Agricultural Research Policy

International Quantitative Perspectives

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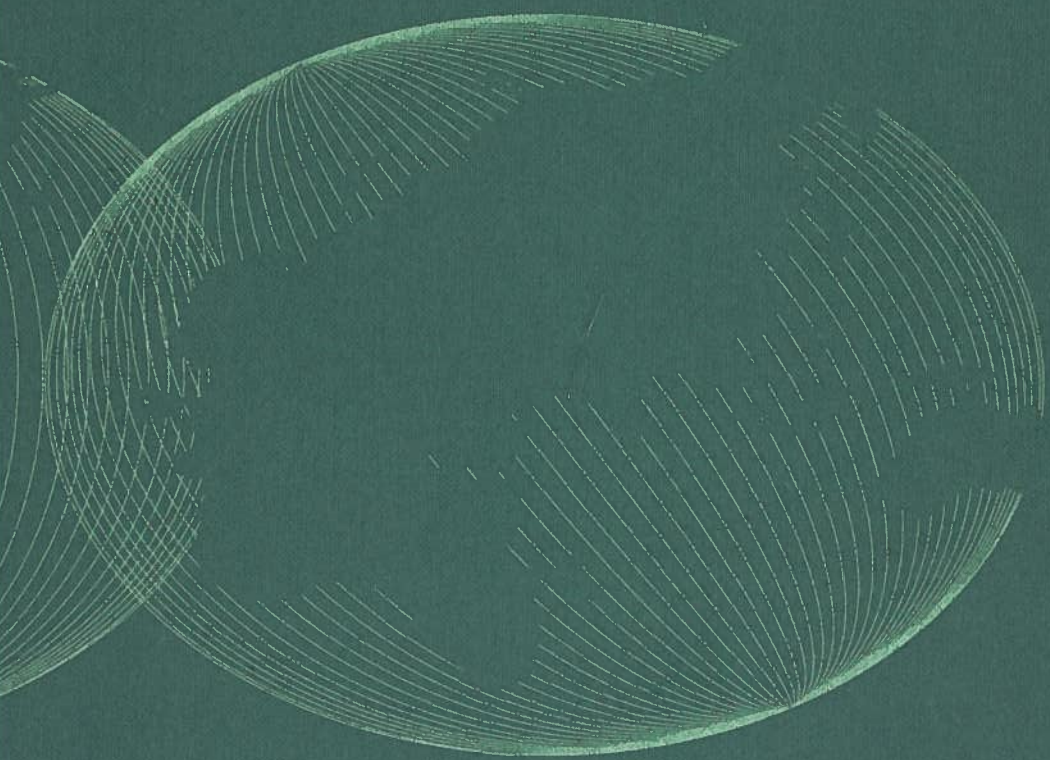

Published by the Press Syndicate of the University of Cambridge
The Pitt Building, Trumpington Street, Cambridge CB2 1RP
40 West 20th Street, New York, NY 10011–4011, USA
10 Stamford Road, Oakleigh, Melbourne 3166, Australia

First published 1991

Printed in Great Britain at the University Press, Cambridge

A catalogue record of this book is available from the British Library

Library of Congress cataloguing in publication data available

ISBN 0 521 40009 0 hardback

Chapter 2

Agricultural Research in an International Policy Context

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The issues we address in this chapter involve the role of agricultural research in the context of international economic policy. The environment which that policy helps to define influences the nature of the technologies demanded by producers as well as the supply of technologies offered by private- and public-sector research systems. It also has a substantial influence on the impact of new technologies on producers, the extent to which consumers benefit directly or indirectly from that technology, and ultimately the manner and extent to which technology contributes to general economic growth. Thus, the international economic policy environment plays an important role in shaping the agricultural science and technology policy of both NARSs as well as international development agencies that seek to strengthen and develop the capacity for agricultural research on the international scene.

In the future, national and international policies toward agricultural research and development (R&D) will have a greater influence on the rate of growth of agricultural output and the contribution agriculture makes to general economic growth. An ever-larger share of the increments of agricultural output on the international scene is accounted for by investments in agricultural research. This share is likely to grow in the future, both because the production and distribution of new technology has been found to be an efficient source of economic growth and because the supply of new land that can be brought into production is available only at a sharply rising supply price. Moreover, nation states must increasingly pay more attention to their science and technology policy in order to remain competitive in international markets and earn the foreign exchange they need to service their international debt and to finance higher rates of economic growth.

The parameters national and international policymakers (and private research decision makers) must consider in shaping their decisions are largely reflected in the system of relative prices that prevail in the international economy. In the past, the structure of those

1 The authors would like to thank Jaime Ortiz for data collection and computer assistance.

relative prices was largely influenced by the trade and exchange rate policies implemented by national governments. These policies influenced both the supply of exports from individual countries and their respective demand for imports. They also influenced the level at which prices in international markets were reflected in domestic economies.

Developments in the international economy these past several decades have significantly broadened the number of policies that must now be taken into account. Domestic monetary and fiscal policies have increasingly important international ramifications, influencing to an ever-larger extent the real exchange rates national governments are able to establish for their domestic economies. Moreover, the growing sensitivity to environmental problems, such as global warming, makes it likely that both national and international environmental policies will continue to play a more important role in shaping the structure of international prices and the market opportunities producers in individual countries face.

Two points are important in establishing the context of the material in this chapter. The first is that the factors influencing the international policy context in which national and international agricultural R&D policymakers must operate have become increasingly complex and far-reaching as a result of developments in the international economy. The second is that such policymakers can no longer afford to take a passive role in relation to these conditions in the international economy. Agricultural science and technology policymakers, both private and public, need to take a more active role in shaping their agricultural research programs if the production and distribution of agricultural technology is to be an efficient source of economic growth and if adequate supplies of food for a rapidly expanding global population are to be assured.

The remainder of this chapter is divided into three main parts. The first part provides the background for the analysis to follow. The second discusses some important policy issues. The third examines the implications of what has preceded for strategic agricultural research policies and for international assistance to agriculture. The underlying assumption of the chapter is that policymakers invest in agricultural research to contribute to the achievement of three major policy goals: increased efficiency in resource use, more equitable distribution of the fruits of economic growth, and a more secure environment for their citizens. The expectation is that a sounder agricultural R&D policy, and one that takes conditions in the international economy into account, will make important contributions to the attainment of those goals.

2.1 BACKGROUND

Four issues are discussed in this section: (a) changes in the structure of the international economy, (b) trends in world agricultural trade, (c) changes in technological capability on the international scene, and (d) the structure of agricultural protection. This background provides the setting for the analysis of policy issues that follows in the next section.

2.1.1 Changes in the Structure of the International Economy

Since the end of World War II, there have been enormous changes in the structure of the international economy. At least four of these changes are important to international commodity markets and thus constitute significant changes in the international context in which agricultural science and technology policymakers must operate. These changes are for the most part rooted in technological developments in sectors that provide the infrastructure for international intercourse. Chief among these are technological developments in the communication and transportation sectors that have significantly lowered the costs of these services. These developments have greatly expanded the scope for international trade and for other economic, political, and social interactions among countries. They have been reinforced by the computer revolution, which has made it possible to assemble and analyze large quantities of information.

The first major change in the international economy in this postwar period has been the growth in international trade relative to the growth in global GNP. Trade has grown at a faster rate than global GNP in every year except five since the end of World War II. The five years of exception have been years of severe economic recession in the international economy. The consequence of this relative growth of trade is that the international economy has become increasingly well integrated and interdependent, with national economies increasingly dependent on trade both for markets and for the raw materials, producer goods and services, and consumer goods and services they need.

The second major change in the international economy has been the emergence of a huge, well-integrated international capital market. Starting from a period at the end of the War when there was no international capital market, the global economy has evolved to a point at which the international capital market now simply dwarfs international trade. In a recent year, international financial flows were on the order of $42 trillion, while total international trade flows were on the order of $2 trillion. International capital markets are now every bit as important in establishing links among national economies as is international trade. More important, they dominate foreign exchange markets and establish important links among the macroeconomic policies of national governments (Schuh 1986).

