University Research and Economic Growth in Japan

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Japanese science is weak in a global comparison. In 1995, the United States produced 33 percent of the world's scientific and technical articles. Japan's share was second, at 9 percent.[1] In 1994, citations per Japanese paper were half the U.S. number, and 18th in international rankings.[2] With R&D spending at 40 percent of the U.S. level, scientific output at 33 percent, and citations per article at 50 percent, Japan gets only two-fifths the results of American science resources as measured by citations.

These figures arguably may be irrelevant. The goal of much of the R&D undertaken in Japan is not to produce articles and citations but to advance the fortunes of the companies that foot the bill. In 1995, corporate Japan funded 72.2 percent of the nation's R&D; the government paid for 20.5 percent. The comparable U.S. figures were 52.5 percent and 34.5 percent, respectively. Even more revealing, of the work done by Japanese industry, businesses financed 98.2 percent.

However, numerous studies conducted over the past decade have documented the increasing importance of the ties between science—especially basic research—and an economy's performance. For example, one study found that citations to science articles in patents issued in the United States jumped more than three times between 1985 and 1995.[3] Patents from other countries showed similar rates of increase, but the scale of American science references was considerably greater than for other countries. Vis-à-vis Japan, the difference was almost threefold.

The scientific literature cited in patents had been authored at the most prestigious universities and laboratories in each field. Several corporate laboratories ranked high on the list in certain technologies, but almost three-quarters of all cited studies had been supported by public sources. Even giants like International Business Machines Corp., which has its own renowned laboratories and whose scientists have received several Nobel Prizes, relied on publicly supported science. At IBM, 40 percent of its science citations were to university research.

Japan would not have to be overly concerned about its relatively weak science base if it could easily take advantage of the best science around the world. However, the diffusion of scientific results is strongly localized. A study showed that basic research supported by the U.S. National Science Foundation is cited three to seven times more frequently by American inventors than by foreign inventors.[4] In another study, researchers at the University of California at Los Angeles investigated the diffusion of science to business by analyzing the influence of so-called star scientists on the creation of biotechnology enterprises. The investigators defined a "star scientist" as a discoverer of more than 40 genetic sequences or an author of 20 or more articles reporting such discoveries through early 1990. Worldwide, 327 such individuals were identified, almost all of whom held university appointments. The United States was home to 207 star scientists—Japan, to 52.

The emergence of U.S. biotech firms in a given year was strongly influenced by the local distribution of star scientists. These start-ups were the result of scientists who remained on faculty staffs while establishing businesses on the side or engaging in close consultations with established companies. Significantly, the presence of top-flight universities and the value of federal research grants at local universities had as strong an effect on the creation of biotech firms as the proximity of stars.[5]

The UCLA team duplicated the U.S. study in Japan.[6] Japan's national or publicly funded universities—the institutions with sufficient resources to play a significant role in basic research—prohibited professors from profiting from their research through consultation for pay or by starting a firm as a principal. Nevertheless, the UCLA researchers found that the incentives were strong enough to motivate collaboration in the biotechnology field. For example, 40 percent of the Japanese stars coauthored articles with a company scientist, compared with a U.S. figure of 33 percent. Comparing the effect of stars on the formation of biotechnology enterprises in Japan and the United States, the UCLA researchers discovered that the impact in Japan was about half the American rate.

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Many new Japanese biotechnology enterprises indicated that it was "understood" that they would place productive professors in "extraordinarily well-paid advisory positions after the professors' mandatory retirement." At least some biotechnology firms made unreported cash payments to key professors equal to their annual salaries. The authors, however, found that the opportunity for a professor to start a biotechnology firm while still in the academic environment was nonexistent.

Can scientists and companies in Japan take advantage of the openness of American science through direct contact? Such associations can arise through the training of doctoral students, university appointments, and coauthorship.

