Special Report

Japan's Science and Technology Policy: Retooling for the Future

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The Science and Technology Basic Plan: Budgetary Aspects

Masao Ito, Director-General of the Frontier Research Program at RIKEN (Institute of Physical and Chemical Research) and former President of the Science Council of Japan, has characterized the Government of Japan's July 1996 adoption of its Science and Technology Basic Plan as one of the three most significant turning points for the country's academic sector in modern times. Outside Japan, attention has focused primarily on the Plan's recommendation to double "R&D investment by the Government as soon as possible" from the 1992 level. The Plan noted that this would require government R&D investments of 17 trillion yen over the next five years in order to doubling by the "desirable" year 2000. This recommendation was, however, accompanied by a caveat; namely:

Japan's budget deficit has deteriorated, even by major western nations' standards, raising fears that the financial deficit will have an unfavorable effect on the national economy and hamper its development. It is a highly urgent task to bring the national finances back on track for a healthy socio-economy in the 21st century.

In December 1997, the government proposed its budget for fiscal year 1998 (starting on April 1st) which essentially invoked this caveat by limiting the increase in R&D expenditures to 0.9 percent over the 1997 level, or from approximately 3.003 trillion to approximately 3.030 trillion yen. In contrast, the percentage increase in initial government R&D expenditures from 1996 to 1997 was 6.8 percent. Assuming that the Diet approves the proposed 1998 budget, total government R&D expenditures from 1996 through 1998 will be approximately 9 trillion yen. It is unlikely that the government will propose to invest the 8 trillion yen that would be required to double the budget during fiscal years 1999 and 2000. On the other hand, the goal of doubling the budget over the 1992 level could be achieved by 2001 by maintaining current annual investment levels of approximately 3 trillion yen. However, the full extent of the problems besetting the country's financial institutions, which only began to be apparent in November 1997, is still not clear. If the government responds through fiscal measures that would increase the budget deficit, that could continue to erode its support for R&D, at least in the short term.

The Science and Technology Basic Plan: Organizational and Institutional Aspects

Despite the uncertain budget environment for research, the Basic Plan includes organizational and institutional aspects, some of which are more ambitious (and problematic) than its financial aspects. In essence, the Plan articulates a policy framework with the overall goal of "constructing a new R&D

system" more effectively linked with the Japanese economy and with Japanese society more broadly. Specific implementation measures include, for example:

- introduction of a system of limited-term appointments for researchers in national research institutes (including national universities);
- creation of 10,000 post-doctoral research positions by the year 2000;
- measures to facilitate university-industry research cooperation, including changes in intellectual property provisions and a relaxation of regulations governing the external activities of national university faculty;
- an increase in the proportion of research support awarded on a competitive basis as opposed to more traditional formula-based funding;
- systematic improvement in R&D facilities at both national and private universities; and
- promotion of public understanding of science and the "establishment of a national consensus on science and technology."

Several of these measures will be relatively simple to implement, particularly if adequate financial resources are forthcoming; others will require significant changes in traditional practices and modes of thinking that have been integral to the Japanese science system for fifty years or more. Yet even among those in Japan who are skeptical about whether the more ambitious organizational and institutional objectives of the Basic Plan are achievable, there is agreement that the overall goal of restructuring the R&D system so that it will be adequate to meet the demands of Japanese society in the new century is eminently desirable (even essential).

Selected Institutional Innovations

Several innovations, which predate the Basic Plan, are consistent with both its broad intent and the specific implementation measures. Examining these initiatives provides a means for illuminating structural barriers the Plan seeks to overcome. These include:

Competitive grants programs for basic research in universities. The bulk of funding for research in Japan's national universities still comes as formula funding from the Ministry of Education, Science, Sports and Culture (Monbusho), even though the percentage derived from competitive funding sources is increasing. In 1985, formula funding supported 85 percent of all research in national universities, 12 percent was supported by competitive programs of government agencies, and the remaining 3 percent by industry. In 1995, these figures were 78 percent, 17 percent, and 5 percent, respectively. Monbusho accounted for approximately two-thirds of the competitively-derived support for university research in 1995, with the remaining one-third coming primarily from the Science and Technology Agency (STA) and the Ministry of International Trade and Industry (MITI).

