Philippines

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The demand for agricultural products is increasing in the Philippines, and, until 1997, foreign demand for Philippine exports of fruits and coconut oil was also growing. Little arable land is available for expansion of production, however, and that land is diminishing as a result of urban and industrial development. Thus, to continue to meet demand, the Philippines need to increase output per unit of land. This means applying better technology. Public sector research is one possible source of this technology, but government investments have been stagnant or declining. Thus, importing technology and developing new technology through research by private firms are likely to be important sources of growth in the future.

This chapter examines private sector research and technology transfer in the Philippines. After a brief introduction to Philippine agriculture, it describes and attempts to quantify how much research is being conducted in the Philippines. The impact of private research is also discussed.

We collected the raw data during two visits to the Philippines during 1996, when we interviewed 20 firms and met with officials from the Philippines Council for Agricultural Research and Resources Development, the Department of Science and Technology, the Patent Office, the International Rice Research Institute, the Philippines Institute of Development Studies, the Agricultural Attaché at the U.S. Embassy, and the U.S. Agency for International Development.

Agricultural Production and the Input Industry

Production

Agricultural production stagnated in the 1980s and the early 1990s growing an average of 1 percent per year during the 1980s and 1.4 percent in 1990-95 (David, 1996). The major areas of growth have been pork and poultry. Livestock and poultry production, which make up 27 percent of agricultural production, doubled between 1985 and 1995. Crop production, which makes up 56 percent, increased much more slowly—a 21-percent increase in the same period (table G-1).

The major factor leading to increased poultry and pork production has been demand. Demand for meat has increased with the increase in per capita income and population growth. Productivity also seems to have increased. About 30 to 35 percent of swine are produced in integrated operations that feature exotic breeds or mixed exotics and local breeds, commercial feed, and confinement management. Sixty to 80 percent of the poultry is produced in integrated operations featuring foreign breeds, commercial feed, foreign pharmaceuticals and vaccines, and confinement management.

The increase in field crop production was also driven by demand driven both by increases in per capita income and by government policies. Technology and increased inputs account for much of the increase in production. Table G-2 shows the rapid increase in use of hybrid maize and fertilizer during this period. The increase in these inputs helped boost maize yields from 1.1 metric tons (mt) per hectare (ha) in 1985 to 1.5 mt/ha in 1995, and rice yields from 2.6 to 2.9 mt/ha in the same period (lower part of table G-1).

Production of plantation crops was driven by foreign markets. Agriculture is no longer the major producer of exports from the Philippines. Total agricultural exports declined from US$4.6 billion in the 1979 to US$1.5 billion in 1994 in nominal dollars. In 1979, agriculture and forestry accounted for 49 percent of total Philippine exports (David, 1996). In 1994, they accounted for 11 percent of exports. The major agricultural exports of the Philippines were coconut oil and fruits—primarily bananas. Demand for fruit was growing largely because of the growing demand in Asia, chiefly Japan, Hong Kong, and South Korea, followed by China. Sugar exports, which were tradition-

Table G-1—Agricultural outputs and inputs

	1985	1990	1995
Agriculture production[1]	86.9	103.7	117.0
Crop production1	91.9	103.9	111.1
Livestock production1	66.6	101.7	137.7
Rice:			
Yield (metric ton/hectare)	2.59	2.98	2.86
Area (hectares)	3,402,610	3,318,720	3,951,140
Production (metric tons)	8,805,600	9,885,000	11,283,600
Maize			
Yield (mt/ha)	1.12	1.27	1.52
Area (ha)	3,510,910	3,,819,560	2,735,720
Production (mt)	3,922,000	4,853,891	4,161,330
Sugarcane			
Yield (mt/ha)	62.7	82.6	69.3
Area (ha)	368,547	318,403	375,098
Production (mt)	2,310,000	2,630,000	2,600,00
Coconut			
Yield (mt/ha)	2.63	3.54	3.98
Area (ha)	3,270,000	3,111,978	3,064,457
Production (mt)	8,600,000	11,023,000	12,183,090

[1] Values indexed to 1989-91=100 levels.

