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Private Sector Agricultural Research and Technology Transfer in Thailand: A Preliminary Survey

by

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Executive Summary

This survey is part of a University of Minnesota/Rutgers University study financed by AID/Washington on private sector research in the Third World. The second phase of this study is a survey of private agricultural research and technology transfer in six countries in South and South East Asia. The purpose of these surveys is to (1) find out how much and what kind of research is being conducted by the private sector, (2) identify the policy constraints and incentives to private research and technology transfer, and (3) identify major impacts of private research and technology transfer on farmers.

The Thai survey was conducted in August 1985. Twenty-three companies interviewed. This sample attempted to include all the major private sector agricultural research programs in Thailand and representatives of both Thai and multinational companies that were doing research.

The total private agricultural research expenditure was at least U.S.$ 4 million and probably was closer to U.S$ 7 million. This is between 8 and 14 percent of the total agricultural research expenditure of the country (government plus private) and .05 to .08 percent of agricultural GDP. There are at least 143 scientists, including 23 PhDs, working in the private sector. Research expenditure has increased quite rapidly from almost nothing fifteen years ago. Ther are now large private research programs in the hybrid corn industry, animal feed industry, pesticides, food processing and plantations. In addition, there are informal research programs in the agricultural machinery industry. The research conducted is primarily very applied, adaptive research.

The major impacts of technology transfer and research have been in the poultry industry where poultry breeds and improved feed have revolutionized the industry; the plantations of rubber, oilpalm and pineapple which are based on technology borrowed from Malaysia and Hawaii; increased cotton and rice yields, reduced cost of plantation crop and rice production and some human poisonings due to pesticides; increased yields of corn due to hybrid corn; and reduced cost of production and increased yields of corn due to hybrid corn; and reduced cost of production and increased yields due to improvements on propeller pumps, power tillers, and threshers.

Thai government policies that have been effective in inducing research

were (1) government hybrid corn research and the sale of inbred lines to the private sector, (2) government distribution of machinery prototypes of propeller pumps and threshers, and (3) the education of Thai scientists. The policy of unrestricted import of technology has led to rapid technological progress in the poultry industry, plantation agriculture and oriental tobacco production.

AID has helped the development of private research and technology transfer through support for CIMMYT and IRRI which assisted the corn research program and the agricultural machinery program. It has also helped by training scientists who now work in the private sector and officials of the government research program and the government institutions that finance and regulate private industry. AID's new science and technology project could potentially have an important effect on the development of private research by promoting better communication between the public and private sector; financing private research; and improving public policy on science and technology. The one area that it neglects is money for higher education of Thai students in the U.S. and elsewhere.

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Introduction

This survey is part of a University of Minnesota/Rutgers University study financed by AID/Washington on private sector research in the Third World. The second phase of this study is a survey of private agricultural research and technology transfer in six countries in South and South East Asia - the Philippines, Indonesia, Bangladesh, Pakistan, India and Thailand. The purpose of these surveys is to (1) find out how much and what kind of research is being conducted by the private sector, (2) identify the policy constraints and incentives to private research and technology transfer, and (3) identify major impacts of private research and technology transfer on farmers.

1 Amount and Type of Private Agricultural Research

1.1 Aggregate Expenditure

There is only one previous study on private sector research in Thailand (Yongyuth and Harit, 1983). This study of 104 companies was conducted in 1983. The agricultural research expenditure was not reported by sector, but it was reported that these companies employed 77 scientists in the agricultural sciences with a bachelor's degree or higher of which one had a PhD. These 77 scientists are about 5 percent of all scientists. Applying this percentage to their total estimate of private research (Baht 65.5 million) a rough estimate of private agricultural research is 3.3 million baht or US$ 143,000.

The data presented in Table 1 are based on a survey of 23 companies conducted in August 1985. This sample attempted to include the major research programs in each of the industries listed in the table. Three companies in the agricultural machinery industry were interviewed, but they were not able to estimate their research and development expenditure. All of them had made improvements on the tractors they produce, but none of them had formal agricultural research programs. The sample is in not complete in any of the other categories.

Table 1. Private Sector Research and Scientists

	Firms Interviewed	R&D Budget	Scientists	PhDs
		(US$ 000s)		
Seeds	5	665-1071	42	8
Pesticides	7	887-1487	31	6
Machinery	3	na	0	0
Livestock & Feeds	2	1725	48	7
Processing & Plantations	6	1034-3284	22	2
Total	23	4311-7564	143	23

Source: Survey.

The total research expenditure was a least US$ 4 million and probably was closer to US$ 7 million. This is between 8 and 14 percent of the total agricultural research expenditure of the country (government plus private) and .05 to .08 percent of agricultural GDP. There are at least 143 scientists including 23 PhDs working in the private sector. The lower estimates of expenditure are based on the actual research expenditures reported by the firms interviewed in this survey. Lever Brothers could not break down their total R&D budget into agriculture and nonagriculture and so we have assumed that 10 percent of their R&D expenditure was on agriculture which is almost certainly an underestimate. The total of $4.3 million is an underestimate of total private sector research because many firms are missing. There are several other important pesticide research programs that could not be contacted because of time constraints. The processing/plantation industry research estimate is also too small because Dole, which has a research program on pineapple, could not provide research budgets, Also, many of the smaller seed companies were not interviewed.

An attempt was made to calculate a more accurate estimate of total research expenditure. One of the seed companies interviewed provided a list of the number of scientists doing research in other complanies. I multiplied this number times the research expenditure per scientists in the five companies which reported to calculate the higher research expenditure. Pesticide research was increased by assuming that the two multinationals which have research programs but did not report research expenditure were spending at about the same rate as the multinationals that did report. Finally, the processing category was increased by assuming that Lever Brothers spends 40 percent of its R&D budget on research. With these modifications, private R&D is about $7.6 million.

The largest agricultural research program is conducted by the Charoen Pokphand (CP) group of companies. Most of this money is for feed and livestock research. Lever Brothers also has a large research program – particularly on oilpalms – but it is not clear how money is devoted to agricultural research. The other companies in plantation and processing research include a mixture of Thai companies like Boonrad breweries and multinationals like Dole. Most of the pesticide research is being conducted by multinationals. In the seed industry, multinationals and CP have large research programs, but a large number of Thai companies have started small

research programs. In the Thai agricultural machinery industry there is little formal R&D, but a number of Thai agricultural machinery companies are conducting informal R&D to improve the machines they produce.

