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PRIVATE SECTOR RESEARCH AND TECHNOLOGY TRANSFER: ISSUES FOR PUBLIC SECTOR RESEARCH MANAGERS AND POLICY MAKERS [1]

INTRODUCTION

We undertook this study because we felt some countries in Asia were missing out on important opportunities for growth by discouraging the private sector from doing research and transferring agricultural technology. We did find this to be the case in some countries. In these times of pressure on government budgets and declining donor enthusiasm for research, private sector research and technology transfer may offer a cheaper and more efficient way to get new technology.

I am presenting this paper to you because (1) the government agricultural research system in most countries can play an important role in inducing more private sector research and making it more productive; (2) the research system of the country as a whole can be made more productive if government research complements rather than duplicates private research, and (3) government scientists usually play an important role in regulating private research, technology sales and importation by the private sector.

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DEFINITIONS AND METHODOLOGY

Before continuing, several definitions are needed. In this study the private sector means for-profit firms and excludes nonprofit organizations and collective activities of for-profit companies. The study was also limited to technology that is applied in production agriculture and excludes technology for post harvest operations.

The methodology for collecting the data in this study was to visit the countries and talk to as many private companies which were doing research or transferring technology as possible. In Bangladesh, Pakistan and Indonesia where there was little private sector research and technology transfer activity, I was able to talk to all of the firms that had formal research programs. In other countries, I talked to a sample of firms. This was not a random sample, rather it was the firms in which I had contact. The sample may be biased in that I may have over sampled the multinationals and undersampled the local firms. I did, however,make special efforts to talk to as many local firms as possible.

WHAT HAS THE PRIVATE SECTOR RESEARCH AND TECHNOLOGY TRANSFER CONTRIBUTED TO GROWTH?

Private sector research has made major contributions to the growth of some economies in Asia. The largest economic impact has been on the plantation industry. The oilpalm varieties of Southeast Asia that have made that area the fastest growing producer of edible oils are largely the result of private research. Many of the clones used in rubber production in Indonesia and Malaysia are the result of Harrison and Crossfield's breeding

program. Yields of oilpalm were increased and costs of production reduced by the introduction of the oilpalm pollinating weevil. Plantation research has substantially reduced the cost of pest control and fertilizer use.

After plantation research, it is difficult to say which type of research has had the most impact. Applied tobacco research in India, Pakistan and Bangladesh introduced Virginia tobacco, increased yields substantially and almost eliminated imports of Virginia tobacco. New high yielding corn nybrids have been developed and are being commercially planted in Thailand, India and the Philippines. They are currently spreading to Indonesia and Malaysia. In India, pearl millet hybrids and sorghum hybrids developed by the private sector have spread to about one million ha. and one half million ha. respectively. These hybrids have raised yield per acre substantially. The Indian machinery industry has developed tractors that run more efficiently and safely than previous tractors under Indian conditions. Research by agricultural chemical companies in Asia have identified chemicals to control Rottboellia exalta, the most serious weed problem in corn in the Philippines; fungicides for seed treatments of corn for downy mildew were developed and are widely used; and new rice herbicides were developed in Thailand. Research in Southeast Asia has developed safer and cheaper methods for applying pesticides.

The private sector is probably more important in the transfer of technology. Fertilizer and fertilizer production technology were imported from North America, Europe and Japan. The first generation of tractors and agricultural chemicals were all developed elsewhere and transferred to Asia. Arbor Acres and Shaver were the pioneers of commercial poultry production in

Asia in the early 1960's, and American and European companies continue to be the source of most commercial poultry breeds. The technology for commercial swine production has been transferred from the United States, Europe and Taiwan to Thailand, Philippines and Singapore by the private sector. Private companies have rapidly transferred rubber and oilpalm technology between Malaysia, Indonesia, Thailand and the Philippines. Banana production for export and pineapple production for canning were both based on introduced production technology.

The private sector has also played an important role in the diffusion of public sector technology within Asian countries. In Thailand, Charaon Pokaphand and Cargill are selling the corn varieties developed by Kasetsart University and Rockefeller. In the early days of the Green Revolution, Esso spread HYV's from IRRI and CIMMYT and fertilizer in Pakistan and the Philippines.