Source: FAOSTAT Statistical Database. *http://apps.fao.org*.

ally the largest exports, have declined in importance, and domestic demand for sugar has increased.

Plantation crops were produced not only on large plantations but also by small-holders. The share of production by small-holders varies by crop and has increased in most of these crops due to land reform. Bananas for export are mainly produced on large plantations. At the opposite end of the spectrum, coconuts are produced by thousands of small farmers, with a few large plantations in Mindanao. Sugarcane production falls somewhere between.

Productivity of fruits has increased somewhat, while sugar productivity has been stagnant. Coconut productivity has increased considerably—from 2.6 mt/ha in 1985 to 4.0 mt/ha in 1995 (FAOSTAT).

Agribusiness

Pesticides are supplied almost entirely through imports. All leading firms are subsidiaries of multinationals or joint ventures with multinationals. Most import the formulated product, with only one local company producing an active ingredient. That product was 2,4-D, one of the oldest herbicides. A few companies import the active ingredients and formulate the product locally in their own factory or contract the formulation out to another firm. The pesticide industry grew to $172 million in 1995, with insecticides accounting for 53 percent of sales, followed by herbicides (19 percent) and fungicides (16 percent) (see table G-3). The most rapid growth was in the "Other" category, while herbicide sales were next most rapid-more than doubling since 1980. Pesticides are used chiefly on rice (38 percent of sales), followed by fruits (33 percent) and vegetables (12 percent).

Most seeds are produced and saved by farmers. Only hybrid corn, vegetables, and hybrids or new varieties of rice are produced commercially in fairly large quantities. The main research and seed production firms are Pioneer, Cargill, Ayala, and Cornworld in corn; East-West Seeds for vegetables; Cargill and Cornworld also produce small amounts of hybrid rice. Pioneer sells its seed through a wholly owned subsidiary. Cargill has an alliance with Ayala for corn seed distribution. Cornworld distributes East-West's vegetables and its own corn and public hybrid rice. Government regulations ensure that most of the commercial seeds are also locally produced. For example, Ciba-Geigy (now Novartis) tested hybrid corn developed in Thailand but has been unable to obtain permission to sell it in the Philippines.

The livestock and poultry businesses are dominated by a few big integrators who had hatcheries, large com-

Table G-2—Agricultural inputs, 1985-95

Item	Unit	1985	1990	1995
Hybrid maize seed	Metric ton	1,100	NA	9,000
Fertilizer consumption	Metric ton	283,181	588,087	603,125
Tractors (Number in use)	Numbers	8,050	10,700	11,500
Irrigated area	1,000 hectares	1,440	1,560	1,580

NA indicates not available.

Sources: Maize data from survey. Rest of data from U.N. Food and Agriculture Organization. FAOSTAT Statistical Database. *http://apps.fao.org*

mercial pig farms, feed mills, poultry and meat processing facilities, and retail outlets. The main firms are 1995 Vitarich, San Miguel Corporation, Purefoods, Swift, and General Milling. All of them were connected to the large families who dominate Philippine business. Poultry breeds were supplied by the major international firms such as Arbor Acres, Cobb-Ventris, Avian Farms, and Hubbard in joint ventures with the integrators. The international firms supplying pig breeds were Dallard, PIC, Babcock, Seghors, and Hypor. One international firm (Ralston-Purina) has recently entered the feed business.

Plantations in the Philippines produce sugarcane, bananas, pineapples, rubber, and coconuts. The plantations are owned by and located near sugarmills, all owned by Philipinos. Bananas and pineapple plantations are mainly associated with Dole and Del Monte. However, local plantations have been increasing their production of bananas. Coconut milling, which had been controlled by Marcos ally Cojuangco, has now opened up to some foreign firms but does not own any copra plantations.

Policies

A number of policies affect agriculture. Economywide policies had kept the peso overvalued, which increased prices of exports and reduced the amount of agricultural exports. A number of agricultural policy changes were put in place starting in 1986. Export taxes on copra were abolished. Government monopoly control on agricultural trade on almost all commodities except rice was eliminated. Quotas and tariffs on agricultural inputs were lowered considerably (David, 1996).

