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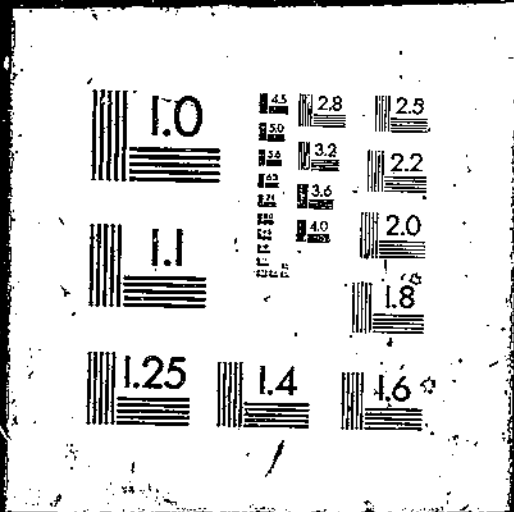
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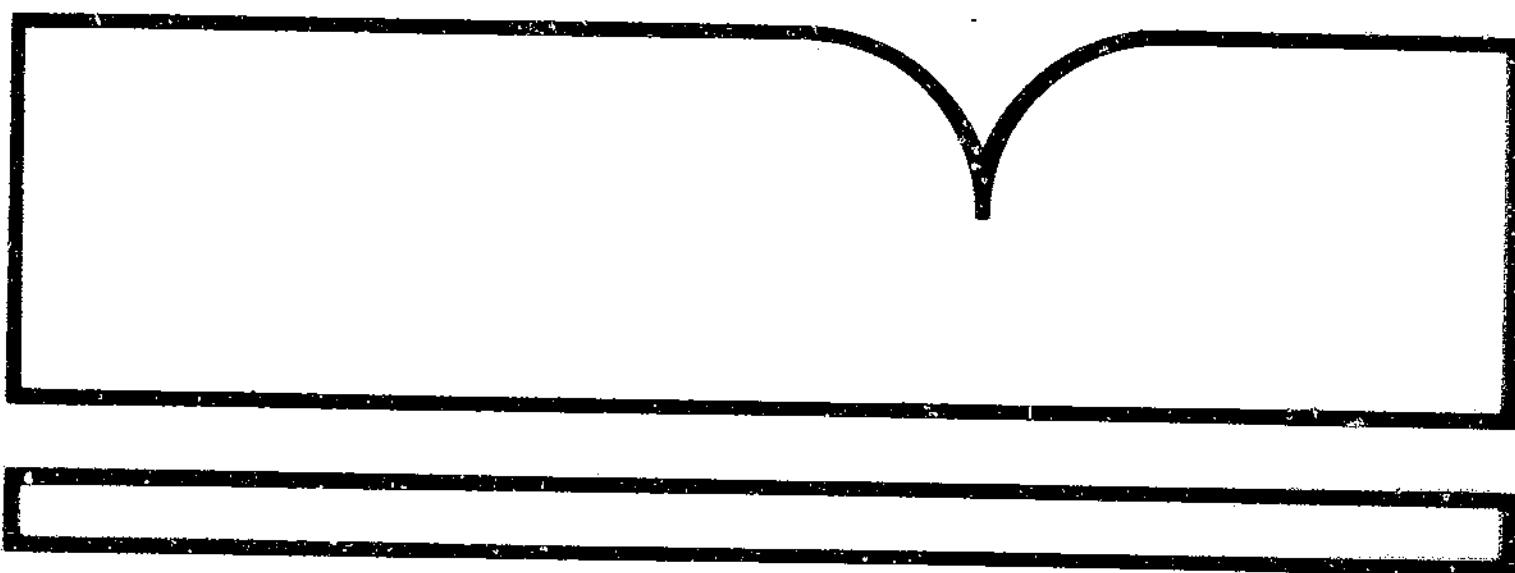


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Foreign Aid's Effect on U.S. Farm Exports. Benefits or Penalties

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Foreign Aid's Effect on U.S. Farm Exports

Benefits or Penalties?

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Foreign Aid's Effect on U.S. Farm Exports: Benefits or Penalties? By Alain de Janvry, Elisabeth Sadoulet, and T. Kelley White. Agriculture and Trade Analysis Division, Economic Research Service, U.S. Department of Agriculture. Foreign Agricultural Economic Report No. 238.

Abstract

Policymakers and economists are debating whether technical assistance to agriculture in developing countries helps or hurts U.S. farm exports. Using several analytical approaches, the authors investigate the more general question of what conditions are necessary to achieve complementarity between aid to agriculture in a developing country and that country's farm imports. Results indicate that both outcomes claimed in the debate are possible but that neither is inevitable. The report identifies conditions that increase aid-trade complementarity and concludes with implications for formulating and implementing development policy.

Keywords: Aid-trade, development, technical assistance, export market, agricultural trade

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List of Abbreviations

AID	Agency for International Development
CGIAR	Consultative Group on International Agricultural Research
EC	European Community
FAIR	Foreign Agricultural Investment Reform bill
GDP	gross domestic product
GNP	gross national product
kg	kilograms
LDC's	less developed countries
MDC's	more developed countries
mt	metric tons
NIC's	newly industrialized countries

Conversions

1 metric ton = 2,204 pounds
1 kilogram = 2.2 pounds

Summary

Policymakers and economists are debating whether technical assistance to agriculture in developing countries helps or hurts U.S. farm exports. Using several analytical approaches, the authors investigate the more general question of what conditions are necessary to achieve complementarity between aid to agriculture in a developing country and that country's farm imports. Results indicate that both outcomes claimed in the debate are possible but that neither is inevitable. The report identifies conditions that increase aid-trade complementarity and discusses implications for formulating and implementing development policy.

Results show that the kind of development project and the characteristics of the recipient country determine whether agricultural aid to developing countries is more likely to result in expanded U.S. markets or greater competition for U.S. farm commodities. Foreign aid is more likely to generate greater demand for U.S. farm products when:

- o aid helps boost the recipient country's productivity;
- o productivity increases over a short period;
- o aid projects concentrate on commodities or industrial products that do not compete directly with those imported by the recipient country; and
- o higher incomes in the recipient country's agricultural sector, generated by productivity rises, accrue to low-income people.

The report uses several analytical approaches to investigate foreign aid's effects on U.S. farmers. The authors review historical evidence, present case studies of Taiwan and South Korea, use econometric analysis to identify conditions promoting harmony between aid and trade, and use a simulation model to evaluate alternative aid policies to developing countries at different stages of development.

Agricultural aid is more likely to create demand for farm imports when it is combined with general development aid that promotes balanced economic growth. The study assumes that aid boosts growth in agricultural productivity and income. Higher agricultural incomes have a ripple effect, causing the general economy of a recipient country to grow rapidly, resulting in increased demand for farm imports. The ripple effect, however, depends on balanced development in all sectors, strong links between sectors, and government policy that refrains from interfering with these links.

Results also indicate that, while aid is most likely to compete with food imports in the short run, it increases import demand in the long run. This finding is the source of much of the debate over whether foreign aid is good or bad for U.S. farmers.

Findings show that aid to the newly industrialized countries produces almost immediate increases in import demand. Aid to the lowest income countries produces the largest increases in import demand in the long run, but reduces import demand in the short run. Help to low-, but not lowest, income countries produces the largest longrun economic growth, but farm imports are reduced for so long that U.S. farmers are likely to consider such aid not in their best interest.

Foreign Aid's Effect on U.S. Farm Exports

Benefits or Penalties?

Alain de Janvry
Elisabeth Sadoulet
T. Kelley White

Introduction

Does agricultural technical assistance to developing countries generate more demand or intensify competition for U.S. agricultural exports? This report takes a close look at this important question, using several analytical approaches.

The report reviews historical evidence, presents case studies of Taiwan and South Korea, and uses econometric analysis to identify what conditions lead to harmony between aid and trade. Then it uses a simulation model to evaluate alternative aid policies for less developed countries (LDC's) at different stages of development. Results indicate that opportunities exist to design aid programs that meet the objectives of those interested in stimulating demand for U.S. agricultural exports and those interested in development.

The Problem Posed

Whether U.S. efforts to promote agricultural development in LDC's benefits or hurts U.S. farm exports is an issue that generates widely differing views among policymakers and economists. Economists at the Economic Research Service of the U.S. Department of Agriculture (USDA) and the World Bank, analysts at the International Food Policy Research Institute, and academics at major American universities have argued on the side of benefits [18, 7, 12, 14, 23, 21, 9, 2].¹ They defend this position with these points:

¹Underlined numbers in brackets refer to items listed in References at the end of this report.

- o International assistance to agriculture in LDC's has been key in making new technologies available and in financing the development of complementary infrastructure, especially irrigation. While the overall record of aid has been, at best, mixed [20], one of the most successful foreign aid organizations has been the Consultative Group on International Agricultural Research (CGIAR) and its network of international agricultural research centers. The centers have made possible the spread of the Green Revolution to agriculture in LDC's. Food crop production has thus increased despite tight limits on expansion of cultivated land.
- o Successful agricultural development is essential for sustained economic growth. The main reasons are that most LDC's do not export lucrative alternative commodities, such as oil, or are not competitive in the international market for industrial products. And, the LDC's prospects for growth from new industrial exports are limited in the short run by slow import demand growth and protectionism among the more developed countries (MDC's) of the global marketplace. Thus, agriculture is uniquely able to promote overall economic growth through lowering the price of wage goods (basic consumer goods, such as cereals, on which low-income wage earners spend a large proportion of their income) and raw materials for industry; creating foreign exchange savings or earnings; transferring financial surplus; and expanding domestic markets.
- o Economic growth raises incomes, leading to increased demand for food and feed. This trend holds for low-income earners whose income elasticity of food demand is high and for medium-income earners who are making the switch from consuming food grains to consuming grain-fed animal products.
- o Developing countries, in their early and middle phases of industrialization, tend to quickly become dependent on food and feed imports as rising incomes create greater demand than domestic producers can supply, as John Mellor shows [16]. Declining self-sufficiency in food and feed grains is thus a symptom of economic success, not failure. In the MDC's, by contrast, Engel's Law implies that, on the demand side, there is saturation of demand for food while, on the supply side, agriculture (which is usually stimulated by rising protectionism) is able to catch up with domestic demand and foster greater self-sufficiency. Thus, LDC's are export markets with the greatest potential for rapid expansion. Coarse grains from abroad are especially sought after in LDC's in which self-sufficiency has fallen fast. Although the LDC's were net exporters of coarse grains until 1976, their self-sufficiency ratio has fallen at an average annual rate of 1.5 percent since then to under 85 percent in 1987. Demand for imported wheat is strong in the tropical countries where urbanization and changing consumption habits cannot be met by domestic supply for ecological reasons.

