in the selection process were shown in the Appendix "Survey Methodology" of this report.

(1) Identification of possible focal papers

The population of the survey was articles and letters in the Web of Science database of Thomson Reuters. Reviews were excluded from the population. The objective of the review papers is to conduct the survey of the existing studies, thus they are not likely to cover a research project. The time window of the papers for the survey is from 2001 to 2006 (database year). Database year refers to the year when the documents are recorded into the database. The bibliographic information and the number of citations as of the end of December 2006 were used in the survey. Two sets of the possible focal papers were selected from the population.

1. Highly Cited Papers

   Top 1% highly cited papers in each journal field (22 fields in total) and in each database year; at least one organization of authors should be located in Japan (approximately 3,000 in total).

2. "Normal" Papers

   Randomly selected papers in each journal field and in each database year from the population of the survey, excluding the above highly cited papers; at least one organization of authors should be located in Japan (approximately 7,000).

In this report, highly cited papers are described as "H papers" and normal papers are described as "N papers." The journal field refers the 22 science fields in the *Essential Science Indicators* ("*ESI*" hereafter) of Thomson Reuters (see Exhibit 1). We covered all fields, including the social science, although the coverage of social science journals by the database is not comprehensive and we have got a relatively small number of the publications by Japanese authors in this field.

(2) Identification of Possible Survey targets and research projects for the survey

Corresponding authors or equivalents of approximately 10,000 possible focal papers were searched and identified as survey targets. If multiple papers were assigned to a single author, one paper was randomly selected as a focal paper while the priority was given to the H papers in the selection process.

As a result, totally 7,652 survey targets were identified. Of those, there are 1,932 researchers whose focal paper is the H paper; and there are 5,720 researchers whose focal paper is the N paper.

This report describes the research projects that are from H papers as "H projects" and describes the research projects that are from N papers as "N projects." The project is defined as a series of research activities in which the specified focal paper and the other closely related research outcomes were produced.

2－2 Implementation of the Survey

The questionnaire survey was conducted on the Web. A request of the cooperation to the survey, the web address of the questionnaire survey website, user ID, and password were sent to the researchers by either e-mail or post mail.

Questionnaires were sent by post, if researchers preferred paper-based survey. Questionnaires in English were also prepared for survey targets having difficulty in answering the questionnaire in Japanese. If a researcher recommended another researcher, the request of cooperation was sent again to the recommended researcher.

The basic time-line of the survey was shown below. Other due date was set for newly recommended survey targets, and survey targets whose focal papers were N papers in chemistry.

- Survey launch: December 21, 2009
- Initial due date: February 7, 2010
- Reminders were sent twice (mid of Jan., mid of Feb.)
- Final due date: April 11, 2010

2－3 Field Classification for the Analysis

Most results of the survey to be presented in this paper are based on 10 fields, aggregated from 22 ESI journal fields. Some results are based on further large 3 fields obtained by a further aggregation of the 10 fields. The relation between the 22 ESI journal fields, the 10 fields, and the large 3 fields is shown in Exhibit 1. Papers of multidisciplinary fields are reclassified into one of 21 fields based on the backward citations of the multidisciplinary papers.

Exhibit 1 Relation between the 22 ESI journal fields, the 10 fields, and the large 3 fields

<table>
<tr><th>22 ESI journal fields</th><th>10 fields</th><th>large fields</th></tr>
<tr><td>Chemistry</td><td>1_Chemistry</td><td rowspan="9">Physical Sciences</td></tr>
<tr><td>Materials Science</td><td>2_Materials Science</td></tr>
<tr><td>Physics</td><td rowspan="2">3_Physics&Space_Science</td></tr>
<tr><td>Space Science</td></tr>
<tr><td>Computer Science</td><td rowspan="2">4_Computer Science&Mathematics</td></tr>
<tr><td>Mathematics</td></tr>
<tr><td>Engineering</td><td>5_Engineering</td></tr>
<tr><td>Environment/Ecology</td><td rowspan="2">6_Environment/Ecology&Geosciences</td></tr>
<tr><td>Geosciences</td></tr>
<tr><td>Clinical Medicine</td><td rowspan="2">7_Clinical Medicine&Psychiatry/Psycholog</td><td rowspan="2">Medicine</td></tr>
<tr><td>Psychiatry/Psychology</td></tr>
<tr><td>Agricultural Sciences</td><td rowspan="2">8.1_Agricultural Sciences&Plant & Animal Science</td><td rowspan="8">Life Sciences</td></tr>
<tr><td>Plant & Animal Science</td></tr>
<tr><td>Biology & Biochemistry</td><td rowspan="6">8.2_Basic Life Sciences</td></tr>
<tr><td>Immunology</td></tr>
<tr><td>Microbiology</td></tr>
<tr><td>Biology & Biochemistry</td></tr>
<tr><td>Neuroscience & Behavior</td></tr>
<tr><td>Pharmacology & Toxicology</td></tr>
<tr><td>Multidisciplinary</td><td>Either of 22 ESI journal fields was assigned based on the analysis of the backward citations</td><td>Either of 22 ESI journal fields was assigned based on the analysis of the backward citations</td></tr>
<tr><td>Economics & Business</td><td rowspan="2">S_Social Sciences</td><td rowspan="2"></td></tr>
<tr><td>Social Sciences, general</td></tr>
</table>

2－4 SECTOR CLASSIFICATION FOR THE AFFILIATION OF SCIENTISTS

The survey asked a researcher to identify the sector of the organization with which he/she was affiliated when the focal paper was submitted. This sector is used for analysis. The five-sector classification shown below is used in this report.

(1) Higher education institutions
(2) Public research institutions
(3) Private firms
(4) Private non-profit organisations, including hospitals
(5) Others

The higher education institutions include universities, inter-university research institutions and colleges of technology. The public research institutions include national experimental and research institutions, independent administrative corporations for research, special corporations and experimental and research institutions of local governments.

2—5 RESPONSE RATE BY FIELD

Out of 7,562 survey targets, we got 2,081 responses. The total response rate is 27%. The response rate is 29% for the H papers and 27% for the N papers. The response rate in the H papers is higher than that in the N papers. Response rate by field is shown in Exhibit 2. The fields shown in Exhibit 2 include multidisciplinary field. In this survey, the papers of multidisciplinary field, those published in the journals like *Nature* and *Science*, were reclassified into either of 10 fields based on the references in the papers. The methodology was discussed in the Part II. There are, however, thirteen papers that could not be reclassified. These papers were excluded from the analysis by field.

The response rate exceeds 30% in chemistry; materials science; environment/ecology & geosciences; agricultural sciences & plant & animal science. The response rate in clinical medicine & psychiatry/psychology is 21% that is the lowest among the 10 fields excluding the residual multidisciplinary field. Comparison between H papers and N papers by field shows that the response rates in the H papers are higher than or equal to those in the N papers in almost all fields. One exception is basic life sciences in which the response rate for the N papers is 4% higher than that for the H papers.

Exhibit 2 Response rate by field

	All Focal Papers			H papers			N papers			
	Survey targets	Responded	Response rate	Survey targets	Responded	Response rate(A)	Survey targets	Responded	Response rate(B)	(A) - (B)
1_Chemistry	837	257	30.7%	208	71	34.1%	629	186	29.6%	4.6%
2_Materials Science	472	142	30.1%	127	43	33.9%	345	99	28.7%	5.2%
3_Physics&Space_Science	1407	380	27.0%	400	127	31.8%	1007	253	25.1%	6.6%
4_Computer Science&Mathematics	323	77	23.8%	66	16	24.2%	257	61	23.7%	0.5%
5_Engineering	707	206	29.1%	197	68	34.5%	510	138	27.1%	7.5%
6_Environment/Ecology&Geosciences	361	115	31.9%	81	30	37.0%	280	85	30.4%	6.7%
7_Clinical Medicine&Psychiatry/Psycholog	1278	264	20.7%	325	66	20.3%	953	198	20.8%	-0.5%
8.1_Agricultural Sciences&Plant & Animal Science	597	192	32.2%	165	60	36.4%	432	132	30.6%	5.8%
8.2_Basic Life Sciences	1504	404	26.9%	351	83	23.6%	1153	321	27.8%	-4.2%
9_Multidisciplinary(*)	13	2	15.4%	0	0	-	13	2	15.4%	-
S_Social Sciences	153	42	27.5%	12	2	16.7%	141	40	28.4%	-11.7%
Total	7,652	2,081	27.2%	1,932	566	29.3%	5,720	1,515	26.5%	2.8%

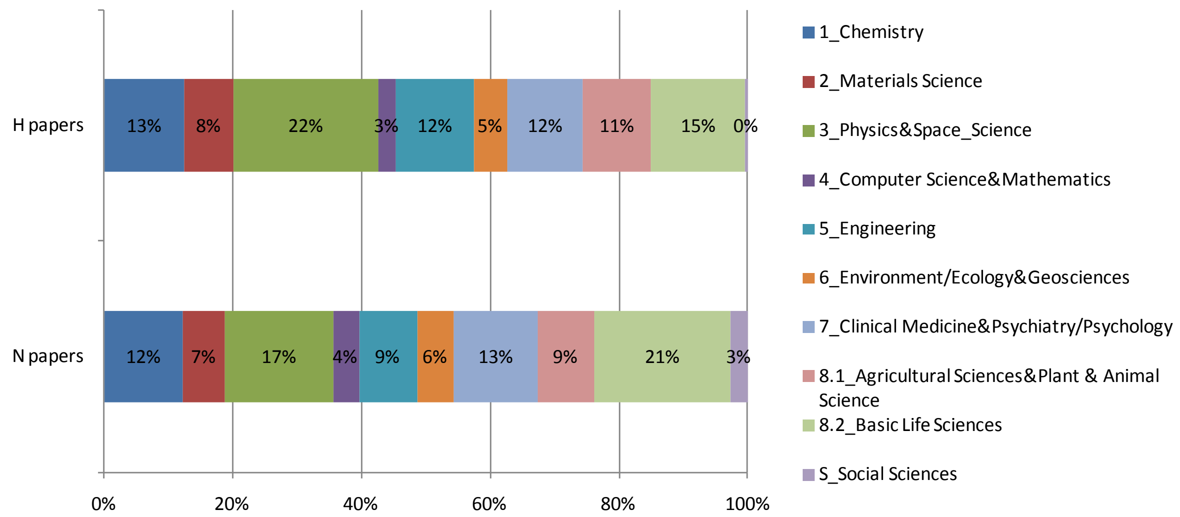
Note1: (*) Papers in multidisciplinary field that could not be reclassified.

2－5－1 Field Composition of the Respondents by Two Types of the Papers

The field composition of the respondents is shown in Exhibit 3. The composition of respondents is the almost same between H papers and N papers in many fields, reflecting our design of the sample population. The share in the H papers is 5.7% higher than that of the N papers in physics & space science and the share of the N projects is 6.6% higher than that of the H papers in basic life sciences.

The field dependence of the magnitude and direction of the differentials in responses between the H and N projects is small in most questions. Thus no correction based on the weight of fields is made for comparison of the statistics across the H and N projects. We have confirmed that the results of the N projects only show slight changes even if the averages are adjusted based on the weights of fields in H projects.

Exhibit 3 Field composition of the respondents



2－6 CHARACTERISTICS OF THE RESPONDENTS

2－6－1 Age

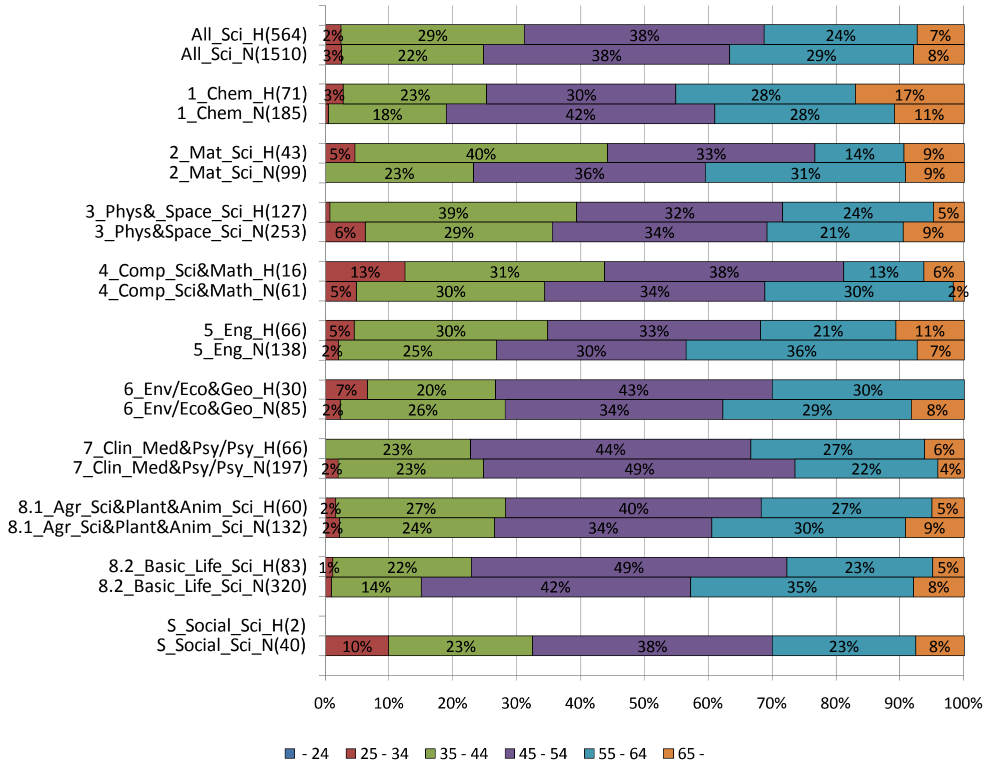
Exhibit 4 summarizes the age distribution of the respondents, at the time when the survey was conducted (the first part of 2010) and when the focal paper was submitted. There exist around 7 years' difference between the two average ages, which reflect both the lag between the submission and the publication as well as that between the publication and the survey.

Average ages of respondents in all fields when the survey was conducted are 50.0 in the H papers and 51.4 in the N papers. The share of the respondents whose age is 44 or less is more than 30% in 4 fields, i.e., materials science; physics & space science; computer science & mathematics; and Engineering, of the H papers and in 3 fields, i.e., physics & space science; computer science & mathematics; and social sciences, of the N papers. The share of age group of 25 to 34 years old reaches 13% in computer science & mathematics of the H projects.

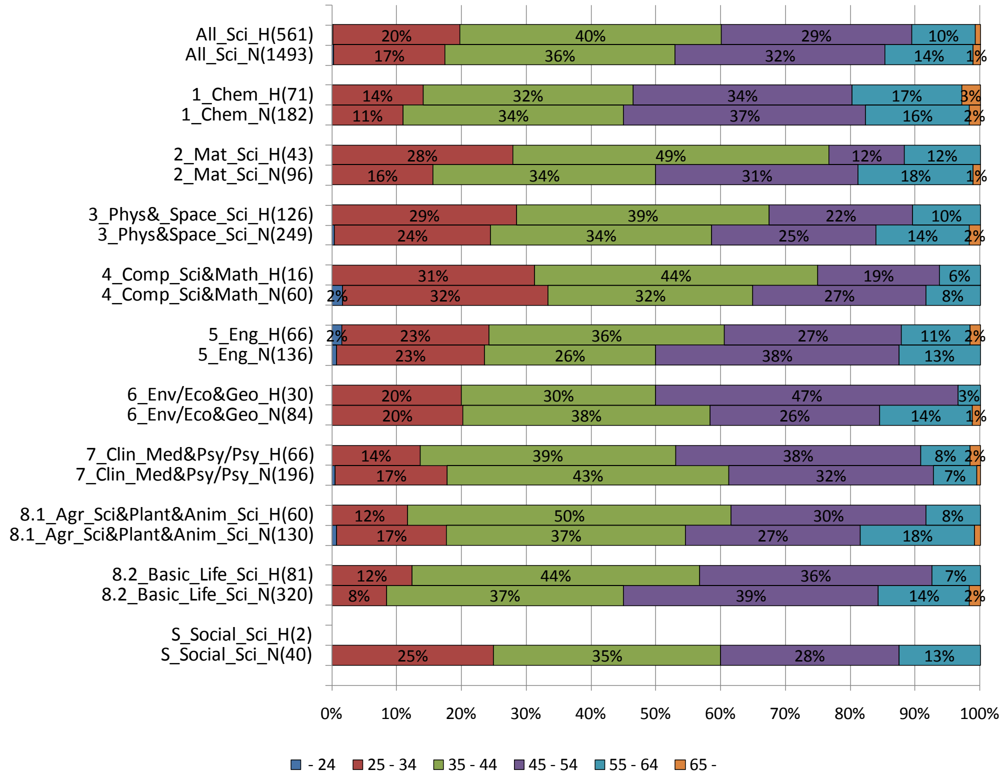
As for submission age, the average ages of respondents in all fields are 42.6 in the H papers and 43.9 in the N papers. The average ages of both types of papers are 7 years younger compared to the average age when the survey was conducted, i.e., average ages in 2010. The focal papers were published between 2001 and 2006. Considering around one year time-lag between the submission and the publication of the focal papers, it could be said that there would be 5 – 10 years time-lag between the submission of the focal papers and 2010. This will explain the differential between the average ages of respondents when the focal paper was submitted and when the survey was conducted. The ratio of respondents whose age is 34 or less is more than 30% in computer science & mathematics both in the H papers and N papers.

Exhibit 4 Age distribution of respondents

(a) Ages when the survey was conducted



(b) Ages when the focal paper was submitted



Note1: In each field, the upper figure is for the H papers and the lower figure is for the N papers.
Note2: Result of social sciences in the H papers was not shown due to the small number of responses.

2－6－2 Sector Composition of the Respondents When the Focal Paper Was Submitted

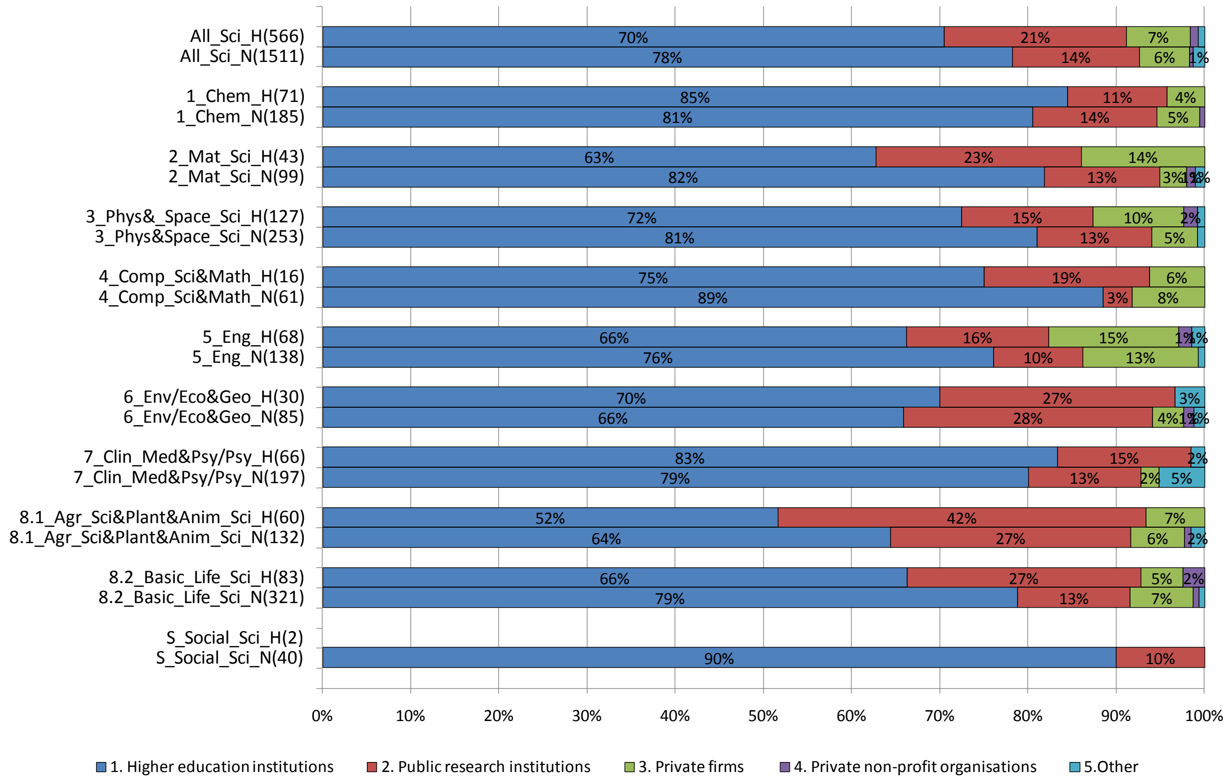
Exhibit 5 shows the sector composition of the organizations with which the respondents were affiliated when the focal paper was submitted. Higher education institutions (HEIs) have the largest share both in the H papers and N papers (70 % and almost 80% respectively), followed by the public research institutions (PRIs). The share of the two sectors combined accounts for 90% of the total. It is however important to note that the response rates of private businesses and private non-profit organizations were substantially lower (by around 30 %).

The share of the public organization is more than 20% in environment/ecology and geosciences; and agricultural sciences & plant & animal science in both the H papers and N papers. The share of the public organization is very large, i.e., 42%, in agricultural sciences & plant & animal science of the H papers. The share of the public organization is also more than 20% in materials science and basic life sciences of the H papers.

The share of the business enterprises is more than 10% in materials science; physics & space science; and Engineering for both H papers and the N papers.

Exhibit 5 Sector of the organization with which the respondents were affiliated

when the focal paper was submitted



Note1: In each field, the upper figure is for the H papers and the lower figure is for the N papers.

Note2: The higher education institutions include universities, inter-university research institutions and colleges of technology. The public research institutions include national experimental and research institutions, independent administrative corporations, special corporations and experimental and research institutions of local governments.

Note3: Result of social sciences in the H projects was not shown due to a very small number of responses.

2－6－3 Roles of the Respondents in the Research Projects

This section summarizes 1) the role of respondents in the management and 2) the role of the respondents in the implementation of the research project that produced the focal paper.

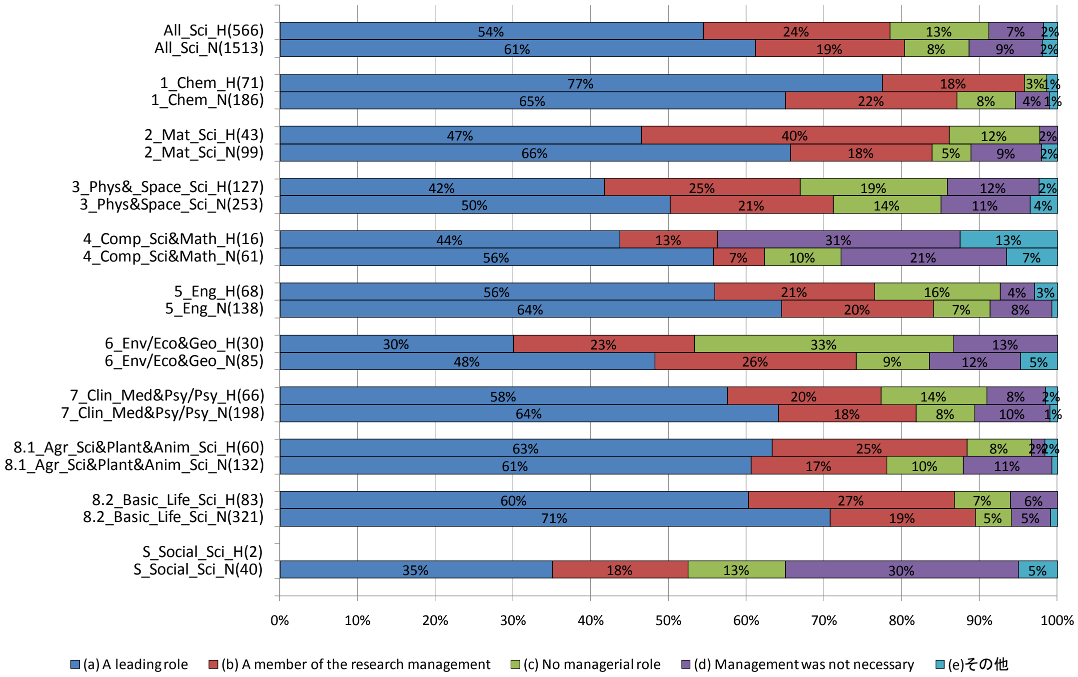
As shown in Exhibit 6, in at all fields of the H projects, 54% of the respondents played the leading role in the management, i.e., the design of the research project, administration of the research project, and application for the research grant. Including the respondents who were a member of the research management but less than that of the leader (24%), approximately 80% of respondents played at least some role in the management. Very similarly, about 80% of respondents from the N projects were a member of research management.

Management was not necessary for a small project, although it is a minority (less than 10% in both types of projects). The share of the response of "Management was not necessary" is large in computer science & mathematics and social sciences, compared to other fields. Our survey also revealed that the number of authors and the amount of research funds in these two fields are relatively small, compared to other fields, indicating that management becomes more important as the project becomes larger and more complex.

A fairly large share of the respondents (20 – 30%) did not play a managerial role in environment/ecology and geosciences and physics & space science of the H projects. One possible explanation of this is that many of the respondents are the researchers who participated in the international research project led by another country. The analysis of the international co-authorship showed that these two fields exhibit relatively high probability of international co-authorship compared to other fields.

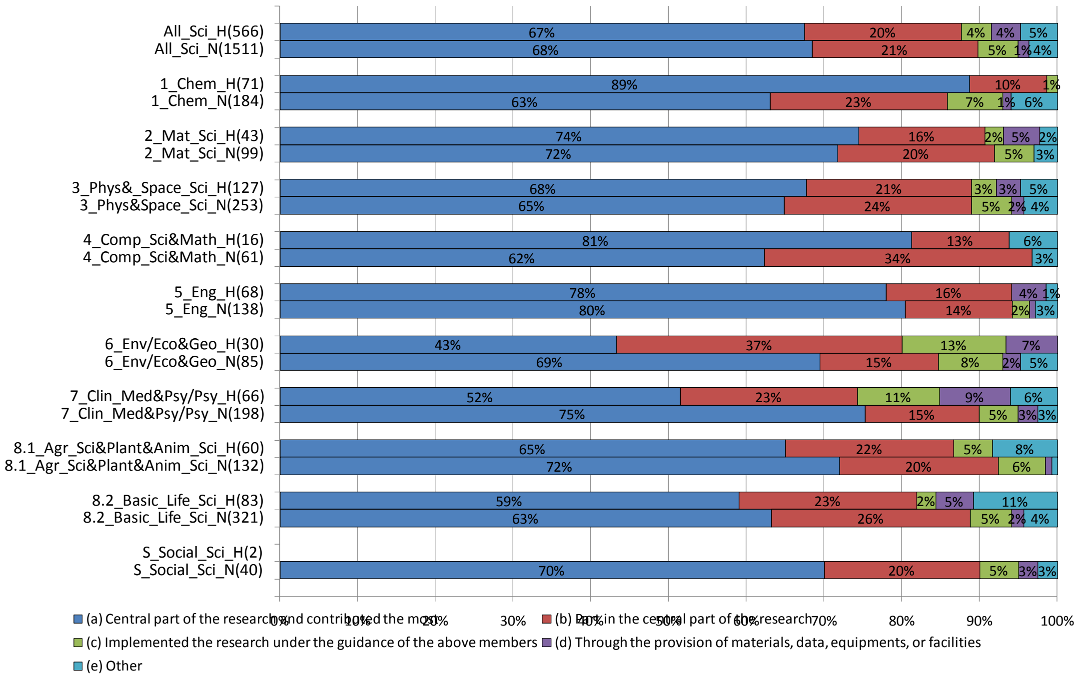
Next we look at the role of respondents in the implementation of research projects, as shown in Exhibit 7. 67% of respondents in the H projects said they executed the central part of the research and contributed the most to the research output. Including the respondents who took part in the central part of the research but their contribution was not as substantial as the above central researcher; approximately 90% of respondents executed the central part of the research. About 90% of respondents in the N projects also executed the central part of the research. Thus, we can conclude that most respondents have a very good knowledge of the research project as well as of its management.

Exhibit 6 Role of respondents in the management



Note1: In each field, the upper figure is for the H papers and the lower figure is for the N papers.
Note2: Result of social sciences in the H projects was not shown due to the small number of responses.

Exhibit 7 Role of the respondents in the implementation of the research project

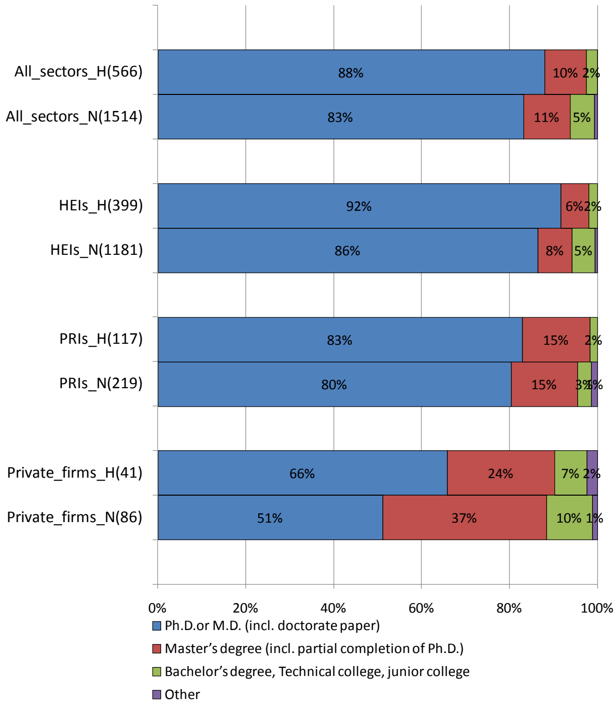


Note1: In each field, the upper figure is for the H papers and the lower figure is for the N papers.
Note2: Result of social sciences in the H projects was not shown due to the small number of responses.

2－6－4　Research Career of the Respondents

An overview of the research careers of the respondents is shown in this section. Exhibit 8 shows the distribution of the highest academic degree of the respondent when the research project was launched. The share of the scientists with a Ph. D or a M. D. is the largest in all sectors in both the H projects and N projects. It is the largest in the HEIs (HEIs), followed by the public research institutions (PRIs), and then by the private firms. The share of respondents whose highest degree was Master's degree or below is large in private firms compared to other sectors. In the private firms for the N projects, 37% of the respondents have Master's degrees as the highest degree and around 10% of respondents have Bachelor's or lower degree as the highest degree.

Exhibit 8 Highest degree of respondents when the research project was launched



Note1: In each sector, the upper figure is for the H papers and the lower figure is for the N papers.

In the HEIs and the private firms, the share of respondents who won a distinguished paper award or a conference award from an academic society is higher in the H projects than in the N projects. About 60% of the respondents of the H papers in the HEIs won the award (Exhibit 9(a)).

In the HEIs, the share of the respondents who served on an editorial board of an international journal is larger in the H projects, compared to those in the N projects. Looking across the sectors, the share is the highest in the HEIs, followed by the PRIs and the private firms (Exhibit 9(b)).

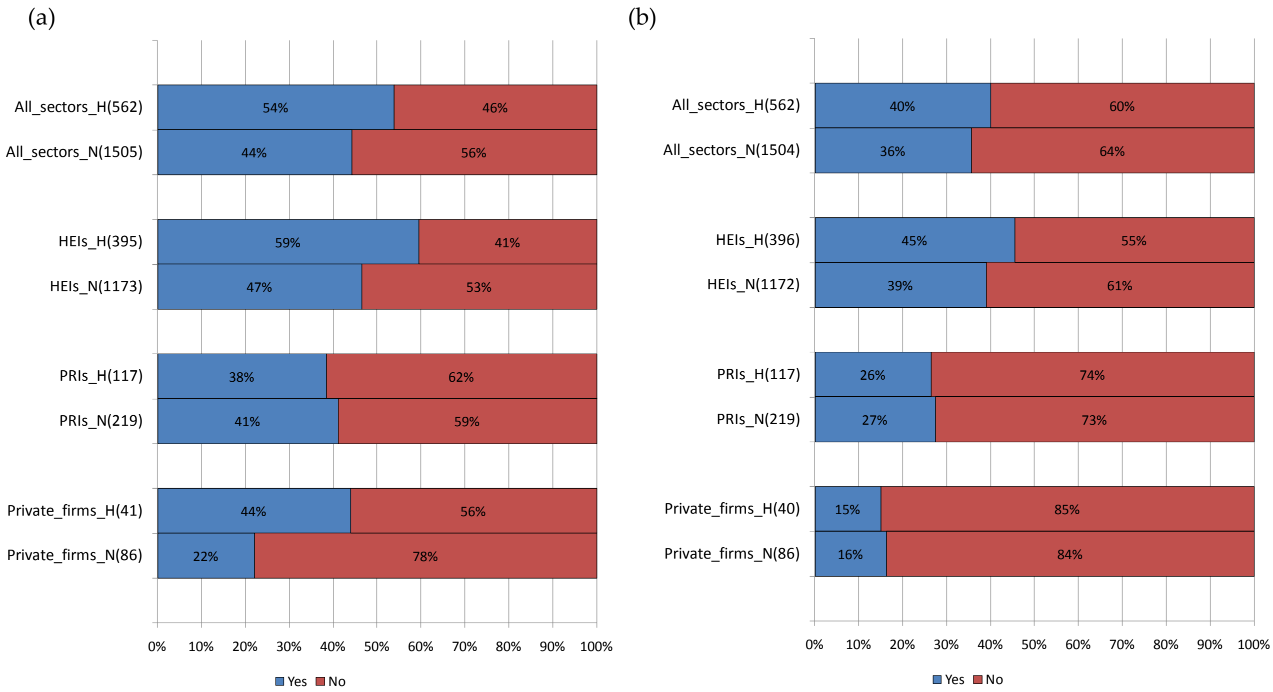
More than a half of respondents of the H papers in the HEIs and those in the PRIs stayed in abroad for one year or more for study or research before the initiation of the project. The share of such respondents is 10% larger for the H projects than for the N projects in the public organization group. The share of the respondents who stayed in abroad for one year or more is smaller in the private firms compared to that in the other sectors. The share is 22% for the respondents with the H papers and 17% for those with the N papers.

The share of the respondents who changed academic or research positions across organizations in the five years proceeding to the initiation of the project is high, 30 – 40% of those in the HEIs and the PRIs. The share in the private firms is relatively small compared to these sectors. In the HEIs, the share of the scientists of the H papers who moved among is 10% higher than that in the N papers.