Private agricultural research expenditure has been rising rapidly. Fifteen years ago, there was a small amount of research on pesticides and poultry feed and management. Now research in the seed industry is large and growing rapidly. Pesticide research and livestock research are also growing. Plantation and processing research is growing in oilpalm but probably not in other commodities. Agricultural machinery is the only industry in which some observers have suggested (informal) R&D may be declining.

1.2 Research Program in Specific Industries

Private research by the seed industry was started in the early 1970's by Pioneer but was discontinued after a few years. Continuous private research on hybrid corn started in 1978 by CP in a joint venture with DeKalb. Since then ten to twelve companies have started corn research programs. Some of these companies are expanding their research to include commodities like sorghum, sunflower, and soybeans. The five companies with the largest research programs are either wholly owned subsidiaries of foreign companies or joint ventures with foreign companies.

Most of the research is on hybrid corn. Companies are developing private corn hybrids through breeding. The main goal of corn research is higher yield per acre. Some of the companies screen promising hybrids under drought and low fertilizer conditions. Most do not because the area where most of the hybrids are grown drought is not a problem and farmers use fertilizer. Research on sorghum, soybeans or sunflower consists of testing varieties from the U.S. for yield and disease resistance. In contrast to corn, there is almost no breeding of these other crops. Instead, companies are importing varieties and testing them under Thai conditions. There is also some research to develop improved vegetables for local markets and for vegetable seed exports.

Pesticide research started twenty years ago when only Yip In Tsoi and Shell had any technical people. They each had one person who was supposed to test fertilizers, pesticides and even some new crop varieties. Now there are over 30 scientists with a budget in excess of US$ 900,000. No

company has a permanent research farm. Instead, fields are leased for the initial trials of new chemicals and management techniques.

Most of the research is testing chemical for bioefficacy under Thai conditions. Insecticides for rice and cotton and herbicides for plantation crops still receive the most attention by researchers, but research on herbicides for rice is growing rapidly. Most companies are testing chemicals that are commercially used elsewhere, but some are testing insect growth regulators and biological pesticides. There is some research on application methods – electrodyne sprayers, sprinkler bottles, ultra low volume applications, and different nossles on sprayers. Also, a few companies do some work on environmental effects of pesticide applications. In contrast to the rest of Asia much less research resources have been spent on research to meet registration requirements because the regulations are almost nonexistant.

There is some work by the central research programs of multinationals in Thailand. Bayer and DuPont test coded compounds[1] in Thailand for their worldwide research programs. ICI, Shell, Bayer and Hoechst have expatriot scientists working here during the cotton season on the serious pesticide resistance problems of insects that attach cotton and vegetables. Thailand was the one country in our surveys where pesticide producers were doing what they called IPM research. This research was being conducted in response to the resistance problems with cotton insects.

There was some applied livestock research by the private sector when the commercial poultry industry started in the 1960's. Companies had to develop ways to modify poultry management to fit Thai climatic conditions, feeds and materials. Feed manufacturers had to analyze the contents of some local materials and run trials on different combinations of ingredients. Now several feed companies have major research programs on combinations of feed and pharmaceuticals and new raw materials that can be used to reduce the cost of feed. Research on feed for swine, aquaculture and ducks is increasing. CP also has a large swine breeding program, research comparing different broilers and some work on the selection of improved ducks.

Research conducted by the processing and plantation industries is quite diverse. Tobacco research is focused on improving leaf quality for export and reducing the cost of production. Tobacco companies develop new va-

[1] New compounds that have not been released commercially.

rieties by testing varieties from other countries, and they do agronomic research and soil analysis. The pineapple processing industry has been working to decrease costs of producing pineapple and increasing factory productivity. They are working to improve management practices in their plantaions. For example, Dole is doing widescale tests of drip irrigation systems.

Boonrad, the beer producer, has been working to decrease its dependence on imported barley and hops. Thus, it has done considerable research on barley varieties and production techniques in Thailand. Several rice mills and exporters are conducting trials of high quality basmati rice in an attempt to cash in on the high price for this rice. Lever Brothers' agricultural research is concentrated on management techniques in oilpalm production, trials of oilpalm plantlets that are supplied by its parent company's tissue culture company in England and trials of mixtalol, a plant growth regulator that was developed by the Unilever subsidiary in India.

2 Impact of Private Agricultural Research and Technology Transfer

Private sector technology transfer and research are virtually inseparable. At least some adaptive research took place in the transfer of all new agricultural technologies to Thailand. There is a continuum of the amount of local research required to transfer technology. Commercial poultry technology from the U.S. was superior to local technology without modification. At the other end of the spectrum, hybrid corn technology could not be transferred without research to breed in resistance to downy mildew. However, even commercial poultry presented many opportunities to further reduce the cost of production through applied research. Feed producers, suppliers of chicks and farmers have conducted poultry research. As a result, the commercial poultry technology used in Thailand today is more efficient than the technology that was originally transferred.

