TAIWAN

Past Success Provides No Sure Guide to the Future

HSINCHU, TAIWAN—In 1976, the Taiwan government sent 19 young scientists to an RCA facility in Somerville, New Jersey, to learn how to make semiconductor devices. Before they arrived, the plant's general manager, Bernard V. Vonderschmitt, wondered if the Taiwanese would be able to understand something as technically challenging as making microchips. After they left, says Vonderschmitt, RCA's chipmakers had a different question: "Would we be able to continue without them?"

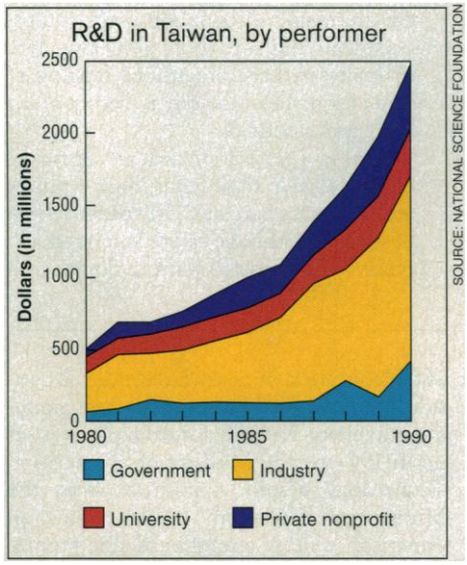
Those scientists were some of the island's brightest young researchers. Today they're at Hsinchu (literally "new bamboo") Science-Based Industrial Park, about 90 minutes south of Taipei, managing one of the eight chipmakers that have sprung up over the past decade and transformed this onetime military base into a miniature version of Silicon Valley. But as successful as these companies have been, their continued prosperity is no longer assured. The government's approach to fostering R&D that once worked so well—made possible by a one-party political system that brooked no disagreement with its top-down management of the country's high-tech industries—is now being called into question.

As industries spawned by government R&D efforts mature, the government is trying to redefine its role. In particular, it hopes to lead the way into more advanced technologies, which will require unprecedented investments in basic research. "It's a completely different game," says Liu Chao-Shiuan, a respected chemist who is minister of transportation and communications. "To go from agriculture to light industry wasn't easy, but compared to what we're facing now.... We haven't seen any successful examples" anywhere in the world.

One measure the government is taking is to rope universities and research institutes like Academia Sinica (see sidebar) into the effort to upgrade the nation's technology base. Although many of these institutes are distinguishing themselves scientifically, that's not enough, says Kuo Nan-Hung, chairman of the National Science Council (NSC). "Most professors are concerned only with publishing in well-known journals, and not with real-world problems," he complains. Getting academics to focus on practical problems, he says, "is our special emphasis in years to come."

Fifty percent of the NSC's grants, about $200 million, will now go to university-industry joint research. Industry partners are expected to put in matching funds. "We hope that by sharing risk, companies will be more willing to do research," explains Steve Hsieh, director general of Hsinchu, which is administered by the NSC.

"I don't think any company in Taiwan can afford to do upstream [basic] research" by itself, says Hsieh. Because the vast majority of Taiwanese companies are too small to afford their own R&D, the government traditionally has done it for them. Typically, it transfers production-ready technology directly from the public to private sector. The flourishing domestic integrated circuit (IC) industry, for example, was spun off from the R&D efforts of the government-run Industrial Technology Research Institute (ITRI). These companies form the pillars of Taiwan's largest industry, with sales expected to top $10 billion in 1993. But now ITRI's role is being challenged by the very industry it spawned. The case of ITRI offers a cautionary tale for the government as it tries to repeat its success with ICs in other areas, such as materials research, nanotechnology, and biotechnology.



Decade of growth. Industry R&D is done mostly by consortia, not by individual firms.

Time for a change. ITRI was founded to accelerate the development of a variety of industrial technologies, including metals, chemicals, energy, and, most recently, aerospace. But electronics has long been the institute's prime focus, with its Electronics Research & Service (ERSO) division accounting for two-thirds of the institute's overall budget of $450 million. Twice in the past, ITRI has spun off laboratories as private companies, United Microelectronics Corp. (UMC) in 1979 and Taiwan Semiconductor Manufacturing Co. (TSMC) in 1986. Today, they are Taiwan's most successful IC makers.