- o The United States can capture an important share of the demand for farm products originating in the LDC's. This prospect particularly applies to coarse grains, the most rapidly expanding market in which the U.S. share has increased steadily since 1960 and in which competition from the European Community (EC) is weak. Although the U.S. share of LDC import demand depends highly on unstable financial variables, it is also backed by market power and a strong financing capacity that give it comparative advantages among exporters of farm products.
- o Farm exports are key to both the U.S. economy and the well-being of the farm population. Farm exports historically have accounted for a significant share of the U.S. balance of trade. When U.S. farm exports drop, export revenues fall and budget deficits, swelled by higher farm subsidies, tend to rise. Demand for farm exports determines the prosperity of the U.S. farm sector. Exports represent a large share of the food and feed grains produced in the United States.

Those who have argued that aiding LDC's in production of commodities exported by the United States hurts U.S. farm export interests and should consequently be stopped include representatives of commodity-based farm lobbies such as the American Soybean Association, the Rice Millers Association, the American Association of Meat Processors, the American Sugar Beet Growers Association, the National Association of Wheat Growers, the National Cattlemen's Association, and the National Grain Sorghum Producers Association. The American Farm Bureau Federation, the National Association of State Departments of Agriculture, and the Women Involved in Farm Economics have voiced similar concerns. The platforms of some senators and representatives from farm States have opposed agricultural assistance to developing countries that compete with U.S. farm exports [10].²

Congress introduced several bills and amendments in the mid-1980's that would restrict U.S. bilateral assistance to LDC's for promoting crops that compete with U.S. farm exports. The Foreign Agricultural Investment Reform (FAIR) bill introduced in 1986 would have extended restrictions to multilateral development banks supported by the United States. Thus far, the Bumpers amendment to the Urgent Supplemental Appropriations Act of 1986 is the only law to have been enacted that restricts assistance to agriculture in LDC's that compete with U.S. farming.

It states that:

None of the funds appropriated by this or any other Act to carry out chapter 1 of part I of the Foreign

²See [10] for examples of statements from lobbies and politicians holding this view.

Assistance Act of 1961 shall be available for any testing or breeding feasibility study, variety improvement or introduction, consultancy, publication, conference, or training in connection with the growth or production in a foreign country of an agricultural commodity for export which would compete with a similar commodity grown or produced in the United States: Provided, That this section shall not prohibit (1) activities designed to increase food security in developing countries where such activities will not have a significant impact on the export of agricultural commodities of the United States; or (2) research activities intended primarily to benefit American producers [19].

The U.S. Agency for International Development (AID) reacted to concerns that its programs increase competition for U.S. farm exports through two policy statements: Policy Determination 71, issued in 1978, which limits projects involving sugar, palm oil, and citrus for export to those cases in which there is a strong development rationale and where the likely impact on U.S. production is low; and Policy Determination 15. Policy Determination 15, issued in 1986 in response to the Bumpers amendment, establishes the general policy of avoiding support projects that would result in increasing LDC exports that would directly and significantly compete with U.S. exports to developing countries.

Arguments contending that aid and trade conflict are often based on a single-commodity perspective. Brazilian soybean exports and Malaysian palm oil exports do compete with U.S. soybean exports. But interest groups pointing to conflict overlook the possibilities that U.S. farmers reallocate resources among export crops. Those who see conflict between trade and aid also take a static view of world agricultural markets in which global demand is fixed, whereby higher production or exports must be at the expense of U.S. exports. Both views ignore the dynamics of development and trade that lead to growth in global demand. For instance, in Malaysia, rising incomes and stronger demand for higher protein foods, such as meat and poultry products, have expanded its livestock sector to where it accounts for 13 percent of national agricultural output. Malaysia must import virtually all of its livestock feed, such as corn and soybean meal, because the land and climate cannot support the needed production [24].

Conflict between aid and trade has also been argued on the ground that any breakdown in the logical sequence that advocates of harmony use to make their case will hurt U.S. trade interests. This sequence is, indeed, long and precarious, and there are four critical links where it may fail:

1. The growth of agricultural output may not have strong multiplier effects on the rest of the economy, leading to increased food/feed self-sufficiency instead of rising imports. This situation can result from intersectoral breakdowns, breakdowns in linkage between major sectors of a

country's economy. An example is India, in which the Green Revolution failed to significantly energize the overall economy because of Government inefficiencies (particularly the public energy and transportation monopolies), heavy licensing constraints, bureaucratic bottlenecks, and high capital/output ratios. Alternatively, the breakdown in income multiplier effect can be caused by a debt crisis, as in Latin America, when the debt crises led to investable funds that were generated by growth in agricultural productivity being exported as debt service instead of being invested in industry. Finally, it may simply be the case that productivity growth confined to agricultural products that compete with imports may not produce income multiplier effects sufficiently strong to raise import demand for the same commodities.

2. Growth of agricultural output may have strong multiplier effects on the rest of the economy but the increase in incomes still fails to stimulate rising food/feed imports, in contrast to the preceding case. A scenario of this sort can result, as in China, from controls on food imports while government gives priority to importing capital goods and intermediate products for industry. Alternatively, this situation can result from a regressive distribution of the income gains from agricultural growth, leading to rising imports of luxury manufactured consumer goods instead of food.
3. The United States need not capture all the increased demand for farm imports generated by the LDC's. Instead, increased demand may benefit a few LDC exporters who have had to devalue their currencies sharply, relative to the U.S. dollar, as they face up to debt obligations. Alternatively, the EC's extensive export subsidies may undercut the competitiveness of U.S. exports. For that reason, U.S. farm export interests may view bilateral trade agreements as more effective than promoting higher income in the LDC's.
4. Although the chain of events predicted by the advocates of aid/trade harmony may occur, there will be a lag between rising agricultural output and rising import demand. If this lag is long, shortrun losses may outweigh gains, particularly if credit is not available to finance these losses or if discount rates are high.

This report shows that the positions of both advocates of harmony between aid and trade and advocates of incompatibility are correct but excessive. The role aid plays in promoting growth in agricultural productivity among LDC's (including products that compete with U.S. farm exports if need be) is essential to economic growth of most developing countries. Moreover, it is vital to expanding export demand for U.S. food and feed products.

At the same time, the strategy of aiding foreign agriculture to help U.S. agriculture is a risky strategy that can fail for a number of reasons the skeptics mention. Simple-minded advocacy

of harmony is unrealistic. Yet, the strategy of using aid to promote trade is probably the only meaningful path to alleviating the crisis of U.S. agriculture, short of massively divesting farm sector resources. We thus identify specific policies that can be used to improve the chances of harmony between aid and trade. If these policies are properly carried out, a strong case can be made for managing the delicate balance between aid and trade.

We use several types of analysis to identify the conditions under which technical aid to agriculture in developing countries can lead to rising farm imports. We first review historical evidence to show under what conditions and in what countries a successful association among agricultural growth, overall economic growth, and rising import demand for food/feed has been observed. We then present and analyze two success stories. Econometric analysis is used to detect what conditions promote harmony between agricultural growth and rising import demand. Finally, results of a simulation analyzing a group of diverse LDC's show that the effects of alternative foreign aid strategies on demand for agricultural imports differ with the country's stage of development.

Historical Analysis

An analysis of the performance of 42 LDC's between 1965 and 1981 reveals that cereal import demand has grown exceptionally fast, at an average annual rate of 6.8 percent (table 1).³ The total volume of wheat, rice, and coarse grains imports increased from 22 million metric tons (mt) in 1965-66 to 58 million mt in 1980-81. Imports, on a per capita basis, were 21 kilograms (kg) of food grains (wheat and rice) and 12 kg of coarse grains in 1980-81.

Several patterns emerged:

- o Most of the import demand originates in only a few fast-growing middle-income countries. They are all either newly industrialized countries (NIC's) or oil exporters. In 1980-81, Brazil, Egypt, Indonesia, and South Korea accounted for 49 percent of all imports of wheat and rice in the 42 countries analyzed. Mexico and Korea together imported 51 percent of all coarse grains.
- o The fastest growth in import demand has been in coarse grains rather than food grains. Wheat and rice imports grew

³The 1965-81 period is one in which LDC's had sustained economic growth accompanied by rapid growth in agricultural trade. It ends in 1981-82 with the debt crisis and downturns in international commodity prices. The subsequent period is one that has significantly different structural features deserving a separate analysis.

Table 1--Annual growth rates of cereal imports in developing countries, 1965-81

Item	Popula- tion, 1980/81	Net imports						Annual growth rates, 1965-81				
		Wheat and rice			Coarse grains			Agricul- tural value added	Gross national product	Net imports		
		Total		Per capita, 1980-81	Total		Per capita, 1980-81			Wheat/ rice	Coarse grains	Cereals
		1965-66	1980-81		1965-66	1980-81	1980-81					
Millions	Million metric tons	Million Kilograms	Million metric tons	Million Kilograms		Percent						
All 42 countries studied	1,730.5	22.0	37.0	21	0.01	21.3	12	3.1	5.7	3.7	1/ 30.2	6.8
Region:												
Asia	1,129.2	13.6	9.8	9	1.3	4.2	4	3.1	5.4	-2.2	12.4	0
Latin America	302.2	4.0	10.6	35	-1.9	13.0	43	4.1	6.3	6.2	2/ 26.1	16.4
Middle East and North Africa	102.6	3.2	11.9	116	.7	3.7	35	3.5	6.4	10.0	13.2	10.7
Sub-Saharan Africa	196.3	1.2	4.8	24	0	.4	2	1.3	4.4	9.7	--	10.4
Income/capita level: 3/ Below \$500 (except India)	468.5	5.1	11.2	24	0	1.1	2	3.0	5.7	6.1	--	6.6
India	692.5	8.7	-.1	0	1.1	0	0	3.1	3.7	4/-12.1	4/-15.3	4/-11.9
\$500-\$1,000	184.6	2.3	6.0	33	-.6	1.2	6	1.8	5.3	7.0	14.2	8.2
\$1,000-\$1,500	258.4	4.1	13.5	52	5/ .1	5/ 5.3	5/ 39	3.6	6.7	7.6	5/ 25.7	10.9
Brazil	123.4	--	--	--	.7	1.6	13	--	--	--	--	--
Above \$1,500	126.5	1.9	6.4	51	-.4	12.1	95	3.9	6.0	8.6	6/ 21.7	19.1

-- = Not significantly different from 0.

1/ 1970-81.

2/ 1972-81.