The third major change in the international economy in the postwar period was the shift in 1973 from the Bretton Woods fixed exchange rate system to what can best be characterized as a bloc-floating exchange rate system. At the end of World War II, the international community established a fixed exchange rate system in which the values of national currencies were fixed in terms of each other and remained fixed except under unusual conditions. An important element of this system was that imbalances in the external accounts of national economies were to be eliminated by changes in domestic economic policies.

This system worked reasonably well until the end of the 1960s when international capital markets had grown so large that they dominated foreign exchange markets. The United States devalued the dollar, the key currency on the international scene, in 1971. When that did not reestablish balance in its external accounts, it devalued it again in 1973

and announced that henceforth the value of the dollar would be determined by foreign exchange markets.

Thus ended, for all practical purposes, the Bretton Woods fixed exchange rate system. The system still has a great deal of "fixity" in it since small countries still peg the value of their currencies to the value of one of the major reserve currencies. However, there is a great deal of implicit flexibility in the system because the values of the major currencies change relative to each other and they take the lesser currencies along with them. Something like 85% of global international trade takes place across flexible exchange rates.

The final change in the international economy that is of importance to agricultural commodity markets is the increase in international monetary instability that started about 1968. Prior to that period, international interest rates were relatively stable. Since that date, they have been relatively unstable, at times experiencing large swings. In light of the other changes in the international economy, this increase in monetary instability is of great importance.

At least four of the implications of these changes in the international economy merit further discussion because of their importance to agricultural science and technology policy. First, contrary to the past, agriculture now bears a significant share of the burden of adjustment created by changes in monetary and fiscal policy. Given the existence of a well-integrated international capital market and the prevalence of flexible exchange rates, changes in domestic monetary and fiscal policy are now reflected in changes in real exchange rates and not in real interest rates. The result is to pass the burden of adjustment of these changes to the trade sectors — export sectors and those sectors that compete with imports. In most countries, agriculture is a trade sector. Many countries either export or import agricultural commodities; most do both. Among other things, this means that agricultural resources need to shift from trade to nontrade activities as monetary and fiscal policies change. This is an important challenge to R&D policymakers.

Second, it isn't just domestic monetary and fiscal policies that matter. The policies of other countries are equally, if not more, important. For example, the unprecedented rise in the value of the US dollar in the first half of the 1980s was as much due to the tight monetary and liberal fiscal policies of the United States as it was to the conservative fiscal and easy monetary policies of Western Europe and Japan. That large rise in the value of the dollar had important implications for other countries trying to compete in international markets.

Third, given the present configuration of the international economy, there are strong linkages between international financial markets and international commodity markets. Developments in international financial markets influence the value of national currencies, and these in turn influence trade flows.

Fourth, national economies are now more dependent on forces in the international economy. This is the obverse of the increased dependence on trade that is a logical consequence of that growth in trade as well as the increased importance of the international capital market. A more open economy is, of course, increasingly beyond the reach of national economic policies. Consequently, policy-making and implementation shift in two

disparate directions. They shift to the international level and become part of the codes, rules, and disciplines of international institutions such as the General Agreement on Tariffs and Trade (the GATT). They also shift downward to the state and local level. It is this latter shift that is important to research policymakers because important components of R&D policy need to be made at the state and local level.

2.1.2 Trends in World Agricultural Trade

National agricultural research programs operate in a setting characterized by a unique human, natural, and physical resource base. Differences in relative resource endowments across countries are the fundamental basis of comparative advantage and the source of potential economic gains from international trade. Resource endowments are not static, however, as they change over time in response to investments in individual countries. Moreover, both production and consumption are affected by government interventions in the economy by means of tariffs, nontariff barriers, export subsidies, and interventions in foreign exchange markets — directly or indirectly. With the growing openness of national economies, as noted above, the intervention of governments in other countries is as important as the interventions of domestic governments. These interventions, as well as international monetary developments, can mask underlying comparative advantage and affect a country's competitive advantage for long periods of time.[2] Furthermore, agricultural research can influence both underlying comparative advantages and the nature of government interventions, an issue we will address in a later section.

World trade in agricultural products has grown steadily throughout the post-World War II period. In addition to this growth in trade, the patterns of trade also have changed, in part associated with changes in the aggregate growth rates. For example, agricultural trade grew at historically rapid rates during the 1970s, fueled in part by the rapid growth in US trade as the value of the dollar fell in foreign exchange markets. This was also fueled by the rapid growth in international monetary reserves as well as in borrowing by the less-developed countries during this period. Aggregate growth rates slowed in the first half of the 1980s, however, as the international economy experienced the most severe economic recession since the 1930s. The value of the dollar rose, thus reducing the competitive edge of the United States, and many less-developed countries experienced serious international debt crises as international liquidity dried up.

Important shifts occurred in this period in both country and regional shares of total agricultural exports. For example, grain production grew steadily during this period, but trade as a percent of total grain production peaked in 1980-81 and declined through 1985. Less-developed countries, which experienced a declining share of total world food exports in the 1960s and 1970s, realized more rapid export growth than the more-developed

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2 Competitive advantage refers to the advantage that remains as underlying comparative advantage is affected by exchange rate and trade policy distortions.

countries in the first half of the 1980s (table 2.1). Among less-developed regions, grain imports grew most in sub-Saharan Africa, China, and West Asia & North Africa, but exports grew most in Asia & Pacific (table 2.2). Many other significant changes occurred in individual countries, not the least of which has been India's shift to being a net grain exporter and the increasing volatility of China's agricultural trade.

Table 2.1: *Average Annual Percentage Growth of Agricultural Exports*

	1965-73	1973-80	1980-85
	%	%	%
Low- and middle-income economies[a]			
Food	2.4	4.2	3.6
Nonfood agriculture	2.1	0.4	1.2
Total reporting economies			
Food	3.6	6.8	1.9
Nonfood agriculture	3.1	0.9	2.1

Source: *World Development Report 1989*, p. 150.

[a] Defined as having a level of per capita GNP below $6000 in 1987.

A variety of factors are responsible for these observed changes in trade patterns. These changes indicate that countries must be continuously concerned with international competition in agricultural markets if they want to retain current sources of foreign exchange and carve out ever-larger markets. Food, agricultural, and research policies must take account of changes in both international comparative and competitive advantages. In a sense, each country finds itself on an international treadmill, with a need for continuous increases in productivity and for policies that do not discriminate against agriculture lest that country loses its share of a particular market. An important implication for research policy is that each country must carefully establish research priorities that are consistent with its resource endowment relative to other countries. It must also take into account any changes in the quality of that endowment that may result from research or investments in other countries.

Production in the less-developed countries has now increased to the point at which roughly the same quantity of cereal and other food is produced in them as in the more-developed countries. However, the extent to which changing production and trade patterns are due to technological changes, as opposed to policy or institutional forces, is difficult to assess without a detailed, in-depth analysis on a country-by-country basis. In addition, there are international as well as domestic factors affecting both technological and economic policy changes and therefore also affecting both comparative and competitive advantages.

