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FUNDING AGRICULTURAL RESEARCH

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SUMMARY

Funding of agricultural research is one of the basic determinants of the ability of a country to produce new technology and effectively utilize existing one. This paper analyzes agricultural research funding emphasizing three interrelated subjects: the level of funding and its profitability; private vs. public research; and the institutional mechanisms by which funds are channeled to research institutions. Funds allocated to agricultural research in Latin America increased dramatically during the seventies and seem to have tapered off with great variations among countries and considerable instability in most of them. The present fiscal crisis suggests that the level of funding will be a growing problem in spite of its high social profitability. Private funding of research has increased in recent years introducing biases in the total allocation of resources in favour of certain types of research and certain products and agricultural systems. At the same time private funding has accelerated the tendency towards project funding as opposed to the more traditional institutional funding. This tendency although favouring closer relationships between researchers and technology users also biases research towards applied

and short run problems with low levels of risk. Overall maintaining an appropriate levels of public research funds with sufficient stability in the long run remains as a fundamental problem of science and technology in developing countries.

INTRODUCTION[1/]

The organization of agricultural research conceptualized in terms of the institutional forms and mechanisms through which human, physical, information and financial resources are combined for the operation of research processes, has received growing attention in recent years. This concern has focused on the overall features of organizations as well as on specific components, such as training human resources, development of physical infrastructure, relationships between national and international research, etc.

At the same time, it is becoming increasingly clear that the effectiveness and productivity of national research systems are not independent of their organizational schemes and particularly of the forms and mechanisms through which they obtain their financial resources. This linkage suggests that the nature and structure of research institutions are not independent of the cultural, economic and political context in which they operate. It also

1/ A previous version of this paper was presented at the "Second Meeting of Directors of National Agricultural Research Systems of Latin America and the Caribbean" held in Madrid Spain, between September 27 and October 1, organized by the International Federation of Agricultural Research for Development (IFARD), and sponsored [illegible] stry of Foreign Relations and the National Agrarian Research [illegible] f Spain, in cooperation with the Inter-American Institute [illegible] ion on Agriculture (IICA), and the International Service for National [illegible] ural Research (ISNAR).

implies that the characteristics of the surrounding context act as determinants of organizational alternatives that must be considered in designing national research system (Ruttan, 1982; Rigney, 1981; Trigo, Piñeiro and Ardila, 1982).

These relationships have not been fully acknowledged in the past. However, they appear to be one of the primary reasons why national efforts to establish highly productive research infrastructure have not attained anticipated success.

This is the general framework in which the financing of agricultural research will be discussed. In doing so, this paper first discusses the extent and evolution of the funds allocated to agricultural research in the region. It also covers a brief evaluation of their magnitude in terms of the financial requirements of a research effort on a minimum scale. This is the most important issue, because of the dramatic fiscal situation faced by the majority of the countries of the region. From the qualitative point of view, special emphasis is given to the discussion of existing alternatives funding mechanisms; and the factors that condition the use and impact of resources on the effectiveness of research organizations. The treatment of these topics is organized in six sections. The first section gives a brief description of the organizational and budgetary background of agricultural research in Latin America; the second section deals with the magnitude of financing for this type of activity, especially with the comparison standars used for measuring resources. The third and fourth discuss alternative sources of funding and the real possibility of linking the recipients of benefits with the financing of research. The fifth section

presents several ideas on operational alternatives for financing research by institution and by project, and finally, the sixth section contains general comments on all the issues discussed in the paper.

BACKGROUND AND MECHANISMS FOR FUNDING AGRICULTURAL RESEARCH IN LATIN AMERICA

The Evolution of Agricultural Research Funding in Latin America and the Caribbean

Agricultural research in Latin America can be divided into two historical periods. The first begins with the initial efforts at research, conducted during the second half of the last century, and runs through the nineteen-fifties. During this stage, activities unfolded in ad-hoc institutional structures which were generally very unstable. In general terms, institutional developments were closely tied to solving crisis situations in specific crops. Examples include Tanguis cotton in Peru and sugar cane in the Cauca Valley of Colombia. During this period, the experiment stations were built, later to become the cornerstones of modern research institutes (Estanzuela in Uruguay, Pergamino in Argentina, the National Agricultural Association in Chile, the Experimental Farms in Palmira, Medellín and Bogotá in Colombia, the Cañete and La Molina Experiment Stations in Peru, etc.).

The second institutional period began toward the end of the forties, and early fifties. It was characterized by the establishment of more integrated research structures with a national scope. Initially, these developments included research as an integral part of the Ministries of Agriculture. After

1960, most of the countries introduced decentralized, independent research organizations with administrative autonomy. This new institutional model is generically known as the National Agricultural Research Institute, and provided the basis for the expansion and strenghtening of research activities, which until the mid-seventies, received uninterrupted, growing financial support from international sources as well as larger budget allocations from domestic sources[1/].

Table 1 shows the evolution budgetary resources for agricultural research from 1960 to 1980 in those countries for which information is available. In overall terms, the information shows, in almost all cases, a strong expansion of resources for research. However, this general trend should be examined in more depth. In the first place, from 1960 to 1970, budgets increased steadily, while from 1970 on, the trend was interrupted and, in some countries, even reversed.

A second observation is that budgetary resources were extremely variable during the nineteen-seventies. This is reflected both in the differences between peaks and valleys, often surpassing fifty percent, and in year-to-year variations. Table 2 illustrates these annual variations, showing the frequency with which budgetary allocations dropped off from one year to the next, and the magnitude of these reductions. The problem of budgetary

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1/ During the expansion period, the "territorial occupation" phase took place through the establishment of new experiment stations and networks of extension agencies. In addition, broad training programs were initiated, oriented toward developing the critical mass of human resources needed for meeting the requirements of research processes. These processes received strong impetus from external assistance programs that called for outside support to be gradually replaced by national efforts. However, this occurred only to a limited degree, leading to a dramatic decay of the programs as external assistance came to an end. For a more detailed discussion of this process and its implications for the development of National Research Systems, see: Piñeiro and Trigo, 1983.

TABLE 1: LATIN AMERICA AND THE CARIBBEAN: BUDGETARY RESOURCES FOR AGRICULTURAL RESEARCH FROM 1960-1980. VALUES EXPRESSED IN CONSTANT 1975 CURRENCY (IN THOUSANDS)

