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The Impact of Economic Development on Agricultural Trade Patterns

Robert E. Christiansen

THE IMPACT OF ECONOMIC DEVELOPMENT ON AGRICULTURAL TRADE PATTERNS. By Robert E. Christiansen, International Economics Division, Economic Research Service, U.S. Department of Agriculture, ERS Staff Report No. AGES861118.

ABSTRACT

This report investigates the relationship between economic development, as measured by two indicators, per capita income and an index of health and educational indicators, and the consumption, production, and trade of selected agricultural commodities. The results indicate that development is strongly correlated with increased levels of certain food grains in developing countries. The evidence indicates that developing country imports of certain feed grains and oilseeds are strongly correlated with economic growth.

Keywords: Agricultural trade, income elasticities of demand, developing countries.

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SUMMARY

There is considerable controversy over the implications of economic growth in developing countries for international agricultural trade. Concern in the developed countries centers on the extent to which development is accompanied by an expansion of agricultural exports and reduction of agricultural imports. To the extent that this occurs, it means a loss of export markets for the developed country agricultural exporters.

To gain an understanding of the behavior of agricultural trade during development, we must ascertain how consumption of agricultural commodities responds to development and, in turn, how domestic production reacts to changes in demand. The pattern of trade, especially imports, can then be studied in the light of changing domestic use and production of agricultural products.

This report investigates the response of agricultural consumption, production, exports, and imports of selected commodities and groups of commodities to changes in two measures of economic development. Additionally, the relative performance of the United States and other agricultural exporters in meeting the growing demand for agricultural commodities in developing countries is investigated. The report is intended to provide an overview of the issue. For this reason, the concern is with establishing broad outlines of agricultural trade during the development process.

The empirical results suggest a strong positive, and we believe causal, relationship between development, whether measured by per capita gross domestic product or by an index of basic needs measures, and the value of agricultural imports. This relationship does not exist to the same degree for agricultural exports. Therefore, this result demonstrates that economic growth creates more import opportunities in developing countries for agricultural commodities than export competition.

Income growth is strongly associated with increased consumption, measured in volume, of a number of agricultural commodities, particularly feed grains (barley, oats, and maize), certain oilseeds (soybeans and sunflower seeds), and meat products.

Food grain consumption is more highly correlated with improvements in the alternative measure of development than with growth in per capita income. Our conjecture on this point is that there is a stronger link between increased consumption of food grains and a social measure of development than there is between consumption and solely an income measure of development.

The response of feed grain consumption to development is greater than that for food grains. This presumably reflects income-based changes in consumer preferences for foodstuffs requiring feeds as an input, such as beef and dairy products.

There is a comparatively strong correlation between income growth and increased production of certain food grains (wheat grain), feed grains, and meat. This correlation for the feed grains is based upon the behavior of barley, oats, and maize as income increases.

The increased consumption of food grains and some feed grains is supplied by increased domestic production, while the increased demand for other feed grains, specifically maize, requires more imports. This point can be extended to the

oilseeds as well. Sunflower seeds and soybeans showed increased consumption as development occurred. Sunflower seeds were supplied largely by increased domestic production, while demand for soybeans was met through increased imports.

Paralleling the results of the value equations, there is little correlation between the volume of agricultural exports and growth of per capita income or the value of agricultural exports and the alternative measure of development.

The evidence presented here indicates that there is not a systematic relationship between the value of agricultural exports or the volume of selected commodities and development. This is not to say that developing countries will not export agricultural commodities as part of their development strategy, but rather that exports will not necessarily be the mainstay of sustained economic growth. The results presented here demonstrate that for the commodities most important to U.S. exporters (maize and soybeans), developing countries actually increase their agricultural imports during the development process.

The evidence indicates that successful development efforts, which include sustained economic growth, are the strongest catalysts for expanding world agricultural trade. For better or worse, the prospects of the two are inextricably intertwined.

The Impact of Economic Development on Agricultural Trade Patterns

Robert E. Christiansen

INTRODUCTION

There is considerable controversy over how economic growth in developing countries affects international agricultural trade. The issue centers on the extent to which economic development is based on the expansion of agricultural production and the concomitant increase in agricultural exports and reduction of imports by developing countries.

To gain an understanding of this behavior, it is necessary to ascertain how consumption of agricultural commodities responds to development and, in turn, how domestic production reacts to changes in demand. The pattern of trade, especially imports, can then be studied in the light of changing domestic use and production of agricultural products. This report investigates the response of agricultural consumption, production, exports, and imports of selected commodities and commodity groups to changes in two measures of economic development. It also investigates the performance of U.S. agricultural exporters in meeting the growing demand for agricultural commodities in developing countries relative to the performance of the rest of the world. The study uses cross-sectional data for 67 countries in 1977, and 66 countries in 1980.

LITERATURE REVIEW

The volume of literature dealing with issues of agricultural production, trade, and consumption, and with the response to income growth, is enormous. Three recent pieces relevant to the subject are discussed.

Mellor and Johnston

Although chiefly concerned with food and nutrition issues, Mellor and Johnston provided such broad coverage that their article constitutes the most comprehensive recent review of many topics of interest to this study (20).1/ The portion of Mellor and Johnston most central to our interests is titled "Trends in Food Production, Trade and Consumption" (20, p. 534). It begins by identifying the three salient characteristics of the current global food and agricultural situation:

> First, there is substantial variation among countries and regions in the extent to which food production growth rates differ from population

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1/ Underscored numbers in parentheses refer to sources listed in the Bibliography.

growth rates. Second, a high growth rate in international food trade, comprised substantially and increasingly of exports from the most developed to the less developed countries (LDCs), is the major source of increased per capita consumption in developing countries as a group. Third, the growth in food crop production in developing countries is increasingly dependent on increased yields per unit area rather than area expansion.

The first two points are especially relevant to this study.

In their overview of food production trends, Mellor and Johnston point out that the aggregate growth rate for food production was 2.7 percent for 1961-77, only slightly ahead of the average population growth rate of 2.6 percent. However, these data mask large regional differences between food and population growth rates. Latin American and Asian food production growth rates exceeded population growth rates by 18 and 12 percent, respectively. For Sub-Saharan Africa, the population growth rate was 2.7 percent, while food production grew by only 1.6 percent.

Mellor and Johnston note that the increasing importance of agricultural trade was signaled by a 360-percent increase in net imports of staple foods by developing countries between 1961-65 and 1973-77 from 5 million to 23 million tons per year (20, p. 536). The average annual growth rates of exports and imports are as follows:

Region	Exports	Imports
	Percent	
Asia	2.5	3.5
North Africa and Middle East	-2.0	7.3
Sub-Saharan Africa	-4.6	7.1
Latin America	3.6	6.9

Referring specifically to food, Mellor and Johnston argued that:

> For each of the regional and GNP growth-rate groupings of developing countries, food imports grew more rapidly than food exports despite different records of growth in per capita food production. Sub-Saharan Africa, with the slowest growth rate for agricultural production, changed from a net exporter to a significant importer and is projected to account for a substantial share of world food imports by 2000. (20, p. 537)

This information (historical trends, and present projections) indicates that the value of agricultural imports by developing countries has grown and is expected to continue to grow much more quickly than their agricultural exports.

Mellor and Johnston demonstrated that food consumption grew 11 percent faster than the population growth rate during 1961-77 (20, p. 538). They argued that the increase came only partly from increased production in developing countries:

> The significant factor was rapid growth in net imports. Of the major regions, only Asia has had a faster growth rate of production than

consumption. However, this was largely due to changes in India: reduced imports were associated with a stagnating level of per capita consumption.

The results cited by Mellor and Johnston indicate a positive correlation between high growth rates for agricultural production and food imports. To reinforce this point, they referred to results of Bachman and Paulino (2) which showed that 16 developing countries with the fastest growth rates in staple food production for 1961-76 more than doubled their imports of food staples during the same period.

Bachman and Paulino

Bachman and Paulino focused on "the sources of growth and changes in the pattern of food production" which they identified in rapid-growth countries during 1961-76 (2). The countries were mostly middle- and high-income developing market economies. (Countries included are Brazil, Colombia, El Salvador, Ghana, Iran, Ivory Coast, Malaysia, Mexico, Morocco, Pakistan, Philippines, Sri Lanka, Sudan, Thailand, and Tunisia.)

Bachman and Paulino (2, p. 14) argued that growth in per capita income significantly increased the demand for staple foods. In the countries studied, domestic use of staple foods increased 61 percent between 1961-65 and 1974-76, roughly 1 percent per capita per year. In contrast, "little improvement occurred in the dietary energy consumption in other DME (developing market economies) countries."

Another dimension of the increased use of staple foods was the expanded demand for livestock and poultry feed. Again, Bachman and Paulino found a significant production response to income growth for feed grains. However, the increases in production of both food and feed grains were not sufficient to meet demand. Therefore, the authors argued (2, p. 14) that:

> ...the traditional net exporters to DMEs need not worry about expansion of food production in the rapid-growth countries. Although the proportion of consumption coming from domestic production generally increased, net imports of staple food also increased. Net staple food imports per year in these countries rose 2-1/3 times between 1961-65 and 1974-76; actual import levels grew by 87 percent while exports increased by 53 percent.

Bachman and Paulino also found that while wheat and sorghum production increased in importance in the rapid-growth countries, rice production declined slightly, from 24 percent to 22 percent.

A more recent study by Paulino (24, p. 9) ".. examines trends in production, consumption, and trade of the basic food staples in 105 developing countries and, through the use of projections based on past trends in output and income, attempts to determine the general size of future food problems in the Third World." Many of the same themes appear in this article as in the joint study. Worldwide food production growth has generally kept up with population growth, but increases in food demand have exceeded output in many countries, thus necessitating that agricultural imports fill the gap. In relative terms, direct food use declined, while feed use increased. The sources and patterns of the growth in demand were sensitive to income growth rates.

> In regions where incomes grew rapidly, the demand for food increased accordingly. These countries also saw a shift in food consumption patterns: demand for livestock and poultry products increased sharply. As production of livestock rose to meet this demand, consumption of basic staple foods as feed for livestock also increased... In Sub-Saharan Africa..., increases in the use of staples for animal feed have been much slower, and population growth is still the dominant factor in consumption growth. (24, p. 10)

With respect to international trade in basic foodstuffs, the evidence indicates that food imports by the developing countries grew at more than double the rate of food exports. Both production and trade displayed quite important regional differences.

All three studies stress the importance of international trade in meeting food needs, as well as the demand for other agricultural products. Also, the critical role of sustained income growth in engendering this increased demand demonstrates the strength of the relationship between these two variables.

A study by the U.S. Agency for International Development (USAID), "Some Relationships Between Growth In Cereal Production and Foreign Trade: Asia/Near East Countries," investigated trends in production and trade of cereals in Asian and Near East (ANE) countries over a 14-year period, 1970-84 (33). 2/ Growth rates for cereal production, cereal trade, cereal imports from the United States, value of imports from the United States, and value of total world imports and exports of agricultural products were estimated by fitting exponential trend equations.

The study showed trends in production to be negatively related to income trends in ANE countries. This finding led the authors to reject their initial hypothesis, "...that growth in cereal production in developing countries expands the export market for agricultural producers in other countries, including the U.S. farmer" (33, p. 1). Instead, the authors concluded that expansion of ANE cereal production is correlated with a contraction of net imports from external sources.

The ANE countries were divided into two components (Asian countries and Near East countries). The separate analyses present some striking differences between growth rates for the two areas. The Asian countries recorded rising trends for cereal production, while Near East countries demonstrated flat or falling trends. Moreover, trends in total imports for Asian countries were flat or falling in contrast to the rising trends associated with Near East countries. Trends for cereal imports from the United States corresponded with those for total imports with a sharper rise associated with the Near East countries. In value terms, ANE country import trends from both the United States and world are positive with a relatively larger increase found in the Near East countries. Finally, value trends for exports to the world are flat for Near East and rising for Asian countries.

These empirical results lead the authors to the primary conclusion that growth in developing country cereal production does not create new and stronger markets for similar products.

2/ ANE countries are Bangladesh, Burma, Egypt, India, Indonesia, Jordan, Morocco, Nepal, Pakistan, Philippines, Sri Lanka, Thailand, Tunisia, and Yemen.

In summary, there is evidence indicating that:

1. Development, as represented by income growth, results in more rapid growth of agricultural imports than exports.
2. A large market for feed grain exports in developing countries is a result of increased demand for meat products.
3. The latter effect is caused by income growth rather than expanded population.
4. At least for cereals, increased domestic production displaces imports.

The last point seems to lend support to the argument referred to in the introduction: agricultural-based development reduces the size of international markets for cereals. As will be seen, however, this point needs to be viewed in the broader context of total agricultural trade and development.

MACROECONOMIC FACTORS AFFECTING CONSUMPTION AND TRADE

The relationship between macroeconomic factors and agricultural trade is not well understood. Although there is literature which addresses some of these linkages in developed countries, there is little theoretical work that deals directly with the developing countries.3/ Mellor observes:

> Compared with the immense gains in our understanding of the agricultural development process per se, the relationships between agriculture and the rest of a developing economy remain less fully explored. While there have been many contributions on the subject, the empirical data underlying the relationships asserted are much less complete than is the case with the micro-economics of agriculture -- and hence the policies implied remain more speculative. (21, p. 75)

Macroeconomic Factors

There are four primary macroeconomic variables that can affect agricultural trade and production: prices, interest rates, the real exchange rate, and national income.4/ Since this report is concerned with the impact of economic development on agriculture, the concentration is on income growth, as a proxy for development.5/ With regard to the impact of income growth on the volume and composition of agricultural trade and production, the best available theoretical perspective comes from the relevant elements of trade and development theory concerning: 1) agricultural exports, 2) factors affecting domestic agricultural production, and 3) factors affecting agricultural imports.

3/ Some of the more important literature on the effects of macroeconomic variables on agricultural trade include: Chambers and Just (6), Longmire and Morey (19), Batten and Belongia (4), and Schuh (27).

4/ Timmer (28, pp. 228-229) identifies five macroeconomic prices (wage rates, interest rates, land rental rates, foreign exchange rates, and the urban-rural terms of trade). However, his interest is primarily with the impact of macroeconomic policy on performance of the domestic agricultural (food) sector.

5/ In large part, the exclusion of other variables can be justified by the decision to use a cross-sectional data base. Prices, interest rates, and exchange rates are treated as fixed variables for a given year.

It is assumed that a country's agricultural exports are determined by its comparative advantage. A developing country can attract foreign demand, but its exports must be priced and, therefore, produced competitively. A developing country will not be able to sustain a significant volume of exports of a particular agricultural commodity if it does not have a comparative advantage.6/ To compete internationally, a country attempting to export an agricultural commodity that it produces inefficiently would need to subsidize the sale of that commodity. Such a policy is not only expensive, but would also constitute a subsidy to the importer. Such a policy may occur occasionally among developing countries, largely for political reasons; however, such actions are costly and are an exception.

Production and Development

It is assumed that agricultural import demand is a function of domestic demand and production. Any conclusions about the relationship between import behavior and economic development must be preceded by an investigation of domestic consumption and production responses of agricultural commodities to economic development.7/

Aggregate consumption is a positive function of national income.8/ The income elasticity of demand for different commodities or commodity groups can take on a wide range of values and in a few cases can be negative. Since income elasticity of demand is relatively high for low-income groups, but decreases as per capita income increases, we expect the increase in demand for agricultural commodities to be greatest among low-income countries experiencing income growth.

This principle cannot be applied uniformly to all agricultural commodities. Apart from the number of substitutes available, consumer preferences cause the basket of agricultural goods to change as income increases. For example, at some point in the development process, we expect the food use of staple grains per capita to level off or possibly decline, and the consumption of other, more expensive, food products to increase. Therefore, while the consumption of agricultural goods is expected to increase as income increases, some variation is expected in this pattern among commodities. Specifically, we expect consumption of food grains to be the least responsive to income changes, while meats and feed grains are thought to be more responsive.9/

The response of agricultural production to increases in per capita income is determined by the interaction of three factors which are integral to the

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6/ This does not mean that policies cannot discourage exports of commodities in a country that does not have a comparative advantage. This problem is common in many developing countries.

7/ The terms "income growth" and "development" are used interchangeably.

8/ Although we deal with aggregates, all variables are expressed in per capita terms. For this reason, population is not explicitly considered in this discussion.

9/ Just as the income elasticity of demand for agricultural commodities will vary among nations because of income differences, the distribution of income within countries will affect aggregate income elasticities. The intracountry elasticity will be large for low-income groups and will decrease as income increases.

development process: technological change in the agricultural sector, net resource transfers out of the sector, and government policy. The first factor helps to increase the supply capacity of the agricultural sector, while the second, when taken alone, tends to reduce the sector's productivity.

The third factor, government policy, is more difficult to assess. Traditional theory suggests that most countries use both imports and domestic production to meet increased domestic demand. A country will import agricultural commodities for which it does not enjoy a comparative advantage. However, this rather narrow view ignores the third factor, the role of the public sector.10/ The impact of government policy on productive capacity of agriculture can be either positive or negative and is capable of dominating the first two factors. The net effect depends on a mix of local factors and the particular view of the development process held by local decisionmakers.

The Role of the Public Sector

Theories about the role of the agricultural sector in development have ranged from agriculture being perceived as an outmoded entity that should function primarily as a source of labor for industrial development to being viewed as the leading sector in an export-oriented strategy.11/ Most strategists agree that the development process centers on increasing the value added during the domestic stages of production, but the question remains, how to achieve the increase. The area with the greatest potential for increasing the value added by local factors of production is an industrial/manufacturing sector.12/ For this reason, many economists advocate that agriculture be de-emphasized and that expectations for the sector be limited to providing labor, and possibly other resources, to the industrial sector. Eicher and Staatz summarize this view as follows:

> The propensity of development economists to give relatively little attention to agriculture's potential "positive role in facilitating overall economic growth" was based in part on the empirical observation that agriculture's share of the economy inevitably declines during the course of development for at least two reasons. First, the income elasticity of demand for unprocessed food is less than unity and declines with higher incomes; hence, the demand for raw agricultural products grows more slowly than consumption in general. Second, increasing labor productivity in agriculture means that the same farm output can be produced with fewer workers, implying a transfer of labor to other sectors of the economy. Because agriculture's share of the economy was assumed to be declining, many economists downplayed the need to invest in the agricultural sector in the short run.(10, p. 5)

10/ See Timmer (28) for an interesting discussion of some of these issues.

11/ The literature on the agricultural sector and the development process is enormous. Little (18) provides an excellent overview of development thinking and practice. The World Bank (37) 1982 World Development Report deals with "Agriculture and Economic Development." The 1986 World Development Report features a report on "Trade and Pricing Policy in World Agriculture." Other recent books on this subject are: Lewis and Kallab (17), Hayami and Ruttan (11), Eicher and Staatz (10), Johnson and Schuh (13), and Timmer, Falcon, and Pearson (29).

12/ See Reynolds (25, pp. 56-60) for an analysis of this point during the growth process.

