Prepared for the IIPS Symposium on

Globalization and Japan's Science and Technology Strategy

19 – 20 November 2007

Tokyo

Session 2

Monday, 19 November 2007

The Major Characteristics of Inventors and Inventing Firms in Japan: Findings from the RIETI Inventor Survey

Sadao Nagaoka
Hitotsubashi University

The Major Characteristics of Inventors and Inventing Firms in Japan: Findings from the RIETI Inventor Survey[1]

Sadao Nagaoka
Research Counselor, Research Institute of Economy Trade and Industry
Professor, Institute of Innovation Research, Hitotsubashi University
November 2007

1. Introduction

Japan's economic growth depends heavily on high-quality research and development (R&D) performed by corporations, universities, and other institutions, combined with their effective commercialization. However, we have very limited social science knowledge of innovation process, including R&D objectives and motivations, knowledge sources, spillover, funding constraints on implementing R&D, constraints on utilizing results, and the inventor motivations. By directly gathering information from the inventors working on the frontlines of R&, we can deepen our understanding of the structural characteristics of Japanese R&D and this will aid in policy research. With this goal in mind, the Research Institute of Economy Trade and Industry (RIETI) undertook a survey on the inventions and the R&D projects that created them, as one component of the research project on the "Characteristics and Future Issues for Japanese Corporate Research and Development". It was conducted from January to June of 2007. The survey yielded close to 5,300 responses and marked the first such systematic survey on R&D projects in Japan.[2]

In this paper, we report the initial findings from the survey on the major characteristics of the inventors and inventing firms in Japan. The sample used in the RIETI Inventor Survey consists of three categories. Approximately 70% of the sample consisted of the inventions, the patents for which have been filed trilaterally—applying for them in Japan, the United States, and in Europe through the Europe Patent Office—and who have been granted a patent in the United States ("*triadic patents*" hereafter). Some 30% of the sample is composed of non-trilateral patent filings (Japanese patents for which the examination has been completed, "*non-triadic patents*"

---

[1] This paper relies entirely on the RIETI discussion paper "Japan's Innovation Process from the Perspective of Inventors: Summary findings of the RIETI Inventors Survey" (in Japanese, 2007)

[2] While the RIETI Inventors Survey relied on the PATVAL-EU survey undertaken in Europe from 2003 to 2004, at the same time, the survey also added a number of original questions, some of which are included in this paper. For the European survey, please refer to Paola Giuri, Myriam Mariani, et al, 2007, "Inventors and invention processes in Europe: Results from the PatVal-EUsurvey", *Research policy*, Vol. 36, Issue 8, 1107-1127

hereafter), and with a very small sample (roughly 120 instances) collected from important patents in important new technology fields[3], such as nano-technology or new materials, or the essential patents of the standards. The majority of the patents claimed a priority year, or filing year, of between 1995 and 2001.

2. Profiles of the inventors who responded and their organizational of affiliations

First, we will take a look at the age, gender, academic background, and the organizational affiliations of the inventors who responded to the RIETI Inventor Survey. The first point that should be noted is that this survey was carried out based upon a random sampling of the patents, not a random sampling of the inventors. As such, these results do not depict a representative sample of inventors. In Table 1, results are displayed in comparison with European survey results (targeting the six countries of Germany, France, England, Italy, Spain, and the Netherlands).

The academic background of inventors is diverse. Of the inventors with trilateral patents, some 86% were university graduates, while 14% did not have a university degree, when they made the inventions. In addition, 12% had doctoral degrees (including the degrees obtained based only on the dissertations). Among those with trilateral patents, the ratio of respondents with doctoral degrees was much higher than among those with non-trilateral patents. 29% of the inventors for important patents in standard and key technology sectors had doctoral degrees. Thus, a positive correlation between the quality of an invention and the educational background of an inventor is observed. In Europe, the percentage of university graduates was 77%, significantly lower than Japan, while the percentage of doctoral respondents was higher at 26%, indicating more diverse academic backgrounds in Europe. However, in all samples, the ratio of female inventors was significantly lower than their male counterparts (for trilateral filings it was 1.5%), which is extremely low even compared to the percentage of female researchers in Japan (approximately 10%, according to the Survey of Research and Development in Japan by Ministry of Internal Affairs and Communications).