But that model is increasingly difficult to follow, says former ERSO deputy general director Lance Wu, "because people challenge the fairness of it." "It's like a family," explains Alex Cheng, vice president of TI-Acer, a joint venture between Texas Instruments and the island's leading local PC maker. "When you only have one son, he gets everything; but when there are brothers, they start competing."

Another factor making that model obsolete is the changing political environment. For 40 years starting in 1949, the nationalist Kuomintang Party ruled and its industrial policy, as carried out through ITRI, was exempt from criticism. But in the wake of recent democratic reforms, according to Wu, "people can now talk about what the government is doing. They want to know where the national budget goes," he says, "and they have begun to ask, 'What benefit do we get from industrial research?' "

That question is being asked increasingly about the 5-year, $275 million Submicron Project at ITRI, by far the largest R&D initiative ever undertaken by the Taiwanese government. The project's goal is to raise the island's IC industry to the level of its competitors in the United States, Japan, and Korea. It is based at an industrial-scale facility in the science


BOB JOHNSTONE

Electronic generator. ITRI launched Taiwan's semiconductor industry.

Wanted: A Few Good Leaders for Academia Sinica

The campus of Academia Sinica, Taiwan's preeminent organization for advanced research, gleams with prosperity. New laboratories built of sparkling red brick, trimmed crisply in white, rise amid swaying palms on the manicured grounds. Inside, scientists work to the hum of air conditioning and computers.

But a cloud of uncertainty hangs over this privileged enclave. Earlier this year, academy members became embroiled in a bitter and divisive fight over a high-handed attempt by the academy's 87-year-old president, Wu Tayu, to get Taiwan to contribute $50 million to the Superconducting Super Collider. (For now, Taiwan has decided not to participate.) And this spring, opposition members of the national legislature verbally assaulted Wu, saying he was too old and out of touch. A few months later, Wu announced that he would retire. No successor has been named, but many scientists have pinned their hopes on chemistry Nobelist Yuan Lee, who is considering early retirement from the University of California, Berkeley. Lee says that he is coming to the academy's Institute of Atomic and Molecular Science "to help" but is undecided about the presidency. In the interim, no other strong candidates have emerged.

Retiring. Longtime president Wu Tayu.

The academy can ill afford a vacuum at the top. The nation's $190 billion, 6-year plan to develop Taiwan's long-neglected physical infrastructure, launched in 1991, has squeezed annual growth in research budgets to less than 5%. "That's very bad news," laments one institute director, who fears that the slowdown could undermine the substantial gains of the past decade.

Since 1980, Academia Sinica's yearly budget soared from about $11.5 million to the current $110 million. (The National Science Council's total grant budget, by comparison, is $400 million.) The academy founded six new science institutes—for molecular biology, atomic and molecular science, biomedical science, statistics, computing, and astrophysics—almost doubling the previous number, and prominent scientists who left Taiwan decades ago to pursue careers abroad have helped to design and run them.

In 1986, Harvard's James Wang cajoled five other U.S. scientists of Chinese descent to spend 14 months in Taiwan setting up the Institute of Molecular Biology (IMB). "I twisted the arms of friends and colleagues," he chuckles. Wang's team designed the new building, drew up shopping lists of equipment, and began hiring and purchasing. By the time they were done, he says, the institute "was better equipped than Harvard." The agenda for the Institute of Biomedical Sciences (IBMS), now the largest of the academy institutes, was hashed out in 1986 and 1987 by several dozen Chinese-American researchers meeting at the LaGuardia Airport Marriott Hotel in New York, including Cheng-Wen Wu, who resigned his professorship at the State University of New York, Stony Brook, in 1990 to became the IBMS's first permanent director.

These institutes have made use of Internet and generous travel budgets to remain linked to the scientific mainstream. At the same time, shrinking job markets in the West cast Taiwan in an increasingly attractive light. The IMB has so far recruited 25 principal investigators, mostly native Taiwanese who had earned their Ph.D.s or done postdoctoral work at respected U.S. labs. The IMB's charismatic present director, C.C. Wang, a noted molecular parasitologist who also holds a professorship at the University of California, San Francisco, has worked hard to secure adequate salaries, housing, and travel budgets for them.