	1960	1965	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980
THERN ZONE													
ta Rica (Colones)	3.565.1	5.210.6	4.637.5	13.521.9	14.387.5	9.235.3	7.081.0	8.972.8	9.937.9	10.839.5	10.329.1	12.525.9	12.143.7
Salvador (Colones)	1.177.5	1.072.5 3/	1.280.3	1.552.2 3/	1.812.5	2.295.1	2.570.0	2.500.0	4.530.4	4.095.8	5.077.2	4.409.2	3.906.3
ico (Pesos)	58.325.0	65.237.0	30.900.0	41.912.5	65.812.5	109.337.5	116.812.5	173.437.5	199.912.5	166.612.5	450.600.0	510.750.0	579.487.5
aragua (Cordobas)	-	5.545.8	7.209.5	7.469.3	7.729.0	6.430.3	6.830.5	7.855.4	8.494.2	9.343.6	7.848.4	8.508.2	9.168.1
temala (Quetzales)	1.840.0 1/	-	-	-	1.911.0	1.578.9	2.330.7	2.380.0	2.293.7	2.668.8	2.841.2	3.426.7	3.484.9
ama (Balboas)	417.0	-	1.176.0	1.437.0	1.698.0	1.649.0	1.600.0	1.218.0	850.0	989.9	1.014.2	1.709.8	1.622.3
IBBEAN ZONE													
bados (BB Dollars)	-	480.0	1.179.7	1.258.5	1.100.9	943.3	843.4	787.4	735.3	735.3	850.4	1.149.4	1.012.0
aica (J.Dollars)	-	137.5	138.0	769.0	814.0	1.257.3	1.360.7	1.301.3	1.340.9	1.178.1	841.5	504.9	554.4
ana (G. dollars)	-	-	-	-	-	1.218.7	1.131.8	1.543.4	1.094.9	583.5	-	-	-
EAN ZONE													
ivia (Pesos)	10.820.0 1/	-	30.980.0	31.360.0	25.080.0	25.620.0	26.140.0	24.820.0	23.520.0	41.240.0	46.020.0	42.080.0	36.680.0
ombia (Pesos)	213.751.2	234.312.0	667.944.0	764.755.0	750.562.0	760.766.0	701.984.0	711.454.0	747.173.0	641.682.0	807.461.0	739.899.0	697.114.0
ador (Sucres)	-	42.850.0	72.628.0	96.552.0	125.806.0	137.143.0	126.025.0	128.825.0	131.600.0	132.880.0	109.321.0	124.156.0	99.666.0
ezuela (Bolivares)	19.850.6 1/	31.757.6	-	-	-	-	-	-	85.207.7	96.647.0	99.330.8	84.387.4	97.699.8
u (Soles)	76.948.8 2/	114.933.6	351.818.0	271.279.2	289.353.6	308.937.6	297.962.4	415.711.2	376.852.0	211.028.0	188.975.0	174.644.0	161.188.0
THERN ZONE													
entina (Pesos)	1.099.976.4	1.066.999.8	1.113.000.0	936.000.0	1.028.000.0	1.283.000.0	1.534.000.0	1.222.000.0	1.145.000.0	1.165.000.0	1.218.000.0	1.209.000.0	1.301.000.0
zil (Cruzeiros)	67.316.4	-	-	-	196.569.0	237.608.0	-	-	700.307.0	713.405.0	758.027.0	945.240.0	949.561.0
le (Pesos)	13.701.7 2/	13.554.4	41.173.8	45.711.6	46.787.1	26.745.3	28.690.1	26.151.1	33.252.4	32.957.7	31.283.1	32.373.3	33.208.2
aguay (Guaranies)	-		-	68.164.0	75.982.0	-	-	-	-	208.232.0	205.767.0	213.733.0	441.135.0
guay (Pesos)	215.0	464.5	372.3	399.0	425.7	525.6	584.1	730.2	573.6	663.3	585.3	773.4	817.8

Note: A hyphen (-) means the Figure was not available
1/ 1962
2/ 1964
3/ 1966

Source: Oram and Bindlish, 1981; Piñeiro and Trigo, 1983.

TABLE 2. LATIN AMERICA AND THE CARIBBEAN: ANNUAL VARIATIONS IN BUDGETARY RESOURCES FOR AGRICULTURAL RESEARCH

1970 - 1980

	1971/1970	1972/1971	1973/1972	1974/1973	1975/1974	1976/1975	1977/1976	1978/1977	1979/1978	1980/1979
NORTHERN ZONE										
Costa Rica	2.91	1.06	0.64	0.76	1.27	1.11	1.10	0.95	1.21	0.97
El Salvador	1.21	1.17	1.26	1.12	0.97	1.80	0.90	1.24	0.62	0.88
Mexico	1.36	1.57	1.66	1.07	1.48	1.15	0.83	2.70	1.13	1.13
Nicaragua	1.04	1.03	0.83	1.06	1.15	1.08	1.10	0.84	1.08	1.07
Guatemala	-	-	0.82	1.47	1.02	0.96	1.16	1.06	1.20	1.02
Panama	1.22	1.18	0.97	0.97	0.76	0.70	1.16	1.02	1.69	0.95
CARIBBEAN ZONE										
Barbados	1.07	0.87	0.86	0.89	0.88	0.98	1.00	1.16	1.35	0.88
Jamaica	5.57	1.06	1.54	1.08	0.96	1.03	0.88	0.71	0.60	1.09
Guyana	-	-	-	0.93	1.36	0.71	0.35	-	-	-
ANDEAN ZONE										
Bolivia	1.01	0.80	1.02	1.02	0.95	0.09	1.75	1.12	0.91	0.87
Colombia	1.14	0.98	1.01	0.92	1.01	1.05	0.86	1.26	0.92	0.94
Ecuador	1.33	1.30	1.09	0.92	1.02	1.02	1.01	0.82	1.13	0.80
Venezuela	-	-	-	-	-	-	1.13	1.03	0.85	1.16
Peru	0.77	1.06	1.07	0.96	1.39	0.91	0.56	0.89	0.92	0.92
SOUTHERN ZONE										
Argentina	0.84	1.10	1.25	1.20	0.79	0.94	1.02	1.05	0.99	1.08
Brazil	-	-	1.21	-	-	-	1.02	1.06	1.25	1.00
Chile	1.11	1.02	0.57	1.07	0.91	1.27	0.99	0.10	1.03	1.03
Paraguay	-	1.11	-	-	-	-	-	0.99	1.04	2.06
Uruguay	1.07	1.07	1.23	1.11	1.25	0.78	1.16	0.88	1.32	1.06

SOURCE: Table 1.
NOTE: A hyphen (-) means that the data was not available.

instability is particularly acute because of the long-term nature of research programs and their resulting inflexibility for making abrupt, short-term adjustments.

The effect of the year-to-year variations is even more dramatic in view of the budgetary structure of research institutes. In general, over seventy percent of total organizational resources are used for personnel costs,which are relatively inflexible over the short-term. Therefore, any variation must be fully absorbed by direct research costs which multiplies its impact. In practice, a total budgetary variation of five percent has an impact on the organization's operating capacity equivalent to a budgetary drop of twenty to twenty five percent.

It should be noted that the countries most affected by budgetary instability include some of those with the oldest research infrastructures such as Argentina, Colombia, Ecuador, Uruguay and Peru.

Alternative Financing Mechanisms

The funding of agricultural research activities has been on the basis of annual allocations from the national budgets[1/]. This funding mechanism is characterized chiefly by: (a) the public nature of the funds and the fact that they are paid out of general income; this means that agricultural research must compete directly with other activities of the public sector;

1/ It has often been suggested that this financing mechanism is one of the determining factors in the budgetary instability discussed above.

and,(b) the allocation of funds, which generally covers the entire institution, without considering the specific use that will be made of the moneys; this decision is left to the research organizations themselves.

In addition to this overall scheme, several important alternatives have existed and continue to be used, concerning origin, means of acquisition, and use of resources. At the National Research Institute level, up until recently Argentina's INTA (National Institute of Agricultural Technology) has received budgetary resources from a specific tax on agricultural exports; also important are the cases of several commodity organizations receiving resources from exports of the commodities they study. The Executive Commission on the Plan for Economic Recovery of the Cacao Industry (CEPLAC), dedicated to cacao research in Brazil and the National Coffee-Growers Federation (FEDERACAFE), which does coffee research in Colombia, are specific examples of this situation. Other special case somewhat similar to these is that of the Sugar Cane Research Center of Colombia (CENICAÑA) which receives financing through a formula based on sugar exports and on the differential between domestic and foreign sugar prices.

These global funding schemes for individual institutions are further supported with specific sources, either with respect to the origin or concerning the use of funds. Examples of this type of funding are the resources received by the Colombian Agricultural Institute (ICA) through the Fifth Law of 1974, and the specific programs developed by the Colombian Rice-Growers Federation with the beer industry; the pasture research programs underway in the National Agricultural Research Institute (INIAP) in Ecuador, which receive support from the Highlands Livestock Association; and a number of efforts in

Brazil such as the programs of the Sugar Producers Cooperative (COPERSUCAR) for sugar cane, and the National Association for the Use of Fertilizer (ANDA) for cotton, beans, corn, soy and wheat (Lópes, 1979).

Similarly international loans and grants from multilateral credit organizations and the bilateral aid programs of the developed countries have become important sources of support to the national budgets. The Inter-American Development Bank (IDB) and the International Bank for Reconstruction and Development (World Bank) both have active programs to provide of loans and technical assistance in support of national agricultural research activities. From 1971 to 1980, the IDB granted thirteen loans to eight latin-american countries for a total value of US$137.9 million. It also provided a total of US$25.0 million in the form of non-reimbursable technical cooperation, distributed among twenty projects in thirteen countries. The World Bank has granted two loans for US$96.0 million. The United States provides the major program for bilateral assistance, which in 1980 had twenty five projects underway and nearly US$70.0 million committed through 1985[1/].