The competitive grants programs of agencies other than Monbusho are intended to support relatively large projects, most of them involving collaboration between university and non-university researchers. For example, STA's Exploratory Research for Advanced Technology (ERATO) program, administered through the Japan Science and Technology Corporation (JST) and begun in 1981, supports teams of 15 to 20 young researchers in multidisciplinary research projects under the guidance of a senior university project director. Projects are supported for five years with total budgets ranging between 1.5 and 2.0 billion yen. Involvement of industrial researchers is encouraged but not required.
Because of regulations imposed on national universities by Monbusho, ERATO projects cannot be conducted on campus. Rather, projects are conducted in rented space off campus. Research teams consist

of post-doctoral appointees from Japan and abroad, but not from the home institution of the project director since they cannot hire their own graduate students until after they have received their degrees. Nor can project directors be actively engaged in the research itself except in an administrative capacity. Although energetic and talented university scientists have welcomed the opportunities for research provided by ERATO grants, the conditions imposed by Monbusho regulations have also resulted in considerable frustration.

STA's Core Research for Evolutional Science and Technology (CREST) program, which was begun in 1995 and is also administered by JST, is subject to fewer restrictions than ERATO. By 1995, with the Science and Technology Basic Law and Basic Plan already near the horizon, Monbusho had begun to relax its regulations on research at national universities. CREST, like ERATO, supports industrially-relevant basic research involving approximately 20 researchers who may come from several institutions, including industrial and government research laboratories. Unlike ERATO projects, however, CREST projects can, and usually are, conducted at on-campus locations. They can, and usually do, involve faculty from several departments of the home university, as well as graduate students. Two of the Basic Plan's objectives are to facilitate more university-industry research cooperation and to increase the amount of research funded by competitive grants. Contrasts between ERATO and CREST suggest a positive prognosis for both these objectives.

The Tsukuba University Advanced Research Alliance (TARA) Program. TARA, established in 1994, is the brainchild of Nobel Laureate Leo Esaki, who was elected President of Tsukuba University in 1992. It bills itself as "an experimental organization which is testing the new system for the promotion and production of new technology."

The competitive atmosphere at TARA is unique in Japan. The institution is organized around six broad research areas, or "aspects": three in the biological and environmental sciences, two in materials science, and one in information science. Project coordinators - all full professors in one of Tsukuba University science or engineering faculties - hold seven-year joint appointments at TARA, renewable subject to the results of performance evaluations. Projects within each of the seven aspects are conducted by interdisciplinary, inter-institutional groups led by other university faculty members whose projects are selected on the basis of a competitive, peer reviewed process. Initial project support is provided for three years, with the possibility of extension for an additional four years, depending on the results of external evaluation.

Few other universities have such ready access to the government and industrial sectors as Tsukuba. On the other hand, although Tsukuba is the most prominent and well developed of Japan's science cities, several others have been created during the past 10 to 20 years(for example, in the Kansai region, which embraces the cities of Kyoto, Kobe and Osaka, and around Fukuoka, the largest city on the southernmost island of Kyushu. If, as President Esaki hopes, TARA succeeds in showing some promise in meeting its objectives, perhaps universities in these and other parts of the country might try to adapt the model to their own circumstances.

Nara Institute for Science and Technology (NAIST): NAIST, established in 1991, is one of two Japanese national universities devoted exclusively to research and graduate education. The other is the Japan Advanced Institute of Science and Technology (JAIST), located in Tatsunokuchi in Ishikawa Prefecture, which was created in 1990. A third advanced study institute, located near Yokahama and devoted to the social sciences, is due to admit its first students during the fall of 1998.

A significant distinction between the advanced study institutes and other national universities lies in the limited number of disciplines encompassed. NAIST has only three faculties: the Graduate School of Information Science which was established in 1992 and admitted its first students in 1993; the Graduate School of Biological Sciences which was also established in 1992 but did not admit its first students until 1994; and the Graduate School of Materials Sciences which was established in 1996 and will admit its first students in the fall of 1998.