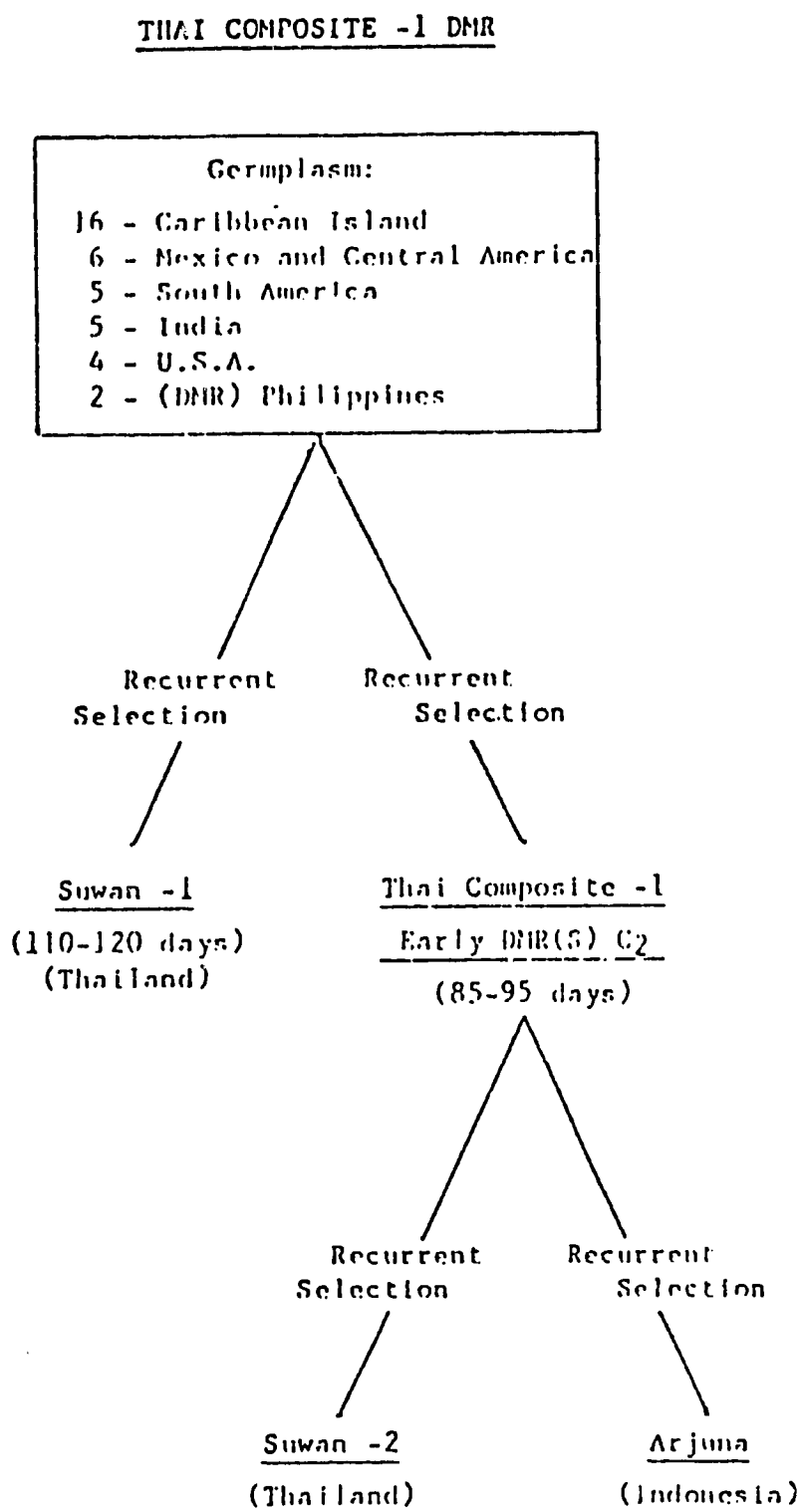
The following examples indicate areas in which there has been a major impact of private sector research and technology transfer. There is no attempt to separate the impact of research from technology transfer. The calculations of impact are rough estimates rather than a precise quantification of impact. In Phase III of this project, we hope to look more closely at the relative importance of research and technology transfer and quantify their impact more precisely.

2.1 Seeds

One of the most important impacts of the private sector research has been the development of hybrid corn varieties that outyield local varieties and outyield public varieites and hybrids. The multinational companies crossed inbreds and varieties from Kasetsart University that are resistant to downy mildew with their elite lines from the United States. Brazil, the Philippines and elsewhere to produce hybrids. The Suwan varieties and Kasetsart hybrids were developed by Kasetsart University with the assistance of the Rockefeller Foundation and CIMMYT. These varieties and hybrids included germplasm from the Caribbean, Mexico, India, the Philippines and elsewhere. Dr. Banjerd of CP has charted the development in Suwan 1 and

Suwan 2 in Figure 1.

Figure 1. Corn Varieties Derived from Thai Composite -1 DMR.



Source: Banjerd, 1985.

The spread of new varieties and hybrids is shown in Table 2. Hybrid sales have almost tripled every year since sales started in 1981. In 1985, hybrid seed sales were about 2500 tons. Some of these were public hybrids which were developed by Kasetsart University (KU). The rest were related to the Kasetsart hybrids. The companies interviewed claimed that about 2000 tons were hybrids that they had developed for Thailand using exotic and Thai germplasm. About 80 percent of the Suwan sales were by the private sector. Hybrid sorghum which was imported and tested here has been sold by one company since 1980.

Table 2. Corn and Sorghum Seed Markets in Thailand (metric tons).

Year	Corn						Sorghum Hybrid
	Suwan		Hybrid		Total Sales	% Total country (40,000)	
	Sales	% Growth	Sales	% Growth			Sales
1980	2,540	-	-	-	2,540	6	20
1981	4,830	90	30	-	4,860	12	80
1982	5,170	7	80	167	5,250	13	100
1983	7,755	50	260	225	8,015	20	150
1984	12,121	56	871	235	13,000	33	400
1985	15,603	29	2,500	187	18,103	45	600-700

Source: Corn, Banjerd Boonsue, 1985; Sorghum, company interviews.

The seed companies claim their hybrids yield about 10 to 25 percent more than Suwan-1. Department of Agriculture field trials (Table 3) shows that on average of 7 stations San Miguel, Pioneer and CP hybrids did 6 or 7 percent better. In some specific regions like Nakornsawan (TF in table), which is in the center of the corn area, the Pioneer hybrid CH 334 yields 24 percent more than Suwan 1, CP's CS.Exp 8402 yields 11 percent more than Suwan 1, while the SMC hybrid's yield is 7 percent more. Thus, it seems safe to assume that farmers are getting at least a 10 percent yield increase by using private hybrids.

Table 3. Mean grain yield of 24 hybrid corn varieties, tested at 7 locations in 1984, rainy season