Table G-3—Pesticide sales, 1980 and 1985

Pesticide	1980	1995	Change
	Millions of 1995 U.S. dollars		*Percent*
Insecticides	50	91	82
Herbicides	14	33	131
Fungicides	14	28	96
Other	5	20	273
Total	86	172	101

Source: Crop Protection Association of the Philippines.

Despite attempts to liberalize agricultural trade around 1990, the Philippines had been protecting agriculture and driving up prices in the 1990s. The attempts to liberalize trade were negated by the 1991 law called the "Magna Carta of the Small Farmers." It placed quantitative restrictions on imports of products produced by Philippine farmers. These include sugar, corn, or other grains for livestock feed, and poultry and pork products. A seed law regulated the imports of seeds and planting materials.

The net result of the changes in macro policy and agricultural policy was that agriculture was protected much more than it had been in 1985 (David, 1996). In 1985, the estimated effective protection on agriculture was 9.2 percent, while effective protection was 74.1 percent on manufacturing. In 1993-95, effective protection on crops and livestock was 28.1 percent, versus 29.1 percent for manufacturing (David, 1996).

The commercial livestock industry had some of the highest feed prices in the world because of the barriers to grain importation. It also had some of the highest meat prices because of trade barriers. The worry of many companies in mid-1996 was that, due to the General Agreement on Tariffs and Trade, the prices of meat would come down faster than the prices of grain.

Land reform started breaking apart the large plantations in 1995. So the cost of getting information out to farmers and back to researchers was increasing. In addition, the type of management practices needed was changing. Small farmers had less access to credit, used lower levels of manufactured inputs, and grew many other crops compared with larger operations.

Public investment policies had been less favorable than other policies toward agriculture. Government invest-

ment in agriculture grew in real terms from the early 1980s until about 1990 when it reached a peak, declined from 1990 to 1994, then started up again in 1995, but most of the increase was for environmental management, rice price stabilization, and agrarian reform. The amounts allocated to productivity-increasing research declined or remained stable. Irrigation investment declined dramatically after the 1990 peak in spending.

Research and extension did better than irrigation. Real expenditures increased from 670 million pesos in 1987 (1994 pesos) to 1 billion pesos in 1990 and stayed at that level through 1994. Extension went from 1.4 billion (1994) pesos in 1987 to 1.7 billion pesos in 1990 and 2.0 billion pesos in 1994 (David, deflated by implicit GDP deflator). As a percent of agricultural gross domestic product (GDP) public research declined. The Philippines could have had a much larger investment in private research relative to the size of its agricultural economy. Its public sector research intensity was 0.23 percent of GDP only about one-third of the level of Malaysia and Thailand and lower than all of the countries in this study except Indonesia.

Public research in the Philippines was conducted primarily by institutes under the Ministry of Agriculture and the Agricultural Universities, which are funded and linked through the Philippine Council of Agricultural and Resource Research and Development. There are also public sector research institutes for sugarcane research and coconut research that are not part of the Ministry of Agriculture. In addition, the International Rice Research Institute (IRRI) is located in the Philippines but financed by the international donor community. Real funding of IRRI has been declining since the early 1990s.

Private Research and Technology Transfer

Private firms spent about $10.5 million on private research in 1995 (table G-4). This is 22 percent of all agricultural research in the Philippines. Relative to the size of agriculture, it was quite a small amount—about 0.1 percent of AgGDP. The plantation sector invested the most money in research, followed by agricultural chemicals, seeds, and livestock. Private research increased by about 60 percent in real U.S. dollars between 1985 and 1996, with almost all the growth in the livestock and plantation industries, which grew very rapidly. Agricultural chemical research also grew, while R&D in the seed industry declined. We were unable to gather data on agricultural machinery.