The role of agriculture was further questioned in the fifties by the work of both Prebisch and Singer. Their argument, as described by Eicher and Staatz, is:

> ...that there is a secular tendency for the terms of trade to turn against countries that export primary products and import manufactures. From this they concluded that the scope for growth through agricultural and other primary exports was very limited. Prebisch and his colleagues ...therefore advocated that priority be given to import substitution of manufactured goods rather than to the production of agricultural exports. (10, p. 5)

Not all thinking on the subject was pessimistic about agriculture's role. Eicher and Staatz describe the position of Johnston and Mellor (14) and the impact of that thinking on the profession:

> ...Johnston and Mellor drew insights from the Lewis model to stress the importance of agriculture as a motive force in economic growth. They argued that far from playing a passive role in development, agriculture could make five important contributions to the structural transformation of Third World economies: it could provide labor, capital, foreign exchange, and food to a growing industrial sector and could supply a market for domestically produced industrial goods.
>
> The work of neoclassical agricultural economists during the 1960s stressed not only the interdependence of agriculture and industry and the potentially important role that agriculture could play in economic development but also the importance of understanding the process of agricultural growth *per se* if that potential is to be exploited. (10, pp. 6-7)

More recently, Mellor has advocated "an agriculture- and employment-based strategy of economic growth" which contains three basic elements:

> First, the pace of agricultural growth must be accelerated despite the limitations of fixed land area. Technological change solves a major, special problem of agricultural growth and allows low-income countries to use the most powerful element of growth. Second, domestic demand for agricultural output must grow rapidly despite inelastic demand. This can occur only through accelerated growth in employment (more precisely, increased demand for labor), which is facilitated by the indirect effects of agricultural growth itself. Third, the demand for goods and services produced by low capital-intensity processes must increase. This, too, is facilitated by the technology-based increase in agricultural income. (21, pp. 67-89)

Returning to the question of the response of domestic production to income growth, the effort on the part of government to implement different and often conflicting development strategies makes it difficult to generalize the impact government policy has on the agricultural sector, especially in food production. There does not appear to be a predictable causal relationship between food policy and income growth across countries. A country's implementation of a particular food policy is based on a mix of political and economic forces used to exercise

influence in the country.13/ Recognizing the political importance of even limited food self-sufficiency, it may well be the case that as income increases, domestic food production will also increase. The nonfood areas of a country's agricultural policy are generally less controversial. Even though there may not be a consumer or urban interest group lobbying for a particular policy toward nonfood agriculture, there is still a significant political component in the formulation of policy. Therefore, the behavior of domestic nonfood agricultural production is ambiguous.

Imports

The presence of government policy makes it difficult to forecast the impact of income growth on agricultural imports. In order to ascertain the impact of increased income on agricultural imports, one must first assess the impact on domestic production. Discretionary public sector policy makes it difficult to anticipate the impact of income growth on production. If a food self-sufficiency policy causes domestic production to keep pace with demand, then food imports would not increase. Imports will need to increase, however, if domestic production does not meet demand. If the hypothesis regarding the dominance of political food self-sufficiency considerations is correct, food imports will either decrease or remain unchanged as income increases. This impact of income growth on demand should also apply to nonfood items. The uncertainty surrounding domestic production makes it difficult to form a hypothesis regarding nonfood imports. Finally, it should be stressed that these effects can be tempered by local tastes and may not apply to all crops.

This discussion began with the hypothesis that economic development causes the demand for agricultural products to increase. Since the response of domestic production to economic growth is uncertain, the reaction of agricultural imports to growth is equally uncertain. If public policy favors food self-sufficiency at the expense of economic efficiency, increased domestic food production may meet demand. The opposite will be the case for nonfood agricultural commodities, thus giving rise to an import market for these commodities.

METHODOLOGY

The first step in an empirical test of the relationship between agricultural imports and development is to determine the response of consumption to some

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13/ The importance of the food policy issue and the consideration local decisionmakers must give to domestic political factors is given in Bates (3, p. 35). He argues that,"Since independence the militance of the urban consumers has remained largely unabated. The contemporary histories of many of the independent African nations might credibly be recorded by focusing on major periods of strike action and worker protest...." All of which "bear witness to the continued importance of urban demands for higher standards of living." Given the overriding importance of food availability and prices in determining that standard of living, it is not surprising that many governments hold strong views on maintaining domestic production of some commodities.

It has been suggested that governments could provide lower food prices to urban workers by importing food, rather than relying on domestic production. Such a policy does not take into consideration the influence of domestic agricultural interests in policy formulation.

measure of development.14/ Reliable data on consumption of agricultural commodities in developing countries are unavailable for most countries. Therefore, a proxy variable, "apparent utilization," was used to approximate consumption levels and was defined as domestic production plus imports minus exports for an individual crop or group of crops.15/ Apparent utilization was then regressed on the independent variables. The independent variables are gross domestic product per capita, an alternative measure of development, dummy variables representing four geographical regions, and foreign exchange reserves per capita. Each of the three component parts of apparent utilization was then regressed on the same set of independent variables. It was then possible to assess how the (hypothesized) increase in apparent utilization of agricultural commodities were supplied (that is, through what combination of increased production and/or imports).16/

There is a long and distinguished literature on the question of the measurement of development. Much of this literature centers on the shortcomings of national income per capita as a proxy for development. However, no generally accepted alternatives have been constructed. In this report, gross domestic product per capita (GDPPC) was used as one of the two proxies for development due to the absence of widely accepted alternatives and the number of advantages of national income per capita: for example, it is easily interpreted and is readily available. Since we recognized the shortcomings of the national income measure, an alternative measure of development (ALTDEV), based on the work of Morris, was also used (22). The alternative development variable was computed as a simple

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14/ The specification of a set of variables in a study of this nature leads to compromises. The most obvious constraint is the limited amount of data that are available. In a number of cases, proxy variables were used because data on the desired variable were unavailable. Further, many detailed cross-sectional studies assume that the underlying economic structure and responsiveness to change of the sample members are the same.

15/ Ideally stock data should be included in this definition, but those data are not available. This is unlikely to be a serious shortcoming since the long-term agricultural storage facilities are quite limited in most developing countries.

16/ This specification portrays the agricultural sector as responding to changes in national income and does not explicitly consider that sector's role in income determination. The justification for this assumption is twofold. First, the focus is on the response of agricultural imports to development rather than on income determination. Typically, the impact of the agricultural sector on income comes through exports rather than imports. Second, this is a cross-sectional study, and income is assumed to be exogenous. In other words, the level of development, as represented by one of the two measures, is constant at a single point in time, and the levels of production and trade in the agricultural sector that are associated with each level of development can be investigated.

weighted average of life expectancy at birth, infant mortality, and the percentage of school age children enrolled in primary school.17/

The dummy variables were included to take account of regional differences in consumption and trade patterns. The three regional dummies were defined as follows:

DAF = 1, if the country is in Sub-Saharan Africa, or
= 0, otherwise,
DAS = 1, if the country is in Asia, or
= 0, otherwise,
DLA = 1, if the country is in Latin America, or
= 0, otherwise.

As can be seen from the country list in Appendix I, countries in the sample that do not fall in one of these categories are Mediterranean Basin countries.

Finally, foreign exchange reserves per capita (FERPC) was included in an attempt to account for the possibility of a foreign exchange constraint on imports. If a country did not have adequate foreign exchange, an increase in demand could not be translated into increased imports.

The equations estimated are:

$$AUPC_i = a_1 + a_2GDPPC + a_3DAF + a_4DAS + a_5DLA + a_6FERPC \quad (1)$$

$$MPC_i = b_1 + b_2GDPPC + b_3DAF + b_4DAS + b_5DLA + b_6FERPC \quad (2)$$

$$PPC_i = c_1 + c_2GDPPC + c_3DAF + c_4DAS + c_5DLA + c_6FERPC \quad (3)$$

$$XPC_i = d_1 + d_2GDPPC + d_3DAF + d_4DAS + d_5DLA + d_6FERPC \quad (4)$$

$$AUPC_i = e_1 + e_2ALTDEV + e_3DAF + e_4DAS + e_5DLA + e_6FERPC \quad (5)$$

$$MPC_i = f_1 + f_2ALTDEV + f_3DAF + f_4DAS + f_5DLA + f_6FERPC \quad (6)$$

$$PPC_i = g_1 + g_2ALTDEV + g_3DAF + g_4DAS + g_5DLA + g_6FERPC \quad (7)$$

$$XPC_i = h_1 + h_2ALTDEV + h_3DAF + h_4DAS + h_5DLA + h_6FERPC \quad (8)$$

where:

AUPC = apparent utilization per capita
MPC = imports per capita

17/ The observations on each of these variables are scaled as index numbers with ranges of 1 to 100. For example, suppose the values for the life expectancy variable lie between 37 and 77, the range would be 40 and, therefore, each "point" on the index would represent 2.5 points on the life expectancy scale. For example Ethiopia, with a life expectancy at birth of 40 years, would be computed as (40-37)*2.5 equals 7.5. The index values for each of the three variables are averaged using equal weights. The scale of the infant mortality variable is reversed so that a larger value will represent an improvement in mortality rates. The values for the three variables used to construct the ALTDEV variable for each country in the sample are presented in Appendix I.

PPC = production per capita
XPC = exports per capita,
i = an individual commodity or commodity group

The commodities included in the analysis were barley, oats, wheat flour, wheat grain, maize, rice, soybeans, sunflower seeds, sesame seeds, and groundnuts. The following commodity groups were analyzed: total cereals (wheat and meslin, wheat flour, rice, barley, maize, rye, oats, and cereals not included elsewhere), food grains (wheat and rice), feed grains (barley, rye, oats, and maize), oilseeds (soybeans, rape and mustard seed, sunflower seed, sesame seed, linseed, groundnuts, copra, and palm kernels), and total meat (total fresh, frozen, and chilled meat products).

The data used in the study came from three sources: the Food and Agriculture Organization of the United Nations (FAO), the International Monetary Fund (IMF), and the World Bank. Data on the volume of imports, exports, and domestic production by commodity and commodity group were supplied by FAO. Data on foreign exchange reserves were taken from the IMF's International Financial Statistics. Data on income per capita, population, child mortality, life expectancy at birth, and percentage of school age children enrolled in primary school were taken from the World Development Report (37).

The sample was constructed by selecting all non-oil exporting countries with a per capita GDP of less than $10,000 per annum. Since the study focused on developing countries, European countries were excluded from the sample. Also, developing countries with limited data were excluded. The only difference between the 1977 and 1980 samples is the exclusion of Afghanistan from the latter period. A listing of the countries (67 countries for 1977 and 66 for 1980) can be found in Appendix I.

In summary, we have specified a general model of agricultural activity arguing that data availability problems and the diversity of the country sample limit the amount of detail that can be incorporated. The model was predicated on the assumption that the structural change that accompanies the development process causes the patterns of consumption, production, and importation of agricultural products to evolve in a predictable manner. While the methodology did not allow a detailed country-specific analysis of these patterns, it did provide insight into broad behavior patterns.

THE IMPACT OF PER CAPITA GDP ON UTILIZATION, PRODUCTION, AND TRADE

Before presenting the estimation results, it is useful to preview the relationships between the variables. Figure 1 shows the value of total agricultural imports for the three major regions in the sample and provides a perspective on regional levels of agricultural imports for 1977. Figure 2 presents the average (country) value of agricultural imports for the various income groups in the sample.18/ Although not all income groups conform, there is a clear pattern of increasing agricultural imports as income increases.

18/ The sample was divided into 10 income groups, all but the first and last have a range of 100. The first category has a range of 0-199. Average imports were plotted on the vertical axis since the number of countries in each income group differed.

Figures 3 and 4 illustrate the volume of food grains imported by region and income group. As was the case for total agricultural imports (figure 1), Asia is the leading food grain importer. The pattern of food grain imports plotted against income groups does not show a positive correlation.

Figures 5 and 6 depict the volume of feed grain imports by region and income group. Volume is more closely associated with income levels for feed grains than for food grains, since the Latin American countries have a substantially higher per capita GDP ($1,097) than either the African ($318) or Asian ($385) countries used in the sample. This trend is also in evidence in figure 6. The level of feed grain imports is lower than the level of food grain imports for all countries; however, this gap seems to narrow as income increases.

Figures 7 and 8 depict the volume of oilseed imports by region and income group. Oilseeds appear to be a less important import commodity for developing countries than either food or feed grains. Among the very low-income countries (those with incomes less than $650 per capita), oilseed imports pale in comparison to feed and food grain imports.19/ Figures 9 through 20 present a more disaggregated perspective on the data.

Figures 9 and 10 show the relationship between gross domestic product per capita (GDPPC) and the value of agricultural imports per capita for 1977 and 1980, respectively. While there is considerable variation around a trend line, the data for both years show an upward trend in imports as income increases. Confirming this impression are the results of regressing the total value of agricultural imports per capita (MTAPC) on GDPPC, the regional dummy variables, and foreign exchange per capita, the results presented in table 1 for both 1977 and 1980. The GDPPC variable is significant in both years and indicates that a $1 increase in per capita GDP is associated with a 1-percent increase for 1980 and a 2-percent increase for 1977 in the income spent on agricultural imports. The size of this coefficient may appear small at first glance, but such an impression is misleading. For example, a 5-percent increase in per capita GDP in the Philippines (an increase of $23 from its 1977 level of $450) would increase imports to approximately $20 million. The significance of the regional variables indicates differences in import levels by geographical area.20/ The comparatively high adjusted R-squared statistic means that the pattern of increasing agricultural imports associated with increasing per capita GDP is typical of the whole range of incomes in the sample.

Figures 11 and 12 plot GDPPC against the value of agricultural exports per capita for 1977 and 1980. As shown in the illustration and confirmed by regressing the value of agricultural exports on the same set of independent variables (table 1), there is no discernible relationship between exports and per capita income growth. The significance of the export equations, as represented by the results of the "F" test, stems largely from the importance of agricultural exports in the

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19/ "Oils" and "cakes and meal" were not included because of data deficiencies. Because the processing capacity of many developing countries is frequently limited, they may import these commodities directly rather than in "seed" form.

20/ A significant coefficient on any one of the dummy variables indicates that the particular activity represented in that equation, e.g., imports, in that region differs from that in the Mediterranean Basin by the amount of the coefficient. This applies only to the intercept and not to the slope, i.e., the response of the dependent variable to changes in the independent variables.