Entry No.	Pedigree	Origin	Grain Yield at 15% moisture (kg/rai)							mean		% Relative to check
			SW	TF	SSR	KK	Loei	PB	BMS	kg/rai	kg/ha	
3	SMC 305	SMC	1035	892	875	906	1017	1113	1204	1006	6287	107
8	CH 334	Pioneer	1061	1036	994	768	908	1052	1199	1002	6262	107
18	CS.Exp.8402	CP.	1179	927	959	950	882	1000	1037	990	6187	106
11	KTX 2602	SW83L	1231	833	972	829	945	1049	1039	985	6156	105
9	2T 005	Pioneer	965	912	1044	796	1002	1024	1149	984	6150	105
17	CS.Exp.8401	CP.	1236	803	943	752	966	1023	1113	976	6100	104
16	CP.1	CP.	974	806	898	819	957	1014	1407	950	5937	101
2	TSI 832	ThaiSeed	1052	828	897	834	865	1023	1116	945	5906	101
22	CG 8301	Agro-Seed	1077	905	879	656	894	1001	1186	942	5887	101
13	Exp.8322	Cargill	1216	750	956	711	869	1019	1046	938	5862	100
4	SMC 307	SMC	1025	802	871	794	978	1003	1086	937	5856	100
23	CG 8401	Agro-Seed	1097	808	868	679	931	970	1195	935	5844	99
5	SMC 309	SMC	1060	718	941	843	879	1027	1067	933	5831	99
10	KSX 2301	SW83L	1019	980	908	678	886	1009	1044	932	5825	99
6	SMC 3203	SMC	1129	723	949	861	802	999	1032	928	5800	99
7	YCF 34	Pioneer	1046	818	933	683	394	950	1148	924	5775	98
15	Suwan 1 (S) C_9 F_3	SW83L	1218	867	837	657	788	989	1067	917	5731	97
1	TSI 831	ThaiSeed	986	830	863	777	878	958	1095	912	5700	97
14	Exp. 8323	Cargill	1118	806	895	584	907	903	1088	900	5625	96
20	Raithong	Pacific	1042	737	871	811	942	863	994	894	5587	95
21	CG 8307	Agro-Seed	961	885	958	755	779	901	978	888	5550	94
19	Pacific 9	Pacific	1037	741	888	741	837	826	971	863	5394	92
12	Exp. 8321	Cargill	1128	807	893	544	846	936	846	857	5356	91
24	Suwan 1 (S)C_8 (check)	SW83L	1141	793	838	683	930	997	1170	936	5850	100
	Mean		1085	833	914	755	899	985	1095	936	5850	
	CV (%)		7.77	9.34	9.19	18.76	14.20	8.24	13.07			
	LSD0.05 (kg/rai)		89	109	-	153	-	144	201			
	LSD0.01 (kg/rai)		117	145	-	-	-	152	268			

SW = Farm Suwan
TF = Nakornsawan Field Crop Research Center
SSR = Sri Sumrong Field Crop Experiment Station
KK = Khon Khaen Field Crop Research Center
Le = Loei Field Crop Experiment Station
PB = Prabudhabaht Field Crop Experiment Station
BMS. = Ban Mai Sumrong Field Crop Experiment Station

Two thousand tons of seed at the recommended planting rate of 50kg/ha is about 40,000 ha. In fact, farmers are used to using about half that seed rate and so as much as 80,000 ha may be under private hybrids. Assuming a base yield of 2 tons per acre, a 10 percent yield increase would give 80,000 to 160,000 tons of increased output and a 20 percent increase would lead to a 160,000 to 320,000 ton of increased output due to hybrid corn. Total output of corn was about 3 to 3.5 million tons in the early 1980's.

2.2 Chemicals

The use of pesticides has grown from almost nothing in 1960 to sales of US$ 100 million in 1985. This is divided 50 percent insecticides, 38 percent herbicides, and 12 percent fungicides. Only a few of these pesticides were developed specifically for Thai conditions. So that almost all of this technology was transferred in from outside. Local research has encouraged more effective use of pesticides, lowered the cost of application and reduced the health hazards to applicators and consumers. These effects would, in turn, increase the spread of pesticides. The impact of the research and technology transfer by the pesticide industry has been substantial. Cotton probably could not be grown at all in Thailand without insecticides. Average rice yields may have been raised through insecticide applications. The cost of producing rice and plantation crops has been reduced through the use of herbicides.

Pesticides have had some negative affects on human health and the environment. In addition, some important cotton and vegetable insect pests have developed resistance to most types of pesticides. Unfortunately, neither the positive nor the negative affects of pesticides have been quantified.

Private research in Thailand has accomplished a number of things. At least one new commercial product – a rice herbicide – was developed through Thai research. Several new combinations of herbicides have also been developed locally. Safer application methods and formulations of pesticides have also been developed in Thailand. Sprinkler bottles to spread e.c. formulations of herbicides evenly in rice paddies are one example. Application methods which reduce the cost of chemical pest control have also been developed locally.

2.3 Agricultural Machinery

There is very little formal agricultural machinery research and development, but there has been a lot of informal development work that has gradually improved the design of foreign power tillers from Japan, threshers from IRRI, and propller pumps invented by the Rice Department. Thai power tillers were better suited to local soil conditions, easier to operate and repair, and less expensive than the Japanese imports. The IRRI threshers have been continually modified by manufacturers to increase the efficiency of the machine and the quality of the rice threshed. The propeller pumps were modified by companies to use power tillers as the power source. These changes have increased the efficiency of farm machinery and reduced the cost of production to farmers. Power tillers and threshers substituted machinery for animal power and labor. The spread of irrigaitn pumps may have increased the demand for labor by increasing irrigation.

Table 4 shows the number of various types of equipment in use in 1975 and 1982. Power tillers, propeller pumps (which are about 75 percent of irrigation pumps) and threshers are widely used and have had a substantial although unquantified impact on the agricultural economy.

Table 4. Major Agricultural Machines in Thailand.

	1975-76	1981-82	% increase
2-axle tractors over 45 hp.	13,338	50,044	275
2-axle tractors under 45 hp.	14,575	39,158	169
Single-axle tractors, power tillers	90,001	284,350	216
Irrigation pumps	251,288	603,538	140
Rice winnowers	42,342	83,801	98
Maize shellers	5,721	11,287	97
Threshers	3,855	20,601	434
Rice mills	24,658	26,212	6

Source: Cochran and Chak, 1984.

Informal research has also been successful in increasing the productivity of the machinery production process which should reduce the price of machinery. There has only been one quantitative study that has examined the impact of changing mechanical technology in Thailand. Paitoon (1982) calculated the growth in total factor productivity (TFP) in the Thai tractor industry. He found that TFP grew by 5.33 percent annually from the mid 1960's to 1979. It accounted for 19 percent of the growth in tractor output during this time.

2.4 Livestock

Poultry technology is one of the areas where foreign technology and private research have had a a major impact on the economy. The poultry technology introduced by Arbor Acres and feed technology introduced by Ralston-Purina led to a revolution in the poultry industry in the 1970's. Swine production was also improved with the introduction of European breeds from Europe and Taiwan.

Livestock productivity has greatly increased due to these technologies. The one available measure of increased livestock productivity due to new technology is the feed conversion ratio (FCR). The FCR is the amount of feed required per unit of output. Imported technology and local research in the commercial broiler and feed industry have reduced the FCR from 4 to 5 in 1965 to 2.55 in 1972 and 1.9 in 1985. Modern swine technology has reduced the swine FCR from an estimated 5 to 7 on small farms using traditional technology to 3 to 3.5 for modern commercial operations. Unlike poultry which is now primarily produced in commercial operations only about 15 percent of pigs are on modern commercial farms (Chesley, 1985).