Research Expenditures and Growth by Industry

Fruit plantations provided the largest amount of research expenditure and the most growth in Philippine private agricultural research. Private research by one sugar milling company—Victorious Milling Company—continues to be important, but in 1996 was overshadowed by research of the fruit plantations. Research on sugarcane started during the colonial

Table G-4—Philippine private agricultural research, 1985 and 1995

Research expenditure	1985	1995
	1,000 1995 U.S. dollars	
Agricultural machinery	305	Unknown, but small
Agricultural chemicals	1,657	2,562
Livestock	708	1,480
Plant breeding	2,242	1,800
Plantations	1,610	4,680
Total private research	6,522	10,522
Public research expenditure	n.a.	37,000
Private research as a percentage of total research	n.a.	22%
Agricultural gross domestic product	11,054,000	16,319,000
Private research as percentage of agriculture gross domestic product	0.059%	0.064%

n.a. indicates not available.

Note: The peso-dollar exchange rate was P26.29.

Source: Private research: Survey by Authors and Pray, 1986. Public Research: David 1996. "Agricultural GDP from World Bank" World Development Report, 1997.

period, while research on bananas started in the late 1960s. In 1996, research was conducted by multinationals and local companies on sugarcane, bananas, pineapple, canning tomatoes, asparagus, coconuts, and mangoes. Most of this research was aimed at reducing the cost of production through better management. There was also a continual search for improving the quality of the product for export. The desired quality characteristics include the appearance and flavor of the fruit as well as low or nonexistent levels of chemical residues. Twin Rivers Research Center was working on biocontrol and manual techniques for reducing pesticides for a "chemical-less" brand of bananas, which is finding a good market in Japan. Some plant breeding and selection research is being carried out on sugarcane and bananas. Firms have also worked on hybrid coconuts in the past.

Agricultural chemical research, the next largest amount of research, is almost entirely conducted by foreign companies. They are testing new products or products that are in commercial production elsewhere. In the past, insecticides for rice had the most attention. In 1996, some of that research effort shifted to herbicides. The private sector worked some on Integrated Pest Management. In addition, a considerable amount of research is being done on the choice and management of pesticides for plantation crops. Plantations are trying to reduce their costs of production and produce a crop free of chemical residues, the presence of which would cause rejection of the crops in foreign markets. Two companies have experiment stations in the Philippines. The rest depend on experiment stations in other countries in the region for testing the newest compounds and then rent land to do local research in the Philippines. One foreign chemical company in the Philippines researches chemicals in the initial stages of testing.

Research by the seed industry concentrates on breeding new varieties of hybrid corn, hybrid vegetables, and, recently, hybrid rice. Pioneer has the largest corn research program, most of which was of yellow corn with about 10 to 15 percent white corn. Its breeding in the Philippines targets the middle and southern parts of the Philippines, as well as Indonesia, which has similar pests and climatic conditions. Pioneer's corn breeding for the northern Philippines is done in Thailand. Cargill is the other multinational with a corn breeding program. It also has close ties with a larger corn breeding program in Thailand. Cornworld, Ayala, and Asia Hybrids—all local companies—have corn breeding programs. DeKalb and Ciba-Geigy (now Novartis), operating from a research base in Thailand, have been testing hybrid corn in the Philippines also. Cargill has been monitoring the development of hybrid rice at IRRI since the early 1990s and has a small rice research program. Toward the late 1990s, East-West Seeds started a hybrid rice research project in the Philippines. East-West Seeds also has a large vegetable research program that includes three or four expatriot breeders and four or five Philippine scientists.

In 1996, no company reported working on genetically engineered crops in the Philippines, although Pioneer had just obtained permission to conduct some confined trials of Bt corn.

The decline in plant breeding research was due in part to the exit of San Miguel Corporation and Pacific Seeds from the seed industry. Another factor that reduced the expenditure on plant breeding was that Pioneer moved its off-season research and multiplication nursery for Japan out of the Philippines and its work on the northern part of the Philippines to Thailand. These declines were only partially offset by the entry of Ayala and Cornworld into corn breeding. In 1996, there was definitely more research on hybrid rice and vegetables than there was in 1985. East-West started its large vegetable research program after 1985 and started its hybrid rice program in the mid-1990s. Cargill seems to have increased the size of its hybrid rice program.

IRRI engineering staff reported that four local firms in the Philippines were researching how to improve small-scale agricultural machinery. They were unaware of any foreign agricultural machinery firm doing such research in the Philippines.