Table 2.2: *Cereal Trade and Percentage Change between 1974-76 and 1986-88*

Region	Imports		Exports		Total change		
	1974-76	1986-88	1974-76	1986-88	Imports	Exports	Net imports
	(*million metric tons*)		(*million metric tons*)		%	%	%
Sub-Saharan Africa	4.1	8.4	0.4	1.0	103	133	99
China	6.7	18.5	2.8	6.0	178	115	224
Asia & Pacific	19.0	21.4	5.2	9.7	13	87	–16
Latin America & Caribbean	13.6	19.5	11.7	11.6	44	–1	320
West Asia & North Africa	13.6	40.6	0.3	3.0	198	1050	181
Less-Developed Countries	*56.9*	*108.3*	*20.4*	*31.4*	*90*	*54*	*110*
MDC Nonmarket Economies	27.2	39.1	8.2	5.3	44	–35	78
MDC Market Economies	72.2	66.8	128.1	180.2	–7	41	–103
More-Developed Countries	*99.4*	*106.0*	*136.3*	*185.5*	*7*	*36*	*–116*
World	156.3	214.2	156.7	216.8	37	38	—

Source: Constructed on the basis of data reported in FAO (1977, 1990c).

Note: Cereals principally include wheat and meslin, rice, barley, maize, rye, and oats.

2.1.3 Structural or Technological Changes

The structural or technological determinants of agricultural production and trade include such things as public and private investments in agricultural research, investments in education, improvements in physical infrastructure (including that for water control), and population growth rates. Relative differences in public agricultural research expenditures across countries, in particular, have been instrumental in altering agricultural productivity and underlying comparative advantage.

A regional summary of changes in cereal yields from the mid-1970s to the mid-1980s is presented in table 2.3. While yield per hectare is only a partial productivity measure and is affected by many factors (chapter 5), these overall levels and trends reflect, in part, the generation and adoption of research results. Research has proved to be a powerful means of altering comparative advantage in world agriculture. In addition, the CGIAR system of international agricultural research centers has generated valuable tropical technologies for rice, maize, wheat, beans, potatoes, cassava, beef, and other commodities. Many new biotechnologies appear to be potentially transferable to those countries with an adequate indigenous research capacity, but decisions regarding the intellectual property rights for new biotechnologies may influence their transfer (chapter 10, Persley 1990).

Table 2.3: *Cereal Yields and Percentage Change between 1974-76 and 1984-86*

Region	Yield		Total change
	1974-76	1984-86	
	(*kg per hectare*)		%
Sub-Saharan Africa	806	928	15
China	2479	3891	57
Asia & Pacific	1428	1902	33
Latin America & Caribbean	1640	2093	28
West Asia & North Africa	1390	1553	12
Less-Developed Countries	*1628*	*2206*	*36*
MDC Nonmarket Economies	1735	2032	17
MDC Market Economies	3033	3937	30
More-Developed Countries	*2394*	*3051*	*27*
World	1955	2560	31

Source: Constructed on the basis of data reported in *FAO Production Yearbooks*.

A historical summary of the regional data on research expenditures as a percentage of the value of agricultural production is presented in chapter 1 of this volume. These data indicate the upward trend in research-intensity that occurred in many countries from 1961 to 1985. A substantial number of less-developed countries, however, experienced a decline in their research intensity ratios from the late 1970s to the mid 1980s. Failure to maintain

research intensity can have serious consequences because much agricultural research serves to maintain past productivity gains as insects and diseases evolve over time and become more resistant to pesticides. Another serious issue in many less-developed countries is that both the capacity to train agricultural scientists and the capacity for research itself appear to have declined in the 1980s as a consequence of severe economic crises (see chapter 7). If so, these declines illustrate the linkage between national agricultural research capacity and the economic environment.

2.1.4 Policy Interventions and the Structure of Protection

Agricultural production, trade, and domestic prices are affected by a variety of policy interventions by domestic and foreign governments. Among these are tariffs, quotas on imports and exports, consumer and producer subsidies, interventions in foreign exchange markets, and monetary and fiscal policies. Each of these policy instruments can affect competitive advantage and mask or enhance underlying comparative advantage.

The emergence of well-integrated capital markets and bloc-floating exchange rates increases the vulnerability of agricultural sectors to foreign economic events, since these markets link economic policies together in ways they have not been linked in the past. They also provide less-developed countries with new development opportunities since they provide individual countries with access to capital from abroad so long as they pursue sound economic policies and are not currently overburdened with debt. They also force those countries that are heavily in debt to improve their export performance, reduce import subsidies, and reduce the overvaluation of their currencies. The latter has probably been the most common policy distortion among less-developed countries.

The implication of this for research is that research that generates new production technology for export commodities, or for those commodities that have been heavily imported in recent years, may deserve more priority than was previously recognized. Emphasis on imported commodities may be called for if it appears that the country has a comparative advantage in those commodities that has been masked under previous policy distortions. Another implication is that these countries may need more sophisticated priority-setting procedures for research that can assess these changing economic forces and draw the implications for research priorities.

An important feature of the international economy in recent decades is that the values of major currencies have experienced large swings relative to each other. For example, the US dollar experienced a six-year decline from 1973 to 1979, during which period the United States became increasingly competitive in international commodity markets. Then the dollar experienced an almost unprecedented rise through May 1985, and the United States lost a great deal of the competitive edge in international markets that it had gained in the previous decade.

This problem was exacerbated by the commodity policy established in the aftermath of the US embargo on sales to the Soviet Union when that country invaded Afghanistan. This policy preordained increases in commodity prices in succeeding years by legislative

mandate. Given the importance of the United States in some international commodity markets, this policy raised prices in those markets and sent misleading signals to producers in other countries. This policy ended in 1986 when US loan levels were lowered significantly.

Both more- and less-developed countries discriminate against their agricultural sectors, although in quite different ways. The results of a USDA survey of producer subsidies and taxes in various countries are presented in table 2.4. An important pattern in the structure of protection is apparent. The more-developed countries, for their part, tend to provide large subsidies to their producers. The less-developed countries, on the other hand, discriminate severely against their producers through a large number of explicit and implicit taxes. The result is that far too much of the world's agricultural output is produced in the high-cost, more-developed countries, and far too little is produced in the low-cost, less-developed countries. The result is the sacrifice of a large amount of global income and welfare due to the inefficient use of the world's agricultural resources. This same pattern of protection has important implications for agricultural research, and this will be discussed below.

The consequence of more-developed countries providing such large subsidies to their producers, largely through interventions in commodity markets, is that domestic prices in those countries are set significantly above border price levels. To protect those prices, the more-developed countries have to discriminate against imports from less-developed and other countries. Examples of nominal protection coefficients, which compare domestic prices with border prices, are presented in table 2.5 for several commodities and more-developed countries.[3] The manner in which protection is provided has changed significantly over the past few years, with tariffs becoming less important and nontariff barriers more significant. More-developed countries need to continue reducing protectionism against imports from less-developed countries if they expect the debts of those countries to be paid, markets for exports from more-developed countries to expand, and all countries to benefit from following their comparative advantage as it evolves through agricultural research and the like.

Another dimension to this structure of protection is that the more-developed countries find themselves using export subsidies to dispose of the surpluses they accumulate from setting their producer prices too high. The use of these subsidies by the United States and the European Community in particular causes the international prices of some commodities to be lower than they would otherwise be. This lowers the returns to investments in research in the less-developed countries, an issue that will also be discussed below.

Finally, each country must decide whether its long-run comparative advantage is primarily in agricultural production or in manufacturing. As less-developed countries continue to expand agricultural production through the generation and adoption of new

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3 Related nominal protection rates for selected commodities in some less-developed countries are presented in tables 1.1 and 1.2 in chapter 1.