The increase in productivity along with increased demand due to income growth lead to the growth of eggs, poultry meat and swine production shown in the botton of Table 5. It also allowed the rapid increase in exports of frozen chicken meat to Japan shown in Table 6.

Table 5. Value added originating from agriculture and livestock sectors at 1972 prices
(million baht)

	1973	1976	1977	1978	1979	1980	1981
1. GDP	180,146	221,225	237,173	261,097	276,907	292,852	311,270
2. Agriculture VA	56,237	65,898	65,537	72,513	71,408	72,784	77,701
3. Crop VA	41,721	49,013	46,794	53,583	51,804	54,179	58,528
4. Fisheries VA	5,360	5,898	7,499	7,414	7,281	6,276	6,777
5. Forestry VA	2,877	3,365	3,142	3,001	3,392	3,318	2,896
6. Livestock VA	6,279	7,622	8,102	8,515	8,931	9,001	9,500
(% of 2)[a]	(11.2)	(11.6)	(12.4)	(11.7)	(12.5)	(12.4)	(12.2)
— Cattle and buffalo	1,784	1,926	2,091	2,101	2,077	2,194	1,858
— Swine	1,226	1,709	1,893	1,833	1,997	2,160	2,014
— Poultry	1,846	2,128	2,182	2,472	2,615	2,854	2,745
— Eggs	1,378	1,817	1,890	2,060	2,190	2,439	2,697
— Dairy	15	16	20	23	26	31	30
— Others	30	26	26	26	26	26	156

VA = value added.

[a] Figures in parenthesis indicate livestock value added as a percentage of agriculture value added.

Source: National Economic and Social Development Board, *National Income*, various issues.

Source: Nipon.

Table 6. Export of frozen chicken[a]

	Quantity (tons)	% to Japan	% to others[b]	Value (1,000 baht)	% change in quantity	% change in value
1973	142.2[c]	n.a.	n.a.	5,530.0	—	
1974	446.8[c]	n.a.	n.a.	14,600.0	214.2	164.0
1975	372.5	98.39	1.61	8,932.5	−16.6	−38.8
1976	2,210.8	99.81	0.19	65,305.7	493.5	631.1
1977	4,254.5	99.56	0.44	157,514.8	92.4	141.2
1978[d]	9,286.5	99.74	0.26	333,735.5	118.3	111.9
1979[d]	14,158.2	99.99	0.01	516,954.6	52.5	54.9
1980	18,503.1	94.20	5.80	656,192.4	30.7	26.9
1981	26,768.9	98.63	1.37	1,186,606.9	36.9	59.2
1982	33,216.6	96.26	3.74	1,310,008.7	21.6	9.9
growth rate 1973-1982 (% per year)	—	—	—	—	60.6	60.8

Source: (1) Data for 1973-1974 from the Bangkok Livestock Trading Co.

(2) Department of Customs, *Foreign Trade Statistics 1975-1982*, (December issues).

Notes: (a) Data code from the Department of Customs refers to fowls ducks fresh chilled frozen which included very small amount of duck.

(b) Other countries are Hong Kong, Laos, France, Malaysia, Sri Lanka and Romania. Since 1981-82, Austria, Saudi Arabia, Singapore, and Kuwait have become new importers.

(c) In 1973 and 1974, the data from the Department of Customs shows that 137.78 and 337.41 tons were exported, respectively. The corresponding figures for export value were 5.53 and 14.35 million baht, respectively.

(d) In 1978 and 1979, Thailand also exported 3,113 and 1,031 of live chicken (day-old chicks) to Indonesia.

Source: Nipon.

2.5 Plantations and Processing

The major impact on researchand technology transfer in this group of industries has been on the pineapple production. One important technology is the introduction of chemical induction known as "forcing" which induces flowering. This allows the production of pineapple year round and the canning factories to stay open eleven months a year. This process has spread beyond the plantations of the major companies to the small producers. Emerson (1980) comments: "In Prachuap Khiri Khan province an interesting transfer mechanism for the technology of forcing has developed. Cannery plantations employing foreign agronomists introduced forcing into Thailand. Workers on the plantations have had to familiarize themselves with this technique and have in many instances subsequently become independent growers or offered their services at a fee to farmers wishing to learn the new process.".

Other agronomic techniques have also been introduced to cut costs of production. Varieties and management practices that are lead to relatively small fruit which fit the automatic cutting knives were introduced. There was not enough data to quantify the effects of thse changes in technology on productivity, but it is clear that they have helped Thailand grow into one of the major exporters of canned pineapple in the world.

After a number of years of barley research and breeding, Boonrad, the main beer company in Thailand, is now producing barley commercially for the first time. Last year, they produced about 250 tons. They are now constructing a malting factory and are continuing to improve the yield per acre of their barley varieties. They expect to replace a substantial amount of their imported malt over the next few years.

Lever Brothers and other small companies have played an important role in transferring oilpalm production technology from Malaysia to Thailand. This has allowed Thailand to shift from importing large amounts of vegetable oil to breaking even in 1985 and possibly exporting in 1986. Extensive tissue culture research by Unilever, Lever Brothers' parent company, led to a process for cloning oilpalms. Lever Brothers is testing clones from Unilever, and these clones will have a substantial impact in a few years when the new clones start to bear fruit.

Virginia tobacco production was originally introduced into Thailand

in the 1930's by British American Tobacco Company. After World War II, the Thai Tobacco Monopoly took over all procurement of tobacco and production of cigarettes. Adams International, working in coordination with the tobacco monopoly, was responsible for the improvement of Oriental tobacco technology after the company was founded in 1969. Their work resulted in a large increase in production and exports of oriental tobacco (Mingsarn, 1980). Adams has also had some success in identifying good tomato varieies for their tobacco farmers to grow as a crop diversification measure.

2.6 Summary

Technology transfer and research has had an important impact on increasing exports and reducing imports. Exports of poultry, pineapple, oriental tobacco and corn have increased in part due to the introduction of new technology. Imports of vegetable oil and barley have decreased. In other Asian economies where the internal economy is isolated from the world economy by policy measures, productivity increases lead to noticeable declines in consumer prices. In contrast in the Thai economy, which is relatively open to the world, productivity has improved Thai foreign exchange earnings and declines in consumer prices are apparent only for items like broilers.