Exhibit 9 Research career of the respondents when the research project was launched (1)

(a) Respondents who won a distinguished paper award or a conference award from an academic society

(b) Respondents who served on an editorial board of an international journal

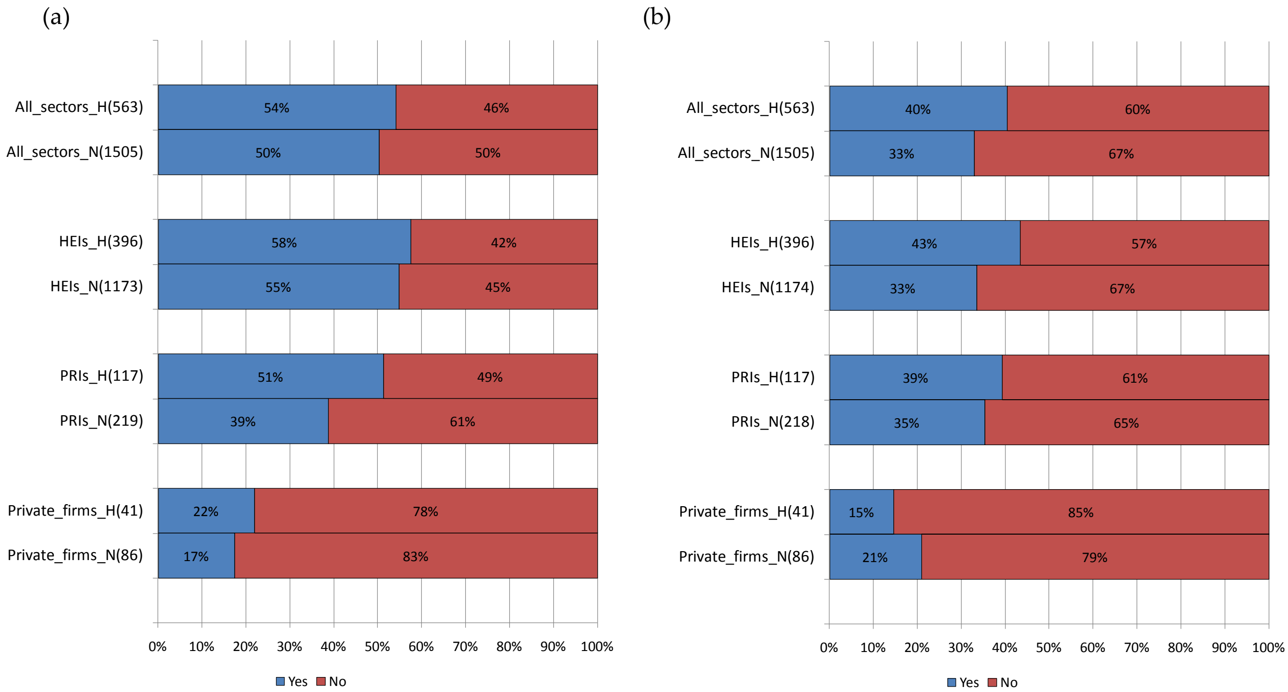


Note1: In each sector, the upper figure is for the H papers and the lower figure is for the N papers

Exhibit 10 Research career of the respondents when the research project was launched (2)

(a) Respondents who stayed in abroad for one year or more for study or research

(b) Respondents who changed academic or research positions across organizations in the preceding five years



Note1: In each sector, the upper figure is for the H papers and the lower figure is for the N papers

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3 Characteristics of the Focal Papers

3－1 Importance of the Focal Paper in the Field

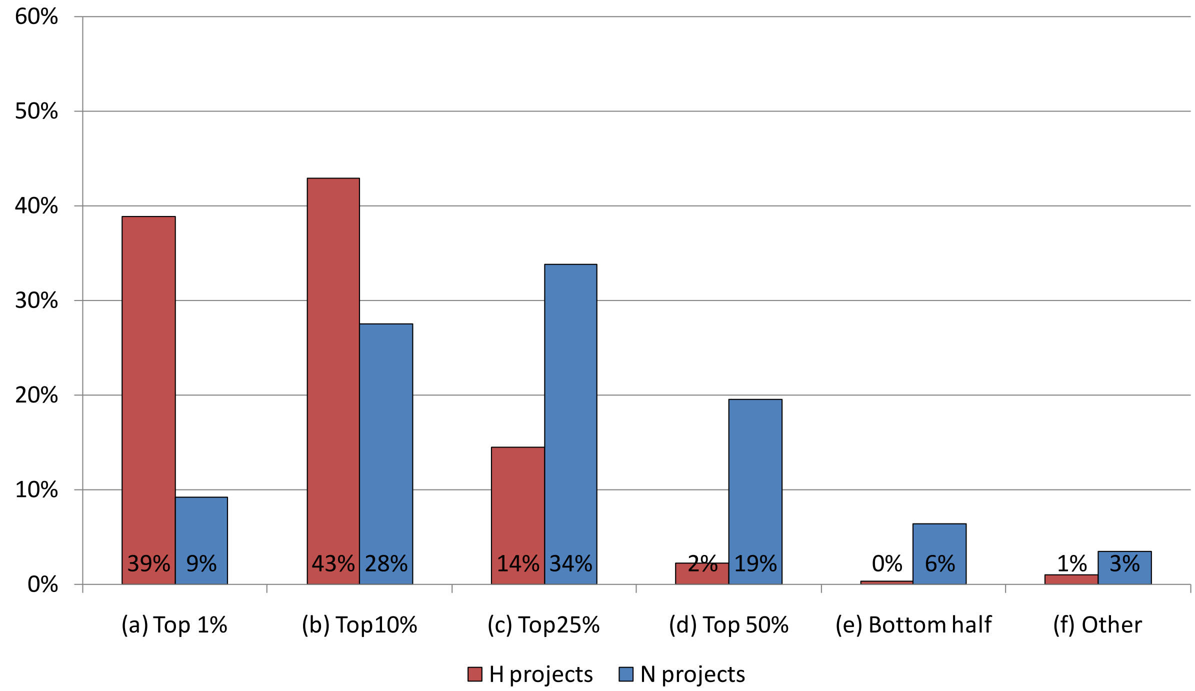
In the design of the target for this survey, we used the number of citations as a proxy to measure the importance of the research papers, and selected the H papers based on that measure. The self-evaluation of respondents also supports our assumption as seen in Exhibit 11. For this exhibit, we asked a respondent to assess the importance of the focal paper compared to the global research findings in the same field during the same period (published within a year before or after the focal paper was published). H papers have significantly higher shares of being recognized by the respondent as the research papers having relatively high self- evaluation than the N papers.

Looking at the H projects, 39% of the respondents thought that the focal paper was one of the most important papers, ranking within the top 1% in the world and 82% of the respondents thought that the focal papers rank within the top 10% in the world. In contrast, 9% of respondents of the N projects ranked the focal papers in the top 1%, 37% of respondents ranked the focal papers in the top 10%. The share of "a relatively important paper, ranking within the top 25%" is the largest in the N papers. The Web of Science database of Thomson Reuters, from which the focal papers were sampled, collects only those academic journals that fulfill the significance criteria set by Thomson Reuters. Thus, there is a possibility that a paper of relatively important outputs of the research project were sampled as the focal paper of the survey even for N papers.

3－2 Importance of the Focal Paper among All Outputs of the Research Project

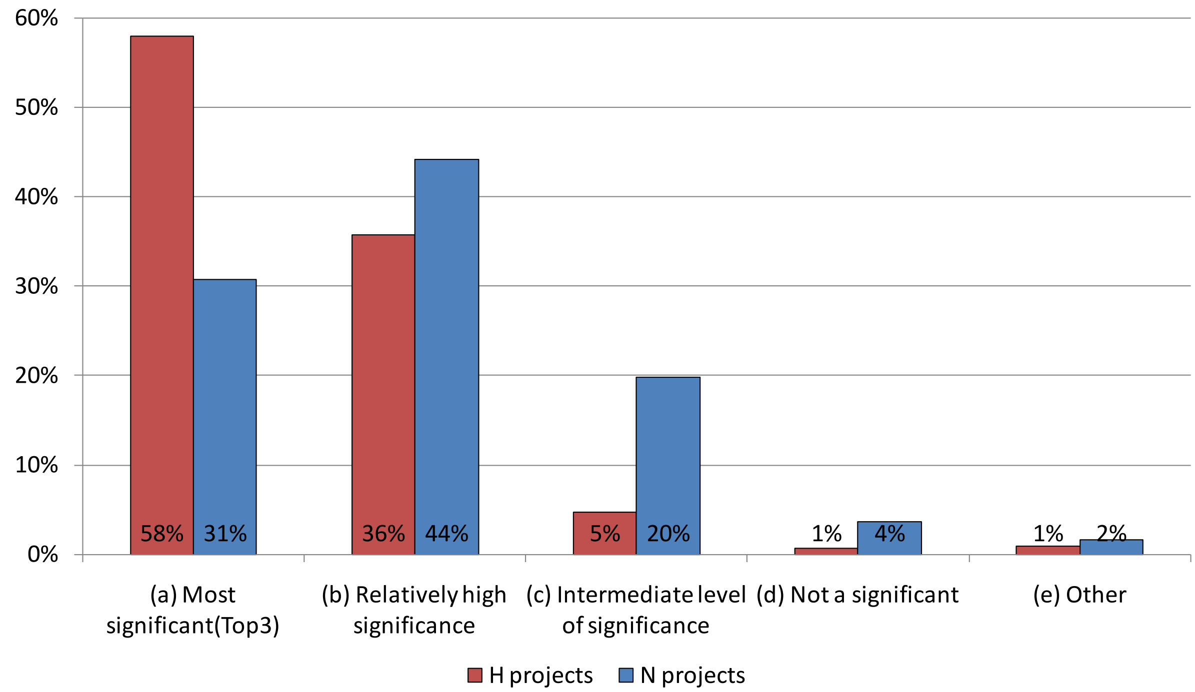
The H papers are significantly likely to receive the highest evaluations among all outputs of the research project, compared to the N papers, as shown in Exhibit 12. 58% of respondents in the H projects think that the focal paper is "one of the most significant papers (one of the top 3) among all the research findings of the research project". This clearly indicates that the H papers often represent the papers of high importance in the outputs of the research projects, although at the same time it also shows that important papers seem to appear simultaneously from the same project so that even most highly cited papers (top 1 % paper) is often not the best paper for such project. 31% of respondents in the N projects also think that the focal paper is "one of the most significant papers (one of the top 3)".

Exhibit 11 Importance of the focal paper in the global research findings



Note1: The self-evaluation of the importance of the focal paper in the global research findings in the same field during the same period (published within a year before or after the focal paper was published).
Note2: The result of all fields.

Exhibit 12 Importance of the focal paper among all outputs of the project

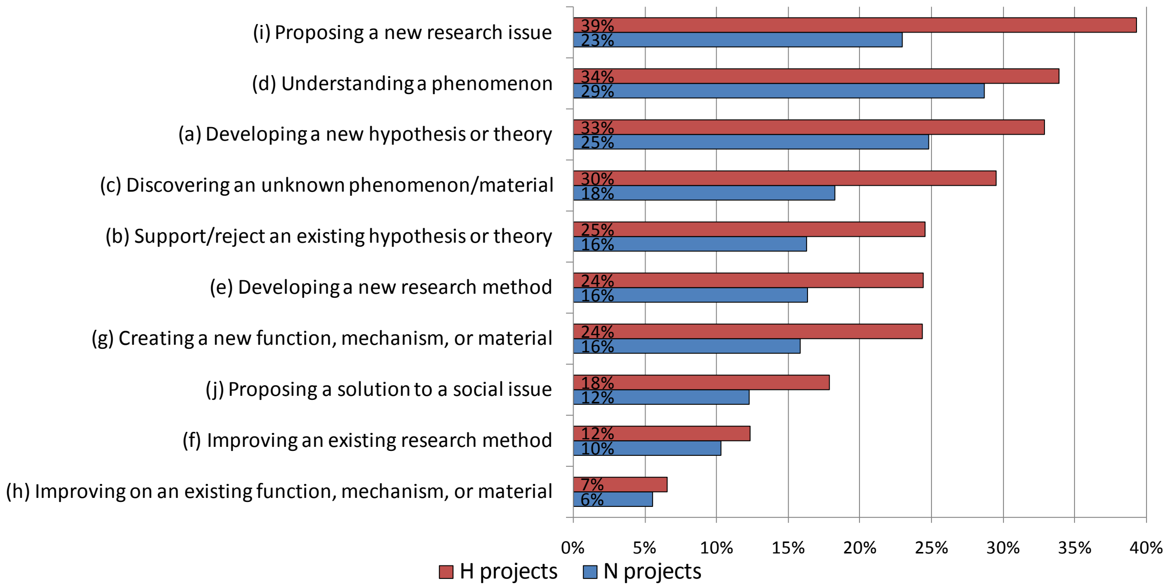


Note1: The self-evaluation of the importance of the focal paper among all outputs of the project.
Note2: The result of all fields.

3―3 Types of the Outputs of the Focal Paper

Exhibit 13 shows how often "highly relevant" are the 10 types of research outputs of the focal paper. The results showed the share of "Highly relevant" in 5-level Likert scale. The share of "Highly relevant" is higher in the all types of the outputs in the H projects than in the N projects, although the order of the types of research outputs in terms of its frequency (%, "Highly relevant") is very similar between H papers and N papers. "Proposing a new research issue", "understanding a phenomenon" and "developing a new hypothesis or developing theory" are the types of the outputs that are highly relevant most frequently. The share of "Highly relevant" is the highest in "Proposing a new research issue" of the H projects. The differential between the H and N projects is more than 15% in this item. Proposing a new research issue means the provision of new research theme to the research community. Some research issues would result in the emergence of new research areas. This result is consistent with the fact that "contribution to the development of research in related field" was chosen very frequently (60%, only next to "high Novelty") by the respondents of the H papers as a reason significantly explaining why their paper was highly cited as we will see in the next section.

Exhibit 13 Types of research outputs of the focal paper (%, highly relevant)



Note1: The results show the share of "highly relevant" in 5-level Likert scale.
Note2: The result of all fields.

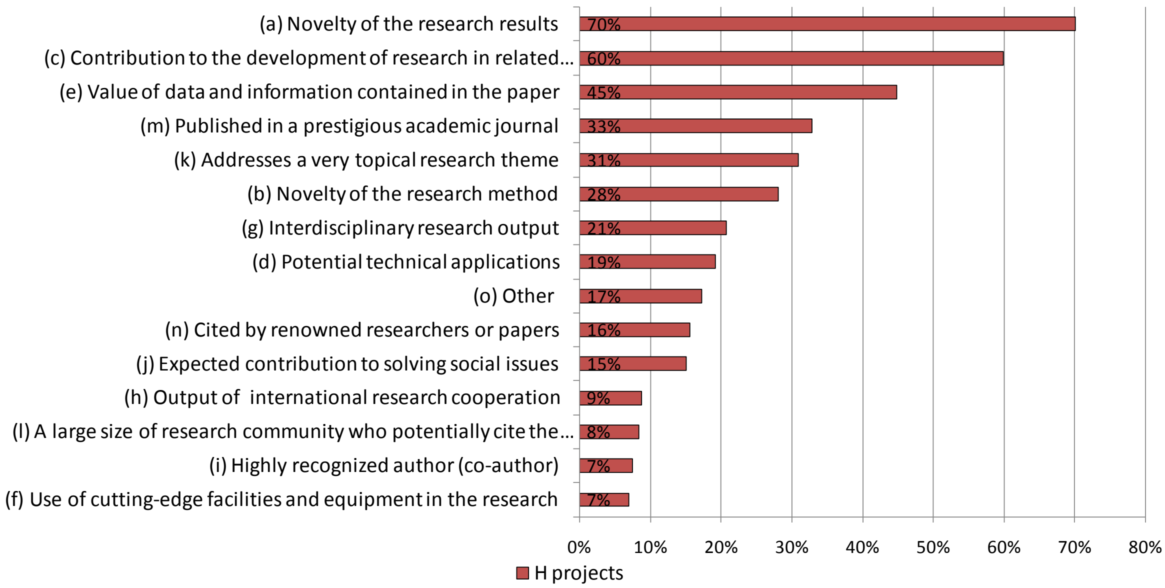
3－4 DETERMINANTS OF CITATION FREQUENCY

Since we selected the H papers based on the relative frequency of being cited, an additional question on the determinants of citation frequency was posed to the survey targets with the H papers. Exhibit 14 shows the results.

The respondents in the H projects pointed out that "(a) Novelty of the research results," "(c) Contribution to the development of research in related fields," and "(e) Value of data and information contained in the paper" as three most important determinants that influenced the (forward) citations of their papers. Whole the top three determinants were related to the quality of the research findings, "(m) Published in a prestigious academic journal" was thought the fourth determinant of citation frequency.

In contrast, less than 10% of respondents noted that "(f) Use of cutting-edge facilities and equipment in the research", "(i) Highly recognized author (co-author)", "(l) A large size of research community who potentially cite the paper" had strong effect on the citation frequency of their paper. Since bibliometric analysis shows that internationally co-authored papers tend to get more citations compared to the domestic papers, there may be a discrepancy between the recognition of the respondents and bibliometric analysis that merits a further analysis.

Exhibit 14 Determinants of citation frequency (%, strong impact)



Note1: The results show the share of "strong impact" in 5-level Likert scale.
Note2: The result of all fields.

4 MOTIVATIONS FOR THE RESEARCH PROJECT AND UNCERTAINTIES IN RESEARCH

4－1 MOTIVATIONS FOR THE RESEARCH PROJECT

According to Stokes (1997), the traditional framework to place a research along one dimension from basic research to applied research is incomplete, since research often has dual motivations. Stokes proposed the "quadrant model of scientific research". In this model a Pasteur's quadrant covers such "use-inspired basic research" exemplified by the research by Pasteur, while Bohr's quadrant covers pure basic research and Edison's quadrant covers pure applied research. Adopting this framework, we asked each researcher to evaluate the importance of the following two basic motivations for initiating the research project that yielded the focal paper and the other closely related papers: (1) pursuit of fundamental principles/understandings and (2) solving specific issues in real life. "Pursuit of fundamental principles/understandings" is defined to be gaining a new knowledge of the principles, underlying natural phenomenon and observed facts, through experiments and/or theoretical analyses and "solving specific issues in real life" is defined to be solving practical and specific problems such as for industrial applications, following *Frascati Manual* of OECD.

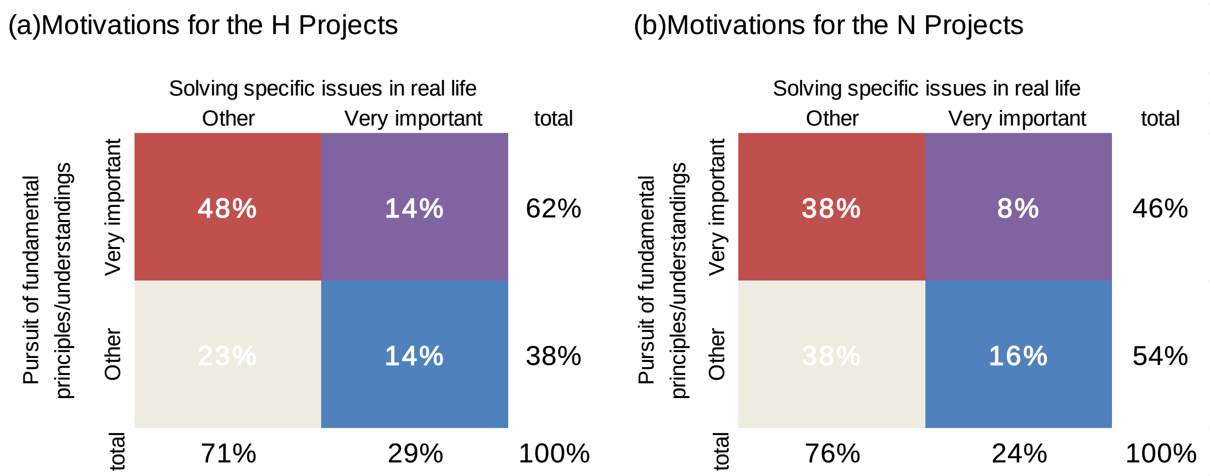
Collecting response to this question on two motivations at project level has allowed us to quantitatively assess how important each quadrant is in each scientific field. Such information would be very important, since the Pasteur's quadrant may play an important bridge between science research and engineering research (Stokes (1997)). As far as we know, there is no systematic quantitative evidence available for the importance of Pasteur's quadrant (see however, Comroe and Dripps (1976), for a very detailed study on the key papers for open-heart surgery from this perspective).

Exhibit 15 shows the aggregate results. 62% of the researchers for H projects, that is, the projects which produced the top 1% highly cited papers, regard the pursuit of fundamental principles/understandings as a very important motivation for the project; 29% of them regard solving specific issues in real life as very important motivations for the project. The corresponding ratios of the researchers for the N projects are 46% and 24% respectively. Thus, the level of motivation is stronger in H projects than in N projects for the two objectives, but especially for "pursuit of fundamental principles/understandings". The projects for which both motivations are very important amount to 14% of the H projects and 8% of the N projects. Thus, even if we define "Pasteur's quadrant" relatively narrowly as the group of the projects for which both motivations are very important (not just important), it constitutes a significant share of the research projects.

This supports the Stokes's view that placing the scientific research projects along one dimension from "pursuit of fundamental principles/understandings" to "solving specific issues in real life" is not adequate. If we define "Bohr's quadrant" as a group of the projects where only "pursuit of fundamental principles/understandings" is very important, 48% (38%) of the projects belong to Bohr's quadrant in the H projects (N projects). If we define "Edison's quadrant" as a group of the projects where only "solving specific issues in real life" is very important, 14% (16%) of the projects belong to Edison's quadrant in the H projects (N projects).

There are significant variations in the importance of each objective by field, as shown in Exhibit 16. "Pursuit of fundamental principles/understandings" is a very important motivation in physics & space science, basic life sciences, chemistry, and agriculture sciences, accounting for more than 60% of the H projects. On the other hand, "Solving specific issues in real life" is very important in engineering, clinical medicine & psychiatry/psychology, materials science, accounting for more than 40% of the projects. The level of motivation for "Pursuit of fundamental principles/understandings" is stronger in H projects than in N projects in most science fields, especially in materials science, physics & space science, and clinical medicine & psychiatry/psychology (more 20 percentage point difference). However, the motivation for solving specific issues in real life is weaker for H projects than for N projects in agriculture sciences, environment/ecology & geosciences and computer science & mathematics. Combining the two, we can say that "Pasteur's quadrant" is especially important in clinical medicine & psychiatry/psychology, materials science, and engineering for H projects.

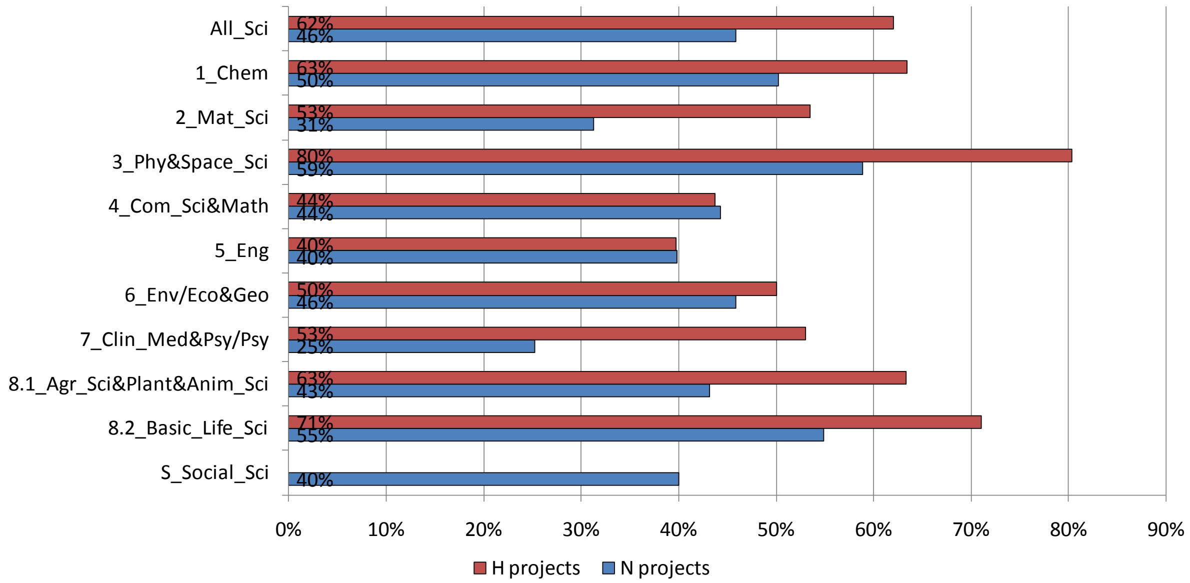
Exhibit 15 Distribution of the projects by a quadrant model



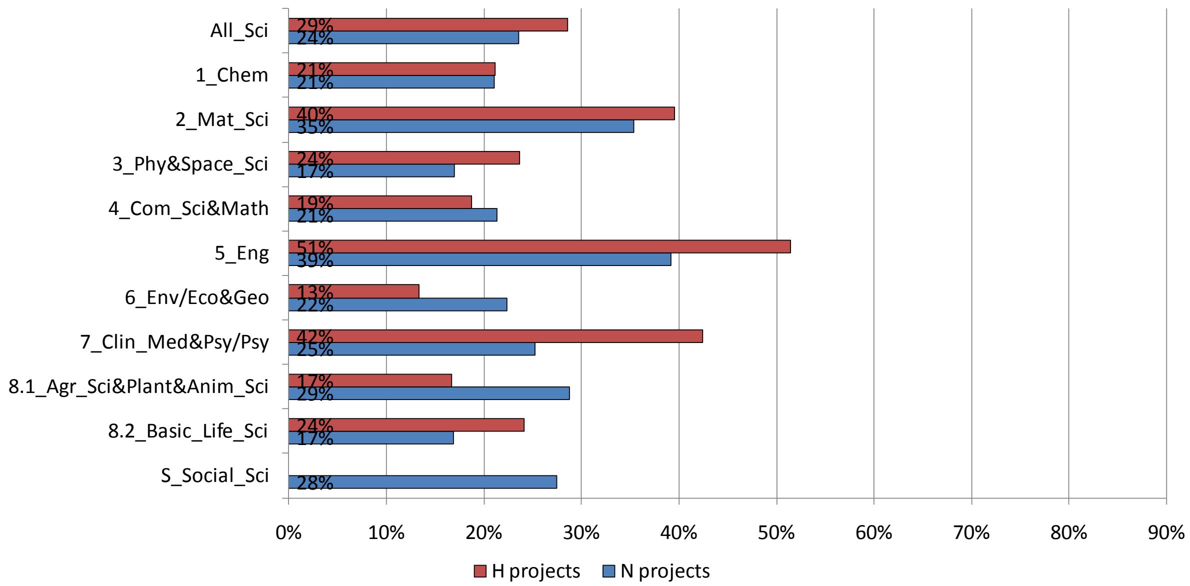
Note1: The result of all fields.

Exhibit 16 Motivations for initiating the research projects by field (%, "very important")

(a) Pursuit of fundamental principles/understandings



(b) Solving specific issues in real life



Note1: The results show the share of "very important" in 5-level Likert scale.
Note2: Result of social sciences in the H projects was not shown due to the small number of responses.

4－2 UNCERTAINTIES IN RESEARCH PROCESS AND IN RESEARCH OUTCOME

Productive research has to add something new relative to the existing stock of knowledge and uncertainty in research can be a very important part of acquiring such novelty. There can be two scenarios of acquiring such novelty: getting a novel research idea which is proven in the research process as initially expected, or novelty is acquired during the course of the research due to its uncertain process or outcome. Compared to inventions, where targeted outcome is often important (see Nagaoka and Walsh (2009a)), uncertainty can be more important in scientific research. In order to clarify this, our survey asked the researcher to evaluate the importance of uncertainty in both research process and outcome. More specifically, whether the research project that yielded the paper proceeded as initially planned and whether the main result of the focal paper more or less significant than the initial expectations of the researchers.

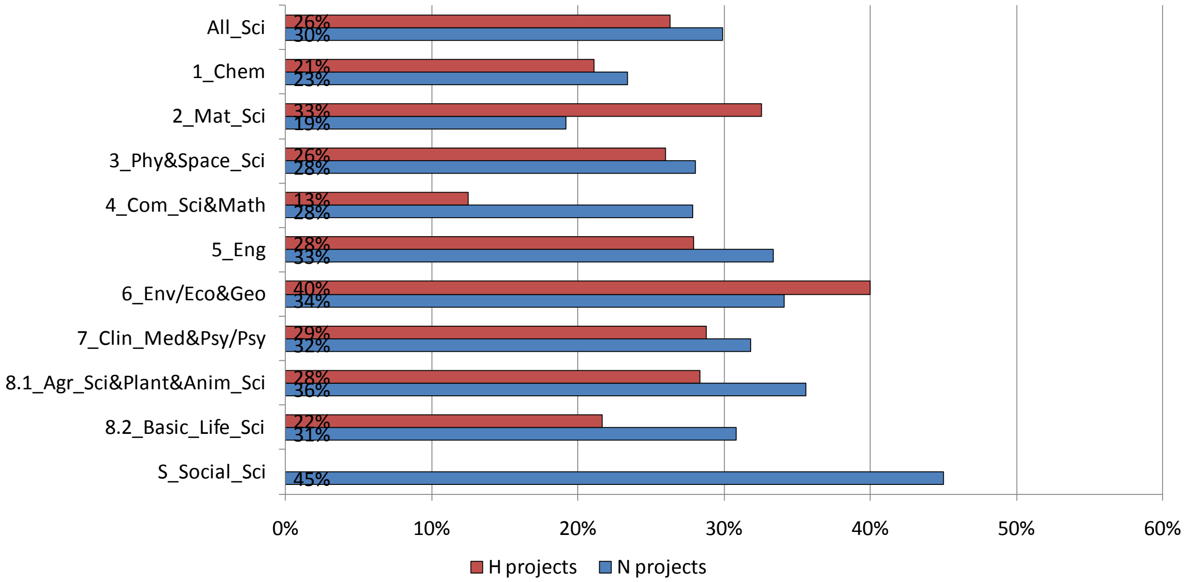
The research proceeded as initially planned for 26% of the H papers and for 30% of N papers, as seen in Exhibit 17. In addition, the main result of the focal paper was as initially expected for 25% of the H papers and for 40% of the N papers. Combining them, the main result as well as the research process for the paper was as initially expected or planned only for 11% of the H papers and 18% of the N papers. Put differently, most papers involved uncertainty either in outcome or in the research process and such uncertainty is significantly higher in H papers.

On the other hand, the research proceeded quite differently from that originally planned for 6.4% of the H papers and for 4.4% of N papers, as seen in Exhibit 18. The main result of the focal paper was substantially more significant than expected for 32% of the H papers and for 14% of the N papers. Thus, unexpected good outcome, and perhaps unexpected research process to the extent that it is useful for generating unexpected good outcome, seems to contribute significantly to generating a H paper.

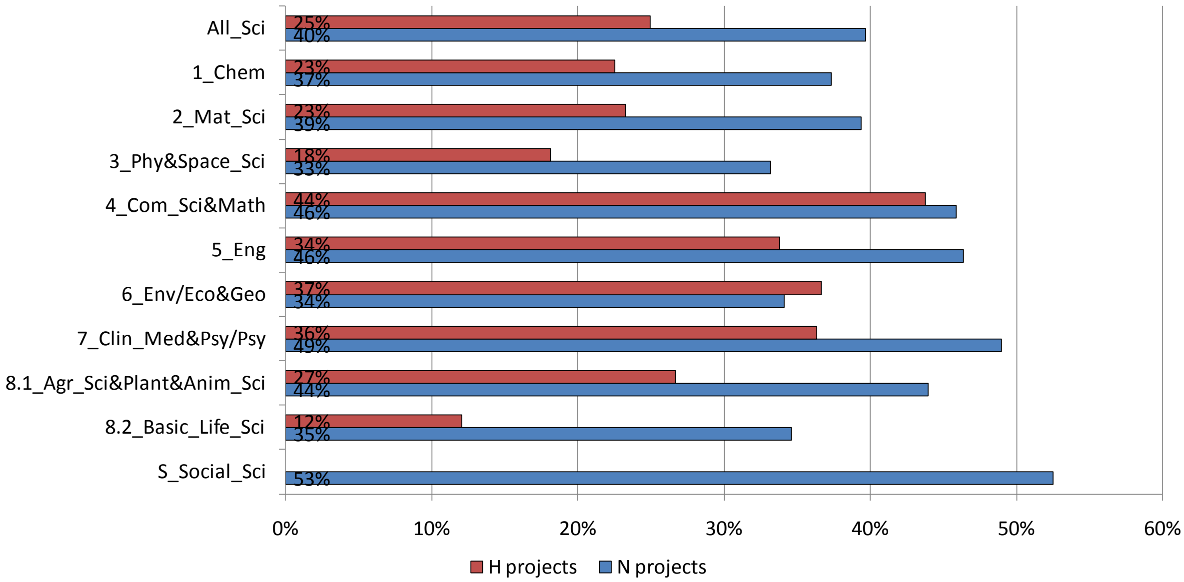
There are significant differences across fields in the level of uncertainty as measured by the incidence of big surprises in the research process and the outcome. Computer science & mathematics involves least uncertainty on both accounts, presumably because most of the research in this field does not use experiments. A H paper involves less uncertainty in research process than a N paper as in environment/ecology & geosciences. On the other hand, a research project of materials science which resulted in a H paper has most often involved a large research process uncertainty (14% of the papers). The research in physics & space science, chemistry, and basic life sciences that resulted in H papers most often generates the results substantially more significant than expected.

Exhibit 17 Incidence of research largely the same as originally planned (%, yes)

(a) Research process



(b) Main result of the focal paper

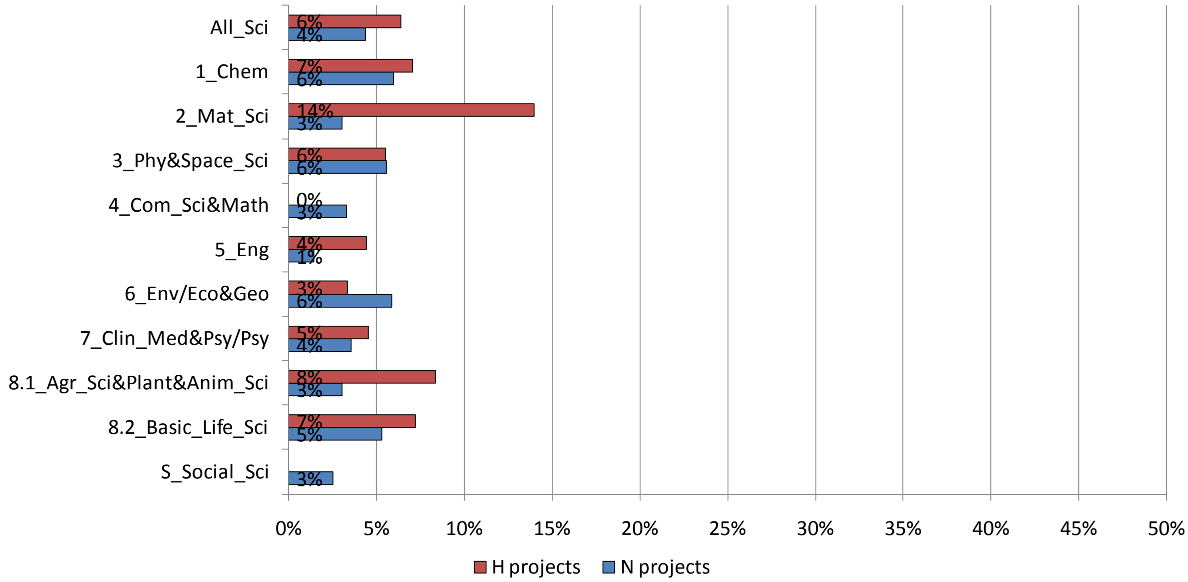


Note1: The results show the share of "research largely the same as originally planned" for research process and for the main result of the focal paper.

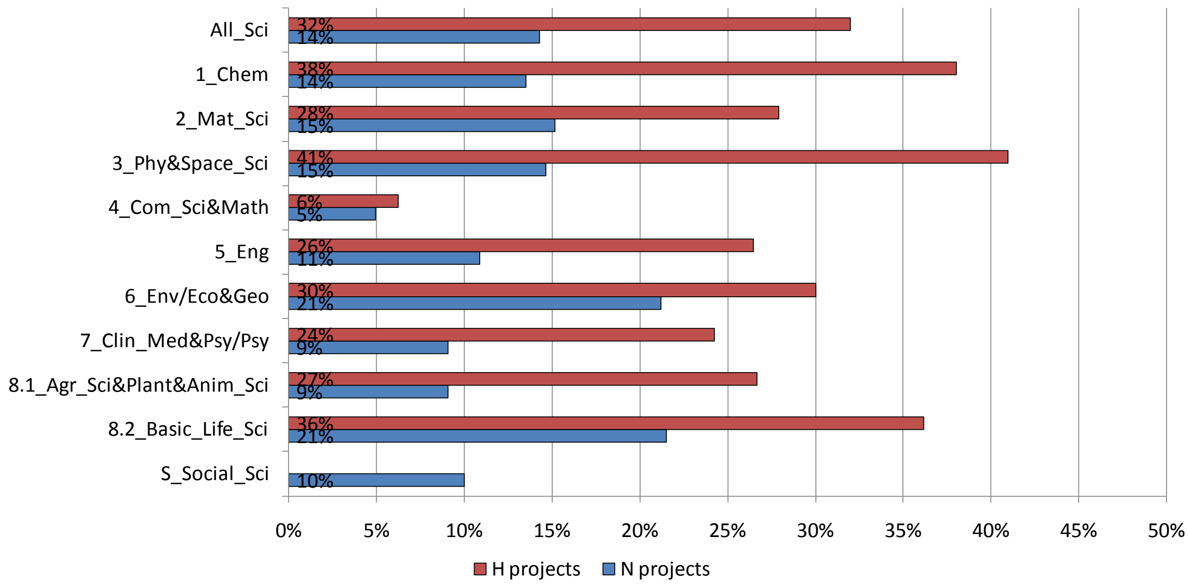
Note2: Result of social sciences in the H projects was not shown due to the small number of responses.