---

[3] Such patents are identified by the experts in fields such as IT, nano-technology, and new materials in the Japan Patent Office's Sectoral Surveys of Technological Trends and Patent Applications

Table 1 Basic profile of the surveyed inventors and their organizational affiliations

		trilateral patents	non trilateral patents	Important patents in standard and key technology sectors	Europe
	Sample size	3,658	1,501	119	9,017
Academic background	University graduate (%)	85.9	86.7	94.2	76.9
	Doctorate (%)	12.4	8.7	28.6	26
	Female (%)	1.5	1.8	1.7	2.8
	Age (years old)	39.5	38.6	39.7	45.4
Organizational affiliation	Employed at large corporation (251 or more employees) (%)	87.8	87.0	85.6	70.6
	Employed at small or medium-sized corporation(%)	8.7	10.2	3.4	22.5
	Institutions of higher education(%)	2.3	1.4	4.2	3.2
	National research institutes or other government organs (%)	0.7	0.8	4.2	2.2
	Foundations and other organizations (%)	0.5	0.7	2.5	

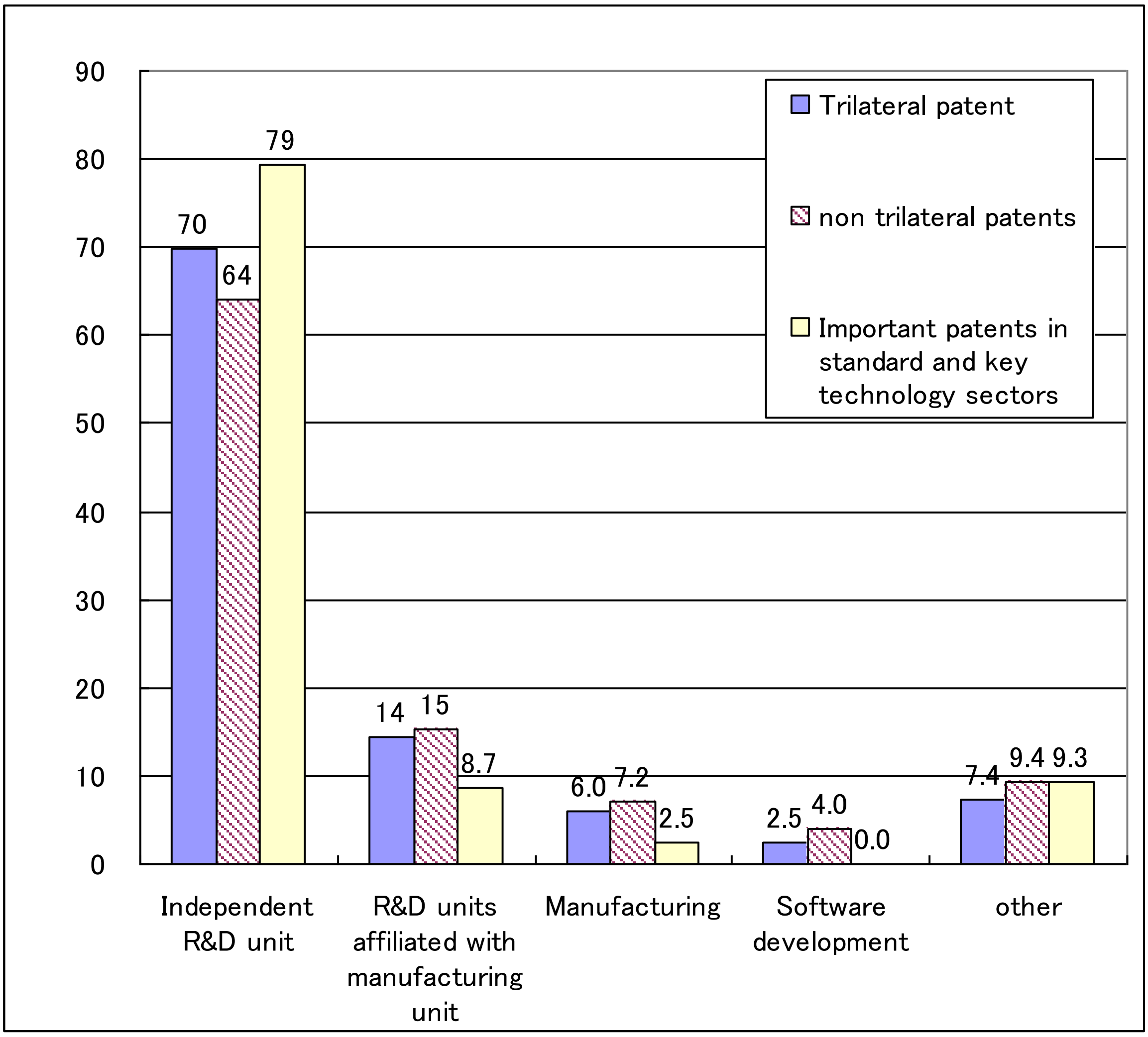
Source: Japan RIETI Inventor Survey, Europe's PatVal-EU (targeting the six countries of Germany, France, England, Italy, Spain, and the Netherlands).
Note: Individual inventors who have no organizational affiliations are extremely low in number.

