Inventors & Invention Process in Japan: Some Implications on R&D Governance

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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. Efficient R&D governance within a firm is one of the key elements for this. However, the analysis of such an issue has been significantly constrained by our limited social science knowledge of the innovation process, including R&D objectives and motivations, knowledge sources, spillover, funding constraints on implementing R&D, constraints on utilizing results, and inventor motivations. In the following I would like to give some highlights of a recent survey of Japanese inventors conducted by the Research Institute of Economy, Trade and Industry (RIETI), which we hope would alleviate some of these information constraints. Findings of the survey are contained in the RIETI discussion paper "Japan's Innovation Process from the Perspective of Inventors: Summary findings of the RIETI Inventors Survey" by Sadao Nagaoka and Tsukada Naotoshi (in Japanese, 2007). The RIETI Inventors Survey relies partly on the PATVAL-EU survey undertaken in Europe from 2003 to 2004. (Cf. "Inventors and invention processes in Europe: Results from the PatVal-EU survey" by Paola Giuri, Myriam Mariani, et al., *Research policy,* Vol. 36, Issue 8, 1107-1127, 2007) The RIETI survey, conducted from January to June of 2007, yielded close to 5,300 responses and marked the first such systematic survey on R&D projects in Japan.

Approximately 70% of the sample consisted of inventions, the patent applications for which have been filed trilaterally—in Japan, the United States, and Europe (through the Europe Patent Office)—and which have been patented in the United States (*"triadic patents"* hereafter). Some 30% of the sample is non-trilateral patent filings (*"non-triadic patents"* hereafter), and with a very small sample (roughly 120 instances) collected from important patents in important new technology fields, such as nanotechnology and new materials, or from essential patents of standards. The majority of the patents claimed a priority year, or filing year, of between 1995 and 2001.

Let us take a look at who the Japanese inventors are. As shown in *Table 1,* the academic background of inventors is diverse. It has to be noted 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 necessarily depict a representative sample of inventors.

Of the inventors with triadic 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. The share of inventors with doctoral degrees is much higher for triadic patents than for non-triadic patents. And 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.

Table 1 Basic profile of surveyed inventors and their organizational affiliations

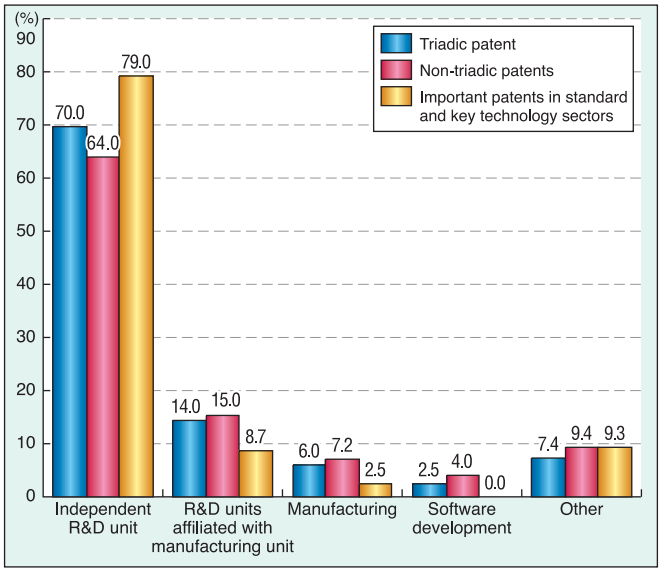
		Triadic patents	Non-triadic patents	Important patents in standard and key technology sectors	Europe
	Sample size	3,658	1,501	119	9,017
Academic background	University graduate (%)	85.9	86.7	94.2	76.9
	Doctorate (%)	12.4	8.7	28.6	26.0
	Female (%)	1.5	1.8	1.7	2.8
	Age (years old)	39.5	38.6	39.7	45.4
Organizational 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	22.6
	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	1.4

Note : Individual inventors who have no organizational affiliations are extremely low in number.
Source : Japan RIETI Inventor Survey