A more different alternative, with broader implications for the organization and management of the research and technology development processes in the agricultural sector has been recently put into operation in the National

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1/ The international loans and grants are channeled primarily toward the development of physical infrastructure and human resources for national research systems. International support has been particularly decisive in training human resources, not only through the research institutes' training programs, but also through the efforts of some countries to develop post-graduate infrastructure in the agricultural sciences. For further discussion, see: Trigo, Piñeiro and Ardila, 1982.

Agricultural Research Institute (INIA) of Chile. The new mechanism formally combines two types of financing perspectives: overall institutional funding, and specific project funding. The system includes basic financing to maintain the core personnel, as well as certain operating costs covered with national (public) budget allocations following the traditional model, and calls for other operations to be covered by contracts and agreements for specific research projects funded by the interested parties. This format is a significant institutional innovation for formalizing a mixed mechanism of funding (public-private). Its importance lies in its implications for the role of the public sector in the research process. It also has major consequences on administrative and managerial aspects of research.

Finally, in recent times, several countries have launched initiatives to reorganize their agricultural research system. These initiatives are mainly concerned with the organizational structure of research and technology transference activities but also have implications for the financing structure of the system. This through the establishment of National Agricultural Research Funds to complement via the financing of specific projects, the regular funding of research organizations. In general, these initiatives have been developed in the framework of processes to forge closer ties between agricultural research and the overall science and technology sector, and a better coordination and increased complementarity among the research programs of the National Institutes, the universities and private sector research organizations. Together with the establishment of the Research Funds, National Agricultural Research Plans are being developed as basic tools to

govern the use of available fund resources. Agricultural Research Councils have also been proposed as mechanism for overall institutional coordination (Colombia, Departamento Nacional de Planeación, 1981).

The systems for financing agricultural research reviewed in the previous paragraphs differ substantially from one another, as each one is the expression of a different concept of the natures of research and agricultural technology. In the following sections an attempt to analyze these differences will be made.

INVESTMENTS IN AGRICULTURAL RESEARCH IN LATIN AMERICA: A CRITICAL ASSESSMENT

Profitability of Research Investments

The discussions of the extend of financing for agricultural research have focused on the amount of resources allocated to this type of activities, and its relationship with other economic variables, such as the value of agricultural production, production value at the level of individual commodities, or total investments in research and development. As a complement to this approach, important descriptive and analytical studies have been performed on budgetary resource allocations for the different activities and areas of research (applied research vs. basic research, commodities, regions, types of producers, etc.).

From a slightly different perspective resources allocation to agricultural research has also been studied in terms of investment profitability. Studies in this area also cover specific commodity situations as well as aggregate cases by institution or by commodity groupings.

Table 3 presents for Latin America expenditures in agricultural research as percentage of the value of agricultural production. Table 4 summarizes studies of return on research investments including Latin America countries and other regions of the world. The main conclusion to be derived from this information is that research activities in Latin America are markedly underinvested.

The percentages of agricultural production value used for research are significantly lower than in more advanced countries, where expenditures on research and development easily surpass 1.5 percent of the value of agricultural production (Boyce and Evenson, 1975). In the majority of cases in Latin America, it does not reach 0.5%. These signs of relative underinvestment are confirmed by findings of studies on investment profitability for research, given in Table 4. In general, the rates of return on research investment range from 30% to 60% per year, and there are no substantial differences between developed countries and developing countries. Returns are also very similar between partial funding (commodities or groups of commodities) and institutional funding. These levels are far above those observed for most other types of investment projects, both public and private.

Regardless of any discussion or criticism that could be made of the methods used for estimating the rates of return in Table 4, it is clear that from the social standpoint, it would be beneficial to increase investment in research instead of allocating resources to other alternatives with less profit potential.

TABLE No. 3 LATIN AMERICA AND THE CARIBBEAN: PERCENTAGE OF AGRICULTURAL GROSS DOMESTIC PRODUCT ALLOCATED TO AGRICULTURAL RESEARCH IN SELECTED COUNTRIES, 1979*

Country	Percentage of GDP
Costa Rica	0.24
El Salvador	0.28
Honduras	0.13
Mexico	0.52
Nicaragua	0.42 1/
Guatemala	0.27
Panamá	0.36
TOTAL (NORTHERN ZONE)	0.45
Barbados	0.90
Haití	0.05 2/
Jamaica	0.25
Suriname	0.29 3/
Grenada	1.19 3/
Guyana	0.36 4/
Trinidad & Tobago	0.51
Dominican Republic	0.23
TOTAL (CARIBBEAN ZONE)	0.24
Bolivia	0.87
Colombia	0.56
Ecuador	0.54
Venezuela	0.94
Perú	0.26
TOTAL (ANDEAN ZONE)	0.61
Argentina	0.79
Brazil	0.67
Chile	0.48 1/
Paraguay	0.26
Uruguay	0.14 1/
TOTAL (SOUTHERN ZONE)	0.66
TOTAL LATIN AMERICA AND THE CARIBBEAN	0.57

TABLE 3 (Cont.)

NOTES: * Preliminary estimates

1/ 1980

2/ 1978

3/ 1974

4/ 1976

SOURCES: Calculated with information from:

World Bank, 1981, Suriname...

World Bank, 1981, Report...

IDB, 1980-1981

IMF, 1981

Piñeiro and Trigo, 1983.

TABLE 4. SUMMARY OF STUDIES OF RETURNS ON AGRICULTURAL RESEARCH

Study	Country	Commodity	Period of study	Annual domestic rate of return, %
Griliches, 1958	U.S.A.	Hybrid Corn	1940-55	35-40
Griliches, 1958	U.S.A.	Hybrid sorghum	1940-57	20
Peterson, 1967	U.S.A.	Poultry	1915-60	21-25
Evenson, 1969	South Africa	Sugar Cane	1945-62	40
Ardito Barletta, 1970	Mexico	Wheat	1943-63	90
Ardito Barletta, 1970	Mexico	Maize	1943-63	35
Ayer, 1970	Brazil	Cotton	1924-67	77
Schmitz & Seckler, 1970	U.S.A.	Tomato harvester	1958-69	
		With no compensation to displaced workers		37-46
		Assuming compensation of displaced workers for 50% of earnings loss		16-28
Ayer & Schuh, 1972	Brazil	Cotton	1924-67	77-110
Hines, 1972	Peru	Maize	1954-67	35-40
				50-55
Hayami & Akino, 1977	Japan	Rice	1915-50	25-27
Hayami & Akino, 1977	Japan	Rice	1930-61	73-75
Hertford, Ardila, Rocha	Colombia	Rice	1957-72	60-82
& Trujillo, 1977	Colombia	Soybeans	1960-71	79-96
	Colombia	Wheat	1953-73	11-12
	Colombia	Cotton	1953-72	none
Pee, 1977	Malaysia	Rubber	1932-73	24
Peterson & Fitzharris, 1977	U.S.A.	Aggregate	1937-42	50
			1947-52	51
			1957-62	49
			1957-72	34
Wennergren & Whitaker, 1977	Bolivia	Sheep	1966-75	44.1
		Wheat	1966-75	-47.5
Pray, 1978	Punjab (British India)	Agricultural research and extension	1906-56	34-44
	Punjab (Pakistan)	Agricultural research and extension	1948-63	23-37
Scobie & Posada, 1978	Colombia	Rice	1957-64	79-96
Tang, 1963	Japan	Aggregate	1880-1938	35
Griliches, 1964	U.S.A.	Aggregate	1949-59	35-40
Latimer, 1964	U.S.A.	Aggregate	1949-59	not sig.
Peterson, 1967	U.S.A.	Poultry	1915-60	21
Evenson, 1968	U.S.A.	Aggregate	1949-59	47
Evenson, 1969	South Africa	Sugar cane	1945-58	40
Ardito Barletta, 1970	Mexico	Crops	1943-63	45-93
Duncan, 1972	Australia	Pasture improvement	1948-69	58-68
Evenson & Jha, 1973	India	Aggregate	1953-71	40
Kahlon, Bal, Saxena & Jha, 1977	India	Aggregate	1960-61	63
Lu & Cline, 1977	U.S.A.	Aggregate	1938-48	30.5
			1949-59	27.5
			1959-69	25.5
			1969-72	23.5
Bredahl & Peterson, 1976	U.S.A.	Cash grains	1969	36
		Poultry	1969	37
		Dairy	1969	43
		Livestock	1969	47
Evenson & Flores, 1978	Asia - national	Rice	1950-65	32-39
			1966-75	73-78
	Asia - international	Rice	1966-75	74-102
Flores, Evenson &	Tropics	Rice	1966-75	46-71
Hayami, 1978	Philippines	Rice	1966-75	75
Nagy & Furtan, 1978	Canada	Rapeseed	1960-75	95-110
Davis, 1979	U.S.A.	Aggregate	1949-59	66-100
			1964-74	37
Evenson, 1979	U.S.A.	Aggregate	1868-1926	65
	U.S.A.	Technology oriented	1927-50	95
	U.S.A. -South	Tech.oriented	1948-71	93
	U.S.A. -North	Tech.oriented	1948-71	95
	U.S.A. -West	Tech.oriented	1948-71	45
	U.S.A.	Science oriented	1927-50	110
			1948-71	45
	U.S.A.	Farm management	1948-71	110
		Research & agricultural		