Figure 1
Agricultural imports: Value by region, 1977

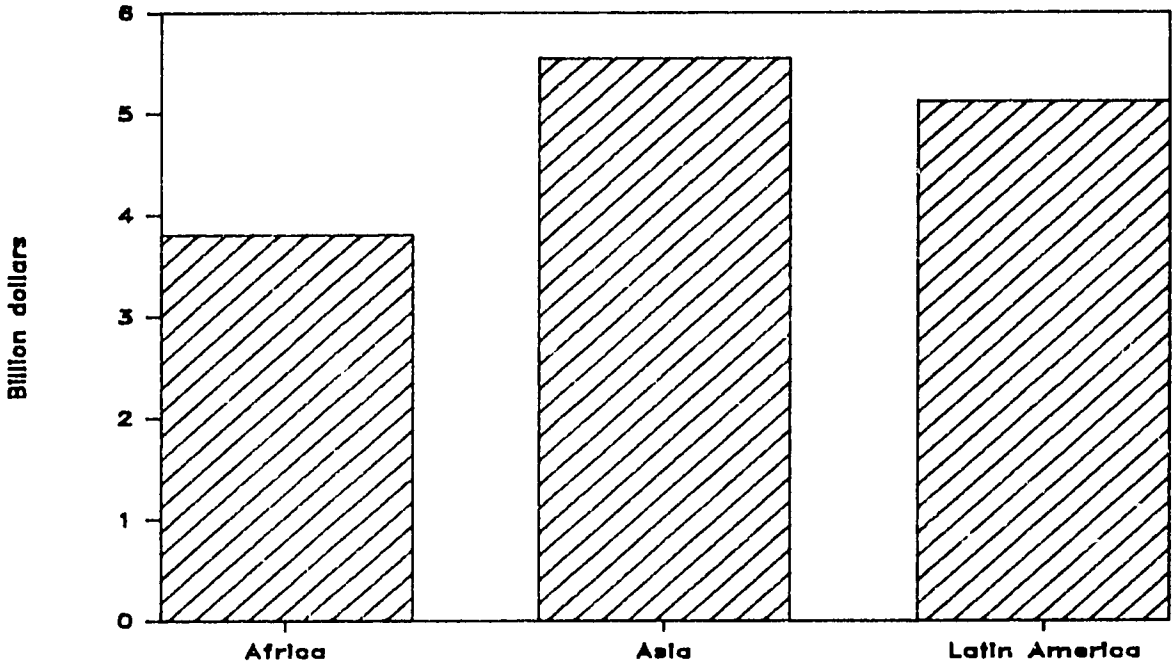


Figure 2
Agricultural imports: Average value by income group, 1977

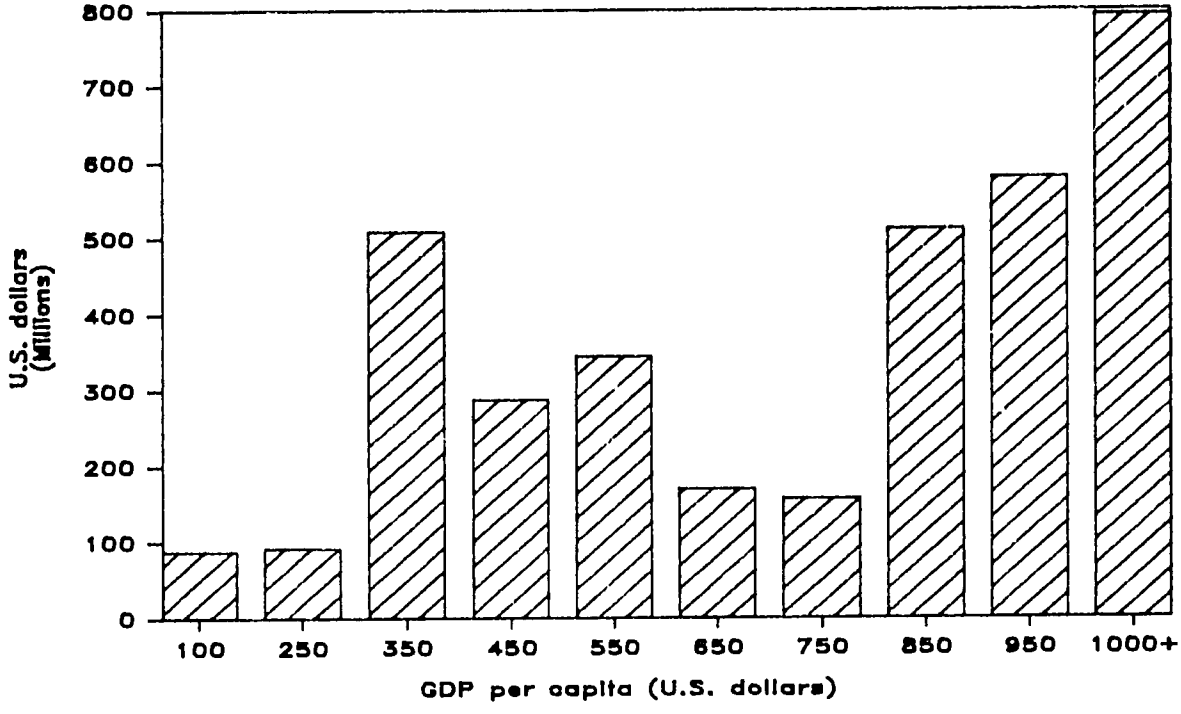


Figure 3
Food grain imports: Volume by region, 1977

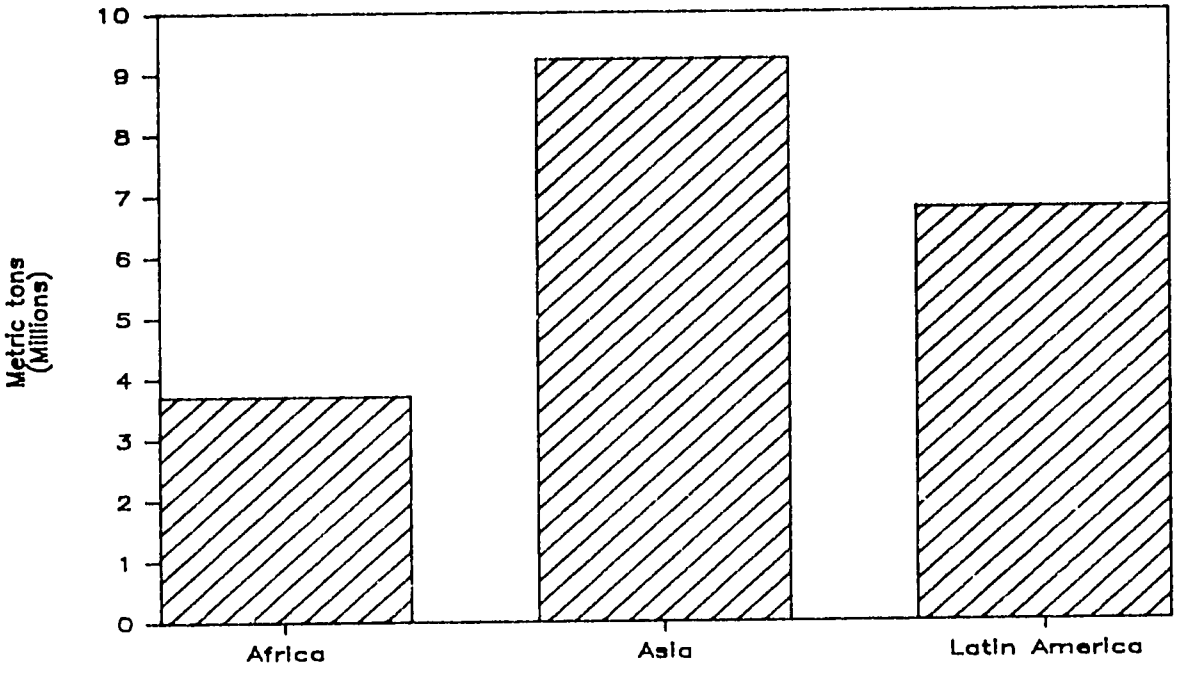


Figure 4
Food grain imports: Average volume by income group, 1977

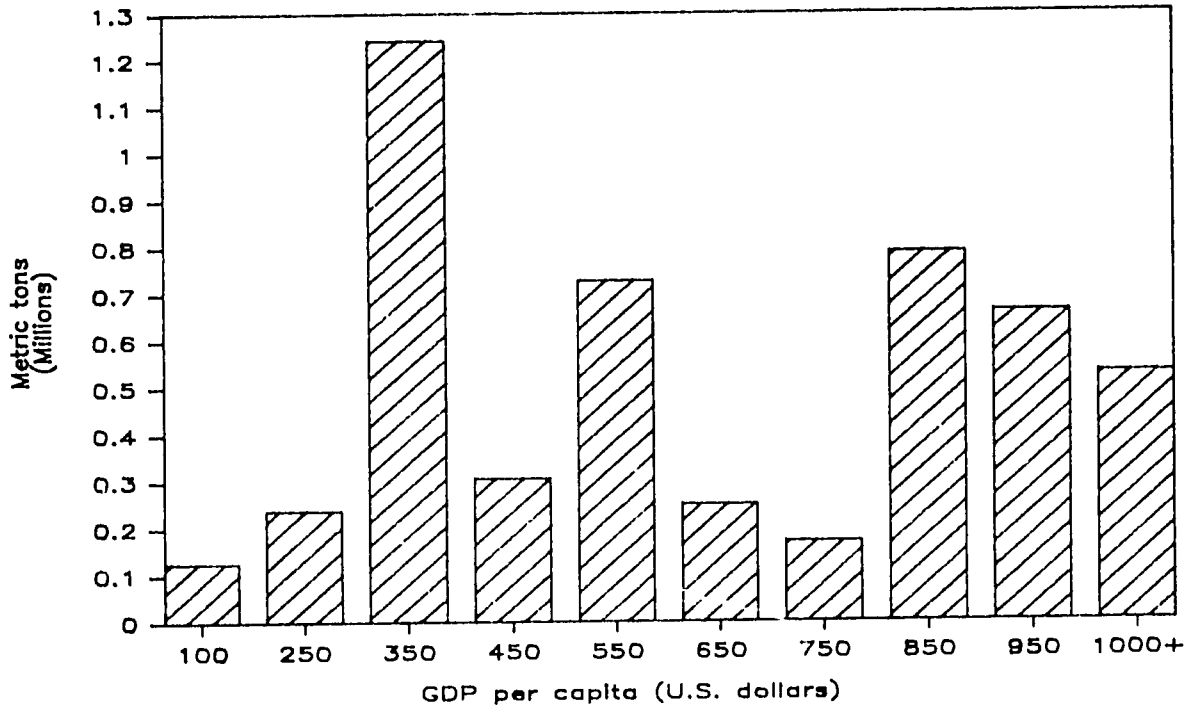


Figure 5
Food grain imports: Volume by region, 1977

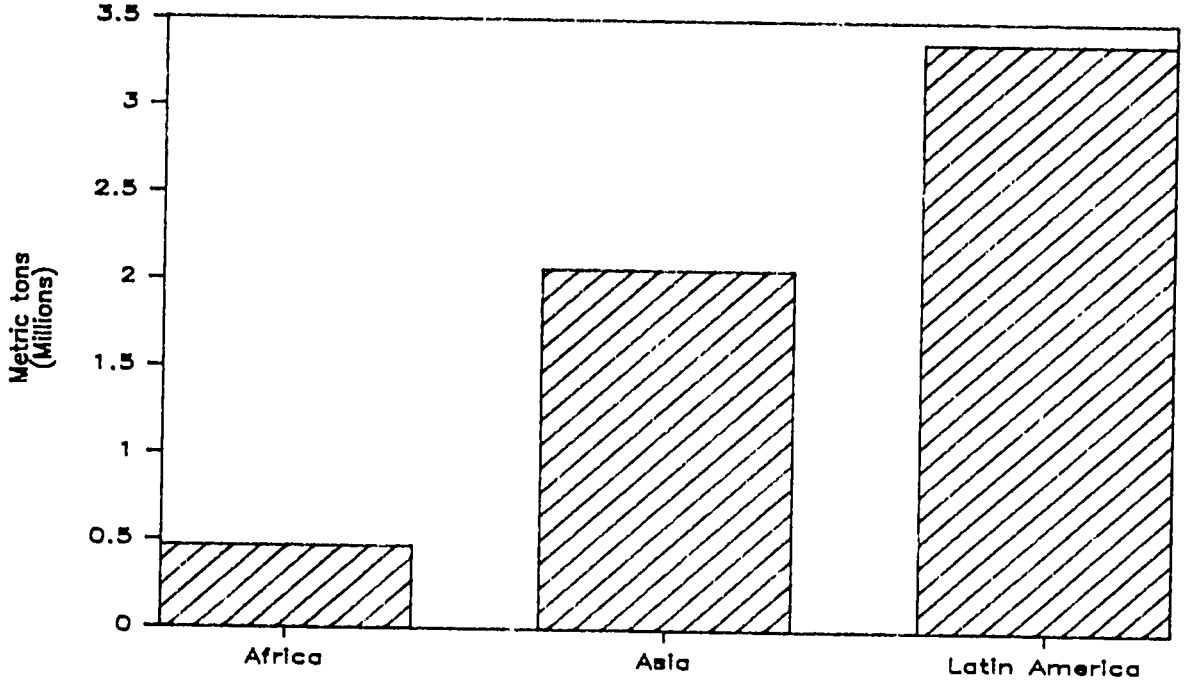


Figure 6
Feed grain imports: Average volume by income groups, 1977

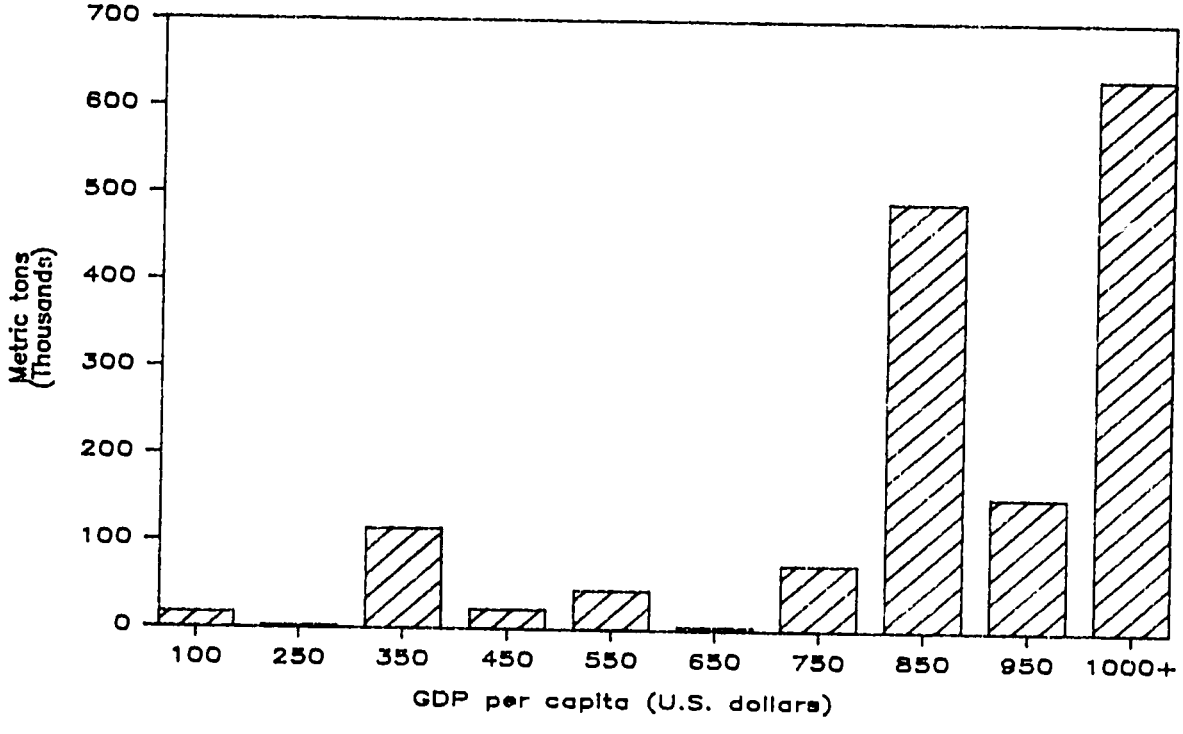


Figure 7
Oilseed imports: Volume by region, 1977

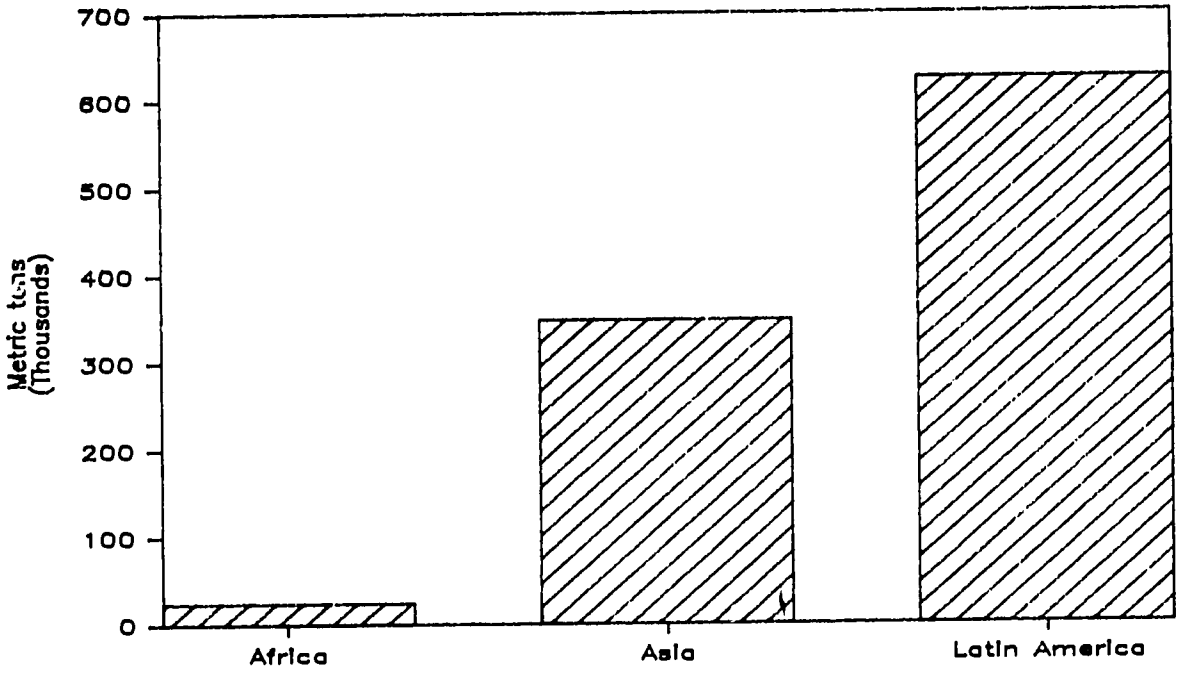


Figure 8
Oilseed imports: Average volume by income group, 1977

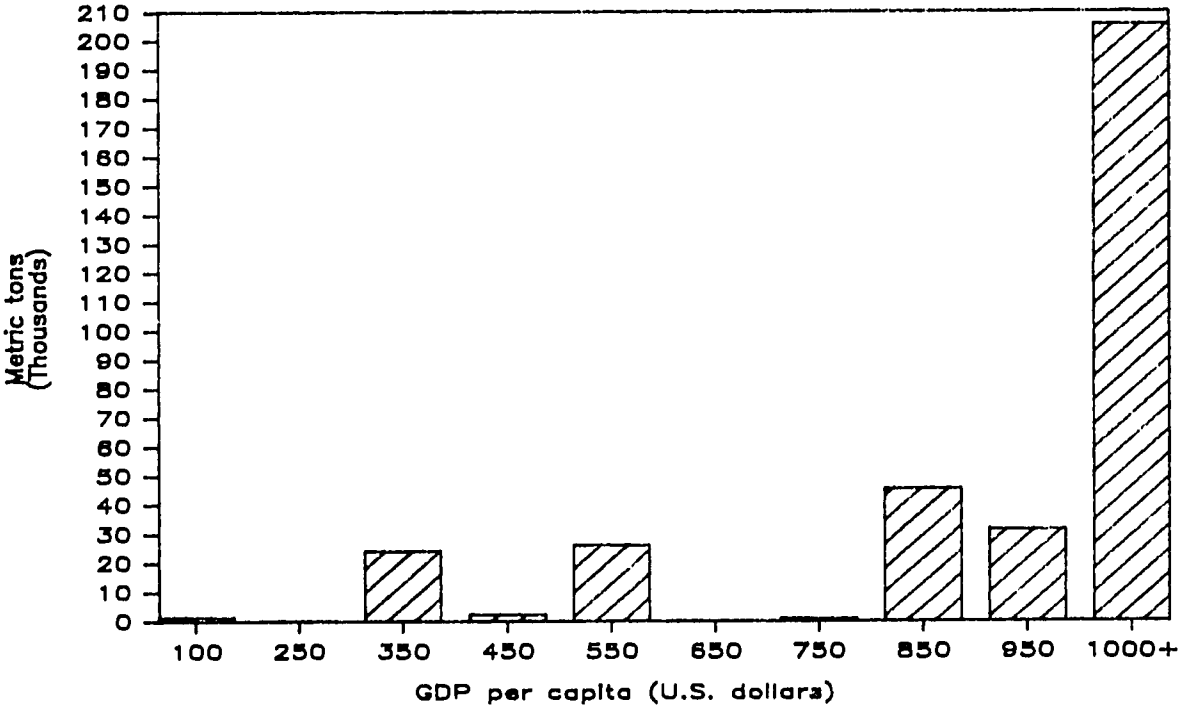


Figure 9
Total value of agricultural imports per capita, 1977

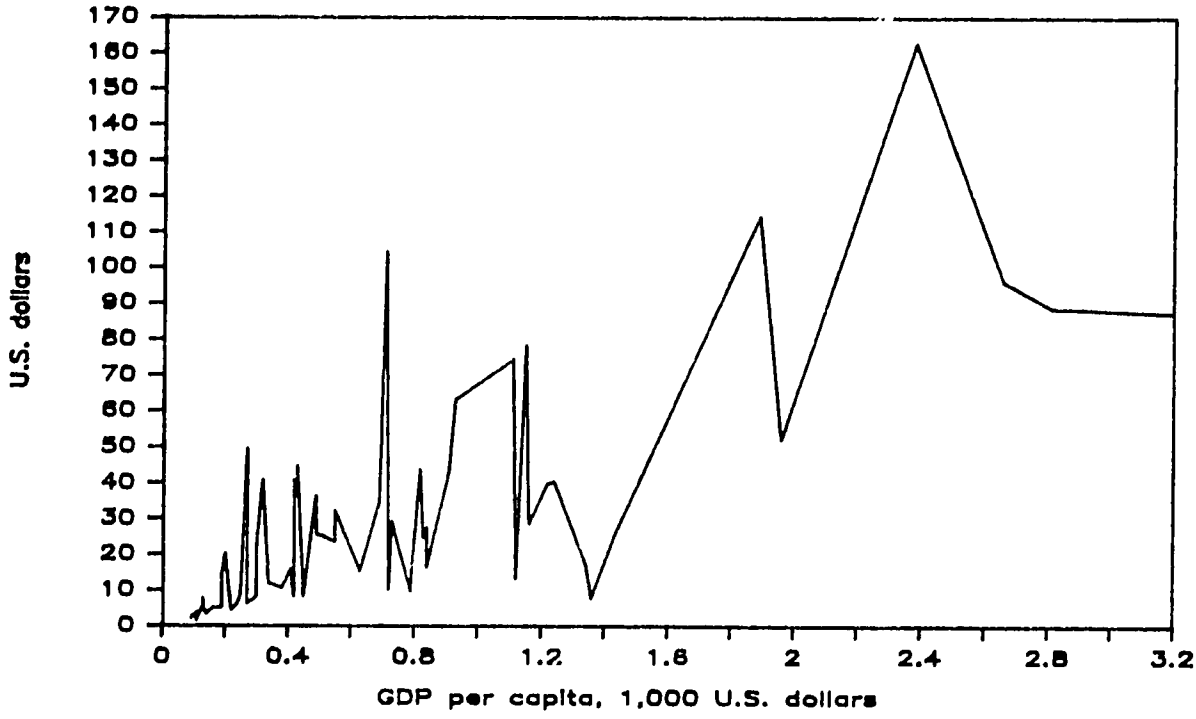


Figure 10
Total value of agricultural imports per capita, 1980

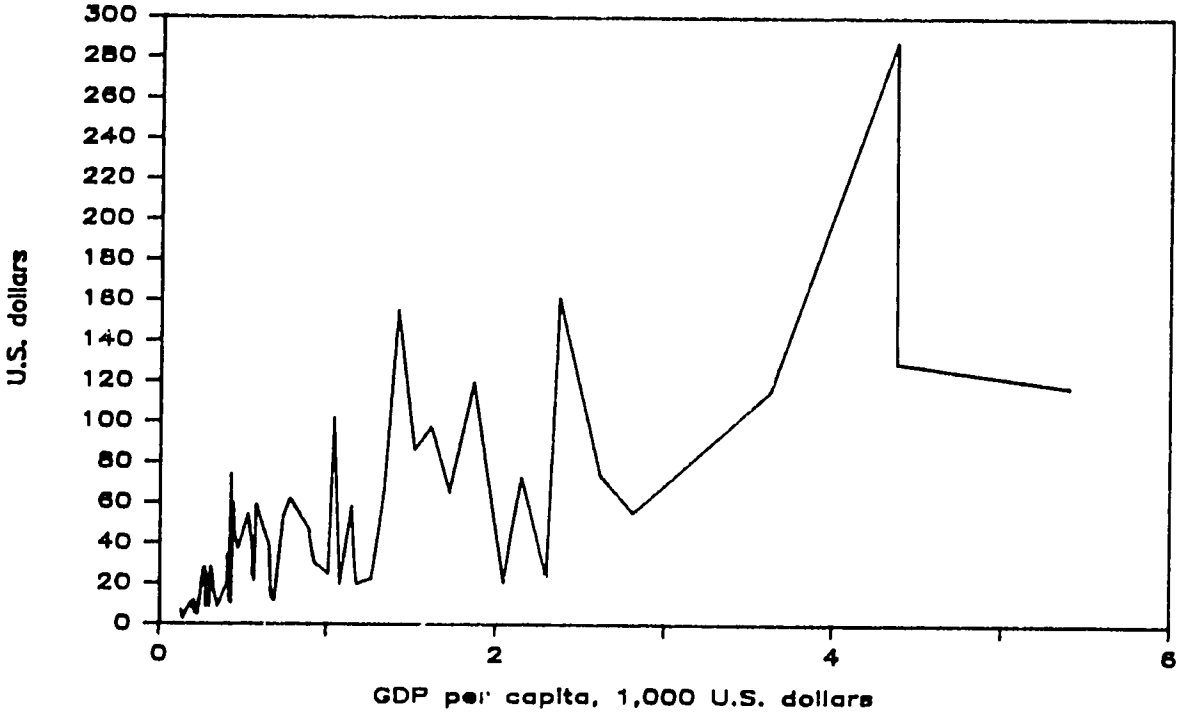


Figure 11
Total value of agricultural exports per capita, 1977

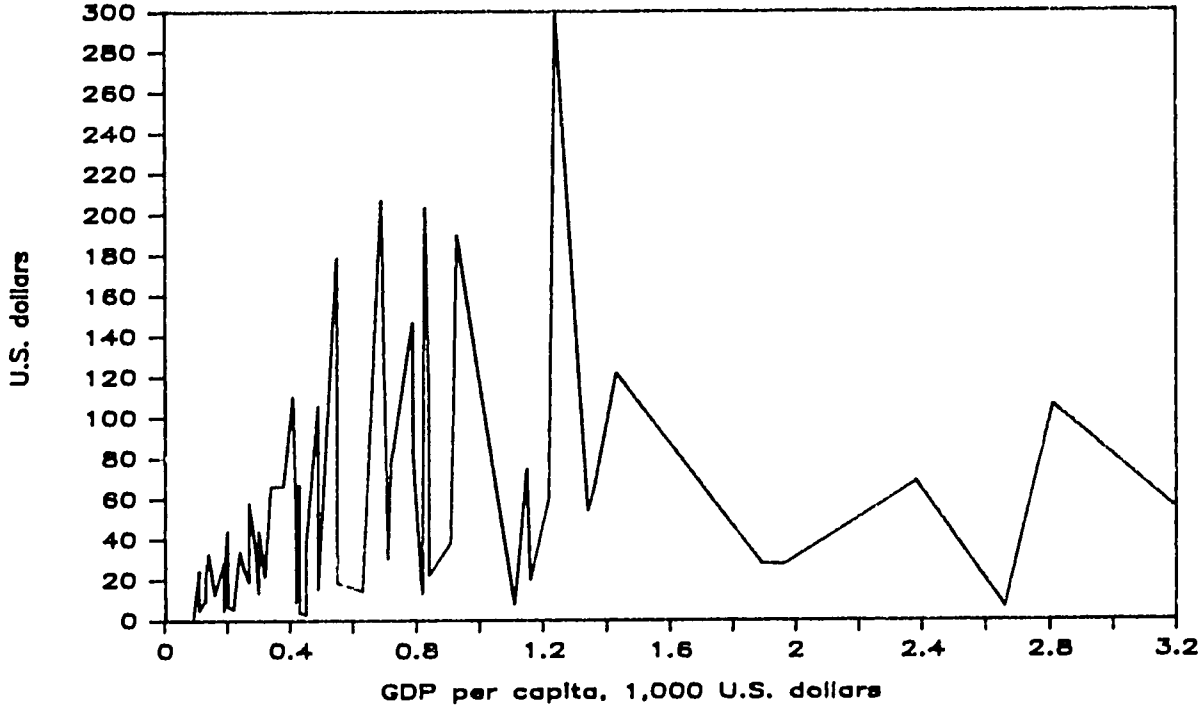


Figure 12
Total value of agricultural exports per capita, 1980

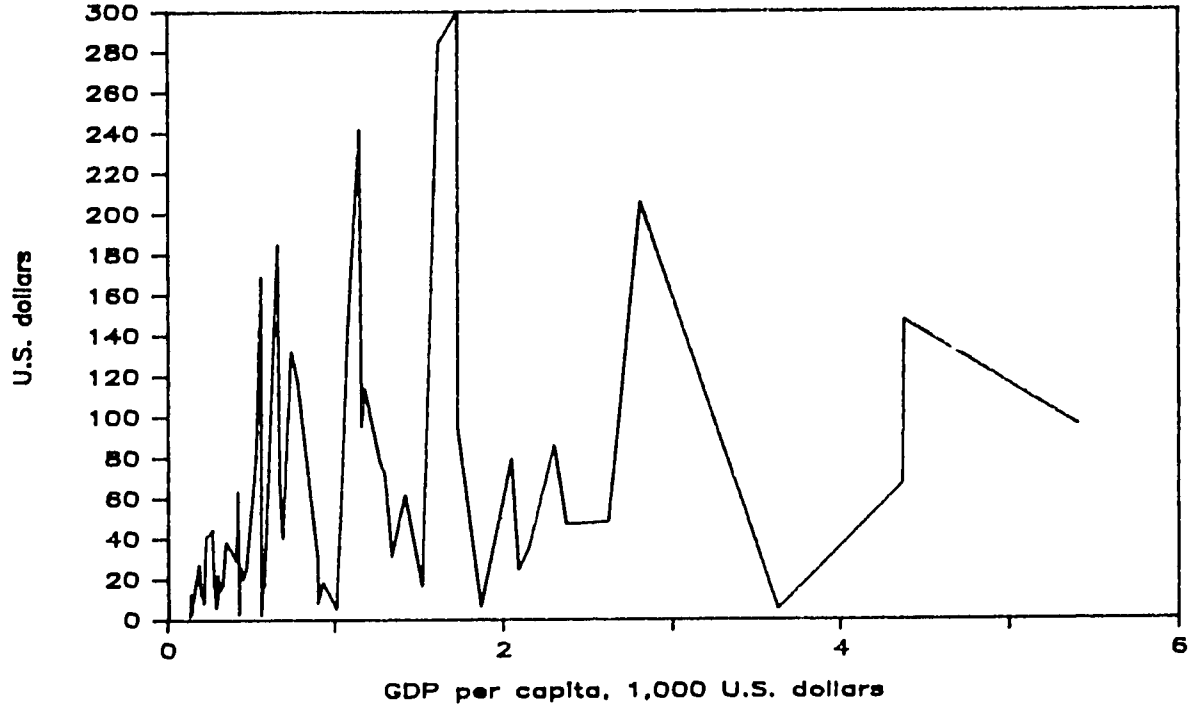


Figure 13
Apparent utilization of food grains per capita, 1977

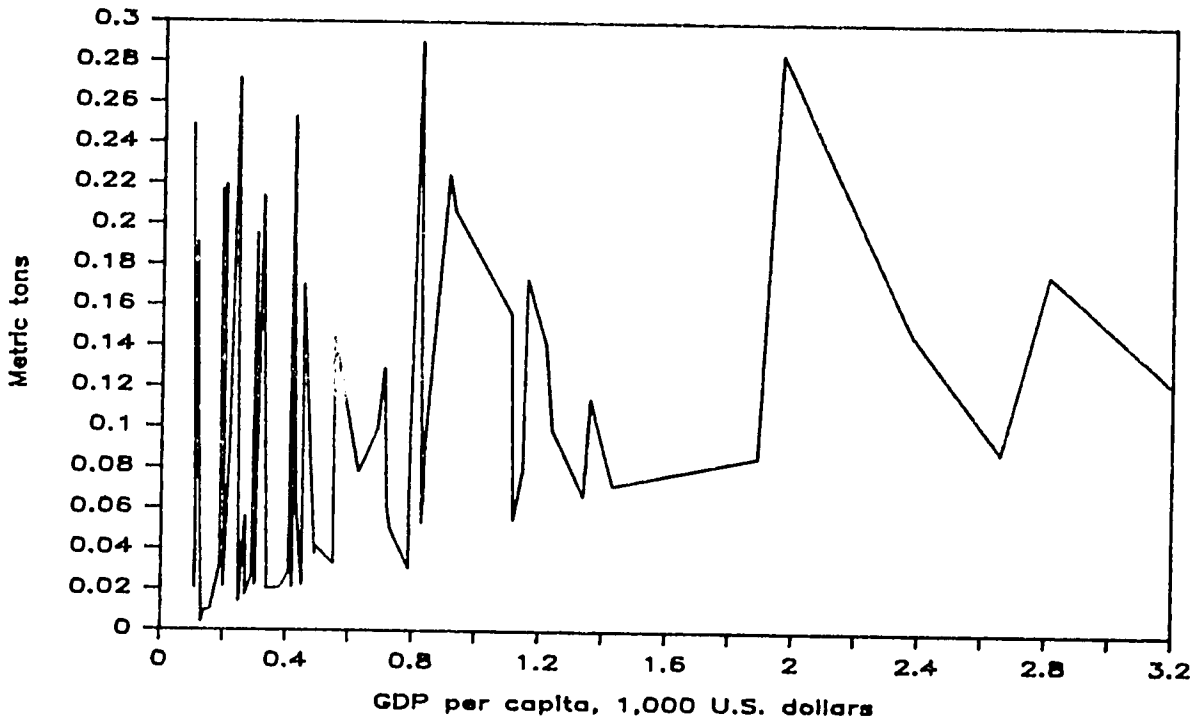


Figure 14
Production of food grains per capita, 1977

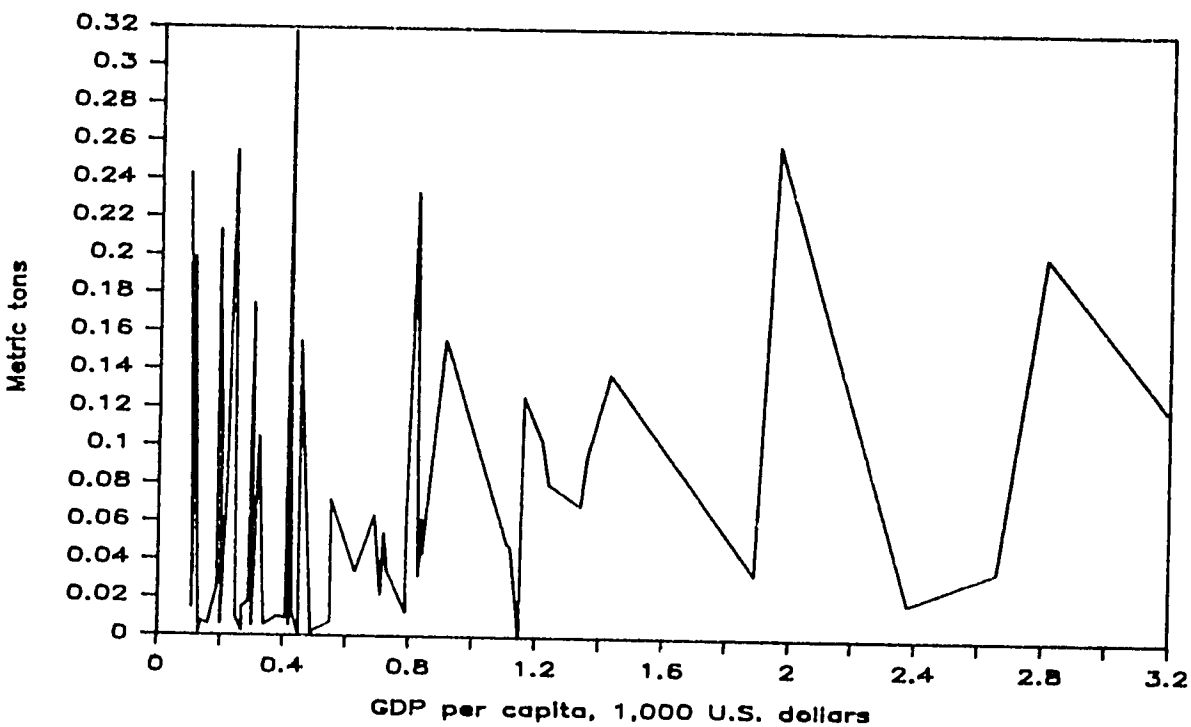


Figure 15
Imports of food grains per capita, 1977

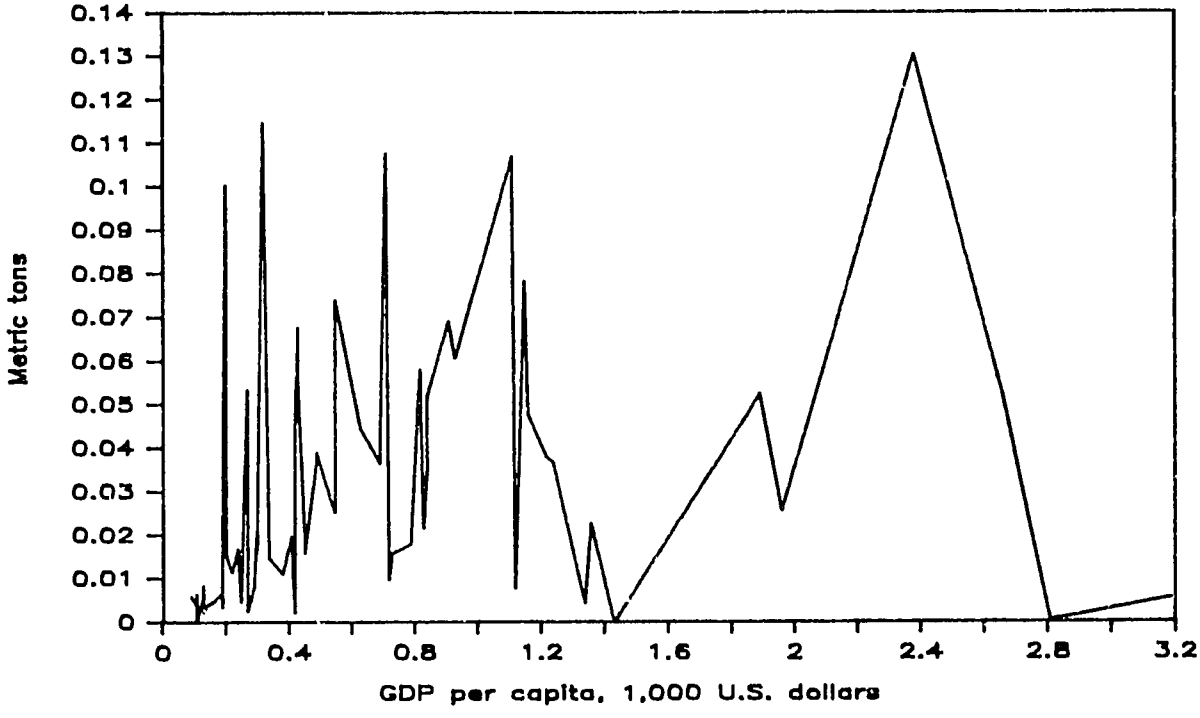


Figure 16
Exports of food grains per capita, 1977

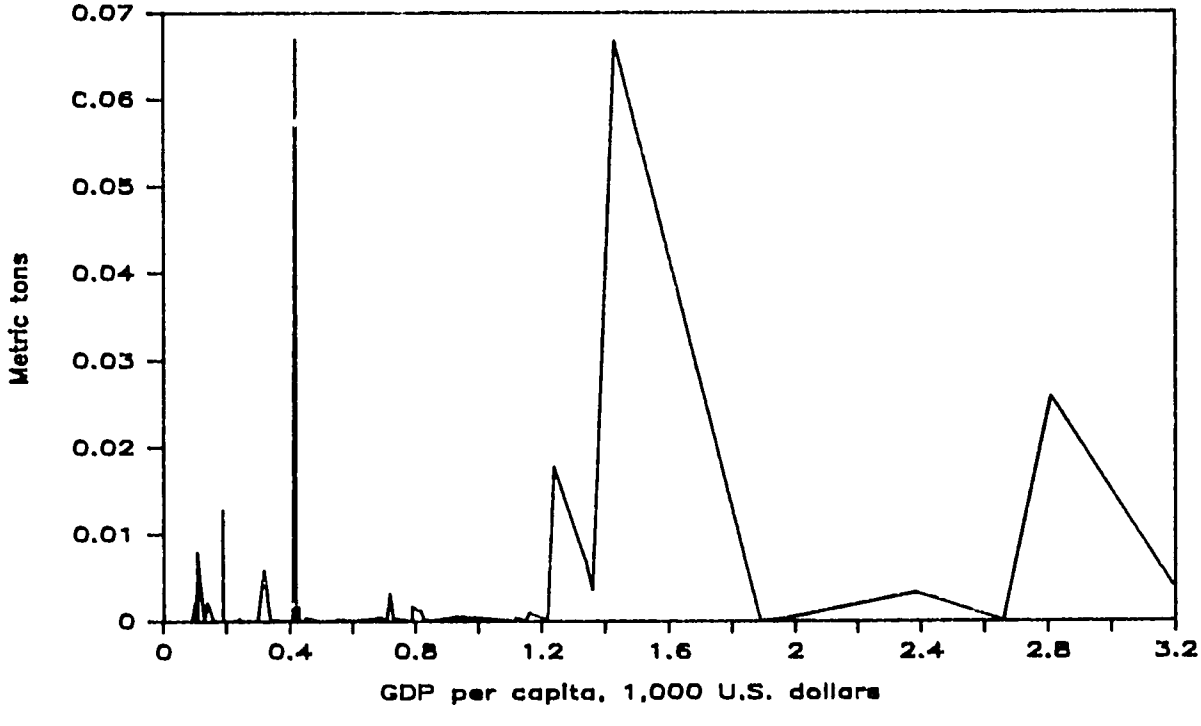


Figure 17
Apparent utilization of feed grains per capita, 1977

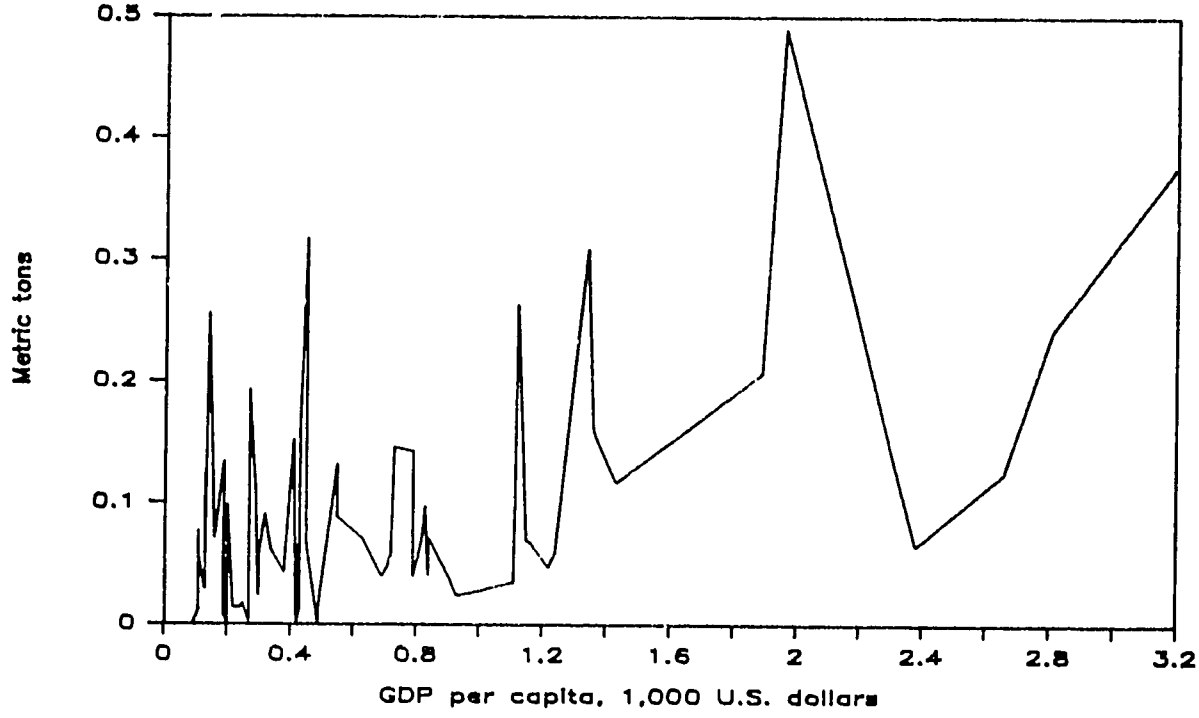


Figure 18
Production of feed grains per capita, 1977

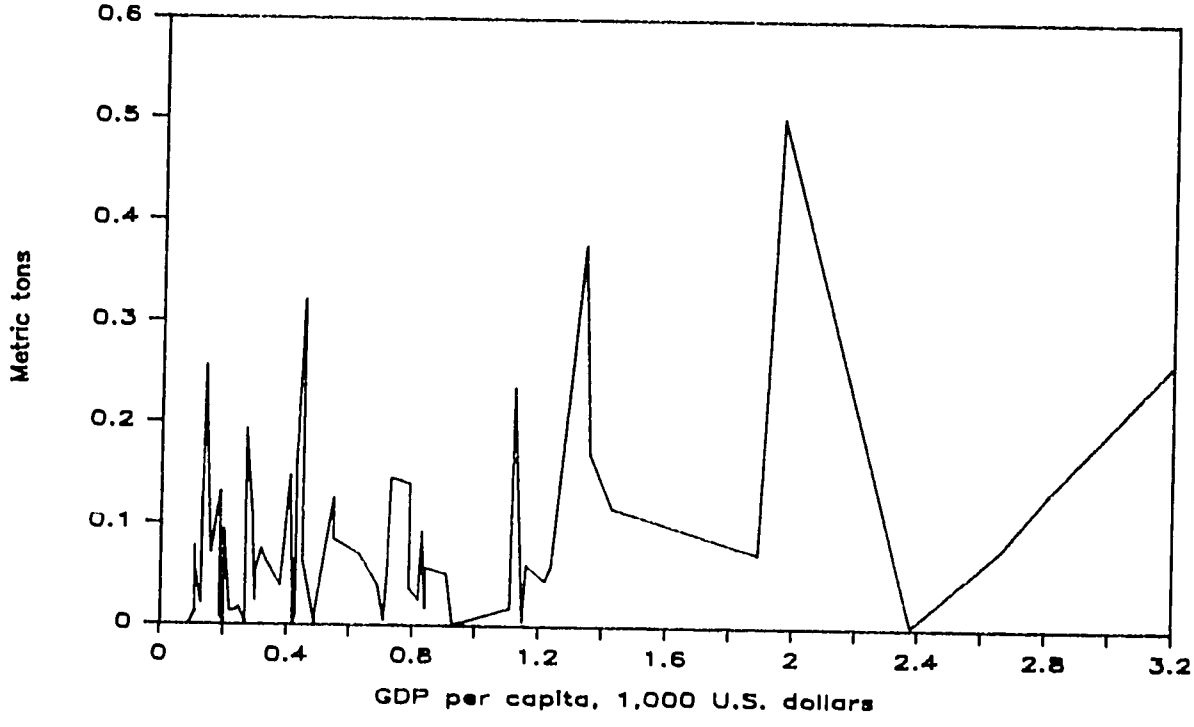


Figure 19
Imports of feed grains per capita, 1977

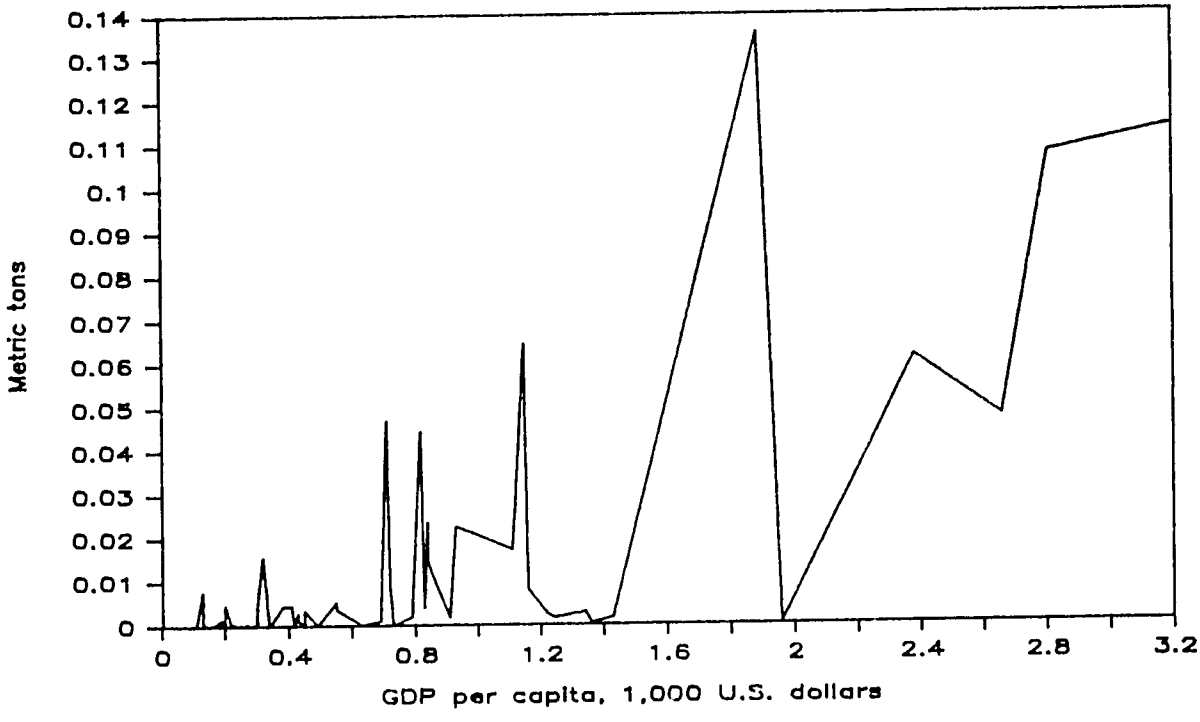
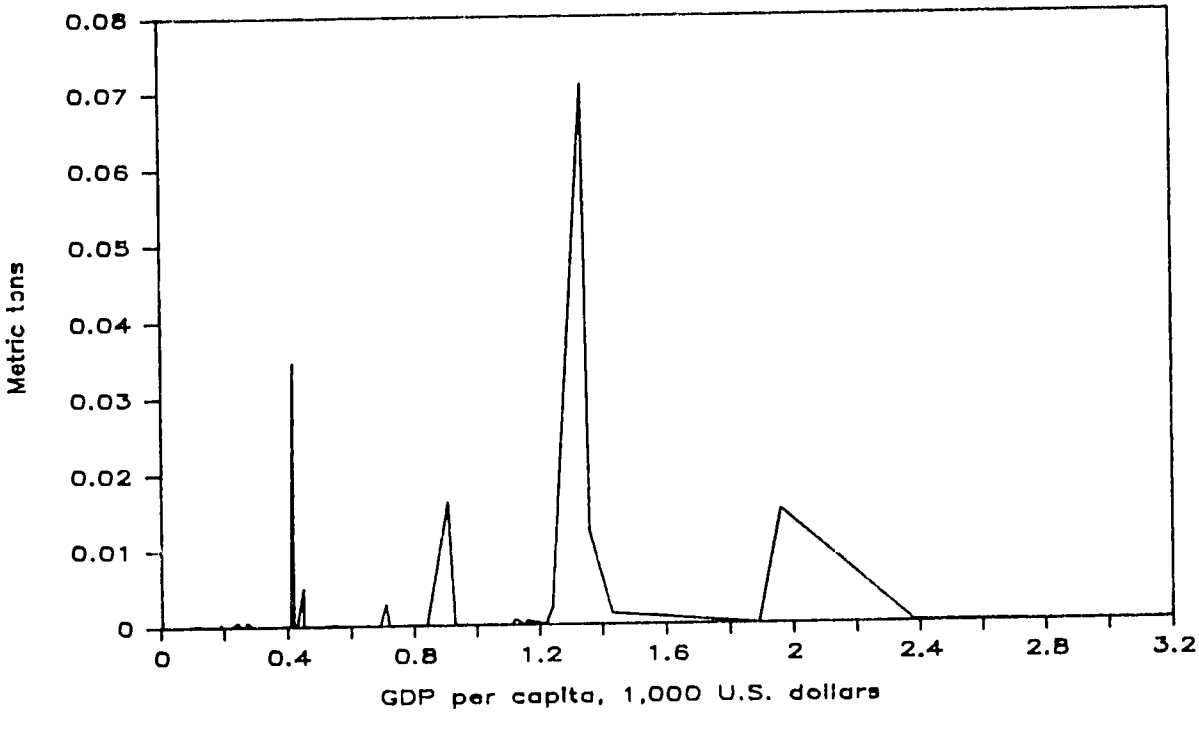


Figure 20
Exports of feed grains per capita, 1977



Latin American region. Except for the weak association in 1980 (at the 10-percent level), the value of agricultural exports is not correlated with per capita income growth.

Table 1--Estimation results for the total value of agricultural imports and exports, 1977 and 1980

Dependent variable	Independent variables					Adjusted R-squared
	GDPPC	DAF	DAS	DLA	FERPC	
Imports-1977 (MTAPC)	0.02* (3.7)	-30.05* (-4.0)	-30.73* (-3.8)	-34.46* (-5.3)	0.97* (7.3)	0.77*
Imports-1980 (MTAPC)	.01* (2.8)	-48.39* (-4.4)	-41.92* (-3.4)	-42.77* (-4.3)	.10* (7.9)	.77*
Exports-1977 (XTAPC)	.02 (1.2)	17.35 (.7)	22.37 (.8)	65.44* (2.8)	-.04 (-.8)	.15*
Exports-1980 (XTAPC)	.02 (1.9)	25.32 (.9)	33.19 (1.1)	62.70* (2.5)	-.04 (-1.2)	.21*

Note: The "t" statistic is in parentheses beneath each coefficient. The critical value for the "t" statistic at 5 (10) percent is 2.00 (1.67). An asterisk on the coefficient denotes statistical significance at the 5-percent level. The critical value for the F-statistic at 5-percent is 2.37. An asterisk on the adjusted R-squared is used to denote a significant "F" statistic.

Figures 13 through 16 illustrate the relationship between per capita GDP and apparent utilization, production, import, and export of food grains, respectively, in 1977.21/ It should be stressed that these figures only provide a perspective on the data; the more substantive analysis is provided by the regression estimates. The most notable characteristic about these illustrations is the considerable variation displayed. Some caution should be exercised when interpreting these figures because allowances for regional variations have not been made. However, the illustrations help to make an important point that can be applied to all commodities in the study. Even though an underlying correlation between the dependent variables (apparent utilization, production, exports, and imports) and per capita income may be detected by examining the figures, variation among individual countries, presumably due to policy differences, may overwhelm these income effects. These policy differences can be based on taxes or subsidies applied to certain crops in some countries, but not others.

There appears to be a clear positive correlation between apparent utilization of food grains and income growth. A similar, but weaker relationship is evident for production of food grains and income growth. Imports and exports of food grains seem to have no correlation with income expansion.