Table 2.4: *Ranking of Producer Subsidy Equivalent (PSE) Levels*

Ranking[a]	United States	Australia	Canada	European Community	Japan	South Korea	India	Argentina	Nigeria	Brazil
High tax									Cocoa[b] Sugar	
Moderate tax					Citrus		Cotton (LS)[b] Wheat	Wheat		
Low tax							Cotton (MS)[b] Peanut meal Rapeseed meal Rice Soybeans Soymeal	Maize[b] Sorghum[b] Soybeans[b]	Cotton Rice	Beef[b] Maize Soybeans[b]
Low subsidy	Barley[b] Beef Pork Poultry[b] Soybeans[b]	Barley[b] Beef[b] Cane sugar[b] Cotton[b] Mfd milk[b] Pork[b] Poultry[b] Rice Wheat[b] Wood[b]	Barley[b] Beef Flaxseed[b] Maize Oats[b] Pork[b] Poultry[b] Rapeseed[b] Soybeans Wheat[b]	Barley[b] Common wheat[b] Maize Pork[b]		Poultry	Peanuts[b] Rapeseed		Maize	Mfd milk Poultry

Table 2.4: *Ranking of Producer Subsidy Equivalent (PSE) Levels (Contd.)*

Ranking[a]	United States	Australia	Canada	European Community	Japan	South Korea	India	Argentina	Nigeria	Brazil
Moderate subsidy	Cotton[b] Dairy[b] Maize[b] Rice[b] Sorghum[b] Wheat[b]	Fld milk	Sugar	Dairy[b] Durum wheat Poultry Rapeseed Rice Sheep Soybeans Wheat[b]	Poultry	Pork	Peanut oil Rape oil Soy oil		Wheat	Cotton[b] Rice
High subsidy	Sugar		Dairy[b]	Beef[b]	Barley Beef Fld milk Mfd milk Pork Rice Soybeans Sugar Wheat	Barley Beef Fld milk Maize Rice Soybeans Wheat				Wheat
Weighted average PSE	22	9	22	33	72	64	8	−22	−9	7

Source: Ballenger, Dunmore, and Lederer (1987).

Note: *Fld* represents fluid, *Mfd* represents modified, *MS* represents medium staple cotton, and *LS* represents long staple cotton.

[a] Low denotes 0-24%; moderate denotes 25-49%; and high denotes≥ 50%.

[b] Net exporter during 1982-84.

Table 2.5: *Nominal Protection Coefficients for Producer and Consumer Prices of Selected Commodities in More-Developed Countries, 1980-82*

	Wheat		Coarse grains		Rice		Beef and lamb	
Country or Region	Producer	Consumer	Producer	Consumer	Producer	Consumer	Producer	Consumer
Australia	1.04	1.08	1.00	1.00	1.15	1.75	1.00	1.00
Canada	1.15	1.12	1.00	1.00	1.00	1.00	1.00	1.00
European Community[b]	1.25	1.30	1.40	1.40	1.40	1.40	1.90	1.90
Other Europe[c]	1.70	1.70	1.45	1.45	1.00	1.00	2.10	2.10
Japan	3.80	1.25	4.30	1.30	3.30	2.90	4.00	4.00
New Zealand	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
United States	1.15	1.00	1.00	1.00	1.30	1.00	1.00	1.00
Weighted average	1.19	1.20	1.11	1.16	2.49	2.42	1.47	1.51

	Pork and poultry		Dairy products		Sugar		Weighted average[a]	
	Producer	Consumer	Producer	Consumer	Producer	Consumer	Producer	Consumer
Australia	1.00	1.00	1.30	1.40	1.00	1.40	1.04	1.09
Canada	1.10	1.10	1.95	1.95	1.30	1.30	1.17	1.16
European Community[b]	1.25	1.26	1.75	1.80	1.50	1.70	1.54	1.56
Other Europe[c]	1.35	1.35	2.40	2.40	1.80	1.80	1.84	1.81
Japan	1.50	1.50	2.90	2.90	3.00	2.60	2.44	2.08
New Zealand	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
United States	1.00	1.00	2.00	2.00	1.40	1.40	1.16	1.17
Weighted average	1.17	1.17	1.88	1.93	1.49	1.68	1.40	1.43

Source: *World Development Report 1986*, pp. 112-3.

Note: Nominal protection coefficients represent domestic prices divided by border prices.

[a] Averages are weighted by the values of production and consumption at border prices.
[b] Excludes Greece, Portugal, and Spain.
[c] Austria, Finland, Norway, Sweden, and Switzerland.

production technologies, this issue will become increasingly important on the international scene.

2.2 POLICY ISSUES

In this section we discuss a number of policy issues facing less-developed countries in which agricultural research has an important role to play in contributing to solutions. Important as new production technology may be in solving these problems, however, it is no substitute for sound economic policy. What the discussion will indicate is that sound science and technology policy and sound economic policy are often highly complementary.

2.2.1 The International Debt Problem

Many less-developed countries are currently burdened with serious international debt problems. These problems are a legacy, in part, of the flood of petrodollars generated in the aftermath of the quadrupling of petroleum prices in 1973. Commercial banks were encouraged by the international community to recycle those dollars lest the international economy collapse. Their efforts to do so were met with open arms by many less-developed countries, who saw borrowing as an alternative to painful devaluations and other policies that were the prescribed medicine for the change in external terms of trade that the rise in petroleum prices represented.

Several indicators of the magnitude of the debt problems are presented in table 2.6. Total debt as a share of total GNP was only about 20% at the beginning of the 1980s. However, this ratio had almost doubled by 1986. Similarly, by the mid-1980s the ratio of interest service to exports was close to 11%, almost double what it had been at the beginning of the decade. Borrowers have to do more than make interest payments, however. They also have to make payments on the principal. Total debt service payments were thus significantly higher than just interest payments. This was especially important since much of the borrowing of the 1970s was on very short terms. Inability to repay meant that the debt had to be refinanced at interest rates that were much higher in the 1980s than they had been in the 1970s.

International debt is serviced either by running a surplus on the trade account, by borrowing additional money, or by some combination of the two. If additional borrowing is to be avoided, policymakers need to increase their trade surplus by either reducing their imports or increasing their exports. This can be done in a number of different ways. The classic means to increase the trade surplus is currency devaluation, which will operate in the desired way on both exports and imports. Devaluations take time to have the desired effect, however. Thus, policymakers typically find ways to reduce their imports in the short term by other means, such as imposing higher tariffs or import quotas. This often reduces the domestic supply of raw materials or critical producer inputs that are imported, thus slowing down economic growth at the very time the economy needs to grow.

Devaluations are painful medicine since they inherently involve reductions in real

Table 2.6: *Debt Indicators for Less-Developed Countries, 1980-86*

Indicator	1980	1981	1982	1983	1984	1985	1986
	%	%	%	%	%	%	%
Ratio of debt to GNP	20.6	22.4	26.3	31.4	33.0	35.8	38.5
Ratio of debt service to GNP	3.7	4.0	4.6	4.5	4.9	5.3	5.5
Ratio of interest service to exports	6.9	8.3	10.4	10.1	10.3	10.8	10.7
				(*billions of dollars*)			
Total debt	428.6	490.8	551.1	631.5	673.2	727.7	753.4

Source: *World Development Report 1987*, p. 18.

Note: Data are based on a sample of 90 less-developed countries, excluding China.

income for the country undertaking the devaluation. The problem is that, as the currency is devalued, the country has to give up more in terms of domestic resources to earn each unit of currency to pay for exports or to service international debt. This is why policymakers almost inevitably avoid devaluations if they can. To the extent that negative shifts in the external terms of trade require devaluation, the proper policy is to get on with the devaluation so the adjustment process can start immediately and spread widely in the domestic economy.

The production of new agricultural technology through agricultural research can make important contributions to the solution of this problem, especially if a capacity for this research is in place. The supply of new technology for export sectors will make the country more competitive in international markets and thus generate an increased supply of foreign exchange. Similarly, the supply of new technology for domestic sectors that compete with imports can do the same thing. Success on both sides of the trade balance reduces the amount by which the domestic currency has to be devalued in order to reestablish a balance in the external accounts, and thereby limits the reduction in real income the country would otherwise have to experience.

Ideally, policymakers devalue their currency and increase expenditures on their research and extension services at the same time. The devaluation increases price incentives for domestic producers to adopt available technology at a faster rate. Policymakers often discriminated against agriculture by overvaluing their currency prior to the emergence of the debt crisis, which partly explains why supplies of foreign exchange have been limited in these countries and why they have experienced a flood of competitive imports. Thus, devaluations, when warranted, can foster sounder economic growth, independent of the debt problem whose resolution will also increase the payoff from investments in agricultural research.

