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Exploring collaborative R&D network: some new evidence in Japan

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Abstract

The growing importance ascribed to science and technology has created new demands on university research to contribute to the solution of social problems. In such background, there is widespread consensus in Japan today that collaborations between Japanese universities and industry should be improved in order to meet the growing expectations in globally competitive marketplace [Sci. Public Policy 26 (2) (1999) 113]. Initially advocated by Monbusho of Japanese government, a number of systems have been established and enforced to encourage collaborative R&D among researchers of universities, industries, and government laboratories. However, there appears to be lack of systematic evidence to enable a proper examination of this subject in Japan so far.

This paper analyzes the latest changes of collaborative R&D network, and attempts at providing some new and unique empirical observations for debates and discussions on this emerging dimension in Japan. It is based on as many as 7029 projects data under "Joint-Research with Private Sector" system of Monbusho. This study shows, the emergence and growth of different modes, and identifies key features in today's Japanese collaborative R&D network. It provides some observations for reference to policy-makers and researchers in Japan and abroad, and may serve as a foundation for further science and technology (S&T) policy and innovation management research in Japan.

Keywords: R&D network; University–industry collaboration; Monbusho of Japan

1. Introduction

Traditionally, there were not many collaborative R&D in Japanese universities. Most research activities were done at small-scale by individual researchers, teams of researchers, or at research laboratories under supervise of few professors or associate professors (Wen and Kobayashi, 2000a). However, the collaborative R&D among Japanese private firms, and public laboratories to some extend, have been active since the World War II. One of the significant phenomena was the nation-wide establishment of Research Association, which was well accepted by Japanese society from its early period. It took various forms and increased especially after the enforcement of "The Research Association for Mining and Manufacturing Technology Law" in May 1961. The establishments of such facilities increased to 32 in 1985–1989, or some three times more than that in 1961–1965, see Table 1 (Miyata, 1997; Wen and Kobayashi, 2000a). Among them, "The VLSI Technology Research Association", led by Ministry of International Trade and Industry

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Table 1
Statistics of research associations for every 5-year period[a]

Year	1961–1965	1970–1974	1975–1979	1980–1984	1985–1989
Numbers of newly established research associations	11	17	14	34	32
Average numbers of jointed firms	16.3	9.76	13.5	13.3	18.4
Average time period (years)	8.36	7.68	10.14	7.79	5.66
Yearly budget per research association (million ¥)	52.4	1776.7	3410.8	802.1	1030.1
Percentage of aid from government (%)	22.1	30.9	44.4	75.1	77.4

[a] Source: Miyata, 1997.

of Japanese Government (MITI), is well known for its significant contributions to the development of Japanese semi-conductor technology, and its leading role in bringing overall Japanese industry into a relatively strong competitive marketplace worldwide.

Until early 1980s, in addition to the boom of establishing research laboratories and conducting in-house researches, Japanese private firms were more willing to perform joint researches with US universities, instead of domestic ones. Under such environment, it was widely recognized that Japanese private firms have higher research capability than Japanese universities. According to a survey conducted by Japan Association of Corporate Executives (KEIZAI DOYUKAI) on research levels of industry and universities, comparing with only 8% of respondents answered with "universities have higher research level", up to 58% of respondents answered with "industry has higher research level" (Keizai Doyukai, 1987).

However, the collaborative R&D activities in Japan have changed rapidly in recent years. With the increasing diverse demands from the industry, Japanese government, such as Ministry of Education, Science, Sports & Culture (Monbusho) has established various systems since early 1980s, aiming at maximizing the university's role in responding adequately to these demands, through the utilization of accumulated achievements and research facilities (Monbusho, 1996; Wen and Kobayashi, 2000b). In addition, the multi-funding system, such as grant-in-aid funding system, has adapted to Japanese universities recently. Consequently, these dedicated systems have become an important and fairly successful organizational vehicle within the Japanese S&T policy framework, and generated great impacts on university–industry (UI) relation and innovation system (Wen and Kobayashi, 1998, 2000a).

Firstly, this paper overviews the major systems on UI collaboration in Monbusho.

Then, this paper examines recent changes in Japanese collaborative R&D network, and explores how these systems affecting UI relation, by using our bibliometric measures. After the presentation of results, we identify key characteristics and provide explanations for some emerging phenomena in latest collaborative R&D network.