Next, the survey data showed that at the time of creating their inventions, 97% of inventors were employed by the organizations so that all most all inventions were "employee inventions". The percentage of individual inventors, such as self-employed or student inventors was extremely low. As indicated in Table 1, by place of employment the data shows that employees of the corporations with more than 250 employees made up nearly 90% of all trilateral and non-trilateral patents, while employees at small to medium-size corporations were responsible for approximately 10%.

The percentages of trilateral patents stemming from higher educational institutions such as universities, national research institutions and other governmental organizations, and foundations and other organizations were responsible for 2.3%, 0.7% and 0.5% of such patents, respectively. A comparison of trilateral and non-trilateral patents shows similar patterns prevailing in terms of organizational affiliations. However, for important patents in standard and key technology sectors, the share composed by large corporations is roughly the same, but the small to medium-sized corporation share falls off and those held by universities and national research organizations increase significantly. In Europe the organizational affiliation for large corporations is on average 70%, implying that the corresponding figure is much larger for Japan. In contrast, in Europe small and medium-sized companies are responsible for roughly 20% of the patents, which is more than twice that of Japan. For universities the percentage is slightly lower in Japan.

In Japan, it is often thought that inventors are drawn from a broad base, including the manufacturing shops, but it is not clear that this is in fact the case. The RIETI Inventor Survey covers the functional affiliation of inventors, the results of which are reported below in Figure 1. For trilateral patents, the ratio of inventors affiliated with an independent R&D unit is close to 70%, by far the highest share. A distant second are those affiliated with R&D units affiliated with the other organizations such as a manufacturing unit, which logged a ratio of 14%. The remaining 16% was composed of inventors affiliated with a manufacturing unit, a software development unit, and the other units (such as from a design unit, etc.) not specialized in R&D. For non-trilateral patents, the independent R&D units account for a slightly lower proportion at 64%, with the units not specialized in R&D conversely recording a relatively larger share of 20%. However, the underlying structure is essentially the same. For the important patents in standard and key technology areas, the independent R&D sector composed a high 80% of the total patents.

Figure 1 Inventor functional affiliation



Note: The "Other" category includes design and engineering sectors.