Exhibit 18 Big surprises in research (%, yes)

(a) Research process (totally different)



(b) Main result of the focal paper (for better)



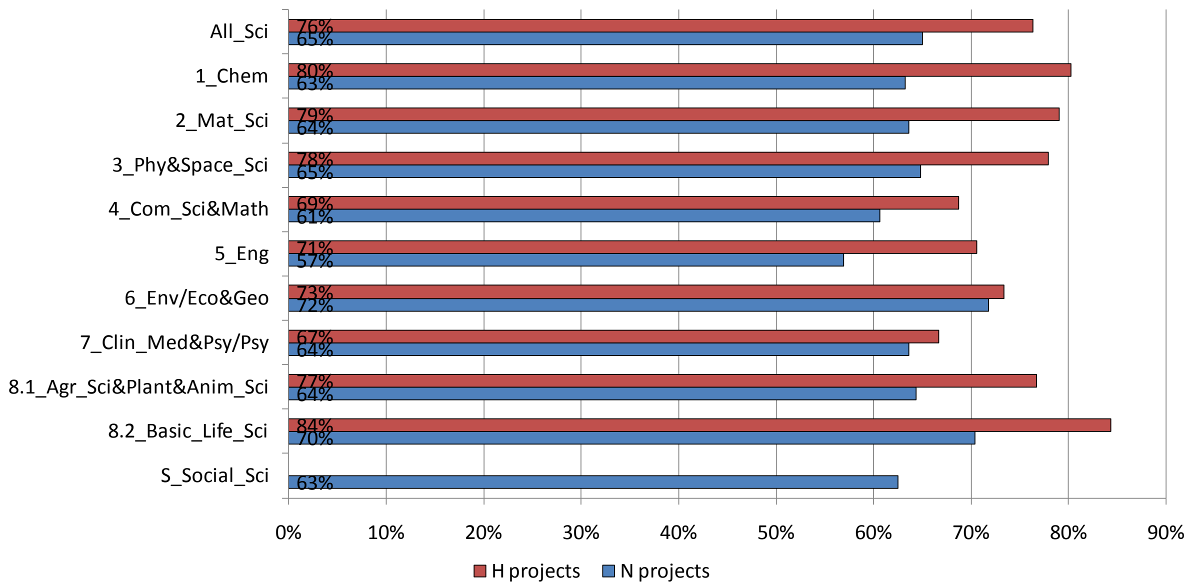
Note1: The results show the share of "totally different" for research process and "better" for the main result of the focal paper.
Note2: Result of social sciences in the H projects was not shown due to the small number of responses.

4－3 SERENDIPITY

One important research outcome due to uncertainty is a serendipitous discovery. Our survey asked a researcher to identify whether the research output was serendipitous, that is, whether he found the answers to the questions not originally posed. This definition of serendipity is based on Stephan (2010) who emphasizes the importance of distinguishing "unexpected" from "accidental ". According to her, "True, Pasteur "discovered" bacteria while trying to solve problems that were confronting the French wine industry. But his discovery, although unexpected, was hardly "an accident."The results are shown in the following Exhibit 19. More than 50% of the researchers for both H papers and N papers answered in an affirmative manner. This high frequency is more than our expectation. One possible explanation is that the research output of science is typically many, so that even if the main research output is not serendipitous, some of the byproduct discoveries could have been serendipitous.

The frequency of serendipity is higher for the H paper (76% for the average of all sciences) than for the N paper (65 % for the average of all sciences). They are relatively high for the fields where uncertainty in research output is important: basic life sciences, chemistry, materials science and physics & space science.

Exhibit 19 Serendipity



Note1: The results show the share of "yes" in the serendipity.
Note2: Result of social sciences in the H projects was not shown due to the small number of responses.

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5 RESEARCH COMPETITION

Scientific research is characterized as competitive process for seeking priority by Merton (1973). For such competitive process to work would require that a researcher recognizes competition *ex-ante* and is disciplined by that. While there are substantial numbers of anecdotal evidence for the importance of priority competition as a motivating force for science, including the ones described by Merton (1973) himself, the systematic evidence for this is not available. To develop a good empirical evidence for such view, our survey asked a researcher the following questions. (1) "Approximately how many major research teams did you recognize as your potential competitors when you began the research project? Please indicate the number of potential competitors in Japan (i.e., the competing team with its leader being located in Japan) and outside of Japan." and (2) "How strongly were you and your team members concerned about the possibility that your competitors would have priority over your research results?"

As shown in following Exhibit 20, most of the researchers could indicate the range of the number of domestic and international (foreign) competitors(teams), even if there were a choice of "unknown". The percentage of the choice of "unknown" for the number of international competitors was only 6.2% for the H projects and 13% for the N projects. Furthermore, there were no international competitors only for 8.7% of the H projects and for 15% of the N projects. Thus, majority of scientists face international competitors for both H and N projects (85% for H projects and more than 70% for N projects). The numbers of international competitors are apparently larger than that of domestic competitors. Thus, (especially international) competition exists for a great majority of the projects and it is well recognized *ex-ante*. Domestic competitors are absent for almost 40% of both H and N projects. On the other hand, there are more than 5 competitors for 36% of the H projects and 25% of N projects. More competitors are recognized *ex-ante* in the H projects.

Exhibit 20 Number of competitors (competing teams) recognized *ex-ante* (at the stage of project initiation)

		None	1	2-5	5-10	More than 10	Unknown
Japan	H projects	36.2%	14.5%	36.0%	4.8%	3.0%	5.5%
	N projects	37.1%	12.7%	33.8%	4.6%	1.5%	10.2%
Foreign (Outside of Japan)	H projects	8.7%	6.2%	43.1%	22.4%	13.4%	6.2%
	N projects	15.1%	6.5%	40.3%	16.7%	8.6%	12.8%

Note1: The result of all fields.

The following Exhibit 21 shows the frequency where 5 or more foreign competitors are recognized *ex-ante* and the incidence of strong priority concern (sum of the two strongest levels of concern) of a researcher by field. The number of competitors recognized by researchers is large especially working in materials science, chemistry, and engineering, where competition might have become more global as the other East Asia countries have also become competitive. We saw earlier that there were no foreign competitors even for 8.7% of H projects. The incidence that no foreign competitors exist is especially high for environment/ecology & geosciences according to the fourth column. In this area international collaborations for data collection are extensive and the incidence of international co-authoring of H papers is also very high (73.3%). Such extensive network of international collaborations might explain a relatively small number of foreign competitors recognized in this field. Another important observation we can make is that a large number of competitors are significantly more recognized for H projects than for N projects across all fields, except for environment/ecology & geosciences and agriculture sciences.

Researchers were concerned over priority loss in 53% of the H projects and they were very much concerned in 18% of them. The corresponding ratios for the N projects are 31% and 6%. Thus, we may conclude that priority competition does work, although only a half of the researchers were concerned even in the H projects and only a minority of researchers was concerned in the N projects. It is interesting to see that researchers for the H projects were significantly more concerned over priority loss. A potential explanation is that there are more competitors for such projects as seen in Exhibit 20. The priority concern varies strongly across fields. Such concern is high in basic life sciences (in both H and N projects), materials science (in H projects), and physics & space science (in both H and N projects).

Exhibit 21 Number of foreign competitors recognized ex-ante and concern over priority loss

	%, 5 or more major foreign competitors		%, no foreign competitors	Very much concerned over priority loss		Concerned over priority loss (including "Very much")	
	H projects	N projects	H projects	H projects	N projects	H projects	N projects
All_Sciences	35.9%	25.3%	8.7%	17.7%	6.1%	53.2%	31.4%
1.Chemistry	47.9%	28.0%	1.4%	22.5%	4.3%	54.9%	25.3%
2.Materials Science	55.8%	34.3%	2.3%	16.3%	6.1%	60.5%	23.2%
3.Physics & Space Science	32.3%	23.3%	7.9%	22.0%	5.1%	56.7%	34.4%
4.Computer Science & Mathematics	37.5%	34.4%	0.0%	6.3%	8.2%	25.0%	29.5%
5.Engineering	42.6%	27.5%	10.3%	13.2%	2.2%	50.0%	21.0%
6.Environment/Ecology & Geosciences	20.0%	22.4%	23.3%	0.0%	4.7%	20.0%	24.7%
7.Clinical Medicine & Psychiatry/Psychology	30.3%	22.7%	16.7%	22.7%	5.6%	56.1%	28.8%
8.1Agriculture Sciences	20.0%	19.7%	11.7%	15.0%	6.8%	53.3%	34.1%
8.2 Basic life Sciences	36.1%	25.5%	6.0%	18.1%	10.3%	61.4%	43.3%
S.Social	-	17.5%	-	-	0.0%	-	22.5%

Note1: Result of social sciences in the H projects was not shown due to the small number of responses.

6 KNOWLEDGE SOURCES AND RESEARCH MANAGEMENT

6－1 EXTERNAL KNOWLEDGE SOURCES THAT INSPIRED THE RESEARCH PROJECT

Since scientific research is a cumulative process, building on the existing stock of knowledge that is embodied in literature, experts and facilities, the scope and depth of exploiting such knowledge would affect significantly the efficiency of scientific research. It may depend on the absorptive capability of the research team as well as its management. While absorptive capability is most often used to characterize the innovation capability of industrial firms (see Cohen and Levinthal (1989)), such capability may well become relevant to the scientific research that has become more complex. Our survey identified 5 broad categories of knowledge sources based on pre-testing (one category having overlaps with the other categories): literature (open to the public and widely accessible), forums and facilities (open but less accessible for a distant researcher), internal or past collaborators (based on personal contacts within collaborative relationship), external experts (based on personal contacts) and experts in a different field or with a different skill (which have overlaps with the other categories). There are 15 subclasses of knowledge sources and a respondent was invited to evaluate each of them in terms of whether it was used or not and, when used, how important it was for suggesting the project by 5 point Likert scale.

The most important knowledge source is scientific literature, as shown in following Exhibit 22(a). Almost 50% of the researchers of both H and N projects say that they are very important. Scientific literature with faster disclosures (preprints, etc.), colleagues in the organization (a university, a laboratory, etc.), conferences, workshops etc., visiting researchers or post-doctoral students in the organization and past research collaborators follow this, exceeding 10% for each of H and N projects. In addition to them, availability of new facilities and equipments for experiments and researchers in different academic fields are important for more than 10% of the H projects.

The importance attached by the researchers of H projects tends to be higher for most knowledge sources (except for patent literature and handbooks and textbooks). The difference of the incidence between these two types of projects are especially large (more than 5% points) for conferences, workshops etc., visiting researchers or post-doctoral students in the organization, scientific literature with faster disclosures, and colleagues in the organization (a university, a laboratory, etc.). These differences suggest that faster access to the outputs of ongoing research as well as person-to-person contact is especially important for getting an idea for initiating a good research project.

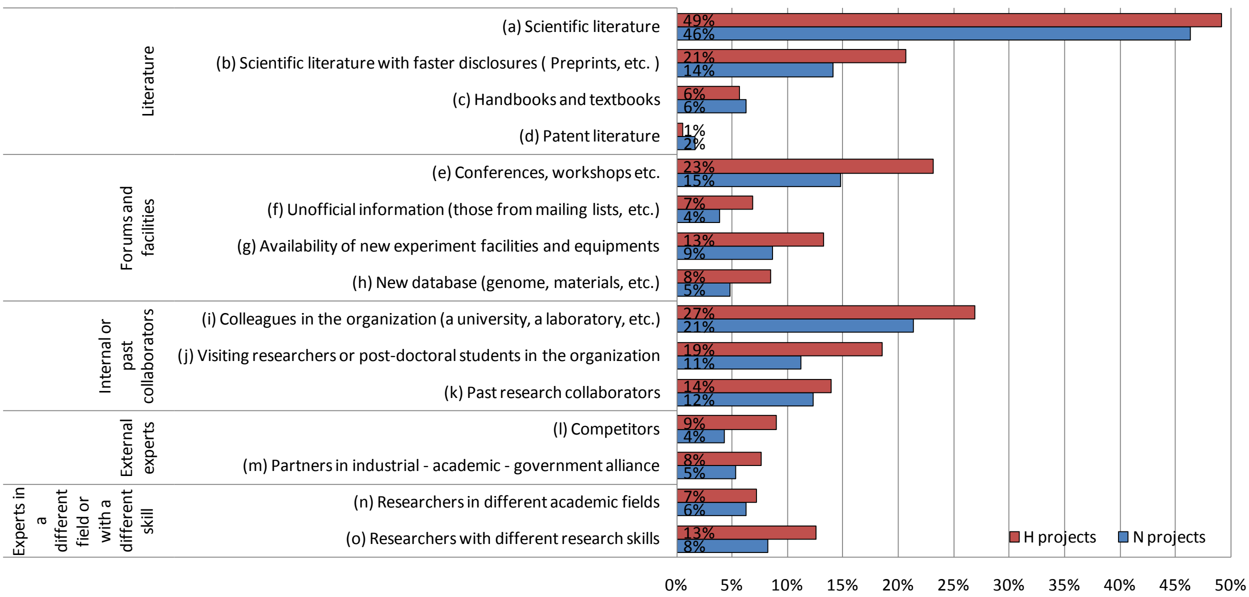
The survey also asked the researchers to identify the country location of the knowledge source (such as the location of the key researcher), when they are "important" or "very important" for suggesting the research projects[1]. As shown in the following Exhibit 22(b), the sources of knowledge that are embodied in researchers and the facilities tend to be domestic. Among relatively important knowledge sources for suggesting the research project, colleagues in the organization (a university, a laboratory, etc.), visiting researchers or post-doctoral students in the organization, past research collaborators and availability of new experiment facilities and

[1] The countries for a choice are Japan, the United States, Germany, the United Kingdom, France, and the other EU member countries, China and others.

equipments are often domestic. On the other hand, the sources of knowledge that are embodied in literature and open forum are very often international. They include scientific literature with faster disclosures, scientific literature, and competitors. Since research competition is global (see section 5), it is not surprising that competitors as important knowledge source are also often international.

Exhibit 22 External knowledge sources used in the research projects

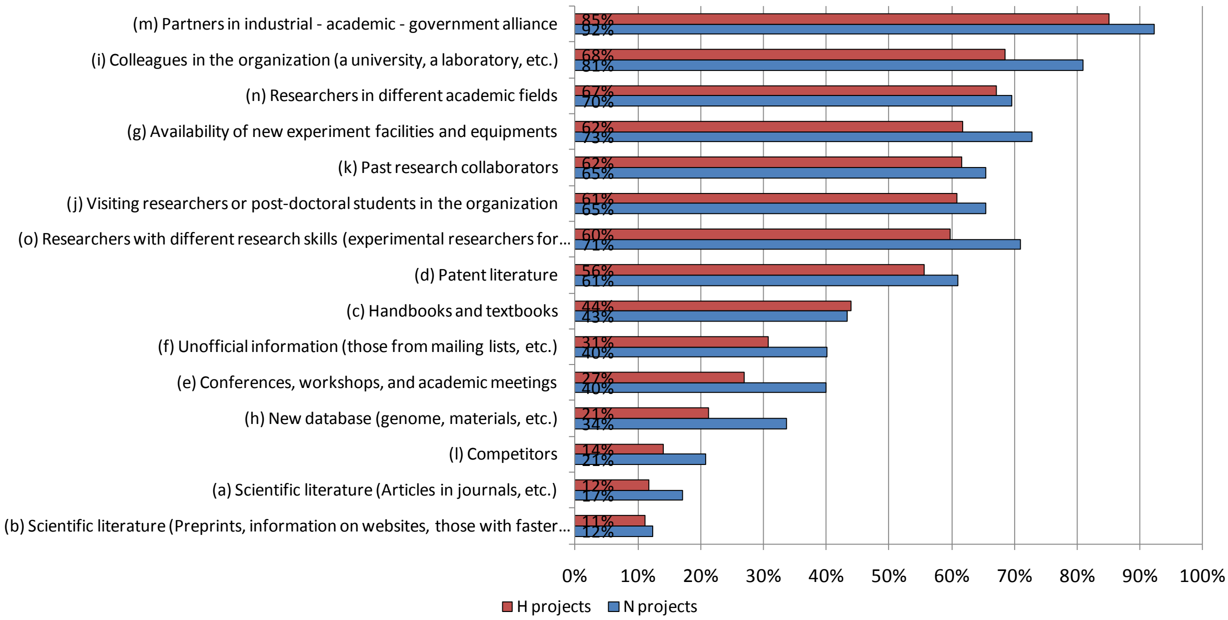
(a) Importance of various knowledge sources for suggesting the research project (% , very important)



Note1: The results show the share of "very important" in the importance of knowledge sources for suggesting the research project

Note2: The result of all fields.

(b) How important Japan is as knowledge sources for a Japanese science research (%, in the cases where each knowledge source is important or very important)



Note1: The share of responses identifying Japan is the most important knowledge source. The countries for a choice are Japan, the United States, Germany, the United Kingdom, France, and the other EU member countries, China and others

Note2: The result of all fields.

6−2 RESEARCH MANAGEMENT AND ITS POTENTIAL CONTRIBUTIONS

As pointed out earlier, most scientific researches today are teamwork. It also builds on the collaborations across organizations and across disciplines (See next section). It also faces, perhaps increasingly more, global priority competition. Therefore, we would expect that management has become increasingly important for research performance. In order to have empirical basis for evaluating the relevancy of management for scientific research, our survey asked what management practices each research team has adopted (we identified major 16 practices based on pre-testing, excluding "the other") and, when it is used, how effective they have been. These 16 practices cover 6 broad categories: goal setting, research team formation, information sharing, accumulation of research output, efficiency of research, and interaction with research community.

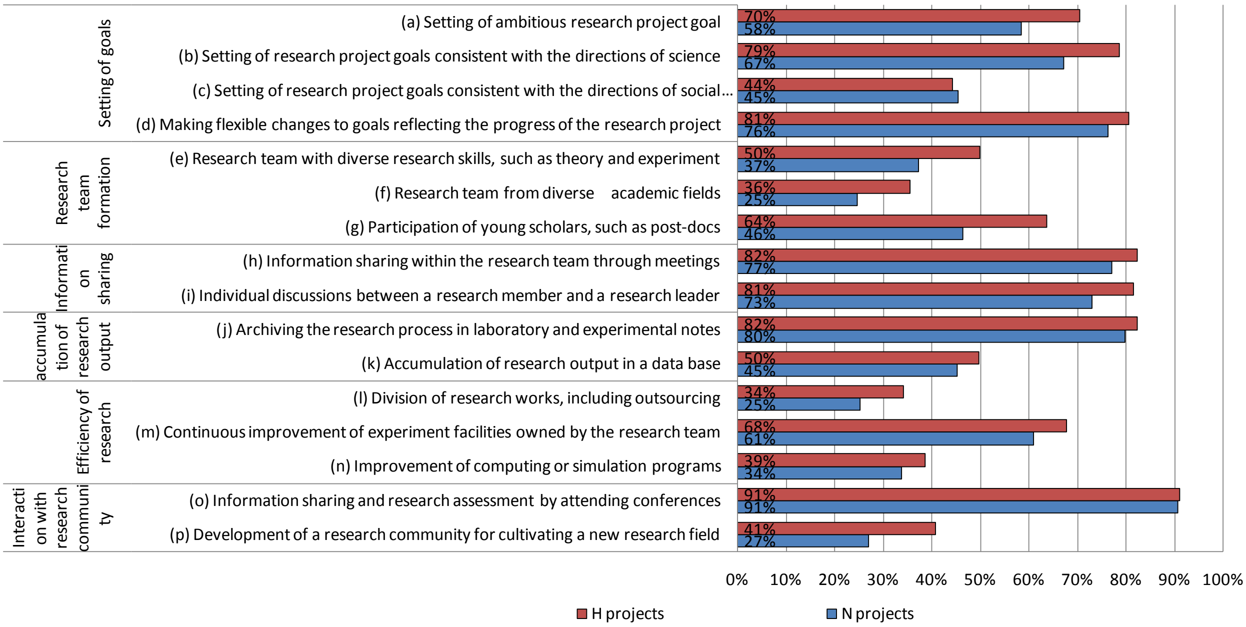
Following Exhibit 23(a) summarizes how often each research management practice is implemented (%, yes). Information sharing and research assessment through presentations in academic conferences are implemented for more than 90% of both H and N projects. This is consistent with the result in the last section where we saw that conference and workshops were often a very important knowledge source. Following this, a setting of an ambitious research project goal, a setting of research project goals consistent with the directions of science, making flexible changes to research goals reflecting the progress of the research project, information sharing within the research team through meetings, individual discussions between a research member and a research leader, archiving the research process in laboratory and experimental notes, continuous improvement of experiment facilities owned by the research team are implemented in more than 50% of both H and N projects. In addition, a formation of a research team with diverse research skills, such as theory and experiment and a participation of young scholars are implemented in 50% or more of the H projects.

Although the pattern of implementation across management practices are similar between H projects and N projects, all management practices, except for a setting of research project goals consistent with the directions of social development, are implemented more in H projects. What are interesting would be the practices that are implemented in a different degree between two types of projects. The management practice with the largest difference in implementation is a participation of young scholars, such as post-docs. It is implemented in 64% of the H projects but in 46% of the N projects, with 17% points' difference. All management practices related to research team formation, in addition to the participation of young scholars, have substantial differences in implementation, exceeding 10%. Thus, one key difference is the formation of a research team with young scholars and diversity. The other two practices for goal settings (ambitious research project goal and research project goals consistent with the directions of science) have also substantial difference in implementation that amounts to more than 10% points in favor of the H projects. This seems to suggest that the H projects are more consciously managed, taking into accounts the research environment and opportunities. Finally, the researchers in the H projects are more involved in the development of a research community for cultivating a new research field. The conscious effort of a researcher to develop a research community could help enhancing the research performance of his own by strengthening the scale of network externality among researchers.

The next question is how effectively each management practice contributed to the main output of the research project. Exhibit 23(b) summarizes the results for the frequency at which each management practice is regarded to be very effective. The effectiveness was evaluated by 5 point Likert scale (from "not effective at all" to "very effective"). A formation of a research team from diverse academic fields, a participation of young scholars, information sharing within the research team through meetings, information sharing within the research team through meetings, individual discussions between a research member and a research leader are regarded to very effective in more than 40% of both H and N projects. All management practices, except for archiving the research process in laboratory and experimental notes, are regarded to be very effective more often by the researchers who participated in the H projects. This common pattern of the higher scores on management practices by H projects may substantially reflect the fact that the H projects were successful projects. However, an interesting finding is that the difference in the effectiveness across these two projects types is very large especially for the practices related to the goal setting as well as a formation of a research team with diverse research skills, and information sharing within the research team through meetings. These suggest again that H projects are more consciously managed, taking into accounts the research environment and opportunities.

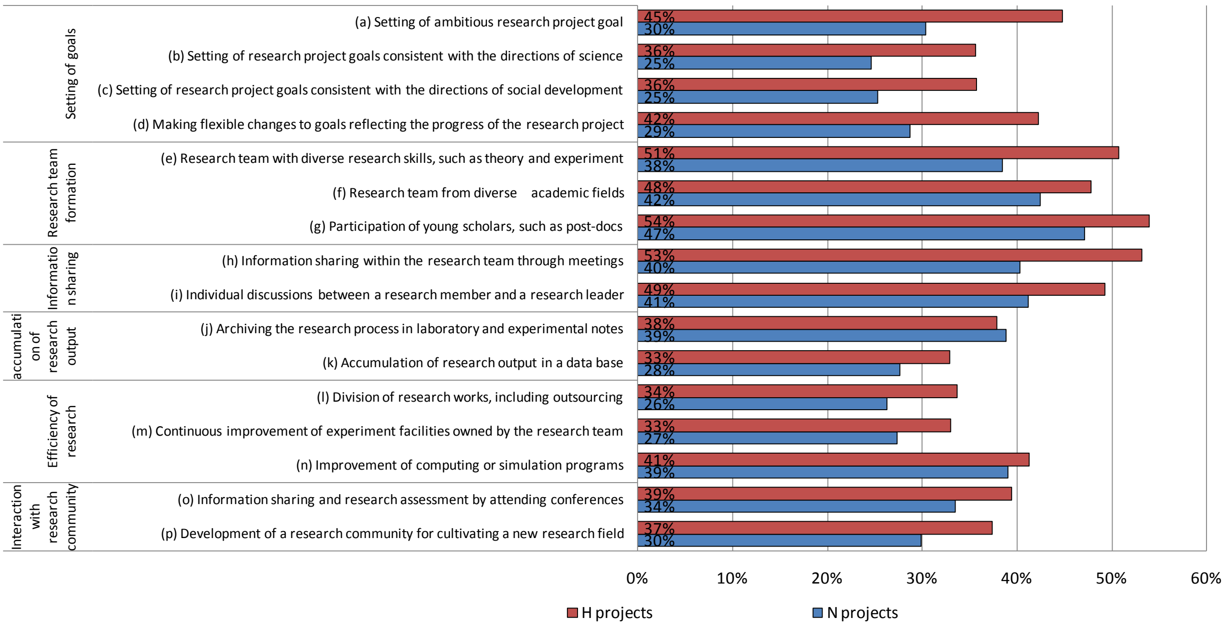
Exhibit 23 Implementation of research management practices (%, yes)

(a) Implementation of research management practices (%, yes)



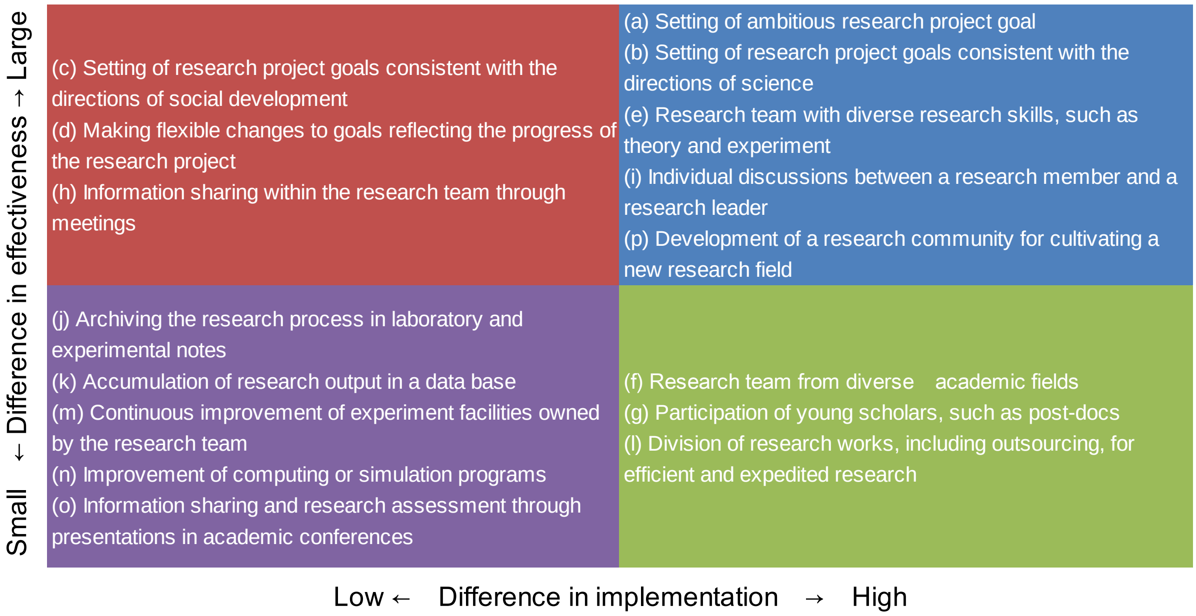
Note1: This is based on a Yes or No question on the implementation of a particular management practice.
Note2: The result of all fields.

(b) Effectiveness of research management practices to the main output of the research project (%, very effective)



Note1: Based on 5 point Likert scale response on the effectiveness of management practices.
Note2: The result of all fields.

Exhibit 24 Implementation and effectiveness of research management practice (H projects - N projects, %)



Note1: Based on the difference of the means of the H projects and N projects.
Note2: "High" and "Low" evaluation of the implementation of each practice along horizontal axis is based on the difference in the implementation rate of such practice from the overall average. "Large" and "Small" evaluation of the effectiveness of each practice is based on the "very effective" share of each practice from its mean.

Exhibit 24 classifies the management practices into 4 quadrants, based on whether they are relatively more used in the H projects than in the N projects as well as on whether they are perceived to be very effective relatively more often in the H projects than in N projects. The vertical axis measures the difference across two project types of the frequency of each practice perceived to be very effective and the horizontal axis measures the difference of the incidence of implementation of a management practice across two project types. Since the level of implementation of a management practice will be high if it is more effective, we can interpret that the upper right quadrant identifies the group of the management practices for which such effects are dominant (that is, they are more effective in H projects and therefore more implemented in H projects). Even if the effectiveness of a management practice may not differ, such management practice may be implemented more in H projects if the cost or the capability of its implementation is low in such projects. The lower right hand quadrant identifies the group of the management practices for which such effect is strong (that is, while they are not perceived to be effective more often in H projects but implemented more in H projects, due to lower marginal cost of such management practices in H projects than in N projects). Similarly, the left upper quadrant identifies the group of the management practices which were more effective in H projects but implemented relatively less in H projects, indicating perhaps significantly higher marginal cost of implementing such practice in H projects than in N projects.

The upper right-hand quadrant (both the difference of the level of implementation and the difference of the effectiveness is larger in favor of H projects) include a setting of an ambitious research project goal, setting of research project goals consistent with the directions of science, a formation of a research team with diverse research skills, individual discussions between a research member and a research leader, and the development of a research community for cultivating a new research field. They are the management practices most discriminating H projects from N projects, although further work is necessary to identify the causality between these management practices and research performance.

The lower right-hand quadrant (the difference of the level of implementation is large but the difference of the effectiveness in favor of H projects is small) include a formation of a research team from diverse academic fields, participation of young scholars, such as post-docs, and a division of research works, including outsourcing, for efficient and expedited research. Such practices may be more used in H projects due to lower marginal cost of using them, perhaps due to a larger research budget and more institutional support specific to the H projects. The upper left-hand quadrant (the difference of the level of implementation is small but the difference of the effectiveness is large) include a setting of research project goals consistent with the directions of social development, making flexible changes to goals reflecting the progress of the research project and information sharing within the research team through meetings. The latter two management practices are extensively implemented (close to 80% in both types of projects), so that the room for further expanding their use may be very limited (high marginal cost).

6—3 USE OF ADVANCED RESEARCH FACILITIES, DATABASES, AND THE INTERNET FOR DISTANT COLLABORATORS

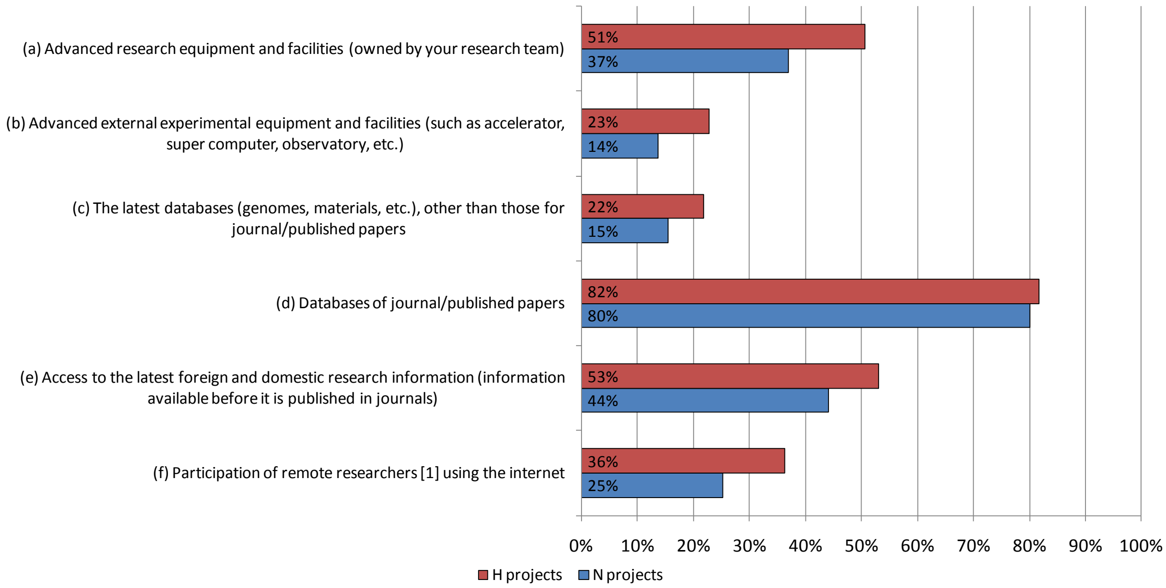
Research equipment and database plays a very important role for scientific research (Stephan (2010)). For examples, the inventions and the progress of a particle accelerator, a scanning tunneling microscope, and a DNA sequencer have been major sources for advancing research in physics, materials science and life science. In addition, the availability of internet has fostered collaborative research among distant researchers and its productivity (see Agrawal and Goldfarb (2008)). Our survey asked researchers whether they used advanced research facilities, and databases as well as whether there were the participation of remote researchers using the internet, and when they do, how effective they were in producing the main research output. As for advanced research facilities, we differentiated between those owned by a research team and the external facilities. We also differentiated research material databases such as genomes, materials, and those for journal/published papers.

Exhibit 25 shows the summary results for the level of the use of these infrastructures as well as their effectiveness to the main output of the research. Databases of journal/published papers are most frequently (more than 80%) used in both H projects and N projects. All facilities and databases are more used in H projects. The differences are especially large for the use of advanced research equipment and facilities owned by the research team and the participation of remote researchers using the Internet.

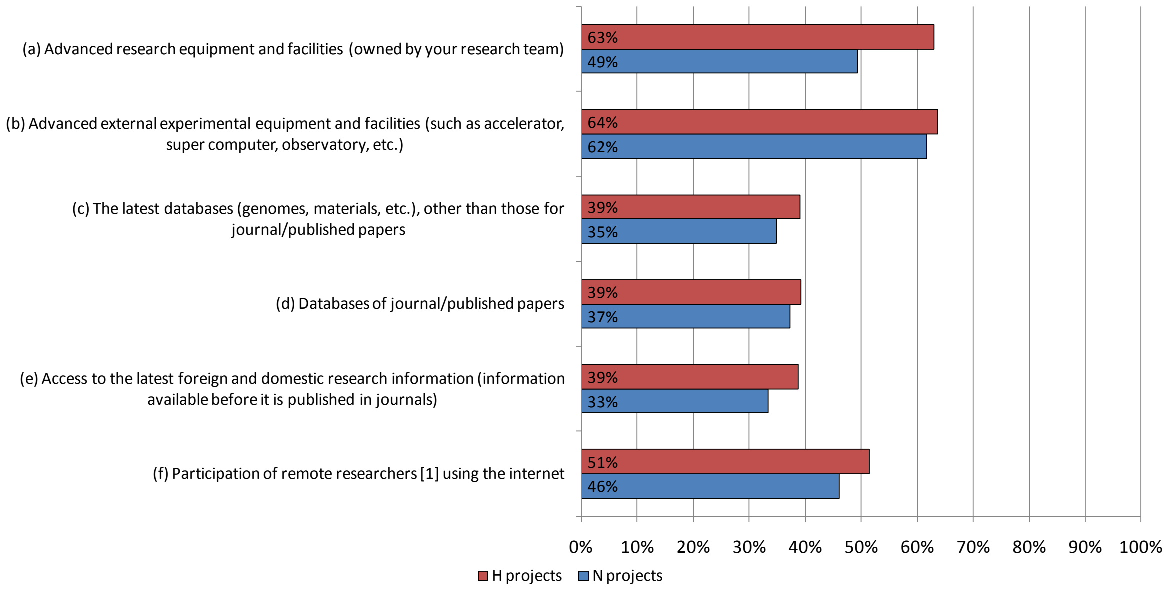
51% of the H projects (37% of the N projects) use advanced research equipment and facilities owned by the research team and 23% of the H projects (14% of the N projects) use the external advanced research equipment and facilities. While the external advanced research equipment and facilities are less used than the owed equipments and facilities, when used, they were found to be equally or more very effective than the owned equipment and facilities (that is, very effective in more than 60% of the cases) in both H projects and N projects. Thus, research equipment and facilities play a very important role. Internet is also extensively used for facilitating the participation of remote researchers (36% of the H projects and 25% of the N projects) and found to be very effective for 39% of the H projects and 33% of the N projects. The database, both literature and research materials, were also found to be very effective when used, for more than one third of both H and N projects.