TABLE 4. (Cont)

SOURCES: The results of many of the studies reported in this table have previously been summarized in:

Thomas M. Arndt, Dana G. Dalrymple and Vernon W. Ruttan (Eds.) Resource Allocation and Productivity in National and International Agricultural Research (Minneapolis: University of Minnesota Press, 1977), pp. 6, 7.

James K. Boyce and Robert E. Evenson, Agricultural Research and Extension Systems (New York: The Agricultural Development Council, 1975), p. 104.

Robert Evenson, Paul E. Waggoner and Vernon W. Ruttan, 'Economic Benefits from Research: An Example from Agriculture.' Science 205 (14 September, 1979), pp. 1101-1107.

Robert J.R. Sim and Richard Gardner, A Review of Research and Extension Evaluation in Agriculture (Moscow: University of Idaho, Department of Agricultural Economics Research Series 214, May 1978), pp. 41, 42.

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Optimum and Minimun Size of Research Infrastructure

The information given above consistently shows that, considering its potential contribution to development, research activities are receiving inadequate levels of support. However, in our opinion, the most important point is not the absolute level of resources invested in research and technology development. Rather, it is the relationship between totals resource and the scale of operation of the different research system. More specifically its is whether or not existing resources enable research activities to sustain the minimum scales required for producing results.

Discussions on the scale of operations for research systems have been almost totally dominated by that refered to the optimum scale of operations, which is viewed as related both to internal aspects of the research process and to factors external to it (Binswanger 1978; Schmookler 1966; Pound and Waggonar 1972; Evenson 1977; Idem 1978; Sehgal 1977; Horsfall et al 1975; Ruttan 1978).

The major consideration for internal aspects is the opposing effect of two different factors. First, there is the positive effect on research productivity derived from the possibilities for exchange among scientists and researchers in different disciplines and with different viewpoints. This type of exchange also allows, in most cases, for major external savings to be made (better use of experiments, etc.) on specific research projects. Both considerations tend to increase the optimum size of research systems, including their degree of diversification. The second group of factors

tends to counteract this tendency. It involves the administrative and institutional difficulties of managing large-scale research programs[1/].

Available empirical evidence is conflicting, Schultz (1971) and Evenson (1971) lean toward economies of scale, especially the association of experiment stations with research-oriented universities. By contrast, Kamien and Schwartz (1975) and Schmookler (1966), as quoted by Ruttan (1978), indicate that productivity --measured in terms of the number of patents per researcher-- is lower in large laboratories than in small laboratories. Supporting evidence for this viewpoint, specific to the agricultural sector can be found in Pound and Waggonar (1972).

As for external factors, the problem of optimum scale should be analyzed from the perspective of the profitability of research investments, which is related to the area of impact covered by the research (Binswanger 1978).

Nevertheless, for this discussion, we believe that the minimum size of the research system is the best basis to judge whether or not resources being allocated to research are presently adequate. This will frame the discussion of current resources in terms of how much can be achieved with what its available.

The minimum operating requirements of a research system cannot be assessed in abstract, as they depend not only on technical questions, but

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1/ In connection with these problems, mention should also be made of the difficulty of maintaining ties with the users of the research. These difficulties grow larger and more complex when research systems diversify.

also very importantly, on institutional considerations. These include the breadth of the mandate the research organizations must cover, in terms of both products and regions. The magnitude of minimum requirements is also affected by the type of problem to be solved and the possibility of using the information generated for other purposes, or of applying information available internationally. It is also important to stress that the capability for making use of research findings from abroad cannot be divorced from the capability for performing original research. Evenson and Kislev (1975) estimated that for a low-increase country with average research capabilities, an investment of US$1.000 for research performed in other countries located in a similar geographic and climatic zone, would produce annual benefits of US$55.000 for the receiving country. If the recipient country had no domestic research capabilities, the annual benefits of the same investment would be only US$1.700. This argument clearly demonstrates the importance and need for achieving and sustaining minimum levels of investments in agricultural research.

The objective of this paper is not to expound at length on the discussion of the minimum scale needed for a research system to work properly. We lack the background and information to enter the topic. Consequently it would not be possible to develop a serious discussion of whether or not budgetary resources are adequate from this standpoint. However, given the importance of the issue for proposing reinforcements for the operations of national research systems, we believe it is appropriate to make brief, general discussion of the subject, in an attempt to assess the current and potential capabilities for maintaining a minimum research module.

Table 5 gives an estimate of maintenance costs for a minimum research module for a single product. If this estimate is compared with the current budgetary levels in U.S. dollars (see Appendix 1), we find that only the larger countries would be in a position to finance a broad coverage (multi-product) research infrastructure. This is fully confirmed if we analyze the situation for specific commodities, taking the figure of 1% of production value as a basis for research investments. Appendix 2 presents production values for six basic commodities from Latin America and the Caribbean (wheat, rice, corn, potatoes, cassava and beans)[1/]. Of 114 production cases, only 40 yielded a production value higher than level required for covering the costs of the minimum research module. Oram (1977) reached similar conclusions after analyzing national capabilities for funding research programs of different sizes, on the basis of land surface area dedicated to different products.

PUBLIC VS. PRIVATE FINANCING OF AGRICULTURAL RESEARCH: IMPLIED ECONOMIC FORCES

The discussion of financing mechanisms (First Section) showed that budgetary resources for research have evolved over time. Increasingly, funding schemes are directly tied either to the users or to the beneficiaries of new technological findings.

The central consideration for private sector financing of research is the possibility of appropriating a proportion of the economic benefits generated through the use of the new technologies. This proportion must be large

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1/ Production value were calculated from average production and international prices for 1975/1980.

Table 5. ESTIMATED COSTS OF A MINIMUM RESEARCH MODULE FOR ONE PRODUCT[1/]
(IN THOUSANDS OF CURRENT U.S. DOLLARS)

I.	**Direct research costs (60% of total budget)**			**US$ 306**
A.	**Personnel**		**245**	
1.	**4 chief researchers, M.S. or Ph. D.** 3 person/years in plant breeding, agronomy and pest and disease control and 1 person/year equivalent in socioeconomics and other specializations, according to requirements (soils, physiology, etc.). Total cost per person/year 2/ US$ 30,000	120		
2.	8 specialists, university graduates. Total cost per person/year US$ 12,500	100		
3.	Training. Calculated on the basis of 2x1 rate of retention; total rotation every 15 years; cost of US$ 100,000 per Ph.D. (M.S. 60%) Total annual cost for a permanent team of 3 Ph.D. and 1 M.S. (approximately).	25		
B.	Services and Materials. Calculated as 12.5% of direct costs.		38	
C.	Equipment. Calculated as 7.5% of direct costs.		23	
II.	General Costs and Administration (40% of total budget). Includes Direction, support and services (administration, laboratories, library, communications, field, etc.).			204
A.	Personnel. Calculated as 60% of general and administrative costs.		122	
B.	Services and Materials. 25% of general and administrative costs.		51	
C.	Investments and Equipment. 15% of general and administrative costs.		31	
	TOTAL BUDGET			510

Percent summary by broad budgetary items (approximate)

A.	Personnel	72.5%
B.	Services and Materials	17.5%
C.	Innovations and Equipment	10.0%

NOTES:

1/ The estimates were made using the budgetary structure of the international agricultural research centers as a guideline, for determining the percent of each item of expenditure.