3/ Mean income per capita over 1965-81 in 1980 U.S. dollars. Income groups include: (1) below \$500: Bangladesh, Egypt, Ethiopia, India, Indonesia, Mauritania, Niger, Pakistan, Sierra Leone, Sri Lanka, Sudan, Tanzania, and Togo; (2) \$500-\$1,000: Bolivia, Cameroon, Dominican Republic, Honduras, Liberia, Morocco, Nigeria, Paraguay, Philippines, and Senegal; (3) \$1,500: Brazil, Colombia, Ecuador, Ghana, Ivory Coast, Jamaica, South Korea, Nicaragua, Panama, Peru, Syria, and Tunisia; and (4) above \$1,500: Algeria, Chile, Costa Rica, Israel, Mexico, Singapore, and Venezuela.

4/ 1965-77.

5/ Brazil omitted.

6/ 1969-81.

at an annual rate of 3.7 percent. LDC's were net exporters of coarse grains until 1969. Between 1970 and 1981, however, import demand for coarse grains in LDC's grew at the rate of 30.2 percent a year.

- o Latin America had the fastest growth in import demand (16.4 percent), although it was also the region in which the growth rate in agricultural value added was the highest (4.1 percent). Latin America's per capita net imports of coarse grains were the highest of all regions we examined (43 kg). Asia's total imports stagnated because of the dominance of India, which changed during that period from a large importer to a net exporter. South Korea and Indonesia have, however, rapidly increased their imports of wheat and rice. In the Middle East and North Africa, wheat and rice imports grew the fastest (10 percent annually) and per capita imports of wheat and rice were the highest (110 kg). Algeria, Egypt, and Morocco together accounted for 28 percent of all wheat and rice imports by LDC's. Sub-Saharan Africa's coarse grains imports were minimal, but its wheat and rice imports grew quickly (9.7 percent a year). Nigeria dominated that region's imports, accounting for 46 percent of the area's wheat and rice imports.
- o Import demand for cereals grew quickly in the higher per capita income countries (10.9 percent in countries with per capita levels ranging from \$1,000 to \$1,500; 19.1 percent in countries with per capita income over \$1,500), although these countries are also the ones in which growth in agricultural value added has been the highest (3.6 and 3.9 percent, respectively). Coarse cereal imports have grown spectacularly since these countries as a group became net importers. They reached an annual average of 25.7 percent in countries having per capita income ranging from \$1,000 to \$1,500 (Brazil excluded) and 21.7 percent in countries with per capita income over \$1,500. By contrast, there was very little demand for import of coarse grains in the poor countries, those with per capita incomes below \$500.

The key issue in the aid-trade controversy is to associate import demand with economic and agricultural growth. Tables 2-5 explore this association. They present a two-way classification of 41 LDC's based on the observed growth rates in per capita agricultural production and per capita gross domestic product (GDP) between 1965 and 1981. We grouped countries according to growth in per capita agricultural production into two groups: those with negative growth and those with positive growth. On the basis of per capita GDP growth, we classified countries as having annual growth rates above or below 2 percent. Growth rates were calculated for a 16-year span and thus characterize longrun patterns.

The first observation is that countries with strong agricultural growth performance tend also to be ones with strong overall economic growth performance; those with weak agricultural performance tend to have weak overall economic performance.

Table 2--Characteristics of countries with annual growth of gross domestic product per capita less than 2 percent and annual growth of agricultural output per capita less than zero, 1965-81

Item	Low-income, low-agricultural-growth countries <u>1/</u>	
Characteristic: <u>2/</u>	<u>Level</u>	
N	12	
Pop	170.5	
Ag	-.9	
NAg	1.1	
NAgX	3.1	
Aid	27	
	<u>Mean</u>	<u>Percentage growth</u>
WRM	4,044	3.8
CCM	1,244	26.9
CeM	5,288	6.9

1/ Ethiopia, Ghana, Mauritania, Niger, Tanzania, Togo, Senegal, Honduras, Jamaica, Peru, Venezuela, and Bangladesh.

2/ Number of countries (N); total population in millions (Pop); annual growth rate of per capita real agricultural value added (Ag), nonagricultural value added (NAg), and nonagricultural exports (NAgX); share of aid in total imports of cereals in 1976-78 (Aid); net imports of wheat and rice (WRM), of coarse grain (CCM), and of grains (CeM) in thousands of wheat equivalent metric tons (mt).

Although this positive relationship does not establish causality, studies of annual time series data show that there is a significant 1- or 2-year lag between the upturn in agricultural performance and the upturn in manufacturing performance in most countries, confirming agriculture's key role in spurring economic development [6].

The second observation is that countries with both strong growth in agriculture and gross domestic product (GDP) have the highest annual growth rate in cereal imports (15.9 percent). This pattern is particularly strong for coarse grains after these countries became net importers in 1972 (28.7 percent). Yet, this is not the case if the growth in GDP did not sufficiently exceed growth in agriculture, such as when GDP growth is less than 2 percentage points above that of agricultural growth (tables 2-5). This observation indicates that agriculture may be a necessary source of growth for most economies of LDC's, but successful agricultural growth is not, per se, sufficient to ensure growth in import demand. Agricultural growth has to be complemented by strong growth in nonagricultural value added and/or in nonagricultural exports to increase demand for foreign farm commodities.

Table 3--Characteristics of countries with annual growth of gross domestic product greater than 2 percent and annual growth of agricultural output per capita less than zero, 1965-81

Item	High-income, low-agricultural-growth countries <u>1/</u>	
Characteristic: <u>2/</u>	<u>Level</u>	
N	4	
Pop	87.9	
Ag	-2.2	
NAg	4.1	
NAgX	11.6	
Aid	4	
	<u>Mean</u>	<u>Percentage growth</u>
WRM	2,067	12.9
CCM	139	Not significant
CeM	2,207	14.0

1/ Morocco, Ivory Coast, Nigeria, and Panama.

2/ Number of countries (N); total population in millions (Pop); annual growth rate of per capita real agricultural value added (Ag), nonagricultural value added (NAg), and nonagricultural exports (NAgX); share of aid in total imports of cereals in 1976-78 (Aid); net imports of wheat and rice (WRM), of coarse grain (CCM), and of grains (CeM) in thousands of wheat equivalent metric tons (mt).

The countries with high agricultural and GDP growth and higher GDP than agricultural growth absorb the bulk of cereal exports, and their share is rapidly rising. Growth in feed grains is particularly high in these same countries, reflecting a shift toward greater animal products consumption. The share of cereal imports that food aid constitutes is relatively low (12 percent), showing that these countries do create growing commercial markets while food aid is phased out. These countries include some of the most successful NIC's and/or oil exporters such as South Korea, Singapore, Indonesia, Mexico, and Brazil. While they constitute only 24 percent of the population of the 41 LDC's analyzed, they account for 47 percent of the LDC group's total cereal imports. Using agricultural development aid to extend this successful growth experience to as many other LDC's as possible is one way to reconcile aid and trade.

Two Case Studies: Taiwan and South Korea

Taiwan and South Korea are two of the fastest growing sources of demand for coarse grain imports in the developing world despite their highly successful histories of agricultural development.

Table 4--Characteristics of countries with annual growth of gross domestic product less than 2 percent and annual growth of agricultural output per capita greater than zero, 1965-81

Item	Low-income, high-agricultural-growth countries excluding India 1/		India	
Characteristic: 2/	Level		Level	
N	6		1	
Pop	36.4		593	
Ag	.3		.5	
NAg	.7		2.1	
NAgX	-1.2		4.9	
Aid	15			
	Mean	Percentage growth	Mean	Percentage growth 3/
WRM	1,243	5.0	3,782	-12.1
CCM	93	Not significant	509	Not significant
CeM	1,336	5.2	4,291	-11.9

1/ Liberia, Sierra Leone, Sudan, Bolivia, Chile, and Nicaragua.

2/ Number of countries (N); total population in millions (Pop); annual growth rate of per capita real agricultural value added (Ag), nonagricultural value added (NAg), and nonagricultural exports (NAgX); share of aid in total imports of cereals in 1976-78 (Aid); net imports of wheat and rice (WRM), of coarse grain (CCM), and of grains (CeM) in thousands of wheat equivalent metric tons (mt).

3/ For 1965-77; net exports after 1977.

It is, consequently, interesting to analyze the particular sequences of intersectoral growth in their economies that led them to their present status.

It is well known that agriculture played a key role in supporting the early phases of industrial development in both countries. Before World War I, increases in agricultural output were about the only sources available to finance investments outside agriculture. Johnston and Kilby [11] report that net capital outflow from agriculture represented more than 30 percent of the total value of agricultural production in 1911-15 and 21 percent in 1931-35. Net real outflow was principally in the form of payment of land rents, interests, taxes, and net negative transfers through financial institutions. After World War II, both countries underwent extensive land reforms and invested heavily in education. They also continued to promote the diffusion of land-saving technology, fertilizers in particular. Although development priorities shifted toward industry, both countries continued to stress agriculture in seeking self-sufficiency in rice.

After 1961, the import performance of the two countries in food and feed responded to markedly different determinants. South

Table 5--Characteristics of countries with annual growth of gross domestic product greater than 2 percent and annual growth of agricultural output greater than zero, 1965-81

Item	Countries with difference between annual growth rate in per capita income and per capita agricultural production > 2 1/		Countries with difference between annual growth rate in per capita income and per capita agricultural production < 2 2/	
	Level	Level	Level	Level
Characteristic: 3/				
N	10		8	
Pop	400.1		97.7	
Ag	1.6		2.0	
NAg	5.7		3.5	
NAgX	12.6		5.4	
Aid	12		17	
	<u>Mean</u>	<u>Percentage growth</u>	<u>Mean</u>	<u>Percentage growth</u>
WRM	12,586	9.4	3,222	0.8
CCM	3,171	4/ 28.7	1,386	8.4
CeM	15,757	15.9	4,608	3.0

1/ Algeria, Egypt, Syria, Brazil, Dominican Republic, Ecuador, Mexico, Indonesia, South Korea, and Singapore.

2/ Israel, Tunisia, Cameroon, Colombia, Costa Rica, Paraguay, Philippines, and Sri Lanka.

3/ Number of countries (N); total population in millions (Pop); annual growth rate of per capita real agricultural value added (Ag), nonagricultural value added (NAg), and nonagricultural exports (NAgX); share of aid in total imports of cereals in 1976-78 (Aid); net imports of wheat and rice (WRM), of coarse grain (CCM), and of grains (CeM) in thousands of wheat equivalent metric tons (mt).

4/ For 1972-81; net exports prior to 1972.