In the Philippines, livestock research was conducted by integrated poultry and swine corporations and by feed companies. San Miguel and its subsidiaries, such as Monterrey Farms, have an animal nutrition lab near Los Banos and experimental farms around the country. The improved poultry and swine breeds were all imported so integrators concentrated on improving management of livestock and identifying the most productive breed, feed additives, pharmaceutical, and machinery inputs. Feed companies have focused on identifying low-cost combinations of inputs into processed feeds and eliminating anti-nutritional factors. Integrators and feedmills are also evaluating new feed additives.

Impact of Research

Plantation research by local organizations, such as the Twin Rivers Research Center, allowed the Philippines to enter the banana production and export business. The plantations had imported the Cavendish variety, which is the standard for exports, but plantations had appropriate plant management. Without this research, local plantations would not have developed the management package needed to compete with the multinational firms such as Dole and Del Monte. Research by Dole and Del Monte had reduced the cost of production by tailoring the use of nutrients to local soil and climatic conditions, reducing potassium applications to zero in some places and adding zinc in some regions. In addition, they reduced fungicide applications and developed management techniques for pests found only in the Philippines.

Agricultural chemical research in the Philippines had resulted in the identification of two pesticides from American Cyanamid, a corn herbicide marketed in Europe in 1996 and an insecticide that was effective on the Diamond Back moth. The applied research needed for the introduction and registration of new pesticides led to a wide number of pesticides becoming available in the Philippines. In what is probably the most detailed study of the impact of pesticides anywhere in the world, Antle and Pingali (1995) found that insecticides and herbicides increased rice productivity in the Philippines, but that insecticides had a negative impact on farmers' health.

The primary effect of private plant breeding research had been to breed and/or identify yellow corn hybrids for the Philippines. This accounts for at least part of the increase in corn yields from 1.1 mt/ha in 1985 to 1.5 mt/ha in 1995. Plant breeders have also had some success developing improved vegetables, which has increased yields of some vegetables. Hybrid rice still has not been adopted widely in the Philippines. Thus, any improvements on IRRI hybrid rice technology by the private sector has not yet affected rice yields.

The very applied management research in livestock by private firms has undoubtedly led to increased livestock productivity in the Philippines, but as of 1996 no studies had measured the impact. Livestock research has reduced the cost of feed production by identifying local ingredients and their optimal proportions in feed. It has also identified useful feed additives, developed labor-saving equipment, and identified the nutritional requirements of animals in the tropics. For example, Ralston Purina claims to have cut $2.00/ton in costs of producing feed in the 4 years they were in operation.

Factors that Influence Private Research

The patterns of private research expenditure that need to be explained are the low amount of private research, the relative size of research expenditure by industry, and the rapid growth of plantation and livestock research while plant breeding research declined. We explain these patterns by looking at the demand for the product of research, the ability of firms to appropriate the benefits of research findings, technological opportunities for innovation, and relevant government policies.

Demand

Much of the explanation for the pattern of R&D growth is due to changes in demand for agricultural products. With livestock the most rapidly growing component of Philippine food consumption, it is responsible for much of the increase in livestock research. Firms already in the livestock business, such as San Miguel Corporation, increased their research and a few new firms, such as Ralston Purina, entered the business in response to increasing demand. The increased growth in plantation research can be traced to increased exports of fresh and canned fruits (see table G-5 for the value of exports). Almost all of the increased research was due to growth in research on bananas and pineapple, with a little research on processing tomatoes and asparagus. Research on other plantation commodities, such as sugar and coconuts, did not grow. The sugar market has experienced decreasing foreign demand, but the coconut market has not other factors, therefore, must explain low research in that area.