UC BERKELEY

Being courted. Berkeley chemist Yuan Lee.

Such lures are resented by home-grown scientists, however. The local scientific establishment, says one prominent scientist who requested anonymity, characterizes the changes wrought by returnees as "organ transplants"—foreign bodies that will be rejected by the host.

The looming leadership vacuum is worrisome to those already troubled by the end of rapid expansion in basic research. Already, the National Science Council has cut funding for investigator-initiated grants by 20% and is diverting the money to university-industry consortia targeting commercial applications.

The dearth of leaders is a serious problem, agrees Lee. "A lot of young people are going back, but experienced people are not abundant." Indeed, the IMB and IBMS initially planned to rotate the directorship among a succession of senior U.S. scientists on 1-year leaves on the assumption that none would sacrifice their professorships and comfortable lives without an iron-clad assurance that they could effect meaningful changes in Taiwan.

It is, in part, a self-fulfilling prophecy: If enough prominent scientists took the plunge, their presence would be felt; but each is waiting for someone else to make the first move. Many hope that person will be Yuan Lee, but he remains reluctant. "I don't enjoy administrative duties," he says. "I want to remain a research scientist."

His caution is understandable. The Academia Sinica's president will have to take sides in public debates involving the national legislature, in which sessions can dissolve into screaming matches and fistfights. "The political environment now doesn't allow for anyone with long-range vision to prevail," sighs one academy member. In these fractious times, it will take a strong voice indeed to speak up for the future of Taiwan's basic science.

–J.K.

park, a site chosen to facilitate construction of a dedicated D-RAM plant after the project runs its course. But in the interim, UMC and TSMC have begun to do submicron research for themselves, and newcomers like TI-Acer, Mosel-Vitelic, and Macronix International have acquired independent access to submicron technology from their U.S. and Japanese corporate partners.

Taiwanese chipmakers like Mosel-Vitelic vice president Tsai Nasa say that the project has given them valuable insights into how processing chips on 8-inch silicon wafers differs from that of the industry's current standard of 6-inch wafers. "ERSO was the first to build an 8-inch [facility]," Tsai says. The project has also given local companies the confidence to invest in their own advanced manufacturing technology.

Although the Submicron Project benefited local industry, most experts agree that funding for IC research at ITRI should be scaled back. "The government should not and will not put that much money into this

industry any longer," says ERSO's director, David C. Hsing, "it's the end of the IC era in ERSO." In fact, Hsing's predecessor, C.C. Chang, the principal architect of the Submicron Project, left the project after 14 years with ERSO because he had lost faith in the organization's function.

"When we began," he says, "I felt we were doing something big and useful for our country and ourselves. But I could no longer convince myself that we were doing good." Now that he is vice president of chipmaker Winbond Electronics Corp., Chang hopes that government will broaden its support for IC projects outside ITRI.

Even ITRI chairman Morris Chang agrees: "I'm in favor of continuing research," he says, "but not under the sole sponsorship of government." For all their success, the combined sales of Taiwan's eight chipmakers are less than those of a single South Korean company, Samsung, and far less than those of U.S. firms like Intel, Motorola, and Texas Instruments. Chang envisions the next generation of IC process technology being developed through an R&D consortium similar to the U.S.'s Sematech, managed by industry instead of ITRI. But Chang cautions that industry might not be able to pay its half of the $50 million a year that he estimates will be needed.

"I don't think any company in Taiwan can afford to do [basic] research" by itself.
—Steve Hsieh

High-tech salesmanship. A more fundamental problem is that Taiwanese industry does not yet see the need to do cutting-edge R&D. The NSC's Synchrotron Radiation Research Center (SRRC) at Hsinchu has set aside several beams for the use of the IC industry, but so far, no company has signed up to take advantage of the $110 million facility. "Industry is slow to catch up on the applications," says SRRC director Edward Yen. "But," he adds, "2 years ago they wouldn't have believed it was possible [to build the machine]." Instead, it has fallen to ITRI, perhaps as part of its effort to find a new niche, to collaborate with the SRRC on experiments in x-ray lithography and micromachining. When the SRRC holds its grand opening this fall, scientists there will make a presentation to try to persuade local firms to get involved.