Korea's Second Five-Year Plan (1967-71) placed heavy stress on industry, allowing an increasingly unbalanced sectoral growth to develop. The strategy South Korea followed was to finance development projects by increasing the export of labor-intensive manufactured goods rather than by taxing the agricultural sector. Agricultural investment remained at a low level, and agricultural productivity failed to improve. The policy of "unbalanced growth" produced a spectacular growth rate in the nonagricultural sectors of about 10 percent a year between 1962 and 1971. However, the relative neglect of agriculture led to rising commercial food imports, because food aid had already been phased out [8].

Serious political pressures were building up as income disparity between the rural and urban sectors worsened. This situation led the country to revise its Third Five-Year Plan (1972-76) and to put more priority on agriculture, especially production of the two staples rice and barley. The Government, to reduce imports,

had instituted in the late 1960's a high-price policy for rice and a two-price system for barley. The price incentives, the release of Green Revolution-inspired, high-yielding rice varieties, and the founding of the New Village Movement (an attempt to close the rural-urban income gap with self-help rural modernization programs) combined to sharply reduce food grain imports. This production performance was, however, not sustained after 1976; production of rice declined and imports increased again.

Table 6 shows a striking pattern, one in which South Korea's growth performance in food grains and coarse grains determines imports. Imports grow when agriculture stagnates and fall when agriculture grows. Sharply rising incomes associated with successful export-oriented industrialization shifted consumption patterns away from food grains and toward animal products, accelerating the demand for coarse grains and their import as the livestock sector expanded to meet that demand. We thus conclude

Table 6--South Korea and Taiwan: Growth and import demand, 1961-84

	South Korea			Taiwan		
	1961- 1968	1969- 1977	1978- 1984	1961- 1968	1969- 1977	1978- 1984
	<u>Percent</u>					
Economic growth:						
GDP	5.0*	7.0*	3.1*	8.2*	7.7*	0.9
Agricultural						
GDP	1.6	2.8*	1.3	4.4*	2.4*	-5.6*
Nonagricultural						
GDP	7.3*	8.6*	3.5*	9.4*	8.6*	1.5
Agricultural production:						
Wheat and rice	-1.7	2.2*	-3.2*	2.0	-1.0	-1.3*
Coarse grains	4.6	-5.9*	-13.0*	8.9	7.3*	3.0
Oilseeds	1.6	2.0	-7.0*	2.6	-5.0*	-7.8*
Consumption:						
Wheat and rice	-.2	-.1	-1.2	-1.0*	-1.1	-2.3*
Coarse grains	2.9	4.6*	6.0*	22.3*	16.0*	7.4*
Oilseeds	2.4*	4.5	7.8*	7.2*	1.6	3.1
Net imports:						
Wheat and rice	11.6	-6.0*	2.0	-33.0	-1.2	-13.0
Coarse grains	-27.5	23.4*	8.4*	42.4*	16.7*	6.2*
Oilseeds	17.7	15.4*	14.7*	13.5	3.4*	4.2*
Total	7.0	1.3	7.1	3.0	8.9*	5.2*

Asterisks () indicate $t > 1.9$. The threshold of significance is at the 95-percent confidence level.

that agriculture played a key role in the early stages of South Korean economic development. Once the economy had secured nonagricultural sources of growth and of foreign exchange earnings, import demand started to vary countercyclically with domestic production, and a conflict between aid and trade in food grains developed. Growth in livestock production, however, is the arena in which aid and trade can be reconciled.

Taiwan shows a pattern of agricultural imports in which demand is determined positively by rising incomes that are partly stimulated by growth in agricultural productivity. This pattern contrasts with the South Korean pattern, in which high production decreases demand for agricultural imports. Thus, while Taiwan's production of food grains fell, its consumption of food grains--which had reached saturation before the 1960's--also fell, and imports declined sharply. By contrast, Taiwan's production of coarse grains increased steadily, but a rapidly rising demand also increased import demand.

Thus, we see that Taiwanese agriculture not only played a key role in the early stages of economic development, but its performance remained closely associated with the performance of the total economy. This continuing close association between agriculture and the total economy is a consequence of a model in which sectors grow at similar rates, has strong links between agriculture and industry, and has a highly decentralized manufacturing sector. As in South Korea, evidence indicates that growth in the Taiwanese livestock sector is a key area in which aid and trade can be harmonious.

Cross-Country Analysis of Production, Consumption, and Imports

We now turn to the estimation of an econometric model of import demand for food and feed grains that ties the growth performance of agriculture to income effects, consumption of food and feed, and import demand for these. The question asked is: Under what conditions will an increase in agricultural output lead, through the mediation of income effects, to an increase in import demand? The data we use are average annual growth rates over the period 1965-81 for 46 LDC's for which a complete data set exists. By using growth rates cross-sectionally, the estimated model captures longrun effects across countries having diverse production arrangements and varying average farm sizes.

Income Equation

The endogenous variable is the average annual growth rate of GDP per capita (\dot{Y}). Variables with dots indicate rate changes. Explanatory variables introduced in the equation that are significant are:

\dot{A}_g : The average annual growth rate of agricultural value added per capita.

\dot{NagX} : The average annual growth rate of nonagricultural exports. This variable is specified with a variable elasticity which is a function of the average share of nonagricultural exports in total exports (X), $NagX/X$.

$\dot{D\grave{e}bt}$: The average annual growth rate of debt service per capita.

$\bar{D\grave{e}bt}$: The average level of debt service per capita in thousands of 1980 U.S. dollars over the period.

Variables introduced in the equation that were not significant are:

- o The average annual growth rate of agricultural exports.
- o The average annual rate of inflation.
- o The average annual growth rate of production of cereals and oilseeds.
- o A variable elasticity of \dot{y} with respect to $\dot{A\grave{g}}$.

The estimated equation is:

$$\begin{aligned} \dot{y} = & .011 + .79 \dot{A\grave{g}} + [.20 + .11 \ln(Nag\bar{X}/X)] \dot{NagX} & (1) \\ & (3.7) \quad (8.5) \quad (6.0) (2.5) \\ & + .09 \dot{D\grave{e}bt} - .17 \bar{D\grave{e}bt} \\ & (3.7) \quad (-3.9) \end{aligned}$$

46 observations, adjusted $R^2 = .77$.

Consumption Functions

Because consumption patterns differ regionally, consumption functions for wheat and rice and for coarse cereals are estimated separately for the Middle East and North Africa, Sub-Saharan Africa, Asia, the countries of Latin America whose diets are corn based, and the countries of Latin America whose diets are wheat based. The endogenous variables are:

\dot{cwr} : The average annual growth rate in per capita consumption of wheat and rice.

\dot{ccc} : The average annual growth rate in per capita consumption of coarse cereals.

The exogenous variables are:

\dot{y} : The average annual growth rate in per capita income. A variable income elasticity ($\epsilon_0 + \epsilon_1 \log \bar{y}$) is estimated where \bar{y} is the average income per capita in 1980 dollars over the period.

Debt: The average annual growth rate of debt service per capita.

AgBias: A measure of the agricultural bias in the gross national product (GNP) growth rate. It is measured as the difference in growth rate of per capita agricultural value added and non-agricultural value added. It is used as a proxy for equity in growth.

Upop: The average annual growth rate in urban population.

Other variables which were tried and found not to be statistically significant are:

- o The average level of debt service per capita.
- o Equity variables: The ratio of income per person employed in agriculture relative to nonagriculture and the average annual growth rate in this variable.
- o The growth rates of agricultural value added in agriculture and in nonagriculture, separately.
- o The rate of inflation.

Table 7 presents the results. Whenever b is significantly different from zero, it is negative for wheat and rice (implying a decreasing elasticity with rising income) and positive for coarse cereals (indicating a rising elasticity). We present only the exogenous variables with significant coefficients, except for income.

Middle East and North Africa

Income elasticity is not significant for wheat and rice, most likely because widespread subsidies on food grains (which led to the rapid rise of imports) muted the relationship between income and consumption. It is, however, high for coarse cereals which these countries use as livestock feed. None of the exogenous variables explains differences in consumption across countries.

Sub-Saharan Africa

Income effects are not significant for the consumption of either wheat and rice or coarse cereals. This finding is surprising in the case of wheat because other studies have found a positive income elasticity of demand [5]. It is not surprising in the case of coarse grains, which are mainly consumed as food and not feed. Consumption, however, is affected by structural variables (debt, agricultural bias, and urban population). Wheat is mainly an urban food, and this fact is reflected by the negative

Table 7--Consumption functions for cereals, cross-sectional analysis 1/

Item	Observations	Endogenous variable	\dot{y}	$\dot{y} \log y$	Debt	Agricultural bias	Upop	R ²
	<u>Number</u>							
All countries	43	wr cc	1.56 (-1.56)*	-0.21 .24	0.14	-0.28		0.35 .37
Region:								
Asia	9	wr cc	3.11 1.09	-.42				.65 .55
Latin America:								
Corn-eating section	9	wr cc	.41 -6.65 1.29	.94	-.26 .39	1.28 2.25		.84 .53 .52
Wheat-eating section	6	wr cc	.18 1.5		.25	1.91	-1.7	.92 .98
Middle East and North Africa	6	wr cc	(.19) 2.21					.05 .58
Sub-Saharan Africa	13	wr cc	(3.8) (-.30)		-.15	-1.24	1.2	.77 .64

1/ Except for \dot{y} , only variables with parameters significant at 90 percent were kept in the regressions. *Parentheses indicate that the parameter is not significant at 90 percent.

coefficient attached to a bias in favor of agriculture. Consumption of coarse grains is positively affected by urban population growth and is negatively affected by debt.

Asia

Income strongly influences consumption of wheat/rice and coarse cereals. Income elasticity decreases with income, reaching a value of 1.1 for Bangladesh's per capita income level and 0.17 for South Korea. No structural variables are significant.

Corn-Eating Nations of Latin America

This group of countries having corn-based diets includes Colombia, Costa Rica, Dominican Republic, Ecuador, Honduras, Mexico, Panama, Peru, and Venezuela. Wheat has a constant income elasticity of 0.41. Accumulation of debt during 1965-81, before the debt crisis hit, dramatically dampened the trend of

increasing wheat imports for urban consumption. Countries with a higher debt service per capita were facing constraints in imports and, thus, higher debt service tended to reduce consumption. Income elasticity for coarse grains is increasing, suggesting that corn is used not only as food but as animal feed. The elasticity assumes a value of 1.06 in Venezuela, the country having the highest per capita income of the group.

Wheat-Eating Nations of Latin America

This group of countries having wheat-based diets includes Bolivia, Brazil, Chile, Guyana, Paraguay, and Uruguay. Income elasticity for wheat and rice is low (0.18). Income elasticity for coarse grains is not significant, reflecting the fact that cattle production in all these countries is forage based, and debt service reduces consumption.