The fact that there are so few disciplines represented at NAIST permits a concentration of financial resources conspicuously absent at other national universities. Each of its three graduate faculties is housed

in its own large and attractive new building; each is well equipped with state of the art apparatus. Faculty point with considerable pride, bordering on awe, to the bright, spacious laboratories available to graduate students, in addition to the large cubicles shared by only two graduate students and two PCs (conditions which contrast sharply with the cramped and aging facilities at many national universities. NAIST, as a new institution, was designed from the outset to take advantage of modern information technologies. One of the first units established was a central information technology center which provides an institute-wide information environment based on ultra-high-speed network facilities and distributed computer technologies. A wide-area network provides connections to external academic networks in Japan and abroad and also provides various types of educational activities related to information technology.
NAIST's very novelty may be a barrier to its ultimate success. Many, perhaps most Japanese students aspiring to academic research careers are still more comfortable about seeking admission to the graduate schools at universities where they pursued their undergraduate studies, most of which are far more prestigious institutions than NAIST or JAIST. Whether these well endowed and imaginative advanced study institutes can successfully surmount this deep-seated cultural barrier remains to be seen.

RIKEN Frontier Research Program: The Institute of Physical and Chemical Research (RIKEN), whose main campus is in Wako, a Tokyo suburb, is supported almost entirely by STA. Established in 1917, it is the oldest and, in the opinion of many observers, perhaps the premier publicly supported scientific organization in Japan. With a 1996 budget of 36.4 billion yen, it is certainly one of the best endowed.
In addition to several ongoing core research programs conducted primarily by permanent staff, RIKEN's Frontier Research Program, started in 1986, is designed to encourage high risk, interdisciplinary research in frontier areas of the physical and biological sciences. This program provides short term contract appointments both for senior scientists from Japanese universities and for younger scholars. It also actively recruits visiting foreign scientists. In 1996, approximately 140 of the visiting scientists working on projects within the Frontier Research Program were non-Japanese: about 50 percent of them from the United States and Europe, with 25 percent from China and Korea.
A Brain Research Institute was established at RIKEN in 1997 to unify--and greatly expand--several ongoing areas of inquiry that had previously been pursued separately within the Frontier Research Program. Masao Ito, Director-General of the Frontier Research Program, envisions the work of the new institute as a 20 year endeavor. Three related themes are to be pursued: Understanding the Brain (that is, elucidating brain functions), Protecting the Brain (that is, conquering brain diseases), and Creating the Brain (that is, developing neuro-computers). The ultimate goal is, "to discover the reasons why humans are humans by understanding the brain mechanisms of intelligence and mind." As with other research work within the Frontier Research Program, the Brain Research Institute will actively recruit senior university researchers, young scholars, and visiting foreign scientists. In addition, it will establish--and help to support--research partnerships with selected Japanese university departments. This initiative should help to vitalize those departments selected as research partners and could even introduce a degree of much needed competitiveness into the Japanese national university system. If so, it could provide an interesting model to be adopted, and adapted, by public research institutions and university departments in other scientific areas.

Human Resources: The Limiting Factor

Perhaps the most ambitious goal of the Science and Technology Basic Plan is to bring about a fundamental change in the approach to national priorities for Japan's science and engineering workforce. The introduction to the Plan emphasizes that:

> *Expectations for basic research are very high; it is not only a basis for innovative development in science and technology, but such development in itself is valuable as*

intellectual property for all humans to share. Japan, especially, is highly expected to boldly challenge unknown fields in science and technology.