2. Data set and methodology

In order to provide realistic analysis and to encompass the multiple aspects of collaborative R&D, we conducted comprehensive survey, based on the complete data set of joint research projects under "Joint Research with Private Sector" system from 1983 to 1993. The richness of the data provided detailed and concrete explanations to recent UI collaboration. In addition, extensive literature reviews served as complementary resources to our research.

The following data and information have been collected and compiled.

1. "Reports of the Survey for Research and Development", by Statistics Bureau of Management and Coordination Agency of Japanese Government (SBMCA), 1967-1996.
2. Up to 7029 performed joint research projects under "Joint Research with Private Sector" system, by Monbusho, 1983–1993.
3. "The Directory for Japanese National Experimental & Research Organizations", by Science and Technology Agency of Japanese Government (STA), 1995-1998.

4. "The Ranking of Corporation Income Declaration" (HOJIN SHINKOKU SHOTOKU RANKING), by Diamond Inc., 1997.
5. Some other published sources, such as "The Directory of Japanese Firms", by Nihon Keizai Shimbun, etc.

3. Overview of systems on university–industry joint research in Monbusho

Monbusho is responsible for the promotion of "Education," "Sports," "Culture" and "Science," the latter of which encompasses natural and social sciences and the humanities, including associated applied research. It plays two main roles in the promotion of science: (1) preparing the basic conditions for scientific research, and (2) encouraging the research which is creative and advanced and of social importance (Monbusho, 1997).

Among the 305 institutions have Ph.D. programs in Japan, research excellence is heavily concentrated in a small number of universities, see Table 2. With a few exceptions, most highly regarded research universities are National Universities, which are funded and controlled by Monbusho (Monbusho, 1997, 1998; Kneller, 1999). Under such environment, collaboration between national universities and industry is regarded as one of the central elements, when building, discussing, and examining collaborative R&D network in Japan.

Comparing with other government departments, Monbusho started efforts to stimulate UI collaboration relatively early, and launched a series of systems in 1980s onward. Tables 3 and 4 summarizes the major collaboration-related systems established so far. Among them, particularly, "Joint Research with the Private Sector" system is widely accepted by both industries and universities, and it serves as our research subject.

In addition, Japan Society for the Promotion of Science (JSPS) also plays a role in promoting UI collaborations. JSPS is a quasi-governmental organization that conducts various programs in line with national S&T policies to promote science. It was originally established in 1932 as a private foundation with an imperial grant, and was classified as a "special juridical person" and placed under the jurisdiction of the Monbusho in 1967. It now operates a wide range of programs to promote scientific activities in Japan and abroad, including research fellowship, international exchanges and university–industry collaboration (Monbusho, 1997).

Table 2
Breakdown of Japanese university and graduate schools, 1997[a]

Number of universities		With graduate schools (Ph.D. courses)
National	98	98 (79)
Public	57	37 (22)
Private	431	285 (204)
The university of the air	1	0 (0)
Total	587	420 (305)

[a] Source: Monbusho, 1997.

4. Results from university–industry collaboration network analysis

It is apparently important to examine policy's outputs and reveal actual patterns and features of collaborative R&D network in Japan. But unfortunately few such evidences are available so far. This section aims at providing new conceptual and empirical findings on such issue.

4.1. Examining the growth of university–industry collaborative R&D

The first level of analysis was to examine the overall changes in collaborative R&D, under "Joint Research With Private Sector" system. The distribution of involved private firms[1] and national universities,[2] which yielded 7029 joint research projects for the years of 1983–1993, was shown in Fig. 1. The increasing trend reflects the constant growing initiatives and supports, from universities and private firms.

Likewise, the increasing trend was observed in industry. In terms of newly entered firms,[3] the total number accumulated to some 1700 in 1993, and more than 200 firms entered the joint research system for

[1] Excluding local governments and non profit-organizations.
[2] Number cannot keep increasing, due to the limited number of national universities in Japan.
[3] Firm, which entered into such collaborations that had never done that before.