Private research and technology can also have negative affects. There is the potential for income distribution problems. When a new technology is widely adopted, almost always someone loses. In general, early adopters and consumers benefit from new technology, while late adopters and nonadopters lose. Increased production of corn, sorghum and pearl millet took place mainly in the most favored regions where these crops are grown and depressed prices for farmers in the poorer areas. Commercial poultry has affected the backyard poultry producers. Research also affects the international distribution of income. The gains in oilpalm productivity in Malaysia and Indonesia have led to lower prices for Philippine coconut producers and United States soybean producers.

Private research may also affect overall priorities of a country's research system. In the Philippines, twenty percent of corn production if yellow corn which is used as animal feed, while eighty percent is white corn for human consumption. Almost all private research is on yellow hybrids and much of the government's research is also on yellow corn although, they were working on varieties rather than hybrids. The private sector is spending thirty million pesos on corn research and has four PhD corn breeders while the government has one PhD corn breeder and is spending six million pesos on corn research. This leaves almost no one doing research on white corn which is an important food crop. A similar situation is found in the plant protection area in Pakistan and the Philippines were many government scientists were hired by foreign multinationals, other government scientists are consultants for the multinationals and the others spend their time testing new chemicals in the registration process. No one is left to work out integrated pest management systems or to work on biological control.

WHAT IS PRIVATE SECTOR RESEARCH DOING AT PRESENT?

Our best estimates of private sector research are presented in Table 1. They are almost certainly underestimates because it was not possible to interview all companies conducting research in most countries. In Malaysia in particular, we only had time to interview a few firms and most of those were in the plantation sector in peninsula Malaysia.

Across all seven countries the most research was carried out by the plantation and processing industries. I have lumped these industries together because many of the processing companies like oilmills or sugarmills also have

Table 1. Private Sector Research Expenditure.

	India	Philippines	Thailand	Indonesia	Malaysia	Pakistan	Bangladesh	Total
				(US$ 1.000s)				
Seeds	833 (8)	1583 (4)	665 (5)	0	0	182 (3)	Less than 1000 (1)	3264
Pesticides	3500 (20)	1170 (8)	887 (5)	800. (1)	500 (3)	387 (5)	40 (2)	7284
Machinery	6775 (3)	215 (22)			?	?	50 (1)	7040
Livestock	2275 (3)	500 (6)	1725 (2)	600. (3)	?	None	None	5100
Processing and Plantations	3324 (25)	1137 (7)	1034 (3)	600. (3)	10000. (9)	234 (2)	50 (1)	16379
Total Private	16707	4605	4311	2000	10500.	804	140	
Government Ag. R & D	248000	7000	48274	62000	(60000)			
Private as Percent of Govt. Research	7	66	9	3	17			
Private as Percent Ag. GDP	.03	.06	.05	.01	.17	.01	.00	

large plantations to supply these mills. Thus, I have included oil millers and planters, rubber planters, cigarette manufacturers, banana growers and exporters, sugarmillers, pineapple canners and producers and a few others. I have only included their agricultural research not their research on processing. It should be noted that almost two-thirds of this research is done in Malaysia. The ownership of these companies is a mixture of local companies, American and European based multinationals and Asian based multinationals.

The research of these firms spans a wide spectrum. Plant breeding and selection is done by oilpalm plantations, rubber plantations, pineapple processors and cigarette companies. Several companies are using sophisticated tissue culture techniques to clone and multiply oilpalms, and at least two companies are doing research to develop techniques to clone coconuts. Plantation and processing firms invest a lot of money in reducing their plant protection costs. Plantations in Malaysia and Indonesia are doing or financing biological pest control research and integrated pest management research. Research in the Philippines are trying to reduce the cost of plant protection on banana plantations and to identify safer pesticides and application techniques.

There are major investments in research by the input industries. Pesticide research is dominated by multinational companies. They and their subsidiaries conduct both centrally funded research that is testing new compounds and locally funded testing for bioefficacy and registration. The only country in which there was some synthesis of new compounds was in India, and the two companies that did any synthesis research have probably stopped in

the last few years. Some bioefficacy and registration research is carried on in every country, but there is a tendency for centrally funded research to concentrate in a few countries where regional stations are located. The Philippines has five regional programs for rice and Malaysia five or six for plantation crops.