The only fly in this ointment is that a devaluation of the currency may raise the price of modern inputs if they are imported. Such inputs typically make up only a small component of factor shares, however, and the adoption of new technology will raise the productivity of these inputs. Thus, the effect of a rise in the price of the inputs may be offset

in part, at least, by an increase in productivity.

The solution to the debt problem involves more than the policies of the countries experiencing them. More-developed countries need to reduce their barriers to imports from less-developed countries so that the latter countries will have greater access to markets. Similarly, the elimination of export dumping by the United States and the European Community would increase international prices for these commodities and make it possible for less-developed countries to increase their foreign exchange earnings.

2.2.2 Shifts in the External Terms of Trade

A common complaint of policymakers in less-developed countries is that their external terms of trade shift against them over time. This creates a balance-of-trade problem and makes it difficult for them to finance a high rate of economic growth or to service their international debt.

There are many problems with the declining-terms-of-trade argument, at least as it is typically posed. In the first place, there are serious problems in measuring shifts in the external terms of trade attributed in part to the difficulty in making adjustments for changes in traded goods. Much of the measured increase in the price of manufactured goods is due to the failure to account for improvements in the quality of these goods over time. Second, the external terms of trade are unique to individual countries, and it is thus easy to overgeneralize about the decline in terms of trade. And third, whether the terms of trade are declining is determined in part by the choice of time period in which to make the comparison.

Despite these caveats, declines in the external terms of trade often pose problems. The issue is what to do about it. Just as in the case of the international debt problem, the classic remedy is to devalue one's currency. This will deal with the balance-of-payments problem and increase the supply of foreign exchange to finance a higher rate of economic growth and to service internationally held debts. Just as in the case of the debt problem, however, it will also result in a reduction in national income.

Here again, agricultural research and the introduction of new technology can play an important role in addressing the problem. After all, the real prices of primary commodities often decline because a process of technical change is taking place elsewhere in the international economy. The only way to deal with this problem is to sustain a comparable rate of technical change in the domestic economy. If that is done, the effects of the decline in the terms of trade will be offset by an increase in the domestic economy. If the rate of productivity growth in the domestic economy is higher than that in the international economy, the domestic economy will actually benefit as its supply of foreign exchange grows because of expanded markets.

As in the international debt problem, moreover, there is much to be said for a combination of devaluation and a vitalized research effort. The introduction of new production technology will reduce the extent to which the domestic currency has to be devalued, but devaluation can provide shorter-term relief and put the economy on the road

to broad adjustment.

2.2.3 Unstable International Monetary Conditions

The exchange rate is the most important price in an economy (Schuh 1986). As it changes over time, it affects the relative prices in an economy between tradables and nontradables, the allocation of resources between these same two sectors, and the distribution of income in the economy. It also affects the terms on which domestic resources are exchanged for foreign goods and services, the competitiveness of domestic export sectors, and the ability of domestic sectors to compete with imports.

Currently, there are many complaints about the instability in exchange rates as a result of the end of the Bretton Woods fixed exchange rate system. Typically, the complaints refer to short-term, day-to-day instability. From our perspective, this is not the critical issue since the risk associated with this instability can be transferred to other sectors by means of futures markets and other marketing arrangements. The more serious problem involves the long swings in the real value of national currencies referred to above. These long swings can mask the underlying comparative advantage for substantial periods of time, reduce the payoff from investments in agricultural research, and create uncertainty about the supply of foreign exchange.

The issue is what can be done about these swings? Reform of the international monetary system is one thing that can be done about it. But barring that, agricultural research can provide some assistance by having a sufficiently diverse agenda where new technology is available for those sectors that bear the burden of adjustment to the swings in exchange rates. Moreover, research that helps build more flexibility in the production sector can make the adjustment problem less burdensome.

2.2.4 The Persistent Need to Diversify

Agricultural diversification issues arise from economic and technological forces operating at the international level, at the national level, and within regions in individual countries. An important component of the diversification issue is the need to transfer resources out of agriculture as economic development proceeds. We approach this set of issues by considering, first, the nature of the diversification problem within agriculture as development proceeds; then, the need to transfer resources out of agriculture; and then international adjustments. Regional issues are left aside since they tend to be subsets of the above.

Increases in per capita income associated with economic development induce strong pressures for agricultural diversification. In the first place, as income increases, there are relative shifts in the demand for individual commodities that induce changes in consumption patterns, other things being equal. Consumption patterns shift away from a dependence on tubers such as cassava and less-preferred grains such as sorghum and millet, and toward higher-income grains such as rice and wheat. Continued increases in income shift demand further, bringing about increases in the demand for livestock and livestock products,

poultry, and fruits and vegetables.

An important component of these shifts in consumption patterns on the international scene is the shift out of direct foodgrain consumption and into the indirect consumption of feedgrains in the form of livestock and livestock products. The demand for feedgrains is derived from the demand for these latter products. Although the consumption of feedgrains is at low levels in most less-developed countries, large income elasticities for livestock and livestock products suggest that there will be significant increases in the demand for feed grains in the future. Research programs need to anticipate these shifts.

Current consumption patterns differ significantly among regions in the less-developed world, largely reflecting differences in the stage of economic growth (table 2.7). In sub-Saharan Africa, for example, which has very low per capita incomes (see chapter 6), the shift from food- to feedgrains is proceeding quite slowly, while major substitutions are occurring among the foodgrains. The consumption of rice and wheat has increased rapidly, while consumption of other, more traditional foods has increased very little or declined.

Table 2.7: *Annual Growth Rates in the Consumption of Grains, 1961-83*

Region	Wheat		Rice		Maize		Other coarse grains		Total cereals	
	Feed	Food	Feed	Food	Feed	Food	Feed	Food	Feed	Food
	%	%	%	%	%	%	%	%	%	%
Sub-Saharan Africa	7.7	6.2	3.2	5.1	5.3	3.3	1.6	1.4	3.9	2.9
Asia & Pacific	6.6	5.9	3.4	3.2	1.5	2.9	1.5	0.03	6.0	3.4
Latin America & Caribbean	4.9	3.5	4.3	3.5	4.2	2.8	9.1	3.4	5.4	3.2
West Asia & North Africa	5.5	4.3	1.0	4.5	7.9	2.7	3.4	1.0	4.7	3.6

Source: Pinstrup-Andersen (1986).

Another factor affecting consumption patterns is urbanization. Urban areas consume more wheat (and rice in some cases), vegetables, and livestock products, while rural areas consume more traditional foods. Urbanization is, in effect, a surrogate for a variety of more fundamental economic forces. For example, some of the observed changes in consumption patterns can be attributed to increases in per capita incomes, others to differences in the opportunity cost of women's time, and others to differences in relative prices.

Still another factor is the change in production costs as an economy experiences increases in per capita incomes. Increases in real wages are associated with increases in per capita incomes. Since commodities differ in their labor intensity, shifts in the structure of production will be induced as labor costs rise.

Finally, technical change itself can induce changes in production patterns. It does this by being non-neutral in its effects on resource use and by eventually lowering the price of the commodity — thus bringing about substitution effects.

We now turn to a consideration of the need to diversify resources out of agriculture

as economic development proceeds. The income elasticity of demand for agricultural production is inherently less than that for nonagricultural goods and services. This by itself implies the need to shift resources out of agriculture. But if technical change raises the productivity of resources in agriculture, this will still further reduce the demand for resources in agriculture. This issue is important because it flies in the face of so much of conventional wisdom.

Last, there is the issue of diversification on the international scene. As technical change occurs in specific commodities or commodity groups, general equilibrium effects will be induced as shifts in supply outpace the growth in demand and as the prices of affected commodities decline. This causes resources to shift out of the affected sectors and the output of other commodities to expand. The international implications of this can be quite great since comparative advantage could shift on a broad scale.

