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In Mexico, Science Goes Begging

Researchers struggle for money to develop homegrown technology

By *MARION LLOYD*

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Mauricio Terrones was a rising star in the competitive field of carbon-atom research, working alongside a future Nobel laureate in England and publishing his discoveries in prestigious journals, when he felt the pull of his native Mexico.

So in 1999, when the Mexican government offered him a coveted research position at the National Autonomous University of Mexico -- which conducts half of all scientific research in Mexico -- he jumped at the chance. Two years later, Mr. Terrones followed his brother and fellow physicist, Humberto, to the newly created Potosí Institute for Scientific Research, 280 miles northwest of the capital, in the desert city of San Luis Potosí.

"There was such a positive atmosphere; it was really something new," Mauricio Terrones, 35, says of the center, which was designed to breed world-class talent in nanophysics and other areas important to building a native technology industry in Mexico.

Four years later, the project has yet to live up to expectations. Millions of dollars' worth of electron microscopes sit idle because the institute lacks the money to install them. Researchers like Mr. Terrones are forced to travel abroad to get access to the equipment and money they need to carry out cutting-edge research.

"You can't get anything done," Mr. Terrones says about research in Mexico. "It's very depressing." He was about to leave on a two-month research tour of South America and Asia. His trip would include a stop in Japan, where the electronics manufacturer Hitachi is sponsoring his research into ultralight carbon molecules, called nanotubes, that could be used to create high-resolution television screens, among other things.

For the scientists at Potosí, he says, the opportunity to work in laboratories outside Mexico is "what's kept us afloat, in the vanguard."

Mr. Terrones's experience is indicative of a generalized -- some say severe -- lack of support for scientific research in Mexico, despite growing recognition that the country's economic future depends on its ability to generate homegrown technology.

Mexico's spending on science is abysmal, even compared with that of countries at similar stages of economic development. Mexico spends less than half as much as Brazil, as a share of industrial output, and about a third as much as China. Mexico also lags in the number of Ph.D.'s, patents, and scientific papers it produces each year.

"In Mexico, the leaders for the past 40 or 50 years have not understood or believed that through scientific advancement, there will be economic progress and benefits for the country as a whole," says Mr. Terrones's oldest brother, Guillermo, a physics researcher at Los Alamos National Laboratory, in New Mexico.

"It's not that it can't be done," he says. "It's just that leaders do not understand the link between scientific achievement and economic prosperity." He is venting frustrations he has accumulated since leaving Mexico in 1983. The devaluation of the peso the year before had drastically reduced the national budget for research, leading to an exodus of scientists. Mr. Terrones recently tried to return to Mexico and join his brothers at the Potosí Institute, but the move would have meant taking a large salary cut.

"I realized that in a way, the director wanted people like me, but the system did not allow it," says Guillermo Terrones, explaining that the center's salary guidelines did not take into account his 15 years of experience in research into dealing with nuclear waste and other urgent problems. He argues that the government and public institutions have long rewarded scientists on the basis of scholarly output -- the amount of research they publish in international journals, the number of times their work is cited by other scientists -- rather than the practical applications of their work. As a result, the system does not encourage economic development.

"Countries have to have a technological and scientific base of their own, not import it," he says.

Losing the Advantage

For decades, Mexico has relied on imported technology from the United States to fuel its domestic industries, most of which have aspired to little more than producing low-quality knockoffs. The bulk of manufactured exports has consisted of clothing and electronics, assembled by Mexico's vast low-paid work force at foreign-owned assembly plants, known as maquiladoras.

But Mexico's economic model may be a bubble waiting to burst as those factories move to countries where salaries are even cheaper. In the past three years, scores of maquiladoras have moved to China and elsewhere, a trend that is expected to accelerate.

"To the degree that Mexico is simply relying on temporarily low labor costs to assemble computers, rather than developing depth in supplying a knowledge base, then these sectors may lose steam in the near future," says a World Bank report released in December, which urges Mexico to spend much more money on scientific research.

Such warnings are not new. But they are starting to sink in among Mexican policy makers.

President Vicente Fox, a former Coca-Cola executive whose election, in 2000, ended 71 years of one-party rule in Mexico, campaigned on a pledge to transform the country from a scientific underperformer to a technology powerhouse. He promised to work with industry to increase spending on scientific research from 0.4 percent of gross domestic product -- the total value of goods and services produced in the country -- to 1 percent of GDP by the end of his six-year term.