Regional and local research consists of screening new compounds in field tests after they have passed all of the basic toxicity tests and the initial greenhouse screens back at headquarters. Among the new products that are being tested now are insect growth regulators such as chitin inhibitors some of which have recently come on the market. Companies also try compounds that are already being used commercially somewhere and try them on different pests. There is some research on improved application methods. In all, seven countries covered by these survey companies are required to prove bioefficacy in local conditions. There is a small amount of private research on integrated pest management (IPM). Some of this is done in cooperation with plantations. Other IPM research is done as a result of the build up of pests which are resistant to many pesticides like some cotton pests in Thailand.

Most of the pesticide research is on insecticides for use in rice and cotton. There has also been considerable research on herbicides for plantation crops. Recently, there has been increased emphasis on rice herbicide research for Southeast Asia and rice fungicides.

Expenditure on formal machinery research is primarily by a few large firms in India which do a lot of research on tractors and pumps. The tractors' firms are concentrating on improving fuel efficiency and increasing their safety for road use because haulage is the major use of tractors in

India. Pump manufacturers are trying to increase the efficiency of their pumps, and at least one company is trying to develop solar powered pumps.

There is a lot of informal research on farm machinery being done in all of these countries. It probably is of more importance to farmers than the formal research. Recent theses on the Philippines (Mikkelson, 1984) and Thailand substantiate the large amount of innovative activity and the impact that this activity had on production. However, because of the short time of our surveys, we could only interview a few small firms in order to corroborate the findings of other studies. The research in this sector was primarily trying out suggestions by farmers for improved machinery or changes to make production cheaper by substituting cheaper inputs for more expensive ones.

Livestock research includes poultry breeding by one firm in India, pork breeding by a Thai firm and then a lot of work on feed by a number of firms in India, Thailand and the Philippines. The research is done mainly by Asia firms but some is carried out by multinationals. Several companies are also doing research on ways of producing shrimp cheaply for export.

The Philippines has the most research expenditure by the seed industry. This largely due to Pioneer's large program in Mindinao which serves Indonesia and Thailand as well as the Philippines. The multinationals play a very large role in this research in the Philippines, Thailand and Pakistan but not in India where several local companies have research programs.

Seed research concentrates on breeding hybrid corn with some breeding work on hybrid sorghum, sorghum-sudan grass, sunflower and pearl millet. There is also a small amount of research on hybrid rice. A few companies have some research on plant protection, agronomy and plant physiology.

It is useful to also remember what the private sector is not doing. There are certain crops which the private sector will not work on. Table 2 is a rough estimate of the distribution of private and public research in the Philippines where the private sector plays a very large role. The table shows a number of crops on which the private sector spends little research money. They spend little on white corn and unirrigated rice and nothing on important subsistence crops like yams and cassana. This is because companies do not sell subsistence farmers many inputs and can not profit by buying the farmer's product. There is little research in sugarcane because it is so; unprofitable. The private sector also will not do much research in certain disciplines or topics. There is very little IPM research, farm management research, plant nutrition research, plant breeding research on nonhybrids or social science research by the private sector. Finally, some regions or countries are almost completely neglected by private sector research. Table 1 indicates that some of the least developed economies have the least private research. This is due in large part to the level of development in the country which means small unprofitable markets for purchased inputs.

IS THERE ENOUGH PRIVATE ACTIVITY?

There really is not standard by which to judge whether there is enough private sector research and technology transfer or not. In the United States private research is about 1.5-2 percent of agricultural GDP and public research 1 percent. In Brazil these intensities are .75 percent for private research and 1 percent public. In South and Southeast Asian countries these ratios are very low. The last line of Table 1 shows the ratios for the

Table 2. Philippines Private and Public Research by Commodity (millions of pesos)

	Private (1985)	Public (1984)
Rice	20	15
Corn	30	6
Sugarcane	3	29
Coconut	2	11
Tobacco	2	19
Fruits and Vegetables	19	3
Other Crops	3	27*
Livestock and Poultry	5	17

Sources: Private from survey; public from Sardido.

*Half of this is root crop reseasrch.

countries I surveyed in 1985 and 1986. In some of the countries - particularly India and Malaysia - these estimates are underestimates. Even if research intensity is double the level of these estimates, it would still be quite low.

If there is underinvestment in private research, where is there room for expansion? In some countries there are obvious legal constraints. In others there are few obvious legal constraints, but investment is still low. In these cases economic and technological constraints are more important and the solutions are less obvious.