3 Determinants of Private Research Levels and Directions

This chapter attempts to identify the affect of policy on the growth of research in major Thai agricultural industries. The first section examines general government policy toward science and technology. Then the main industries are examined to first determine the factors that caused growth in the industry as a whole and then specific role of the government in inducing research.

3.1 General Science and Technology Policy

The implicit policy of the Thai government was that as long as appropriate technology could be purchased from abroad, there was little point in investing local private or public resources in R&D. Thus, there are very few restrictions on the importation of technology. On the contrary, there may be special tax incentives for firms that import technology in high priority areas. There are no tax incentives for local private research and little patent protection for local (or foreign) technology. In addition, the government investment in R&D has been rather low. Agriculture, however, is something of an exception to this last generalization. Due to recent investments in agricultural research, Thailand in 1984 was spending almost 1 percent of agricultural GDP on government agricultural research.

A patent law was first passed in 1979. Its coverage is compared with the laws of other Asian countries in Table 7. Chemical inventions are the only agricultural technologies covered by the law. Some chemical companies expressed doubt about how much protection is actually provided. Because it is quite new, it is just now being tested in the courts. The outcome of several cases in the near future will give companies a better assessment of the protection it provides.

Table 7.

Availability of Patent/Variety Protection for "NRC" Inventions in Selected Developing Countries

	Mechanical/Electrical		Chemical				Biogenic						Other	
Country	Plough I Major	Plough II Minor	Fertilizer	Insecticide	Herbicide	Chemical Vaccine	Soybean	Corn Hybrid	Rice	Beef Cattle	Nitrogen-Fixing Bacteria	Live Virus Vaccine	Computer Program	Accounting System
U.S.A.	yes	no	yes	yes	yes	yes	yes	no	yes	no	yes	yes	no	no
Asia														
Bangladesh 1,2	no	no	no	no	no	no	no*	no*	no*	no*	?	?	no*	no*
India	no*	no	no**	no**	no**	no**	no*	no*	no*	no*	no*	no*	no	no
Indonesia 2	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Korea (South)	yes	yes	no**	no**	no**	no*	no*	no*	yes	no*	yes	no*	no	no
Malaysia 1,2	yes	no	yes	yes	yes	yes	no*	no*	no*	no*	no	no	no*	no*
Nepal 4	yes	no	yes	yes	yes	yes	see footnote						no	no
Pakistan 3	yes	no	yes	yes	yes	yes	no*	no*	no*	no*	yes	yes	yes	no**
Philippines 5	yes	yes	yes?	yes?	yes?	no	no	no	no	no	yes	yes	no	no
Singapore 1,3	yes	no	yes	yes	yes	yes	no*	no*	no*	no*	no	no	no**	no**
Sri Lanka 3	yes	no	yes	yes	yes	yes	no*	no*	no*	no*	no	no	no	no**
Taiwan	yes	yes	no**	no**	no**	no**	no*	no*	no	no*	no	no*	no	no
Thailand	no*	no	yes	yes	yes	no**	no*	no*	no*	no*	no*	no*	no*	no

* This invention is specifically excluded from patent protection by national law.
** Although this substance is specifically excluded from patent protection by national law, the process used to produce the substance is not excluded.

Source: Evenson, Putnam, Evenson, 1983

Table 7
Footnotes

1. British patent law is assumed to hold in this country, owing to the provisions in its laws. British patent applications (whether or not by British citizens) have priority. In practice, a prior British patent is routinely granted approval in this country at the applicant's request. We refer the reader to chapter 37 of the Patents Act of 1977 of Great Britain. The U.K. prohibits the patenting of microbial processes or products for use of humans or animals. Ghana independently prohibits patents on pharmaceutical and mesdical substances.

2. This country has no patent act of its own.

3. "Microbiological processes and the products of such processes" are patentable. Whether this protection extends to microorganisms per se is not known and will depend on the interpretations of the domestic courts. In the absence of specific indications to the contrary, we have assumed that the nitrogen-fixing bacteria and the live virus vaccine are not patentable under these circumstances.

4. A patent is granted to a foreign inventor if he has obtained a patent in his own country and any three other countries. Presumably, patentability standards in those countries apply.

5. Other than meeting public standards of health and morality, no other criteria for patentability are cited. In general, we take mechanical, chemical and electrical inventions to be patentable, and others to be unpatentable. In the Philippines, U.S. law is assumed.

There are a number of other policies which affect the size and profitability of industries which, in turn, affects their incentives to do research. Government price policies, subsidies, tax policies and exchange rate policies are examples of these more general policies. The Board of Investment (BOI) has considerable power to give tax incentives protection against foreign competition and other incentives to firms that invest in industries or regions that the government in trying to develop.

Regarding foreign investment one observer (Emerson, 1980) noted: "Thailand has a comparatively liberal foreign investment policy. Restrictions on the entry of foreign companies are limited to a small number of industries notably wholesale and retail trade, public utilities, banking and finance, industries producing military goods and those industries reserved for state monopolies. BOI approval, involving the granting of promotional incentives, is not a precondition for the establishment of a commercial venture in Thailand. In principle, incentives are offered in exchange for contributions by the project to national development.".

3.2 Development of the Seed Industry

The private seed industry dates back to the first part of this century. It has grown as the demand for vegetables around the larger cities has grown. Recently, it has also received some stimulus from foreign markets which need vegetable seed.

The modern private seed industry started in the mid 1970's. The timing was due to the development of Suwan varieties of corn by a joint program of Kasetsart University, the Department of Agriculture, the Rockefeller Foundation and CIMMYT. Suwan-1 was a composite variety which was resistant to downy mildew. It was first released in 1975. The government could not meet the demand for seed and so CP and Cargill set up seed production facilities and started selling Suwan-1. Several other companies set research operations to produce hybrid corn in the late 1970's. By the mid 1980's, Pacific seeds, CP, Cargill and Pioneer were selling hybrid corn.

Seed companies in Thailand had two types of motivation. First, there are those who hope to profit from their seed activities. Second, there are the companies whose major business is feed production and who hope to make money on seed but also see important benefits for their other businesses.

They have some of the characteristics of the processing firms which are trying to lower the costs of their inputs – in this case corn. The three main factors which foreign seed companies gave as important determinants of their descision to invest in the Thailand seed industry were (1) the large and growing market for corn as an export commodity and a feedgrain; (2) downy mildew resistance of the Suwan varieties and hybrids; and (3) the well developed marketing structure for inputs.