21/ Illustrations of the 1980 data are similar to those for 1977 and, therefore, are not included.

Figures 17 through 20 show the relationship between apparent utilization, production, exports, and imports of feed grains and per capita income. Again there is considerable variation in the data series. Apparent utilization, production, and imports show a discernible increase as per capita income increases. Feed grain exports do not display a positive correlation with income growth.

Apparent Utilization and Income Growth

The results of regressing apparent utilization of various commodities and commodity groups on independent variables (GDPPC, DAF, DAS, DLA, and FERPC) for 1977 and 1980 are presented in tables 2 and 3, respectively.22/ There was a significant relationship between GDPPC and apparent utilization of all commodity groups in 1977, except food grains. A similar result was obtained for 1980, except that income was insignificant in both the oilseed and food grain equations. It was hypothesized that imports of food grains would not increase as income rose and that apparent utilization would increase with income. There are three possible explanations for the absence of a significant relationship between food grain utilization and income growth. First, the food grains category includes only wheat and rice; maize, an important food grain, is excluded. Unfortunately, this cannot be corrected because it is impossible to distinguish between the use of maize as a food and as a feed grain.23/ Second, it may be that one of these grains is an inferior good. As income increases, consumers may prefer other foods and possibly other grains, such as wheat. The results for the apparent utilization of wheat flour, discussed below, lend some support to this notion. Third, the results may be due to an aggregation problem, such that the lack of a trend in rice overshadows a possible relationship between wheat flour consumption and income. This suggests that there may be a specification bias in this particular equation and that the marginal propensities to consume various food grains differ across countries. If this is the case, a different specification of the dummy variables would be required to detect the effect.

The significance of the dummy variables, as initially formulated, indicates that regional variations in the level of apparent utilization do occur and that they are not consistent across commodity groups or time. For example, Latin America's apparent utilization of food grains was less than that for Asia in 1977, while

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22/ Throughout this section, the reader is provided with numerical interpretations of the estimated regression coefficients rather than with income elasticities. These estimates should be treated with caution. They are included primarily to aid in the interpretation of the coefficients and should not be viewed as precise estimates. Income elasticity computations are somewhat easier to interpret; however, the income range of the sample size is so large that it is doubtful that a meaningful elasticity can be computed. However, estimated elasticities are computed in Appendix IV.

23/ The 1977 data were disaggregated into three groups based on which of the three commodities (maize, wheat, or rice) a country used as a staple crop. To qualify as the staple crop, the commodity had to account for at least 50 percent of the total apparent utilization of the three grains. Only 12 countries had wheat as a staple crop, which did not allow sufficient degrees of freedom for an analysis. Rice use in 21 countries did not display a significant relationship between apparent utilization and GDPPC. Maize consumption in 25 countries had a positive and significant relationship with GDPPC. Because it is impossible to distinguish between feed and food grain use of maize, it is impossible to argue that apparent utilization of maize as a food grain increased as income rose.