How Agricultural Growth Influences Import Demand

We used the income and consumption equations estimated above to predict the level of import demand for wheat/rice and coarse cereals. The complete model is:

Per capita income growth:

$$\dot{Y} = \mu A \dot{g} + \sum_k a_k \dot{z}_k \quad (2)$$

Growth in per capita consumption of cereal i:

$$\dot{c}_i = (\epsilon_{i0} + \epsilon_{i1} \log \bar{Y}) \dot{Y} + \eta_i (A \dot{g} - N A \dot{g}) + \sum_k b_{ik} \dot{z}_k \quad (3)$$

Total imports of cereal i:

$$M_i = (c_i - A g_i) \text{Pop} \quad (4)$$

where

$$D_i = M_i / (c_i \text{Pop}) \quad (5)$$

is the dependency ratio for cereal i and Pop is population.

Relative performance of production of cereal i:

$$\Pi_i = \frac{A g_i \text{Pop}}{A g \text{Pop}} \quad (6)$$

Thus

$$\dot{M}_i = (1/D_i) \dot{c}_i - (1/D_i - 1) A \dot{g}_i + \dot{\text{Pop}}. \quad (7)$$

The growth in import demand of cereal i, induced by growth of agriculture, is:

$$\frac{\delta M_i}{\delta A_i} = \left[\frac{1}{D_i} \right] [\eta_i + (\epsilon_{i0} + \epsilon_{i1} \log \bar{y}) \mu] - \left[\frac{1}{D_i} \right] \Pi_i \quad (8)$$

Results show that there is very little compatibility between agricultural growth and increased demand for imported wheat and rice (table 8). In Sub-Saharan African countries, the incompatibility is due to the negative effect of agriculture's performance, relative to nonagriculture's performance, on the consumption of wheat and rice. In the areas of Latin America having corn-based diets, lack of compatibility comes from the excellent production performance of wheat and rice relative to growth in total agricultural production. And, in Asia, incompatibility comes from good production performance and low dependency ratios.

The opposite is true for coarse cereals. Overall agricultural growth induces a longrun increase in import demand for coarse cereals, except in Africa. Income elasticity is negative and nonsignificant in Africa. In the Middle East, compatibility is due to a high income elasticity. In areas of Latin America having wheat-based diets, compatibility is due to both a high income elasticity and a strong income effect created by strong agricultural performance. In areas of Latin America having corn-based diets, compatibility is due to poor production of coarse cereals and a strong income effect generated by high total agricultural performance despite exceedingly low consumption elasticities. Compatibility is strongest in Asia, particularly in South Korea and Indonesia. There are, however, three Asian countries in which we observed no compatibility: the Philippines, Sri Lanka, and Thailand. Very strong performance in production of coarse cereals and very low levels of dependency on imports are the reasons.

We conclude from this econometric analysis that compatibility between agricultural growth and rising import demand is rarely observed for wheat and rice, basically because higher income induced by agricultural growth does not strongly influence consumption of these food grains. This is not the case with coarse cereals, suggesting that agricultural growth can expand markets for these grains. However, the analysis needs to be refined to take into account specific structural differences in economies. And the important question of magnitude of the time lags between growth in agricultural productivity, rise in incomes, and change in import demand needs to be examined. We cannot accomplish these tasks through econometric analyses of historical data because there are too few observations to estimate the relevant theoretical model, so we turn to constructing archetype, dynamic general equilibrium models that we can use to simulate policy alternatives.

Table 8—Frontier of harmony: Where agricultural growth and demand for commodity imports coexist

Region/country	Growth		Wheat and rice					Coarse cereals				
	Agricul- tural	Popula- tion	Income elasti- city	Depend- ency ratio	Per capita production growth	Relative perform- ance 1/	Harmony 2/	Income elasti- city	Depend- ency ratio	Per capita production growth	Relative perform- ance 1/	Harmony 2/
Percentage increase per year												
Asia:												
Bangladesh	-0.79	2.53	1.01	0.08	-0.52	1.15	-	1.09	0.16	-4.66	-1.22	+
India	.51	2.16	.86	.05	1.84	1.50	-	1.09	.02	-.69	.55	+
Indonesia	2.08	2.02	.67	.09	3.12	1.25	-	1.09	-.03	.68	-.66	+
South Korea	.81	2.02	.17	.26	.59	.92	-	1.09	.46	-4.45	-.86	+
Pakistan	.63	2.65	.82	.01	2.93	1.70	-	1.09	0	-1.72	-.28	+
Philippines	1.69	2.77	.44	.13	1.61	.98	-	1.09	.04	2.74	1.23	-
Singapore	1.30	1.60	-.25	1.00	0	.55	-	1.09	1.00	-4.34	-.95	+
Sri Lanka	.97	1.81	.84	.44	2.73	1.63	-	1.09	.03	1.00	1.01	-
Thailand	2.11	2.62	.48	-.20	-.19	.51	-	1.09	-.52	4.17	1.44	-
Latin America (corn-based diet):												
Colombia	1.98	2.19	-.41	-.20	4.64	1.64	-	-.14	.07	.35	.61	+
Costa Rica	.78	3.16	-.41	.34	3.11	1.59	-	.37	.21	-.96	.56	+
Dominican Republic	1.16	2.93	-.41	.37	2.97	1.44	-	-.23	.44	-.92	.49	+
Ecuador	.38	2.96	-.41	.28	-1.14	.54	-	-.06	.03	-2.89	.02	+
Honduras	-1.64	3.40	-.41	.73	4.84	4.69	-	-.65	-.02	-1.74	.94	-
Mexico	1.24	2.94	-.41	.08	-.26	.64	-	.52	.07	.34	.79	+
Nicaragua	.28	2.75	-.41	.36	1.15	1.29	-	-.11	.04	-2.18	.19	+
Panama	-.22	2.60	-.41	.24	-1.17	.60	-	.21	.15	-4.77	-.91	+
Peru	-1.58	2.72	-.41	.54	-.77	1.71	-	-.09	.13	-2.15	.50	+
Venezuela	-.11	3.83	-.41	.68	4.08	2.13	-	1.06	.43	-1.01	.76	+
Latin America (wheat-based diet):												
Bolivia	1.30	2.41	.18	.61	1.19	.97	-	1.50	0	.19	.70	+
Brazil	2.11	2.53	.18	.23	.67	.69	-	1.50	-.03	.77	.71	+
Chile	.08	1.69	.18	.35	-3.90	-1.25	+	1.50	-.03	.77	.71	+
Guyana	-.13	1.56	.18	-.46	.29	1.30	-	1.50	.67	.08	1.15	+
Jamaica	-1.10	1.50	.18	.99	3.78	13.08	+	1.50	.95	2.64	10.26	+

See footnotes at end of table.

Continued--

Table B—Frontier of harmony: Where agricultural growth and demand for commodity imports coexist—Continued

Region/country	Growth		Wheat and rice					Coarse cereals				
	Agricultural	Popula- tion	Income elasti- city	Depend- ency ratio	Per capita production growth	Relative perform- ance 1/	Harmony 2/	Income elasti- city	Depend- ency ratio	Per capita production growth	Relative perform- ance 1/	Harmony 2/
Percentage increase												
per year												
Latin America (wheat-based diet)												
Continued:												
Agricultural performance parameter = 0												
Agricultural performance parameter = 1.91												
Paraguay	2.67	2.68	.18	.47	5.94	1.61	-	1.50	-.02	4.87	1.41	+
Uruguay	.76	.38	.18	-.23	1.47	1.62	-	1.50	-.05	5.12	4.81	-
North Africa and Middle East:												
Agricultural performance parameter = 0												
Agricultural performance parameter = 0												
Algeria	.48	3.01	.19	.49	-2.55	.13	+	2.21	.26	1.14	1.19	+
Egypt	.41	2.29	.19	.40	-.76	.57	-	2.21	.09	-.68	.60	+
Israel	7.77	2.56	.19	.67	-.28	.22	+	2.21	.94	-6.23	-.36	+
Morocco	-1.01	2.68	.19	.35	-3.34	-.40	+	2.21	0	-2.73	-.03	+
Syria	1.71	3.36	.19	.23	3.15	1.28	-	2.21	-.02	2.39	1.13	+
Tunisia	2.82	2.34	.19	.34	-.26	.40	-	2.21	.38	1.95	.83	+
Sub-Saharan Africa:												
Agricultural performance parameter = -1.24												
Agricultural performance parameter = 0												
Cameroon	1.08	2.29	.38	.77	7.87	3.02	-	-.30	0	-.76	.45	-
Ethiopia	-.67	1.91	.38	.14	-2.49	-.47	-	-.30	0	1.16	2.47	-
Ghana	-1.24	2.75	.38	.68	3.05	3.83	-	-.30	.03	-1.57	.78	-
Ivory Coast	-.02	4.20	.38	.39	-.04	.99	-	-.30	.01	-1.58	.63	-
Kenya	.91	3.64	.38	0	-2.02	.36	-	-.30	-.02	-2.38	.28	-
Liberia	1.96	3.02	.38	.28	1.34	.88	-	-.30	1.00	0	.61	-
Mauritania	-3.24	1.76	.38	.95	16.54	-12.37	-	-.30	.44	-9.01	4.90	-
Niger	-6.07	2.94	.38	.41	-.81	-.68	-	-.30	-.01	-.47	-.79	+
Nigeria	-1.97	3.08	.38	.58	4.74	7.06	-	-.30	.01	-1.62	1.32	-
Senegal	-1.95	2.87	.38	.79	-4.11	-1.36	-	-.30	.07	-1.24	1.77	-
Sierra Leone	.11	2.17	.38	.13	-.41	.77	-	-.30	.02	.25	1.06	-
Sudan	.60	2.96	.38	.52	6.37	2.62	-	-.30	.04	2.37	1.50	-
Tanzania	-.01	3.15	.38	.23	5.91	2.89	-	-.30	.03	3.61	2.15	-
Togo	-1.31	3.03	.38	.56	-4.38	-.79	-	-.30	0	-2.24	.46	-

1/ Relative performance is defined as the ratio of the commodities' production growth rate to total agricultural production growth rate.
 2/ Harmony is defined as the sign of the change in commodities' imports as total agriculture grows. A negative sign indicates disharmony and a positive sign indicates harmony.
 3/ Agricultural performance parameter is defined as the elasticity of consumption with respect to the agricultural bias in GDP growth.