A recent AID report viewed the research which produced Suwan-1 as the key factor in the development of the private seed industry. "Suwan 1 served as a catalyst because it represented a major genetic breakthrough, demonstrated farmer acceptance of an improved variety and higher seed quality at a higher cost, and demand could not be met by the Royal Thai Government." (Brown et al. 1984).

The burst of seed research since 1978 was partially due to the availability of technology but was also clearly influenced by policy changes. Banjerd Boonsue (1985) of CP says "In 1978 the government launched an open policy for private investors, domestic and foreign, to invest in corn seed industry with incentives including tax exemptions on imported equipment and tax holiday ... Many seed enterprises, ranging from multinational to small domestic companies, have come in and started their operations, with various structures of organization since 1979."

People in the industry are generally pleased with the lack of interference by the government. It is easier to import seed and genetic material than elsewhere in Asia. The Board of Investment offers special tax breaks to seed companies. They allow 100 percent ownership by foreign companies for a period of time. The government research system and Kasetsart University in general work quite closely with private breeders – most of whom used to work at the University. Kasetsart sells inbred lines to anyone who wants to buy them and genetic material from earlier generations seems to move informally between the public and private sector.

Companies expressed only two complaints about government policy. First, they did not like the pricing policy for government seed. They say the government charges less than the cost of production. The government does not produce much seed and so this does not cut into companies' profits much. It does, however, give them a bad name with their customers who ask why government seed is so much cheaper. The government now is rais-

ing the price their seeds gradually to cover their cost of production. The second complant was about the size of government sales. Since government sales are less than 10 perceent of commercial corn seed sales, only a few companies were concerned about this.

Seed production in a new country automatically means research to most multinational seed companies. There are sufficient differences in agroclimatic, pest, and socio-economic conditions between countries that hybrids have to be adapted local conditions and that requires research. In Thailand, the major hurdle for corn was downy mildew. Research by Kasetsart University played an important role in inducing multinationals and small local companies to do research in Thailand. The cost of producing an adapted hybrid in Thailand was lowered greatly by the availability of Kasetsart University inbred lines and germplasm which included material that was resistant to downy mildew. Companies that had outside sources of germplasm just had to incorporate downy mildew resistance into their hybrids and they were ready with their hybrid. Local companies could recombine the government material in different ways and produce a hybrid that worked well for a particular area.

Two other policies which influenced the amount of research were the openness to the transfer of germplasm and the possibility of 100 percent ownership for a period of time which allows control of private germplasm resources. These policies along with the potential market for hybrids in Thailand led three multinationals to place their regional breeding programs for Southeast Asia in Thailand.

3.3 Pesticides

Most large companies import active ingredient and formulate locally either in their own facilities or they contract it out to someone else. The only plant for producing active ingredient is the ICI's paraquat plant.

Demand for pesticides started to grow about 25 years ago due to the Thai Tobacco Monopoly research and recommendations for tobacco. It grew more rapidly with the governments' program to grow long stapled cotton in Thailand which introduced long stapled varieties that were susceptible to pests. Pesticides were also used extensively in vegetables. There real takeoff of pesticide use came about fifteen years ago. Improved rice

varieties and increased double cropping increased insect attacks. Tobacco, sugar and cassava production increased and with it pesticide use. Demand for herbicides is growing rapidly in rice production because farmers are switching from transplanting to direct seeding of rice. The growth of oil-palm plantations in recent years has also stimulated demand for herbicides. Another factor that has helped stimulate herbicide use is rising agricultural wages especsially around Bangkok.

The main determinants of the applied research carried out in Thailand are (1) the availability of new products synthesized elsewhere, (2) specific local problems with a major pest or pesticide and (3) opportunities for expanding a major local product.

Thai policy has relatively little influence on these three determinants. The availability of new products is determined by the success of central research and companies decision about introducing it to Thailand. The latter decision is a function of expected market size and the cost of introducing a new product. Market size influenced by biological conditions and level of development but also the strength of weakness or the patent system. some of the multinationals commented that they introduced less new technology in Thailand because of the weak patents and the possibility that copies of their pesticides might be imported from Taiwan, Israel or Eastern Europe. Other companies said that the low cost of introduction because of easy registration procedures outweighed the risks of copying.

The other two determinants are even less sensitive to specific science and technology policies. specific problems likle insect resistance in cotton and the accusations of environmental problems due to paraquat led to private research on these issues. However, nature rather than specific policies is the main cause of these problems. The profitability of research to increase markets by combining products with other products and reducing the cost of application are determined by the size of the markets which are very indirectly determined by government policy.

Regional research and research funded by and carried out by personnel from the central research facilities of multinationals are conducted in Thailand. Although none of the major multinationals has a permanent station here, at least four companies surveyed had regional or central research here. They are attracted to Thailand by the absence of restrictions on the testing of chemicals and by the resistance problems in cotton and vegetables.

3.4 Machinery

Growth of the agricultural machinery industry seems to be largely the result of increasing wages. Informal, adaptive R&D in this industry is the result of the introduction of major innovations from outside Thailand or from government research which could be easily modified to meet Thai conditions.

This is one of the few places in Asia where government machinery research was the source of a major agricultural machinery innovation – the axial-flow lowlift pump. The original design and improved designs were released to private manufacturers in the 1950's and 1960's. These companies saw that it would be profitable to modify and improve this design through informal research programs (Winit and Cochran, 1985). Government programs to introduce IRRI portable threshers have also stimulated local innovation. Government attempts to introduce IRRI power tillers have been ess successful, perhaps because Thai manufacturers had already developed more efficient machines for Thai conditions.

Over the years, the Agricultural Engineering Division of the Department of Agriculture has developed close relations with private companies. They provide designs of new equipment to companies to develop prototypes and then work with the companies to modify it to meet problems or opportunities for improvement.

It appears that the policy of relatively free importation of machinery has spurred certain types of innovation. Imported power tillers provided the basic idea for the d evelopment of a Thai power tiller. Thai inventors have now developed small four-wheeled tractors and small trucks which use power tiller engines. These enterprises have been successful despite competition with foreign tractors and trucks. The one area where there are no local companies and little local research by the Japanese multinationals is in engine production. However, it seems unlikely that import barriers would do much to increase local research.

There is no patent protection for machinery and so there is a lot of copying. This may be one reason why there is are not formal research programs. Economic theory suggests that an effective patent system would induce more private research. it is impossible to say what it would cost to develop an effective patent system and how much more research such a

system would induce.