Table 3
Systems to encourage the collaboration

Measures		Contents
Measures extended by the university side	Joint research with private sector	This system was created in 1983, by the Monbusho to encourage researchers at national universities to conduct joint research in their laboratories on an equal footing with researchers from private companies on topics of common interest. Research funds are also received from the participating companies. Joint research is being actively carried out particularly in such fields as materials development, equipment development, software, civil and architectural engineering, biotechnology, and electronics. Patents generated from the joint research are owned jointly with the participating companies and the companies (or persons designated thereby) receive patent-licensing priority for up to 7 years. (FY 1997 budget[a]: ¥ 5.5 billion)
	Commission research	This system enables instructors and researchers employed by national universities to conduct, on a contract basis, research commissioned by private companies, government institutes and other external bodies. The cost of such research is borne by the external body. The consignor (or his designee) receives patent licensing priority for up to 7 years. (FY 1997 budget: ¥ 41.9 billion)
	Commissioned researchers	This system provides researchers and engineers employed by private companies the opportunity to conduct graduate-level research in national universities. This system, which had been formerly limited to scientific and engineering fields, was opened up to all academic fields including humanities and social sciences in 1989. (FY 1997 budget: ¥ 0.5 billion)
	Centers for co-operative research	To promote full-scale co-operation with the private sector through joint and commissioned research, the Monbusho has been establishing centers within the national universities since 1987
Measures extended by industry side	Grants and endowments	National universities are authorized to receive donations from private companies and other outside organizations for promoting scientific research and educational activities. The donations are utilized flexibly in line with the donors' objectives. (FY 1997 budget: ¥ 52.8 billion)
Other measures	Joint research by Monbusho grants	Under the category of "Development Scientific Research" of the grants-in-aid program for scientific research (developmental and applied research with a high potential for practical use), joint research is encouraged between universities and industry
	JSPS program	JSPS promotes co-operation between industry and academia, and between basic research and applied developmental research, by providing for where researchers from industry, academia and government sectors can discuss various problems. It has established an "Advisory Committee on University–industry Research Activities" consisting of eminent members of academia and industry to study the fields of research which have a high potential for advancement through university–industry co-operation JSPS also creates industry-industry co-operative research committees on specific themes, through which researchers from the two sectors have an opportunity to discuss basic and technological problems. (FY 1997 budget: ¥ 333 million. Fifty such committees are operational.)

[a] The budget is based on survey to faculty members in previous year and adjustment by Monbusho. It is approximate amounts that universities expect to receive. Source: Monbusho (1996, 1997).

Table 4
Systems to encourage the collaboration

System	Organizations concerned	Participating researchers
Joint research with private sector	University[a]	University[b]
	Industry[c]	Industry[d]
Commissioned research	University[a]	University: faculty members
	Industry[e]	Industry: no researchers
Commissioned researchers	University: national universities/inter-university research institutes	University: faculty members
	Industry[e]	Industry[d]
Grants and endowments	University[a]	
	Industry: private companies, etc., excluding local governments	

[a] National universities/technological colleges/inter-university research institutes, center for national university finance, etc.
[b] Faculty members, part-time lecturers or technicians.
[c] Private firms, local governments, non-profit organizations, quasi-governmental juridical bodies, excluding national organizations, private individual researcher.
[d] Researchers dispatched to university, while status guaranteed in industry.
[e] Private firms, local governments, quasi-governmental juridical bodies, non-profit organizations, private individual researchers, national/international organizations; Source: Monbusho, 1996.

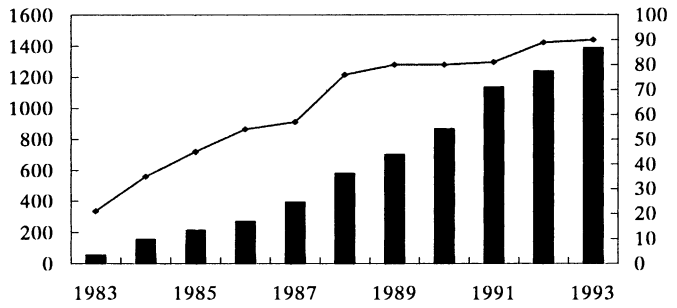

Fig. 1. Numbers of joint-research projects & joint-research involved universities.

the years 1990–1993, see Fig. 2. This fact indicated that, in addition to those firms conducted joint research projects repeatedly, more and more new firms, which entered into the collaborations that had never done that before, started to use the joint-research system and university resources. This phenomenon showed that such system already widely penetrated in industry community, and the changing attitude of industry toward university.

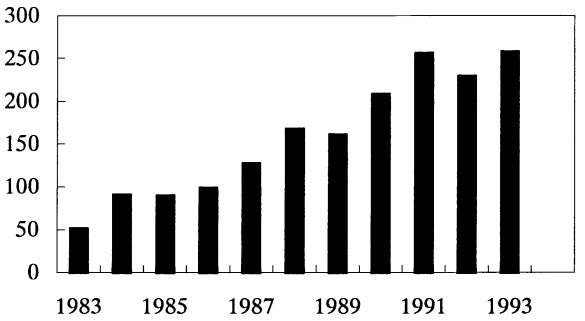

Fig. 2. Distribution of newly entered firms.