Simulations

We use, in this section, archetype, computable general equilibrium models for LDC's at four levels of development corresponding to the World Bank's classification:

Range of countries ranked by per capita GNP

<u>Country type</u>	<u>1987 U.S. dollars</u>
Very low income	\$120 to \$250
Low income	\$251 to \$500
Middle income	\$501 to \$1,500
Newly industrialized (NIC's)	\$1,501 and above

The central question asked in the simulation experiments is: Under what conditions and after how long will land-saving technological change in the production of food and feed grains lead, through general equilibrium income effects, to increased demand for food/feed imports? We sought to identify policies that can be used to enhance the compatibility between growth in productivity of food/feed and increased demand for imports of these same products.

The detailed mathematical specification of these models appears in de Janvry and Sadoulet [6]. We explain here the general qualitative features of these models, give the parameter values used, and simulate a number of growth paths induced by technological change in agriculture.

A word of caution about models is appropriate. Archetype models are useful as policy laboratories to experiment with alternatives when tradeoffs among variables are not obvious. The models, however, cannot easily be calibrated because there is no real-world experience against which to measure their performance. Hence, the absolute values presented in results, such as length of time lags between change in agricultural technology and change in demand, are, at best, reasonable approximations to reality. The relative values presented in the results, such as the direction of change in the endogenous variables caused by a change in policy regime, are more reliable. Therefore, we have stressed the more reliable relative values in presenting and drawing implications from our model simulation results.

Specifying the Model

The models have three sectors to reflect the contrast between importing sectors, exporting sectors, and nontradable sectors. The agricultural sector producing food/feed (A) is importing. Consequently, there is room for import substitution, which can help save on foreign exchange.⁴

⁴We do not address the question of the entry of LDC's into the world market as food and feed grain exporters.

The industrial sector, defined to include tropical agricultural commodities, (T) is exporting. It is thus key in generating foreign exchange. Services, construction, and the informal urban economy form a nontradables sector (NT).

The three sectors use inputs differently. The agricultural sector uses land, which is in fixed supply, and labor. The nontradables sector uses capital, which is in fixed supply in that sector, and labor. The export sector uses labor and two types of capital goods which are imperfectly substitutable: domestic capital and imported capital. The productivity of imported capital is higher than that of domestic capital. The productivity of the total capital stock increases with the size of that stock, reflecting economies of scale and gains in labor force experience.

The agricultural and nontradables sectors have labor surpluses. The real wage in these two sectors is exogenous, following a Leibenstein-Stiglitz theory of efficiency wage [15, 22]. Income sharing occurs between the employed and the unemployed, determining the level of real per capita income. The A and NT sectors maintain the same rates of unemployment through migration between the two sectors. There is no labor surplus in industry, and the wage in that sector is determined by the opportunity cost of labor. The opportunity cost of labor is the real per capita income in the agricultural and nontradable sectors adjusted for migration cost. Real income effects in the A and NT sectors, consequently, are determined only by employment effects. In the T sector, employment is determined by equation of the value marginal productivity of labor to the wage. There are six social classes: workers in the A, NT, and T sectors; landlords in the A sector; and entrepreneurs in the T and NT sectors.

The demand system is a linear expenditure system which has as parameters the income shares, the income elasticities, and the flexibility of money. Grain demand is the sum of the direct demand for food grains and the indirect demand for feed grains derived from consumption of animal products. The elasticities of both food and feed grains decline with income. As rising incomes cause a shift from the direct consumption of food grains to the consumption of animal products, the total elasticity of food and feed grains increases.

The industrial sector generates foreign exchange. Because most LDC's will face only modest prospects for industrial exports in the coming decades due to industrial protectionism and slow growth in the MDC's, we specify that only a constant share of the industrial output of LDC's can be exported.

Foreign exchange earnings from the T sector and foreign exchange savings from the A sector are used for two purposes. First, any demand for food that is not satisfied by domestic production has first priority in the use of foreign exchange. Rising demand for imported food is, thus, never obtained at the expense of food

security.⁵ Second, the balance of foreign exchange is used to import capital goods for the T sector. The model thus belongs to the generation of two-gap growth models [3]: Both domestic savings and foreign savings are used to accumulate capital, but it is the availability of foreign savings that is binding on capital accumulation.

Because imported foreign capital goods have a higher productivity than domestic capital goods, the availability of a foreign exchange surplus is an important determinant of the T sector's growth rate. The NT sector's growth source is the level of effective demand it faces. Growth is demand determined because the NT sector's stock of capital is fixed and its supply of labor is surplus. The higher the elasticity of substitution between labor and capital, the higher the elasticity of supply response of that sector.

Tables 9 and 10 present the values of the structural parameters characterizing the four levels of archetype LDC's.⁶ Exogenous productivity growth in agriculture, in the following experiments, reflects the effect of technological aid, of the Green Revolution type, to agriculture in LDC's. Productivity growth is also applied to the stock of industrial capital in some experiments.

Because the models are intertemporal (simulating economic activity over time), the effect of productivity changes over time must be assessed by calculating present values in a way that allows comparison of different streams of costs and benefits. The choice of discount rates, the interest rate used to calculate the present value of future income or expenditure, is crucial. Depending on the perspective from which one evaluates the benefits of technical assistance, different discount rates will be used. One may view benefits, for example, as accruing to society in general or as accruing to the private sector.

We use two levels of discount rates to reflect both points of view. When aid is viewed as a long-term social project with

⁵This assumption is made to avoid the argument that food dependency may increase at the cost of rising malnutrition in some segments of the population; for example, if plantation agriculture displaces smallholders producing food crops. It is well known that there are complex tradeoffs and complementarities between food security and trade, and we are abstracting from this subject here. Note that if there are quantity constraints on the use of foreign exchange to import food, the model will overestimate food imports. Food imports are, however, usually determined by effective demand, not by foreign exchange restrictions.

⁶Structural parameters are derived from average values of the countries in the GNP per capita brackets that appear in the World Bank Development Report, 1987 [25].

Table 9--Selected parameters for archetype economies

Selected parameters	Unit	Country type			
		Very low income	Low income	Middle income	Newly industrialized
Total production	Index	100	100	100	100
Production:					
A ^{1/}	Percent	41	33	25	12
T	do.	17	30	35	40
NT	do.	42	37	40	48
Per capita income	1984 U.S. dollars	190	300	585	1,765
Sectoral employment shares:					
A	Percent	42.3	36.2	26.7	12.4
T	do.	8.5	16.5	23.3	28.6
NT	do.	49.2	47.3	50.0	59.0
Wages:					
A, NT	Index	.85	1.1	1.6	4.2
T	do.	1.00	1.5	2.0	5.2
Capital/output ratio:					
A	Ratio	2.0	2.0	3.0	3.5
T	do.	3.0	4.0	4.0	7.5
NT	do.	2.0	1.5	2.0	3.8
Imported capital as a share of total	Percent	29.4	25.0	25.0	46.7
Elasticity of substitution between KM and KD ^{2/}	Elasticity	.4	.4	.4	.8
Relative productivity of KM and KD	Ratio	3.0	3.0	3.0	3.0
Elasticity of capital productivity in T	Elasticity	.1	.2	.3	.3
Elasticity of substitution between capital and labor:					
A	do.	.1	.1	.1	.1
T, NT	do.	1.0	1.0	1.0	1.0

^{1/} A = agricultural sector, T = nonagricultural tradables sector, and NT = nonagricultural nontradables sector.

^{2/} KM is imported capital and KD is domestic capital.

Source: [25].

Table 10--Consumption parameters for archetype economies

Consumption parameters	Country type							
	Very low income		Low income		Middle income		Newly industrialized	
	Share	Elasticity	Share	Elasticity	Share	Elasticity	Share	Elasticity
A and NT workers: <u>1</u> /								
Food	0.51	0.9	0.42	0.7	0.33	0.5	0.16	0.3
Feed	.03	2.0	.07	2.0	.11	1.8	.14	1.4
T	.09	1.4	.18	1.3	.21	1.2	.26	1.0
NT	.37	1.0	.33	1.0	.35	1.2	.44	1.1
Frisch parameter	-7.0		-5.0		-4.0		-3.0	
T workers:								
Food	.32	.7	.26	.5	.22	.4	.11	.2
Feed	.06	1.8	.10	1.5	.12	1.4	.12	1.1
T	.22	1.3	.27	1.2	.28	1.1	.30	1.0
NT	.40	1.0	.37	1.1	.38	1.2	.47	1.2
Frisch parameter	-5.0		-4.0		-3.0		-2.0	
Capitalists:								
Food	.21	.4	.12	0	.08	0	.04	0
Feed	.10	1.5	.12	1.1	.14	1.0	.12	.9
T	.20	1.1	.34	1.1	.34	.8	.33	.8
NT	.49	1.1	.41	1.2	.44	1.4	.51	1.2
Frisch parameter	-4.0		-1.6		-1.3		-1.0	

1/ A = agricultural sector, T = nonagricultural tradables sector, and NT = nonagricultural nontradables sector.

Source: [25].

important public benefits or costs which are not reflected in market-determined values, a discount rate of 2 percent is used. This viewpoint characterizes the philosophy on aid held by such institutions as the U.S. State Department, AID, and other international development organizations. When aid is viewed as action that affects trade, a private discount rate of 15 percent corresponding to commercial real interest rates is used. This viewpoint characterizes the stance of farm lobbies and farm product exporters. The same aid-trade project will generate vastly different interpretations depending on which discount rate is used to calculate present value of costs and benefits.

The reason that social discount rates are lower than private discount rates is that society places a positive value on some of the effects created by the project and the private sector does not. A project viewed from society's perspective will thus have a higher value than when viewed from a private perspective. With a higher perceived value, a lower discount rate is required to yield the same present value. If the present value of a project assessed at the private discount rate is negative but it is positive when assessed at the social discount rate, the gainers (society) can compensate the losers (the private sectors). The transfer ensures Pareto optimality (whereby a change results in gains for some but a drop in well-being for none) after compensation.

Development Strategies: Agriculture's Key Role

Using the model, we performed an experiment to explore how different development strategies affect the growth of GNP and agricultural imports. We did this using the archetype model for low-income countries. An evident temptation in designing a foreign aid program aimed at benefiting U.S. farm export interests would be to confine productivity growth to either the industrial sector, following the successful models of Hong Kong and Singapore, or to noncompeting agricultural exports such as tropical products. A strategy that develops a nonagricultural, export-oriented industry or an export-oriented plantation agriculture with no food/feed sector would fulfill that function.