The combination of new agricultural and macroeconomic policies that raised effective protection for the agricultural sector made agriculture more profitable in the early 1990s thereby increasing farmers' demands for modern inputs. Table G-3, for example, shows a doubling of the value of pesticide sales between 1980 and 1995, with a particularly large increase in herbicide sales. Equally important for research-based chemical firms, the major government-subsidized firm Planters Products had its subsidies and other advantages eliminated when Marcos fell. The company soon went into bankruptcy, leaving pesticide markets open

Table G-5—Value of total Philippine exports, 1991-96

Commodities	1991	1992	1993	1994	1995	1996
			Million U.S. dollars FOB			
Fruits and vegetables	497.0	503.8	600.3	571.7	581.5	650.0
Sugar and products	146.4	121.8	137.8	85.1	88.8	100.0
Coffee, cocoa, etc.	25.4	16.6	16.6	29.8	31.2	35.0
Fats and oils	311.6	495.2	370.2	490.7	844.4	750.0
Total agricultural exports[1]	1,352	1,454	1,427	1,486	1,934	1,964
Total exports[1]	8,840	9,824	11,210	13,483	17,447	20,500

[1]Totals may not add up due to rounding.

Source: American Embassy, Manila, Philippines. Agricultural Situation 1996.

for other firms. In addition, the government started to restrict the use of the "dirty dozen" pesticides—those pesticides most dangerous to people and the environment. This significantly reduced the market share of older low-priced insecticides and increased the market share of new high-priced chemicals.

Appropriability

Demand is only part of the explanation for the patterns of growth and the levels of research expenditure. Industries in which demand is high and increasing, such as coconut, were not the focus of private research efforts unless there was some way that private firms could capture the benefits of research. Industry structure allowed firms in certain industries to capture the benefits of research. Until the latter 1990s, processors and exports also owned banana and pineapple plantations. They could benefit from plantation management research through lower costs on their large plantations and by reducing the prices they had to pay to procure more of the crop that they produced. In contrast, small farmers grow most of the coconuts. Since the Marcos government, oil processing has become more competitive. Thus, it was difficult for any big firms to capture a share of the benefits of coconut research, which left this crop with little private research. Recent land reform may force fruit processing and export firms out of controlling plantations, compelling them to buy fruit from small holders.

Most private livestock research concentrates on poultry and pigs rather than beef and dairy. A number of large firms are vertically integrated from feedmills and hatcheries to butcher shops and fast-food restaurants. Some dairy organizations are vertically integrated, but few beef operations are. Vertical integration allows poultry and pig firms to appropriate the benefits of research and technology imports through lower costs of procuring eggs, broilers, and pigs from contract growers and lower transaction costs in the marketing chain.

The agricultural chemical industry illustrates the importance of intellectual property rights. In the Philippines, pesticides can be patented using product patents, but in general, Philippine patents give very little protection. For pesticides, however, the regulatory system strengthens the protection given. Registration materials that companies submit to prove the safety and efficacy of new compounds are kept secret, and only one firm is allowed to produce the compound for a certain number of years after registration. This could give a firm protection for a compound in the Philippines even after it was no longer protected by patents elsewhere in the world.

The seed industry depended on hybrids to be able to appropriate the benefits from research. Their breeding activity was concentrated entirely on hybrids, such as corn, vegetables, and hybrid rice. A new patent law was passed in 1997, but plant varieties were still excluded and no separate plant breeders' rights legislation has been passed. The Philippine Government signed the World Trade Organization treaty, which committed it to passing plant breeders' rights legislation by 2000. As of 1996, several Plant Breeders' Rights (PBR) laws had been proposed but none had passed. This kept multinational companies from bringing in double-cross hybrids of corn, and it ensured that no research was done on crops that were not hybrids. One firm suggested that PBRs would lead to more expenditures on banana breeding.

Cost of Innovation (Technological Opportunity)

Two industries show how technical opportunities interact with the other factors to encourage or discourage private research. There is little technological opportu-

nity in fertilizers and thus little research, in spite of fertilizer's being a large and growing industry. In contrast, there is a lot of technological opportunity in biotech but little private research, even though biotech has stimulated billions of dollars of private agricultural research internationally. IRRI is conducting a lot of biotech research on rice, and private firms are interested in introducing insect- and herbicide-resistant corn. As of 1996, IRRI had almost no effect on the amount of private agricultural research in the Philippines. In this case, the reason is not appropriability or lack of market. Until 1998, lack of biosafety regulations prevented government scientists, IRRI scientists, and private firms from testing biotech in the field.