there was no significant difference between regions for feed grain utilization. The same pattern of differences was evident for food grains in 1980, but feed grains in Africa, Asia, and Latin America were all lower than those for the Mediterranean Basin countries. The signs on the regional variables are negative (especially for African and Latin American countries), indicating that initial levels of apparent utilization (as represented by the intercept) are significantly less than those found in the Mediterranean Basin countries. This is likely due to a range of factors, such as income differentiation, tastes, and environment.24/

The meat equation has the best fit for both years, with the GDPPC variables highly correlated with the volume of meat consumption. The ratio of the unrounded coefficient on GDPPC in the feed grain equation to that in the meat equation was 4.6 in 1977 and 4.9 in 1980.

The foreign exchange variable is included in the apparent utilization equation because it is hypothesized to have an influence on the imports variable, which is a component of the apparent utilization variable. With this being the case, the FERPC variable will be discussed in the context of import equations.

The results for apparent utilization of individual commodities are consistent with those for aggregate commodity groups. Neither wheat grain nor rice displays a utilization response to income growth. The overall significance of the two food grain equations is the result of regional differences. The feed grains which display a significant response to income growth are barley, oats, and maize. The coefficients on the GDPPC variable relate to the dependent variable, which is measured in metric tons. The coefficient on GDPPC is expressed in scientific notation, E-03. When metric tons were converted to pounds, the increases in apparent utilization per capita of barley, oats, and maize in response to a $1 increase in GDPPC for 1977 were 0.06, 0.008, and 0.16 pounds, respectively. These are trivial amounts on an individual basis, but nationwide they can be quite large. These coefficients suggest that a 5-percent increase in per capita income would increase utilization of maize by 26,000 tons per annum for Bangladesh.

The dummy variables indicate that barley utilization in both periods displays significant regional fluctuations in the aggregate.25/ This is probably due to a range of factors similar to those affecting the apparent utilization of commodity groups. Neither maize nor oats is characterized by regional differences, although oat utilization in Latin America is below that for the Mediterranean Basin countries.

The R-squared statistics for the barley and oats equations are much higher than for the maize equation. Even though the coefficient on the maize variable is larger than either the barley or oats coefficient, the pattern of correlation between maize utilization and income increases is less consistent than that for barley or oats. This may be due to the variability of agricultural production in areas of the world where maize is the staple crop, such as parts of Africa.

24/ This, again, raises the possibility that the dummy variables may need to be specified as a function of income.

25/ Because the dummy variables are not in per capita terms, the coefficient represents the average difference between a country in the region and a country in the Mediterranean Basin.

Table 2--Apparent utilization: Estimation results using GDPPC, 1977

Dependent variable	Independent variables					Adjusted R-squared
	GDPPC	DAF	DAS	DLA	FERPC	
Cereals	0.11*	-76.73	-9.90	122.54*	-0.14	0.43*
	(4.4)	(-1.8)	(-.2)	(-3.3)	(-1.9)	
Food grains	.01	-102.53*	32.40	-83.73*	-.01	.43*
	(.8)	(-3.4)	(1.0)	(-3.2)	(-.1)	
Feed grains	.10*	4.19	-32.52	-31.58	-.15*	.31*
	(4.3)	(.1)	(-.8)	(-.9)	(-2.1)	
Oilseeds	.02*	20.99*	13.94	6.22	-.03	.07*
	(2.9)	(2.1)	(1.3)	(.7)	(-1.5)	
Meat	.02*	3.58	-.21	10.04	-.02*	.56*
	(6.2)	(.6)	(-.1)	(1.9)	(-2.2)	
Barley	.03*	-22.11*	-18.55*	-33.46*	-.01	.53*
	(4.3)	(-2.7)	(-2.1)	(-4.6)	(-.9)	
Oats	.01*	-1.20	-1.18	-1.81*	-.01*	.56*
	(6.4)	(-1.3)	(-1.1)	(-2.2)	(-3.4)	
Wheat flour	NA	NA	NA	NA	NA	NA
Wheat grain	.01	-137.03*	-101.41*	-113.21*	.02	.59*
	(.6)	(-7.3)	(-4.9)	(-7.0)	(.5)	
Maize	.07*	13.26	-19.95	-4.79	-.12	.20*
	(3.4)	(.4)	(-.5)	(-.2)	(-1.8)	
Rice	.01	35.42	141.79*	33.07	-.03	.28*
	(.5)	(1.1)	(4.2)	(1.2)	(-.5)	
Soybeans	.01*	3.21	4.53	7.25	-.03*	.19*
	(3.4)	(.5)	(.7)	(1.4)	(-2.6)	
Sunflower seeds	.01*	.41	-.42	-2.35	-.01*	.30*
	(4.4)	(.3)	(-.2)	(-1.6)	(-2.2)	
Sesame seeds	.01	.64	.32	-.01	.01	-.03
	(.6)	(.8)	(.4)	(-.1)	(.7)	
Groundnuts	.01	15.40*	.38	.25	.02	.22*
	(.1)	(2.4)	(.1)	(.1)	(.1)	

NA = Not available.