2.2.5 Environmental and Natural Resource Problems

Although food production is expanding in most areas of the world, deterioration of the natural resource base threatens agricultural and domestic development in a number of countries, with important implications for agricultural research. In some cases, the technical knowledge is currently available on how to sustain the productive natural resource base in the face of expanding population pressures, but the institutional means for encouraging the implementation of that knowledge is not. In other cases, the technical knowledge is also lacking, particularly for the fragile soils in parts of Africa (Lal 1987). The result is that one observes deforestation, overgrazing, desertification, and increasingly severe soil erosion and flooding around the world. In addition, lakes, streams, and rivers are becoming increasingly polluted with industrial wastes and agricultural runoff, weakening their potential as a direct source of food and threatening their potential as a source of water for modern agriculture. Biologists, physical scientists, socioeconomists, and policymakers must cooperate to help solve these environmental problems.

A concerted effort will be required, both on the part of national agricultural research systems and on the part of multilateral and bilateral development assistance agencies. Natural resource or environmental problems have implications both within countries and internationally. The river silting and resultant flooding of northern India as a result of deforestation and soil erosion in Nepal is one example; so are the changes in climate and water quality associated with the cutting of tropical rain forests and with certain types of industrial growth.

Many natural resource problems are associated with the most marginal lands within countries and can be understood only as a subset of the general problem of rural underdevelopment and poverty. Marginal lands become a problem when the socioeconomic factors associated with underdevelopment are combined with a land resource subject to degradation under expanding human use (Bremer et al. 1984). Consequently, part of the solution may lie in creating opportunities for off-farm employment or intensification of the use of nonmarginal lands, while another part lies in intervention on the marginal lands themselves.

National agricultural research systems seeking solutions to problems of environmental degradation must consider on- and off-site technologies and institutions (chapter 3).

Recently, the World Bank has recognized the need to place greater emphasis on issues of environmental degradation associated with development activities. Bilateral assistance agencies are also expanding support for activities in the area of preserving natural resources. Institutional means must be found for (a) creating incentives to reduce regional and international environmental externalities, (b) overcoming rates of time preference that skew consumption toward the present in many less-developed countries, and (c) offsetting income elasticities of demand for environmental improvements that value food consumption over the environment. The latter two factors are closely related to income levels.

Economic policies contribute to many of these environmental and sustainability problems. For example, policies that discriminate against agriculture in poor countries cause land and water to be undervalued, as do the export-dumping policies of the European Community and the United States. When land and water are undervalued, producers have less incentive to protect their value as productive agents, or to invest in enlarging the flow of services from them in the future. Moreover, these same policies, together with the failure to invest in the creation and diffusion of productivity-enhancing technologies, causes output to expand on the extensive margin rather than on the intensive margin. The result is to push agriculture into marginal areas, up hillsides, and onto land with fragile topsoil, where degradation and erosion are almost inevitable.

Thus, once again one observes the complexity between economic policy and science and technology. More nearly optimal policies on both sides can do much to improve sustainability and to strengthen the underlying resource base for the future.

2.2.6 The Role of Foreign Aid to Agriculture in the Context of International Trade

An international policy issue with broad and important ramifications for agriculture and for agricultural research systems in less-developed countries, as well as for policymakers in more-developed countries, is the importance and desirability of foreign economic assistance for agricultural development. Countries are poor in large part because of the relatively small amount of capital per worker or per hectare in their agricultural sectors. Much foreign assistance involves capital transfers and might, therefore, relieve a major development constraint. Technical assistance and food aid are, of course, other major forms of foreign assistance. Agricultural research systems are often recipients of foreign assistance.

Recently, policymakers in the United States (and to a smaller extent in other more-developed countries) have received pressure from agricultural commodity groups to reduce foreign assistance to less-developed countries on the grounds that aid encourages competition with US agricultural exports. Some economists have supported this view (Avery 1985). However, many agricultural economists have argued that agricultural growth stimulates income growth with resulting positive effects on less-developed country imports of US farm

products.[4] This debate is of importance to agricultural research institutions in less-developed countries if the following apply: (a) if in fact aid to agricultural research systems has borne positive results, (b) if aid to agriculture in general (including policy reform, credit programs, infrastructure, etc.) has influenced adoption of new technologies, and (c) if (assuming aid has had positive results) a misunderstanding of the impact of aid on agricultural trade has resulted in the curtailment of aid, thereby hindering agricultural and overall development.

The studies cited above presuppose that foreign aid increases agricultural productivity. The authors then examine the impact of agricultural productivity on trade. Surprisingly little empirical analysis of the linkage between foreign aid and agricultural productivity actually exists. However, Peterson (1989), who fitted a Cobb-Douglas production function to data from 113 countries, does provide evidence that capital transfers from rich to poor nations increase output per worker (including nonagricultural output) in less-developed countries.

In an attempt to examine the impact of foreign assistance on agricultural productivity more closely, we estimated the parameters of an aggregate agricultural production function for a sample of 98 less-developed countries using cross-sectional time-series data. Official development assistance (ODA) was included as a variable in the analysis. The basic model was as follows, with all variables measured in logs:

$$Q = \alpha_0 + \alpha_1 X_1 + \alpha_2 X_2 + \alpha_3 X_3 + \alpha_4 X_4 + \alpha_5 X_5 + \alpha_6 X_6 + \alpha_7 X_7 \qquad (2.1)$$

where Q measures the real value of agricultural gross domestic product; X_1 is livestock measured in number of cattle equivalents; X_2 is labor measured as economically active population in agriculture; X_3 is a land quality index; X_4 measures tractor power; X_5 is a schooling variable measured as the number of pupils enrolled in primary and secondary levels; X_6 is a level-of-technology variable proxied by the number of pupils enrolled in the third level of schooling; X_7 is the real value of foreign aid (ODA); and $\alpha_0, \ldots, \alpha_7$ is a set of coefficients to be estimated.

The output and input variables represent annual data from 1975-1985, while the foreign aid variable — included as a quadratic distributed lag of a three-year moving average of ODA receipts — was lagged six years back to 1970. The output variable measured in nominal local currency units was first deflated to 1980 currency units using country-specific implicit agricultural GDP deflators and then converted to an "international" dollar using 1980 purchasing power parity indices obtained from Summers and Heston (1988). To reduce problems with heteroskedasticity due to large differences in country size, all outputs and inputs were measured on a per hectare basis.

The results of the estimation are presented in table 2.8. Seven models were estimated.

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4 See for instance, Kellogg, Kodl, and Garcia (1986), Lee and Shane (1985), de Janvry and Sadoulet (1986b, 1988) Houck (1987), Vocke (1987), and Christiansen (1987).