Biotech was slowed by lack of regulations, which reflects the controversy within the Philippines about the costs and benefits of biotechnology in agriculture. A number of firms would have liked to test products in the Philippines but were deterred by the lack of an established procedure. In 1995, a biosafety committee was established. Pioneer applied to do trials of Bt corn with the Institute of Plant Breeding of the University of the Philippines at Los Banos (UPLB) in an enclosed field. In May 1996, this committee approved those trials. In 1998, the government issued new rules to govern the release of a transgenic variety in field tests. No field trials have yet been approved.

Public sector research could stimulate private research. Public research at IRRI on tropical hybrid rice induced a few firms to start rice breeding programs. Private pesticide and livestock nutrition firms located their research stations near Los Banos to take advantage of the scientists and knowledge at UPLB and IRRI. Public banana research was limited and has had little impact, but some companies were finding the INIBAP germplasm collections in Los Banos and Davao useful. They were using this germplasm to identify varieties for niche markets abroad. Unfortunately, the low levels of public research and expenditure on higher education in the Philippines, as shown by the low research intensity, may help explain overall low levels of private research.

In the Philippines, there seems to be very little basic biotechnology research on which to build private research programs. Strong public biotechnology programs at U.S. universities produced technology that became the basis of a large number of agricultural biotech firms in the 1980s and induced some of the large agricultural chemical firms to invest in research. Public programs did not have the same impact in the Philippines. The strongest biotech research programs were at IRRI and the National Institutes of Biotechnology and Applied Microbiology (BIOTECH) at UPLB. IRRI and UPLB are parts of the Rockefeller Rice Biotechnology Network. IRRI has been concentrating its biotech research on increasing the productivity of rice research and increasing the resistance of rice to pests, diseases, and abiotic stresses such as drought. This has strengthened public research programs in Asia, but it has not led to private research. Biotech research at BIOTECH was very applied, working on microbial fertilizer, food and feeds, pest and disease control, as well as environment, industry, and plant biotechnology. BIOTECH has about 120 scientists of whom 16 have a Ph.D. It has produced a few technologies since being established in 1979, but none of the agricultural input firms that we talked to worked with BIOTECH. BIOTECH did not identify any private agricultural research that they had induced.

The cost of some private research has been affected by public funds and R&D tax credits. An example of R&D funds for the private sector is the PCARRD's (Philippine Council of Agricultural and Resource Research and Development) past funding of projects at Twin Rivers Research Center. PCARRD was also considering an application for funding for a project to develop management techniques to reduce chemical use in banana plantations.

Science and Technology Policies

Specific policies designed to stimulate private research appear to have had limited impact in the Philippines. The Department of Science and Technology (DOST) established a number of programs to stimulate R&D, but the funding for these programs is so small that they could not have much impact. DOST has invested in several science parks including one in Los Banos for food and agricultural technology. By 1996, DOST had invested 30 million Philippine dollars (about $1 million) for buildings, and the university had given 55 hectares of its land for the University of Philippines at Los Banos Science Park in Los Banos. As of 1996, the Park was only open to technologies from the UPLB. When we visited it, there were several buildings with two companies in operation but still no assured supply of electricity or water. Thus, little work could be done.

DOST is developing a Venture Capital fund in collaboration with the government-owned development bank, because while government-guaranteed loans from banks were available, equity financing institutions for

small business were almost nonexistent. DOST also has a Technology Application and Promotion Institute to help small firms in all types of industries with export potential to market their products. Although we did not have time to evaluate these programs, their size and effectiveness appear to have been limited by low levels of funding.

These incentives must be balanced against weak intellectual property rights for most industries, except perhaps pesticides where they were reinforced by the regulatory system. The intellectual property rights (IPRs) laws were similar to the U.S. laws except that there is no plant breeders' rights law. Patent protection for micro-organisms and microbial processes was granted in the 1997 patent law. An additional difference from that in the United States was a weak patent system. The main problem is not the laws but the enforcement of the laws, which is quite difficult because neither the police nor the courts have enough resources to adequately deal with IPR cases.