Fig. 3 depicts the distribution by research fields, in terms of numbers of joint research projects. Besides the constant increases in all major fields, higher percentages were witnessed in some particular fields, such as new materials (23.4%) and apparatus development (20.4%). By contrast, the lower percentage of 10.7% in the field of software was observed as well. It virtually started to decrease, even slightly, in 1994, while percentages in other fields kept increasing. This result may reflect the industry's viewpoint toward university's research competence. The higher percentage suggests more demands, the lower percentage

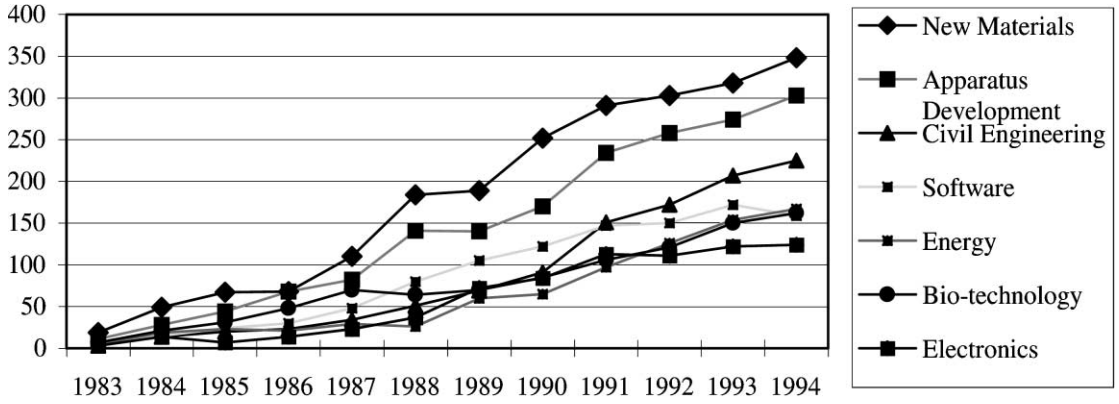

Fig. 3. Distribution of joint-research project number, by research fields.

on the other hand, implies little demands for collaboration with universities from industry in such fields. This analysis provided additional supporting evidence, in terms of UI collaboration, on existing opinion of lower competitiveness in software research in Japanese universities.

4.2. Exploring features of university–industry collaborative R&D network

Fig. 4 showed the results by analyzing joint research projects (in terms of numbers) performed by one (1) newly jointed firm and one (1) university, by one newly jointed firm and two (2), by three (3), and by four (4) or above universities. In 1983, there were 21 newly entered firms collaborated with four (4) or above universities, while 18 newly entered firms collaborated with one (1) university (noticing different scales in *Y*-axis). In 1993, however, there were more than 250 newly entered firms collaborated with one (1) university, which was overwhelmingly more than the number of newly entered firm (only 2) collaborated with four (4) or above universities. The significant increase reflected the fact that universities were becoming important resources for innovations in industry; and revealed the features that newly entered firms tended to collaborate with more universities when "Joint Research With Private Sector" system started in 1983, but kept changing afterwards. This analysis showed clearly how collaborative R&D network was shifting from the pattern of one (1) firm versus multiple (4 or above) universities to the pattern of one (1) firm versus one (1) specified university. In addition to interests in collaborating with academic institutions beyond regional boundary, Japanese private firms were increasingly tended to collaborate with local academic institutions. It reflected recent UI relation changed to be more localized, although the joint research system was originally established to encourage more UI collaboration at wider scope.

In order to analyze actual patterns of collaborative R&D network, illustrations were given according to the degree of involvement, defined as the calculations of average numbers of performed joint research projects.

Results of analysis are shown, respectively, in Fig. 5 for the distribution of universities with their firm counterparts, and in Fig. 6 for the distribution of firms with their university counterparts. The pattern in Fig. 5 shows two distinct clusters. Firstly, the cluster of top Japanese academic institutions, including top general national universities such as Tokyo University, has predominantly been in collaborative R&D network. For example, of the 1740 total firms and 90 total universities involved in the joint research system in 1983–1993, some 8% (142 firms) collaborated with Tokyo University. The next highest university of origin was Osaka University at 7%. This result suggests that the prestigious universities, or the quality of faculty, continued having significant impact on the formation of collaborative R&D network in Japan. In addition to these top general universities, quite a few universities, such as The Toyohashi Technical University and Tokyo Agriculture University, were among the major