According to NSF figures, 1,276 Japanese students earned doctoral degrees in science and engineering in the United States over the 10-year period from 1986 through 1995. Students from the People's Republic of China, Taiwan, South Korea, and India earned 6 to 11 times as many U.S. doctoral degrees in that time. Hong Kong had almost as many science and engineering Ph.D.s to its credit as Japan. Moreover, with respect to recent doctoral recipients in the sciences with jobs in the United States, Japan ranked last among the top 10 countries, with only 30 in 1995. It had the third-smallest number of graduates and the lowest proportion of those remaining to work in American laboratories. China led the list with 2,446 postdoctoral workers. Japan did not even appear on the top-10 list of the country of origin of foreign-born science and engineering faculty in U.S. higher education.[7]

Japanese science does not seem any more cosmopolitan in terms of international coauthorship. From 1991 to 1995, the ratio of internationally coauthored scientific articles to all scientific literature coming out of Japan was 13 percent. That placed it in a multiple tie for last place with India and "other former USSR" countries.[8]

In conclusion, the business orientation of Japan's R&D was correctly identified in the past as the foundation of the country's technological strength. Now, that is a growing problem. In advanced countries, the linkages between basic research and the economy have intensified to such a degree that the practical orientation of much of Japan's scientific community and the acknowledged weaknesses of its basic research and university science may retard productivity growth in the future. ■

Notes

1. National Science Board, *Science & Engineering Indicators—1998* (NSB 98-1) Washington, D.C.: Government Printing Office, 1998), 5–41.
2. Robert M. May, "The Scientific Wealth of Nations," *Science*, February 7, 1997, 793.
3. Francis Narin, Kimberly Hamilton, and Dominic Olivastro, "The Increasing Linkage Between U.S. Technology and Public Science," *Research Policy*, 1997, 318–19.
4. Francis Narin, *Linkage Between Basic Research and Patented Technology* (Haddon Heights, N.J.: CHI Research, August 14, 1996).
5. Lynne Zucker, Michael Darby, and Marilynn Brewer, "Intellectual Human Capital and the Birth of U.S. Biotechnology Enterprises," *American Economic Review* 88, no. 1 (March 1998): 297.
6. Michael R. Darby and Lynne G. Zucker, *Star Scientists, Institutions, and the Entry of Japanese Biotechnology Enterprises* (Working Paper 5795) (Cambridge, Mass.: National Bureau of Economic Research, October 1996), 1.
7. National Science Board, *Science & Engineering Indicators*, Appendix tables 2-43, 2-38, 2-42.
8. Ibid., Appendix Tables 5-53.

Higher Education Reform in Benin in a Context of Growing Privatization

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Over the last two decades, considerable progress has been made in expanding the knowledge base relating to the state of higher education in sub-Saharan Africa and of possible strategies and actions to improve its overall condition. This was facilitated by the numerous regional studies as well as diagnostic studies conducted at the country level. Nowadays, "revitalization" has become one of the most common and recurring themes in the literature concerning reform in higher education in the region and stands as the key strategy recommendation of the 1997 report prepared by the Association of African Universities and the World Bank.[1] In line with this report, the February 1999 meeting of the Conference of Rectors, Vice Chancellors and Presidents of African Universities in Arusha, Tanzania, focused on the theme "Revitalizing Universities in Africa: Strategy for the 21st Century."

Despite the availability of a solid, relevant, and reliable information base on which reform could be founded, not much has happened, and the condition of African universities keeps worsening. This situation is mainly due to the fact that the solutions proposed by the several studies are not being (or cannot be) implemented because of an inability to take the necessary actions. The reasons accounting for this inability include:

- the scope of the available information;
- the lack of will to effect changes as a result of conservatism (resistance to change) and various nonacademic concerns;
- a limited perception of the role of higher education in a country's development; and
- the nature and scope of the solutions proposed, which are sometimes too ambitious for the limited resources available.

The inability to take necessary actions results from objective and subjective factors. Thus, it is necessary that effective policies should address both macropolicy issues regarding the relationship between higher education and development in general and internal questions specific to the institutions of higher education.

The recent "audit" (comprehensive review)[2] of Benin's higher education system addresses these aspects. It analyzed the overall functioning of the university (structures,