India is the most obvious example of a country in which a change in government regulation would bring more research and technology transfer. Large scale industries do not invest in research because they may not be given the right to commercialize the products that they invent. I was given an example from the chemical industry or products an explosive invented and developed in India and then no one was allowed to commercialize it. In the areas of agricultural chemicals and pharmaceuticals the Indian government has significantly weakened the patent system which may also weaken the incentive for research by companies operating in this area.

Because of the size of the Indian market multinational seed companies have been trying unsuccessfully to operate in India since 1960. The well publicized liberalization of the economy by Rajiv Gandhi has induced to seek to enter the market. The history of problems goes back to 1960 when DeKalb started corn research with a local partner and developed what they thought would be commercially acceptable hybrid corn varieties. In 1968 after many difficulties with the government they gave up when they could not get government inspectors to approve their product for sale and that year's crop rotted. Pioneer has 40 percent ownership in Pioneer India and has operated since 1976. They have not been able to get any varieties approved by the national seed board despite the fact that farmers on 180,000 ha. of the land find Pioneer's hybrids profitable to use. Since their variety has not been approved their agents have been harassed by the government and their seed taken off the market until after planting time. They have never made a profit but still hope that in the long run this will be a profitable market. At present at least three MNCs continue to test their hybrids in India and wait

for a sign that they could actually get them approved by the Indian government.

Most chemical companies based in the United States or Europe do not introduce their new pesticides in India at all or introduce them only after they have been released everywhere else in Asia. This is due to a combination of little patent protection, requirements of local production, difficulties of ownership and repatriation of profits. Some major chemical companies do not operate in India at all.

These restrictions on foreign research and technology transfer can be justified if it allowed strong local companies to develop which then produced more appropriate and cheaper local technology. In fact, local seed companies have not been very successful in producing local corn hybrids or inexpensive and safe pesticides.

Pakistan has a similar situation in seeds. One corn starch manufacturer has had a small breeding program to supply its contract farmers with hybrids since the early 1960s. However, it has never been allowed to sell the hybrids they developed to the general public. Now there is a seed law in effect and they applied for approval of their hybrid about three years ago. They are hopeful that it will be approved soon. A multinational has recently started a seed program and is selling monopoly is also selling uncertified seeds. Several foreign companies are waiting on the sidelines to see the results of these activities.

Most of the other countries in the region have barriers to research and technology although few are as general as in India. Indonesia has delayed the expansion of private pesticide research program. It has recently banned

the importation of planting material for plantations. The new government of the Philippines has banned the importation of vegetable seeds. In Bangladesh and Pakistan, private research is low because their agricultural in general or some specific parts are not sufficiently commercialized to provide incentives for research or technology transfer. In these countries economic development led by public sector investments in research, human capital and infrastructure are the policies required not specific policies to encourage private sector research. In Indonesia many part of the country are not very commercialized. In addition, government policy has been very unstable and at times very restrictive on private input and plantation industries.

Thailand has a very open economy with the least restrictions on technology transfer. It has the most commercialized agriculture of the region. In the Thai case, more public investment in research and human capital development along with stronger patent legislation might induce more private research.

WHY SHOULD GOVERNMENT RESEARCHERS PROMOTE THE PRIVATE SECTOR?

More private sector research and development can lead to more effective government research program and more financial and political support for government research. The results of government research will reach farmers more rapidly if private input supply companies get early access to new technology. Research itself can be more efficient and productive if the private sector - farmers, input suppliers, marketing people and processors - work with the government to plan research. Then public research can reduce duplication of effort - government tobacco research in Bangladesh duplicates

private research rather than complementing it. The government can concentrate resesarch on areas where the private sector will transfer the results to farmers most rapidly. The public sector can work on the areas which are not profitable to the private sector - like farm management, IPM and breeding self pollinated crops.

Many government research systems are missing out on important opportunities for political and financial support by not cooperating more closely with the private agribusiness. There are many examples of private support for public research in Asia. Exxon provides support to the government for fertilizer research in Pakistan. The poultry industry supports research seminars on corn in Bangladesh. Indian industry provides general support to some research universities and also supports specific projects that they think will benefit them. The private sector can provide important political support for government investments in research and training. This is a source of support that few government research systems in Asia have taken advantage of. Such support has its perils because the government can look like it is in league with multinationals or local big business.