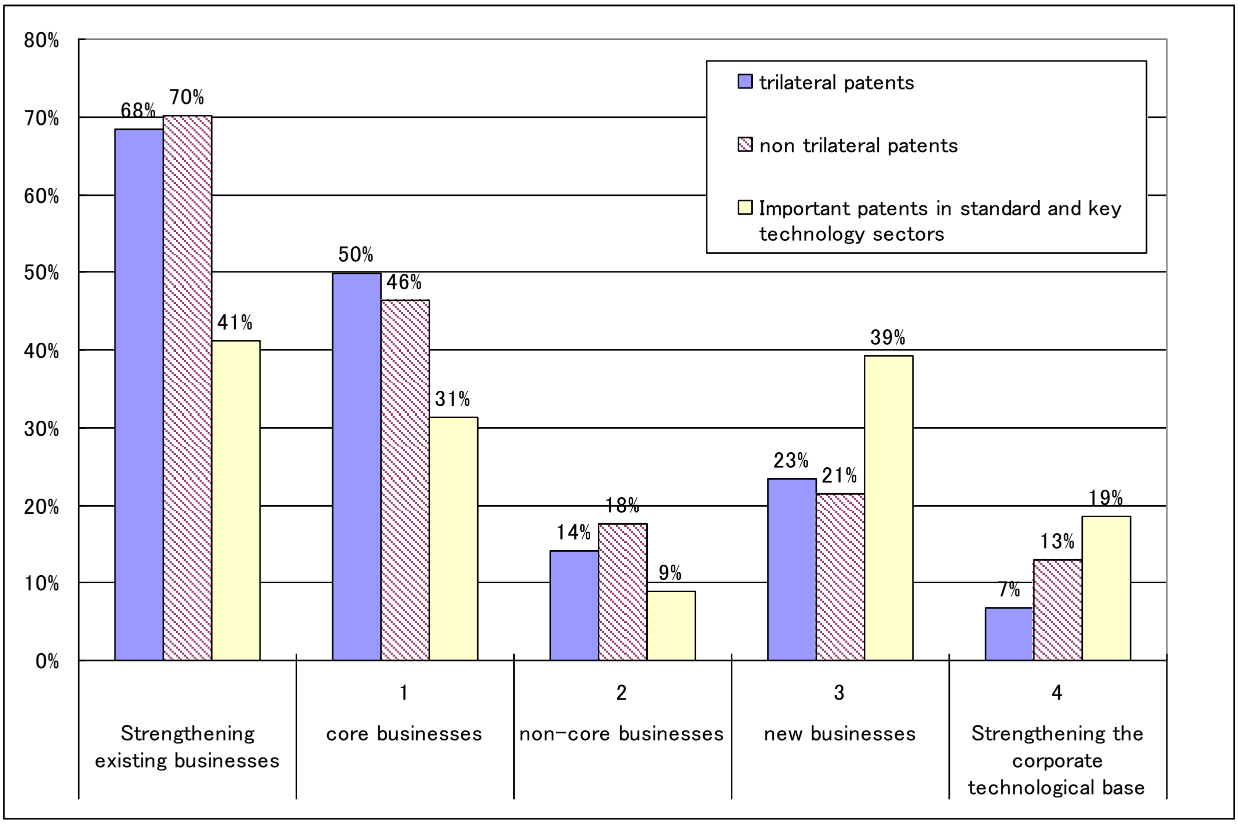
3. Business objectives of R&D

The importance of focusing on the core competency of a firm has often been argued in Japan in recent years. There is a question of how the R&D project of a firm is related to its scope of business, in particular, whether it is for strengthening R&D in its core business or for diversification.[4] It is also important to clarify what kinds of tradeoffs the firm faces in such choice. As shown in Figure 2, "Strengthening existing businesses" accounted for 70% of the responses by the inventors belonging to firms, "Starting new

[4] In the survey, "Core Business" is defined as that business in which a company has a competitive advantage in the market in this field, and that forms the core of the sales and profits of the company.

businesses," for roughly 20%, and "Strengthening the corporate technological base not linked to the current business" accounted for the remaining 10%. The results for trilateral patents and for non-trilateral patents are very similar. Therefore, when research for starting new business is included, it becomes apparent that 90% of the corporate R&D projects under the survey is closely related to the current business strategy of a firm. In addition, roughly 50% of the total R&D projects are undertaken with the objective of strengthening existing core businesses. However, it may be important to note that 40% of the R&D projects resulting in the important patents in standard and key technology areas stems from the R&Ds designed to generate new business, while 20% is for enhancing the corporation's technology base level over the long term.