Exhibit 25 Use (a) and effectiveness (b) of advanced research facilities, databases, and the internet for distant collaborators

(a)



(b)



Note1: (a)This is based on a Yes or No question on the implementation of a particular management practice. (b) Based on 5 point Likert scale response on the effectiveness of management practices.

Note2: The result of all fields.

7 RESEARCH TEAMS AS SEEN FROM AUTHORS

The recent studies on the scientific research, based on the bibliographic information,[1] show that a unit of scientific research has increasingly shifted from an individual to a team, involving multiple organizations rather than a single organization, which is also an international rather than domestic. The recent research on science mapping[2] also suggests that interdisciplinary or cross-cutting research areas, which require combination of knowledge from different fields, have emerged broadly in science.

These developments suggest that the issue of how to design and manage a research team has become an increasingly important issue. However, the bibliographic information alone provides only limited information on who are the researchers, including their status, the role in research, disciplinary diversity and skill diversity. Furthermore, it is important to note that a significant number of researchers are not listed as authors, while those who contributed only research fund and materials are listed as authors, as will be shown in this section.

This survey asked a respondent to identify the authors' organizational affiliations, academic/professional positions in the organization, academic areas, areas of expertise, and the countries of birth to identify the structure of research team. This question on author profile was asked for all authors when the number of them is 6 or less and to the first, last and corresponding authors and the randomly selected authors when it is 7 or more. This question was also asked to the responding author, when it was not included. Furthermore, our survey also clarified the numbers of collaborating researchers, students and technicians who are not included in the authors list.

[1] See Jones Wuchy and Uzzi (2008), and Saka and Kuwahara (2008)

[2] See Saka, Igami and Kuwahara (2010)

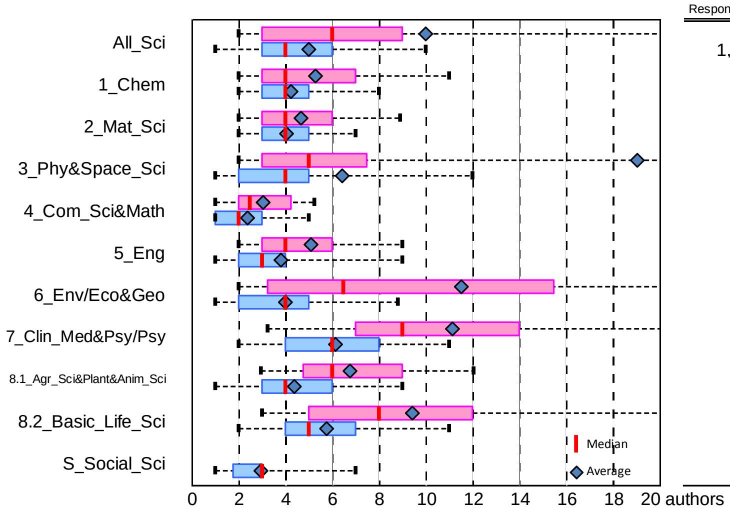
7—1 Number of Authors

The share of single authored papers is 3% for the H papers and 6.9% for the N papers. This indicates that most scientific research is done by a team rather than by an individual in our sample too. The median and average number of authors is 6 and 10 persons respectively for the H projects and 4 and 5 persons respectively for N projects, as shown in the following exhibit. Thus, the size distribution of authors is skewed especially in the H projects.

(Number of authors by field)

The boxplots in Exhibit 26 shows the distributions of the number of authors by field. Red boxplots indicate the distributions for the H papers; and blue ones for the N papers. Left ends of boxes indicate the first quartiles; and right ends of boxes the third quartiles. Left ends of whiskers indicate the 5th percentile; and right ends of whiskers the 95th percentile. The red bands in bars indicate the medians; and rhombi in bars the means. The bars display the range (25% to 75%) of the distribution of authors on a paper by type of the focal paper and by field.

Exhibit 26 Distributions of number of authors by field



unit: authors

	Respondents	Minimum	Q1	Median	Q3	Maximum	Average
All_Sci	566	1	3.0	6.0	9.0	327	10.0
	1,513	1	3.0	4.0	6.0	209	5.0
1_Chem	71	1	3.0	4.0	7.0	20	5.3
	186	1	3.0	4.0	5.0	13	4.2
2_Mat_Sci	43	1	3.0	4.0	6.0	13	4.7
	99	1	3.0	4.0	5.0	10	4.1
3_Phy&Space_Sci	127	1	3.0	5.0	7.5	327	19.1
	253	1	2.0	4.0	5.0	209	6.4
4_Com_Sci&Math	16	1	2.0	2.5	4.3	6	3.1
	61	1	1.0	2.0	3.0	8	2.4
5_Eng	68	1	3.0	4.0	6.0	21	5.1
	138	1	2.0	3.0	4.0	18	3.8
6_Env/Eco&Geo	30	1	3.3	6.5	15.5	50	11.5
	85	1	2.0	4.0	5.0	33	4.0
7_Clin_Med&Psy/Psy	66	1	7.0	9.0	14.0	46	11.1
	198	1	4.0	6.0	8.0	31	6.1
8.1_Agr_Sci&Plant&Anim_Sci	60	1	4.8	6.0	9.0	23	6.8
	132	1	3.0	4.0	6.0	12	4.4
8.2_Basic_Life_Sci	83	1	5.0	8.0	12.0	34	9.4
	321	1	4.0	5.0	7.0	18	5.8
S_Social_Sci	-	-	-	-	-	-	-
	40	1	1.8	3.0	3.0	8	3.0

Note1: Red boxplots indicate the distributions for the H projects; and blue ones for the N projects. Left end of boxes indicate the first quartiles; and right end of boxes the third quartiles. Left end of whiskers indicate the 5th percentile; and right end of whiskers the 95th percentile. The red bands in bars indicate the medians; and rhombi in bars the means.

Note2: Result of social sciences in the H projects was not shown due to the small number of responses.

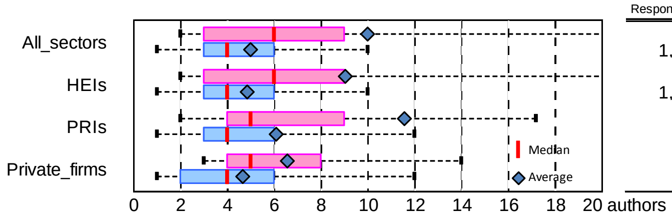
The number of authors varies significantly across scientific fields. Since the number of authors varies significantly even in a specific scientific field, we use mainly the medians for the following comparison across fields. The size of authors is small in computer science & mathematics and social sciences, while it is large in basic life sciences and clinical medicine & psychiatry/psychology. The range of the author size between the first and the third quartile for physics & space science is not especially large, but the gap between the median and the average is very large. This reflects the existence of the papers with a huge number of authors (more than 300) on such subject as particle physics.

The number of authors tends to be larger for H papers than N papers in most fields. The medians are strictly larger in all fields except for chemistry and materials science, and the means are larger in all fields. The variation of the number of authors is large in environment/ecology & geosciences, clinical medicine & psychiatry/psychology, and basic life sciences. In these fields, the maximum size of the research team is also very large, following physics & space science.

(Number of authors by sector)

Exhibit 27 shows distributions of number of authors by sector. The median of the number of authors hardly differs between sectors. It is larger in the H papers than that in the N papers across all sectors. It is interesting to note that the maximum size of the authors reaches several hundred in higher educational institutions and PRIs, while it amounts to only a few dozens in private firms.

Exhibit 27 Distributions of number of authors by sector



unit: authors

	Respondents	Minimum	Q1	Median	Q3	Maximum	Average
All_sectors	566	1	3.0	6.0	9.0	327	10.0
	1,515	1	3.0	4.0	6.0	209	5.0
HEIs	399	1	3.0	6.0	9.0	250	9.0
	1,181	1	3.0	4.0	6.0	183	4.8
PRIs	117	1	4.0	5.0	9.0	327	11.6
	219	1	3.0	4.0	6.0	209	6.1
Private_firms	41	1	4.0	5.0	8.0	26	6.6
	86	1	2.0	4.0	6.0	18	4.7

Note1: Red boxplots indicate the distributions for the H projects; and blue ones for the N projects. Left end of boxes indicate the first quartiles; and right end of boxes the third quartiles. Left end of whiskers indicate the 5th percentile; and right end of whiskers the 95th percentile. The red bands in bars indicate the medians; and rhombi in bars the means.

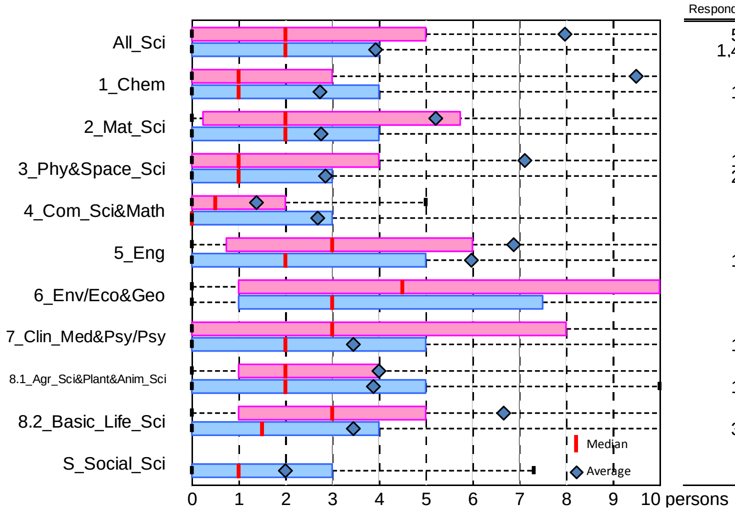
7―2 Number of Collaborating Researchers, Students and Technicians, Who Are Not Coauthors on the Paper

(Number of collaborating researchers, students and technicians, who are not coauthors by field)

The sum of the numbers of collaborating researchers, students and technicians, who are not coauthors, are shown in Exhibit 28. Similar to the number of authors, there exist big research projects with more than 100 non-author researchers so that its distribution is skewed. Thus, we focus on the medians.

The median size of non-author research team members is 2 persons for both H papers and N papers. Since the median size of authors is 6 for H papers and 4 for N papers, we can conclude that non-author research members are important. The median size of non-author research team members is large in three life science related fields, environment/ecology & geosciences, materials science and engineering, compared to computer science & mathematics, chemistry, physics & space science and social sciences (clinical medicine & psychiatry/psychology, clinical medicine & psychiatry/psychology and agricultural sciences & plant & animal science). Comparison of H papers and N papers suggest that H papers have more such non-author research team members in computer science & mathematics, engineering, environment/ecology & geosciences, clinical medicine & psychiatry/psychology, and basic life sciences.

Exhibit 28 Number of collaborating researchers, students and technicians, who are not coauthors on the paper by field



unit: person

Field	Respondents	Minimum	Q1	Median	Q3	Maximum	Average
All_Sci	549	0	0.0	2.0	5.0	300	8.0
	1,482	0	0.0	2.0	4.0	600	3.9
1_Chem	69	0	0.0	1.0	3.0	163	9.5
	181	0	0.0	1.0	4.0	30	2.7
2_Mat_Sci	42	0	0.3	2.0	5.8	60	5.2
	96	0	0.0	2.0	4.0	19	2.8
3_Phy&Space_Sci	123	0	0.0	1.0	4.0	300	7.1
	249	0	0.0	1.0	3.0	50	2.9
4_Com_Sci&Math	16	0	0.0	0.5	2.0	5	1.4
	61	0	0.0	0.0	3.0	30	2.7
5_Eng	64	0	0.8	3.0	6.0	142	6.9
	135	0	0.0	2.0	5.0	100	6.0
6_Env/Eco&Geo	30	0	1.0	4.5	20.0	90	17.6
	82	0	1.0	3.0	7.5	600	12.8
7_Clin_Med&Psy/Psy	64	0	0.0	3.0	8.0	250	13.4
	194	0	0.0	2.0	5.0	31	3.5
8.1_Agr_Sci&Plant&Anim_Sci	59	0	1.0	2.0	4.0	45	4.0
	130	0	0.0	2.0	5.0	52	3.9
8.2_Basic_Life_Sci	81	0	1.0	3.0	5.0	162	6.7
	316	0	0.0	1.5	4.0	85	3.5
S_Social_Sci	-	-	-	-	-	-	-
	38	0	0.0	1.0	3.0	12	2.0

Note1: Red boxplots indicate the distributions for the H projects; and blue ones for the N projects. Left end of boxes indicate the first quartiles; and right end of boxes the third quartiles. Left end of whiskers indicate the 5th percentile; and right end of whiskers the 95th percentile. The red bands in bars indicate the medians; and rhombi in bars the means.

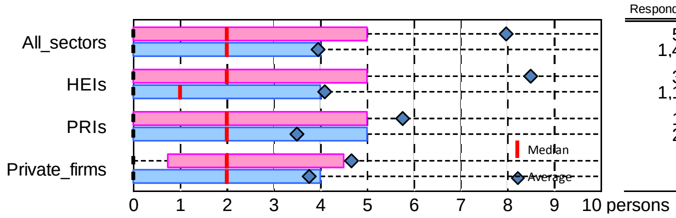
Note2: Result of social sciences in the H projects was not shown due to the small number of responses.

Note3: Result shows the summation of the number of collaborating researchers, students and technicians.

(Number of non-author research team members by sector)

Number of non-author research team members by sector is shown in Exhibit 29. The distributions are similar, except for that the median value of such members is larger in H papers than in N papers, when the paper is from higher educational institutions.

Exhibit 29 Number of collaborating researchers, students and technicians, who are not coauthors on the paper by sector



unit: person

Sector	Respondents	Minimum	Q1	Median	Q3	Maximum	Average
All_sectors	549	0	0.0	2.0	5.0	300	8.0
	1,484	0	0.0	2.0	4.0	600	3.9
HEIs	387	0	0.0	2.0	5.0	300	8.5
	1,161	0	0.0	1.0	4.0	600	4.1
PRIs	113	0	0.0	2.0	5.0	162	5.8
	211	0	0.0	2.0	5.0	41	3.5
Private_firms	40	0	0.8	2.0	4.5	60	4.7
	84	0	0.0	2.0	4.0	40	3.8

Note1: Red boxplots indicate the distributions for the H projects; and blue ones for the N projects. Left end of boxes indicate the first quartiles; and right end of boxes the third quartiles. Left end of whiskers indicate the 5th percentile; and right end of whiskers the 95th percentile. The red bands in bars indicate the medians; and rhombi in bars the means.

Note2: Result shows the summation of the number of collaborating researchers, students and technicians.

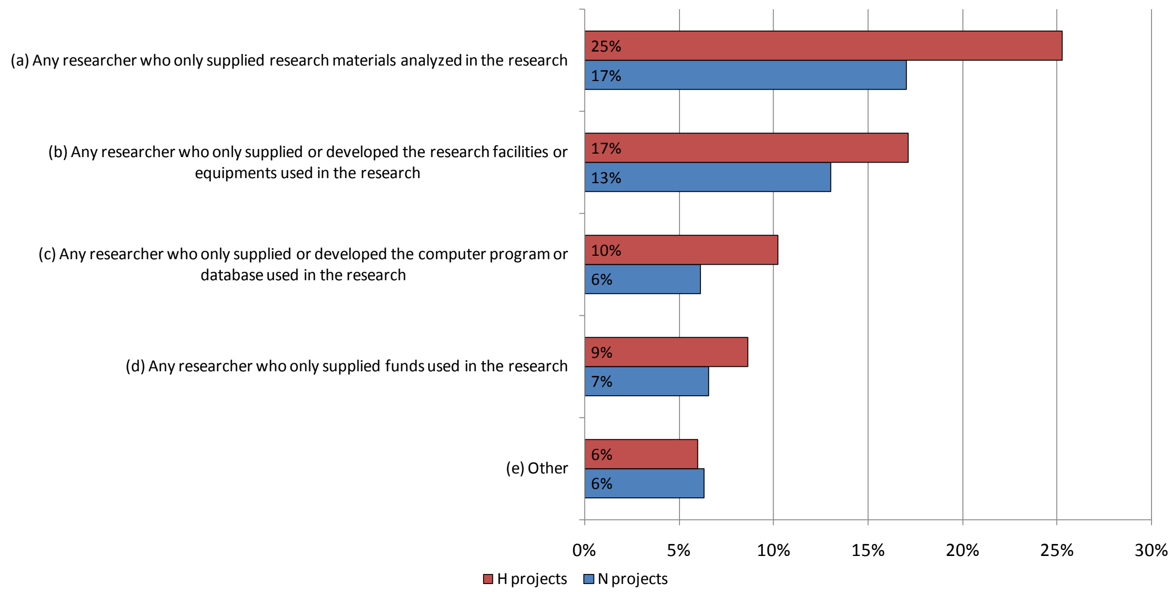
7－3 Scope of Authors: Who Are the Authors?

The basic question we asked in our survey is who are included among the authors, beyond those who directly contributed to the research project such as those who engaged in experiments, observations and theoretical analysis. We asked a respondent whether there are those authors who did only non-research works such as providing research materials in the project under the survey.

A large number of researchers who supplied only research materials are included as an author in both H papers (25%) and N papers (17%). In addition, a researcher who supplied or developed only the research facilities or equipments is also frequently included as an author in both types of papers (17% in H papers and 13% in N papers). Frequent inclusion of these researchers among the authors might have been important to provide them the incentives to provide such materials and equipments. It also indicates their importance in research.

It is also noteworthy that a researcher who provided only research fund is also included as an author relatively frequently (8.7% in H papers and 6.5% in N papers).

Exhibit 30 Incidence of authors who did not contribute directly to the research



Note1: The choice is non-exclusive.
Note2: Others are those researchers who did not provide direct contribution to the research project nor any four of the listed contributions
Note3: The result of all fields.

7－4 COMBINATION OF AUTHORS IN ACADEMIC/PROFESSIONAL POSITION

The following analysis is limited to the samples of the focal papers written by six or less authors, so as to avoid the possible biases due to our selective sampling of the first, last and corresponding authors of the focal papers which would become important as the number of author increase to seven or more.

Exhibit 31 shows the compositions of the authors classified by academic/professional position by sector and by types of papers. Each paper has an equal weight for aggregating the incidence. For example, in the case of a paper consisting of n authors, each author is given a weight of $1/n$ for the purpose of aggregation.

In the HEIs, the share of professors is the largest, followed by associate professor and assistant professors. Professors account for around 40% in the H and N papers. On the other hand, junior researchers, who are undergraduates or graduate students or postdoctoral fellows, account for 28% of the authors of H papers and 25% of the N papers. Students alone account for close to 20% of the authors of both types of papers.

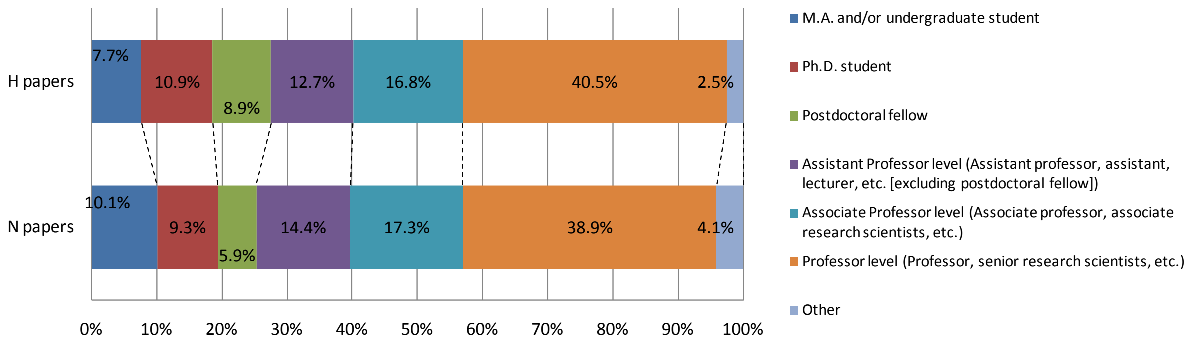
In PRIs, the share of the professor level scientists is the largest, followed by associate professor level research scientists. Junior researchers account for 15% of the authors of H papers and 17% of N papers. The share of students is small.

In private firms, the share of the junior researchers accounts for 14% in the H papers, which however is due to the fact that a research paper collaboratively done with universities and/or PRIs are included as the papers of the private firms[1]. This effect seems to be especially important for H papers. 13% of the authors of N papers are "others", half of which are technicians.

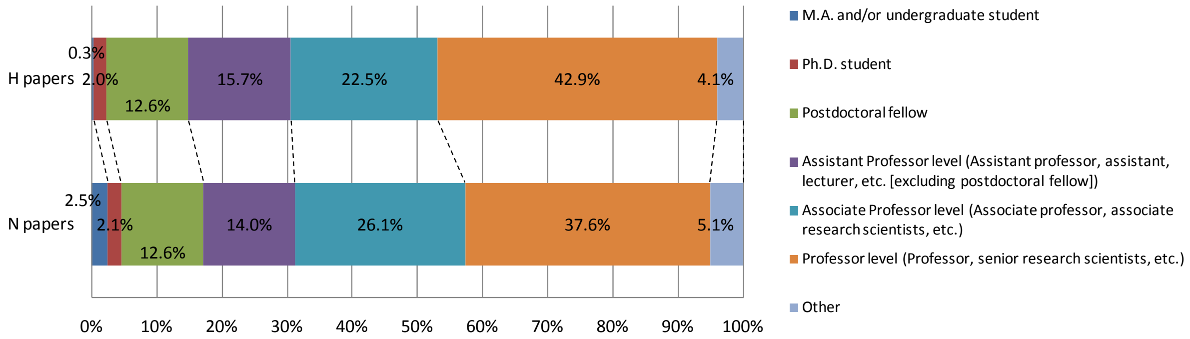
[1] The paper is assigned to the sector with which the responding author is affiliated.

Exhibit 31 Compositions of authors in academic/professional position (a paper basis, by sector)

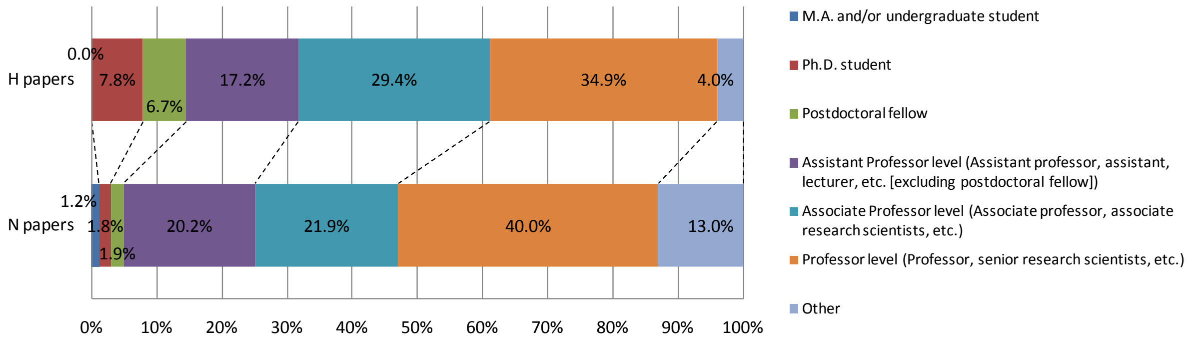
(a) Higher education institutions



(b) Public research institutions



(c) Private firms



Note1: These exhibits cover only papers with 6 or less authors (1,528)
Note2: Each author of the paper with n authors has a weight of 1/n for aggregation
Note3: "Other" includes technician, the others and unknown.

7―5 Who Are the First Authors When the Authors Are Listed in Order of their Degree of Contributions

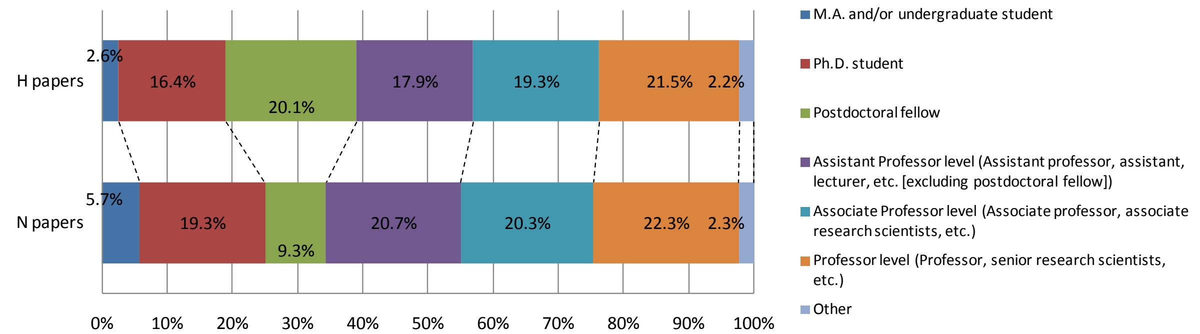
Exhibit 32 (a) shows who are the first authors in the focal papers whose authors are listed in order of their degrees of contributions. It shows the shares by academic/professional position. It indicates the types of researchers who made the most contributions to the focal papers. Stephan (2010)[1] pointed out that Ph.D. students and postdoctoral fellows appear disproportionately more as the first authors in US articles in the journal *Science*. We extend her analysis by covering all journals and by focusing on the articles where the order of the authors is according to their contributions.

In the HEIs, Ph.D. students and postdoctoral fellows made more contributions to the focal papers as the first authors than their shares in all authors of the papers. As shown in Exhibit 32 (b), the combined share of Ph.D. students and postdoctoral fellows as first authors are 1.8 times higher than those in all authors. Their share was 37% as the first author while it was 20% of all authors in the H papers and 29% as the first author and 15% of all authors in the N papers. In particular, in the H papers, the share of postdoctoral fellows as first authors is close to that of professors. On the other hand, in the N papers, the share of postdoctoral fellows declines (from 20% down to 9.3%) while that of Ph.D student increases somewhat from 16% to 19%. This indicates that postdoctoral fellows are especially likely to be involved to produce H papers.

The shares of Ph.D. students and postdoctoral fellows as first authors vary across scientific fields. They made large contributions, especially in life sciences. The combined share amounts to 50% of the H papers and 39% of the N papers in life sciences.

Exhibit 32 Academic/professional positions of the first authors in the focal papers whose authors are listed in order of their degree of contributions (by sector)

(a) Higher education institutions

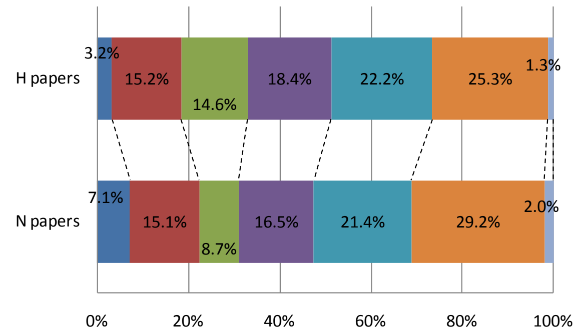


(b) Participation of Ph. D. Studcents and posdoctoral fellow as authors

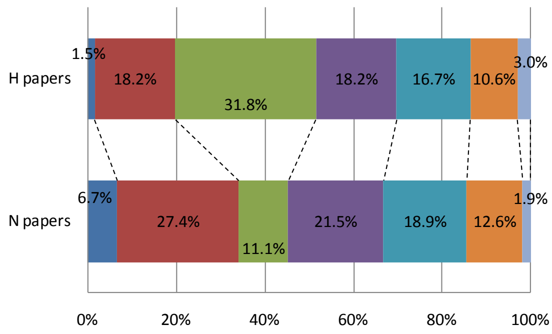
	All Authors			First Author		
	Ph.D. student	Postdoctoral fellow	Total	Ph.D. student	Postdoctoral fellow	Total
H papers	10.9%	8.9%	19.8%	16.4%	20.1%	36.5%
N papers	9.3%	5.9%	15.2%	19.3%	9.3%	28.6%

[1] Based on her seminar presentation on Economics of Science at the Research Institute of Economy, Trade and Industry (March 2010).

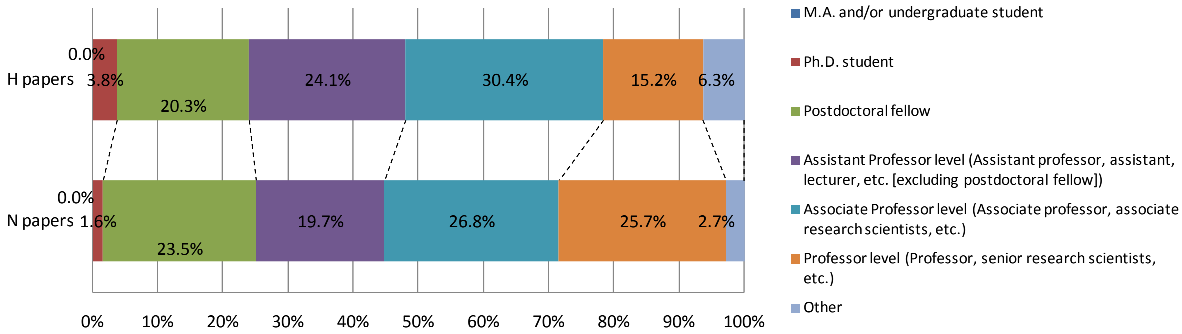
(c) Higher education institutions (physical sciences)



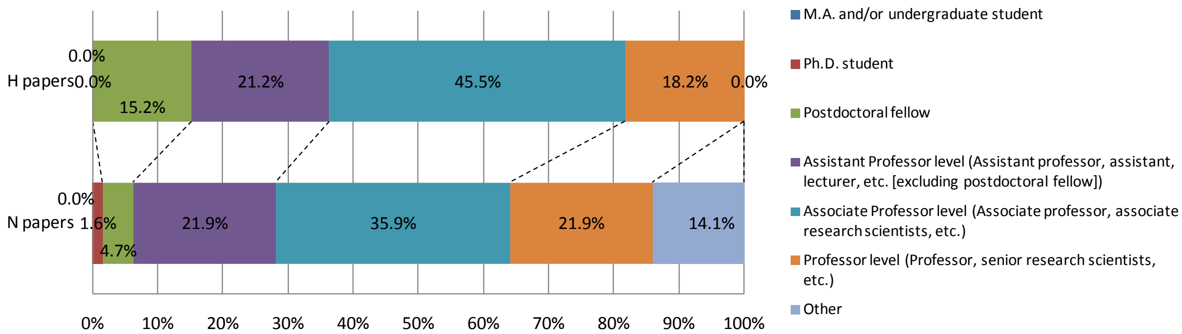
(d) Higher education (life sciences)



(e) Public research institutions



(f) Private firms



Note1: The sample focuses on those papers the authors of which are ordered according to the contribution of the authors to the research (the total sample size is 1,525).
Note2: "Other" includes technician, the others and unknown.

Also, in the PRIs, the contributions of postdoctoral fellows as first authors appeared to be substantially larger than that as all authors. For H papers, the share of postdoctoral fellows increased by 1.6 times from 13% for all authors to 20% for the first author. The same point applies to private firms. It increases from 6.3% to 15%.

7－6 DIVERSITY OF AUTHORS IN RESEARCH TEAM

This subsection looks briefly at the diversity of authors in specialized academic field, specialized skill, country of birth, and affiliating sector at the time of submitting the focal papers (Exhibit 33). It is based on the profiles of up to six authors of the focal papers, who include the first, last and corresponding authors on a preferential basis.

Exhibit 33(a) shows the distribution of the number of academic fields covered by research teams, where academic fields consist of 27 fields, covering such fields as mathematics, computer science and chemistry. For both types of papers the authors are most likely to belong to one discipline. The authors of the H papers are more likely to cover more than one specialized academic field than the N papers, as shown in the exhibit. This suggests that the researches tend to be conducted by more interdisciplinary research teams in the H papers (48%) than in N papers (40%).

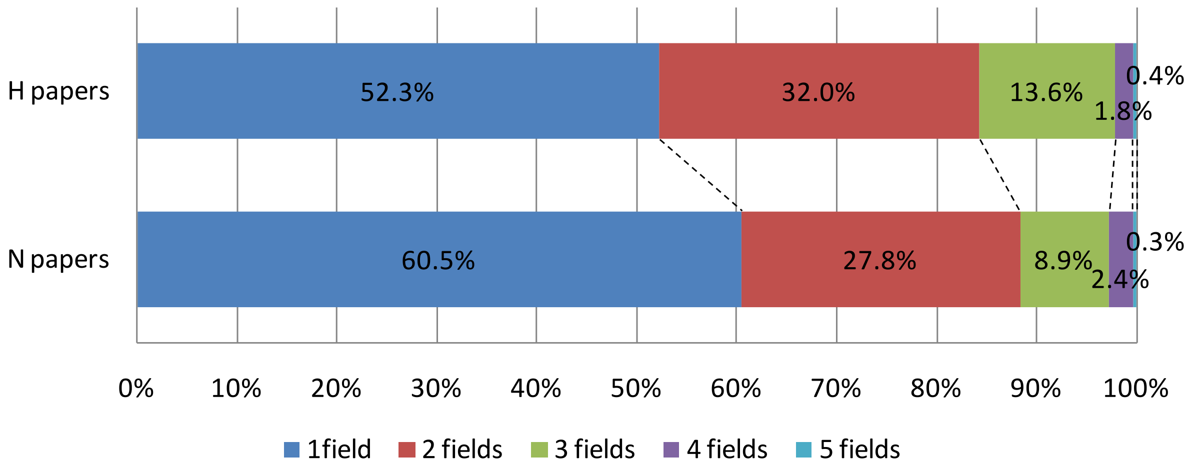
Exhibit 33(b) shows the distribution of the number of skills covered by research teams, where there are 3 broad categories of skills: theory, experiment and clinical analysis. In terms of the specialized skills of authors, there is no large difference between the H papers and N papers. The share of papers covering 2 or more skills amounts to 31% for H papers and 28% for N papers.

Exhibit 33(c) shows the distribution of the participation of foreign born researchers in research teams. The H papers are likely to involve the authors who were born in foreign countries as well as in Japan. This suggests that the researches tend to be conducted by international teams in the H papers more than those in the N papers. There are a few cases where there are only foreign authors among 6 authors identified. Including these cases, the shares of the papers with a foreign-born author amount to 48% of the H papers and to 31% of the N papers.

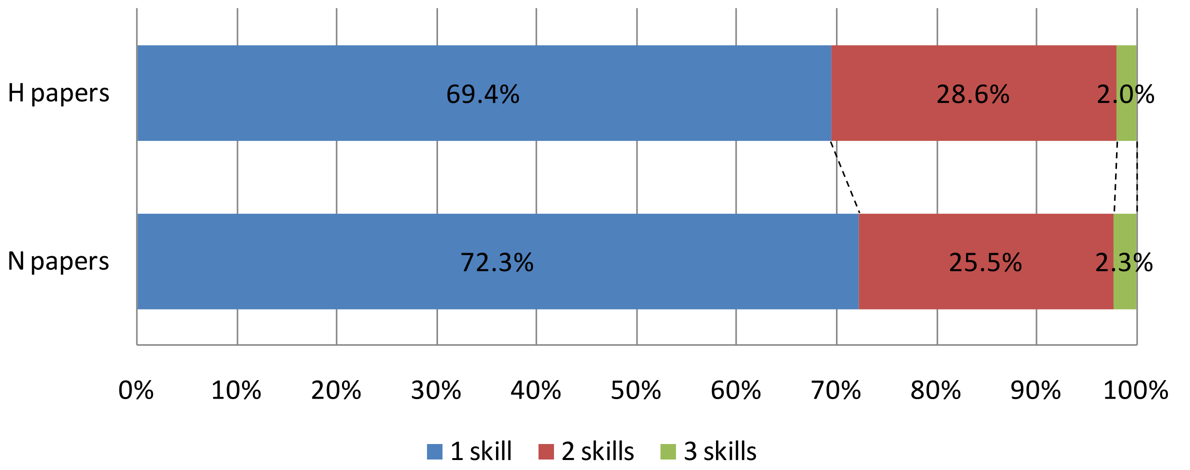
Exhibit 33(d) shows the distribution of the number of sectors with which the authors of the research team is affiliated. The types of the sectors cover higher education institutions, PRIs, private firms and private non-profit research institutions. The authors of the H papers are likely to cover more than one sector than the N papers. The share of papers with the authors covering more than 2 sectors amounts to 41% in H papers and 31% in N papers.