Note: The coefficients on GDPPC, DAF, DAS, DLA, and FERPC are expressed in scientific notation, E-03. An asterisk on the coefficient denotes significance at the 5-percent level; an asterisk on the adjusted R-squared statistic denotes a significant equation using the F statistic at the 5-percent level.

Table 3--Apparent utilization: Estimation results using GDPPC, 1980

Dependent variable	Independent variables					Adjusted R-squared
	GDPPC	DAF	DAS	DLA	FERPC	
Cereals	0.07*	-167.60*	-148.37*	-186.03*	-0.13*	0.63*
	(5.3)	(-4.3)	(-3.4)	(-5.3)	(-2.9)	
Food grains	.01	-120.16*	-48.91	-104.00*	-.01	.30*
	(1.1)	(-3.8)	(-1.4)	(-3.6)	(-.1)	
Feed grains	.07*	-65.93*	-97.68*	-74.50*	-.13*	.54*
	(5.5)	(-2.0)	(-2.6)	(-2.4)	(-3.3)	
Oilseeds	.01*	14.66	21.18	9.80	-.02	.08*
	(3.1)	(1.2)	(1.6)	(.9)	(-1.8)	
Meat	.01*	1.93	-.41	11.06*	-.02*	.64*
	(6.8)	(.4)	(-.1)	(2.3)	(-3.3)	
Barley	.02*	-56.73*	-56.20*	-68.16*	-.03	.51*
	(3.3)	(-4.0)	(-3.6)	(-5.4)	(-1.6)	
Oats	.01*	-1.84	-2.07	-2.39*	-.01*	.54*
	(6.1)	(-1.5)	(-1.5)	(-2.2)	(-2.9)	
Wheat flour	NA	NA	NA	NA	NA	NA
Wheat grain	.01	-163.59*	-156.66*	-135.66*	-.01	.74*
	(1.6)	(-10.1)	(-8.5)	(-9.3)	(-.1)	
Maize	.04*	-22.95	-40.92	-12.83	-.08*	.31*
	(3.4)	(-.7)	(-1.1)	(-.4)	(-2.2)	
Rice	.01	42.54	103.23*	31.15	-.01	.09*
	(.2)	(1.4)	(3.1)	(1.2)	(-.1)	
Soybeans	.01*	1.68	4.29	10.48	-.02	.16*
	(2.9)	(.2)	(.4)	(1.3)	(-1.9)	
Sunflower seeds	.01*	-1.40	-1.49	-2.17	-.01	.52*
	(2.8)	(-1.1)	(-1.1)	(-1.9)	(-.8)	
Sesame seeds	.01	-.02	.28	-.13	-.01	-.07
	(.3)	(-.1)	(.4)	(-.2)	(-.4)	
Groundnuts	-.01	11.80	4.66	.19	.01	.08*
	(-.2)	(1.9)	(.7)	(.1)	(.1)	

NA = Not available.

Note: The coefficients on GDPPC, DAF, DAS, DLA, and FERPC are expressed in scientific notation, E-03. An asterisk on the coefficient denotes significance at the 5-percent level; an asterisk on the adjusted R-squared statistic denotes a significant equation using the F statistic at the 5-percent level.

The correlation between the apparent utilization of oilseeds and income growth is based on the behavior of sunflower seeds and soybeans, with the response of the sunflower seeds being much more consistent, that is, the sunflower seed equations have a higher R-squared statistic. Africa and Latin America in 1980 displayed significant differences from the Mediterranean Basin countries in groundnut utilization.26/ The other oilseeds did not demonstrate a significant response to income changes. The discussion of the FERPC variable is best dealt with in the context of import equations.

Domestic Production and Income Growth

Production is the first component of apparent utilization to be analyzed, the results of which are contained in tables 4 and 5. The production of each aggregate commodity group, except oilseeds, displays a significant response to income growth.27/ The domestic agricultural sector in sample countries displays a strong positive correlation between production and income growth.28/ The strongest relationship, judging by the size of the coefficients in tables 4 and 5, is between income per capita and feed grain production. The coefficient on GDPPC in the feed grain equation for 1977 suggests that a $1 increase in per capita income is associated with an increase in feed production of 0.16 pound per capita per annum. The explanatory powers of many of these equations are low, which indicates that per capita income does not explain production behavior.29/ As with apparent utilization, meat products display the most consistent correlation across countries, based on the R-squared statistic.

In contrast to results for apparent utilization, a country's food grain production level is highly correlated with its per capita income level. Evidently, other variables overshadowed the production response in the apparent utilization equation. The relatively small regional variation in per capita production indicates that the per capita baseline (intercept) production of the commodity groups is broadly the same across regions. The only exceptions are food grains in Asia and meat products in Latin America, both of which are larger than for other countries.

As with apparent utilization, the results for the production of individual commodities are generally consistent with those for the aggregates. Wheat grain is positively correlated with income, but does display considerable regional variation. The lack of a production response for rice seems to conflict with time series analyses by Bachman and Paulino (2) and Paulino (24).

26/ Groundnut production and trade in Africa is difficult to come to grips with because the nuts can be used as a food crop (nuts), a feed grain (cake), or an oilseed.

27/ The coefficient on GDPPC in the oilseeds equation for 1980 is statistically significant, but the F statistic for the equation as a whole indicates that the result is not significant.

28/ One of the key issues to be considered when interpreting these results is the direction of causation. In the production equations, causation is bidirectional: increases in production lead to higher per capita income at the same time that rising income stimulates production. We deal with this point by using a single-equation model rather than a simultaneous model.

29/ The low explanatory powers are not surprising because a number of important variables were excluded. Data deficiencies include climatic variation, irrigation, taxes, and subsidies.

Table 4--Production: Estimation results using GDPPC, 1977

Dependent variable	Independent variables					Adjusted R-squared
	GDPPC	DAF	DAS	DLA	FERPC	
Cereals	0.11*	6.15	70.69	-52.76	-0.27*	0.21*
	(3.5)	(.1)	(1.2)	(-1.1)	(-2.9)	
Food grains	.04*	-36.67	96.26*	-38.06	-.12*	.39*
	(2.3)	(-1.2)	(2.8)	(-1.4)	(-2.2)	
Feed grains	.07*	22.89	-16.25	-8.71	-.16*	.14*
	(3.0)	(.5)	(-.3)	(-.2)	(-2.0)	
Oilseeds	.01	24.01	18.32	18.09	-.02	-.02
	(.8)	(1.7)	(1.2)	(1.5)	(-.6)	
Meat	.02*	4.87	1.24	15.68*	-.03*	.41*
	(4.5)	(.6)	(.1)	(2.2)	(-2.1)	
Barley	.03*	-19.37*	-16.81	-30.60*	-.02	.51*
	(4.4)	(-2.3)	(-1.8)	(-4.0)	(-1.3)	
Oats	.01*	-1.04	-1.08	-2.11*	-.01*	.54*
	(6.3)	(-1.1)	(-1.0)	(-2.5)	(-3.4)	
Wheat flour	NA	NA	NA	NA	NA	NA
Wheat grain	.03*	-66.53*	-39.75	-71.81*	-.07*	.40*
	(2.8)	(-3.3)	(-1.8)	(-4.1)	(-2.0)	
Maize	.05*	28.60	-6.36	15.89	-.12	.04
	(2.0)	(.7)	(-.1)	(.4)	(-1.7)	
Rice	.01	29.86	136.01*	33.76	-.05	.28*
	(.5)	(1.0)	(4.1)	(1.3)	(-1.0)	
Soybeans	.01	-.17	1.48	14.54	-.01	.02
	(.1)	(-.1)	(.1)	(1.6)	(-.7)	
Sunflower seeds	.01*	.76	-.27	-1.58	-.01	.26*
	(4.1)	(.5)	(-.1)	(-1.1)	(-1.6)	
Sesame seeds	.01	1.02	.52	.42	.01	-.05
	(.3)	(1.0)	(.5)	(.5)	(.4)	
Groundnuts	.01	17.41*	1.57	1.30	-.01	.20*
	(.2)	(2.4)	(.2)	(.2)	(-.1)	

NA = Not available.

Note: The coefficients on GDPPC, DAF, DAS, DLA, and FERPC are expressed in scientific notation, E-03. An asterisk on the coefficient denotes significance at the 5-percent level; an asterisk on the adjusted R-squared statistic denotes a significant equation using the F statistic at the 5-percent level.

Table 5--Production: Estimation results using GDPPC, 1980

Dependent variable	Independent variables					Adjusted R-squared
	GDPPC	DAF	DAS	DLA	FERPC	
Cereals	0.08*	-51.21	-51.81	-133.31*	-0.21*	0.37*
	(4.4)	(-1.0)	(-.9)	(-2.5)	(-3.6)	
Food grains	.03*	-42.97	13.31	-65.91*	-.07	.21*
	(2.8)	(-1.2)	(.3)	(-2.1)	(-1.7)	
Feed grains	.05*	-34.27	-68.55	-50.02	-.15*	.34*
	(4.2)	(-1.0)	(-1.8)	(-1.6)	(-3.6)	
Oilseeds	.01	18.83	26.12	22.38	-.01	-.02
	(.9)	(1.3)	(1.6)	(1.7)	(-.7)	
Meat	.01*	5.54	2.28	17.82*	-.03*	.54*
	(5.5)	(.8)	(.3)	(2.9)	(-3.6)	
Barley	.02*	-51.05*	-50.59*	-62.80*	-.03	.51*
	(3.5)	(-3.9)	(-3.5)	(-5.3)	(-1.7)	
Oats	.01*	-1.70	-1.96	-2.64*	-.01*	.54*
	(6.2)	(-1.4)	(-1.4)	(-2.4)	(-3.1)	
Wheat flour	NA	NA	NA	NA	NA	NA
Wheat grain	.03*	-85.39*	-92.54*	-102.23*	-.05*	.61*
	(4.4)	(-4.7)	(-4.6)	(-6.3)	(-2.3)	
Maize	.03*	12.01	-17.57	12.08	-.09*	.09*
	(2.4)	(.3)	(-.5)	(.4)	(-2.3)	
Rice	.01	37.17	102.09*	32.91	-.02	.09*
	(.3)	(1.2)	(2.8)	(1.1)	(-.5)	
Soybeans	.01	1.65	2.65	18.90	-.01	.02
	(.3)	(.1)	(.2)	(1.7)	(-.6)	
Sunflower seeds	.01*	.82	.01	-.99	-.01*	.39*
	(5.7)	(.8)	(.1)	(-1.1)	(-3.0)	
Sesame seeds	-.01	.23	.29	.45	-.01	-.07
	(-.1)	(.3)	(.3)	(.6)	(-.4)	
Groundnuts	-.01	11.97	4.52	.28	-.01	.09*
	(-.2)	(1.9)	(.6)	(.1)	(-.1)	

NA = Not available.

Note: The coefficients on GDPPC, DAF, DAS, DLA, and FERPC are expressed in scientific notation, E-03. An asterisk on the coefficient denotes significance at the 5-percent level; an asterisk on the adjusted R-squared statistic denotes a significant equation using the F statistic at the 5-percent level.

As was the case for apparent utilization, production of three feed grains (barley, oats, and maize) is positively correlated with income growth. Again, mirroring the results for the apparent utilization equations, geographic variation for barley is greater than that for either oats or maize. The consistency across countries for maize production is weak, compared with that for oats and barley. This is especially interesting because Bachman and Paulino (2, p. 14) found that maize was the most important cereal crop for food use in 1961-65 and 1974-76. This being the case, a better fit for the maize equation was expected. However, as was the case for the apparent utilization of maize, the weak results are probably due to the variability of production in areas where maize is an important crop.

Only sunflower seeds in the oilseed group are correlated with income growth. The coefficient on GDPPC is comparatively small in both years. The groundnut equation is significant because of the regional dummy variable for Africa. The increase in the coefficient on DAF between 1977 and 1980 reflects the performance of development aid projects concentrating on increasing groundnut production.30/

Agricultural Trade and Income Growth

The results of regressing agricultural exports per capita on the set of independent variables for 1977 and 1980 are in tables 6 and 7. These results show that, in general, income growth is not correlated with the export volume of these crops.31/ Results for the commodity groups in 1977 show that although the GDPPC variable was significant by itself, the equation as a whole was not. Income was positively correlated with food grain exports in 1980, which accounts for the significance of GDPPC in the cereal exports equation. Additionally, meat exports were correlated with income growth in 1980, but only at the 10-percent level. Exports of both wheat flour and wheat grain were affected by income growth in both years. These two are combined in the "wheat flour and grain" equation. Exports of oats are statistically significant. The coefficient on maize is also significant, but the F statistic indicates that the equation is not.

The results for both years indicate that agricultural exports of the commodities examined are generally not correlated with growth in per capita income levels, except for wheat and oats. However, the low R-squared value indicates that the finding is not especially pervasive.

Tables 8 and 9 contain the results for the agricultural import equations. The results suggest that food grain imports tend to decrease as income increases for both years. Feed grains imports, on the other hand, display a significant positive correlation with income growth. These two components of total cereals are offsetting and account for the insignificance of income in the cereals equation. Imports of oilseeds and meats increase as income grows. The results for the meat equation, however, are inconsistent for the two years, suggesting

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30/ Real prices for groundnut meal and oil fell between 1977 and 1980. The index prices for oil were $1,217.60 per metric ton in 1977 and $858.80 in 1980, while the prices for meal were $311.40 in 1977 and $240.30 in 1980.

31/ It should be stressed that agricultural exports are not an unimportant source of economic growth. Exports of these commodities have not increased in a systematic way as economic development has progressed. Had tropical crops been included in the sample of commodities, exports would, no doubt, be highly correlated with income growth.

Table 6--Exports: Estimation results using GDPPC, 1977

Dependent variable	Independent variables					Adjusted R-squared
	GDPPC	DAF	DAS	DLA	FERPC	
Cereals	0.01*	8.37	15.67	4.61	-0.02	0.03
	(2.4)	(.9)	(1.6)	(.6)	(-1.4)	
Food grains	.01	2.35	9.46	3.93	-.01	.02
	(1.7)	(.4)	(1.5)	(.8)	(-1.1)	
Feed grains	.01*	4.91	5.29	-2.13	-.01	.03
	(2.0)	(1.0)	(1.0)	(-.5)	(-1.1)	
Oilseeds	-.01	.56	2.82	5.69	-.01	-.04
	(-.3)	(.1)	(.4)	(1.1)	(-.2)	
Meat	.01	1.02	1.05	4.71*	-.01	.06
	(.9)	(.4)	(.4)	(2.1)	(-.9)	
Barley	-.01	-2.61*	-2.59*	-2.11*	.01	.05
	(-1.2)	(-2.7)	(-2.5)	(-2.5)	(.4)	
Oats	.01*	.08*	.06	.07*	-.01*	.11*
	(3.4)	(2.5)	(1.8)	(2.5)	(-2.5)	
Wheat flour	.01*	.67	.49	-.71	-.01	.36*
	(6.2)	(1.2)	(.8)	(-1.4)	(-1.4)	
Wheat grain	.01*	2.45	1.96	.49	-.01*	.30*
	(6.0)	(1.6)	(1.2)	(.4)	(-2.7)	
Wheat flour and grain	.01*	2.53	2.00	-.37	-.01*	.42*
	(7.7)	(1.9)	(1.3)	(-.3)	(-3.0)	
Maize	.01*	7.44	8.03	-.11	-.01	.05
	(2.3)	(1.6)	(1.6)	(-.1)	(-1.2)	
Rice	.01	.87	8.32	4.05	-.01	.01
	(.8)	(.2)	(1.6)	(1.0)	(-.9)	
Soybeans	-.01	-1.31	-1.20	6.16	-.01	-.01
	(-.5)	(-.3)	(-.2)	(1.3)	(-.2)	
Sunflower seeds	.01	.10	.03	.17*	-.01	.01
	(.7)	(.9)	(.3)	(2.0)	(-1.1)	
Sesame seeds	-.01	.07	-.08	.08	-.01	-.06
	(-.5)	(.2)	(-.2)	(.2)	(-.1)	
Groundnuts	.01	1.14	-.01	.01	-.01	-.01
	(.1)	(1.1)	(-.1)	(.1)	(-.2)	

NA = Not available.

Note: The coefficients on GDPPC, DAF, DAS, DLA, and FERPC are expressed in scientific notation, E-03. An asterisk on the coefficient denotes significance at the 5-percent level; an asterisk on the adjusted R-squared statistic denotes a significant equation using the F statistic at the 5-percent level.

Table 7--Exports: Estimation results using GDPPC, 1980

Dependent variable	Independent variables					Adjusted R-squared
	GDPPC	DAF	DAS	DLA	FERPC	
Cereals	0.02*	17.63	11.59	-0.39	-0.02	0.20*
	(4.4)	(1.8)	(1.0)	(-.1)	(-1.6)	
Food grains	.01*	5.22	5.23	-2.89	-.01	.20*
	(4.1)	(.9)	(.8)	(-.6)	(-.5)	
Feed grains	.01*	13.47	7.31	3.84	-.01	.04
	(2.5)	(1.9)	(.9)	(.6)	(-1.3)	
Oilseeds	-.01	.44	3.25	5.41	-.01	-.03
	(-.1)	(.1)	(.6)	(1.2)	(-.1)	
Meat	.01	1.89	1.99	4.83*	-.01	.10*
	(1.8)	(.8)	(.8)	(2.3)	(-1.7)	
Barley	.01	-.71	-.79	-.46	-.01	.01
	(.6)	(-1.3)	(-1.3)	(-.9)	(-.3)	
Oats	.01*	.03	.03	.04	-.01	.10*
	(2.9)	(.8)	(.7)	(1.2)	(-1.8)	
Wheat flour	.01*	-1.46	-1.80	-4.02	.01	.23*
	(3.0)	(-.6)	(-.7)	(-1.8)	(.1)	
Wheat grain	.01*	-1.81	-2.51	-6.75	-.01	.22*
	(3.3)	(-.4)	(-.5)	(-1.7)	(-.4)	
Wheat flour and grain	.01*	-2.72	-3.56	-8.75	-1.28	.23*
	(3.2)	(-.5)	(-.6)	(-1.7)	(-.2)	
Maize	.01*	14.15*	8.07	4.25	-.01	.04
	(2.4)	(2.0)	(1.0)	(.7)	(-1.3)	
Rice	.01	5.77	3.59	4.91	-.01	-.03
	(1.5)	(1.2)	(.7)	(1.2)	(-1.1)	
Soybeans	-.01	-.44	-.41	4.72	.01	-.02
	(-.2)	(-.1)	(-.1)	(1.1)	(.1)	
Sunflower seeds	.01	.01	-.01	-.01	-.01	-.04
	(.1)	(.4)	(-.4)	(-.6)	(-.1)	
Sesame seeds	-.01	-.08	-.16	.25	-.01	.02
	(-1.3)	(-.3)	(-.6)	(1.1)	(-.3)	
Groundnuts	-.01	.21	-.07	.03	-.01	-.04
	(-.2)	(.8)	(-.2)	(.1)	(-.1)	

NA = Not available.

