tution and other overseas research bodies have already expressed their intention to join the RWC partnership.

The other mode of international participation is to become research subcontractors of the RWC partnership. Potential subcontractors submit specific (3-year or 5-year) research proposals to the RWC partnership and they are screened through the standard review process conducted by the RWC evaluation committee. The request for proposals is being made public in October 1992 and the deadline for submission is the end of December 1992.

A facility to promote the international participation and collaboration is also being formed: The RWC international network. This global computer network allows European partners and subcontractors to use the computing facilities and databases for research information available at the RWC Research Center located in Tsukuba City. Although the level of access to the research information depends on the mode of participation and collaboration, this network is expected to accelerate the mutual exchange among the RWC partnership members and subcontractors international as well as domestic.

The major concern in allowing international participation and collaboration was how Japanese intellectual property right (IPR) law might affect the collaborations. In essence, the Japanese government committed itself to particular agreements stating that the international joint research related to industrial technology will benefit the foreign corporations. According to this commitment, it has become possible to reduce to zero or to a small amount the royalty of the patent rights and utility model rights that needs to be paid for the international joint research. The extent of the reduction is determined for each patent with an approval obtained from MITI. Furthermore, noncommercialized research-phase software and patents can be transferred to third parties with no restrictions. In fact, MITI made it clear that even the software developed for the Fifth Generation Computer Project was to be made available at no cost.

The RWC project is Japan's effort to contribute to basic science and technology for information processing, not to advance the country's own technology alone. The program is generously long-termed, very oriented toward basic research, and reasonably well funded. The project structure is internationally open as much as MITI possibly allows. The research goals and public stance are rather low-key and not inflated in contrast to the Fifth Generation Computer Project, but the success or failure of RWC will surely draw the attention of the world.

REFERENCES AND NOTES

1. Based on an interpretation of a 1988 U.S.–Japan science agreement that requires that large-scale international projects be coordinated through government channels, U.S. researchers can at present only participate in the optical computing fields through the coordination of the two governments, and cannot participate in any other parts of RWC.

Public and Private Support of Basic Research in Japan

Yukihiro Hirano

Basic research in Japan is characterized by increased efforts on the part of Japanese private companies but a generally poor research environment in the public sector.

Private companies' share of basic research expenditures in Japan has increased from 18% in 1978 to 39% in 1990 (*1*) (see figure), whereas the corresponding value for the United States was 20% in 1989 (*2*). It follows that any examination of Japanese basic research activities should pay due attention to the contributions of private companies.

The trend toward an increase in basic research undertaken by Japanese companies reflects a more general expansion of the relative importance of the research and development (R&D) activities of Japan's private sector. In 1978, the government's share of Japan's total R&D funding stood at 28.0% but, by 1990, this figure had dropped to only 16.5% of the total (*1*). This share is much smaller than that for advanced Western nations. For example, the government shares of R&D funding are 46.1% in the United States (in 1990), 49.9% in France (in 1988), 36.7% in the United Kingdom (in 1988), and 32.5% in West Germany (in 1990) (*3*). Although a large part of the gap is explained by the difference in defense-related R&D expenditures, even after taking this into account, Japan remains conspicuous for its low level of government funding of R&D.

The science and technology policy circle in Japan has taken these facts to support the idea that Japan's government investment in R&D falls short of the standards that should be adopted by a leading industrial country. They argue that an expansion of public sector spending on R&D and, in particular, basic research would be in the interest of the public.

Japanese companies have increased their own in-house basic research activities since about 1980. Expenditure on basic research, as a proportion of total R&D expenditure, increased from 4.6% in 1979 to 6.4% in 1990 (*1*). The corresponding ratios for Japan's Western counterparts are 3.9% in the United States (in 1990), 4.9% in West Germany (in 1983), 4.5% in France (in 1988), and 2.5% in the United Kingdom (in 1981) (*3*). Therefore, Japanese companies are more eager to pursue basic research than their counterparts in the advanced Western countries. As evidence of this trend, many Japanese companies have established new institutes for basic research since the middle of the 1980's. Big firms such as Hitachi and NEC constructed new facilities for basic research.

Why are Japanese companies so eager to conduct basic research? Corporate executives believe that fundamental knowledge is of increasing importance to their business. They are now trying to shift their business strategies away from low-profit, large-sales commodities towards high value-added commodities supported by advanced technologies. Future advanced technologies cannot be fully developed without a basic understanding of fundamental phenomena and of the working mechanisms of natural laws in the related areas. An increased awareness of the necessity of such basic understanding for development of advanced technologies has forced Japanese companies to try to gain this understanding through in-house basic research.

Yet, however eager Japanese companies become to pursue basic research, Japan cannot rely totally on private companies to produce the nation's basic scientific knowledge. Research targets and the openness of research activities will be restricted by business operating requirements. Private sector research inevitably involves commercial restraints which can, on occasion, compromise creativity. By contrast, public sector research can provide for more open-ended projects that will support tomorrow's technologies.