He also vowed to more than triple the number of scientific researchers, to 25,000, by increasing scholarships for graduate studies in science and the number of technological institutes.

Mr. Fox's administration has sought to reward scientists whose discoveries have practical applications and can fuel economic growth. The government has also worked to pair up industry with scientists.

"What we want to do in this administration is to pass from theory to practice, to find applications for our knowledge," says Guillermo Aguirre, deputy director of technology for the National Council for Science and Technology, or Conacyt. Mr. Fox recently elevated the council to cabinet level, strengthening its mandate to oversee scientific research and administer grants.

In addition, the government has set aside \$20-million to help scientists bring their inventions into the market. It is also encouraging technology specialists, incorporating them into its National System of Researchers, which pays monthly bonuses of up to \$2,000 to researchers who do promising work.

Sparse Results

But Mr. Aguirre acknowledges that the government is a long way from reaching even its own goals, much less embarking on the kind of overhaul that is needed if Mexico is going to move forward.

The number of researchers has increased only slightly in the more than three years of Mr. Fox's administration, from 8,000 to 10,400, says Mr. Aguirre. There is also a shortage of openings at public research institutes, which means that many graduate students in science will be forced to go abroad or to work for private universities, despite their limited capacity to conduct research.

And with two and a half years left in President Fox's term, spending on science has remained stagnant at 0.42 percent of gross domestic product. Mr. Aguirre and other officials attribute the government's failure to meet the goals to the downturn in the American economy since 2001, which has had a devastating effect on Mexico, a major trading partner. But privately, many experts wonder whether the government lacks the capacity and determination to carry out major changes in science and technology.

By contrast, Brazil and China, both of which have lower per-capita incomes than Mexico's, put 0.9 percent and 1.2 percent of their GDP's, respectively, into developing science and technology in 2001, according to the latest figures from the Organization for Economic Cooperation and Development. The United States spent more than twice that, 2.65 percent of GDP.

Mexico's meager spending creates a vicious cycle, limiting scientists' ability to achieve breakthroughs and discouraging potential investors in the private sector, whose support would lead to more research. Mr. Aguirre cites a World Bank study showing that countries must spend a minimum of 0.5 percent of GDP for research to start paying off and scientists to start finding markets for their innovations. "The main goal of this administration is to get past that critical hump," he says.

In an effort to force that to happen, one of the two chambers of Mexico's National Congress passed a law last month requiring the government to bring research spending up to 1 percent of GDP by 2006. The law, if approved by the other chamber and the president, would create incentives for industry and government agencies to spend more on technological research.

For example, the government's Health Secretariat might be required to pay a tax on all medicines and equipment it imports. The logic is similar to the U.S. government's policy of using taxes from cigarettes to finance medical research. Brazil has applied a similar approach, taxing its newly privatized industries to support scientific research.

But those proposals clash with the reality of Mexico's economic woes. The National Congress, with the president's approval, decreased support for Conacyt by about 20 percent in November, citing the global economic recession. The science council's annual \$460-million budget is less than what the U.S. government spends on nanotechnology research alone.

And there are areas where the government's math doesn't add up, says Pablo Rudomín, a renowned neurophysiologist who served as chief presidential science adviser from 1997 to 2003. He calculated the cost of doubling -- rather than tripling -- the number of scientific researchers at \$3.5-billion, almost eight times Conacyt's current budget. Asked about the disparity, Mr. Aguirre simply shrugged.

Even if the government came up with the money, Mr. Rudomín says, finding so many new researchers would require an overhaul of science teaching from the elementary-school level on up. Mexican students rank last in science-and-math performance among the world's 30 largest capitalist nations.

"It's not like buying a new refrigerator," he says. "It takes time."

Partners in Industry

Others blame laws that severely limit opportunities for Mexican scientists to profit from their inventions, which are considered the property of the institution where the research was conducted. In the United States, a 1980 law gives American scientists title to their inventions, allowing them to keep up to 60 percent of the profits on the sale of patents or from royalties.

Only a handful of Mexican research institutes have guidelines allowing scientists to retain a specified percentage of profits from the sale of technology. But those researchers are still banned from setting up businesses using knowledge acquired at state research institutions.