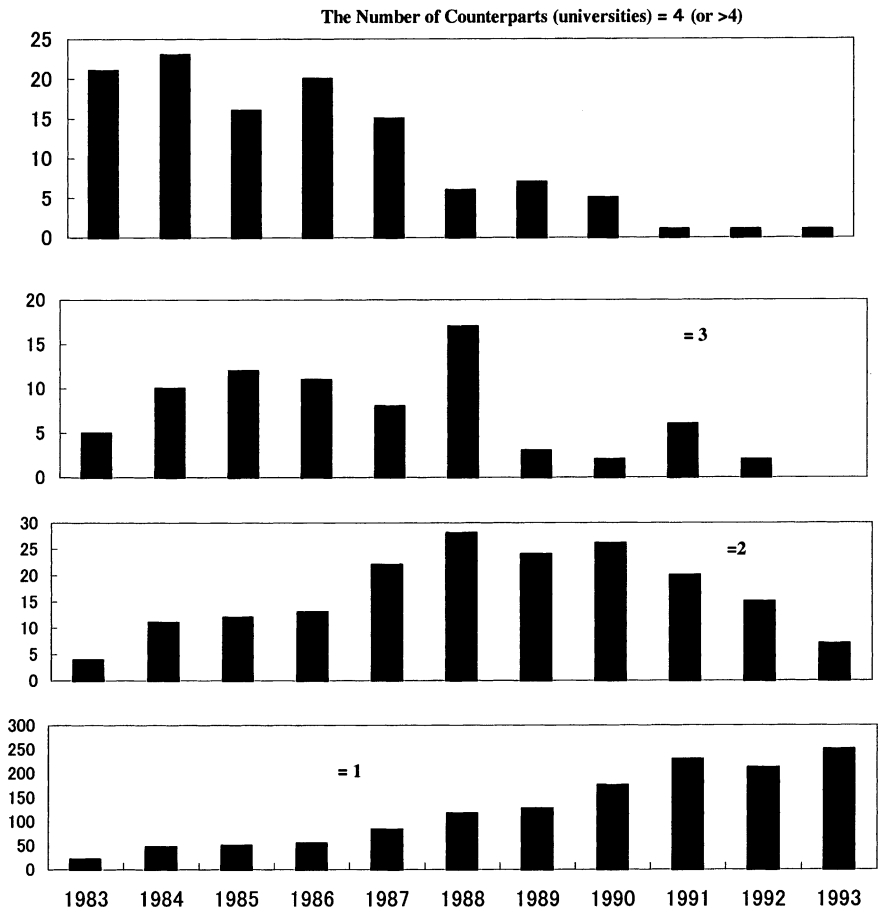

Fig. 4. Distribution of newly entered firms, by number of counterparts (universities).

players by collaborating with relatively large numbers of firms (70), respectively. This was considered, partially, that these universities entered into the system from the early time. In case of The Toyohashi Technical University, a local organization, called "The Toyohashi Science Core", was set up more than a decade ago. Joint research activities were promoted under such local organization, and, consequently, the number of joint research projects was accumulated afterwards.

In contrast to above cluster, it was interesting to note that a group of local universities, such as Hirosaki University (in Aomori Prefecture) and Akashi College of Technology (in Hyogo Prefecture), had considerable presence in the formation of collaborative R&D network, by collaborating repeatedly with limited specified local firms (in terms of average numbers of performed joint research projects). This fact indicates that a hanging/dangling cluster, represented by local universities, already got into shape in today's collaborative R&D network, in addition to the major university-predominated cluster.

Next, we explored the distribution of private firms with their university counterparts. The results of this analysis are plotted graphically in Fig. 6, in terms of the average number of performed joint research projects with universities and the number of counterparts (universities). The complex network was broken down into three major clusters. The first one comprised the major Japanese multinational firms, such as Hitachi Co. Ltd., Toshiba Co. Ltd. For example, of the total 90 universities took part in the joint research