2/ US$ [illegible] was used as an avera[illegible] for the different co[illegible] of the region. The [illegible] ies plus [illegible] tion of US[illegible] r below this average [illegible] increase [illegible] of US$4,250 in the total [illegible]

enough to cover research costs incurred and this depends essentially on the nature of the findings or products of the research process, and specifically on their economic characteristics. In this sense, it is helpful to examine two closely related questions: (a) whether or not the research findings are likely to have economic value; and (b) whether or not this economic value can be appropriated by specific economic sectors.

The Economic Value of Agricultural Research

In conceptual terms, all findings or products of the research process have a potential economic value. However, certain characteristics intrinsic to these findings determine whether or not they will have real economic value in the marketplace, translated into a price. In general, this value is associated with whether or not research findings can eventually be incorporated into physical inputs and capital goods. Capital goods and inputs can be subject to buying and selling and may be protected by patent and copyright laws thus enabling the holders of the rights to enjoy exclusive use. Thus, a proportion of the economic value generated by the new technology can be transformed into private benefit through concessions for the use of patents and the receipt of royalties, or through the pricing system itself.

The findings of scientific --basic-- research and of research and development activities oriented toward improving productive processes, agronomic practices, management, etc. have a different behavior in terms of the possibilities of private appropriation of the economic value generated through their use. In general new scientific findings are useful for highly diverse situations and problems, and have no direct application to productive processes.

This makes it difficult to determine their economic value. These findings and information are difficult to patent, and their use is practically cost-free. In this context, scientific research findings are public goods, and no economic agent can exclusively appropriate the economic value generated by them[1/]. This, added to high investment costs and the uncertain nature of research processes, means that this type of activity can be of interest to the private sector only under very special conditions.

By contrast, research findings related to organizational, techniques, agronomic and management practices, etc. are generally tied to specific productive process. Consequently, it is possible to determine quite precisely what economic benefits will be derived from their use (i.e. attach an economic value to them). Nevertheless, because of the difficulty of framing policies of exclusion for the use of these findings, the possibility of the benefits accruing only to those who generated then are reduced substantially. Thus, this type of information has the same characteristics of a public good as the findings and scientific principles discussed above.

As a result, the private sectors are interested primarily in the former type of activities: those that focus on commodities and/or inputs. Part of the economic value generated by this type of finding can easily be appropriated and therefore the investments can be recovered. Activities of the other type would be less attractive and would receive private sector attention only

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1/ "Public goods" are those that once they are available no one can be precluded from enjoying them,whether he contributed to their provision or not their essential characteristic is that they are enjoyed but not consumed and that their benefits are derived without any act of appropriation. (Steiner, 1977).

in specific institutional situations. This point will be discussed in the next section.

Risk, Levels of Investment and Private Interest

The general assertions discussed above may be altered by certain specific characteristics of the research processes associated with the different types of out put. This is particularly true for the risks involved in obtaining results and in recovering investments.

The possibility that certain types of research will ultimately produce results of economic value is uncertain. This would be the case of preliminary research for exploring ideas and approaches that have intuitively practical implications for solving productive problems. In other situations, such as research to generate know-how and methods for preventing the occurrence of some given event, the uncertainty stems from the impossibility of determining when the out put might be used so that the investment can be recovered. These factors have a negative effect on the private sector willingness to assume the funding of activities, because the impact on profits is uncertain.

Another factor related to the interest an likehood of private sector participation in funding research activities is the magnitude and complexity of required investments and the scale of application of findings. Certain types of research require a critical mass of physical and human resources that can be provided only by the public sector. The scale of application of the findings has a substantial impact on the rate of recovery of research costs,

and consequently on the extend to which the private sector is interested in funding this type of activity. If the new technologies have a broad field of application, benefits will be greater, and/or recovery of initial research and development costs will be faster. As a result, investments will be more profitable. Regardless of the economic nature of specific research out put, if the application of findings is too narrow to ensure profitability, the private sector will have no interest in taking part.

These characteristics show that the choice between public and private financing depends not only on the characteristics and nature of research findings, but also on the economic and political contexts in which research unfolds. The possibility of private participation will be greater in larger countries with more homogeneous production situations. This further underscores the problems discussed above. It is also clear that certain models for organizing economic activities, such as multinational initiatives, offer much broader alternatives than those which are limited to the national context. These considerations form plausible hypothesis for explaining differences in the degree of private sector participation in the different countries, and the more dynamic nature of multinational enterprises in this area.

IS IT POSSIBLE TO DEVELOP MECHANISMS THROUGH WHICH THOSE WHO BENEFIT FUND RESEARCH?

In the previous section, we discussed the economic characteristics of different types of research, and their implications for research financing. The arguments indicate the possibility of private sector participation in

funding certain types of research, particularly those related to technological areas where private appropriation of benefits would eventually be possible.

In this section we will evaluate this possibility, analyzing the institutional mechanisms needed to make it work. First, the discussion will cover those processes through which research produces benefits, and the principles that guide the distribution of those benefits among the different economic sectors. The discussion will then move specifically to the limitations and real possibilities of having potential beneficiaries pay research costs.

Economic Sectors Participating in the Distribution of Agricultural Research Benefits[1/]

In general terms, the benefits of research consist of increased economic surplus as a result of production cost reductions through technical change[2/]. This process takes place through a shift to the right in the supply curve for the commodity under consideration; thereby permiting reduced production costs and increased consumption levels. Both processes imply rising levels of economic activity and, consequently, an increase of the well-being of society.

This process is shown in Figure 1 (a). Line AD is the demand curve, and line CO is the supply curve before technological change. In this situation,

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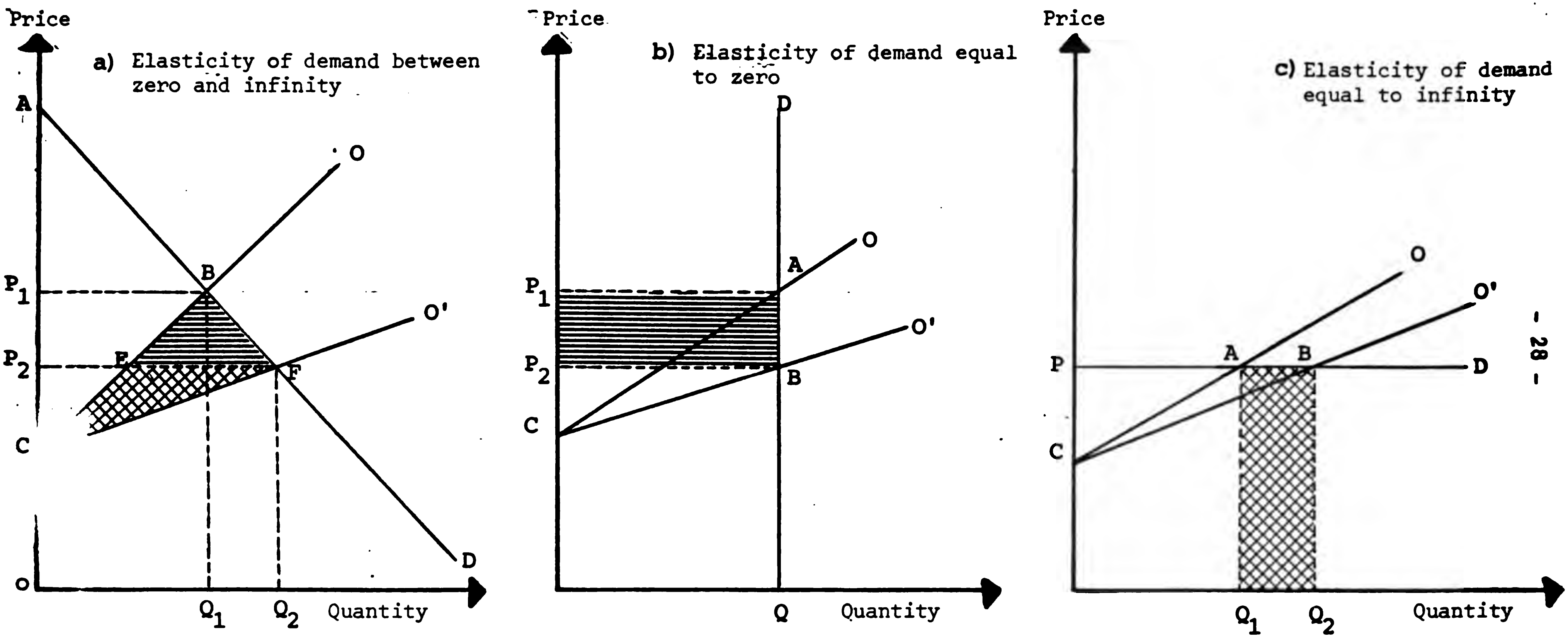
1/ For a detailed discussion of the generation of economic surplus and the mechanisms for appropriating them, see: Trigo, Piñeiro and Ardila, 1982, Appendix 7:497.