The other policy disincentive, which was mentioned above, is that there was no system for judging the biosafety of genetically engineered organisms until the summer of 1998. Thus, it was impossible to conduct field trials of transgenic plants.

Summary of Determinants of Private Research Patterns

The industries that had attracted the largest investments in private research had large markets, a way of capturing benefits from new technology, and there was the possibility of producing new innovations without major investments. This set of conditions holds for fruit and vegetable plantations, pesticides, hybrid seeds, and poultry and pig production. These conditions did not hold for fertilizer (little opportunity for improvement), coconuts (little appropriability), or agricultural machinery.

Growth in private R&D was mainly due to growth in demand for livestock, pesticides, and fruit as indicated by the fact that research as a percent of AgGDP grew very little. The only changes in appropriability were that rice hybrids have moved closer to commercial feasibility and there were changes in industry structure as some Marcos allies lost some of their market power. Such changes, however, appear to have led to few additional opportunities to appropriate the gains from research. The IPR laws did not change until 1998, although the Philippines did sign the Uruguay Round of GATT, which requires them to eventually strengthen their laws and enforce IPRs. Technological opportunities for profitable applied research may have improved somewhat with the liberalization of input imports. However, as indicated above, the major technological breakthrough—biotechnology—has not stimulated research in the Philippines.

Policy Options

The Philippines was unlikely to have a very large absolute amount of private research because it is a medium-sized country. However, as a tropical country in a world where most research was conducted in temperate countries, there may be an opportunity for adaptive research to have important payoffs. The Philippines could have made a much larger investment in private research, relative to the size of its agricultural economy, than it did. Its private research intensity was about the same as India and considerably lower than that in Malaysia and Thailand. This section looks at the policy options for increasing private research.

There are three types of private sector firms or groups that could increase their research in the Philippines: the large Philippine business groups such as San Miguel Corporation and the Ayalas; the subsidiaries of multinationals; and the smaller firms in biotechnology or small engineering firms in agricultural machinery.

For these firms to invest more in research, four major government policy changes would be useful:

- **Government investments in basic research.** Strong basic research programs in biotechnology can attract science-based firms to work with strong public laboratories. Philippine firms are also looking for basic research that can be the basis of their research programs. Basic research generates ideas that are the basis of start-up firms.
- **Stronger intellectual property rights.** This gives all types of firms incentives to make money from research. Small start-up firms will seldom be able to raise venture capital without patents. Larger Philippine and multinational firms do research only where they can capture benefits. One way the government can help is through enforcing patents and protecting plant breeders' rights. The new patent regulations of 1997 were a step in the right direction. Enforcement remains the problem.

- **More science-based regulation.** Pesticide regulations have gradually been rationalized to make them more science based and transparent. The 1998 biosafety rules was another step in the right direction. These rules must now be applied in a consistent fashion and other rules have yet to be rationalized.
- **Policy that ensures competition in high-tech industries.** A certain amount of concentration in an industry can stimulate research, as it has in the livestock industry. But too much concentration can keep innovative foreign or Filipino firms out of food and agricultural markets and would be harmful to farmers and consumers. Entry into agricultural markets can be made easier through antitrust policy and limited barriers to foreign direct investment.

In addition, certain policies are important for specific industries:

- **Financing of research and extension for export crops.** For export and plantation crops, cess (tax on production or exports) funding of research could be increased. Some of Colombia's major export commodities (flowers and fruits), for example, were not covered by government research programs or by commodity research organizations, so Colombia is organizing such programs to do research. In Southeast Asia, the rubber and oil palm research in Malaysia are two excellent examples or cess funding for research. In the Philippines, sugar research was reorganized to be financed by a cess, and the banana research at Twin Rivers Research Centers was primarily funded by a cess.
- **Science parks, marketing assistance, and venture capital programs for start-up firms**. The availability of these programs is critical for assisting scientists in starting firms, but there must be strong basic research to produce the ideas and strong intellectual property rights laws and enforcement first. Further, the benefits of these programs are increased if they encourage not only UPLB scientists but also scientists from private firms in the Philippines or outside.

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