Note: The coefficients on GDPPC, DAF, DAS, DLA, and FERPC are expressed in scientific notation, E-03. An asterisk on the coefficient denotes significance at the 5-percent level; an asterisk on the adjusted R-squared statistic denotes a significant equation using the F statistic at the 5-percent level.

Table 8--Imports: Estimation results using GDPPC, 1977

Dependent variable	Independent variables					Adjusted R-squared
	GDPPC	DAF	DAS	DLA	FERPC	
Cereals	0.01	-76.78*	-67.46*	-65.05*	0.01*	0.55*
	(1.4)	(-4.7)	(-3.7)	(-4.5)	(3.3)	
Food grains	-.02*	-63.06*	-51.63*	-45.67*	.11*	.47*
	(-3.3)	(-5.8)	(-4.4)	(-4.8)	(5.8)	
Feed grains	.03*	-14.74	-13.06	-24.00*	-.01	.62*
	(7.1)	(-1.8)	(-1.5)	(-3.5)	(-1.0)	
Oilseeds	.01*	-2.46	-1.56	-6.18*	-.01*	.47*
	(5.6)	(-.9)	(-.5)	(-2.5)	(-2.5)	
Meat	.01*	.06	-.21	-.62	.01	.36*
	(4.2)	(.1)	(-.2)	(-.8)	(1.0)	
Barley	-.01*	-5.68*	-4.96*	-4.92*	.01	.19*
	(-2.0)	(-4.0)	(-3.2)	(-4.0)	(1.8)	
Oats	.01	-.09	-.02	.35*	-.01	.18*
	(.7)	(-.5)	(-.1)	(2.1)	(-.1)	
Wheat flour	-.01*	-16.81*	-13.92*	-12.66*	.01	.22*
	(-3.2)	(-4.6)	(-3.5)	(-4.0)	(1.7)	
Wheat grain	-.02*	-68.64*	-58.83*	-43.64*	.09*	.55*
	(-4.0)	(-7.6)	(-6.0)	(-5.5)	(5.4)	
Wheat flour and grain	-.02*	-65.77*	-55.05*	-43.69*	.07*	.48*
	(-4.1)	(-7.3)	(-5.6)	(-5.5)	(4.5)	
Maize	.03*	-8.70	-7.89	-20.26*	-.02	.62*
	(7.8)	(-1.1)	(-.9)	(-3.0)	(-1.3)	
Rice	-.01	5.50	6.05	-.76	.02*	.12*
	(-.2)	(1.2)	(1.2)	(-.2)	(2.9)	
Soybeans	.01*	-1.02	-.60	-4.05*	-.02*	.46*
	(6.3)	(-.5)	(-.2)	(-2.1)	(-4.1)	
Sunflower seeds	.01	-.60	-.58	-.78*	-.01	.08*
	(1.4)	(-1.3)	(-1.2)	(-2.0)	(-.9)	
Sesame seeds	-.01	-.33*	-.26*	-.32*	.01	.27*
	(-.9)	(-4.3)	(-3.0)	(-4.8)	(1.4)	
Groundnuts	.01	-.63	-.72	-.88*	.01	.12*
	(1.1)	(-1.4)	(-1.4)	(-2.2)	(1.3)	

NA = Not available.

Note: The coefficients on GDPPC, DAF, DAS, DLA, and FERPC are expressed in scientific notation, E-03. An asterisk on the coefficient denotes significance at the 5-percent level; an asterisk on the adjusted R-squared statistic denotes a significant equation using the F statistic at the 5-percent level.

Table 9--Imports: Estimation results using GDPPC, 1980

Dependent variable	Independent variables					Adjusted R-squared
	GDPPC	DAF	DAS	DLA	FERPC	
Cereals	0.01	-91.51*	-82.50*	-65.75*	0.06*	0.50*
	(1.5)	(-4.4)	(-3.5)	(-3.5)	(2.2)	
Food grains	-.01*	-71.74*	-62.25*	-45.15*	.07*	.41*
	(-3.2)	(-5.6)	(-4.4)	(-3.9)	(4.[illegible])	
Feed grains	.02*	-21.84	-24.51	-30.80*	-.01	.45*
	(4.7)	(-1.5)	(-1.5)	(-2.4)	(-.2)	
Oilseeds	.01*	-3.72	-1.68	-7.17	-.01*	.39*
	(5.0)	(-.8)	(-.3)	(-1.7)	(-2.3)	
Meat	.01	-1.71	-1.21	-1.55	.01*	.33*
	(.9)	(-1.6)	(-1.0)	(-1.6)	(4.0)	
Barley	.01	-6.39*	-6.39*	-5.82*	-.01	.34*
	(.7)	(-4.3)	(-3.9)	(-4.4)	(-.3)	
Oats	-.01	-.11	-.08	.29*	.01	.18*
	(-.7)	(-.7)	(-.5)	(2.0)	(1.3)	
Wheat flour	-.01*	-19.21*	-17.13*	-15.44*	.01	.19*
	(-3.0)	(-4.4)	(-3.5)	(-4.0)	(1.6)	
Wheat grain	-.01*	-78.64*	-67.82*	-45.48*	.05*	.51*
	(-3.5)	(-7.2)	(-5.6)	(-4.6)	(4.3)	
Wheat flour and grain	-.01*	-73.09*	-63.88*	-47.51*	.05*	.43*
	(-3.5)	(-6.6)	(-5.2)	(-4.8)	(3.6)	
Maize	.02*	-15.35	-17.79	-25.27	-.01	.40*
	(4.5)	(-1.1)	(-1.1)	(-1.9)	(-.2)	
Rice	-.01	7.29	6.32	.56	.01*	.08*
	(-.5)	(1.4)	(1.1)	(.1)	(2.1)	
Soybeans	.01*	-.41	1.22	-3.71	-.01*	.35*
	(5.1)	(-.1)	(.3)	(-.9)	(-2.4)	
Sunflower seeds	.01	-2.16	-2.17	-2.08	-.01	.03
	(.6)	(-1.6)	(-1.5)	(-1.7)	(-.6)	
Sesame seeds	-.01	-.31*	-.16	-.30*	-.01	.20*
	(-.3)	(-3.1)	(-1.5)	(-3.4)	(-.1)	
Groundnuts	.01	.05	-.01	-.11	.01*	.52*
	(.9)	(.4)	(-.1)	(-1.0)	(6.7)	

NA = Not available.

Note: The coefficients on GDPPC, DAF, DAS, DLA, and FERPC are expressed in scientific notation, E-03. An asterisk on the coefficient denotes significance at the 5-percent level; an asterisk on the adjusted R-squared statistic denotes a significant equation using the F statistic at the 5-percent level.

that the behavior of total meat imports should be treated with some caution. Regional variations are greatest for the food grain equations and for the Latin American variable.

The import behavior of individual commodities is complementary to domestic production with regard to apparent utilization. That is, increases in apparent utilization must be supplied by increases in domestic production and/or imports. Despite the fact that the apparent utilization of food grains did not display a significant correlation with income growth, the increase in production and, to a lesser extent, exports, combined with the reduction in imports, argues that a consumption response did occur. Therefore, the increase in domestic production of wheat (grain and, secondarily, flour) seems large enough to reduce the need for imports and should allow for some wheat exports. Evidently, demand for wheat flour is met through imports when per capita income is at low levels. As income increases, the increase in production displaces some wheat grain and flour imports.32/

The results for the feed grains are mixed. Although the apparent utilization of barley, oats, and maize all increase with income, the combination of supply sources that meet the increased demand differs for each crop. Barley production in 1977 increased more than apparent utilization, causing imports to decline. The increase in barley production in 1980 was equal to the increased apparent utilization and, therefore, resulted in no significant change in imports. For both years, the increases in apparent utilization of oats were matched by production rises, causing no change in imports attributable to income changes. The increases in apparent utilization of maize gave rise to the large import responses for feed grains during 1977 and 1980. The increase in apparent utilization exceeded the production responses, causing the excess demand to be met via imports. Maize exports were also correlated with income growth in 1980. This may reflect the redistribution of maize among developing countries during what was a drought year in some areas.

The two oilseeds with increases in apparent utilization as income rose were soybeans and sunflower seeds. Because GDPPC is not significant in the sunflower import equations for either 1977 or 1980, we conclude that the increases in domestic production in response to income were the sole sources of supply. For soybeans, the opposite is the case. There was no correlation between GDPPC and production of soybeans, but imports do demonstrate a response to increasing income. Therefore, we conclude that rising apparent utilization was supplied entirely by increased imports.

Finally, even though the meat aggregate is not broken into its component parts, some comment on meat is still possible. Meat consumption levels displayed the most consistent correlation with income increases of any of the aggregate commodity groups. The increases were met entirely through increases in domestic production. Although higher levels of income did not generate higher meat

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32/ The analysis is complicated somewhat by the fact that data on the wheat flour for apparent utilization and production are unavailable. Wheat flour data are not available because it is presumed that all grain is milled. To obtain data on apparent utilization of flour, it would be necessary to use individual country milling ratios, which are difficult to find and are frequently unreliable. A unit of wheat grain when milled yields between 0.6 and 0.8 units of wheat flour. As a compromise, wheat grain was converted to flour equivalents by multiplying the grain value by a factor of 0.7.

imports, income did account for a large part of the increased derived demand for feed grains. Presumably, the cost of transporting meat, combined with the absence of storage facilities for chilled or frozen meat in most developing countries, and the presence of an indigenous livestock industry in many of these countries, causes domestic meat production to be favored over imports.

Table 10--Supply sources for income-based increases in apparent utilization

Commodity	Coefficient on GDPPC in the specified equations			
	Apparent utilization	Production	Imports	Exports
1977:				
Barley	0.028	0.028	-0.005	NS
Oats	.004	.004	NS	0.001
Wheat grain	NS	.032	-.022	.005
Wheat flour	NA	NA	-.007	.002
Wheat flour and grain	NA	NA	-.020	.010
Maize	.071	.047	.032	.007
Rice	NS	NS	NS	NS
Soybeans	.011	NS	.010	NS
Sunflower seeds	.004	.004	NS	NS
1980:				
Barley	.017	.016	NS	NS
Oats	.003	.003	NS	.001
Wheat grain	NS	.027	-.013	.005
Wheat flour	NA	NA	-.004	.002
Wheat flour and grain	NA	NA	-.010	.010
Maize	.043	.030	.023	.006
Rice	NS	NS	NS	NS
Soybeans	.010	NS	.008	NS
Sunflower seeds	.002	.002	NS	NS

NA = Not available.
NS = Insignificant.
Note: The coefficients on GDPPC are expressed in scientific notation of E-03.

Table 10 summarizes the results for GDPPC by depicting the share of increased apparent utilization supplied by changes in domestic production versus imports for each commodity. Ideally, the sum of production, imports, and exports should equal apparent utilization. The summation, however, is not always perfect.33/ In general, though, the results are close and allow us to form an impression of what sources of supply are used to meet the increased demand. There are two points to be made with reference to table 10. First, there is a clear pattern of increased apparent utilization of certain agricultural commodities as income levels among countries increase. In general, these results can be expected to be valid as real income levels within countries increase. Second, the results suggest that increased utilization of these commodities is accompanied by a supply response from domestic production for food grains and meat products. The

33/ The parts do not always equal the whole because one of the components may contribute to apparent utilization but may not be statistically significant.

increased consumption of feed grains was supplied through a combination of increased domestic production and imports.

The foreign exchange variable was included in the import equations in tables 8 and 9 to determine whether supplies of foreign currency acted as a constraint on agricultural import capacity. In the apparent utilization equation, FERPC is negative and significant only in those equations where income is significant, with the exception of the oilseed equation for 1977. The same pattern is evident for the production equations with the exception of the oilseed aggregate and sunflower seed equation in 1977. The pattern is the same for the import equations. The FERPC variable is negative for those aggregates or crops that have a positive import response to income increases. Conversely, a negative import response to income growth yields a positive coefficient on the foreign exchange variable. The behavior of the FERPC variable reflects the expenditure of foreign exchange on imports rather than foreign exchange constraints. Thus, reserves decline as imports increase and when increases in domestic production reduce the need for imports reserves increase. The significance of FERPC in the apparent utilization and production equations reflects the impact of these variables on imports.

In summary, the results presented in this section clearly indicate that certain agricultural commodities display increases in apparent utilization as per capita income rises. These increases in apparent utilization are supplied by increased domestic production and/or imports.

ESTIMATION RESULTS USING AN ALTERNATIVE MEASURE OF ECONOMIC DEVELOPMENT

In the discussion of factors that influence agricultural imports by LDCs, it was noted that measurement of economic development is difficult and controversial, if for no other reason than single-value summary measures miss many aspects of the development process. Nonetheless, an econometric study is, for practical purposes, confined to such simple measures. A partial attempt at remedying the problem was to introduce an alternative measure of development (ALTDEV) as a substitute for GDPPC in the equations discussed in the preceding section. The results using the ALTDEV variable are presented in tables 11 to 19. A detailed description of the construction of the ALTDEV variable was presented earlier. Briefly, ALTDEV is a composite index number ranging from zero to 100 that is an unweighted average comprised of life expectancy at birth, child mortality rates, and the percentage of school age children enrolled in primary school.34/ The correlation coefficient for GDPPC and ALTDEV is 0.72 in 1977 and 0.65 in 1980, indicating that the two variables are clearly, but not perfectly, related.

The results of regressing the total value of agricultural imports and exports on ALTDEV are similar to those for the equations that used GDPPC (table 11). Increases in agricultural imports have a strong positive association with increases in the ALTDEV variable and, referring to the R-squared, are quite consistent across income levels. Agricultural exports, on the other hand, display a weak correlation at the 10-percent level with increases in ALTDEV, but

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34/ The alternative measure of development is based on a similar measure constructed by Morris (22). The three components used by Morris are infant mortality, life expectancy at age one, and literacy rates. The ALTDEV variable uses somewhat different measures because data used by Morris are not available.

the low explanatory power of the equations suggests that ALTDEV was not strongly associated with export behavior in 1977. Regional differences are more pronounced in import equations than in export equations.

Table 11--Estimation results for total value of agricultural imports and exports, 1977 and 1980

Dependent variable	Independent variables					Adjusted R-squared
	GDPPC	DAF	DAS	DLA	FERPC	
Imports-1977 (MTAPC)	0.26* (2.4)	-36.01* (-4.7)	-42.36* (-5.7)	-42.16* (-6.4)	0.12* (9.5)	0.74*
Imports-1980 (MTAPC)	.42* (2.7)	-49.52* (-4.4)	-51.86* (-4.7)	-51.80* (-5.4)	.12* (10.6)	.76*
Exports-1977 (XTAPC)	.62 (1.8)	19.70 (.8)	13.95 (.6)	52.48* (2.5)	-.03 (-.7)	.18*
Exports-1980 (XTAPC)	.54 (1.3)	15.02 (.5)	13.87 (.5)	48.12 (1.9)	-.01 (-.5)	.18*

Note: An asterisk on the coefficient denotes significance at the 5-percent level; an asterisk on the adjusted R-squared statistic denotes a significant equation using the F statistic at the 5-percent level.

In general, the results of regressing the various commodity volume measures on the ALTDEV variable are similar to, but not as strong as, those where GDPPC was used as the proxy for development. The coefficients on GDPPC and ALTDEV are not directly comparable, because a 1-point increase in the ALTDEV index number is a much greater relative increase than a $1 increase in per capita income.

The ALTDEV variable in the apparent utilization equations was strongly correlated with feed grains and meats in 1977 (tables 12 and 13). The ALTDEV variable did not perform well in 1980 and there is no immediate explanation for this. For this reason, the balance of this section concentrates on 1977 results. The contrast with the behavior of the GDPPC variable is illustrative. GDPPC was significant in the same two equations as ALTDEV and for the oilseeds and feed grains equations as well. This suggests that improvements in basic needs type indicators are most closely associated with directly consumable agricultural commodities.

For individual commodities, the apparent utilization of rice was unaffected by changes in per capita income, but was positively correlated with the ALTDEV. This presumably reflects the link between improved nutrition and two components of ALTDEV, life expectancy and child mortality. The scope for greatest improvement in these two measures is among low-income groups in developing countries, where the most immediate improvement in nutrition comes from an increase in staple food (rice) consumption. Although the ability to improve nutritional levels probably stems from income increases, this effect is not detected by the GDPPC variable. Interestingly, ALTDEV is insignificant in the apparent utilization equation for wheat grain. The insignificance of ALTDEV in

Table 12--Apparent utilization: Estimation results using ALTDEV, 1977

Dependent variable	Independent variables					Adjusted R-squared
	GDPPC	DAF	DAS	DLA	FERPC	
Cereals	1.49*	-128.97*	-95.57*	-175.41*	0.01	0.31*
	(2.3)	(-2.8)	(-2.1)	(-4.5)	(.1)	
Food grains	.75	-86.88*	27.31	-93.55*	.01	.44*
	(1.9)	(-3.1)	(1.0)	(-3.8)	(-.1)	
Feed grains	1.37*	-40.83	-108.16*	-78.77*	-.02	.18*
	(2.4)	(-1.0)	(-2.7)	(-2.2)	(-.3)	
Oilseeds	.19	11.72	.29	-1.78	-.01	-.03
	(1.4)	(1.2)	(.1)	(-.2)	(-.2)	
Meat	.22*	-5.92	-13.61*	2.91	-.01	.37*
	(2.3)	(-.9)	(-2.0)	(.5)	(-.1)	
Barley	-.04	-25.01*	-21.33*	-32.95*	.01	.41*
	(-.3)	(-3.3)	(-2.7)	(-4.9)	(.1)	
Oats	.04*	-2.83*	-3.83*	-3.24*	-.01	.36*
	(2.8)	(-2.5)	(-3.5)	(-3.3)	(-1.0)	
Wheat flour	NA	NA	NA	NA	NA	NA
Wheat grain	-.14	-149.34*	-110.83*	-116.03*	.03	.59*
	(-.6)	(-8.1)	(-6.2)	(-7.4)	(1.0)	
Maize	1.56*	4.76	-62.96	-39.44	-.03	.18*
	(3.2)	(.1)	(-1.8)	(-1.3)	(-.5)	
Rice	.91*	64.15*	151.31*	28.48	-.03	.34*
	(2.2)	(2.2)	(5.4)	(1.2)	(-.6)	
Soybeans	.10	-5.44	-5.55	.99	-.01	.06
	(1.1)	(-.9)	(-.9)	(.2)	(-.8)	
Sunflower seeds	.08*	-.79	-3.31*	-4.38*	-.01	.21*
	(3.2)	(-.5)	(-2.0)	(-3.0)	(-.4)	
Sesame seeds	-.01	.01	-.16	-.14	.01	-.03
	(-.7)	(.1)	(-.2)	(-.2)	(1.3)	
Groundnuts	-.09	11.11	-2.00	.08	.01	.23*
	(-1.0)	(1.8)	(-.3)	(.1)	(.2)	

NA = Not available.

Note: The coefficients on GDPPC, DAF, DAS, DLA, and FERPC are expressed in scientific notation, E-03. An asterisk on the coefficient denotes significance at the 5-percent level; an asterisk on the adjusted R-squared statistic denotes a significant equation using the F statistic at the 5-percent level.