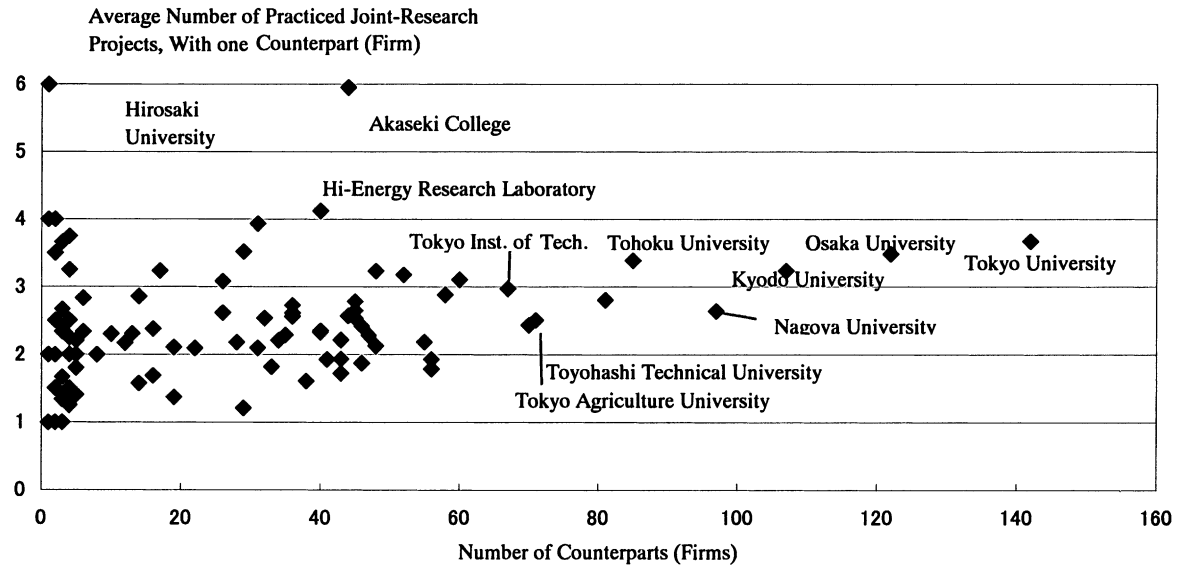

Fig. 5. Distribution of universities, by number of counterparts (firms) and average number of joint-research projects.

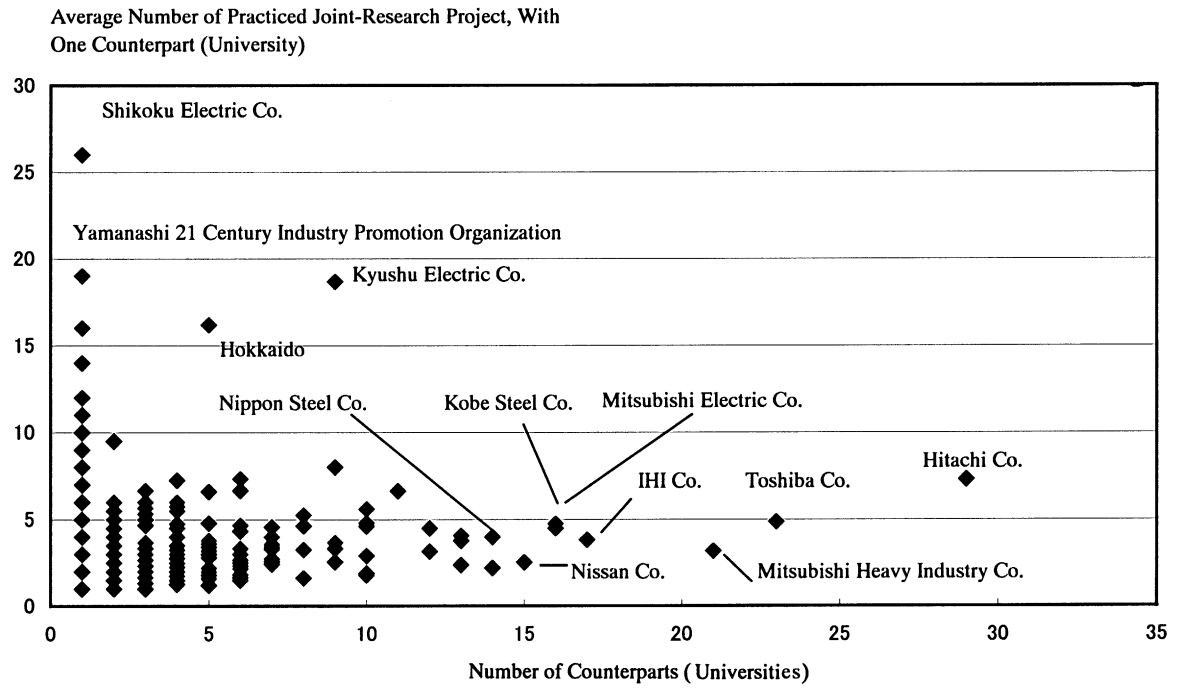

Fig. 6. Distribution of firms, by numbers of counterparts (universities) & number of joint-reseaerch projects.