Materials scientist M.K. Wu also finds himself playing salesman as director of the Materials Science Center at National Tsing Hua University. Wu, known for his role in developing high-temperature superconductors, was enticed back from Columbia University after the government decided to invest in his area of research. Wu tried to interest local firms in various applications growing out of his lab. "They were skeptical," he says, so "I visited their factories, hoping to identify something we could work on together." So far, he's convinced a local electrical equipment maker to collaborate on a high-power circuit breaker using ceramic superconductor materials.

Returnees like Lance Wu and M.K. Wu have made enormous contributions to the island's industry and to science and technology in general. But returning to their native land often entails considerable sacrifice, especially for their families. The planners of Hsinchu had the foresight to build a bilingual school, but returnees elsewhere must contend with sending their non-Chinese-speaking children to public schools and subjecting them to "exam hell." Decades of neglect of roads, utilities, housing, and natural resources make for a "terrible living environment," complains Lance Wu. "There's more opportunity here, but you have to suffer."

In 1991, the government launched its $190 billion, 6-year National Development Plan to improve Taiwan's infrastructure, but many say it should have done this long ago. "A lot of people are going back to the United States" because they can't take the poor living conditions, says Lance Wu. The loss of talent, worries C.C. Wang of the Academia Sinica's Institute of Molecular Biology, "could haunt Taiwan for a long time to come."

The massive cost of the National Development Plan is hitting research directly in the purse, however. The Academia Sinica's budget, for example, has ceased growing at its previous healthy rate. ITRI's budget, which had been growing at 20% to 25% a year, has also been frozen at 1992 levels.

While ITRI's critics say there is no longer a need for the lab to grow, Lance Wu thinks the freeze is disastrous. "It's too early for Taiwan to face this problem," he says. "Our R&D capability is still so low." In his view, R&D has become "a target" because "physical infrastructure is pork barrel," whereas there is no politically powerful constituency for science and technology.

The consensus among Taiwanese technocrats is that a new industrial policy for R&D is required. But there is no agreement on what the policy should look like. What is clear, however, is that the choices are more complicated than they were in 1976.

–Bob Johnstone

Bob Johnstone is a science and technology writer based in Tokyo. Additional reporting by June Kinoshita.

HONG KONG

Jockeying for Position in The World After 1997

HONG KONG—Hong Kong's new University of Science and Technology (HKUST) perches on a bluff near the border between Hong Kong and China. Its location is appropriate: The territory's government wants the new university to be a focal point for scientific collaboration with Chinese institutions when Hong Kong comes under Chinese rule in 1997. But that's not all. Until HKUST opened in 1991, Hong Hong wasn't even a bump on the technology landscape in this part of the world. But now the government hopes HKUST will drive regional development and keep the area's talent at home.

Vice-chancellor Chia-Wei Woo modestly acknowledges such lofty goals. But swiveling away from his office window overlooking the blue sweep of Port Shelter Bay, he insists that, despite the nickname favored by the media, "We are *not* the MIT [Massachusetts Institute of Technology] of Asia."

Not yet, anyway. Woo, a physicist and former president of San Francisco State University, is feeling the growing pains of bringing a major institution to life in a very short time. (The British governor of Hong Kong, Chris Patten, is officially chancellor of the university, but Woo runs its day-to-day operations.) Two years after HKUST opened, it is running at about 30% capacity. By 2000 it expects to have 888 faculty members, 7000 undergraduates, and 2496 postgraduate students, a growth rate that means recruiting 10 faculty members a month. "That's a killing pace," Woo says with a wry smile. "But what will make us a world-class institution is how we perform."

Planning for the university began in 1986 after the government decided to stop both exporting students—who lead the world on standardized science and math tests— and importing technology. Just as Hong Kong has established itself as a regional financial center, local leaders expect HKUST to help make it a regional research center as well. "Technology should be a part of Hong Kong life, just like commerce is," says Research Center director Jay-Chung Chen, formerly of the National Aeronautics and Space Administration's (NASA) Jet Propulsion Lab.

Bolstering its regional scientific aspirations, the university will become a downlink site and research center for data from a