Exhibit 33 Diversity of authors in the research team

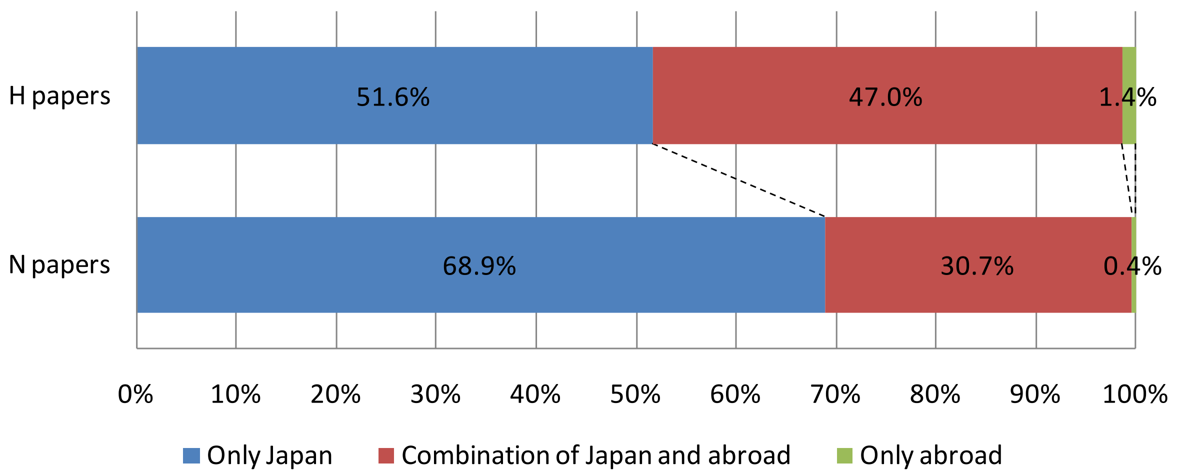
(a) Combination of specialized academic fields



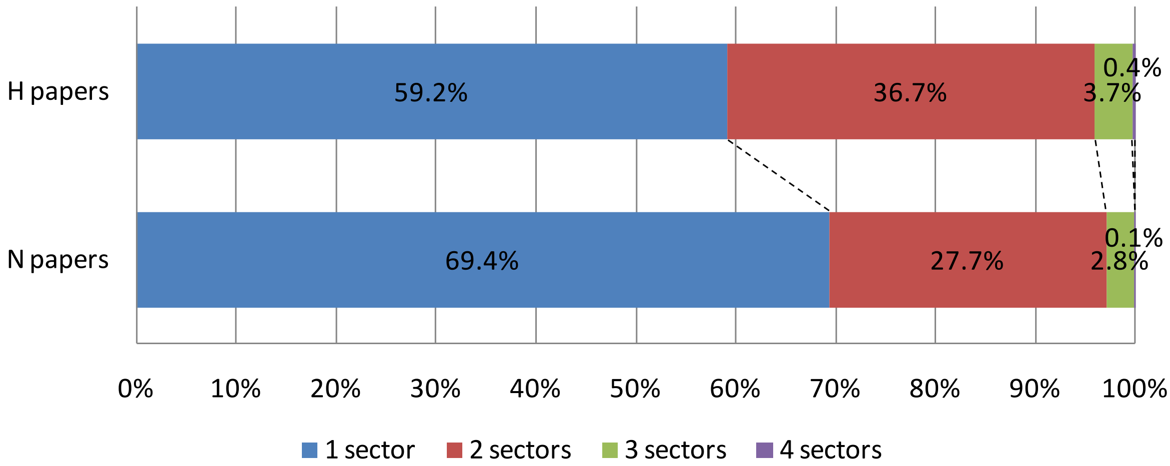
(b) Combination of specialized skills



(c) Combination of origins



(d) Combination of sectors



Note1: (Academic fields of specialization) One specialized field is chosen for each author among 27 fields, covering such fields as mathematics, computer science and chemistry.

Note2: (Specialized skills) One skill is chosen for each author among theory, experiment and clinical analysis

Note3: (Country of birth) Birth place chosen for each author among Japan and outside of Japan.

Note4: (Institutions) One institution is chosen for each author among university and the other higher education institutions, public research institutions, private firms and private non-profit research institutions

Note5: Based on the sample of all science fields

8 INPUTS FOR RESEARCH PROJECTS

8－1 TIME BETWEEN RESEARCH PROJECT CONCEPTION AND THE FOCAL PAPER SUBMISSION

This survey clarifies how many years it takes from the conception of research project through the actual launch of research projects to the submission of the focal paper, by asking the scientists the year they conceived their research projects, the year they actually started their research projects and the year they submitted their focal papers.

Exhibit 34 shows the average years between the conception and the launch of research projects and the average years between the launch of research projects and the focal paper submissions, by type of projects and by scientific field. It shows that the research projects were launched in around one year after the conception on average in most scientific fields, except for environment/ecology and geosciences in the H projects where it took two years on average.

It shows that, in terms of the period between the launch of research projects and the submission of the focal papers, it took 3.0 and 3.6 years for the H projects and the N projects, respectively. In the scientific fields except for medicine and life sciences, such as clinical medicine & psychiatry/psychology, basic life sciences and agricultural sciences & plant & animal science, the average periods for the H projects are more than 0.5 year shorter than those for the N projects.

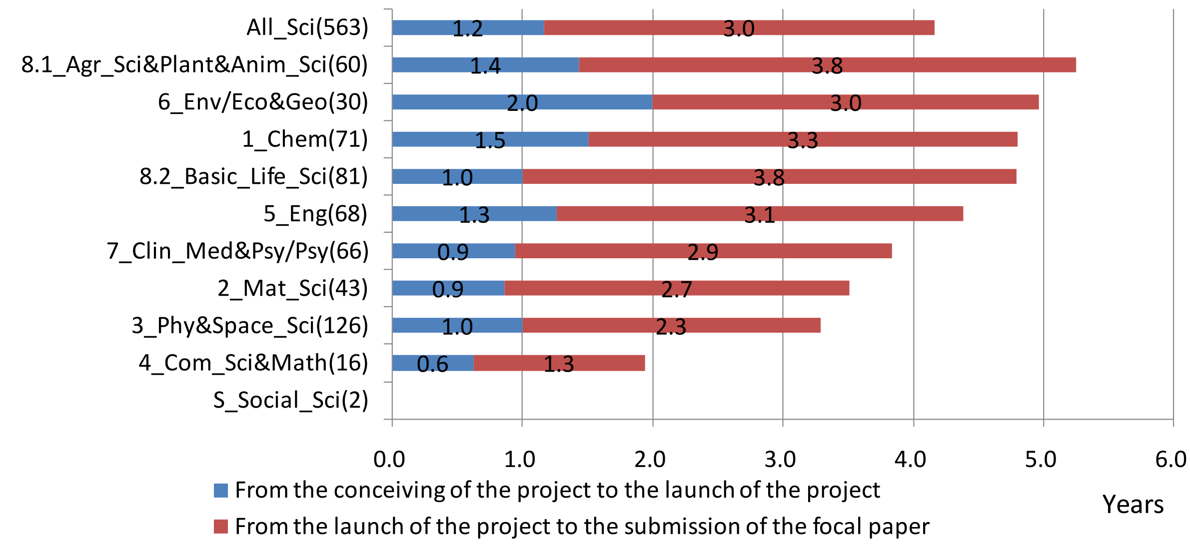
Those findings suggest that it usually takes four or five years between the conception of research projects and the submission of the focal papers and that those periods for the H projects are usually shorter than those for the N projects, although there can be found some differences between scientific fields[1].

As described in Section 6, the researchers of the H projects are likely to recognize their competitions both nationally and internationally, and to be concerned to be scooped by the competitors than those of the N projects. This may partly explain the differences between the H and N projects.

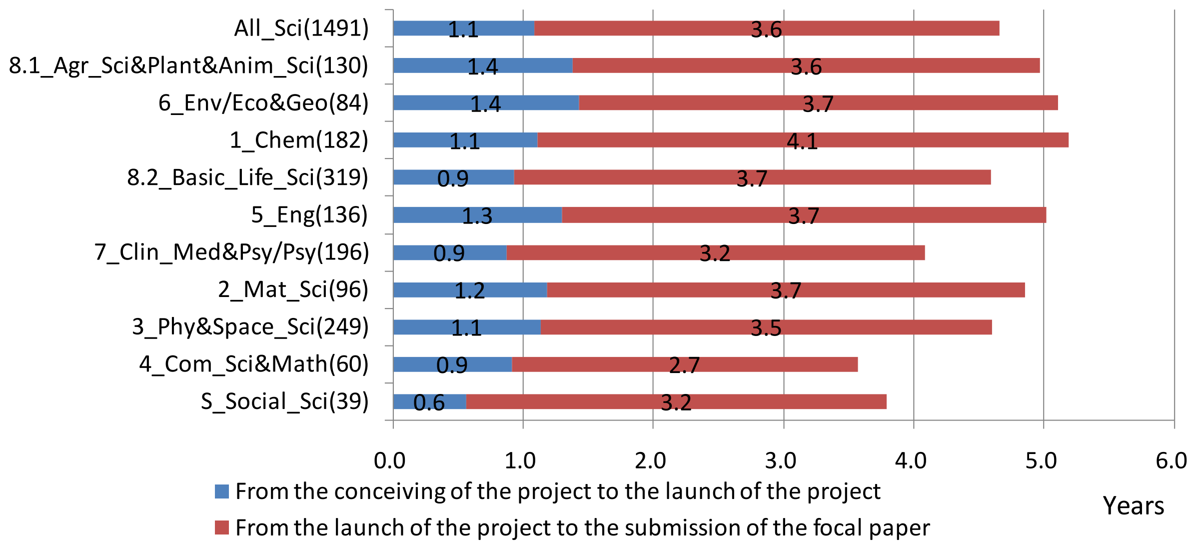
[1] It is important to note that the focal paper may not be the earliest paper resulted from the research project.

Exhibit 34 Time-lags between the year when the project was conceived and the year when the focal paper was submitted

(a) H projects



(b) N projects



Note1: Result of social sciences in the H projects was not shown due to the small number of responses.

8−2 Labor Input for Research Projects

Labor input is the most basic input for a research project. We asked the respondent to identify the total labor input in man-month units, which were consumed by a research team as a whole from the time of substantially initiating the research project to the time of submitting the latest paper from the research project, were asked.

Exhibit 35 shows the following results. First, the distributions of the labor input differ across scientific fields. Second, the medians and quartiles of distributions of the labor input in the H projects are higher than those in the N projects, except for environment/ecology and geosciences and computer science & mathematics. Third, this tendency holds in the distributions by sector.

Forth, the distributions of the labor input do not differ across sectors. Those suggest that the H projects are likely to consume more labor input for research projects than the N projects in many fields and in all sectors, and that the labor input for research projects seem not to be dependent on sectors.

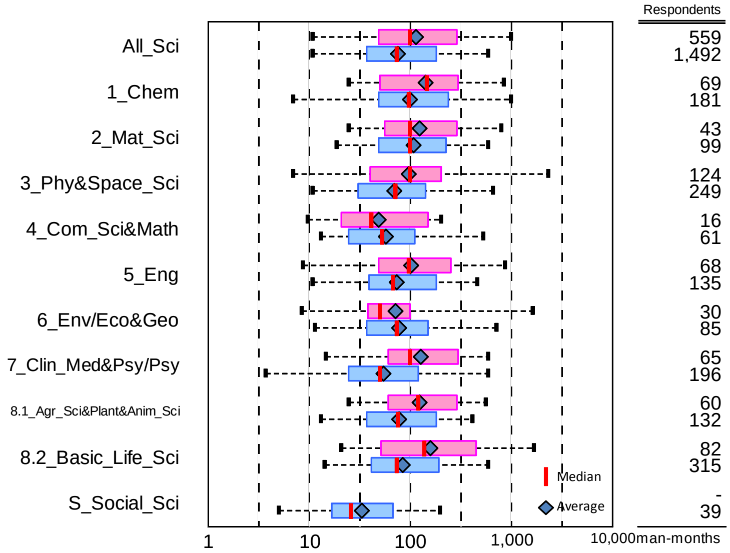
Some research projects consumed more than ten thousand man-month. They include a large international research and a research using huge experimental facilities, for example, in particle physics.

Median labor input for research projects was 100 man-months for the H projects and 72 man-months for the N projects; average labor input for research projects was 115 man-months for the H projects and 74 man-months for the N projects. In some scientific fields, such as chemistry, clinical medicine & psychiatry/psychology, agricultural sciences & plant & animal science, and basic life sciences, the median labor input for research projects for the H projects was 1.5 to 2 times that of the N projects. In terms of size of research projects, the median labor input for the H projects were more than 130 man-months in chemistry and basic life sciences, and more than 100 man-months in materials science and clinical medicine & psychiatry/psychology and agricultural sciences & plant & animal science. In materials science, even the median labor input for the N projects exceeded 100 man-months.

As for the distribution of labor input for research projects, no major differences exist between the sectors. For the H projects, the median labor input for research projects in life sciences was more than 120 man-months in both the HEIs and the PRIs.

Exhibit 35 Total research man-months expended on the research project

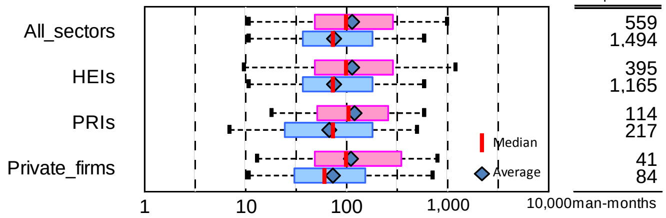
(a) Total research man-months expended on the research project by field



unit: man-month

Field	Respondents	Minimum	Q1	Median	Q3	Maximum	Average
All_Sci	559	1	48	100	294	25,000	115
	1,492	0	36	72	180	90,000	74
1_Chem	69	6	50	144	300	2,500	144
	181	2	48	96	240	3,000	98
2_Mat_Sci	43	4	55	100	294	2,000	125
	99	1	48	100	225	2,000	106
3_Phy&Space_Sci	124	1	39	98	204	25,000	98
	249	0	30	70	140	3,600	68
4_Com_Sci&Math	16	6	20	41	150	420	48
	61	1	24	52	112	720	56
5_Eng	68	2	48	96	251	11,000	101
	135	2	38	67	180	2,268	74
6_Env/Eco&Geo	30	6	37	49	100	3,600	71
	85	5	36	72	150	90,000	77
7_Clin_Med&Psy/Psy	65	6	60	100	300	12,000	128
	196	1	24	50	120	3,360	54
8.1_Agr_Sci&Plant&Anim_Sci	60	1	60	120	291	1,250	123
	132	5	36	76	180	1,200	78
8.2_Basic_Life_Sci	82	3	50	136	450	3,600	159
	315	1	41	72	192	5,400	83
S_Social_Sci	-	-	-	-	-	-	-
	39	1	16	25	67	300	33

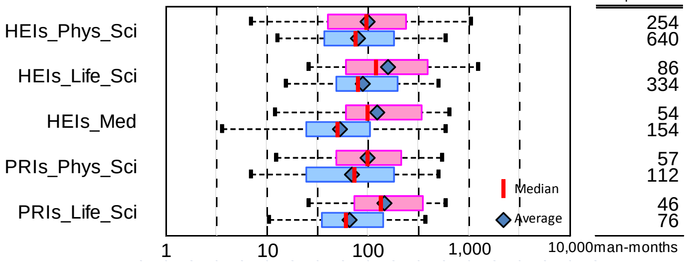
(b) By sector



unit: man-month

	Respondents	Minimum	Q1	Median	Q3	Maximum	Average
All_sectors	559	1	48	100	294	25,000	115
	1,494	0	36	72	180	90,000	74
HEIs	395	1	48	100	288	18,000	113
	1,165	0	36	72	180	90,000	75
PRIs	114	6	50	104	259	25,000	119
	217	1	24	72	180	2,000	67
Private_firms	41	1	48	100	350	2,000	110
	84	1	30	60	152	3,000	74

(c) Total research man-months expended on the research project by sector, by large field



unit: man-month

	Respondents	Minimum	Q1	Median	Q3	Maximum	Average
HEIs_Phys_Sci	254	1	40	96	240	18,000	98
	640	0	36	74	180	90,000	80
HEIs_Life_Sci	86	3	60	120	390	3,000	159
	334	1	48	80	200	5,400	88
HEIs_Med	54	6	60	100	344	12,000	124
	154	1	24	49	104	3,360	52
PRIs_Phys_Sci	57	6	48	99	216	25,000	98
	112	2	24	72	180	2,000	69
PRIs_Life_Sci	46	10	72	134	351	3,600	145
	76	4	34	60	142	768	65

Note1: Red boxplots indicate the distributions for the H projects; and blue ones for the N projects. Left end of boxes indicate the first quartiles; and right end of boxes the third quartiles. Left end of whiskers indicate the 5th percentile; and right end of whiskers the 95th percentile. The red bands in bars indicate the medians; and rhombi in bars the means.

Note2: Result of social sciences in the H projects was not shown due to the small number of responses.

Note3: Total research man-months in the boxplots are shown in the logarithmic scale.

8－3 Amount of Money Spent for Research Projects

Amount of money spent for research projects was also surveyed. As for the personnel expenditures, the surveyed amount includes only those for employing researchers and research assistants specifically for the research projects, which are typically defrayed by extramural funds. It was evident from our interviews with faculty members in universities that they tended to exclude their own salary from the research money spent, which is usually defrayed by intramural funds. Also, the surveyed amount included only the expenditures for the facilities that were introduced specifically for the research projects, and excluded the cost of using the other facilities, including those facilities that had existed. For these reasons, the surveyed amount of money spent for research projects may be significantly less than the total cost for the research projects, especially in HEIs.

Exhibit 36 shows the results. First, the distributions of the amount of research money spent differ significantly across scientific fields. Second, the medians and quartiles of the distributions of the amount of research money spent in the H projects are higher than those in the N projects, only except for computer science & mathematics. Third, this tendency holds for the distributions by sector. Forth, the distributions of the amount of research money spent also differ between sectors.

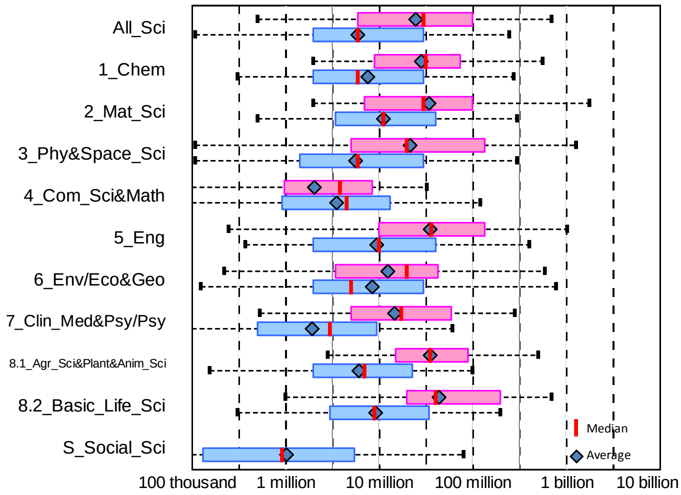
For the N projects, depicted by blue boxplots, social sciences spent the least amount of the money spent among scientific fields (the median was 0.9 million yen); materials science the most amount of money spent (the median was 11 million yen). In other fields, the median amount of money spent for research projects was less than 5 million yen in clinical medicines & psychiatry/psychology, computer sciences & mathematics; that was 5 to 10 million yen in environment/ecology and geosciences, chemistry, physics & space science, agricultural sciences & plant & animal science and basic life sciences; and that was more than 10 million yen in engineering. There are some huge research projects that spend several billion yen.

The median amounts of money spent for research projects for the H projects were three to five times more than those for the N projects, except for computer science & mathematics. In total, the median amount of money spent for research projects was 30 million yen for the H projects and 6 million yen for the N projects. In the previous section, it was mentioned that the median labor input for H projects (100 man-months) was 1.39 times that of the N projects (72 man-months). These results suggest that in the H projects, more amounts of money per unit labor input were spent. The reasons for such difference may include the following: the H projects involved more researchers employed for the projects, such as postdoctoral fellows and were more likely to have advanced experimental equipment and facilities than the N projects.

The results also suggest that the research money spent for research projects seem to be dependent on sectors. More research money is spent by a private firm, followed by PRIs and then by HEIs. However, it is important to note that the personnel expenditures are differently attributed to the projects across HEIs and PRIs, which in turn would influence the results.

Exhibit 36 Amount of money spent directly used for the research project

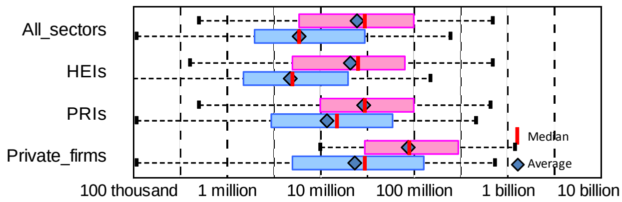
(a) By field



unit: 10,000 yen

	Respondents	Minimum	Q1	Median	Q3	Maximum	Average
All_Sci	556	0	600	3,000	9,925	2,000,000	2,495
	1,487	0	200	600	3,000	3,000,000	600
1_Chem	71	40	894	3,200	7,483	300,000	2,864
	176	0	200	600	3,000	500,000	770
2_Mat_Sci	41	8	700	3,000	10,000	500,000	3,433
	99	0	346	1,100	4,000	300,000	1,123
3_Phy&Space_Sci	123	0	500	2,000	13,416	2,000,000	2,182
	248	0	142	600	3,000	500,000	564
4_Com_Sci&Math	16	0	97	387	846	4,000	202
	61	0	90	450	1,300	200,000	355
5_Eng	68	5	1,000	3,578	13,473	600,000	3,519
	133	0	200	1,000	4,100	400,000	939
6_Env/Eco&Geo	30	0	341	2,000	4,223	80,000	1,243
	85	0	200	500	3,000	3,000,000	848
7_Clin_Med&Psy/Psy	64	0	500	1,732	6,000	60,000	1,465
	196	0	50	300	957	100,000	193
8.1_Agr_Sci&Plant&Anim_Sci	60	80	1,500	3,500	9,000	50,000	3,543
	132	0	200	693	2,296	40,000	617
8.2_Basic_Life_Sci	81	3	2,000	4,000	20,000	560,000	4,416
	318	0	300	900	3,400	200,000	932
S_Social_Sci	-	-	-	-	-	-	-
	39	0	12	90	548	30,000	101

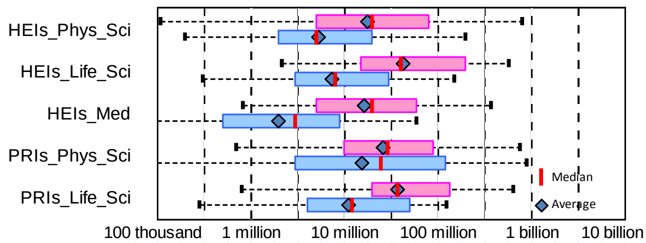
(b) By sector



unit: 10,000 yen

	Respondents	Minimum	Q1	Median	Q3	Maximum	Average
All_sectors	556	0	600	3,000	9,925	2,000,000	2,495
	1,489	0	200	600	3,000	3,000,000	599
HEIs	392	0	500	2,550	8,000	800,000	2,110
	1,163	0	150	500	2,000	900,000	482
PRIs	115	0	1,000	3,000	9,950	2,000,000	2,889
	215	0	300	1,500	6,000	3,000,000	1,189
Private_firms	40	80	3,000	8,944	30,000	500,000	8,661
	84	0	500	3,000	12,688	500,000	2,342

(c) By sector, by large field



unit: 10,000 yen

	Respondents	Minimum	Q1	Median	Q3	Maximum	Average
HEIs_Phys_Sci	253	0	500	2,000	8,000	800,000	1,763
	636	0	200	500	2,000	900,000	538
HEIs_Life_Sci	85	100	1,500	4,000	20,000	560,000	4,289
	336	0	300	800	3,000	120,000	729
HEIs_Med	53	20	500	2,000	6,000	60,000	1,656
	154	0	50	300	900	100,000	195
PRIs_Phys_Sci	58	0	1,000	2,898	9,078	2,000,000	2,594
	109	0	300	2,500	12,000	3,000,000	1,543
PRIs_Life_Sci	46	3	2,000	3,742	13,554	90,000	3,767
	77	1	400	1,200	5,000	200,000	1,102

Note1: Red boxplots indicate the distributions for the H projects; and blue ones for the N projects. Left end of boxes indicate the first quartiles; and right end of boxes the third quartiles. Left end of whiskers indicate the 5th percentile; and right end of whiskers the 95th percentile. The red bands in bars indicate the medians; and rhombi in bars the means.

Note2: Result of social sciences in the H projects was not shown due to the small number of responses.

Note3: Amounts of research money spent in the boxplots are shown in the logarithmic scale.

8－4 Sources of Funds for Research Projects

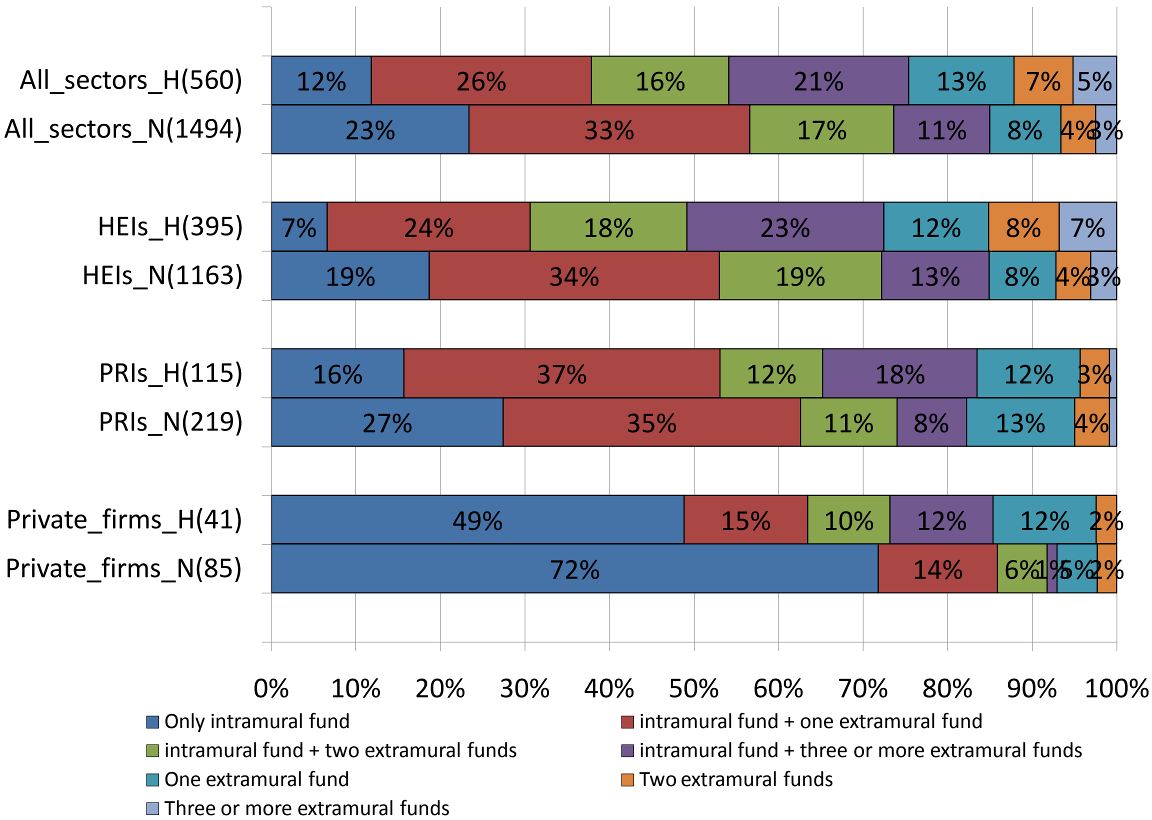
8－4－1 Combination of Multiple Sources of Funds

Exhibit 37 shows the frequency of the combinations of multiple sources of funds for research projects. Most projects use extramural funds: only 12% of the H projects use only intramural fund and only 23% of the N projects use only intramural fund. At the same time, a majority of the projects use intramural fund: 75% of the H projects and 85% of the N projects.

The H projects are likely to use more multiple sources of funds for research projects than the N projects. The H projects tend to use extramural funds more than the N projects; and the H projects tend to use intramural funds less than the N projects. Especially, for 23% and 18% of the H projects in HEIs and PRIs and 13% and 8% of the N projects in HEIs and PRIs, respectively, their research projects had been supported by more than three sources of extramural funds as well as by intramural funds.

The combination of sources of funds also differs between private firms and the others. More than 80% of research projects conducted in private firms had been supported by intramural funds, while more than 80% of research projects conducted in HEIs had been supported by extramural funds.

Exhibit 37 Combination of sources of funds



Note1: In each sector, the upper figure shows the result of the H projects and the lower figure shows the result of the N projects

Note2: The "intramural fund" indicates fund of the institutions that the research team members belong to, based on the government grants for operative expenses *etc*. for the HEIs, and the internal fund for private firms.

Note3: The "extramural" covers both the fund from the institution-base programs, such as the subsidies of the COE programs, as well as the funds from the project-base programs, such as the Grant-in-Aid for Scientific Research, the Health and Labor Sciences Research Grants, and from JST, NEDO, and private firms.

8－4－2 Disaggregated sources of funds

Exhibit 38 shows the composition of disaggregated sources of funds on a simple average basis over the projects. For example, in the case of a fund accounting for *n*% for a research project such source has a weight of *n*/100, irrespective of the amount of funds for research projects.

The compositions of sources of funds differ between sectors. Even in the same sector, the H projects are likely to be supported by more multiple sources of funds than the N projects.

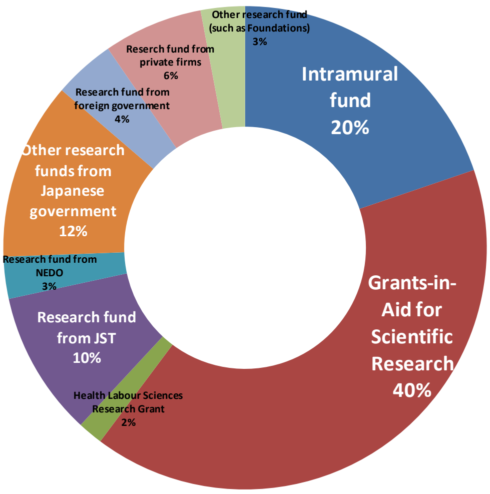
In HEIs, the N projects were funded by intramural funds (40% of the total cost) and by the Grants-in-Aid for Scientific Research (34%), which is the fundamental funds for academic research in Japan, for research projects. They also used the other extramural funds from governments in Japan and from private firms (8% and 8%, respectively). On the other hand, the H projects were funded by the Grants-in-Aid for Scientific Research (40%), intramural funds (20%), and other extramural funds from governments in Japan (12%). It is noteworthy that funds from JST (the Japan Science and Technology Agency), a funding agency for strategic research under MEXT (the Ministry of Education, Culture, Sports, Science and Technology), accounted for 10% of the funds of the H projects. In PRIs, the two most utilized types of sources of funds were intramural funds and other extramural funds from governments in Japan for both H and N projects. They also use the funds of the Grants-in-Aid for Scientific Research, and the funds from JST. It is distinctive that funds from NEDO (the New Energy and Industrial Technology Development Organization), a R&D funding agency under METI (the Ministry of Economy, Trade and Industry), accounted for more in the H projects (7%) than in the N projects (2%).

In private firms, the two most utilized types of sources of funds were intramural funds and extramural funds from other private firms, which might include commissioned research. The sum of them accounted for 82% and 92% in the H and N projects, respectively. Also other extramural funds from governments accounted for 12% in the H projects.

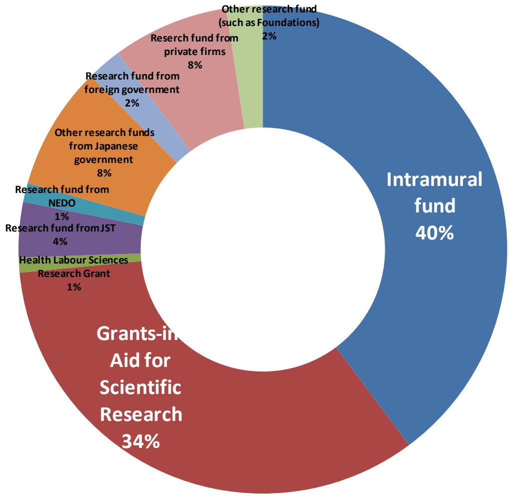
Those results suggest that each type of source of fund fulfils different function. Presumably, intramural funds underpin the whole of research projects. Funds of the Grants-in-Aid for Scientific Research have the functions of supporting to produce research results continuously as well as of underpinning the whole of research projects. Funds from JST and NEDO may provide large inputs for the promising research projects to produce papers to be highly cited.

Exhibit 38 Composition of Sources of Funds (a research project base)

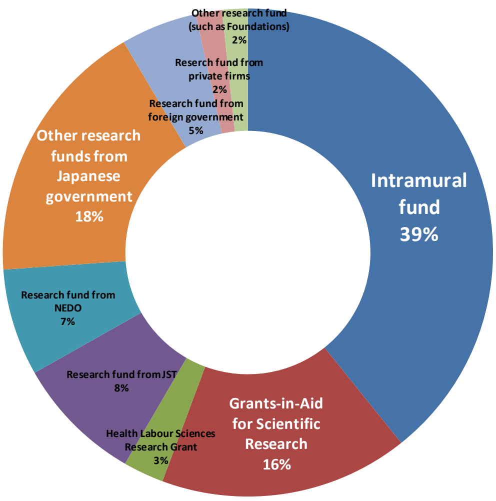
(a) HEIs（H projects）



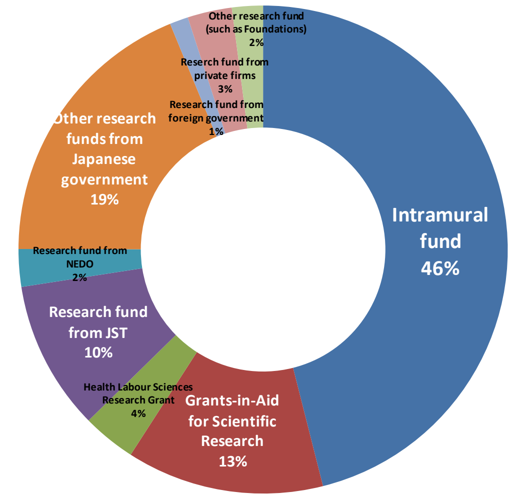
(b) HEIs(N projects)



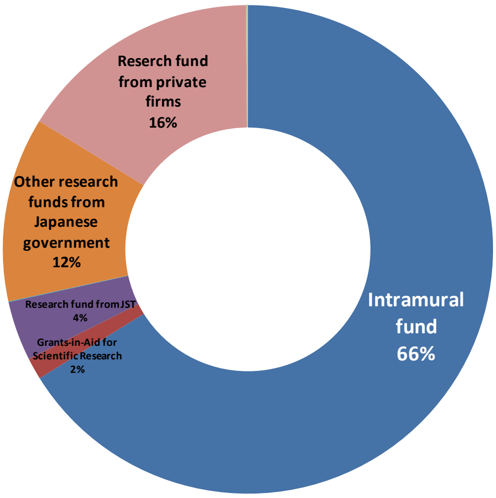
(c) PRIs（H projects）



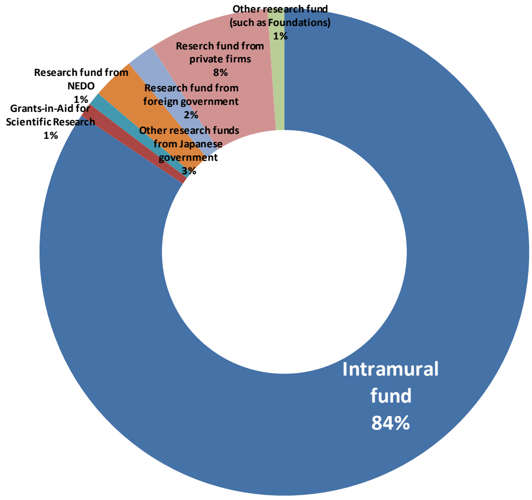
(d) PRIs (N projects)



(e) Private firms（H projects）



(f) Private firms (N projects)



Note1: The "intramural fund" covers the fund of the institutions that the research team members belong to, based on the government grant for operative expenses etc. for the HEIs, and its own fund for private firms.