3.5 Livestock

Private research by the swine, poultry and feed industry is a response to the growing local demand for meat and export demand for frozen poultry plus the opportunities for adapting imported technology from the North America, Europe and Taiwan.

A large part of the livestock research in Thailand is conducted by the companies of the CP group. this suggests that size and market share has provided an important incentive for research. The CP groupo is a large complany in Thailand and is also expanding into other countries in East and Southeast Asia. The CP group also have a large share in all of the important poultry input and sales markets as shown by Table ??. The absence of a strong antitrust policy may have encouraged total research on livestock in Thailand.

3.6 Processing and Plantation Industries

These industries have grown rapidly in recent years primarily in response to export opportunities, but in a few cases they also responded to import substitution possibilities. Canned pineapple, oriental tobacco, rubber, basmati and, most recentlyl, oilpalm have all attracted attention of investors due to their export potential. Beer companies started research on barley in order to reduce imports of barley malt, and oilpalm investments were originally aimed at substituting for imports.

Government tax incentives were important in the development of the pineapple canning industry. The government gave Adams International a monopoly position in oriental tobacco in return for company investment in the development of the oriental tobacco industry. The virtual monopoly of Boonrad in the beer industry clearly increases that company's ability to capture any returns from its research program.

Government and university research had almost no connection with private oilpalm or pineapple research. Barley research is closely connected to Kasetsart University and also has received some assistance from CIMMYT. The introduction of oriental tobacco was the result of a coordinated

technology transfer program of Adams and the government-owned Thai Tobacco Monopoly. At present, Adams has close cooperation with researchers at Kasetsart and Khon Kaen Universities.

3.7 Policy Implications

Thai government policies have been effective in inducing research were (1) government hybrid corn research and the sale of inbred lines to the private sector, (2) government distribution of machinery prototypes of propeller pumps and threshers, and (3) the education of Thai scientists. The policy of unrestricted import of technology has led to rapid technology progress in the poultry industry, plantation agriculture and pesticides.

Because Thailand has an open policy toward private technology transfer and research, there is little possibility for increased innovation by reducing government interference. In fact, in some areas like pesticide use, more regulation is probably needed which might reduce the amount of R&D by agricultural chemical companies. In addition, Thailand has a fairly high level of government expenditure on agricultural research and so it seems unlikely that there are large gains to be made from increasing expenditures on government research. Two possible ways of increasing private research are (1) redistributing government research resources towards activities that will induce more private research and technology transfer and (2) providing greater incentives for private research through more patent protection, tax incentives, subsidized R&D inputs like technical information and capital, reducing the cost of researchers through suport for higher education.

The redistribution of research resources will require communication and between public and private researchers and then planning shifting public resources to areas that will have high payoffs both for farmers and consumers but also increase companies' incentive to do research. The linkages between public and private research institutions might also be improved by reducing constraints on private consulting by scientists at the agricultural universities. Joint research public private research projects might also be encouraged.

The problem with establishing incentives for more private research is that there is not much experience to draw on as to which policies work best. Taiwan has been able to modernize and increase productivity very

rapidly without a patent law. Would Thailand really benefit from such a law? Would plant breeders' rights provide more incentive for private plant breeding? How effective are tax incentives or grants for private research? No one really knows. Therefore, policy research in this area is needed.

4 AID Projects and Policy

AID has had an indirect but important impact on Thai private research and technology transfer. Some of the scientists who work in the private sector were educated in AID sponsored programs in the U.S. In addition, many of the government scientists and the bureaucrats who determine government regulations and science and technology policy were trained in AID financed programs.

AID has also had some impact on private research in the seed industry. The KU maize program that AID supported indirectly through its support for CIMMYT has been very important in developing the Thai seed industry. The KU program made an important contribution to the germplasm that the seed industry uses. The sale of inbred lines has been particularly important for the small Thai companies that are trying to compete with the multinationals and CP. It allows them to produce their own hybrids without the expense of developing their own inbred lines.

The AID seed industry programs is also having an impact by training technicians who can work in the seed industry, providing technical assistance to smaller companies, strengthening the Seed Club and helping the government establish appropriate legislation for the seed industry to regulate the seed industry. AID loans have also been used as incentives to reduce the role of the government in the seed industry in general.

Another AID financed program which has encouraged innovation is the AID/Washington Extension of Small Scale Agricultural Equipment Project that was managed by IRRI. As indicated in Chapter II, the Agricultural Engineering office of the Ministry of Agriculture has had some success introducing IRRI threshers which were then modified by manufacturers. In addition, their programs on other implements have encouraged small scale manufacturers to experiment and improve their current lines of equipment.

AID/Thailand has program of providing credit to joint ventures between U.S. and Thai firms that transfer agricultural technology.

In 1985, AID/Bangkok signed the most comprehensive AID project in Asia aimed at strengthening public and private R&D and the linkages between the public and private institutions that are involved in research, innovation and diffusion of technology. The goal is Thai self-reliance in S&T, but the project paper reminds readers that "self-reliance does not

mean autarchy". The project purpose is "to help Thailand enhance the effectiveness and extent of public and private sector application of S&T to the country's development." (AID, 1985)

Although the project is not restricted to agricultural science and technology, one of the three technical areas of concentration was bioscience and biotechnology. This part of the project will be important in agriculture, the chemical industry and medicine.

The project will support an S&T policy review which includes strengthening analytical capacity, policy studies and policy dialogue particularly with policy makers in other Asian countries. Strengthening local capacity to study S&T policy should be very useful because there are a number of issues like the importance of a strong patent system, the potential of tax incentives for research and the role of government research that need to be carefully examined.

A second component of this project supports research, development and engineering projects. These projects will include (1) "designated" supuport for specific research projects in the three priority areas at selected government universities and research laboratories; (2) competitive research grants[2] and (3) a fund to finance private sector directed research, development and engineering activities. This fund would provide money to match company funds for research. The research would be conducted by the company or for the company by government or university laboratories. The company must contribute at least 50 percent of the cost of the research either in cash or in kind.

The third major part of the project is called industrial development support. It consists of strengthening standards, testing and quality control; a technical information access center; and a diagnostic/research design service which is basically a consulting firm to iron out technical problems.

In the future, AID might consider the following options:

1. More resources for the agricultural part of the S&T project;

2. Continued core support to the international agricultural research centers and specific support for projects which assist local private research and innovation;

[2]The project proposal is not clear whether private research programs can apply for these grants or not.

3. More support for science and technology policy research; and

4. Support for PhD training in the U.S.

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