Results show that confining productivity growth to industry and plantations while neglecting productivity growth in the food/feed sector (table 11, strategy (1)) does not offer a viable development strategy to LDC's when growth in industrial and plantation exports are modest, as assumed in this analysis. An annual productivity growth of 1.4 percent in industry leaves GNP virtually stagnant after 25 years. The reason is that meager foreign exchange earnings are increasingly used to import food/feed products, gradually starving industry for foreign exchange and inducing industrial stagnation. Agricultural imports do increase by 12.6 percent over the period, and the present value of the net increase in agricultural imports of the LDC is positive using both social and private discount rates. Yet, it is evident that this strategy, however tempting for farm interests of an MDC, is untenable for the LDC. This leads us to conclude that agricultural growth is necessary to sustain economic growth in the absence of another strong generator of foreign exchange. If this agriculture is directly competitive with U.S. farm exports, there exists the basis for a conflict between aid to agriculture and trade interests.

If technologically generated growth in productivity is confined to the food/feed sector to the neglect of productivity growth in industry (table 11, strategy (2)), we observe the reverse situation. GNP grows by 30 percent over the period but agricultural imports decline by 60 percent. The LDC benefits but

Table 11--Alternative development strategies

Strategy	Growth after 25 years		Present value of net increase in agricultural imports	
	GNP	Agricultural imports	$\delta = 2 \frac{1}{\delta}$	$\delta = 15 \frac{1}{\delta}$
			<u>Percent</u>	
Annual productivity growth of 1.4 percent in:				
(1) Capital in T sector	1.7	12.6	398	81
(2) Land in A sector	30	-60	-2,000	-139
(3) Capital in T sector and land in A sector	40	19	438	-11

$\frac{1}{\delta}$ = discount rate.

U.S. farm export interests are hurt, whatever the discount rate. Focusing on agriculture alone in the low-income LDC's fails to create enough income growth to ever reconcile aid and trade.

When growth is balanced across sectors and productivity increases equally in agriculture and industry (table 11, strategy (3)), we found compatibility between growth in LDC's and U.S. farm exports. GNP grows by 40 percent and agricultural imports by 19 percent when productivity increases by 1.4 percent a year over a 25-year period.

However, increased food self-sufficiency and decreased farm imports occur in the early years, and only after 13 years does the demand for farm imports rise above the initial level. Thus, the present value of the stream of imports is positive, or negative, according to the discount rate used. At a social discount rate, the present value of import demand is 438 percent. At a private discount rate, it is negative although small. Unless those who assess the aid project at a social discount rate compensate those who assess it at a private discount rate (which they can easily do because their gains are much larger than the losses incurred by farm interests), the aid program is unacceptable to farm interests.

We thus conclude that (1) productivity growth in the food/feed sector is necessary to sustain economic growth in the LDC's when

possibilities for foreign exchange earnings generated by exports from other sectors of the economy are limited and (2) international assistance in promoting productivity growth in the LDC's must be balanced among economic sectors of the recipient nations to ensure strong growth in the general economy. Then economic growth in LDC's can be reconciled with farm export interests in MDC's.

Targeting Aid by Countries

Countries will feel the effect of productivity growth in agriculture and industry differently depending on their stage of economic development. Although countries differ in many aspects that influence growth and import demand, they have many structural similarities when grouped by level of GNP per capita [13, 4, 1].

In order to simulate the differential effects of productivity growth (aid) in agriculture of LDC's at different stages of economic development, we incorporated structural parameters in four archetype models to reflect behavior at four different levels of per capita income (stages of development). The structural differences, as level of GNP per capita increases, are a declining share of GNP from agriculture, a rising share of labor in industry, and an increasing share of feed grains in the total consumption of cereals.

Table 12 and figure 1 show how constant productivity growth of 1.4 percent a year affects both agriculture and industry in economies at four levels of development. Results of aid's effect on GNP, imports of food and feed, and the share of feed in the increase in total cereal consumption are reported for a 25-year period. The present value of the change in cereals imports is measured at both social and private discount rates to show the economic basis for both viewpoints in the aid-trade debate.

Results show that conflict between aid and trade never exists in the NIC's because agricultural imports immediately increase when productivity starts to rise. Productivity growth in industry creates strong income effects because these economies are already highly industrialized and urbanized. At a private discount rate, the present value of this aid project is 29 percent. Feed grains accounted for 88 percent of the increase in cereal consumption in these countries.

It is in the very low-income countries that the percentage increase in farm imports will have been greatest after 25 years. This outcome results from the very high income elasticity for cereals that exists at low levels of income.

At a social discount rate of 2 percent, it is, consequently, in the very low-income countries that the aid project will have the largest trade effect. During the first 5 years, the level of

Table 12--Effect of aid by level of economic development 1/

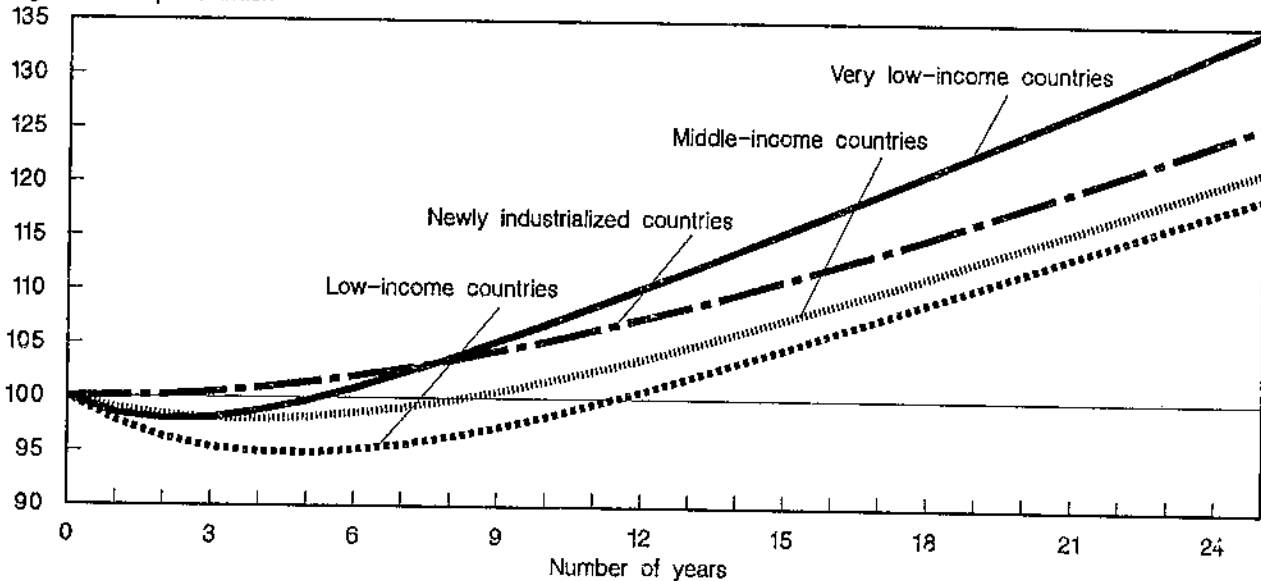
Country types	Effect after 25 years on--			Present value of net increase in cereal imports at discount rates		Time lag 2/
	Growth in GNP	Growth in agricultural imports	Share of feed in increase in cereal consumption	2% discount rate	15% discount rate	
			Percent			Years
Very low income	37	35	22	946	25	5
Low income	40	19	46	438	-11	11
Middle income	35	22	68	569	7	8
Newly industrialized	30	28	88	799	29	0

1/ Experiment with a 1.4-percent annual increase in productivity in both agriculture and industry.

2/ Time lag is the number of years before agricultural imports return to their original level.

Figure 1
How agricultural imports are affected by technological change in countries at four levels of economic development 1

Agricultural imports index 2



1/ The technological change introduced is characterized by annual productivity growth of land in agriculture and capital in the tradable goods sector of 1.4 percent a year.

2/ 100 = Level of agricultural imports before technology was introduced.

food self-sufficiency increases relative to the base period. Despite this, the present value of the stream of import demand, even when based on private discount rates, is positive and reaches 25 percent, making the aid project attractive to farm interests. At most, credit rather than compensation is needed to allow farm interests to weather the period of losses in farm exports.

The effect on GNP growth after 25 years will be largest in the low-income countries. This result is due to the fact that balance of agricultural and industrial sectors in these economies maximizes the growth effect of productivity gains in both. The shortrun loss in farm export opportunities, however, implies that the aid project is not attractive at private discount rates. Here, some of the large gains captured by those who value the project at social discount rates could be taxed to compensate private farm exporters.

Agricultural exporters and farm lobbies will be most interested in directing aid toward the NIC's because the trade gains are immediate. Seen in a longrun social perspective, however, aid has the highest payoff for expanded trade in the very low-income countries. Even when results are assessed based on a private discount rate of 15 percent, aid to agriculture (complemented by aid to industry) in the very low- and middle-income countries yields significant payoffs. The negative effects on import demand in LDC's during the first 5 and 8 years, respectively, should not be misread as indicators of a conflict between aid and trade. Credit may, however, be needed to allow farm interests to wait for the long-term income gains. It is only in the low-income countries that a conflict exists at private discount rates, requiring transfers between gainers (the public) and losers (the private sector).

Policy Implications

Our results permit us to be explicit about how the conditions under which the positions assumed by the advocates of aid-trade harmony and by the advocates of incompatibility can be expected to hold. In some way, both are eventually correct, but the unqualified positions of both are scientifically untenable and not helpful for policymaking.

We found that there is no escape from the aid-trade debate because growth in agricultural productivity in LDC's, particularly through land-saving technology in cereal production, is necessary for these countries to grow during a period of skepticism about export-induced growth. Yet, this finding does not negate the fundamental importance of relentlessly seeking opportunities to establish comparative advantages in world trade and of increasing exports of industrial products, tropical commodities, and minerals whenever possible. It must be stressed that our research, which assigns agriculture a key role in economic development in terms of agriculture's contribution to foreign exchange, was based on a mildly optimistic assumption

about nonagricultural exports. The model used an assumption that LDC's are able to keep on exporting at least a constant share of their nonagricultural tradable products.

Given that production of food and feed grains plays a major role in world agriculture, we found that conflicts between aid and trade can result but that an arsenal of policies can be used to reduce or eliminate this conflict. Our research finding, that evidence is favorable on prospects of harmony between aid and trade, is especially strong because we analyzed it under a worst-case scenario. For instance, in our research, aid increased production of a commodity that competed directly, in the short run, with imports, which is the most difficult case in which to demonstrate harmony.

The main policy implications we identified follow.

Economic Sectoral Balance

We found that productivity growth confined only to agricultural production that competes with farm product imports is likely to create an aid-trade conflict. This finding indicates that aid should be delivered in packages that simultaneously promote productivity growth in industry and agriculture. It is notable, however, that U.S. aid is no longer delivered comprehensively, as it was in the 1960's, but has evolved toward a project and commodity approach. Even one of the most successful recent achievements of international assistance, the CGIAR and its network of international agricultural centers, followed a commodity or farming systems approach with little consideration for balance among economic sectors or for linkage effects.