Note2: The "other research funds from Japanese government" covers both the institution-base competitive extramural research funds, such as the subsidies in the COE programs, and the project-base competitive extramural funds, except for the Grant-in-Aid for Scientific Research, the Health and Labor Sciences Research Grants, and funds from JST and NEDO, and non-competitive extramural research funds, such as government-led national projects, and extramural funds from local governments in Japan.

9 OUTPUTS AND IMPACTS OF THE RESEARCH PROJECTS

9－1 NUMBER OF REFEREED PAPERS FROM RESEARCH PROJECTS

Exhibit 39 and Exhibit 40 show the distribution of the refereed papers from a research project by language and the combined number of such papers by field (the sum of number of Japanese papers, English papers, and the others). The papers written in English account for most of the papers from H projects (91.9%) and from N projects (87.0%). The percentage of papers written in Japanese is higher in the N projects than in H projects.

In Exhibit 40, red boxplots indicate the distributions for the H projects; and blue ones for the N projects. The left end of boxes indicates the first quartile; and the right end of boxes the third quartile. The left end of whiskers indicates the 5th percentile; and the right end of whiskers the 95th percentile. The red bands in bars indicate the medians; and rhombi in bars the means.

In all fields combined, H projects produced 15 papers for the median and 40 papers on average. N projects produces 7 for its median and 18 on average. In all fields, there is a large gap between the median and the average and the averages are significantly larger than the medians. It is because there exist a small number of research projects that produce many papers in each field and at the same time more than one quarter of the projects produce 6 or less (3 or less) papers in H (N) projects. It is considered that it reflects the fact that the discovery process in scientific research is uncertain and cumulative[1]. The following discussion uses mainly the medians of the number of papers from a project.

We can see that H projects produce substantially more papers than N projects in all fields. In all fields aggregated, the ratio of the median number of papers across H and N projects (15/7) is larger than the ratio of research's man months (100 /72), although it is smaller than the ratio of research fund (30 million yen/6 million yen). According to the distribution of the number of papers, the distance between the first quartile and the third quartile is much larger in H projects, compared to N projects. This indicates that a relatively large share of H projects generate a large number of the refereed papers.

There is no big difference across sectors in the number of produced papers (Exhibit 40(b)).

[1] In fact, the number of papers follows more a power law distribution than a log normal distribution, unlike the size of labor input. Newman M. E. J. (2006), "Power laws, Pareto distributions and Zipf's law", *Contemporary Physics*, 46 ; 323－351.

Exhibit 39 Distribution of the refereed papers from a research project by language

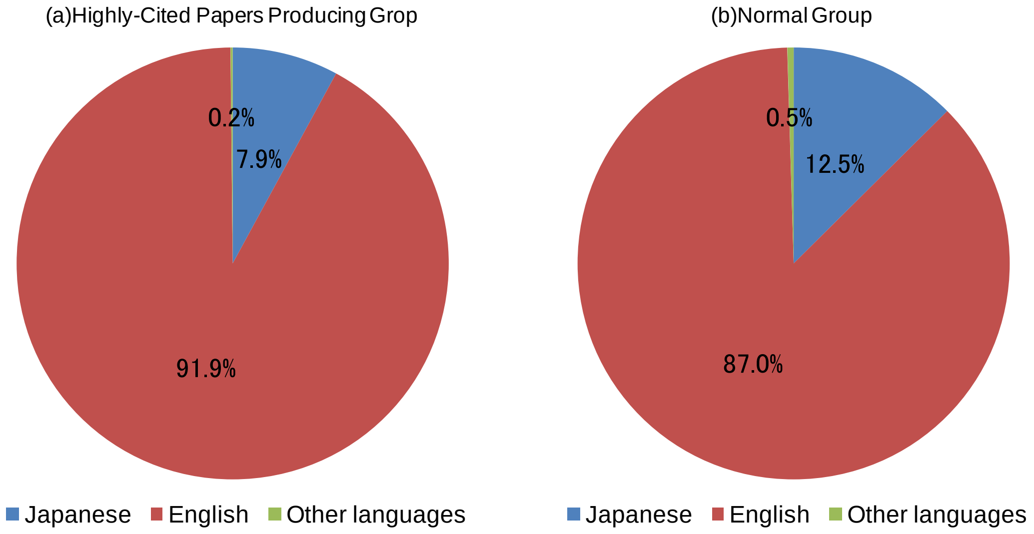
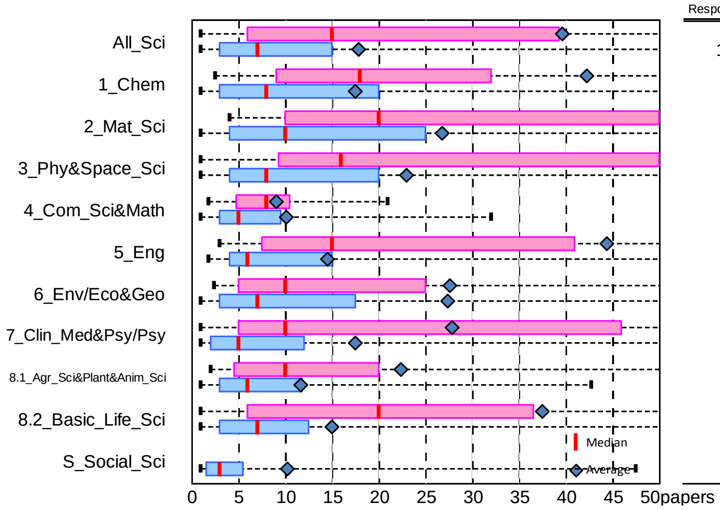


Exhibit 40 Distributions of the number of refereed papers yielded from research project

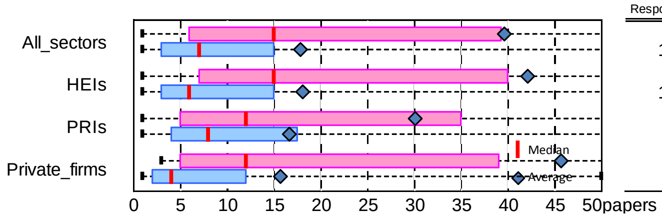
(a) Distribution of the number of refereed papers by field



unit: papers

Respondents	Minimum	Q1	Median	Q3	Maximum	Average
556	1	6.0	15.0	39.3	590	39.7
1,472	1	3.0	7.0	15.0	950	17.8
71	1	9.0	18.0	32.0	322	42.3
180	1	3.0	8.0	20.0	298	17.5
43	1	10.0	20.0	51.0	500	53.9
98	1	4.0	10.0	25.0	343	26.8
126	1	9.3	16.0	50.0	500	51.6
249	1	4.0	8.0	20.0	350	23.0
16	1	4.8	8.0	10.5	24	9.1
59	1	3.0	5.0	9.5	120	10.1
67	1	7.5	15.0	41.0	590	44.4
136	1	4.0	6.0	15.0	179	14.6
29	1	5.0	10.0	25.0	130	27.6
83	1	3.0	7.0	17.5	950	27.4
61	1	5.0	10.0	46.0	120	27.8
187	1	2.0	5.0	12.0	440	17.6
59	1	4.5	10.0	20.0	170	22.4
130	1	3.0	6.0	11.8	122	11.7
82	1	6.0	20.0	36.5	419	37.5
311	1	3.0	7.0	12.5	406	15.0
-	-	-	-	-	-	-
39	1	1.5	3.0	5.5	110	10.2

(b) Distribution of the number of refereed papers by sector



unit: papers

Respondents	Minimum	Q1	Median	Q3	Maximum	Average
556	1	6.0	15.0	39.3	590	39.7
1,473	1	3.0	7.0	15.0	950	17.8
393	1	7.0	15.0	40.0	590	42.1
1,151	1	3.0	6.0	15.0	950	18.1
113	1	5.0	12.0	35.0	350	30.2
215	1	4.0	8.0	17.5	194	16.7
41	1	5.0	12.0	39.0	400	45.7
81	1	2.0	4.0	12.0	406	15.7

Note1: Red boxplots indicate the distributions for the H projects; and blue ones for the N projects. Left end of boxes indicate the first quartiles; and right end of boxes the third quartiles. Left end of whiskers indicate the 5th percentile; and right end of whiskers the 95th percentile. The red bands in bars indicate the medians; and rhombi in bars the means.

Note2: Result of social sciences in the H projects was not shown due to the small number of responses.

Note3: Results show the summation of refereed papers written in Japanese, English, and other language. The responses saying the number of reviewed paper from the projects was 0 were excluded from the results.

9－2 Follow-up Research, Commissioned Research, Joint Research and Technical Guidance

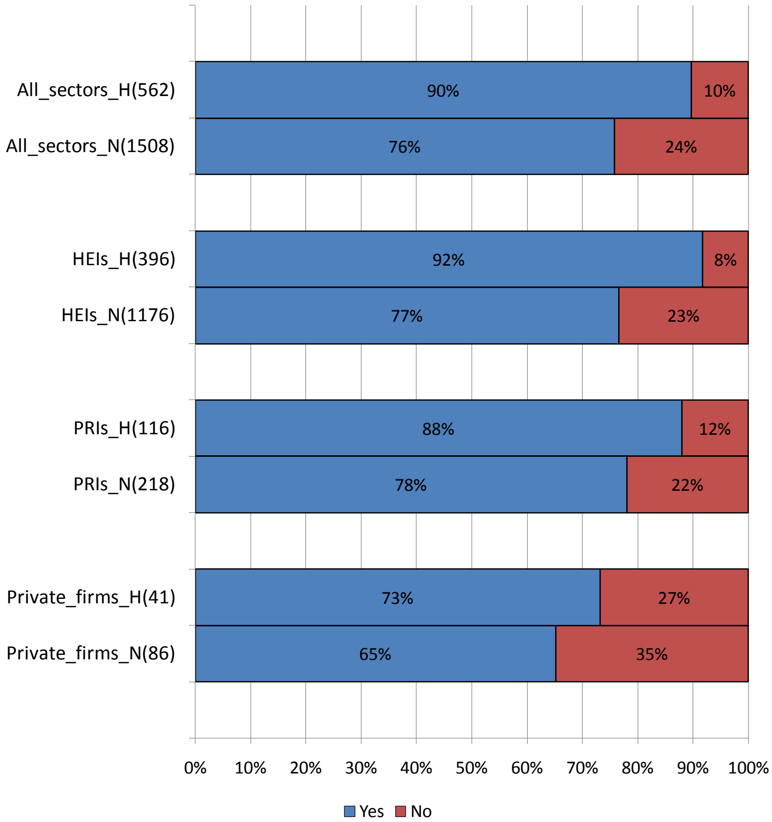
Most of the research projects have brought about follow-up research to the research team. Comparing H projects and N projects, the incidence of the existence of follow-up research is higher in H projects (90%, vs. 76% for all sectors aggregated). HEIs and the public research section have similar levels of the probability of follow-up research, and such probability is low for private firms' research.

As shown in Exhibit 41, the reasons of the absence of follow-up research are as follow: (a) research project completed its mission for around 70% of such cases, and (f) the transfer of the member made the follow-up impossible for 20% of such cases. (g) "Others" reason is also often the change of the research team members such as the retirement of a professor. Thus, there are substantial number of cases that research project become to an end because of the personnel change and professor's retirement.

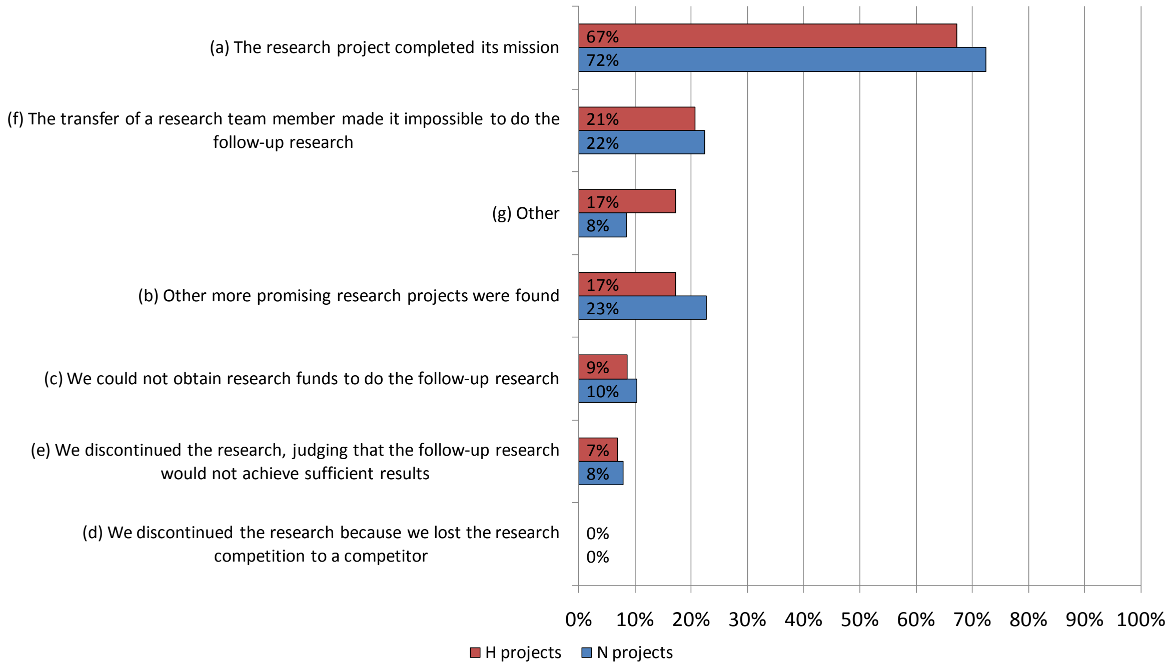
On the other hand, the share of answers that refer to a research funding constraint is not so large, about 10%. No one chose a lost competition reason [(d)].

Exhibit 41 Status of the follow-up research and the reason of not bringing follow-up research

(a) Status of the follow-up research



(b) Reason for the absence of a follow-up research



Note1: In each sector, the upper figure is for the H projects and the lower figure is for the N projects

Also, the research project outcome and the research capability built through the project have developed into a commissioned research, a joint research and technology guidance by the research members. While the technical guidance would be mainly provided to a company, the source of the fund for commissioned research could be either a private company or a public research support organization. Comparing H projects and N projects, the former group is much more likely to result in these events, as seen in Exhibit 42 (40% vs. 23% in commissioned research、76% vs. 57% in joint research, 38% vs. 27% in technical guidance).

Materials science and basic life sciences belong to the 3 highest rank fields in all three incidences of commissioned research, joint research, and technical guidance. In these fields, the probability that the research result is further developed in cooperation with an outside organization or it is transferred to private companies is high. However it is important to note that the follow-up research and the commissioned research/joint research may overlaps each other, although there are cases where only follow-up research exists or the cases where only commissioned research and joint research exists.

Exhibit 42 Status of commissioned research, joint research and technical guidance

	Responses		%, projects resulted in commissioned research		%, projects resulted in joint research		%, projects resulted in technical guidance	
	H projects	N projects	H projects	N projects	H projects	N projects	H projects	N projects
All_Sci	539	1,401	40.1%	23.4%	75.9%	57.0%	37.5%	27.4%
1_Chem	65	142	40.0%	21.1%	76.9%	58.5%	30.8%	33.1%
2_Mat_Sci	43	97	60.5%	39.2%	86.0%	63.9%	51.2%	35.1%
3_Phy&Space_Sci	119	238	31.9%	21.8%	75.6%	56.3%	24.4%	21.8%
4_Com_Sci&Math	16	56	0.0%	14.3%	56.3%	35.7%	12.5%	12.5%
5_Eng	65	132	56.9%	29.5%	67.7%	50.0%	40.0%	26.5%
6_Env/Eco&Geo	30	82	36.7%	36.6%	70.0%	64.6%	16.7%	25.6%
7_Clin_Med&Psy/Psy	63	185	28.6%	16.2%	71.4%	47.0%	46.0%	24.3%
8.1_Agr_Sci&Plant&Anim_Sci	58	127	43.1%	26.0%	79.3%	66.1%	44.8%	37.0%
8.2_Basic_Life_Sci	78	308	44.9%	21.1%	84.6%	65.6%	55.1%	29.5%
S_Social_Sci	2	34	-	8.8%	-	20.6%	-	14.7%

Note1: The number of research projects which yielded 1 or more commissioned research, joint research and technical guidance was counted.

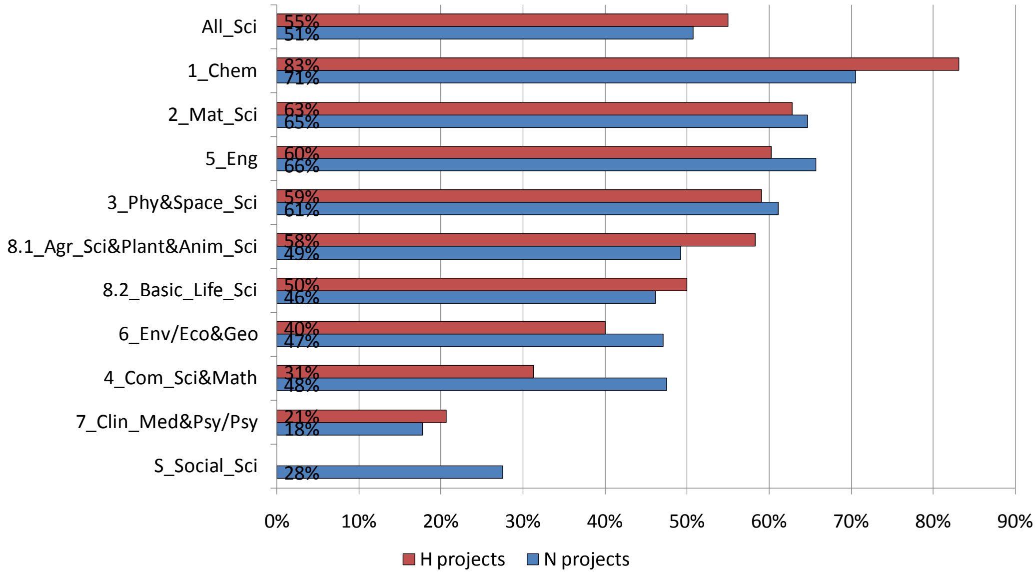
9—3 GRADUATE EDUCATION THROUGH THE RESEARCH PROJECT

In order to see the education effects of the research project, Exhibit 43 shows the share of research projects that produced a master's degree and a doctoral degree. In all fields combined, almost a half of research projects produce master's degree, and about 70% of them produce doctoral degrees. As a whole, a research project produces doctoral degrees more often.

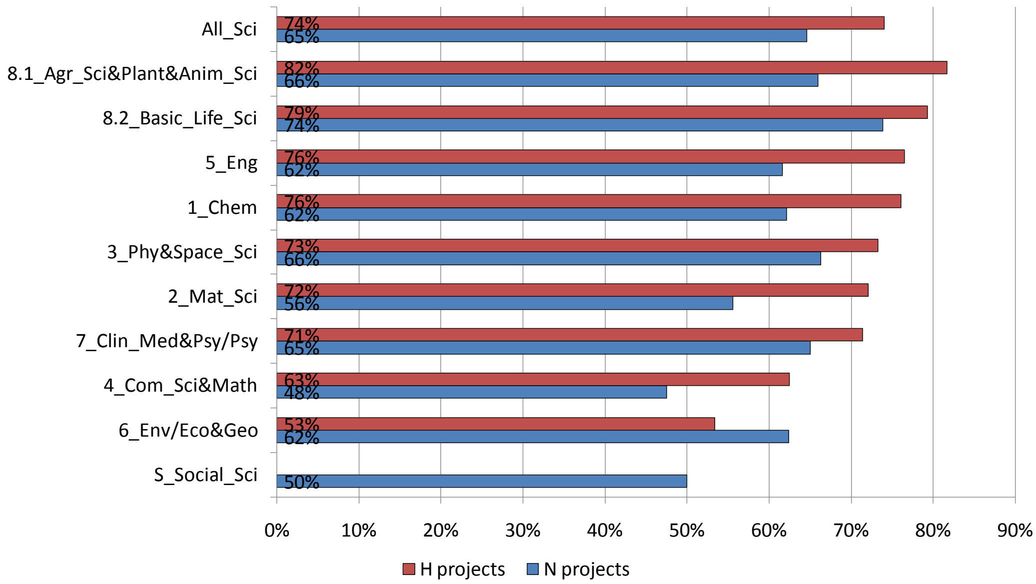
We have seen earlier that doctoral students are often the first authors of the papers when the order of the authors is according to their contribution to the research, while it is rare that master or undergraduate students are the first authors (see Exhibit 32). This is consistent with a larger incidence of doctoral degrees from research projects. H projects tend to produce more degrees.

Exhibit 43 Training of human resources in the research project

(a) Share of research projects that produced a master's degree



(b) Share of research projects that produced a doctor's degree



Note1: Both degrees cover both domestic and foreign born students.

9－4 Patent Application, License Agreement or Patent Assignment

Exhibit 44 and Exhibit 45 show the incidence of patent application (domestic and/ or foreign application), license agreement or the assigned patent. 42% of the H projects and 23% of the N projects led to at least one patent application on average. The incidence that the H projects led to patent applications is high. In addition, the incidence of a foreign patent application conditional on a patent application is 62% in the H projects and 50% in the N projects as Exhibit 45 shows.

If we focus on sectors, many research projects of private company led to patent application: 78% from the H projects and 63% from the N projects. Comparing universities and public research organization, the incidence that the research project of the public research organization has resulted in patents application tends to be higher. About 50% of the H projects of the public research organization led to patent applications.

As for a license agreement and the assignment of patents[1], both of them are significantly more frequent for the H projects on average, and the incidence of the license agreement is particularly high (7.5% in the H projects vs. 3.6% in the N projects). Since higher quality patent is more likely to be licensed, these results suggest that there is a positive correlation between the quality of academic publication and the quality of a patent at project level, consistent with the patterns observed across individuals (See Stephan (2010) for a review). However, interestingly, in the private firms, there are more license agreements and assignments in the N projects than in the H projects. The assignments of a patent reach 18% of N projects in particular. The share of license agreement and assignments would be higher in N projects than H projects in the private firms because private firms would use the higher value patents internally while they are more ready to assign or license lower value patents.

As Exhibit 46 indicates, know-how is supplied for most cases when patent license agreement and assignments occur (73% in the H projects, 80% in the N projects in all fields). This suggests that the invention that became the object of the license agreement is often actually used in one way or another, including its development research, since the provision of knowhow is not necessary for blocking. In addition, it is possible that there the incidence of license and assignment is underestimated, because about 20% of the responses on the license agreement and assignment were "unknown".

Next, the variation across fields can be seen in Exhibit 45. The shares of the patent application are especially high in materials science, chemistry, engineering, and exceed 50% in the H projects. The incidence of foreign application conditional on patent application does not vary significantly, but the incidence is high (77.8%) in clinical medicine & psychiatry/psychology of the H projects. It is thought that it reflects the importance of the U.S. market in the field of medicine and the clinical testing in U.S. As for the incidence of the license agreement, it exceeds 10% in chemistry, materials science, and basic life sciences in the H projects, 5% in materials science and basic life sciences in the N projects.

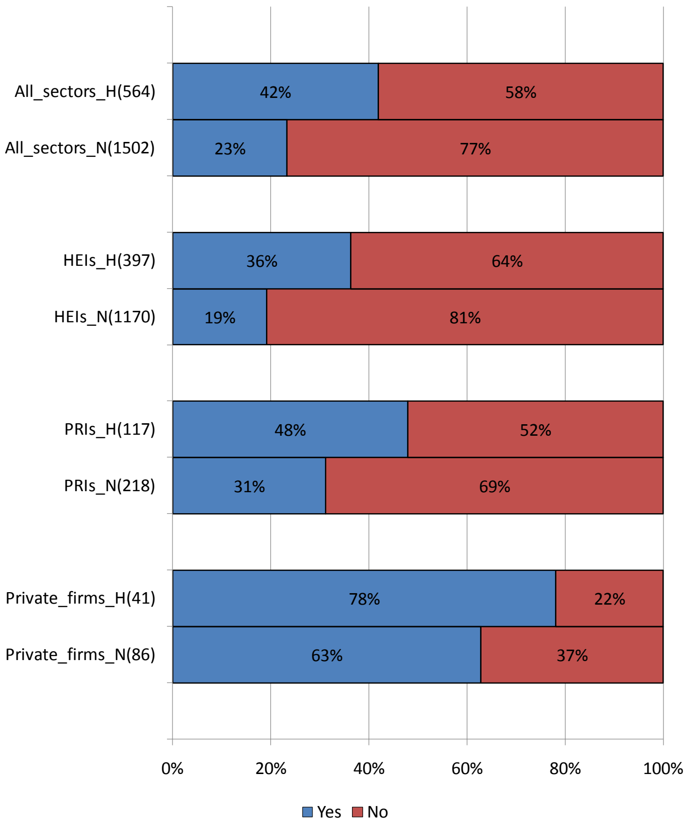
Finally, the Exhibit 47 shows the size distribution of the licensees or assignees. It focuses on the cases that the license agreement took place in the H projects. Companies that employ more than 250 employees are about three-fourths. In addition, the start-up companies, which were

[1] It is important to note that an assignment of a patent can take place without a patent application, since the legal right to apply for a patent can be transferred.

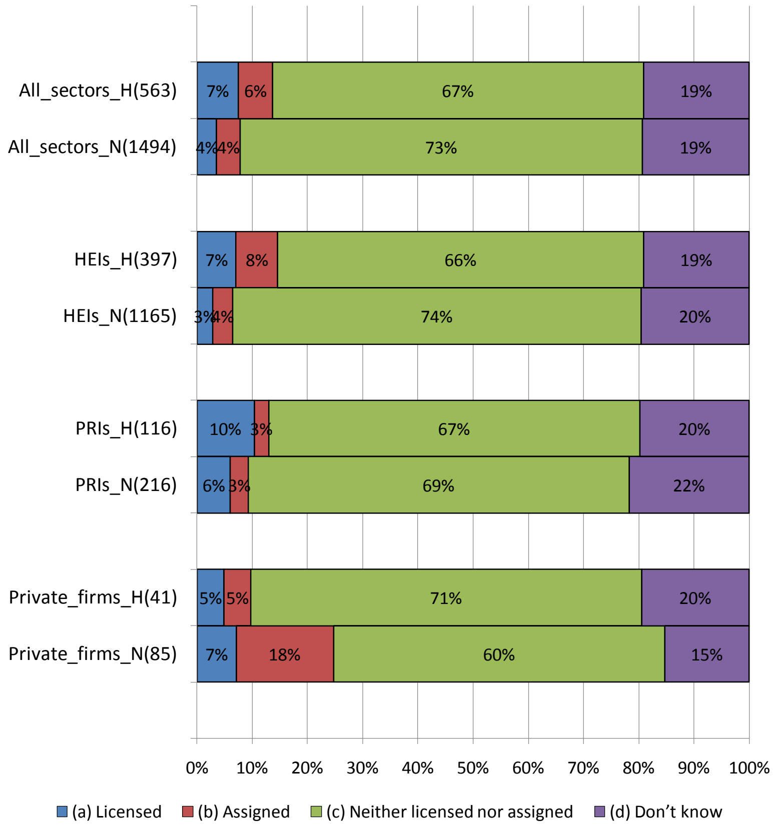
established less than 5 years ago, got license agreements for around a quarter of the cases. They play a relatively important role for the commercialization of new discovery from science.

Exhibit 44 Patent application, license agreement or patent assignment

(a) Incidence of patent application



(b) Incidence of license agreement or patent assignment



Note1: In each sector, the upper figure shows the result of the H projects and the lower figure shows the result of the N projects

Exhibit 45 Patent application by field and patent application abroad

	Projects which resulted in patent applications		%, projects which resulted in patent applications		%, of which, the projects which resulted in patent applications to abroad	
	H projects	N projects	H projects	N projects	H projects	N projects
All_Sci	236	350	41.8%	23.3%	62.1%	50.0%
1_Chem	43	64	60.6%	36.4%	62.8%	40.6%
2_Mat_Sci	33	46	76.7%	46.5%	66.7%	39.1%
3_Phy&Space_Sci	43	51	33.9%	20.2%	61.9%	54.9%
4_Com_Sci&Math	4	16	-	26.2%	-	75.0%
5_Eng	40	44	58.8%	32.1%	57.5%	47.7%
6_Env/Eco&Geo	1	7	-	8.2%	-	57.1%
7_Clin_Med&Psy/Psy	18	17	27.3%	8.6%	77.8%	52.9%
8.1_Agr_Sci&Plant&Anim_Sci	24	30	40.0%	22.7%	62.5%	43.3%
8.2_Basic_Life_Sci	30	75	37.0%	23.4%	56.7%	58.7%
S_Social_Sci	-	-	-	-	-	-
"yes" responses	236	350	236	350	146	175
Respondents	564	1,500	564	1,500	235	350

Note1 : Figures are not shown for the cases where the sample number is very small.

Exhibit 46 License agreement or the patent assignment and the provision of know-how (by field)

	%, License agreement		%, License agreement or patent assignment		%, of which, the know-how was also provided	
	H projects	N projects	H projects	N projects	H projects	N projects
All_Sci	7.5%	3.6%	13.7%	7.8%	72.7%	79.5%
1_Chem	12.7%	3.6%	19.7%	11.4%	92.9%	84.2%
2_Mat_Sci	14.0%	7.1%	27.9%	18.2%	83.3%	77.8%
3_Phy&Space_Sci	1.6%	1.2%	4.0%	4.3%	80.0%	70.0%
4_Com_Sci&Math	-	4.9%	-	8.2%	-	100.0%
5_Eng	5.9%	2.9%	16.2%	8.0%	45.5%	90.0%
6_Env/Eco&Geo	0.0%	2.4%	3.3%	3.5%	-	100.0%
7_Clin_Med&Psy/Psy	7.6%	3.0%	13.6%	3.0%	77.8%	100.0%
8.1_Agr_Sci&Plant&Anim_Sci	6.8%	2.3%	15.3%	9.8%	55.6%	84.6%
8.2_Basic_Life_Sci	12.2%	5.9%	17.1%	9.7%	64.3%	65.5%
S_Social_Sci	-	-	-	-	-	-
"yes" responses	42	53	77	117	56	89
Respondents	563	1,492	563	1,492	77	112

Note1: 20% of the respondents chose "don't know" for license and assignment.
Note2: No statistics shown for small sample cases.

Exhibit 47 Size of firms to which the patents were licensed or assigned; and the share of the start-up firms (H projects)

	0 - 9 employees	10 - 49 employees	50 - 249 employees	250 or more employees	Average share of the stat-up firms	Total
%, size of firms to which the patents were licensed or assigned	11.7%	11.7%	10.4%	74.0%		83
%, start-up firms	77.8%	66.7%	12.5%	8.8%	22.9%	19

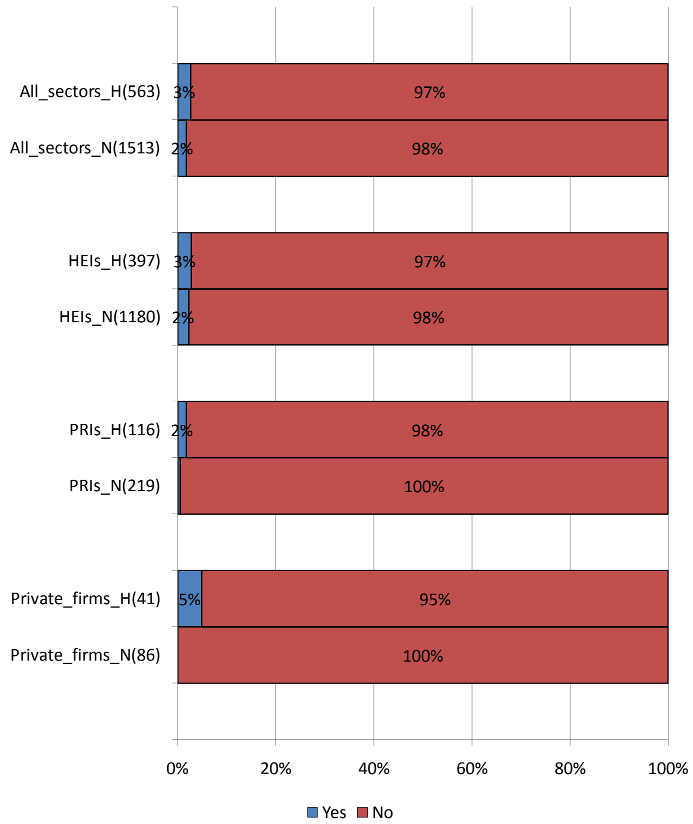
9—5 ESTABLISHMENT OF START-UP COMPANY AND CONTRIBUTION TO THE STANDARDIZATION

The share of the research projects that led to a new start-up company is only a few percents (less than 3% in the H projects on average). However, a little over 6% of cases they examined seriously starting-up a company even when they did not actually do so. Combining them would amount to about 10% in total, suggesting that the possibility of a start-up company is considered as a real option.

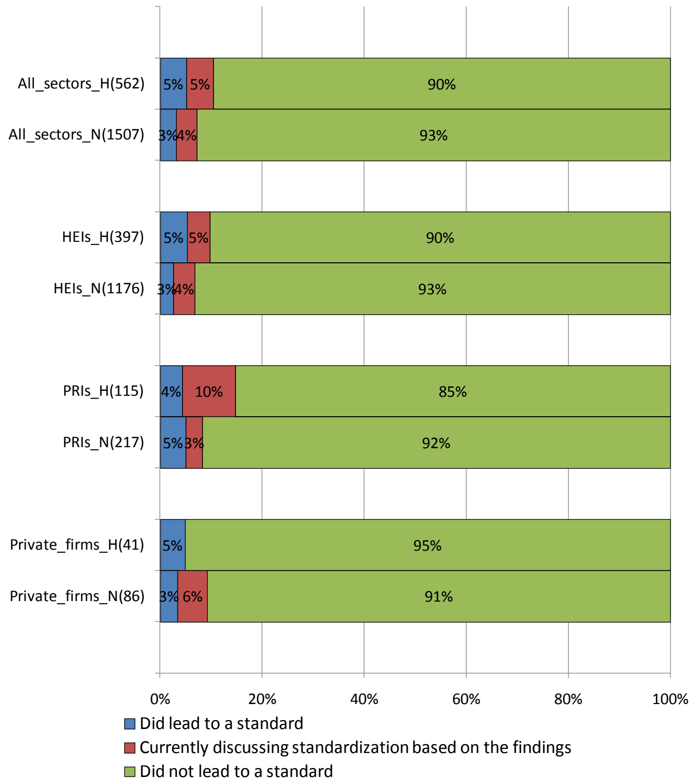
As for standard, positive answers that either the research outcome led to a standard or its standardization is under consideration were given for around 10% of the projects in all sciences, including universities.