This theme echoes assertions that have been made for several years by scientific leaders such as Ito and Akito Arima, the President of Riken and quite possibly the most influential scientist in Japan. They argue that the very future of the country requires that a premium be placed on the performance of creative, high quality research. Yet the number of adequately qualified people remains disappointingly low. In 1994, for example, the numbers of PhDs awarded in the natural sciences in the US and the UK were approximately 10,000 and 8,600, respectively; during that same year Japan produced only slightly more than 1,100. Rather than pursuing research careers, most young Japanese scientists opt for more routine careers in industry where the Ph.D. degree is not required and, in fact, may not even be valued. Arima has also noted that whereas the number of papers in international peer reviewed scientific journals by Japanese authors was second only to those with US authors during that year, the number of papers normalized to Gross Domestic Product was only one third as large: 100 vs. 300. [Indeed by this measure, the productivity of UK scientists was larger than US scientists, since the number of peer reviewed scientific papers per GDP was 400, vs. 300 for the United States.] Leaving aside questions about the merits of this particular indicator as a measure of scientific creativity, the fact remains that Arima and his colleagues are convinced that unless Japan can increase the proportion of young scientists who are able and willing to devote themselves to research careers, the country will be ill equipped to address the social and economic needs of the new century.

The principal rationale underlying the Basic Plan's recommendation for a substantial increase in government R&D investments is to provide what is regarded as adequate support for research in universities and public research facilities--the sites where most of the creative basic research so desired by the scientific leadership is conducted. The competitive grant programs favored by the Plan also emphasize research opportunities for young scientists. Additionally, the Plan includes specific measures designed to encourage young scientists to gain experience with independent research: for example, creation of attractive five-year contract positions for new PhDs as an alternative to immediate, often permanent appointment to junior positions in university research groups headed by their mentors; and an increase in the number of available post-doctoral research positions from approximately 8,000 to 10,000 by the year 2000. Both measures are intended to enhance the quality of the research conducted in universities and government laboratories, and to promote the mobility of scientific personnel. They also aim to improve the capabilities of talented young people before they embark on life-long careers which, traditionally, are spent in a single organization.

Yet significant barriers will have to be surmounted in order to increase substantially the number of Japanese Ph.D. scientists engaged in what the leadership regards as creative research. Most obviously, the country is currently producing far too few PhDs in science to fill even a moderate fraction of the 10,000 post-doctoral positions that are to be created by the year 2,000. Thus, for the foreseeable future young foreign scientists--including a significant number from Asia--will occupy a sizable fraction of those positions. Any substantial increase in Ph.D. production will itself require a considerable expansion in opportunities available to new PhDs. In the United States and to a somewhat lesser extent in Europe, private industry employs significant numbers of PhDs. This is decidedly not the case in Japan, where the Ph.D. degree is required only for entry-level positions in national universities and publicly financed research organizations. With some notable exceptions, the research facilities available in these organizations are still inferior to those available in private industry, and this in itself constitutes a disincentive towards seeking a Ph.D. degree.

The tradition of life-long employment in a single organization coupled with a system in which promotions and rewards are determined on the basis of seniority rather than initiative and merit may constitute the most formidable barriers to the goal of encouraging the creative potential of young researchers. From a US perspective, the opportunity for a new Ph.D. to conduct independent research in a first class facility under the terms of a five-year contract appointment or a post-doctoral fellowship before making a commitment to a long-term position is exceedingly attractive. From the perspective of a young Japanese scientist, the prospect of striking out in such a semi-independent direction without the security of a future position is unsettling. Even those who are exhilarated by the challenge provided by opportunities for independent research must recognize that they will eventually be employed in a system in which seniority remains all important with the result that their research accomplishments during their early, independent years may not be viewed in an entirely positive light.

Japan's scientific leadership, who were instrumental in crafting the Science and Technology Basic Law that underlies the Basic Plan, are well aware that a fundamental cultural change will be required if the all important human resources objectives of the Plan are to be realized. But it would be a serious error to regard the existing barriers to such a change as insurmountable. Masao Ito, who characterizes adoption of the Basic Plan as the third fundamental turning point for science in Japan, has explained that the first took place during the four decades between the 1850s and the turn of the last century. During those years of the Meiji Restoration, Japan transformed itself from a feudal society that had been cut off from the world for two and a half centuries into the foremost industrial power in Asia. Much of that transformation was accomplished because rising generations of younger Japanese were challenged to think and act in ways that were at odds with the traditional culture. Conceivably, rising generations of younger Japanese scientists revitalize Japan's science system, as envisioned by the Basic Plan, if given consistent encouragement and support.

Biographical Information

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Note on Sources

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National Science Foundation's Tokyo Regional Office:
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