2. Where Do Inventors Come From?

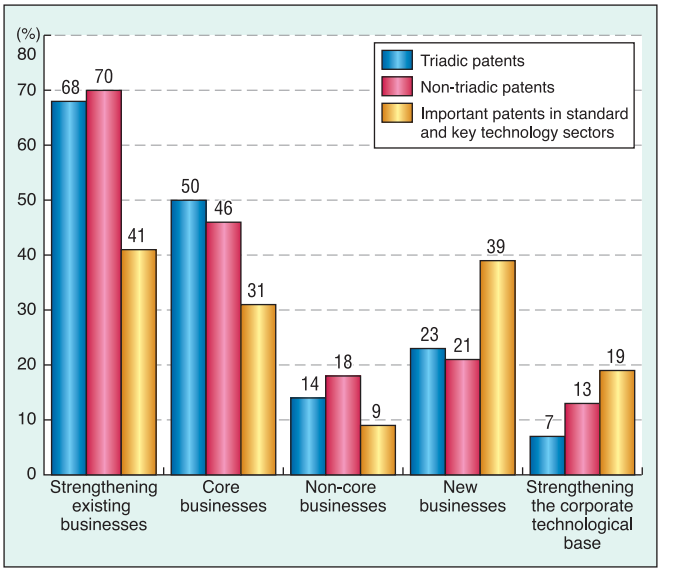
The governance issue will be absent if the inventor is self-employed. However, at the time of creating their inventions, 97% of inventors were employed by organizations, so that almost all inventions were "employee inventions." To put it another way, the share of individual inventors such as self-employed or student inventors is extremely low. In the case of employee inventions, there is a separation between a person who invents and another who invests the financial resources (including the salary for the inventor) for the invention, so that the governance issue inevitably arises. In addition, as indicated in *Table 1,* the inventors belonging to corporations with more than 250 employees made up

Chart 1 Inventors' functional affiliation



Note : The "Other" category includes design and engineering sectors.
Source : Japan RIETI Inventor Survey

Chart 2 Business objectives of the research that 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.
Source : Japan RIETI Inventor Survey

nearly 90% of all triadic and non-triadic patents, while employees at small to medium-size corporations were responsible for approximately 10%.

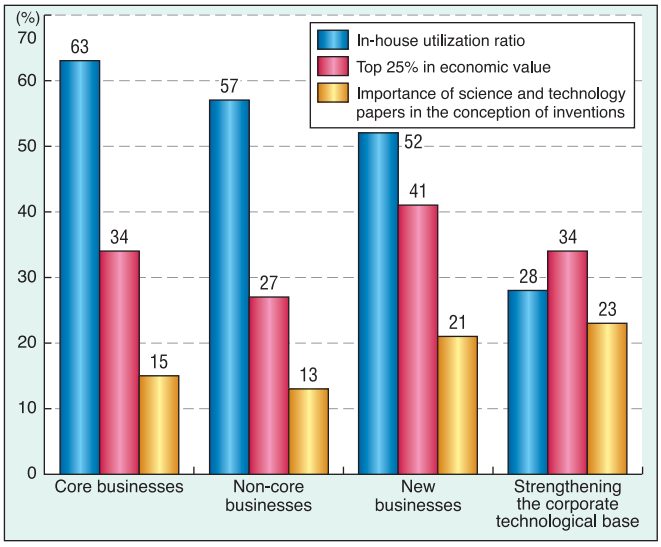
One central issue of R&D governance within a firm is where inventors work in the organization. If R&D activity is performed within a manufacturing unit or in a subunit of a manufacturing section, it is very likely that the R&D activity is closely monitored by the division that will use its outcome. However, if it is an independent unit, the governance problem would become more important. For triadic 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 within other groups such as a manufacturing unit, which logged a ratio of 14%. Thus, almost 80% of the inventors belong to an autonomous unit, or only 16% were composed of inventors affiliated with a manufacturing unit, a software development unit, and other units (such as from a design unit, etc.) not specialized in R&D. For non-triadic patents, 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.

3. Business Objectives of R&D

The fact that as much as 70% of the inventors belong to autonomous R&D units does not imply that they pursue R&D projects independent from the existing business lines of the firm. As shown in *Chart 2,* "strengthening existing businesses" accounted for 70% of the R&D projects, "starting new businesses" for roughly 20%, and "strengthening the corporate technological base not linked to the current business" accounted for only the remaining small part. The results for triadic patents and for non-triadic patents are similar. Therefore, when research for starting new business is included, it becomes apparent that 90% of the corporate R&D projects under the survey are 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. 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.