Exhibit 48 Incidence of the establishment of a start-up company and of the research output resulting in standards

(a) Start-up companies



(b) Standards



Note1: In each sector, the upper figure is for the H projects and the lower figure is for the N projects

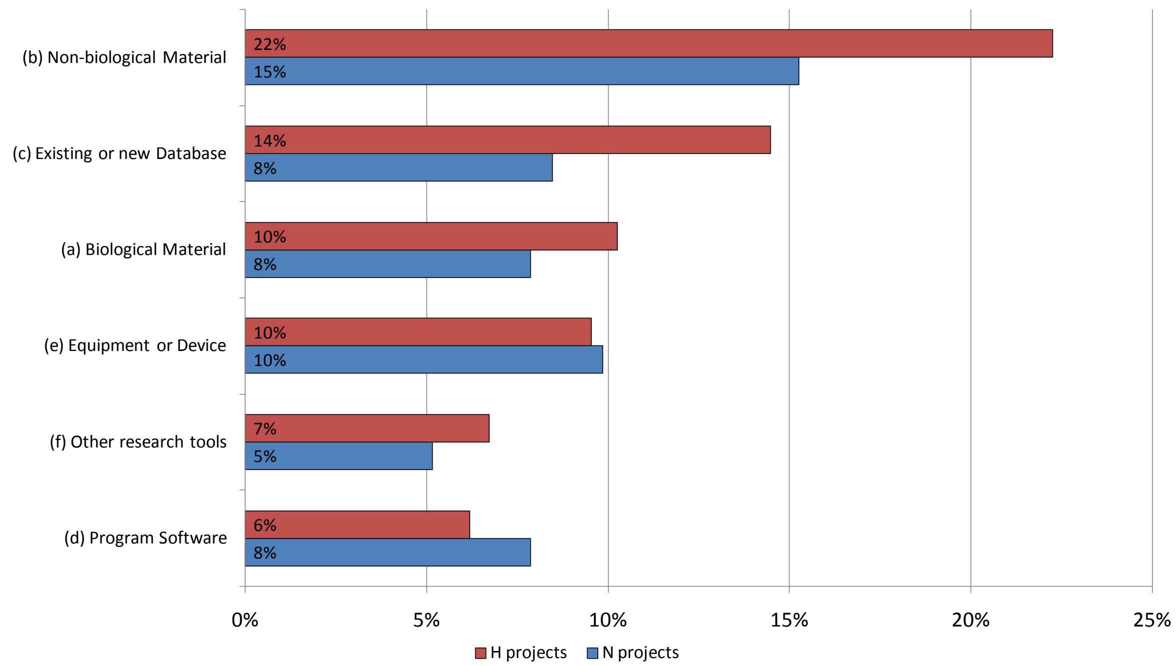
9−6 Other Research Results such as Materials

The results coming out of research projects are diverse. In many research projects, diverse research materials came about, which the other research teams can use, such as biological or non-biological material, a database, software, and the other "research tools". 32% of the H projects (biological 10%, non-biological 22%) and 23% in the N projects (biological 8%, non-biological 15%) produced materials.

In addition, 14% of the H projects generate database (the development of the database, the offer of new data to an existing database), 10% generate devices, and 6% generate the program software (8%, 10%, and 8% each in the N projects).

Comparing with the H projects and the N projects, the H projects generates materials and databases substantially more frequently than the N projects.

Exhibit 49 Other research results such as materials (all sciences, %)



Note1: The choice is non-exclusive.
Note2: The result of all fields.

9—7 Summary of the Output of Research Projects

Finally, Exhibit 50 provides a summary of the outputs from a research project. Outputs are ordered with their incidences in the H projects. It can see that diverse outputs are produced by research projects. All of follow-up research, commissioned or joint research, doctoral degrees, master's degrees, and research tools are produced in more than 40% of research projects of both H projects and N projects. The training of the post-doctor is performed in 63% in the H projects, and the research projects that have applied for patent did exceed 40%.

Comparing the H projects and the N projects, the incidence of the output is higher in all aspects in the H projects.

Exhibit 50 Summary of the output and the impact of research project

	H projects			N projects			
	Projects that resulted in the output/impact	Responses	Ratio(a)	Projects that resulted in the output/impact	Responses	Ratio(b)	(a)/(b)
Refereed papers	556	556	100%	1,472	1,472	100%	1.0
Follow-up research	504	562	90%	1,142	1,508	76%	1.2
Commissioned research and Joint research	428	539	79%	853	1,403	61%	1.3
Ph. D recipients	416	562	74%	974	1,509	65%	1.1
Training of Post Doctoral fellows	354	562	63%	571	1,506	38%	1.7
Master's degree recipients	309	562	55%	764	1,506	51%	1.1
Research tools 1)	284	566	50%	654	1,515	43%	1.2
Patent applications	236	564	42%	350	1,502	23%	1.8
Technical guidance	202	539	37%	385	1,403	27%	1.4
Licensing or assignment	77	563	14%	117	1,494	8%	1.7
Internal commercialization 2)	61	564	11%	155	1,507	10%	1.1
Standards 3)	59	562	10%	110	1,507	7%	1.4
Stat-up firms	15	563	3%	27	1,513	2%	1.5

Note1: Either of 6 categories of research tools in Exhibit 49.
Note2: Commercialization by a team member or by the organization with which it is affiliated.
Note3: Include both the case where the research outcome led to a standard and the case where it is under discussions.

10 CONCLUSIONS

This paper has reported the initial findings from a large-scale survey of Japanese researchers on the knowledge creation process in science. One third of the samples are from highly cited papers in each science field by year (top 1% in the world, H papers) and the rest are from the other randomly selected papers (N papers). We call the research projects that yielded H (N) papers by H projects (N projects). The response rate is 29% for the H papers and 27% for the N papers and we collected 2,100 responses in total. The survey covered all scientific fields, including social sciences. Around 90 % of the surveyed scientists belonged to university and the other higher education institutions or public research institutions. Approximately 90% of the respondents executed the central part of the projects and 80% of them at least some role (more than a half of the surveyed scientists the central role) in the management of the projects.

The survey characterized the motivations of the research projects, the knowledge sources which inspired the projects, uncertainty in the knowledge creation process, research competition, composition of the research team, sources of research money, and the research outputs, including the papers, the patents, license/assignment, the collaborative research projects and startups.

Major findings are as follow:

1. The Japanese scientists are fairly mobile. 40 % (33%) of the respondents for H (N) papers moved across organizations during 5 years preceding to the initiation of the projects. 54 % (50%) of the respondents for H (N) papers stayed abroad for one year or more for study or research. The scientists with H papers are more mobile.
2. As for research outputs, "proposing a new research issue" is much more prevalent for H papers than for N papers, consistent with another finding that "contribution to the development of research in related field" was chosen very frequently by the respondents of the H papers as a reason significantly explaining its high level of citations (60%, only next to "high Novelty").
3. A significant part of the research projects are very importantly motivated both by "Pursuit of fundamental principles/understandings" and by "Solving specific issues in real life". Thus, even if we define "Pasteur's quadrant" narrowly (both motivations are very important), it is quantitatively important in scientific research. The level of motivation is stronger in H projects than in N projects for both objectives, but especially on "Pursuit of fundamental principles/understandings".
4. A large majority of the focal papers involved surprise in either research process or in research outcome. A majority of research projects generated serendipitous output (that is, the research output found answers to questions not originally posed). H papers involved more surprises and serendipity.
5. Most researchers recognize the extent of research competition ex-ante (only a minority chose "don't know answer") and a significant share of researchers were concerned with priority loss (more than 50%) in H projects, although substantially less (a little over 30%) in N projects. Competition is global in most fields.
6. There are significant differences in the level of implementation and the perceived effectiveness of research management practices across H projects and N projects.

Such differences are large for setting the research goal (such as setting of ambitious research project goal and setting of research project goals consistent with the directions of science) and the design of the research team (such as having the participations of researchers with diverse academic fields and young scholars).

7. Non-author research members are important (the median size of authors is 6 persons (4 persons) for H papers (N papers), while the median size of non-author research team members are 2 persons for both). At the same time, the authors of the focal paper often cover those who did only non-research works such as providing research materials, equipments and funds.
8. Research teams with more diversity in terms of disciplines and nationalities seem to perform better. Young scholars are important contributors for research efforts. Post-doctoral students and doctoral students are often the first authors of H papers (around 40%) when the order of the authors is according to their contributions.
9. Majority of research projects use more than one funding sources. While H projects use more multiple external funding sources, only a minority of projects use only external funding.
10. The distribution of the number of refereed papers produced from a project is highly skewed. There exist a small number of research projects which produced many papers and at the same time a significant fraction of them produced only a modest number of papers.
11. Research projects generate not only research papers, but also outputs useful for industrial innovation, including patent applications, licensing/assignment, collaborative research, startups and standard. 40% (23%) of the H projects (N projects) resulted in commissioned research and 76% (57%) of the H projects (N projects) resulted in joint research with an external organization. More than 42% (23%) of the H projects (N projects) involved at least one patent application. 7.5% (3.6%) of the H projects (N projects) resulted in licensing. In addition, the patents of 6 % (4%) of the H projects (N projects) were assigned. 3 % (2%) of the H projects (N projects) resulted in startups. 5% (3%) of H projects (N projects) led to standards. Thus, H projects yielded significantly more outputs useful for industrial innovation in all these measures.
12. A majority of licensing/assignment (70% to 80%) was associated with the provision of know-how.
13. Educational outputs of the research projects are also important. 74% (65%) of H (N) projects produced doctoral degrees. They also often produced materials and the other research tools.

There are some important implications of our initial findings upon "research on research" and upon science policy, although many of them are preliminary observations. First, Pasteur's quadrant is quantitatively important. This implies that complementarity exists for science and innovation even at project level for a significant share of science. In such area, a university and industry collaboration would be particularly important. Second, uncertainty is important in scientific discovery process, so that it is important to ensure ex-post flexibility in research scope to capture unexpected opportunities. This implies that the funding system has to be flexible enough to facilitate such response. It will be an important research issue to assess how the funding system as whole, including the intramural fund, function efficiently to support the development of the seeds for the research from diverse perspectives, their selection as well as the ex-post flexibility.

Third, scientists perceive competition well ex ante although scientists perceiving priority threat is more a minority for the scientists for N projects (a half for the scientists for H projects). There is a significant variation of perceived competition across sectors, and it will be an important research issue to understand the determinants of ex-ante competition and their impact on research performance. Fourth, research management seems to matter, especially given that the team has become important. In this context, analyzing how particular management practice such as ensuring the diversity of academic fields and the participation of a young scholar in a research team affects the research performance is an important issue. Fifth, our study shows that there is an important gap between bibliographic information on the authors and the survey results on the researchers of the project. Thus, it is important to deepen our understanding on the usefulness and constraints of bibliographic information as a measure of research input. Sixth, 70 % or more of licensing and assignment were associated with the provision of know-how. This implies that these inventions were often put into real practice, rather than for being used just for blocking.

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Appendix 1
for Survey Methodology

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1 POPULATION AND SAMPLING: DATA SET AND IDENTIFICATION OF SURVEY TARGETS

The unit of analysis in the Researchers Survey is a research project. The knowledge production process was analyzed through collecting the information on research projects by using a questionnaire to the researchers who had produced research papers resulted from them.

The "focal paper" here is defined as a research paper that is selected. The questionnaire was addressed to a survey target who is usually the corresponding author or the other suitable author of the author for responding. The "research project" here is defined as a set of research activities that had produced the focal paper.

The survey targets were asked to define the scope of their research projects that produced the focal papers and closely related research outputs. They were also asked to maintain the consistency between the inputs and the outputs of the research project.

The main steps of identifying survey targets were as follows:

- Identification of possible focal papers:
- Identification of the survey targets based on the possible focal papers; and
- Selection of one focal paper per survey target.

The details of the procedures will be described below.

1－1 IDENTIFICATION OF FOCAL PAPERS

1－1－1 Population

The population of the survey is the papers that had been recorded in the Web of Science database, developed by Thomson Reuters, between 2001 and 2006 in database year and were classified into articles or letters and whose authors' affiliations include an affiliation in Japan. Most papers have been recorded into the database the same year as the publications.

The bibliographic information and number of citations used in the survey as of the end of December 2006 were used.

The 22 fields in *Essential Science Indicators* of Thomson Reuters were adopted for the journal classification of research papers. Fields of journals were identified based on the list of journals disclosed by Thomson Reuters. The list is available on the web. The list as of April 30, 2008 was used.

We used Science Citation Index Expanded (SCI-EXPANDED) available in National Institute of Science and Technology Policy, which contains mainly research papers related to natural science. Therefore, the scope of journals of social sciences covered by the database is limited. Exhibit 51 shows the number of extracted journals and selected papers by science field of journals in this stage. There are 4.9 million papers and 9.9 thousand journals. Social sciences and Economics & Business account for only 1% of the papers and 1.8% of the journals. Exhibit 52 shows the number of extracted papers produced in any organization in Japan by science field of journal and database year. These papers produced in Japan account for 9% of the entire papers.

Exhibit 51 Number of journals and research papers by field (2001 – 2006)

22 ESI jorunal fields	Journals	%, Journals	Papers	%, Papers
Agricultural Sciences	214	2.2%	95,932	2.0%
Biology & Biochemistry	397	4.0%	283,792	5.8%
Chemistry	544	5.5%	619,452	12.6%
Clinical Medicine	1,488	15.0%	1,134,128	23.1%
Computer Science	262	2.6%	89,551	1.8%
Economics & Business	39	0.4%	10,275	0.2%
Engineering	777	7.8%	421,182	8.6%
Environment/Ecology	228	2.3%	131,131	2.7%
Geosciences	313	3.1%	141,290	2.9%
Immunology	83	0.8%	61,009	1.2%
Materials Science	277	2.8%	218,687	4.5%
Mathematics	312	3.1%	127,177	2.6%
Microbiology	114	1.1%	80,682	1.6%
Molecular Biology & Genetics	230	2.3%	131,468	2.7%
Multidisciplinary	25	0.3%	51,475	1.0%
Neuroscience & Behavior	209	2.1%	154,464	3.1%
Pharmacology & Toxicology	147	1.5%	83,291	1.7%
Physics	319	3.2%	485,010	9.9%
Plant & Animal Science	643	6.5%	282,461	5.7%
Psychiatry/Psychology	109	1.1%	42,569	0.9%
Social Sciences, general	141	1.4%	41,175	0.8%
Space Science	50	0.5%	58,686	1.2%
Others	3,028	30.4%	168,989	3.4%
Total	9,949	100.0%	4,913,876	100.0%

Note1: Analyzed by National Institute of Science and Technology Policy based on the Web of Science of Thomson Reuters.

Note2: Fields of journals were identified based on the list of journals disclosed by Thomson Reuters. The list is available on the web (http://in-cites.com/journal-list/index.html). The list as of April 30, 2008 was used.

Note3: Only Articles and letters were counted.

Exhibit 52 Number of Japanese papers by journal field (2001 – 2006)

22 ESI jorunal fields	2001	2002	2003	2004	2005	2006	2001 - 2006	2001 - 2006 (%)
Agricultural Sciences	1,110	1,130	1,169	996	1,277	1,185	6,867	1.5%
Biology & Biochemistry	5,732	5,442	5,779	5,231	5,607	4,949	32,740	7.3%
Chemistry	10,769	10,696	10,934	10,337	11,357	10,098	64,191	14.4%
Clinical Medicine	15,863	15,874	16,275	14,486	16,420	14,787	93,705	21.0%
Computer Science	854	842	1,017	876	1,121	968	5,678	1.3%
Economics & Business	29	25	37	20	38	35	184	0.0%
Engineering	5,988	5,582	6,733	5,707	6,204	5,903	36,117	8.1%
Environment/Ecology	798	745	858	884	932	1,045	5,262	1.2%
Geosciences	1,203	1,227	1,579	1,547	1,819	1,726	9,101	2.0%
Immunology	975	959	893	865	884	748	5,324	1.2%
Materials Science	4,336	4,550	4,544	4,435	4,516	4,725	27,106	6.1%
Mathematics	1,211	1,120	1,270	1,149	1,162	1,121	7,033	1.6%
Microbiology	1,246	1,176	1,264	1,218	1,331	1,246	7,481	1.7%
Molecular Biology & Genetics	2,287	2,196	2,262	2,266	2,300	2,253	13,564	3.0%
Multidisciplinary	385	374	370	395	398	439	2,361	0.5%
Neuroscience & Behavior	2,443	2,346	2,517	2,261	2,467	2,109	14,143	3.2%
Pharmacology & Toxicology	1,761	1,822	1,848	1,723	1,929	1,644	10,727	2.4%
Physics	7,930	9,197	10,474	8,993	11,280	10,362	58,236	13.1%
Plant & Animal Science	3,192	3,148	3,400	3,310	3,652	3,684	20,386	4.6%
Psychiatry/Psychology	137	151	144	156	195	167	950	0.2%
Social Sciences, general	58	82	122	133	130	197	722	0.2%
Space Science	641	591	683	648	635	700	3,898	0.9%
Others	4,289	2,757	4,794	4,164	3,070	987	20,061	4.5%
Total	73,237	72,032	78,966	71,800	78,724	71,078	445,837	100.0%

Note1: Analyzed by National Institute of Science and Technology Policy based on the Web of Science of Thomson Reuters.
Note2: Articles and letters were counted by the whole count method. The papers including at least one author affiliated with Japanese organization was counted.

1—1—2 Highly Cited Papers and Normal Papers

Given that the values of the papers are highly skewed so that only a few percentages of them command significant intellectual impact, the population was divided into two types of sets: highly cited papers set and normal papers set.

The highly cited papers set consists of the papers whose citation frequency are ranked at belongs to top one percent in each ESI journal field by each database year. The normal papers set consists of the others in each science field by in each database year. Stratified sampling by field and by year was implemented so as to avoid the effects of field and time dependences of the backward citations.

In this report, highly cited papers are described as "H papers" and normal papers are described as "N papers."

1—1—3 Targeted Number of Focal Papers by Science Field of Journals

All H papers were sampled as candidates of focal papers. The number of N papers sampled is twice the number of H papers in principle. If the number of H papers in an ESI journal field A and in a database year Y is equal to $N_{HC}(A, Y)$, the targeted number of the candidates of focal papers from N paper set is $2 \times N_{HC}(A, Y)$.

We set the minimum targeted number in the sampling of the possible focal papers. The minimum number is 170. If $3 \times N_{HC}(A, Y)$ is smaller than the minimum number, we sampled $2 \times N_{HC}(A, Y)$ or more N papers until the number of papers sampled reaches to 170. "Economics & Business" and "Social Sciences, general" were merged in the sampling, because of small number of Japanese papers in the two fields.

From Exhibit 53 to Exhibit 55, the targeted numbers of focal paper candidates by journal field are shown. The total targeted number of focal paper candidates is 9,558.

Exhibit 53 Targeted numbers of focal paper candidates by journal field (2001 - 2006)

22 ESI jorunal fields	2001	2002	2003	2004	2005	2006	Total
Agricultural Sciences	33	42	26	20	23	26	170
Biology & Biochemistry	60	63	72	48	69	87	399
Chemistry	135	168	195	174	180	159	1,011
Clinical Medicine	237	225	210	198	240	210	1,320
Computer Science	11	32	31	31	31	34	170
Engineering	138	60	168	129	120	123	738
Environment/Ecology	24	24	23	32	32	35	170
Geosciences	23	29	32	26	26	34	170
Immunology	24	33	41	26	32	14	170
Materials Science	90	105	69	123	105	114	606
Mathematics	21	18	35	29	38	29	170
Microbiology	26	26	19	28	37	34	170
Molecular Biology & Genetics	30	27	27	45	48	45	222
Multidisciplinary	249	210	255	240	183	132	1,269
Neuroscience & Behavior	32	20	35	20	29	34	170
Pharmacology & Toxicology	37	25	19	19	31	39	170
Physics	264	216	258	249	294	255	1,536
Plant & Animal Science	54	48	57	102	66	90	417
Psychiatry/Psychology	30	24	26	29	32	29	170
Space Science	22	31	42	27	27	21	170
Economics & Business + Social Sciences, general	25	28	28	25	22	42	170
Total	1,565	1,454	1,668	1,620	1,665	1,586	9,558

Exhibit 54 Targeted numbers of focal paper candidates by journal field (H papers, 2001 - 2006)

22 ESI jorunal fields	2001	2002	2003	2004	2005	2006	Total
Agricultural Sciences	7	10	5	3	4	5	34
Biology & Biochemistry	20	21	24	16	23	29	133
Chemistry	45	56	65	58	60	53	337
Clinical Medicine	79	75	70	66	80	70	440
Computer Science	2	9	9	9	9	10	48
Engineering	46	20	56	43	40	41	246
Environment/Ecology	2	2	2	5	5	6	22
Geosciences	7	9	10	8	8	11	53
Immunology	5	8	11	6	8	2	40
Materials Science	30	35	23	41	35	38	202
Mathematics	2	1	7	5	8	5	28
Microbiology	2	2	0	3	6	5	18
Molecular Biology & Genetics	10	9	9	15	16	15	74
Multidisciplinary	83	70	85	80	61	44	423
Neuroscience & Behavior	10	6	11	6	9	11	53
Pharmacology & Toxicology	8	4	2	2	6	9	31
Physics	88	72	86	83	98	85	512
Plant & Animal Science	18	16	19	34	22	30	139
Psychiatry/Psychology	2	0	1	2	3	2	10
Space Science	6	9	13	8	8	6	50
Economics & Business + Social Sciences, general	1	2	2	1	0	7	13
Total	473	436	510	494	509	484	2,906

Note1: Analyzed by National Institute of Science and Technology Policy based on the Web of Science of Thomson Reuters.
Note2: Articles and letters were counted by the whole count method. The papers including at least one author affiliated with Japanese organization was counted.
Note3: For fields indicated by yellow cells, the number of the randomly sampled papers was more than twice of the HC papers to make the number of the sample papers equals to 170.

Exhibit 55 Targeted numbers of focal paper candidates by journal field (N papers, 2001 - 2006)

22 ESI jorunal fields	2001	2002	2003	2004	2005	2006	Total
Agricultural Sciences	26	32	21	17	19	21	136
Biology & Biochemistry	40	42	48	32	46	58	266
Chemistry	90	112	130	116	120	106	674
Clinical Medicine	158	150	140	132	160	140	880
Computer Science	9	23	22	22	22	24	122
Engineering	92	40	112	86	80	82	492
Environment/Ecology	22	22	21	27	27	29	148
Geosciences	16	20	22	18	18	23	117
Immunology	19	25	30	20	24	12	130
Materials Science	60	70	46	82	70	76	404
Mathematics	19	17	28	24	30	24	142
Microbiology	24	24	19	25	31	29	152
Molecular Biology & Genetics	20	18	18	30	32	30	148
Multidisciplinary	166	140	170	160	122	88	846
Neuroscience & Behavior	22	14	24	14	20	23	117
Pharmacology & Toxicology	29	21	17	17	25	30	139
Physics	176	144	172	166	196	170	1,024
Plant & Animal Science	36	32	38	68	44	60	278
Psychiatry/Psychology	28	24	25	27	29	27	160
Space Science	16	22	29	19	19	15	120
Economics & Business + Social Sciences, general	24	26	26	24	22	35	157
Total	1,092	1,018	1,158	1,126	1,156	1,102	6,652

Note1: Analyzed by National Institute of Science and Technology Policy based on the Web of Science of Thomson Reuters.
Note2: Articles and letters were counted by the whole count method. The papers including at least one author affiliated with Japanese organization was counted.
Note3: For fields indicated by yellow cells, the number of the randomly sampled papers was more than twice of the HC papers to make the number of the sample papers equals to 170.

1－1－4 Results of the Sampling of the Possible Focal Papers

The result of the sampling of the possible focal paper was shown in Exhibit 56.

Exhibit 56 Results of the sampling of the possible focal papers

	Targeted number of possible focal	Results of sampling of possible focal
H projects	2,906	2,906
N projects	6,652	7,106
Total	9,558	10,012

1－2 Identification of Possible Survey targets Based on the Focal Papers

1－2－1 Methods of selecting survey target

The most knowledgeable respondents are the researchers who had managed the research projects producing the selected papers because the questions include many research management issues. The response rate of Japanese scientists would be higher to a survey administered by Japanese institutions. For this reason, the corresponding authors affiliated in institutions in Japan are the most preferred survey targets.

If the corresponding authors were not identified from the papers, ones of the authors affiliated in institutions in Japan were selected as possible survey targets in consideration of prevalent order of a corresponding author in authorship in each science field of journals. In the fields where more corresponding authors stand in the first authors rather than in the last authors, possible survey targets were selected in the reverse order from the last authors to the first authors. In the other fields, where more corresponding authors stand in the last authors rather than in the first authors, possible survey targets were selected in the reverse order from the last authors to the first authors in the forward order from the first authors to the last authors. The same procedures were used when the corresponding authors were affiliated in foreign counties.

For some survey targets, the contact information that can be extracted from the papers is not always enough to identify the current address of survey targets. For example, information of the affiliations of authors except for corresponding authors is not available in the Web of Science database. The authors may have changed their affiliations after the submissions. Only the alphabetical spellings of the names of Japanese scientists are available. And, only the initials of the first names are available.

To complement the information, we searched for the latest information on full names and postal addresses and/or e-mail addresses of the possible survey targets by using various kinds of internet resources, such as researchers' websites, Google Scholar, journals' websites, PubMed, esp@cenet and the ReaD database which is a database on researchers in Japan provided by JST. For this process, it took long time and much RA resources.

1－3 Selection of Survey targets and Focal Papers

The above-mentioned identification procedures ascertained that the full names, addresses and affiliations of the possible survey targets were available for 9,732 of 12,021 (97.2%) possible focal papers in the H and N papers. Some of the 9,732 possible survey targets may be counted more than one time. After removing the duplications, 7,652 survey targets were identified.

The interviews with researchers prior to implementing the survey suggested that when a researcher has multiple candidate papers for the survey, they are often from the same project. Considering also the burden on each scientist, we decided that we would choose only one focal paper for each scientist. 6,522 of the 7,652 survey targets were matched with only one possible focal paper. In this case, the focal papers were equal to the possible focal papers. On the other hand, 1,130 of the 7,652 survey targets were matched with more than one possible focal paper (Exhibit 57). In this case, one focal paper was selected by using the following procedures: i) If possible focal papers were found both in the H papers set and in the N papers set, then, ones in the H papers set are selected; ii) After the procedure i), one out of the possible focal papers was randomly selected as a focal paper. Consequently, 7,652 survey targets matched with 7,652 focal papers were identified.

The H projects here are identified as a group that consists of the survey targets matched with the focal papers in the H paper set. The N projects here are a group that consists of the survey target matched with the focal papers in the N papers set. Exhibit 58 shows the number of survey targets by science field of journals of the matched focal papers.

Exhibit 57 Distribution of the number of the focal papers per survey target

Number of the focal papers per survey target	Number of survey targets	Share
1	6,522	85.2%
2	764	10.0%
3	187	2.4%
4	75	1.0%
5	42	0.5%
6	23	0.3%
7	7	0.1%
8	5	0.1%
9	4	0.1%
10 or more	23	0.3%
Total	7,652	

Exhibit 58 Number of the focal papers by field

22 ESI journal fields	Focal papers	Top 1% highly cited papers	Normal papers
Agricultural Sciences	157	32	125
Biology & Biochemistry	337	98	239
Chemistry	791	184	607
Clinical Medicine	1,081	296	785
Computer Science	160	39	121
Engineering	704	197	507
Environment/Ecology	147	16	131
Geosciences	154	42	112
Immunology	113	12	101
Materials Science	460	122	338
Mathematics	161	27	134
Microbiology	140	13	127
Molecular Biology & Genetics	165	50	115
Multidisciplinary	807	269	538
Neuroscience & Behavior	153	44	109
Pharmacology & Toxicology	148	22	126
Physics	1,193	326	867
Plant & Animal Science	375	98	277
Psychiatry/Psychology	135	10	125
Space Science	120	23	97
Economics & Business + Social Sciences, general	151	12	139
Total	7,652	1,932	5,720

1−3−1 Affiliations of Survey targets

Exhibit 59 shows the number of survey targets by sector on the basis of the searched information. Exhibit 60 shows the top 30 institutions where more survey targets were affiliated on the basis of the searched information. It was found after implementing the survey that a few survey targets were different from the original researcher who is one of authors of focal papers because they had the same names and worked in the same field.

Exhibit 59 Number of survey targets by sector on the basis of the searched information

Sector		Number of survey targets	Share
Domestic	Higher education institutions	5,653	73.9%
	Government	920	12.0%
	Business Enterprises	473	6.2%
	Private non-Profit organizations	132	1.7%
	Hospitals	283	3.7%
Overseas		167	2.2%
Unkown		24	0.3%
Total		7,652	

Note1: The result presented here was based on the scientists' affiliations identified by Hitotsubashi Univ. It may include miss-identification of scientists.
Note2: Higher education institutions include university hospitals, colleges of technology, and inter-university research institute corporations
Note3: Government includes central and local government; and public research institutions.
Note4: Hospitals exclude university hospitals and include hospitals run by government.
Note5: The classification of sectors is different from that is used for the analysis in this report.

Exhibit 60 Top 30 institutions in terms of the number of survey targets

Name of institutions	number of survey targets	Name of institutions	number of survey targets
University of Tokyo	493	Keio University	77
Kyoto University	343	Okayama University	76
Tohoku University	280	Kobe University	76
Osaka University	273	Kanazawa University	65
Nagoya University	203	Japan Atomic Energy Agency	60
Advanced Industrial Science and Technology	199	Nihon University	57
Kyusyu University	188	Shinshu University	56
Hokkaido University	180	Nippon Telegraph and Telephone Corporation	55
Tokyo Institute of Technology	173	Kumamoto University	52
RIKEN	138	Waseda University	52
University of Tsukuba	108	Niigata University	47
Hiroshima University	100	University of Tokushima	43
National Institute for Materials Science	88	Kinki University	42
Chiba University	84	Osaka City University	42
National Institutes of Nature Science	83	Nagasaki University	40
		National Agriculture and Food Research Organization	40

Note1: The result presented here was based on the scientists' affiliations identified by Hitotsubashi Univ. It may include miss-identification of scientists.

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2 QUESTIONNAIRE

The questionnaire was designed as follows. First, we prepared the draft questionnaire. We conducted a pre-survey on eight researchers. We interviewed them and received their feedbacks on the design of questionnaire.

The questionnaire is composed of seven parts, each of which includes several questions. Consequently, it consists of 39 questions. Some questions are further subdivided. Exhibit 61 shows the organization and items of the questionnaire.

Exhibit 61 Organization of the questionnaire

1. Motivation and the other basic characteristics of the Research Project that yielded the Focal Paper
   Motivation for the Research Project that yielded the focal paper; Research process for the Focal Paper; Research method of the research project that yielded the paper; Types of the Outputs of the Focal Paper; Research Competition; Threat from Competition; Importance of the Focal Paper in the Field; Importance of the Focal Paper among all the Outputs of the Research Project
2. The Knowledge Production Process
   Your roles in the Research Project; External Knowledge Sources that Inspired the Research Project; Research management; Use of Advanced Research Facilities, Databases, and the Internet
3. Research Inputs
   History of the Research Project; Total research man-months expended on the Research Project; Research funds; Sources of Research Funds
4. Research Team
   Composition of the authors; Number of collaborating researchers, students and technicians, who are not the coauthors of the paper; The number of R&D personnel specifically hired for this Project; Scope of authors; Order of Authors
5. Research Outputs
   Number of Papers Produced by the Research Project; Training of Researchers; Follow-up research; Projects in Collaboration with an External Organization; Application for Patents; Internal Commercialization; Licensing or Assignment; Start-up Companies; Standards; Other Outputs: Research Tools
6. Questions about yourself
   Basic Questions; Family Situation; Educational Background; Research Career; Publication of refereed paper
7. Others
   Effects on industries and on society; Your view on science and innovation; Determinants of citation frequency

Question on the determinants of citation frequency was asked only for the survey targets in the H projects. It was designed to appear on the last stage of the online questionnaire so that the survey targets do not recognize themselves as any of the groups in responding to the preceding questions.

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3 IMPLEMENTATION OF THE SURVEY

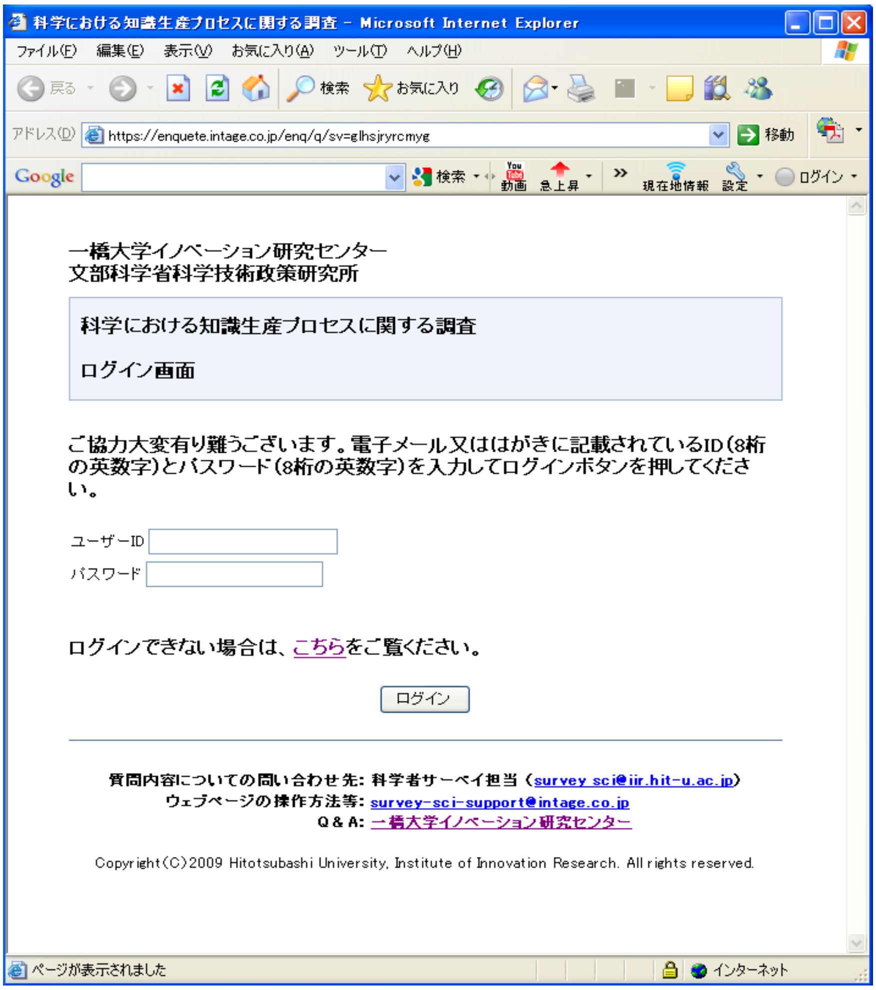
3−1 METHODS OF IMPLEMENTING THE SURVEY

The survey was conducted in principle on line. First, we sent, to the survey targets, a letter of asking his/her participation in this survey as well as the information on the access to the online questionnaire, including user IDs and passwords. We also sent, to the heads of the organizations where ten or more survey targets were identified, a letter of asking their assistance so that the survey targets can participate in this survey.

When the survey targets requested to reply by using a paper questionnaire, they received it. When the survey targets found it difficult to reply by the Japanese version of the questionnaire, they received the English version of the questionnaire instead. When the survey targets recommended other authors in the focal papers who should participate in the survey, we sent the same letter and information to them as substitute survey targets.

Some letters were sent to wrong researchers who had similar names as right survey targets. When this was found out, we searched the information of the right survey target and sent out the letters.

Exhibit 62 Screenshot of the survey webpage (in Japanese)



3－2 Basic Time-Line of the Survey

The basic time-line of the survey was shown below although some exceptions exist.

- Survey launch: December 21, 2009
- Initial due date: February 7, 2010
- Reminders were sent twice (mid of Jan., mid of Feb.)
- Final due date: April 11, 2010

4 DATA CLEANING

4－1 OUTLINES OF DATA CLEANING

There are some inaccurate responses. Before we conducted tabulation and analysis, we made the following data cleaning to correct them:

i) Examining consistency in questions with branches;
ii) Substituting missing values for specific numerical items with non-response codes;
iii) Translating years in the Japanese era systems to years of the Christian Era;
iv) Examining consistency between questions on conceiving the research idea, initiating the research project, submitting a focal paper and submitting the latest paper from the project, and substituting missing values for inconsistent responses;
v) Examining consistency in number of researchers employed for the research projects with number of authors and numbers of other types of researchers, and substituting missing values for inconsistent responses;
vi) Examining consistency in year of birth, year of earning the highest degrees, and year of submitting the first refereed paper, and substituting missing values for inconsistent responses;
vii) Encoding country name of birth into ISO 3166-1 alpha-2 codes;
viii) Examining consistency in the shares of research funds by funding source, and substituting missing values for inconsistent responses;
ix) Checking the consistency of multiple answers for alternative questions, and substituting missing values for inconsistent responses; and
x) Examining specific numerical questions, and substituting some "0"s for missing values.

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5 Classifications of Scientific Field

5—1 H Projects and N Projects

The "H projects" here is identified as the group of research projects which produced the focal papers in the H papers set. The "N projects" here is the group that of the research projects which produced the focal papers in the N papers set.

5—1—1 Classifications for Scientific Field

Most results of the survey to be presented in this paper are based on 10 fields, aggregated from 22 ESI journal fields. Some results are based on 3 large fields obtained by a further aggregation of the 10 fields. The focal papers in the multidisciplinary field were re-classified into a scientific field based on the subject of the paper. The method is described in the following section 5.2.