Table 2.8: *Agricultural Production Function with Foreign Aid Variables for 98 Less-Developed Countries*

Explanatory variable	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7
Constant	−1.421 (−9.60)[a]	−3.325 (−20.05)	−3.704 (−20.95)	−3.270 (−12.34)	−2.462 (−13.27)	−0.819 (−4.24)	−1.250 (−6.02)
Labor[b]	0.463 (20.06)	0.366 (21.85)	0.442 (23.95)	0.518 (29.05)	0.518 (29.05)	0.518 (29.05)	0.518 (29.05)
Land quality	0.375 (9.76)	0.901 (20.06)	0.855 (19.25)	0.673 (15.75)	0.673 (15.75)	0.673 (15.75)	0.673 (15.75)
Livestock[c]	0.275 (17.69)	0.336 (23.39)	0.297 (20.24)	0.213 (14.60)	0.213 (14.62)	0.213 (14.62)	0.213 (14.62)
Tractor horse power[d]	0.177 (22.52)	0.104 (12.68)	0.089 (10.79)	0.087 (11.38)	0.087 (11.38)	0.087 (11.38)	0.087 (11.38)
Primary and secondary education[e]	0.070 (6.28)	0.081 (8.06)	0.081 (7.85)	0.069 (7.21)	0.069 (7.21)	0.069 (7.21)	0.069 (7.21)
Higher education[e]	0.073 (11.20)	0.052 (8.64)	0.040 (6.58)	0.020 (3.48)	0.020 (3.48)	0.020 (3.48)	0.019 (3.48)
Foreign aid	0.005[f] (0.68)	0.027[f] (3.50)	0.051[f] (5.50)	0.127[f] (8.25)	0.030[f] (3.05)	−0.010[f] (−0.87)	−0.011[f] (−1.03)
Sub-Saharan Africa intercept dummy	—	—	—	0.808 (3.18)	—	−1.640 (−8.40)	−1.212 (−6.34)
Sub-Saharan Africa slope dummy on aid	—	—	—	−0.970[f] (−5.60)	—	0.390[f] (7.43)	0.041[f] (7.27)
West Asia & North Africa intercept dummy	—	1.859 (9.96)	2.200 (11.01)	2.450 (9.10)	1.642 (8.40)	—	0.430 (2.00)
West Asia &North Africa slope dummy on aid	—	−0.077[f] (−5.25)	−0.091[f] (−6.33)	−0.137[f] (−9.10)	−0.039[f] (−2.77)	—	0.013[f] (0.09)

Table 2.8: *Agricultural Production Function with Foreign Aid Variables for 98 Less-Developed Countries (Contd.)*

Explanatory variable	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7
Asia & Pacific intercept dummy	—	—	—	—	–8.080 (–3.17)	–2.450 (–9.10)	–2.020 (–7.25)
Asia & Pacific slope dummy on aid	—	—	—	—	0.097[f] (5.60)	0.137[f] (7.43)	0.138[f] (7.27)
Latin America & Caribbean intercept dummy	—	—	1.154 (5.77)	2.020 (7.25)	1.212 (6.34)	–4.300 (–2.00)	—
Latin America & Caribbean slope dummy on aid	—	—	–0.062[f] (–4.40)	–0.138[f] (–7.27)	0.041[f] (–3.03)	-0.00002[f] (0.09)	—
$\bar{R}^2$ (n = 98)	0.905	0.924	0.927	0.938	0.938	0.938	0.938

Source: Output, World Bank (1989); Land Quality, Peterson (1987); Labor, Livestock, Machinery and, Land, *FAO Production Yearbooks*; Education, *UNESCO Statistical Yearbooks*; Foreign Aid, *OECD Development Cooperation.*

[a] Figures in parantheses are *t*-ratios.

[b] Defined as the number of economically active population in agriculture.

[c] A measure of "animal unit aggregates" with weights of: 0.8 for cattle and asses; 1.0 for horses, mules, and buffalos; 1.1 for camels; 0.2 for pigs; 0.1 for sheep and goats; and 0.01 for chickens, ducks, and turkeys.

[d] Represents number of tractors weighted by a time-varying (country-invariant) weight of average tractor horsepower where weights represent a linear interpolation and extrapolation of Hayami and Ruttan's (1971, 1985) 1970 and 1980 estimates of 35 hp and 40 hp, respectively.

[e] Measures the number of students enrolled in primary plus second and third levels of education.

[f] Calculation based on coefficient taken from the distributed lag variable.

[g] Measures net receipts by individual less-developed countries of total net official development assistance from DAC countries and territories. Grants, loans, and credit for military purposes are excluded by definition.

The coefficients of all variables were significant to at least the 5% level, except for foreign aid. The coefficient for foreign aid was significant in some regressions but not in others. In model 1, which included all 98 countries in the aid variable, the coefficient on foreign aid was positive but nonsignificant at the 5% level. However, in model 2, where an intercept dummy variable and a slope dummy variable on foreign aid were included for West Asia & North African countries, the foreign aid variable was highly significant for the remaining countries.

In model 3, the countries in both West Asia & North Africa and Latin America & Caribbean were excluded. As a result, the coefficient on foreign aid for the remaining countries became larger and more significant than in model 2. In model 4, all countries except those in Asia & Pacific were excluded and the foreign aid coefficient became larger and still more significant. In model 5, all countries except those in sub-Saharan Africa were excluded and the aid coefficient, although smaller and less significant than for Asia & Pacific, was still significant at the 5% level. However, when all countries except for those in West Asia & North Africa were excluded, foreign aid was nonsignificant. This was also the case when all countries except those in Latin America & Caribbean were excluded.

The conclusion that can be drawn from this is that foreign aid had a positive and significant impact on agricultural output in sub-Saharan Africa and particularly in Asia & Pacific, from 1975-1985. Impacts on agriculture in West Asia & North Africa and Latin America & Caribbean were, on average, nonsignificant. The agricultural marginal value product (MVP) of foreign aid in Asia & Pacific was around $10.40 per dollar of aid. The aid MVP in sub-Saharan Africa was $0.40, and for the world as a whole, except for West Asia and North Africa, it was $0.85. While these MVPs may at first appear to be a small return on the dollar, remember that the measure of official development assistance used as the foreign aid variable in the analysis was directed at nonagricultural as well as agricultural development. The agricultural impact is, therefore, an underestimate of the total impact.

The results of the analysis are time-period specific and clearly vary by region. The effects of foreign aid in Latin America & Caribbean may have been masked by the effects of the debt crisis in several countries of that region. A high proportion of the aid in West Asia & North Africa may well have been directed at nonagricultural programs. It appears that aid has had a positive impact on agriculture in the most populous region of the world (Asia & Pacific) and in the poorest region (sub-Saharan Africa). This evidence that aid has had at least some of its intended economic effects should encourage recipients and donors alike.

If aid has, in fact, improved agricultural productivity, the next question is whether increased agricultural productivity has spurred overall economic growth, consumption, and additional imports. Several recent studies have examined different aspects of this question, as noted earlier. One of the studies that examined each of these pieces was by de Janvry and Sadoulet (1986b, 1988). The estimated model included the following equations based on growth rates between 1970 to 1980 for 60 less-developed countries:

Growth rate of manufacturing:

$$\dot{I} = \alpha_0 + \alpha_1 \dot{A} + \alpha_2 \dot{X} + \alpha_3 \dot{P} \tag{2.2a}$$

Income equation:

$$\dot{Y} = \beta_0 + \beta_1 \dot{A} + \beta_2 \dot{I} \tag{2.2b}$$

Consumption equation:

$$\dot{C}_i = \gamma_{0i} + \gamma_{1i} \dot{Y} = \gamma_{2i} \dot{U} + \gamma_{3i} \dot{POP} \tag{2.2c}$$

Import equation for product i:

$$\dot{M}_i = (C_i / M_i)\, \dot{C}_i - (Q_i / M_i)\, \varepsilon_i \dot{A} \tag{2.2d}$$

such that

Agricultural growth structure equation:

$$\varepsilon_i = \dot{Q}_i / \dot{A}$$

and where $\dot{Y}$ represents the growth rate of GDP; $\dot{C}_i$ is the growth rate of consumption of agricultural product i; $\dot{U}$ is the growth rate of urbanization; $\dot{POP}$ is the growth rate of population; $\dot{Q}_i$ is the growth rate of agricultural product i; $\dot{M}_i$ is the growth rate of net imports of agricultural product i; $\dot{P}$ is the inflation rate; and $\dot{A}$ is the growth rate of agriculture.

From the above model, they derive the elasticity of import demand for product i with respect to agricultural growth:

$$d\dot{M}_i / d\dot{A} = \varepsilon_i = (g_i - \varepsilon_i)/D_i$$

where $g_i = \gamma_{1i}(\beta_1 + \alpha_1 \beta_2) = (d\dot{C}_i / d\dot{A})$ represents the elasticity of consumption with respect to agricultural output, and $D_i = (M_i / C_i)$ represents a "dependency" ratio for product i.