"They don't motivate research. You will earn the same if you work with industry or not," says Mauricio Terrones, whose work at Sussex University, in England, contributed to Harold Kroto's sharing of the Nobel Prize in chemistry, in 1996. "You tell yourself, It doesn't make much sense if I'm going to start killing myself and others will get rich."

Mr. Aguirre agrees. Conacyt is trying to change the law so that scientists are treated more like entrepreneurs, he says. But they will have to do their part, he adds, by concentrating their energies on solving practical problems.

One example of productive cooperation between science and industry is the pharmaceutical industry, which works closely with medical researchers from the government health institutes who carry out clinical trials of new drugs. That partnership has paid off: It was in Mexico, in the early 1950s, that the first birth-control pill was developed. At about the same time, Mexico won the international race to create a synthetic substitute for the steroid cortisone, used to treat arthritis, among other health problems.

And while most scientific fields in Mexico are poorly financed, the number of Mexican researchers doing world-class work has increased in recent decades, even if many have to travel abroad to keep up to date in their fields. "You can invite selected Mexican researchers to give a colloquium in the U.S., and he's a top researcher," says Mildred Dresselhaus, a physics professor at the Massachusetts Institute of Technology, who was a science adviser to President Clinton. "It wasn't like that 30 years ago. There is quite a lot of state-of-the-art research."

Ms. Dresselhaus, who was central in persuading the Clinton administration to start an ambitious program in nanotechnology research, says she expects Mexico to follow the leads of the United States and Japan in encouraging scientists to conduct research that has commercial applications.

Such an emphasis angers some scientists, who say the pressure to come up with commercially viable findings stifles creativity. Others say the policy shift is long overdue. "This country has devoted 50 years worth of funding to basic science, and it is time to move on to the next phase," says Jesús González Hernández, director of the Querétaro campus of the prestigious state-run Center for Research and Advanced Studies. The nine-year-old center, 120 miles northwest of Mexico City, is a pioneer in devising responses to such pressing problems as housing scarcity and insufficient food production.

"In a country that has 50 million poor people, we can't have billions of pesos going to basic science that doesn't benefit the poor," says Mr. González. "Right now is the moment to put money into resolving real problems."

The next hurdle is convincing Mexican industry to spend money in research. The private sector provides only 24 percent of the support for civilian science-and-technology research in Mexico, compared with 40 percent in Brazil, 60 percent in China, and 68 percent in the United States.

"Mexican businessmen aren't used to taking advantage of new technology," says Mr. González. "They need to learn to trust Mexican scientists. They don't respect us very much."

He should know. When he and three fellow scientists at the advanced-studies center figured out a way to produce tortillas in 2 hours, rather than the traditional 18, they rushed to tell food-industry executives about their discovery. But not a single Mexican company was interested in buying the rights to the new technique, since it would have involved changing equipment.

The scientists were devastated. "We designed it for Mexico," says Gerónimo Arámbula, one of the team members, explaining that the researchers had been inspired by the need to make production of one of the country's staple foods cheaper and more efficient.

Studying the thermal properties of corn, they had discovered that by grinding the kernels to a certain size and adding the right combination of water and the mineral lime, they could drastically reduce both the processing time and the amount of wastewater. "There aren't many of us who can find a common, practical use for our research findings," says Mr. Arámbula. "If it's what we need, the logic is that it should benefit us."

In February Mr. González sold the patent for the equivalent of \$680,000 to an American grain company, Minneapolis-based Cargill, which also sponsored the final two years of research in the six-year project. The scientists -- whose center is among the few in Mexico with contracts allowing its researchers to retain a portion of the profits (40 percent) from selling a patent -- plan to invest the money in more research on food.

But only a tiny handful of scientists find such a commercial use for their discoveries, much less profit from them. In almost all cases, Mexican companies are not interested in buying the technology, and entrepreneurial scientists lack the contacts to sell their inventions abroad.

"There is this idea that science is very expensive and we should just buy technology from other countries," says René Drucker Colín, coordinator of scientific research at the National Autonomous University of Mexico. "This is a very myopic vision. As a result our productive sector can't compete."

He produces a catalog of dozens of recent inventions by the university's scientists. Only one discovery, an antigraffiti paint, has found a domestic buyer.

"It's not a quality issue," says Mr. Drucker. "Mexican scientists are as good as any in the world. But as long as the government and industry don't think science is important, we won't change and grow. We can't keep being orange sellers."

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