According to a survey conducted by the Science and Technology Agency of Japan (STA), Japanese researchers themselves view Japan as being inferior to the United States but as nearly equal to Western Eu-

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rope in almost all areas of basic research. In particular, Japan is weak in the life sciences and oceanographic-earth sciences. Material science is Japan's favorite field, but even there Japan is still perceived to be only equal to or a little behind the United States. Other data suggest that the impact of Japanese research papers has gradually increased, but that it still looks small compared to the impact of papers from some other countries (3). Generally speaking, Japanese basic research is weaker in areas that are not directly relevant to business needs and stronger in subjects where one can expect possible industrial applications to follow.

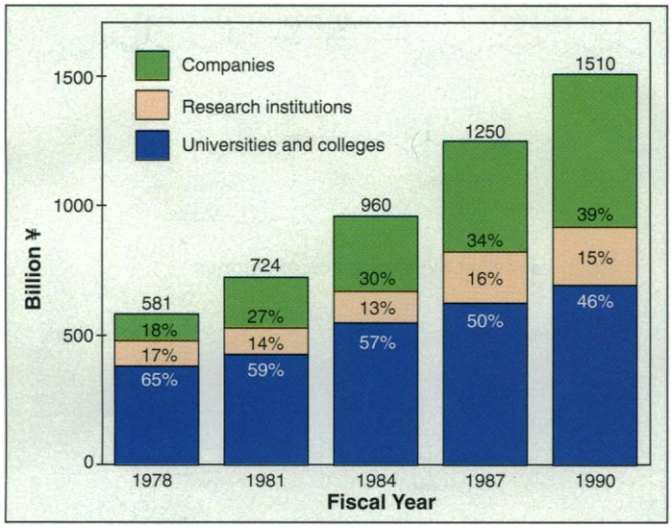
Although scientists in the Japanese public sector are proud of their achievements, there are doubts, especially in Japanese universities, as to whether they can progress satisfactorily in the future without a dramatic improvement in their research environment. Around 1985, when Japan had attained a good reputation in the area of corporate R&D, the general weakness of Japanese basic research in the public sector became a top-priority issue on the agenda of Japanese science and technology policy makers. Since then, many new government programs have been developed with the aim of enhancing basic research in the Japanese public sector. For example, Monbusho (the Ministry of Education) introduced a postdoctoral fellowship program to the university sector in 1985, while similar programs at RIKEN (Institute of Physical and Chemical Research) and other national laboratories were provided by STA in 1989 and 1990. Postdoctoral fellowship programs were quite an innovation for Japanese public research organizations. Short-term employment contracts of this type were very different from Japan's prevailing employment practices.

However, these schemes were so small in scale that they could not significantly improve basic research in the public sector. Furthermore, the general infrastructure for the university research has been eroded by the tight budgetary policy that has been strictly applied since about 1980.

There are a number of problems in the Japanese public sector research environment. The basic infrastructure and support system for research is poorly funded. Many accounting regulations are hampering effective use of research funds. There is no adequate system of evaluation of researchers' performance. Such an environment is frequently criticized as having a tendency to oppress ambitious young scientists and to hinder them from making full use of their own creative capabilities. Many excellent Japanese scientists are choosing to take their research abroad. The most well-known case is Massachusetts Institute of Technology Professor Susumu Tonegawa, who won the Nobel Prize in 1987 for his explanation of the genetic mechanism of immunology. He did great work during his thirties while working in Switzerland. Almost all in Japan would admit that if he had worked in Japanese public laboratories, he could not have enjoyed a research environment of the same quality that he experienced in Switzerland or in the United States.

Although Japanese scientists in the public sector used to be reluctant to complain about their poor situation, they are no longer able to endure their plight silently and have started to cry for help more loudly in recent years.

In part because of the impact of such a cry, on 24 April of this year the Japanese government published a *Basic Policy for Science and Technology*, which articulated a cabinet decision to double its R&D investment as early as possible. It made this decision after a recommendation by the Prime Minister's Council for Science and Technology, which is the supreme advisory body for Japanese government on science and technology policy. The recommendation was published last January as a general guideline for the government's science and technology policy in the next decade. A wide variety of people including business leaders, academic scholars, scientists and engineers in both the public and private sectors, mass media leaders, and statesmen have publicly proclaimed their support for the decision to double the government's R&D investment. Now we can expect the start of a new trend of expansion in funding for basic research in the public sector.



Basic research expenditure by sectors in Japan. Prepared by the Research Division of STA. [Adapted from (*1*)]

Japan needs high-level research centers that will be capable of attracting excellent scientists from around the world. Business leaders also wish for strong public laboratories that are respected around the world. Japanese citizens feel that Japan's present economic performance should be reflected in the support of excellent basic research that produces benefits that can be extended to the rest of the world. Japan should grapple seriously with such an endeavor if it really wants to be respected by the world in the next century.

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