The R&D project directly related to the core business of a firm would have an advantage that the results can be easily utilized by the firm since it has complementary assets such as manufacturing facilities. Thus, even the research results that are relatively minor technological improvements could easily find profitable applications. At the same time, since such an R&D project aims at using the existing complementary assets, it can be potentially inhibited from making a technological leap. Following this line of thought, we would expect that there is a trade-off between in-house utilization possibility of the inventions and the use of knowledge in new scientific and technological papers for the conception of inventions. In fact, as shown in *Chart 3,* the utilization rate of the patents is the highest (63%) in the case of R&D for core business. At the same time, the level of the importance of scientific and technological papers 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 replied that science and technology journal 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 businesses. In addition, R&D for new businesses has substantially more valuable patents than R&D targeting core business, in terms of the share of the top 25% inventions.

Chart 3 Distinguishing characteristics of R&D for core business and for other business objectives *(triadic patents)*

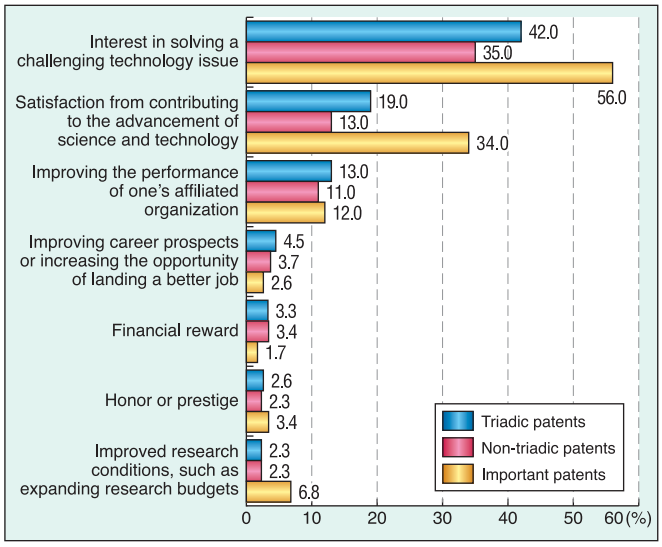


Note : "In-house utilization" rate indicates the ratio of inventions used in the products or production processes of the firm in question. "Top 25% in economic value" refers to the ratio judged by the inventors to fall in the economic top quarter of technology accomplishments. "Importance of science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

Source : Japan RIETI Inventor Survey

Chart 4 Inventor motivations

(% of responses who regard each motivation to be very important)



Source : Japan RIETI Inventor Survey

4. Inventor Motivation

Finally, we will address the inventor motivations for inventions, as depicted in *Chart 4* (the share of inventors who regard a particular motivation to be "very important"). A look at the data for the triadic patents shows that the most important motivation for an inventor for the invention was the "interest in solving a challenging technology problem," with 42% of the respondents regarding this as very important. "A challenging technology problem" is often defined in the context of business challenges for a firm, so that such motivation is congruent with the business objective of a firm. Next in importance, and representing 19% of the respondents, was the "satisfaction of contributing to the advancement of science and technology." Such motivation is not necessarily in conflict with the business objective of a firm. In particular, the patent is granted only to the inventions that are novel and include an inventive step. Thus, those who are at the frontier of science and technology could presumably better contribute to inventions in some technology areas. The third most important motivation was "improving the performance of one's affiliate organization," indicating that organizational motivation (team success) is also important. On the other hand, those who regard personal economic motives to be "very important" as a motivation for inventions are a relatively small minority. Such personal motives include 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.

5. Conclusions & Discussions

Most Japanese inventors work for organizations and are employed by a large firm with more than 250 employees. Furthermore, around 70% work in autonomous R&D units, according to a newly implemented inventor survey in Japan. These facts indicate the existence of a potential governance problem of R&D. Inventors often do not directly take risk and work in the autonomous units, which are independent of the units using the results of R&D.

However, it is also found from the survey that 70% of the R&D projects are designed for enhancing the existing business of a firm and one quarter of them for creating a new business. Only 8% aim at enhancing the technology base of a firm or at creating new seeds. Thus, the room for R&D projects to diverge significantly from the business objective of a firm seems to be relatively limited. Furthermore, the inventor motivations for inventions suggest that inventors have motivations not identical but significantly coherent with the business objective of a firm, such as high regard for solving a challenging technical problem and improving the performance of one's affiliate organization. Only a minority of inventors rank the other motives such as personal economic motivations as very important.

Thus, while R&D activity is significantly decentralized within a firm in Japan, the congruency of such activity with a business objective seems to be relatively high, although we cannot deny the possibility that some R&D projects have been pursued for the project's sake rather than for the business's sake. I would like to point out that there is a possibility that the R&D of Japanese firms is too much targeted at their current business. JS

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