Figure 2 Business objectives of the research which yielded the inventions (%)

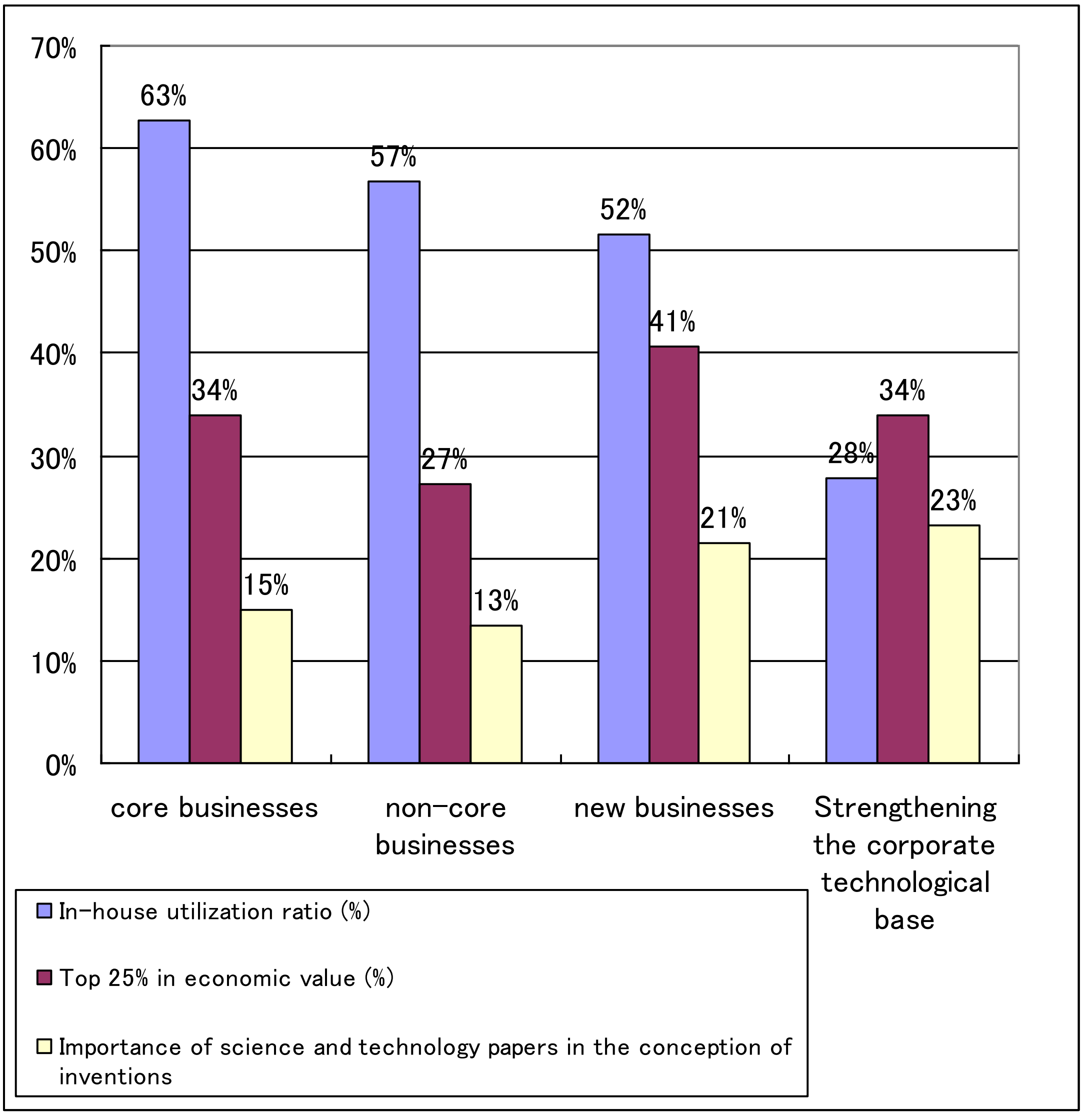


Note: Responses are limited to inventors belonging to corporations. A small number of responses said that the distinction between core business and non-core business was not clear.