An indirect benefit of an effective private sector research program is that scientists' salaries could be increased. The scientists who are hired away from the government to work in private research receive much higher salaries. As the government loses its best scientists, it is forced to increase salaries to hold its remaining scientists. Private pressure does not necessarily lead to higher salaries but without this pressure higher salaries are much harder to get.

WHAT CAN RESEARCH AND POLICY MAKERS DO TO ENCOURAGE PRIVATE RESEARCH?

Government scientists and research administrators can encourage private research both through the programs that they control and through their role as advisors to policy-makers on science policy.

Government scientists can plan their research program so that it stimulates private technology transfer and research programs that are useful to farmers. The successful private seed research programs in Asia are baseds on public research programs tnat developed inbred lines neededs by private research. Examples include the Kasetsart University corn research program in Thailand; the corn, sorghum, pearl millet and cotton research in India; and the Philippines corn program. The local power tiller and rice harvester industry in Philippines is an example of an industry which was induced to do more research by IRRI and government research which fit their needs.

The government can fund research on science and technology policy which might lead to better policies in the future.

More cooperation and communication with the private sector can also help stimulate more research and more effective research by the private sector. The joint research and testing program of the Pakistan Tobacco Board is an example of this. The tobacco board has a research program which is financed and partially controlled by the tobacco industry. The board carries out joint research programs with the two companies that have their own research and conduct trials with all the major tobacco companies. The companies get to test their varieties under a broader range of conditions than they did in the past which helps improved varieties to be developed faster and to spread faster. The companies are able to get the tobacco board to do

research that individual companies would not finance like reforestation and better fuel efficiency in flue curing.

Government scientists are the major advisors on science and technology policies like seed laws, pesticide regulation, mechanization laws and certain import and taxation laws. Government scientists are a major barrier to private sector research in a number of countries. The government maize program in India does not cooperate with the private sector and so private hybrid maize varieties have not been approved by the seed board which is controlled by government scientists. Government scientists determine who can import scientific equipment in India. Companies complain that they hold up approval or turn down permission without justification.

WHAT CAN POLICY MAKERS DO TO ENCOURAGE PRIVATE RESEARCH?

They must start by asking the questions: What policy restrictions are there on private research and technology transfer? and How do these restrictions affect farmers and consumers?

So far, the main beneficiaries of import protection have been protected local industry and, in many cases, not even that group. Poor farmers pay high prices for pesticides to support local chemical companies in the Philippines and India. Unless there is evidence that protection is leading to more research and growth of infant industries, the government should reduce the barriers to importing technology.

Government production of inputs, which squeezes out the private sector, is costly to taxpayers, donors and farmers who usually get dangerous products, sporadically, at a high price. Unless the product is being produced

efficiently by the government or it has the characteristics of a public good, it should be produced by the private sector. Cutting back on government input supply would encourage more research.

Policies on industrial structure are more complicated both because we know less about which industrial structures induce the most research and because most of the policy instruments for shaping industrial structure are not well understood. However, some things can be done. Monopolies should not be created or they should be carefully regulated. Industries can be reulated so that the processor gets a share of the cost reduction due to research. For example, if the Bangladesh Tobacco Company introduces an innovation that will decrease the cost of producing Virginia tobacco, it can then negotiate a reduction in the regulated price it pays to producers.

Patent systems can give a limited monopoly in return for public disclosure of the invention. The limited monopoly on the use of the invention provides an incentive to the inventor. The public disclosure helps other researchers invent new technology based on the original invention and thus reduces the rents a company receives on the original invention. In some industries, there may be a problem that foreign multinationals get most of the patents. One alternative is to introduce utility patents which cost less to get, provide more limited protection and seem to stimulate more local invention. For plants, some form of plant breeders' rights might encourage companies to do research on plant varieties in addition to hybrids.

Government procurement of new technology or policies that restrict the use of subsidized credit to certain technologies can encourage research. This can be a positive policy if the government has more knowledge and can make a

better choice of technologies than farmers. This is not usually tne case and so this policy must be used sparingly.

Finally, most governments should allocate more resources to government research and graduate education in the agricultural sciences. Government research stimulates private research in most cases and private research can not be done without trained manpower. All seven countries in my surveys have low levels of investment in public research and education which should be increased.