Exhibit 63 shows the concordances between the classification of the 22 ESI journal fields, 10 fields, and 3 large fields.

Exhibit 63 Relation between the 22 ESI journal fields, the 10 fields, and the large fields

22 ESI journal fields	10 fields	large fields
Chemistry	1_Chemistry	Physical Sciences
Materials Science	2_Materials Science	
Physics	3_Physics&Space_Science	
Space Science		
Computer Science	4_Computer Science&Mathematics	
Mathematics		
Engineering	5_Engineering	
Environment/Ecology	6_Environment/Ecology&Geosciences	
Geosciences		
Clinical Medicine	7_Clinical Medicine&Psychiatry/Psycholog	Medicine
Psychiatry/Psychology		
Agricultural Sciences	8.1_Agricultural Sciences&Plant & Animal Science	Life Sciences
Plant & Animal Science		
Biology & Biochemistry	8.2_Basic Life Sciences	
Immunology		
Microbiology		
Biology & Biochemistry		
Neuroscience & Behavior		
Pharmacology & Toxicology		
Multidisciplinary	Either of 22 ESI journal fields was assigned based on the analysis of the backward citations	Either of 22 ESI journal fields was assigned based on the analysis of the backward citations
Economics & Business	S_Social Sciences	
Social Sciences, general		

5—2 Field Classification of the Multidisciplinary Papers

The journals classified in the "multidisciplinary" field in the 22 ESI fields include a wide range of research results from life sciences to physical sciences. As shown in Exhibit 64, many focal papers identified in the multidisciplinary were included in multidisciplinary journals such as *PNAS (Proceedings of the National Academy of Sciences)*, *Nature*, and *Science*.

To identify the relevant research field, the focal papers in the multidisciplinary field were re-classified into specific science fields by the following procedures:

i) Collecting the references of a focal paper in the multidisciplinary cited;
ii) Identifying the science field of the journal for each cited paper;
iii) Finding the most frequent science field of the journals in the classification, except for the multidisciplinary, based on science fields of journals of all the cited papers in the focal papers; and
iv) Using the most frequent science field of journals as the science field of the focal paper, instead of the multidisciplinary.

Consequently, 794 of 807 focal papers that had originally identified in the multidisciplinary were re-defined as any of other 21 science fields of journals.

Exhibit 64 Journals in the multidisciplinary field and the focal papers

Jorunal name	Focal papers
PNAS	376
NATURE	225
SCIENCE	154
CHINESE SCIENCE BULLETIN	19
NATURWISSENSCHAFTEN	12
CURRENT SCIENCE	6
ADVANCES IN COMPLEX SYSTEMS	4
JOURNAL OF SCIENTIFIC & INDUSTRIAL RESEARCH	3
IRANIAN JOURNAL OF SCIENCE AND TECHNOLOGY	2
TEXT, SPEECH AND DIALOGUE, PROCEEDINGS	2
ANAIS DA ACADEMIA BRASILEIRA DE CIENCIAS	2
NATURE METHODS	1
SCIENTIFIC AMERICAN	1
Total	807

Note1: Analyzed by National Institute of Science and Technology Policy based on the Web of Science of Thomson Reuters.
Note2: Articles and letters were counted by the whole count method. The papers including at least one author affiliated with Japanese organization was counted.

5—3 Sector Classification for Affiliation of Researchers

The survey asked a researcher to identify the sector of the organization with which he/she was affiliated when the focal paper was submitted. This sector is used for analysis by sector. The five-sector classification shown below is used in this report.

(1) Higher education institutions
(2) Public research institutions
(3) Private firms
(4) Private non-profit organisations
(5) Others

The higher education institutions include universities, inter-university research institutions and colleges of technology. The public research institutions include national experimental and research institutions, independent administrative corporations, special corporations and experimental and research institutions of local governments.

6 Responses

6—1 Responses by Group and Scientific Field

Exhibit 65 shows the number of survey targets, the number of responses and the response rate by group and scientific field. This exhibit includes 13 survey targets in multidisciplinary that remain not to be re-classified by the procedures described in 5.2., which are excluded in analyses by scientific field.

Of 7,662 survey targets, 2,081 responses were realized. The response rates of all the samples, the H papers and the N papers were 28%, 29% and 27%, respectively.

The response rates in chemistry, materials science, environment/ecology and geosciences, and agricultural sciences & plant & animal science were more than 30%. On the other hand, the response dates in clinical medicine & psychiatry/psychology was 21%. In many scientific fields, the response rate of the H projects is the same as or slightly higher than that of the N projects, except for basic life sciences, where the response rate of the H projects is 4 percentage points less than that of the N projects.

Exhibit 65 Response rate by field

	All Focal Papers			H papers			N papers			
	Survey targets	Responded	Response rate	Survey targets	Responded	Response rate(A)	Survey targets	Responded	Response rate(B)	(A) - (B)
1_Chemistry	837	257	30.7%	208	71	34.1%	629	186	29.6%	4.6%
2_Materials Science	472	142	30.1%	127	43	33.9%	345	99	28.7%	5.2%
3_Physics&Space_Science	1407	380	27.0%	400	127	31.8%	1007	253	25.1%	6.6%
4_Computer Science&Mathematics	323	77	23.8%	66	16	24.2%	257	61	23.7%	0.5%
5_Engineering	707	206	29.1%	197	68	34.5%	510	138	27.1%	7.5%
6_Environment/Ecology&Geosciences	361	115	31.9%	81	30	37.0%	280	85	30.4%	6.7%
7_Clinical Medicine&Psychiatry/Psycholog	1278	264	20.7%	325	66	20.3%	953	198	20.8%	-0.5%
8.1_Agricultural Sciences&Plant & Animal Science	597	192	32.2%	165	60	36.4%	432	132	30.6%	5.8%
8.2_Basic Life Sciences	1504	404	26.9%	351	83	23.6%	1153	321	27.8%	-4.2%
9_Multidisciplinary(*)	13	2	15.4%	0	0	-	13	2	15.4%	-
S_Social Sciences	153	42	27.5%	12	2	16.7%	141	40	28.4%	-11.7%
Total	7,652	2,081	27.2%	1,932	566	29.3%	5,720	1,515	26.5%	2.8%

Note1: (*) Papers in multidisciplinary field that could not be reclassified.

6—2 POSSIBLE RESPONSE BIASES

Although this survey had a relatively high response rate, the non-response rate was more than 70%. For this reason, it is necessary to examine whether there are some major sources of response biases.

First, there was a concern that a productive scientist with good many papers may not respond since he/she is busy. However, we found that survey targets producing one or more highly cited papers were more likely to respond this survey. As shown in Exhibit 65, the response rate of the H projects was slightly higher than that of the N projects. Also, as shown in Exhibit 66, survey targets with more than one, especially 10 or more, papers were more likely to respond this survey.

Second, there was a concern that a paper with multiple authors might have a low response rate. In fact, survey targets producing focal papers written by many authors or by authors in many countries seemed reluctant to respond this survey. As shown in Exhibit 67, the response rate of survey targets producing a focal paper written by 50 or more authors was 17%, which was significantly lower than the average, although the survey targets accounted for only less than 1% of the samples. Also as shown in Exhibit 68, the response rate of survey targets of the focal paper with authors in six or more countries was less than 16%. However, the response rate is stable across a significant range of the number of authors and of the number of countries except for their extreme values.

Third, survey targets in some sectors or types of affiliations seemed unwilling to respond the survey. As shown in Exhibit 69, the response rates of survey targets staying in foreign countries, working at hospitals, and affiliated in business firms were 11%, 17%, and 23%, which were lower than the average.

Exhibit 66 Response rate by the number of the focal papers per survey target

Number of the focal papers per survey target	Survey targets	Responses	Response rate
1	6,522	1,738	26.6%
2	764	228	29.8%
3	187	56	29.9%
4	75	23	30.7%
5	42	13	31.0%
6-9	39	11	28.2%
10-	23	12	52.2%
Total	7,652	2,081	27.2%

Exhibit 67 Response rate by the number of authors

Number of authors	Survey targets	Responses	Response rate
1	454	122	26.9%
2	876	267	30.5%
3	1,166	366	31.4%
4	1,157	334	28.9%
5	988	255	25.8%
6	731	186	25.4%
7	554	158	28.5%
8	397	104	26.2%
9	299	63	21.1%
10-14	683	152	22.3%
15-19	150	31	20.7%
20-49	126	31	24.6%
50-	71	12	16.9%
Total	7,652	2,081	27.2%

Exhibit 68 Response rate by the number of countries where the authors of the focal paper reside

Number of countries where the authors of the focal paper reside	Survey targets	Responses	Response rate
1(Domestic)	5,290	1,484	28.1%
2	1,665	453	27.2%
3	399	77	19.3%
4	114	32	28.1%
5	58	15	25.9%
6-9	74	12	16.2%
10-	52	8	15.4%
Total	7,652	2,081	27.2%

Exhibit 69 Response rate by sector with which the survey targets are affiliated

Sectors		Survey targets	Responses	Response rate
Domestic	Higher education institutions	5,653	1,587	28.1%
	Government	920	289	31.4%
	Business Enterprises	473	108	22.8%
	Private non-Profit organizations	132	27	20.5%
	Hospitals	283	47	16.6%
Overseas		167	19	11.4%
Unkown		24	4	16.7%
Total		7,652	2,081	27.2%

Note1: The result presented here was based on the scientists' affiliations identified by Hitotsubashi Univ. It may include miss-identification of scientists.
Note2: Higher education institutions include university hospitals, colleges of technology, and inter-university research institute corporations
Note3: Government includes central and local government; and public research institutions.
Note4: Hospitals exclude university hospitals and include hospitals run by government.
Note5: The classification of sectors is different from that is used for the analysis in this report.

Appendix 2

Questionnaire for the Survey on the Knowledge Creation Process in Science

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Questionnaire for the Survey on the Knowledge Creation Process in Science

December 2009

Institute of Innovation Research, Hitotsubashi University
National Institute of Science and Technology Policy,
Ministry of Education, Culture, Sports, Science and Technology

YOUR CONTACT ADDRESS

If the contact address indicated is wrong or insufficient, please supply the correct information below.

Your name	
Your affiliation	
Your Section/Department	
Your position title	
Contact address	
Email address	

	Yes	No
Would you like to have the electronic file of the summary results of the survey sent to the above Email address?	○	○

1 Motivation and the other basic characteristics of the Research Project that yielded the Focal Paper

Q1-1	Motivation for the Research Project that yielded the focal paper					
	How important were the following two basic motivations for initiating the research project that yielded the focal paper and other closely related papers? Please rate on a scale of 1 to 5, ([1] : Totally unimportant motivation; [5]: very important motivation)					
		[1] Totally unimportant motivation	[2]	[3]	[4]	[5] Very important motivation
1)	Pursuit of fundamental principles/understandings To gain a new knowledge of the principles, underlying natural phenomenon and observed facts, through experiments and/or theoretical analyses.	○	○	○	○	○
2)	Solving specific issues in real life Solving practical and specific problems such as for industrial applications.	○	○	○	○	○

Q1-2	Research process for the Focal Paper					
	Did the research project which yielded the paper proceed as initially planned? Was the main result of the focal paper more or less significant that your initial expectations? Has the research output found the answers to questions not originally posed (was the research output serendipitous)?					
		[1] (largely the same as originally planned)	[2]	[3]	[4]	[5] (Quite different than originally planned)
1)	Research process yielding the main finding	○	○	○	○	○
		[1] (substantially LESS significant than expected)	[2]	[3]	[4]	[5] (substantially MORE significant than expected)
2)	Significance of the main finding	○	○	○	○	○
					Yes	No
3)	Has the research output found answers to questions not originally posed (was the research output serendipitous)?				○	○

Q1-3	Research method of the research project that yielded the paper					
	Which of the following research methods did your research project use? If used, rate the intensity of the use on a scale of 1 to 5, (1: rarely used; 5: used very extensively)					

	[0] Not used	used [1] Rarely used	[2]	[3]	[4]	[5] Extensively used
(a) Experiment or observation	○	○	○	○	○	○
(b) Numerical computation or simulation	○	○	○	○	○	○
(c) Theoretical analysis	○	○	○	○	○	○
(d)Development of new experimental methods or equipments and facilities	○	○	○	○	○	○

Q1-4 Types of the Outputs in the Focal Paper

Which of the following best define the types of contributions of the focal paper? Rate on a scale of 1 to 5, (1: Not relevant at all; 5: Highly relevant)

	[1] Not relevant at all	[2]	[3]	[4]	[5] Highly relevant
(a) Developing a new hypothesis or theory	○	○	○	○	○
(b) Support/reject an existing hypothesis or theory	○	○	○	○	○
(c) Discovering an unknown phenomenon/material	○	○	○	○	○
(d) Understanding a phenomenon	○	○	○	○	○
(e) Developing a new research method	○	○	○	○	○
(f) Improving an existing research method	○	○	○	○	○
(g) Creating a new function, mechanism, or material	○	○	○	○	○
(h) Improving on an existing function, mechanism, or material	○	○	○	○	○
(i) Proposing a new research issue	○	○	○	○	○
(j) Proposing a solution to a social issue	○	○	○	○	○
(k) Other (Please provide the specific type of the contribution.)	○	○	○	○	○

Q1-5 Research Competition

Approximately how many major research teams did you recognize as your potential competitors when you began the research project? Indicate the number of potential competitors in Japan (i.e., the competing team with its leader being located in Japan) and outside of Japan.

		None	1	2-5	5-10	More than 10	Unknown
1)	Number of potential competitors in Japan	○	○	○	○	○	○
2)	Number of potential competitors outside of Japan	○	○	○	○	○	○

Q1-6 Threat from Competition

How strongly were you and your team members concerned about the possibility that your competitors would have priority over your research results? Please choose one from the following.

	[1] Never concerned	[2] Hardly concerned	[3] Somewhat concerned	[4] Concerned	[5] Very much concerned
Level of concern	○	○	○	○	○

Q1-7 Importance of the Focal Paper in the Field

From your perspective, how important is the focal paper compared to the global research findings in the same field during the same period (published within a year before or after the focal paper was published). Please select the answer below that best describes your evaluation.

(a) It is one of the most important papers, ranking within the top 1%. ○

(b) It is a very important paper, ranking within the top 10%. ○

(c) It is a relatively important paper, ranking within the top 25%. ○

(d) It ranks within the top 50%. ○

(e) It ranks in the bottom half among papers published around that time. ○

(f) Other (Please provide the specific type of the contribution.) ○

Q1-8 Importance of the Focal Paper among all the Outputs of the Research Project

Which of the following categories best characterize the focal paper's position among all the research papers from the research project? Evaluate the significance as a research output, whether or not the papers were in line with the objective of the research project

(a) The focal paper is one of the most significant papers (one of the top 3) among all the research findings of the research project. ○

(b) The focal paper is a paper of relatively high significance among all the research findings of the research project, although it is not one of the top 3. ○

(c) The focal paper is an intermediate level of significance among the research findings. ○

(d) The focal paper is not a significant research finding of the research project ○

(e) Others (Please provide the specific type of the contribution.) ○

2 THE KNOWLEDGE PRODUCTION PROCESS

Q2-1 Your roles in the Research Project

Please indicate which of the following characterization best describes your roles in the management and in the implementation of the Research Project.

1) Managerial Role

- (a) A leading role in the research management, designing the research project, organizing the research team, and/or acquiring research funds (Principal investigator or Co-PI)
- (b) A member of the research management but less than that of the leader
- (c) No managerial role
- (d) Management was not necessary
- (e) Other(Please provide the specific type of the contribution.)

2) Role in the Research Implementation

- (a) I executed the central part of the research and contributed the most to the research output
- (b) I took part in the central part of the research but my contribution was not as substantial as the above central researcher
- (c) I implemented the research under the guidance of the above members
- (d) I contributed to the research through the provision of materials, data, equipments, or facilities.
- (e) Other (Please provide the specific type of the contribution.)

Q2-2 External Knowledge Sources that Inspired the Research Project

1) How important was each of the following external knowledge sources (excluding the members of the research team) for conceiving the research project? Rate on a scale of 1 to 5. (1: Not important at all; 5: Very important)

2) If you answered "important" or "very important" in the question above, please specify the country where the key knowledge source, such as the key researcher, was located (choose one).

	1) Knowledge source that was useful in conceiving the research project						2) Key knowledge source (Choose one)							
	Was not use	Was used: 1.Not Important at all	2.	3.	4.	5.Very important	Japan	USA	Germany	France	UK	Other EU country*	China	Other country
(a) Scientific literature (Articles in journals, etc.)														
(b) Scientific literature (Preprints, information on websites, those with faster reporting than 1.)														
(c) Handbooks and textbooks														
(d) Patent literature														
(e) Conferences, workshops, and academic meetings														
(f) Unofficial information (those from mailing lists, etc.)														
(g) Availability of new experiment facilities and equipments														
(h) New database (genome, materials, etc.)														
(i) Colleagues in the organization (a university, a laboratory, etc.)														
(j) Visiting researchers or post-doctoral students in the organization														
(k) Past research collaborators														
(l) Competitors														
(m) Partners in industrial - academic - government alliance														
(n) Researchers in different academic fields														
(o) Researchers with different research skills (experimental researchers for theorists)														
(p) Other (Please provide the specific type of the contribution.)														

* Other EU country: Austria, Belgium, Bulgaria, Cyprus, Czech, Denmark, Estonia, Finland, Greece, Hungary, Ireland. Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Poland, Romania, Slovakia, Spain, Sweden

Q2-3 Research management

Did your research team utilize the following approaches? If so, how effective were they in producing the main research output? Rate on a scale of 1 to 5. (1: Not effective at all; 5: Very effective)

	Whether used or not: Yes	No	Contribution to the main output of the research project: 1.Not effective at all	2.	3.	4.	5.Very effective
(a) Setting of ambitious research project goal	○	○	○	○	○	○	○
(b) Setting of research project goals consistent with the directions of science	○	○	○	○	○	○	○
(c) Setting of research project goals consistent with the directions of social development	○	○	○	○	○	○	○
(d) Making flexible changes to goals reflecting the progress of the research project	○	○	○	○	○	○	○
(e) Research team with diverse research skills, such as theory and experiment	○	○	○	○	○	○	○
(f) Research team from diverse academic fields	○	○	○	○	○	○	○
(g) Participation of young scholars, such as post-docs	○	○	○	○	○	○	○
(h) Information sharing within the research team through meetings	○	○	○	○	○	○	○
(i) Individual discussions between a research member and a research leader	○	○	○	○	○	○	○
(j) Archiving the research process in laboratory and experimental notes	○	○	○	○	○	○	○
(k) Accumulation of research output in a data base	○	○	○	○	○	○	○
(l) Division of research works, including outsourcing, for efficient and expedited research	○	○	○	○	○	○	○
(m) Continuous improvement of experiment facilities owned by the research team	○	○	○	○	○	○	○
(n) Improvement of computing or simulation programs	○	○	○	○	○	○	○
(o) Information sharing and research assessment through presentations in academic conferences	○	○	○	○	○	○	○
(p) Development of a research community for cultivating a new research field	○	○	○	○	○	○	○
(q) Other	○	○	○	○	○	○	○

Q2-4 Use of Advanced Research Facilities, Databases, and the Internet

Did your research project team use advanced research facilities, databases or the participation of remote researchers using the internet? If so, how effective were they in producing the main research output? Rate on a scale of 1 to 5, (1: Not important at all; 5: Very important). If you wished to use them but could not, please indicate whether that strongly constrained your research.

	Did you use it?		Contribution to the main output of the research project (Not effective at all → Very effective)					You did not use it. Did you wish to use it?		You did not use it. Did the lack of access significantly constrain the research?	
	Yes	No	1	2	3	4	5	Yes	No	Yes	No
(a) Advanced research equipment and facilities (owned by your research team)											
If you marked Important or Very important, please provide specific equipment name(s) (optional).											
(b) Advanced external experimental equipment and facilities (such as accelerator, super computer, observatory, etc.)											
If you marked Important or Very important, please provide specific equipment/facilities name(s) (optional).											
(c) The latest databases (genomes, materials, etc.), other than those for journal/published papers											
If you have marked Important or Very important, please provide specific database name(s) (optional).											
(d) Databases of journal/published papers											
(e) Access to the latest foreign and domestic research information (information available before it is published in journals)											
(f) Participation of remote researchers [1] using the internet											
(g) other (Please provide the specific type of the contribution.)											

[1] three hours or more are required for a one-way trip

3 Research Inputs

Q3-1 History of the Research Project

Please indicate the time lines of the research project, as follows

1) Year when the project was conceived	2) Year when the project was initiated	3) Year when the focal paper was submitted	4) Year when the most recent research paper was submitted
Year ☐☐☐☐	Year ☐☐☐☐	Year ☐☐☐☐	Year ☐☐☐☐

5) Has the project been completed?

If yes, when		Year ☐☐☐☐
If no (on-going), expected year of completion	unknown ○ expected year	Year ☐☐☐☐

Q3-2 Total research man-months expended on the Research Project

Please indicate the approximate man-months that the entire research team spent, from the point when the Research Project began to the point when the most recent research findings were submitted. ☐☐☐☐☐☐ man-months

Example: If three team members worked for 24 months, 18 months, and 6 months respectively in a two-year project, then the total is 48 man-months. Please round your answer to an integer.

Q3-3 Research funds

Please tell us about the amount of funds directly used for the Research Project. Indicate the number that best applies and please give a rough amount, if possible.

1) <u>Please exclude faculty salary, unless the individual was hired specifically for the research project. The research funds should include personnel costs for researchers and research supporters when they were hired for this project.</u>

2) Regarding the costs for large equipment, if the equipment was purchased solely for the project, include it as part of the research costs; otherwise exclude it from your calculation.

(a) Less than 1 million yen	→ ○	☐☐0 , 0 0 0 yen
(b) More than 1 million yen but not more than 10 million yen	→ ○	☐ , ☐ 0 0 , 0 0 0 yen
(c) More than 10 million yen but not more than 50 million yen	→ ○	☐☐ , 0 0 0 , 0 0 0 yen
(d) More than 50 million yen but not more than 100 million yen	→ ○	☐☐ , 0 0 0 , 0 0 0 yen
(e) More than 100 million yen but not more than 500 million yen	→ ○	☐☐0 , 0 0 0 , 0 0 0 yen
(f) More than 500 million yen but not more than 1 billion yen	→ ○	☐☐0 , 0 0 0 , 0 0 0 yen
(g) More than 1 billion yen	→ ○	☐ 0 0 , 0 0 0 , 0 0 0 yen

Q3-4 Sources of Research Funds

(Please inform us about the source of research funds for the project. Indicate the approximate percentage of each of the following sources that apply.

Type of research fund				Percentage
Internal funds				
	Funds of the institution that the research team members belong to (domestic or foreign)			%
External funds				
	External funds from central Japanese government			
	Center grants (such as 21st Century COE, etc.)		Name	%
	Competitive research grants for projects			
		Grant-in-aid for Scientific Research		%
		Health and Labor Sciences Research Grants		%
		Japan Science and Technology Agency (JST)	Name	%
		New Energy and Industrial Technology Development Organization (NEDO)	Name	%
		Other competitive project grant from a government	Name	%
	Non-competitive research grants (such as national projects lead by the government)		Name	%
	External funds from local Japanese Government			
	Name			%
	External funds from foreign Government			
	Name			%
	External funds from Japanese private enterprises			
	Commissioned research from firms			%
	Collaborative research with firms			%
	Donations from firms			%
	Other	Name		%
	External funds from foreign firms			
	Name			%
	Other (such as Foundations)			
	Name			%
			Total	1 0 0 %

* Regarding the research money that national universities and public research institutions received from the government (excluding competitive research funds), if you cannot determine whether the funds are internal to your institution or are other external funds (government), choose non-competitive research grant if the funds are tied to specific research subjects, and choose internal funds of your institution if they do not target a specific subject.
* When national research funds were allocated via a foundation, choose external funds from central Japanese Government (including independent administrative institutions).
* If the headquarter of the firm is located in Japan (abroad), please identify the fund as "External funds from Japanese (foreign) firm.

4 RESEARCH TEAM

A separate sheet provides the authors of the focal paper (maximum 6). The following questions refer to these authors and yourself.

Q4-1 Composition of the authors

Please identify the job position; the types of their organizational affiliations; the field of expertise; the skill; and the country of birth of each author, at the time when the focal paper was submitted for publication. When there are more than six authors, ones in the list have been randomly selected, except for the first and last authors.

Author	Job position	Types of organizatioin al affiliations	Field of expertise	Skill	Country of birth (if not Japan)	If the author is you, check the box
Author 1 (First Author)						○
Author 2						○
Author 3						○
Author 4						○
Author 5						○
Author 6						○
If you are not listed above, please identify your information						
Your self						

(1) Job position
1. Professor level (Professor, senior research scientists, senior staff scientists, managerial/executive personnel, etc.)
2. Associate Professor level (Associate professor, associate research scientists, associate staff scientists, etc.)
3. Assistant Professor level (Assistant professor, assistant, lecturer, research scientists, staff scientists, etc. [excluding postdoctoral fellow])
4. Postdoctoral fellow 5. Technician 6. Ph.D. student
7. M.A. and/or undergraduate student 8. Other 9. Do not know

(2) Types of organizational affiliations
1. University, etc[1] 2. Public research organization[2] 3. Private firm
4. Private and non-profit organization 5. Other 6. Do not know
[1] Universities refer to universities, joint university research institutions, and higher technical schools.
[2] Public research institutions refer to national testing/research institutions, independent administrative institutions, special corporations, and testing/research institutions of local governments.

(3) Field of expertise
1. Mathematics 2. Computer science 3. Chemistry 4. Material sciences
5. Physics 6. Space science 7. Earth science
8. Environmental studies, Ecological science 9. Clinical medicine
10. Psychiatric medicine, Psychology 11. Biology, Biochemistry 12. Immunology
13. Microbiology 14. Molecular biology, Genetics
15. Pharmaceutical science, Toxicology 16. Neuroscience, Behavioral science
17. Agriculture science 18. Botany, Zoology 19. Urban engineering
20. Electrical engineering, Electronic engineering, Information engineering

21. Mechanical engineering
22. Chemical engineering
23. Material engineering
24. Medical engineering
25. Environmental engineering
26. Economics, Management
27. Social science
28. Do not know

(4) Main Skill

1. Theoretical
2. Experimental
3. Clinical
4. Do not know

Q4-2 Number of collaborating researchers, students and technicians, who are not coauthors on the paper

Indicate the numbers of collaborating researchers, students and technicians who played a significant role in the implementation of the project but are not co-authors of the focal paper.

(a) Collaborating researchers			
(b) Graduate students			
(c) Undergraduate students			
(d) Technicians			

※Technicians provide technical service for the research under the guidance and direction of researchers. This does not include those who were involved in general affairs, accounting and miscellaneous duties in research-supporting work.

Q4-3 The number of R&D personnel specifically hired for this Project

Please identify the number of R&D personnel (authors of the paper as well as cooperating researchers, students and technicians) specifically hired for this project, whose personnel costs were covered in Q3-3 above. Approximate numbers will do if the exact count is difficult.

Q4-4 Scope of authors

Please indicate whether the following types of researchers are included among the authors.

- (a) Any researcher who only supplied research materials analyzed in the research ☐
- (b) Any researcher who only supplied or developed the research facilities or equipments used in the research ☐
- (c) Any researcher who only supplied or developed the computer program or database used in the research ☐
- (d) Any researcher who only supplied funds used in the research ☐
- (e) Other (Please provide the specific type of the contribution.) ☐

Q4-5	Order of Authors	
	Which of the following best describes the name order of the authors on the focal paper?	
	(a) Ordered by degree of the contribution of authors.	○
	(b) Alphabetical order	○
	(c) Seniority (Senior author first)	○
	(d) Seniority (Senior author last)	○
	(e) Other (Please provide the specific type of the contribution.)	○

5 Research Outputs

Q5-1 Number of Papers Produced by the Research Project

1) Approximately, how many refereed papers (including refereed conference proceedings) did the research project lead to, including the focal paper itself?

	Japanese	English	Other language
Published paper (refereed)			

2) Please provide us a bibliography (journal name, volume, number of pages) or DOI of the three most important papers in order of importance. If the focal paper under the survey is included in the three, write as "focal paper" in the Journal Name box.

	Journal name	Vol.	Issue	Year published	Beginning page
Paper 1					
(or) DOI					
Paper 2					
(or) DOI					
Paper 3					
(or) DOI					

Q5-2 Training of Researchers

Please inform us how many people received a masters or a PhD degree or received Post-Doctoral training through the research project. Approximate numbers are sufficient.

	Born in Japan	Born outside Japan
(a) Received a PhD degree		
(b) Received a masters degree		
(c) Post Doctoral fellows		

Q5-3 Follow-up research

1) Did the results from the project lead your research team to initiate a follow-up research?

	Yes	No
Research followed by your research team	○	○

2) If the results did not lead to follow-up research by your research team, what do you think the reason was? Indicate all answers that apply.

- (a) The research project completed its mission ☐
- (b) Other more promising research projects were found ☐
- (c) We could not obtain research funds to do the follow-up research ☐
- (d) We discontinued the research because we lost the research competition to a competitor ☐
- (e) We discontinued the research, judging that the follow-up research would not achieve sufficient results ☐
- (f) The transfer of a research team member made it impossible to do the follow-up research ☐

(g) Other (Please provide the specific type of the contribution.) ☐

Q5-4 Projects in Collaboration with an External Organization

Did the research output or the capabilities gained from the research project lead to a follow-up research project involving an external organization? Please specify the number of external institutions from which your research team engaged in commissioned research, joint research or technical cooperation. An approximate number is sufficient.

(a) Commissioned research				institutions
(b) Joint research				institutions
(c) Technical cooperation				institutions

Q5-5 Application for Patents

		Yes	No
1)	Did the findings from the research project lead to a patent application?	○	○

2) If any, write the number of applications. For PCT international applications or those not to the Japanese Patent Office (JPO), all applications from the same invention should be counted as one.

	JPO application			Non-JPO application (including PCT international application)		
(a) Patent applications						

3) Please inform us of the most important patent from the project by indicating its application (or publication or grant) number below. If it is not a patent from the Japanese Patent Office, please indicate the name of the patent office.

	(application or publication or grant)	Name of the patent office
Publication number ○		
Grant number ○		
Application number ○		

Examples:
Publication number:「特開 2010-123456」,「EP2345678(A1)」,「WO2010/012345」,「US2010/0123456」,or just a number.
Grant number:「特許 4412345」,「EP2345678(B1)」,「US7345678」,or just a number.
Application number::「特願 2010-123456」,「EP20101234567」,「PCT/JP/2010/123456」,「US11/123456」,or just a number.

		Yes	No
4)	Was any research team member or the organization with which he was affiliated the assignee (or coassignee) of the above patent?	○	○

Q5-6 Internal Commercialization

Were any research results from the research project used for a commercial purpose such as developing or improving a product or a production process by any of your research team members or the institutions they belong to?

(a) Commercialized ○

(b) Not commercialized ○

(c) Don't know ○

Q5-7 Licensing or Sales

1) Were any research results from the research project licensed or sold?

(a) Licensed.	○
(b) Sold	○
(c) Neither licensed nor sold	○
(d) Don't know	○

2) If some research results were licensed or sold, how large (number of employees) were the licensees or the buyers? When there were multiple licensees or buyers, indicate all that apply. Also inform us whether they include a startup firm, a firm five years old or younger.

	Size	Start-up (five year old or younger)
250 employees or more	☐	○
Less than 250 employees but more than 50 employees	☐	○
Less than 50 employees but more than 10 employees	☐	○
Less than 10 employees	☐	○

	Yes, it involved provision of know-how.	No, it did not involve provision of know-how.
3) Did the licensing or sales of the patent involve provision of the research team's know-how?	○	○

Q5-8 Start-up Companies

	Yes	No
1) Did the findings from the research project lead to a start-up company? A start-up company here means a new company established based on the findings of the research project, and does not include an existing company that is granted a license.	○	○

	Yes	No
2) No, the project did not lead to a start-up company. If your answer is no, did you seriously consider the possibility?	○	○

3) Yes, it led to a start-up company

Name of company	
Year established	
Address	

4) How were the members of research team involved in the start-up company? Check all that apply.

(a) Research team members themselves founded the company	☐
(b) Research team members assumed executive positions	☐
(c) Research team members were involved as a member of the scientific advisory board	☐
(d) Research team members consulted for the startup (technical guidance, etc.)	☐
(e) Research team members worked as employees on a part-time basis	☐
(f) Research team members worked as an employee on a full-time basis	☐
(g) Other involvement (Please provide the specific type of the contribution.)	☐
(h) Research team members were not involved	☐

5)	Why was the start-up company formed as a channel for commercialization?
	(a) An established company has not shown interest ○
	(b) Government policy favors a start-up company ○
	(c) The researchers can retain a more control right ○
	(d) The researchers can expect more financial gain ○
	(e) A start-up was likely the best way for the research result to reach the market. ○
	(f) Other (Please provide the specific type of the contribution.) ○

Q5-9	Standards			
		Did not lead to a standard	Currently discussing standardization based on the findings	Did lead to a standard
1)	Did the findings of the research project lead to a standard approved by a standards organization?	○	○	○
2)	If it did, write down the name of the most important standard.			

	Name (standard of XXX, etc.)	Standards organization (ISO, IEEE, etc.) for the cases of 2 and 3

Q5-10	Other Outputs: Research Tools		
	Did the project produce other forms of research outputs such as materials, data or tools that are publicly accessible (for example, through a materials database or genome database)? Indicate the types that apply from the list below and inform us the name of the material, database or research tool. Please include the case in which your team provided an existing database with new data.		
	Category of Deliverable		Name of Research Tool (optional)
	(a) Biological Material	→ ☐	
	(b) Non-biological Material	→ ☐	
	(c) Existing or new Database	→ ☐	
	(d) Program Software	→ ☐	
	(e) Equipment or Device	→ ☐	
	(f) Other research tools	→ ☐	

6 QUESTIONS ABOUT YOURSELF

Q6-1	General Questions Please provide the following information about yourself.		
1)	Year of birth	Year 1 9	
		Male	Female
2)	Gender	○	○
3)	Please indicate your organizational affiliation during the project period. If the name of the organization changed, please indicate its current name.		
	Name of university, company, research institute, etc.		
	Name of school/department, and group/division etc.		

Q6-2	Family Situation		
		Yes	No
	Marital status (at the time when the research project started) Married?	○	○
	Children (at the time when the research project started)	○	○
	If yes, how old are they?		Fill in the number of children in the following age brackets
	(a) up to age 5		
	(b) age 6-18		
	(c) age 19 or above		

Q6-3 Educational Background

1) What was your highest degree at the time you initiated the research project?

- (a) Ph.D.or M.D. (incl. doctorate paper)
- (b) Master's degree (incl. partial completion of Ph.D.)
- (c) Bachelor's degree, Technical college, junior college
- (d) Other (Please provide the specific type of the contribution.)

If you answered (a) or (b), please proceed to 2). If you answered (c) or (d), please go directly to 3).

2) With respect to your highest degree (master's or Ph.D.) in the above question, please tell us the following

(a) Year you received the degree	Year	
(b) Name of university at where you received your degree and the major you studied	University	
	Major	

3) In what year did you first submit a paper to a refereed journal? Write the year of submission, regardless of whether it was accepted or not.

Year

Q6-4 Research Career

Please inform us about your research experience at the time when you started the research project.

		Yes	No
1)	Won a distinguished paper award or a conference award from an academic society		
2)	Served on an editorial board of an international journal		
3)	Stayed in abroad for one year or more for study or research.		
4)	Changed academic or research positions across organizations in the preceding five years ※This excludes taking a job after your graduation.		
5)	Been seconded (i.e. transferred temporarily) to another institution in the preceding five years		

Q6-5 Publication of refereed papers

Please tell us how many refereed papers (including refereed conference proceedings) you published during the period of 2006-2008. Please include the co-authored papers.

	Japanese	English	Other language
1) Published paper (refereed)			

7 OTHERS

Q7-1 Effects on industries and on society

What kinds of direct or indirect effects did the results of the research project have on firms and on society (individuals as consumers or workers)? We welcome any specific descriptions.

Example) Firms have used the method that you developed in your research project; industries used the material that you developed in your research project; etc.

Q7-2 Your view on science and innovation

Please tell us what you think are the main issues for enhancing the knowledge creation process in science and the process of generating innovation from scientific discoveries? Your comments will be greatly appreciated.