4. R&D tradeoffs by business objective

The R&D project directly related to the core business of a firm would have an advantage that their results can be used easily utilized by a firm, since a firm has the complementary assets. Thus, even the research results that are relatively minor technological improvement could easily find the profitable applications. At the same time, since such R&D project aims at using the existing complementary assets, such as manufacturing facilities, it can be potentially inhibited from making a technological leap. Following this line of thought, we would expect that there is a tradeoff involving in-house utilization ratio and the use of new scientific and technological knowledge in the choice of R&D projects. In fact, as shown in Figure 3, in R&D catered for core business, the utilization ratio of the results for in-house is the highest (63%). At the same time, it is clear that the level of the use of scientific and technological knowledge for the conception of inventions is lower for such R&D than that for R&D for new businesses, or for strengthening the technology base (For the conception for inventions, only 15% of respondents answered science and technology papers were extremely important for R&D catered for core business, while the corresponding figure was 21% for R&D targeting the generation of new business). In addition, the R&D new business has substantially more valuable patents than the R&D targeting the core business, in terms of the share of top 25% inventions.

Figure 3 Distinguishing characteristics of R&D for core business and that for the other business objectives (triadic patents)

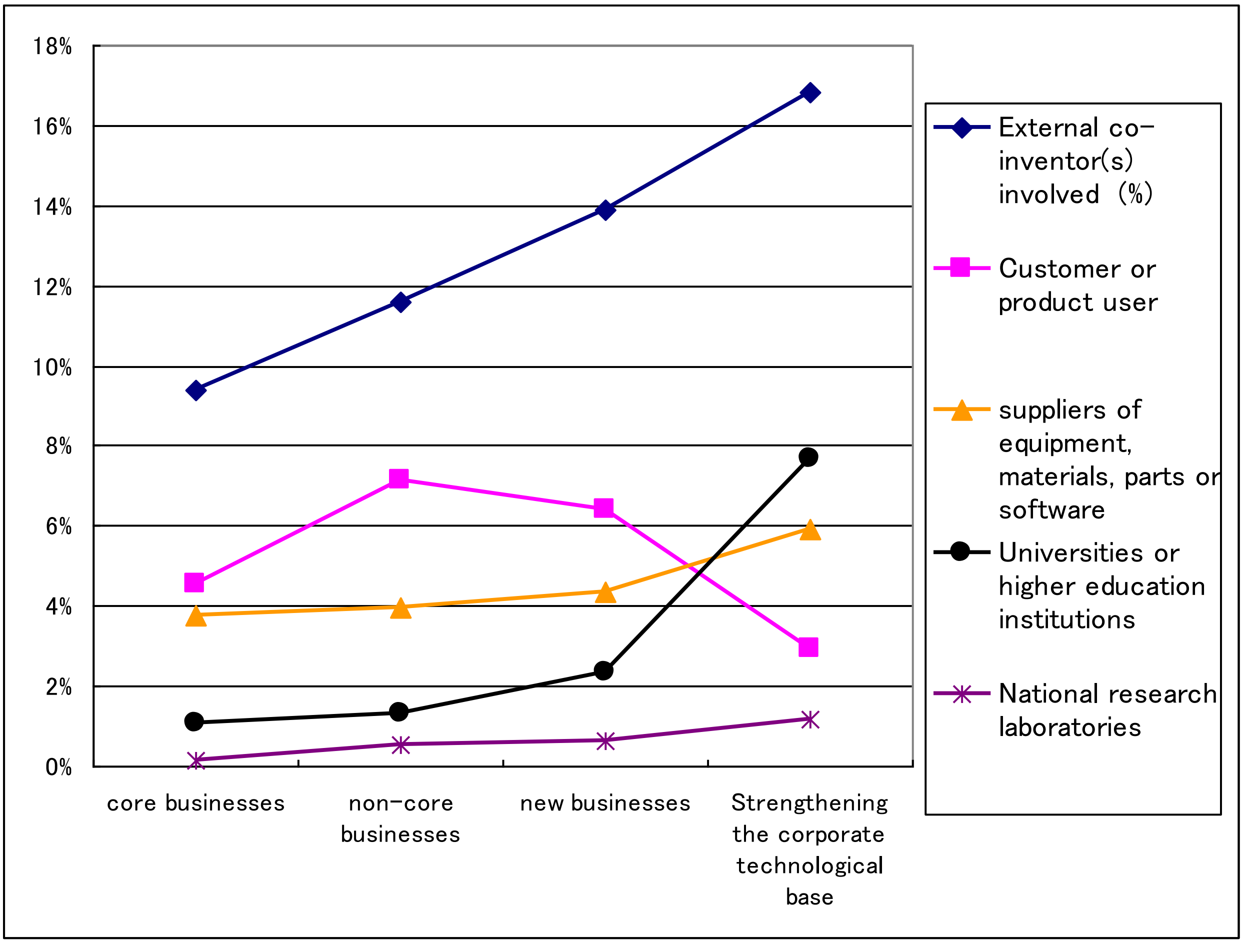