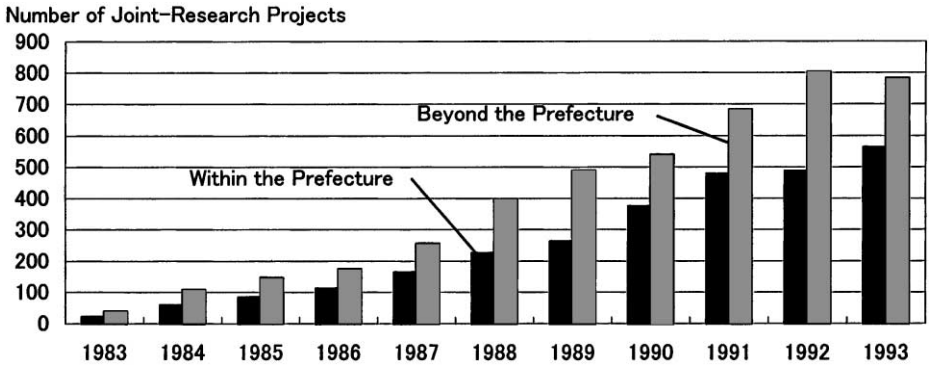

Fig. 7. Distribution of joint-research within and beyond the prefecture.

system in 1983–1993, some 32% (29 universities) and 26% (23 universities) collaborated with these two companies. These large innovative firms presented significantly at nation-wide scale. This phenomenon reflects the changing attitude of Japanese private firms toward Japanese universities, and the shift from traditional in-house research mode to collaborative mode with universities in Japanese industry (Wen and Kobayashi, 1998). By further analysis, this result can in part be explained as that many of these large firms have regional R&D establishments or laboratories that contributed to the formation of such pattern.

On the other hand, the most active representatives of the second cluster were the major local private firms, such as Shikoku Electric Power Co. Ltd. (in Shikoku Prefecture), Yamanashi 21 Century Industry Promotion Organization (in Yamanashi Prefecture, also called The Third Sector). This collection of firms collaborated intensively and repeatedly with limited number of local universities, reflecting lasting demands for joint researches with local universities. In other words, the universities in these areas can generate relatively satisfied research outputs to meet needs of innovation in local private firms.

The above findings, in Figs. 5 and 6, empirically showed noticeable similarity in today's collaborative R&D network in Japan: the major multinational firms and top national universities have presented and have greater impacts in the whole country, while the local counterparts have emerged as important local players. Obviously, these results can raise questions concerning R&D strategies and UI collaboration strategies that both Japanese firms and universities pursue.

We next conducted analysis to find out patterns and features, in terms of geographic dispersion. Results were shown in Fig. 7, measured by numbers of joint research projects within the same prefecture and beyond the prefecture boundary. In either case, steady increases were observed. The rapid increase, under the category of "Beyond the Prefecture", indicated that collaboration was getting more and more active across the prefecture boundaries. It is not rare phenomena for individual researchers from different universities, or private firms, or different prefectures, to group temporarily and do joint researches in Japan, particularly for more complicated projects, such as projects in priority research fields. Such kind of collaborative network extends gradually among individuals, organizations and sectors, and is of particularly importance in Japan, due to its geographic proximity. It usually takes less than 3 h to Tokyo from most local areas, and more than 1/3 university teachers concentrate in Tokyo and Tokyo Metropolitan area (Wen and Kobayashi, 2000a,b). The feature of proximity makes joint researches possible and easier to be performed by researchers from different locations. Therefore, joint researches among universities and firms around Tokyo Metropolitan area contributed significantly to the increase of transprefecture collaborations, and the formation of collaborative R&D network.