Our results stress that it is important to pay close attention to the links between the agricultural sector and other sectors of the economy. Most of the links, or interactions, take place in the factor markets (especially labor and capital) and product markets. These interactions allow increases in agricultural productivity to stimulate higher income levels that lead to greater national demand for food/feed. If these interactions do not take place and productivity gains are trapped in the agricultural sector, supply will increase but demand will grow little. The result will be increased self-sufficiency in food/feed and conflict between aid and import demand.

Complementary projects, focused on promoting links between economic sectors and increasing productivity in nonagricultural sectors, consequently are needed to induce the economy-wide income growth required for aid-trade harmony.

Reform of policies that distort agricultural factor and product markets and reduce links between agriculture and the rest of the economy can be an important means of increasing the size of the income multiplier. Reforms should be targeted at eliminating exchange rate distortions and credit subsidies that cheapen capital, thereby increasing the capital/labor ratio and decreasing the income and import multipliers.

AID and the World Bank have used the processes of policy dialogue and conditional lending to stimulate policy reform in LDC's. These actions should thus be important complements to technological assistance to agriculture in LDC's.

The recent shift in emphasis at development agencies from project lending to policy-based sectoral lending is a step toward achieving harmony between aid and trade. Policy recommendations must, however, focus explicitly on potential tradeoffs between shortrun welfare and future growth. Carefully crafted policy recommendations will prevent situations in which harmony between aid and trade is achieved at the cost of shortrun welfare.

Livestock Development Increases Feed Import Demand

We found that, within agriculture, increased demand for animal feed is the most dynamic source of import demand in developing countries, mainly in the middle-income countries and the NIC's. Lack of technological change in coarse grain production under rain-fed conditions severely limits the capacity of these countries to meet internally the rapid increase in demand. Moreover, the United States has the best established comparative advantage in coarse grains production. For that reason, administrators of aid aimed at boosting productivity in agriculture of developing countries should look favorably at livestock, dairy, and poultry development projects. These activities are particularly desirable when combined with rural development projects or with initiatives providing the landless with greater access to assets, because income redistributive effects enhance overall demand and reduce the aid-trade conflict. Programs like Operation Flood in India, which promotes dairy production among small landholders and the landless, show success in that direction [17].

Not all of the observed rise in import demand for cereals by LDC's is attributable to income effects. A part is due to the differential applicability of new production technology to countries with temperate climates versus those with tropical climates. New wheat technology is most applicable in temperate areas and has allowed countries such as India to become self-sufficient in wheat. New technology for production of rice is most applicable in tropical areas and has allowed countries such as Indonesia to become self-sufficient in rice. As urbanization spread and new consumer habits evolved, demand for wheat increased in many tropical countries that have comparative disadvantages in wheat production. The result has been a rapid increase in demand for imported wheat in tropical countries. For example, Indonesia's wheat imports rose from 20,000 tons in the mid-1960's to 1.6 million tons today [24]. Undoubtedly, Indonesia's success in increasing rice production led to higher income in the general economy and freed up foreign exchange, which, in turn, contributed to greater demand for imported wheat.

Timing

The overall economic effect lags a productivity increase in agriculture because it takes several rounds of interaction between agriculture and other economic sectors to create full income and import demand effects. It is, for that reason, always better to achieve the productivity change quickly than to spread it gradually over a long time. Technological aid should occur, therefore, as early and rapidly as possible, suggesting that massive campaigns of technological change should be organized over a set period if they are to stimulate farm imports.

Evaluation of costs and benefits of an aid program depends on the level of discount rate different groups use, because the costs and benefits are spread over time. With private discount rates larger than social rates (reflecting the fact that society captures returns from aid that private markets cannot), farm interests may lose while society's interests may gain. We have seen that two types of policy interventions are called for:

1. There are situations in which the present value of the increase in import demand is positive when calculated at a private discount rate. If import demand never declines, Government intervention is unnecessary. If, however, import demand declines during a transition period before pushing past its initial level, public credit may be necessary for farm exporters who cannot get credit in the financial market. The interest rate on these loans need not be subsidized below the level of the discount rate, because present value is positive. It is possible that the short-term negative effect of any aid project would not be large enough or its effect on export commodity producers focused enough to make compensation via credit necessary.
2. There are situations in which the present value of the increase in import demand is negative when calculated at a private discount rate but positive when calculated at a social discount rate. In this case, a system of tax and subsidy is necessary to transfer some of society's gains to farm trade interests to compensate them for the losses they incur. We have seen that in all the cases studied, society's gains are large and the private-sector's losses are small, allowing compensation to be funded from a light tax. Exporters of capital goods and intermediate products to industry in LDC's are immediate gainers from agricultural productivity growth in LDC's, even when self-sufficiency in food and feed increases, because these exports increase sharply with import substitution in agriculture. Consequently, the taxes to compensate farm interests for aid's negative effect could be targeted at exporters of capital goods and intermediate products in MDC's that sell to industry in LDC's. As poorer countries increase their self-sufficiency in food, the cost to U.S. taxpayers for foreign food aid

drops. If the need for food aid declines, taxpayers benefit. Taxpayers could also help bear the cost of compensating U.S. farmers for any forgone exports.

Productivity Versus Equity

Any measure that results in a more progressive income distribution in LDC's will play in favor of farm exporters' interests because the demand for food/feed will increase. A more progressive distribution of income can be obtained by decreasing the industrial capital/labor ratio, which has implications for technological choices and the industrial structure. Farm exporters' interests will also be enhanced by increasing the productivity of imported capital, increasing the availability of capital for the informal urban sector, and easing the substitution of capital for labor in the industrial sector. Focusing aid programs on the informal rural and urban sectors appears to be an effective way of enhancing the multiplier effects created by rising farm incomes originating from productivity growth. Finally, redistributing agricultural assets toward peasants, who spend a larger share of income increases on food than do wealthier landowners, also leads to higher food/feed consumption and import demand. Reducing the aid-trade conflict thus calls upon aid programs that stress the complementarity between productivity growth and equity.

Tradeoffs Among Countries

We have seen that the bulk of commercial import demand for food and coarse grains originates in just a few LDC's, either NIC's or oil exporters. Harmony between aid and trade should, therefore, be relatively easy to manage on a case-by-case basis with each of these key partners. We have also seen that the safest bet for aid to avoid conflicting with farm trade interests would be to confine it to the NIC's, provided aid is focused on productivity growth in both agriculture and industry. Yet, the United States typically discontinues aid to "graduating countries" with per capita income levels below those of the principal NIC's, unless those countries are of national security interest to the United States.

Legitimizing aid to the MDC's could require that aid be spread over a broader range of countries, some with immediate trade payoffs and others with longer run trade payoffs. U.S. nonagricultural trade interests fear that aid to industry in LDC's might help solve the problem of foreign markets for U.S. agriculture but would reduce U.S. nonagricultural exports. Such fears are based on the vision of a static world economy or on beliefs that U.S. industry cannot maintain its competitive edge with NIC's.

Trade payoffs from aid are highest in the very low-income countries because agriculture accounts for a large share of the economy and because such countries have high income elasticities

for cereals. It is in these countries that the humanitarian goals of aid can best be combined with the U.S. farm trade interests.

Sources of Failure

We have shown that there is ample room for aid to agriculture in LDC's to also benefit U.S. farm export interests if aid programs are properly managed. Yet, there are a number of reasons why aid and trade can fail to be compatible. The LDC's need agricultural productivity growth to achieve development goals, and the United States needs expanding agricultural export markets. Therefore, the possibilities of failure should be carefully understood and avoided.

One potential source of failure is that aid may not induce productivity growth in agriculture and industry. While agriculture has had many significant successes, sustaining these achievements and extending them to the regions not yet benefited by the Green Revolution is open to question. More importantly, the ability of aid to stimulate growth in productivity among other sectors of the economy has been questioned. The informal rural and urban sectors pose potential opportunity, as yet unexplored, to which greater attention should be devoted.

Another potential source of failure is that productivity growth in agriculture may not create the desired income multiplier effects because of linkage failures, as we observed in the cases of India and China. Or, potentially investable funds may be siphoned off to repay heavy foreign debts, such as in Latin America. Resolving the debt crisis of developing countries is an area in which a coalition between LDC's and U.S. farm interests could emerge.

Finally, it is remotely possible that an aid-trade program will benefit exporting countries other than the United States. In an era of both massive devaluation of currencies in LDC's and heavy subsidies to EC exporters, third parties could capture the benefits. We believe it is unlikely in the short run, because there are few significant exporters of food and feed grains among the LDC's. If economic growth in LDC's is only moderately successful, it is unlikely that many countries could become major exporters or even remain exporters. The recent return of China to the status of net food/feed importer illustrates this point. Even modest growth in Indian industry would quickly transform that country from net exporter to importer. U.S. competition with subsidized EC farm exports is a more serious problem that urgently needs to be addressed in the GATT trade negotiations. Finally, an unfavorable U.S. exchange rate and other antitrade macroeconomic policies could rob the U.S. farm sector of gains from aid and trade as they did in the first half of the 1980's.

Broad Implications for U.S. Aid

Both historical analysis and simulation results make the sobering point that U.S. agriculture depends heavily on dynamic, growing

agriculture in developing countries, even in products competitive with U.S. farm exports. Our results stress the fundamental role aid can play in expanding future export markets in an increasingly interdependent world in a period when the U.S. aid budget is increasingly squeezed and the developmental role of aid is given a low priority.

The land-grant universities, which are also squeezed for resources, are sometimes under pressure from the farm lobbies to restrict transfer of technology applicable to developing countries as a way to resolve the aid-trade conflict at its roots. By contrast, our results suggest that land-grant universities have a major role to play in alleviating the U.S. farm income and balance-of-trade crises by helping spur growth in agricultural productivity in LDC's. Research conducted at land-grant universities should not be directed only at noncompetitive crops. It should also emphasize the livestock sector and investigate how to sustain and expand the productivity gains made by the Green Revolution in the mid-1960's.

We showed that the relationship between aid and trade is fraught with tradeoffs that are difficult to model and to analyze empirically. The debate between advocates and opponents over aid to agriculture in developing countries could be made more objective by grounding it in more precise research. The multilateral and bilateral aid institutions should have a major responsibility in conducting some of this research and in educating the farm sector and the public about the issues involved. Appropriations for the aid budget could then be made with full information on the expected costs and benefits.

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