Note: “In-house utilization" indicates the ratio of inventions used in the products or production processes of the firm in question. “Top 25% in economic value” refers to the ratio judged by the inventors to fall in the nation’s economic top quarter of the technology accomplishments. “Importance of science and technology papers in the conception of invention” refers to the responses stating that such papers are very important in inspiring the invention.

5. Cooperation in R&D: Collaboration with users, suppliers and universities

The more that a firm diversifies out from its core business area, the more it needs to deepen its understanding of the market and to acquire new technological capabilities. Consequently, establishing cooperative relationships with external organizations in the area of R&D will become important. Figure 4 shows the percentage of patents with external co-inventors as well as their types by business objective. According to this, the R&D targeting the core business has the lowest probability of having external co-inventors (10% of inventions). The probability of having external co-inventors increases as the R&D of a firm targets non-core business, new businesses, and then strengthening the firm's technology base level, to a peak of 17%. Also, except for the R&D with the objective of strengthening a firm's technology base level, the most frequent collaboration is that with clients or product users, with the collaborations with suppliers of equipment, materials, parts, or software as the second most common. Users play an important role for R&D related to current business lines. In contrast, when corporations are conducting R&D with an eye to increasing their technology base level, they most often select researchers at universities or other higher education institutions as partners.

Figure 4 Frequency of external co-inventors by business objectives of R&D (%) (incidence of external co-inventors by types)



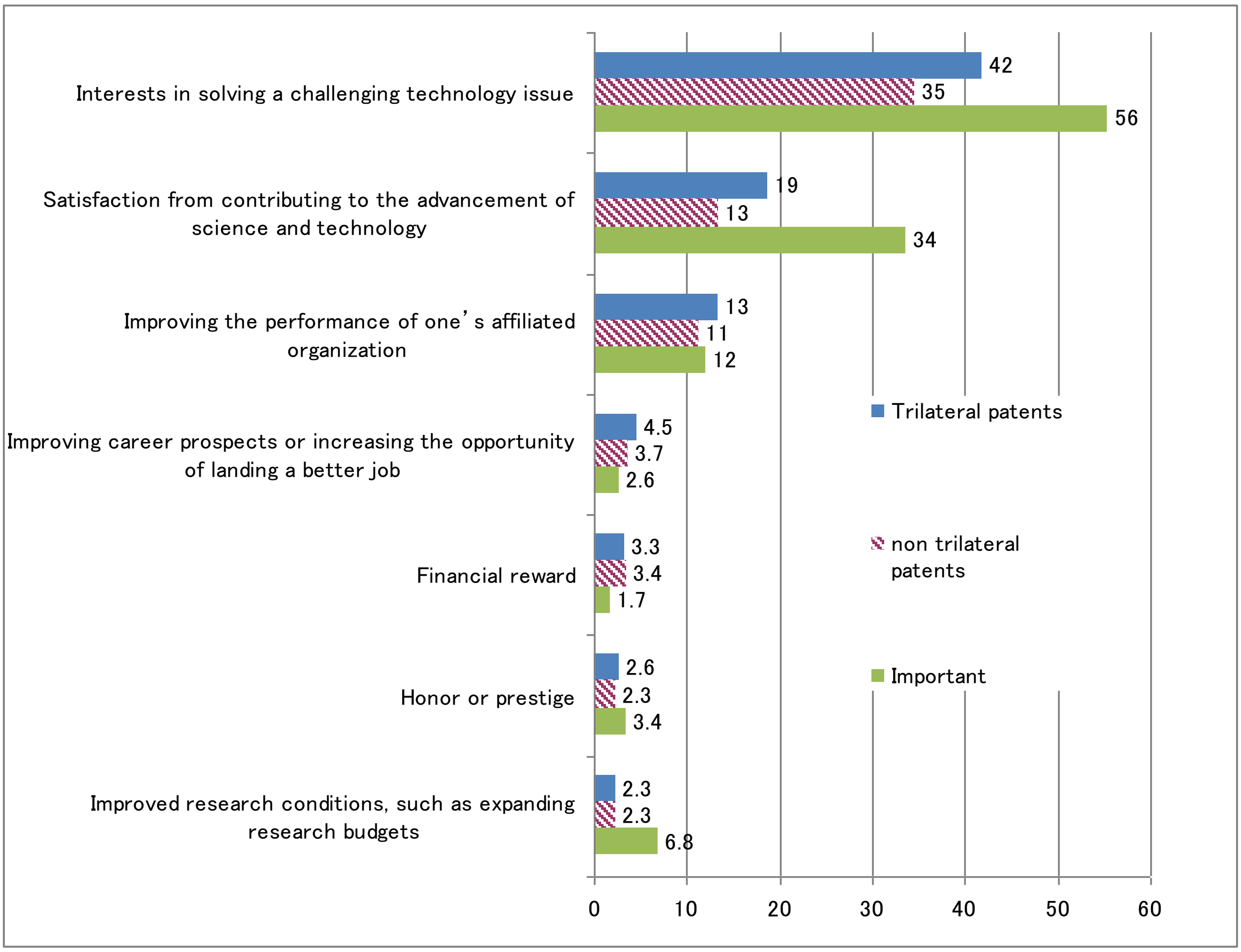
Note: Limited to R&D engaged by the inventors affiliated with firms.