Their estimated parameters from this model for all 60 countries as well as the results for the least-developed countries (GDP per capita <$600) are shown in table 2.9. They found the elasticities of manufacturing output with respect to agricultural output and of consumption with respect to income to be positive and highly significant. Their derived elasticity of consumption with respect to agricultural output was highest for wheat in the least-developed countries and for maize in the newly industrialized countries, as one might expect.

The resulting elasticity of import demand with respect to agricultural growth is positive or negative depending on g_i, on the level of dependency for product i ($D_i = M_i/C_i$), and on the growth rate of product i relative to that of agriculture in general (ε_i). Moreover, de Janvry and Sadoulet found that agricultural growth led to growth in the demand for

Table 2.9: *Parameter Estimates from Growth Model, 1970-80*

Per capita GDP	Number of				δ_{li}			g_i			ε_i		
(1965 US$)	countries	α_1	β_1	β_2	cereal	wheat	maize	cereal	wheat	maize	cereal	wheat	maize
< 600	37	0.94*	0.56*	0.31	0.26*	1.01*	0.27	0.22	0.86	0.23	1.20	1.43	1.39
> 600	23	0.56*	0.50*	0.46	0.35*	0.36	1.34*	0.26	0.27	1.01	1.62	–0.35	1.24
all	60	0.82*	0.53*	0.37	0.33*	0.80	0.93	0.28	0.67	0.78	1.33	0.79	0.78

Source: de Janvry and Sadoulet (1988, p. 10).

* Significant at the 5% level.

imports of cereals in 27% of the countries in their sample, of wheat in 90%, and of maize in 48%. The countries that had positive growth rates of agricultural output per capita, high growth in per capita GNP, non-negative growth rates of product i relative to the growth rate of agriculture (ε_i), and positive elasticities of import demand for product i with respect to agricultural growth, included South Korea (cereals and maize), Brazil (wheat and maize), Malaysia (cereals and maize), Egypt (wheat), Tunisia (cereals and maize), Kenya (wheat), Guatemala (wheat), Colombia (maize), and Paraguay (wheat).

These examples suggest a strong relationship in many cases between increased agricultural production and increased agricultural imports. The primary reasons for this relationship are, first, that agriculture is an important sector in most of the less-developed countries and consequently overall economic growth depends on agricultural growth. Second, people in less-developed countries have high income elasticities of demand for food, often 0.5 or higher, which means that a high proportion of every extra dollar is spent on food. Population growth rates are still relatively high in most of the less-developed countries and when a high population growth rate is combined with a high income elasticity of demand for food, even modest per capita income growth can cause the demand for food to exceed increases in domestic production. In addition, diets shift to livestock products with resulting increases in the derived demand for feedgrains, as discussed earlier.

The above scenario depends to a major extent on (a) the size of the income elasticity of demand for food and (b) the degree to which agricultural growth is translated into overall income growth. Income elasticities depend on the stage of development, which implies that, in the long run, as development occurs and income elasticities of demand for food decline, then the less-developed and more-developed countries will increasingly compete for world markets. The degree to which agricultural growth is translated into overall income growth depends on the growth paths that countries choose (e.g., heavy reliance on industrial exports, cash crop exports, oil and primary product exports, food production increases through technical change, or some other path). Furthermore, those countries that follow a path of increasing food production through technical change may, with the help of public policies, translate that growth in food production into broad-based, employment-generating growth or perhaps into narrower capital-intensive industrial growth.

2.3 IMPLICATIONS FOR AGRICULTURAL RESEARCH

Considering agricultural research in the context of international policy leads to a substantial broadening of the research agenda from what it is conventionally taken to be. This section draws the implications from the two previous sections for this broadened agenda.

1. The development of more flexible agricultural sectors should receive priority in research programs. Not only do resources need to flow in and out of agriculture as international monetary conditions change, but they also need to shift on the margin back and forth between the tradable and nontradable sectors. An important corollary is that more efficient adjustment policies and programs need to be

designed for agriculture.

2. Assessments of competitive advantages must take into account configurations of monetary and fiscal policy on the international scene.
3. Strategies are needed for dealing with long swings (five to seven years) in real exchange rates which mask underlying comparative advantage.
4. Because of the decentralization of economic policymaking and implementation, decision making about agricultural research also needs to be decentralized. It also needs to reflect local resource endowments and to give more attention to local resource problems. An important corollary is that expanded research efforts in the social sciences are needed to design local institutional arrangements to deal with agricultural poverty.
5. National research systems need to give more attention to identifying the constant changes in the comparative and competitive advantage of agriculture in their country as the basis for sharpening their research priorities. However, their priorities should not reflect a passive acceptance of changing comparative advantage, but rather, should seek to identify potential niches in the emerging pattern for their producers and to commit resources to help them realize their potential advantages.
6. An important related challenge is to identify those cases in which a country's external terms of trade are shifting against it because of technological developments in other parts of the world. If the potential for catching up in the domestic economy can be realized efficiently, resources should be committed to this end. This will help the country deal with its longer-term problems with balance of payments.
7. An international effort is needed to verify the extent of declines in national postgraduate training in the agricultural sciences and agricultural research capacity in the less-developed countries. Programs to arrest this decline and restore growth should be developed.
8. Research is needed that identifies the extent to which international trade patterns are a reflection of existing trade and exchange rate distortions. An important part of establishing national agricultural research priorities is to determine whether national research efforts have a higher social payoff if domestic export sectors are made more competitive or if domestic sectors that compete with imports are made more competitive. More generally, research priorities need to be established in terms of the reality of existing or probable future trade and exchange rate distortions.
9. Social science research that helps reduce existing barriers to trade among both the more- and less-developed countries can lead to significant efficiency gains on the international scene and a more equitable distribution of global income. It can also raise the social rate of return from investments in agricultural research and thus induce a larger flow of resources to this important source of economic

growth.

10. Social science research is needed for a better understanding of international labor markets and for designing policies and institutional arrangements to facilitate the transfer of labor out of agriculture as economic development proceeds. This will help to realize the full benefits of agricultural research and thus raise the social rate of returns to investments in such research.
11. The research agenda to deal with environmental and sustainability problems is growing rapidly. Because of the long lags involved, more resources need to be committed to assessing and dealing with the potential problems of global warming. Of particular importance are studies that assess the regional impact of global warming around the world. To date, such studies have focused primarily on the United States. On deforestation and sustainability issues, the highest priority should go to evaluating existing policies that motivate such counterproductive activities and to designing policies and institutional arrangements that lead to more socially rational behavior.
12. Careful assessments are needed of the extent to which agricultural modernization leads to more general economic growth by means of the production and dissemination of new productive technologies, as well as the extent to which the benefits of economic development that this generates rebound to the benefit of low-income groups. Such research should help justify expenditures on agricultural research by both national governments and the international community.
13. Research is also needed to better understand how such broad-based economic growth translates into import demand and the structure of international trade.
14. Social science research needs to receive much higher priority on both the national and international scene. This research is needed to guide domestic economic policy in directions that minimize distortions to underlying comparative advantage, to understand policies in other countries that affect comparative and competitive advantages, and to assist in establishing research priorities domestically. It is also needed to better understand the linkages between economic policies and science and technology policies.

2.4 CONCLUDING COMMENT

The days are gone when highly segmented national economies could develop agricultural research agendas in isolation of the rest of the world and without taking into consideration the effects of domestic and international economic policies. The research agenda that results from the consideration of international policies and the changing structure of the international economy is far more complex than the agenda from the more segmented world, as is the problem of establishing research priorities. Moreover, an important part of the broadened agenda is the need for a stronger social science research agenda and a more sensitive interaction between the social sciences on one side and the biological, natural, and physical sciences on the other.