2/ Economic surplus is understood as the difference between social value and social costs of producing and consuming a given quantity of the commodity.

DISTRIBUTION OF RESEARCH BENEFITS AMONG PRODUCERS AND CONSUMERS FOR [illegible]
DEMAND SITUATIONS



Proportion of net surplus obtained by consumers

Proportion of net surplus obtained by producers

SOURCE: Compiled by the authors

Q_1 is the quantity being produced for price P_1, and the total economic surplus consists of area ABC[1/]. Technological change displaces the supply curve to CO', generating a new equilibrium situation with a higher quantity Q_2 and a lower price P_2. In the new situation, the economic surplus is AFC, and area CBF is the net increase in the surplus produced by technical change.

The economic surplus generated by research through technical change is distributed among five different economic sectors: Consumers; Agricultural Producers; Landowners; Producers of technological inputs (hybrid seed, machinery, fertilizer, agrochemicals, etc.); and Rural Workers.

The proportion of total benefits of the technical change that accrues to each sector depends on the shape (basically, elasticity) of the supply and demand curves, the type of technology involved, and the structure of the market for inputs and products.

From the point of view of the discussion of research funding schemes and alternatives, there are three distributive conflicts that should be considered.

(a) Between producers and consumers. That is what proportion of economic surplus flows toward the consumers in the form of prices and higher consumption, and how much is obtained by the producer sector? Given a supply situation (changes), the distribution of surplus will depend on the elasticity of the demand curve for the commodity in question. When the demand for the good is

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1/ This analysis is based on the assumption that the demand curve reflects the commodity's marginal utility for consumers; and the supply curve reflects the marginal opportunity costs of resources used in production.

more elastic (inelastic), price changes produced by supply increases are smaller (greater) and the benefits to consumers are greater(smaller) than those to producers.

Figure 1 illustrates several possible situatins, on the basis of different elasticities of demand.

(b) Between farm producers and manufactures of technological inputs

The key point in this equation is the ability of those who produce the strategic input to protect the know-how incorporated into their product through patents, brands or other mechanisms of exclusion for the use of the input. If this protection is possible, input suppliers obtain a certain degree of oli-polistic power (monopolistic in the extreme case of total protection). Under this market structure suppliers will have the ability to set input prices above production costs, thus securing part of the surplus generated by the use of the input in the productive process. Through this process, part of the surplus obtained by the producer sector will be transferred via the higher input prices to input producers. This higher input prices, vis a vis those that would prevail in a perfect competition situation, limit the adoption of the new technology, and the total surplus generated by technical change thus falls short of meeting its potential.

Briefly, when input producers are able to protect the know-how incorporated into their goods, the total surplus generated by technical change is less

than when the new know-how is available free of charge. This sector also has the capability of appropriating part of the surplus of the producing sector[1/]. However, in a temporal context, these effects are dependent on the effective capacity to protect new knowledge through patents and brands; in general, this capacity diminishes as the period of analysis is extended.

(c) Between producers (as entrepreneurs) and landowners[2/]

The distribution between these two groups depends essentially on the impact that the new techniques have on the productivity of other production factors. This, in turn, depends on the type of technology in question, and the relative availability of each factor (mainly land, capital and business skills). Because most of the countries are faced with long-term absolute limitations on land availability, all benefits generated by technical change are appropriated by landowners through increases in the price of land.

How the Economic Surplus Generated by Technical Change can be Channeled Toward Research Funding

Three economic sectors must be considered in determining how to connect economic surplus with research funding. They are: consumers, input producers, and agricultural producers which includes landowners.

1/ The consumer is also affected through the reduction of total economic surplus.

2/ This distinction between producers and landowners is of strictly academic value for cases in which the producer is also the owner.

In most cases, the consumers are the major beneficiaries of technical change processes. However, from the institutional standpoint this is the most difficult sector to involve directly in research funding. The major drawbacks are the magnitude, dispersion and poor organization of the sector, and the minimal size of the benefits that accrue to each individual consumer. Another difficulty is that they very seldom relates the benefits obtained (lower prices, better product quality) to technical change and the research which produces it. This means that the needed surplus must be obtained through indirect mechanisms. The primary alternative is the use of traditional mechanisms for allocating resources from national budget[1/].

In the case of agricultural producers, it is more feasible to channel the surplus generated by technical change toward research funding. However, there are certain limitations, similar to those that block consumer contributions. The major problem is the relative difficulty of demonstrating the exact relationships among research, technical change and economic surplus. Consequently, producer interest in research activities has been relatively low, and has been limited chiefly to crisis situations (pests, etc.). These constraints have at times been used to justify the indirect mechanisms traditionally adopted. Over the long term, all economic surplus generated by technical change generally accrues to higher land prices. Thus, land taxes appear as a viable mechanism for redirecting surplus toward research[2/].

1/ The means by which the consumer sector obtains surplus generated by technical change is such, that broad political support for research activities is difficult to obtain. This has been put forward as one of the fundamental causes of unstable budgetary support for research activities(see First Section).

2/ Naturally, this is collected in addition to the general income and profit taxes paid by producers as economic ag

Other alternatives geared toward obtaining part of the economic surplus generated by technical change are also available; they depend however on the nature of the markets in which production is sold, and on certain characteristics of the economic and institutional structure of the agricultural sector. The case of INTA in Argentina illustrates one of these possibilities. Because a considerable percentage of agricultural production goes to the foreign market, the agricultural sector confronts a highly elastic demand, thus any shift supply benefits mostly the producing sector[1/]. In this economic framework, an export tax serves to capture part of those benefits[2/].

A second situation occurs when institutional formats bring together different groups or sub-sectors of agricultural producers, thus facilitating an awareness of the importance of research and its close ties to the generation of economic surplus. This paves the way toward institutionalization of direct financing mechanisms. Examples of these possibilities include FEDERACAFE and CENICAÑA en Colombia, and CEPLAC in Brazil. They appear to be related to certain characteristics of the products in question (for export), the degree of regional concentration of production, and the homogeneity of the producing sector (Piñeiro and Trigo, 1983). This alternative may take the form of specific taxes for research or allocations from promotional funds, fed by

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1/ This is the case in the Argentine economy. Taking the market as a whole into consideration, foreign consumers enjoy a certain percentage of the total benefits. However it is impossible to involve these consumers in funding the research conducted in Argentina.