6. Inventor motivation

Finally, we will address the inventor motivations, as depicted in Figure 5 (the share of the inventors who regard a particular motivation to be highly important). A look at the trilateral patents shows that the most important motivation for an inventor for the invention was the "Interest in solving a challenging technology issue," with 42% of respondents regarding this as very important. Next in importance, and representing 19% of the respondents, was the "Satisfaction of contributing to the advancement of science and technology." The third most important motivation was "Improving the performance of one's affiliate organization," indicating that organizational motivation (team success) is also important.

Those who regard personal economic motives (including improving career prospects, increasing the opportunity of landing a better job, financial reward, honor or prestige, and issues related to improved research conditions, such as expanding research budgets) to be "very important" as a motivation for invention is a relatively small minority. It is important to note that these motives do reflect the environments in which inventors work. For example, comparing the results for important patents in standard and key technology sectors and those for trilateral inventions, or those for trilateral inventions and those for non-trilateral inventions shows that both the "Interest in solving a challenging technology issue" and the "Satisfaction of contributing to the advancement of science and technology" is more important in former than in the latter. Such difference would be due to the fact that the technology level of R&D is higher for the former patents.

Figure 5 Inventor motivations (% of responses who regard each motivation to be very important)



7. Summary

The major findings of the inventors and inventing firms in Japan as uncovered by the RIETI Inventor Survey can be summarized as below.

(1) Diversity is high in terms of academic backgrounds of inventors, although the inventors engaged in producing high-quality patents tend to have higher academic backgrounds. The percentage of female inventors is extremely small.

(2) The bulk of inventions are "employee inventions". In addition, the firms with more than 250 employees account for approximately 90% of both triadic and non-triadic patents.

(3) Approximately 70% of R&D aim at strengthening existing business lines, approximately 20% to generating new business, and approximately 10% to strengthening the firm's long-term technology base which is unrelated to the business operations over the short term. Therefore, when generating new business is included, 90% of R&D is closely related to the current business strategy. An R&D targeting a firm's core business often finds the application in-house, while it involves less use of new scientific and technology knowledge in its conception. In addition, as might be expected, the more removed from a company's core business the R&D project becomes, the more important it becomes for a firm to forge cooperative relationships with external organizations.

(4) The strongest motivation for inventors for an invention is the "Interest in solving a challenging technology issue." Next in importance is the "Satisfaction of contributing to the advancement of science and technology." Only a minority of inventors rank the other motives such as personal economic motivations as very important.