Next, we were concerned to determine the actual patterns for the entire country, in terms of prefectures. In order to analyze the locality of universities and private firms, we calculated numbers of performed joint research projects in each prefecture. The results were plotted graphically in Fig. 8. A tense cluster, including

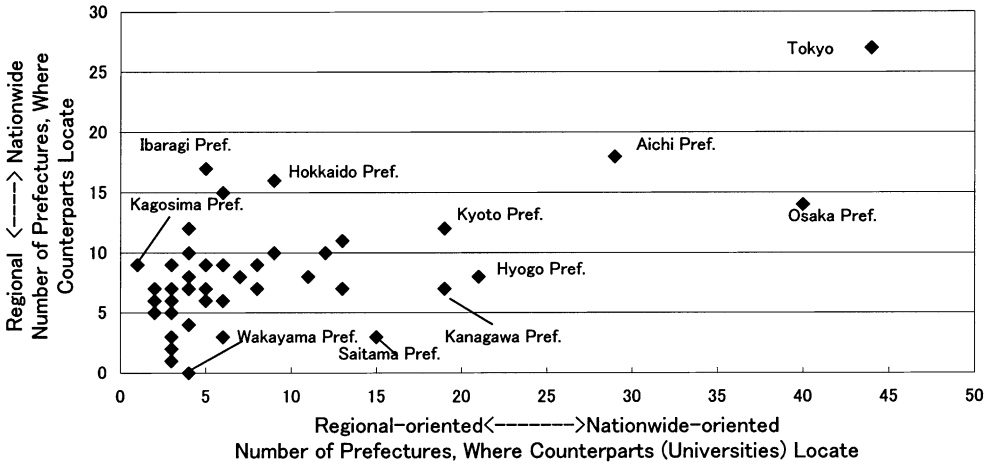

Fig. 8. Distribution of firms, universities, by prefectures.

Wakayama and Kagoshima Prefecture, which concentrated around origins of co-ordinate axes, displayed those prefectures with joint researches performed mostly within same regions. In contrast, another loose cluster, including Tokyo Metropolitan area and Osaka Metropolitan area, represented prefectures in which universities and private firms performed more collaboration with counterparts in other prefectures, or transprefectures. Combining findings in previous analysis, such as Fig. 5, this result convinced us further that prestigious universities with wider research fields and good faculty quality in metropolitan areas were more "attractive" to private firms in the entire country. Meanwhile, major private firms, with subsidiaries nation-wide while positioning headquarters and major facilities in metropolitan areas, were more likely to be involved in collaborative R&D with universities in respective regions.

In addition, we can use similarly approach to identify actual patterns in particular prefecture for particular private firm and/or academic institution, in terms of performed joint research projects.

5. Conclusions and future researches

UI collaboration is one of the current Japanese S&T policy issues. This study is one of the first studies that provide empirical evidence in such domain from the perspective of Monbusho, in terms of joint research projects. The overall findings of this study suggest that Monbusho policies, "Joint Research with Private Sector" system in particular, have generated profound impacts on recent innovation system in Japan, since its enforcement in 1983. Results from this study, hopefully, can shed some new lights on policy debate. Specifically, according to the analysis, results lend supports to the hypothesis that academics and industry became more open-minded, more favorably exposed toward collaboration in the 1990s than in 1980s and earlier. And the collaborative R&D is shifting from the traditional in-house-oriented, private firm consortium-led mode to UI collaborative, cross-sector, transprefecture mode.

With respect to the finding of constant increase of newly entered firms, our interpretation is increasing demands and opportunities for collaborations in both university and industry sectors. It also reflects the changing attitude toward universities from Japanese private firms. The analysis by research fields yields additional evidence on research capability in Japanese universities, from the viewpoint of collaboration.

Our results pertaining to distributions of universities and private firms indicated that prestigious universities and major firms are the most active participators in joint research, and play significant role in the formation of collaborative R&D network for the entire country. These major players represent nation-wide, and continue to contribute primarily in Japanese innovation system. However, another finding

of interest is the existence of loose/dangling regional/local sub-network for collaboration, represented by universities and firms within some specific prefectures. Our interpretation for this finding is the heterogeneous shift from nation-wide scale to regional one, and regional universities are emerging as an important part in Japanese innovation system.

Although, the unquestionable achievements have been made under Monbusho policies, the Japanese government keeps seeking opportunities to fill impetus to push its sluggish economy. Consequently, the UI collaboration was positioned as one of the R&D priorities in the country's innovation system, and the enforcement of multi-funding systems, such as *Teian-koubo-gata* scheme, were witnessed (Wen and Kobayashi, 2000a,b). In particular, the Science and Technology Basic Law was enacted in 1995, and the Science and Technology Basic Plan was formulated by the government based on the Law in 1996. Under both the law and the plan, the R&D investment was required to be doubled to a total of ¥ 17 trillion by FY 2000 (STA, 1995, 1996; Monbusho, 1997). Under such environment, the continuing dynamic changes of UI collaboration in Japan can be expected. And, such changes lead us to question their impacts on R&D organizations and management in Japan. These issues remain as our next research focus.

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