2/ This same type of economic alternative is available in cases that have a broad potential for import substitution. In this situations, production expansion has no substantial impact on domestic prices, and the producing sector captures benefits of technical change.

taxes of direct producer contributions. It also provides better opportunities than the national institutes for establishing ties between producers and research[1/].

In this context, mention should be made of the experience of the Regional Consortia for Agricultural Experimentation (CREA Groups) in Argentina and other Southern Cone countries. In this case, producers participate directly in the dissemination of new technologies by setting up producer groups that fund technical assistance and horizontal exchange of technology. On ocassion they also participate in testing and adapting certain technologies to the specific conditions of each producer group (especially for agronomic and management practices).

The discussion of the case of the producers of technological inputs must distinguish between two situations essentially related to the nature of the input markets involved. In the first situation, if markets operate under standards of perfect competition, research costs are reflected in the input supply curve and are passed on through prices. The magnitude of increase depends on the shape (elasticity) of the demand curve. Increases in input prices reduce the level of adoption, and the technical change will produce a smaller surplus than if the research had been conducted by the public sector. In such a case, an alternative finance mechanism is a system of research subsidies that prevent research costs from being on input prices. The advisability of this type of alternative must be assessed in terms of the

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1/ The observed imperfect ties appear to be related to how the research institutes are organized, rather than what financing mechanisms they use. However, the comprehensive nature of these financing mechanisms has made it difficult to use funding for connecting research to research users (Piñeiro and Trigo, 1983).

magnitude of the subsidies needed, by comparison with surplus lost through higher input prices[1/].

The second situation involves cases in which input markets operate under oligopolistic or monopolistic conditions. Here, input prices do not respond to production costs or research and development costs, but instead are determined on the basis of the degree of monopoly held by the producing firm. In these cases, the operation of subsidy mechanisms is very limited. The alternative would be to establish tax plans based on the economic benefits (earnings) of enterprises. This would make it possible to recover part of the surplus appropriated by the producing enterprise, without imposing total losses of the surplus resulting from higher input prices.

A final consideration related to the discussion about how the economic surplus generated by technical change can be channeled toward financing research, refers to the long-term nature of this type of activity. This means that while research costs are incurred in the present, research results must wait for the future. This temporal dissociation between financial requirements and the impact of activities is one of the features generally associated with the limited political support that research has received. Traditional research financing schemes, based on public funds (annual allocations from the national

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1/ While not directly related to the appropriation of surplus, another aspect to be considered is that this type of subsidy can facilitate the decentralization of certain phases of the process of developing new technologies. This gives them greater competitive potential and keeps them more closely in touch with the problems and needs of productive processes. An important discussion in this area is that of policies on brand names and patents for technologies developed under subsidy, as the possibility of taking out a patent would incorporate imperfections into the market operations by allowwing input manufacturers to recover part of the economic surplus generated by technical change by raising prices.

budget) mean, in fact, that the income from today's taxpayers is being transferred or forcibly used to subsidize future generations. Another alternative would be the use of medium -and long- term credits to finance research. This means that those who actually benefit from the new technology would assume the cost of generating it. However, it would intesify one of the problems already facing research in Latin America: too little contact with the potential users of technology which could provide a basis for selecting priorities and providing the system with feedback. Indeed, financing through credit weakens the ties between research organizations and users of research and complicates the ability of researchers to follow up on the effectiveness and relevance of the innovative process.

OPERATIONAL ALTERNATIVES: INSTITUTIONAL AND PROJECT FUNDING[1/]

In Latin America, the basic mechanism for funding agricultural research has been at the institutional level. In this format, resources are apportioned to support the research program of a research organization, in accordance with the budgetary needs of their operations and overall programs.

In recent years, several countries have introduced modifications that incorporate increasingly project funding schemes. In these, funds are allocated to researchers or research teams on the basis of specific research proposals[2/].

1/ This section builds upon some of the ideas presented by Ruttan 1982, Chapter 9.

2/ In general terms, this financing mechanism was limited to research situations by special order (from industries, guild associations, etc.) or those funded by National Science and Technology Councils as part of their general support programs for scientific activities. Historically, none of these alternatives has provided large amounts of funds, either public or private, for agricultural research.

Both alternatives have advantages and disadvantages of an administrative and managerial nature, as well as profound long-term implications for research priorities and institutional organization.

Advantages and disadvantages from the Point of View of the Use of Resources Available for Research

In the area of administration and management, institutional funding involves fewer administrative costs per unit of resources used for research (Ruttan, 1982). Similarly, this format minimizes the time researchers must spend in obtaining funds to support their projects (Bredhal, Bryant and Ruttan, 1980).

The major advantage of financing by project is the increased ability to mold research programs to the needs of specific users and, consequently, the possibility of maintaining better and more direct ties with them. This format can help eliminate the barriers between research institutes and productive sectors, which is one of the causes of the loss of political support that has affected research in recent times. At the same time the greater flexibility of the system is an important feature for attracting specific resources that otherwise would not be channeled to research. This feature is of importance in as much as it possibilitates a better use of the research capabilities existing in organizations which are not oriented toward research as a high priority activity, but which have human and institutional resources useful for developing this type of activity. In Latin America, this is a particularly important possibility for universities; since the fact that they

have large contingents of human resources, they do not received the budgetary support needed for effectively incorporating research into their educational activities. In this sense project funding permits a feer flow of resources and better use of certain existing resources. However, it does not appears as effective in assuring the development of certain types of basic research, or the endurance of long-term programs in specific areas. Concrete examples of this problem suggest that institucional financing schemes, have special advantages, as seen with coffee in Colombia and Costa Rica, cacao in Brazil, rubber in Malaysia, etc. (for products), and the experiences of international centers financed by the Consultative Group on International Agricultural Research (CGIAR).

Finally, the systems that rest primarily on institutional support tend to generate a high degree of self perpetuation in research programs, something that has been pointed up as one of the main causes for the loss of contact with user groups. The greater flexibility of the project financing system facilitates the incorporation of new areas of scientific and technological interest. Thus offering an important alternative for counteracting these "geriatric" tendencies and orienting research more effectively toward solving production problems.

Long-Term Effects on Research Priorities

The different funding systems discussed have important implications for the composition of the research package and the organization of the research system. These implications are based on the different institutional location

of decision making on research priorities. In the case of institutional funding, these decisions are made by the research organization, which submits a comprehensive program of activities which is rarely viewed as a central point in discussions of the amount of budgetary allocations[1/]. With project funding, decisions on what will be researched are closely tied to the funding source.

These differences have an important impact on the continuity of research programs and the possibility of ensuring a proper balance between the different types of research and/or the needs of the different users.

In the case of institutional funding, this is done through the process of planning and allocating priorities for the agricultural sector. Formally, this process is the responsibility of the planning agencies, but in practice, the research institutes have considerable independence for decision-making[2/]. This has made it possible to maintain a certain continuity in research programs, even though in many cases, they may have been disconnected from national priorities in general, from agrarian policies in particular, and from the priorities of users.

Project - based funding schemes tends to fragment decision - making on research priorities. It therefore introduces the need to develop alternative mechanisms for maintaining consistency among research

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1/ Given the nature and origin of public resources used for research, these discussions are traditionally dominated by overall fiscal considerations such as intersectoral allocations, target levels for the fiscal debt, needs for obtaining foreign exchange, etc.

2/ This trend has been reinforced because a high proportion of total resources for the research go into the budgets of national institutes; similarly, the institutes have been relatively independent from scientific and technological planning agencies. For a more d[illegible]ssion of these considerations, see Piñeiro and Trigo, 198[illegible]

programs and keeping them relevant to overall policy objectives. The current trend toward the establishment of Research Councils seems to provide an appropriate framework for maintaining the capability to orient the full array of activities in the systems and strike a balance among the various types of research and the needs of users.

SOME FINAL CONSIDERATIONS

The problems of funding research in Latin America can be synthesized in two issues closely interrelated. The first involves the amounts of budgetary support received for research activities during the past twenty years. The second involves the nature of the mechanisms through which funds are made to flow toward research activities.

The analysis of the budgetary allocations to agricultural research for the entire region during the last twenty years shows, for the overall period, a dramatic expansion. However, the picture is strikingly different if the particular situation of each country is examined. Different conclusions are also reached if the analysis is done for subperiods or on annual basis. For some countries, the trend toward budgetary growth in the nineteen-sixties gave way to situations of stagnation, and even cases of market breakdown in the seventies. The analysis on annual basis shows extreme variations in the levels of financing available for research; this fact has serious implications, given the long run nature of research activities and its relative inflexibility in terms of year to year program adjustments.

At the same time, a comparison between the levels of investment in Latin America and other regions of the world, and an analysis of the profitability of research investments suggest that the region is underinvesting in this type of activity. Moreover, if available budgets are compared with the requirements of a minimum research module, it becomes clear that, in many Latin American countries, available financing is inadequate to maintain research infrastructures with a realistic chance of success.

This situation can be interpreted as an indication of a relative lack of interest of the governments in agricultural research activities. Such an attitude may have serious implications in the future given the severe fiscal crisis being faced by most countries in the region.

From the standpoint of origin an mode of financing, the most common mechanism has been institutional financing based on public resources in the form of annual allocations from the national budget. This format has placed agricultural research in direct competition with other activities in the public sector. Growing fiscal deficit in these countries, and the long-term nature of research activities, as compared to other more pressing needs, are one explanation for the loss of budgetary support experienced during the past decade. The emergence of alternative financing schemes, such specific private sources and funding by projects, may be interpreted as a response to these situations. The new formats offer alternatives that in principle may solve some of the problems related to the breakdown and instability of research budgets. However, certain issues must be taken into consideration in designing financing mechanisms for the research of technology system.

In the first place, the participation of private sectors concentrates on certain types of products and specific institutional situations (export goods, and the presence of producers organizations), that permit and adequate private profitability of the investments made. Also private participation tends to focus on certain types of research (applied and adaptive) and on those activities which are more closely related to the development or improvement of inputs, capital goods and in general technologies used by the more economically developed sectors.

A second and closely related point to consider in this discussion is the closeness of ties that bind together the different types of research in the process of developing new technologies[1/]. The financing mechanisms must be able to ensure that all these types of research will be undertaken, otherwise, the potential of the total system and its capability for generating concrete technological solutions to productive problems would soon be exhausted.

As a result of these elements public participation has great importance, both for providing service to the small farm sector, and for maintaining the overall productive capacity of the technological system.

There are several mechanisms by which private participation can be implemented. The key issues for the discussion of this topic are the advantages of

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1/ Scientific knowledge and principles are the building blocks of technological potential, which then goes into specific technologies (inputs, processes, products). These relationships must interact, providing one another with feedback as part of an ongoing cycle in which the former provide the overall framework and constraints for the process of developing new technologies, while the latter pose new questions and supply information for validating and improving basic knowledge (for a discussion of these interrelationships, see: Evenson 1971; and Arndt and Ruttan, 1977).

different policy tools (specific taxes, credits, etc.) under different circumstances, and the institutional formats under which they can be used without altering long-term objectives and the productive capacity of the technological system.

The lack of budgetary support that haunts agricultural research in Latin America and the Caribbean has been attributed to different causes. These include the economic restrictions and fiscal crises which have plagued the countries of the region, and the common perception that research activities are ineffective and unrelated to production problems.

These difficulties, especially those related to the orientation of research activities, may be related to certain characteristics of the existing institutional models. These models tend to minimize contact with specific technology users, in favor of a centralized organization designed for making more efficient use of the few available resources. This strategy may have been unavoidable given the budgetary constraints faced during the initial stages of the development of the institutes, however it also contributed to the weak development of the political support needed for the consolidation of research organizations.

Recent trends show that if more flexible schemes, such as funding by projects, can be incorporated, research programs could be streamlined and the resources available for agricultural research could be increased. However, it is important to stress that these funding schemes, based on specific projects, tend to fragment the capacity of the research systems, they hinder long-term research programs, especially for basic research, and also tend to interfere with the setting of research and development priorities on the basis of the countries overall development objectives.

Looking ahead, in view of past experiences and future requirements, the central issues in reference to the funding of agricultural research appears to be how to improve the level and stability of financing for research activities. In doing so, there is no doubt that private participation and more competitive schemes, such as funding by projects, offer valuable alternatives. However, it is also clear that private participation cannot replace public funds, and that project funding do not eliminate the need for effective institutional support. The central point is that institutional proposals must be designed so as to make use of the advantages of each scheme for improving the levels and stability of funding. At the same time, they must ensure a research package that will maintain a proper balance between the different types of research and technological needs of different agricultural sectors.

APPENDICES

APPENDIX 1: LATIN AMERICA AND THE CARIBBEAN: BUDGETARY RESOURCES FOR AGRICULTURAL RESEARCH IN 1980. THOUSANDS OF U.S. DOLLARS

Zone and country	Budgetary resources (Thousands of dollars)
NORTHERN ZONE	
Costa Rica	2.083
El Salvador	2.875
Honduras	979
Mexico	66.155
Nicaragua	1.815
Guatemala	5.785
Panama	2.255
CARIBBEAN ZONE	
Barbados	901
Haiti	290 1/
Jamaica	770
Surinam	248 2/
Grenada	206
Guyana	419 3/
Trinidad & Tobago	771
Dominican Republic	2.336
ANDEAN ZONE	
Bolivia	3.292
Colombia	42.610
Ecuador	6.857
Venezuela	39.171
Perú	4.355
SOUTHERN ZONE	
Argentina	152.410
Brazil	142.317
Chile	12.866
Paraguay	6.547
Uruguay	847

NOTES:

1/ 1978
2/ 1974
3/ 1977

SOURCE: Piñeiro and Trigo, 1983, Chapter 10, Appendix 1; Oram and Bindlish, 1977.

APPENDIX 2: PRODUCTION VALUE OF WHEAT, RICE, CORN, POTATOES, CASSAVA AND BEANS FOR COUNTRIES OF LATIN AMERICA AND THE CARIBBEAN AVERAGE FOR 1956-1980. DATA IN THOUSANDS U.S. DOLLARS

Zones and Countries	Wheat	Rice	Corn	Potatoes	Cassava	Beans
NORTHERN ZONE						
Costa Rica	-	59.332	9.639	2.775	3.586	7.873
El Salvador	-	16.626	54.740	1.332	2.527	23.352
Honduras	147	9.128	42.126	555	1.712	23.908
Mexico	397.929	156.480	1.097.180	83.916	5.151	479.828
Nicaragua	-	21,842	23.443	222	3.847	29.079
Guatemala	7.644	10.758	97.818	5.550	1.891	42.256
Panama		59.658	8.330	1.221	6,520	2,129
CARIBBEAN ZONE						
Barbados	-	-	179	-	163	-
Haiti	-	37,164	22.372	888	32.682	26.132
Jamaica	-	1,304	1.309	1.221	3,423	-
Suriname	-	-	-	-	-	-
Grenada	-	-	119	-	-	-
Guyana	-	-	-	-	-	-
Trinidad & Tobago	-	-	-	-	815	-
Dominican Republic	-	106.602	5.355	2,664	28.574	21,217
ANDEAN ZONE						
Bolivia	8.350	33,904	38.437	84.582	44.499	1.112
Colombia	6.659	545.398	98.770	197.469	343.115	41.700
Ecuador	5.954	109.536	28.203	44.955	49.389	15.568
Venezuela	147	167.564	82.467	21,423	58,517	25.576
Peru	16.905	166,912	73,780	184.371	68.297	30.580
SOUTHERN ZONE						
Argentina	1,198.050	101.386	925.582	175.824	35,860	101.748
Brazil	374.556	2.749.810	2.055.963	212.343	4.111.512	1.177.608
Chile	120.687	36.838	41.293	89.910	-	52.820
Paraguay	4.998	20.212	51.884	666	280,360	31.136
Uruguay	49.333	75.958	16.898	15.207	-	1.573

SOURCE: Compiled on the basis of data from FAO production yearbooks.

NOTE: A hyphen (-) means that data were not a[illegible] or did not exist.

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