Table 13--Apparent utilization: Estimation results using ALTDEV, 1980

Dependent variable	Independent variables					Adjusted R-squared
	GDPPC	DAF	DAS	DLA	FERPC	
Cereals	1.06	-234.26*	-247.38*	-237.08*	-0.03	0.50*
	(1.6)	(-5.1)	(-5.4)	(-6.0)	(-.6)	
Food grains	.85	-103.76*	-54.74	-114.43*	.01	.33*
	(1.9)	(-3.3)	(-1.7)	(-4.3)	(.3)	
Feed grains	.78	-130.88*	-171.88*	-117.12*	-.04	.33*
	(1.3)	(-3.2)	(-4.3)	(-3.4)	(-.9)	
Oilseeds	.10	-2.65	2.14	-.93	-.01	-.06
	(.5)	(-.2)	(.2)	(-.1)	(-.2)	
Meat	.04	2.98	.52	13.14*	-.01*	.49*
	(.5)	(.6)	(.1)	(2.8)	(-2.8)	
Barley	.12	-79.49*	-80.76*	-84.33*	.01	.43*
	(.6)	(-5.3)	(-5.4)	(-6.7)	(.2)	
Oats	.02	-4.67*	-4.92*	-3.70*	.01	.36*
	(1.0)	(-3.3)	(-3.5)	(-3.0)	(.1)	
Wheat flour	NA	NA	NA	NA	NA	NA
Wheat grain	.29	-166.65*	-166.58*	-143.94*	.01	.73*
	(1.2)	(-10.0)	(-10.1)	(-10.2)	(.9)	
Maize	.84	-50.07	-82.33*	-41.47	-.03	.21*
	(1.6)	(-1.4)	(-2.3)	(-1.4)	(-.8)	
Rice	.55	62.04	109.49*	29.40	-.01	.12*
	(1.3)	(2.1)	(3.7)	(1.2)	(-.1)	
Soybeans	.13	-8.87	-8.71	2.60	-.01	.06
	(.9)	(-.9)	(-.9)	(.3)	(-.5)	
Sunflower seeds	.02	-1.83	-2.14	-2.64*	.01	.48*
	(.8)	(-1.4)	(-1.6)	(-2.3)	(.1)	
Sesame seeds	-.01	-.30	.09	-.18	-.01	-.07
	(-.5)	(-.4)	(.1)	(-.3)	(-.3)	
Groundnuts	-.17	5.21	2.42	.52	.01	.13*
	(-1.9)	(.9)	(.4)	(.1)	(.2)	

NA = Not available.

Note: The coefficients on GDPPC, DAF, DAS, DLA, and FERPC are expressed in scientific notation, E-03. An asterisk on the coefficient denotes significance at the 5-percent level; an asterisk on the adjusted R-squared statistic denotes a significant equation using the F statistic at the 5-percent level.

Table 14--Production: Estimation results using ALTDEV, 1977

Dependent variable	Independent variables					Adjusted R-squared
	GDPPC	DAF	DAS	DLA	FERPC	
Cereals	1.49*	-44.74	-13.58	-105.00*	-0.13	0.11*
	(2.0)	(-.8)	(-.3)	(-2.2)	(-1.5)	
Food grains	.91*	-42.19	70.89*	-58.26*	-.08	.38*
	(2.1)	(-1.4)	(2.4)	(-2.2)	(-1.5)	
Feed grains	1.13	-7.34	-71.69	-44.56	-.06	.06
	(1.9)	(-.2)	(-1.7)	(-1.2)	(-.9)	
Oilseeds	.07	19.90	12.70	14.94	-.01	-.03
	(.4)	(1.5)	(1.0)	(1.3)	(-.3)	
Meat	.25*	-5.00	-13.54	7.47	-.01	.28*
	(2.0)	(-.6)	(-1.6)	(1.0)	(-.4)	
Barley	-.06	-22.69*	-19.76*	-29.30*	-.01	.38*
	(-.5)	(-3.0)	(-2.4)	(-4.3)	(-.4)	
Oats	.05*	-2.78*	-3.87*	-3.82*	-.01	.33*
	(3.0)	(-2.4)	(-3.5)	(-3.9)	(-.7)	
Wheat flour	NA	NA	NA	NA	NA	NA
Wheat grain	.04	-98.89*	-73.45*	-87.23*	-.02	.33*
	(.1)	(-4.8)	(-3.7)	(-5.0)	(-.7)	
Maize	1.35*	36.28	-27.90	-6.90	-.07	.07
	(2.5)	(.9)	(-.7)	(-.2)	(-1.1)	
Rice	.87*	56.70*	144.35*	28.98	-.05	.33*
	(2.2)	(2.0)	(5.2)	(1.2)	(-1.1)	
Soybeans	.01	-.78	.71	14.13	-.01	.02
	(.1)	(-.1)	(.1)	(1.7)	(-.7)	
Sunflower seeds	.07*	-.29	-2.78	-3.57*	.01	.19*
	(3.2)	(-.1)	(-1.7)	(-2.6)	(.2)	
Sesame seeds	-.01	.26	-.05	.37	.01	-.05
	(-.9)	(.3)	(-.1)	(.4)	(.5)	
Groundnuts	-.11	12.10	-1.17	1.24	.01	.22*
	(-1.2)	(1.7)	(-.2)	(.2)	(.1)	

NA = Not available.

Note: The coefficients on GDPPC, DAF, DAS, DLA, and FERPC are expressed in scientific notation, E-03. An asterisk on the coefficient denotes significance at the 5-percent level; an asterisk on the adjusted R-squared statistic denotes a significant equation using the F statistic at the 5-percent level.

Table 15--Production: Estimation results using ALTDEV, 1980

Dependent variable	Independent variables					Adjusted R-squared
	GDPPC	DAF	DAS	DLA	FERPC	
Cereals	1.16	-132.19*	-155.30*	-177.33*	-0.08	0.19*
	(1.4)	(-2.3)	(-2.8)	(-3.7)	(-1.5)	
Food grains	1.07*	-56.27	-17.94	-91.56*	-.03	.17*
	(2.0)	(-1.5)	(-.5)	(-2.8)	(-.9)	
Feed grains	.87	-83.93	-138.10*	-93.35*	-.05	.18*
	(1.6)	(-2.1)	(-3.6)	(-2.8)	(-1.4)	
Oilseeds	-.03	10.13	18.19	18.56	-.01	-.04
	(-.1)	(.7)	(1.3)	(1.5)	(-.3)	
Meat	.07	3.34	-.85	17.72*	-.02*	.40*
	(.6)	(.5)	(-.1)	(2.9)	(-2.6)	
Barley	.13	-73.30*	-74.63*	-78.68*	.01	.42*
	(.6)	(-5.2)	(-5.3)	(-6.6)	(.2)	
Oats	.02	-4.55*	-4.66*	-3.85*	-.01	.35*
	(1.0)	(-3.2)	(-3.2)	(-3.1)	(-.1)	
Wheat flour	NA	NA	NA	NA	NA	NA
Wheat grain	.48	-111.28*	-125.25*	-121.74*	-.01	.51*
	(1.6)	(-5.4)	(-6.2)	(-6.9)	(-.6)	
Maize	.83	-13.45	-59.27	-17.27	-.05	.05
	(1.6)	(-.4)	(-1.7)	(-.6)	(-1.5)	
Rice	.59	.01	107.31*	30.17	-.02	.11*
	(1.3)	(1.7)	(3.3)	(1.1)	(-.6)	
Soybeans	.04	.69	.96	17.71	-.01	.02
	(.2)	(.1)	(.1)	(1.7)	(-.5)	
Sunflower seeds	.03	-.63	-1.94	-2.18*	.01	.15*
	(1.8)	(-.5)	(-1.5)	(-2.0)	(.1)	
Sesame seeds	-.01	-.01	.17	.48	-.01	-.06
	(-.8)	(-.1)	(.2)	(.7)	(-.5)	
Groundnuts	-.17	5.40	2.37	.68	-.01	.14*
	(-1.9)	(.9)	(.4)	(.1)	(-.1)	

NA = Not available.

Note: The coefficients on GDPPC, DAF, DAS, DLA, and FERPC are expressed in scientific notation, E-03. An asterisk on the coefficient denotes significance at the 5-percent level; an asterisk on the adjusted R-squared statistic denotes a significant equation using the F statistic at the 5-percent level.

Table 16--Exports: Estimation results using ALTDEV for 1977

Dependent variable	Independent variables					Adjusted R-squared
	GDPPC	DAF	DAS	DLA	FERPC	
Cereals	0.32*	9.19	9.51	-1.28	-0.01	0.05
	(2.7)	(1.1)	(1.1)	(-.2)	(-.6)	
Food grains	.14	2.31	6.34	1.15	-.01	.03
	(1.8)	(.4)	(1.2)	(.2)	(-.5)	
Feed grains	.17*	6.35	2.83	-2.83	-.01	.04
	(2.7)	(1.4)	(.6)	(-.7)	(-.5)	
Oilseeds	-.03	.49	3.31	6.16	-.01	-.04
	(-.3)	(.1)	(.6)	(1.3)	(-.3)	
Meat	.01	1.09	.36	4.06	-.01	.06
	(1.0)	(.4)	(.1)	(1.9)	(-.7)	
Barley	-.01	-2.16*	-1.99*	-1.78*	-.01	.03
	(-.5)	(-2.3)	(-2.2)	(-2.2)	(-.1)	
Oats	.01*	.07*	.03	.04	-.01	.09*
	(3.1)	(2.2)	(.8)	(1.3)	(-1.2)	
Wheat flour	.01	-.80	-1.21	-1.50*	.01	.09*
	(1.3)	(-1.1)	(-1.7)	(-2.4)	(1.2)	
Wheat grain	.06*	-.31	-1.98	-1.76	.01	.06
	(2.1)	(-.2)	(-1.1)	(-1.1)	(.3)	
Wheat flour and grain	.05*	-1.09	-2.73	-2.87	.01	.09*
	(2.0)	(-.6)	(-1.5)	(-1.8)	(.8)	
Maize	.18*	8.44	4.80	-1.08	-.01	.05
	(2.9)	(1.9)	(1.1)	(-.3)	(-.5)	
Rice	.09	2.51	7.97	2.98	-.01	.04
	(1.4)	(.5)	(1.8)	(.8)	(-.8)	
Soybeans	-.01	-.39	.01	6.86	-.01	-.01
	(-.2)	(-.1)	(.1)	(1.6)	(-.5)	
Sunflower seeds	.01	.13	.03	.15	-.01	.03
	(1.3)	(1.3)	(.3)	(1.8)	(-1.0)	
Sesame seeds	-.01	-.02	-.07	.13	-.01	-.05
	(-1.0)	(-.1)	(-.2)	(.5)	(-.2)	
Groundnuts	-.02	.33	-.44	-.01	.01	.03
	(-1.3)	(.3)	(-.5)	(-.1)	(.1)	

NA = Not available.

Note: The coefficients on GDPPC, DAF, DAS, DLA, and FERPC are expressed in scientific notation, E-03. An asterisk on the coefficient denotes significance at the 5-percent level; an asterisk on the adjusted R-squared statistic denotes a significant equation using the F statistic at the 5-percent level.

Table 17--Exports: Estimation results using ALTDEV, 1980

Dependent variable	Independent variables					Adjusted R-squared
	GDPPC	DAF	DAS	DLA	FERPC	
Cereals	0.47*	11.55	-5.73	-13.36	0.01	0.08*
	(3.1)	(1.1)	(-.5)	(-1.5)	(.8)	
Food grains	.17	-1.99	-8.20	-8.16	.01	.03
	(1.7)	(-.3)	(-1.2)	(-1.4)	(.6)	
Feed grains	.22*	12.30	1.55	-1.18	-.01	.02
	(2.2)	(1.7)	(.2)	(-.2)	(-.3)	
Oilseeds	.01	.96	3.62	5.53	-.01	-.03
	(.1)	(.2)	(.8)	(1.3)	(-.1)	
Meat	.03	.53	.09	3.59	-.01	.06
	(.8)	(.2)	(.1)	(1.8)	(-1.0)	
Barley	.01	-.62	-.85	-.56	-.01	.02
	(.9)	(-1.1)	(-1.6)	(-1.2)	(-.1)	
Oats	.01	.01	-.01	.02	-.01	.04
	(.9)	(.1)	(-.2)	(.6)	(-.4)	
Wheat flour	.03	-4.46	-5.45*	-6.22*	.01	.12*
	(.9)	(-1.7)	(-2.1)	(-2.7)	(1.7)	
Wheat grain	.07	-7.54	-9.57*	-11.03*	.01	.10*
	(1.0)	(-1.6)	(-2.0)	(-2.7)	(1.3)	
Wheat grain and flour	.01	-9.74	-12.15*	-13.94*	.01	.11*
	(1.0)	(-1.6)	(-2.1)	(-2.7)	(1.5)	
Maize	.21*	12.93	2.42	-.63	-.01	.02
	(2.1)	(1.8)	(.4)	(-.1)	(-.3)	
Rice	.10	5.55	1.36	2.87	-.01	-.03
	(1.4)	(1.2)	(.3)	(.7)	(-.5)	
Soybeans	.02	.79	.37	4.93	-.01	-.02
	(.3)	(.2)	(.1)	(1.3)	(-.1)	
Sunflower seeds	-.01	.01	-.02	-.01	.01	-.04
	(-.3)	(.1)	(-.6)	(-.6)	(.1)	
Sesame seeds	-.01	-.05	-.05	.35	-.01	.01
	(-1.1)	(-.2)	(-.2)	(1.6)	(-1.0)	
Groundnuts	-.01	.16	-.08	.04	-.01	-.03
	(-.5)	(.6)	(-.3)	(.2)	(-.1)	

NA = Not available.

Note: The coefficients on GDPPC, DAF, DAS, DLA, and FERPC are expressed in scientific notation, E-03. An asterisk on the coefficient denotes significance at the 5-percent level; an asterisk on the adjusted R-squared statistic denotes a significant equation using the F statistic at the 5-percent level.

Table 18--Imports: Estimation results using ALTDEV, 1977

Dependent variable	Independent variables					Adjusted R-squared
	GDPPC	DAF	DAS	DLA	FERPC	
Cereals	0.35	-75.92*	-74.52*	-72.12*	0.11*	0.56*
	(1.6)	(-4.7)	(-4.8)	(-5.4)	(4.6)	
Food grains	-.08	-49.06*	-36.08*	-40.43*	.10*	.39*
	(-.5)	(-4.5)	(-3.3)	(-4.1)	(4.9)	
Feed grains	.41*	-27.14*	-33.64*	-37.04*	.04*	.43*
	(3.0)	(-2.7)	(-3.5)	(-4.4)	(2.4)	
Oilseeds	.10*	-7.69*	-9.10*	-10.55*	.01	.26*
	(2.3)	(-2.4)	(-2.9)	(-3.9)	(.01)	
Meat	.03*	-1.08	-1.94	-1.82*	.01*	.25*
	(2.0)	(-1.0)	(-1.9)	(-2.1)	(3.1)	
Barley	.01	-4.14*	-3.47*	-4.42*	.01	.14*
	(.1)	(-3.0)	(-2.5)	(-3.6)	(1.1)	
Oats	.01	-.09	-.06	.31	.01	.18*
	(.7)	(-.5)	(-.3)	(1.9)	(.2)	
Wheat flour	-.03	-10.77*	-7.20	-9.40*	.01	.09*
	(-.5)	(-2.8)	(-1.9)	(-2.9)	(.1)	
Wheat grain	-.11	-55.05*	-43.53*	-39.36*	.07*	.44*
	(-.8)	(-5.9)	(-4.6)	(-4.7)	(4.2)	
Wheat flour and grain	-.11	-51.46*	-38.53*	-37.81*	.05*	.35*
	(-.8)	(-5.4)	(-4.1)	(-4.5)	(3.1)	
Maize	.41*	-23.07*	-30.26*	-33.62*	.04*	.39*
	(3.0)	(-2.3)	(-3.1)	(-4.0)	(2.3)	
Rice	.03	7.29	7.19	-.55	.02*	.12*
	(.5)	(1.6)	(1.6)	(-.1)	(3.1)	
Soybeans	.09*	-5.85*	-7.31*	-8.13*	-.01	.18*
	(2.2)	(-2.0)	(-2.6)	(-3.4)	(-.6)	
Sunflower seeds	.01	-.69	-.82	-.94*	-.01	-.07
	(1.1)	(-1.6)	(-1.9)	(-2.5)	(-.4)	
Sesame seeds	-.01	-.34*	-.24*	-.30*	.01	.28*
	(-1.3)	(-4.6)	(-3.3)	(-4.8)	(1.3)	
Groundnuts	.01	-.61	-.87*	-1.02*	.01	.13*
	(1.2)	(-1.4)	(-2.0)	(-2.7)	(1.9)	

NA = Not available.

Note: The coefficients on GDPPC, DAF, DAS, DLA, and FERPC are expressed in scientific notation, E-03. An asterisk on the coefficient denotes significance at the 5-percent level; an asterisk on the adjusted R-squared statistic denotes a significant equation using the F statistic at the 5-percent level.

Table 19--Imports: Estimation results using ALTDEV, 1980

Dependent variable	Independent variables					Adjusted R-squared
	GDPPC	DAF	DAS	DLA	FERPC	
Cereals	0.38	-95.06*	-94.57*	-75.84*	0.07*	0.50*
	(1.3)	(-4.5)	(-4.5)	(-4.3)	(3.5)	
Food grains	-.05	-52.48*	-43.14*	-39.98*	.05*	.32*
	(-.3)	(-3.8)	(-3.1)	(-3.4)	(3.7)	
Feed grains	.59*	-38.15*	-53.32*	-50.16*	.04*	.34*
	(2.6)	(-2.4)	(-3.3)	(-3.7)	(2.3)	
Oilseeds	.15*	-11.27*	-12.60*	-15.43*	-.01	.20*
	(2.1)	(-2.2)	(-2.5)	(-3.6)	(-.1)	
Meat	.02	-1.53	-1.40	-1.77	.01*	.32*
	(1.2)	(-1.4)	(-1.3)	(-1.9)	(4.5)	
Barley	.01	-6.70*	-6.86*	-6.13*	.01	.34*
	(.4)	(-4.5)	(-4.7)	(-4.9)	(.1)	
Oats	-.01	-.05	-.02	.33*	.01	.17*
	(-.1)	(-.3)	(-.1)	(2.4)	(1.1)	
Wheat flour	.01	-11.33*	-9.86*	-12.32*	.01	.08*
	(.1)	(-2.4)	(-2.1)	(-3.1)	(.3)	
Wheat grain	-.01	-59.53*	-50.21*	-41.29*	.04*	.41*
	(-.1)	(-5.0)	(-4.2)	(-4.0)	(3.3)	
Wheat flour and grain	-.03	-52.14*	-42.71*	-36.32*	.02	.31*
	(-.2)	(-4.3)	(-3.6)	(-3.5)	(1.9)	
Maize	.57*	-31.95	-46.25*	-44.11*	.04*	.28*
	(2.4)	(-1.9)	(-2.8)	(-3.1)	(2.1)	
Rice	-.05	6.56	6.76	1.22	.01*	.08*
	(-.7)	(1.2)	(1.3)	(.3)	(2.2)	
Soybeans	.12	-8.55	-9.38*	-11.35*	-.01	.13*
	(1.7)	(-1.8)	(-2.0)	(-2.8)	(-.1)	
Sunflower seeds	.02	-1.94	-2.29	-2.29*	-.01	.03
	(.9)	(-1.5)	(-1.8)	(-2.0)	(-.5)	
Sesame seeds	.01	-.24*	-.13	-.29*	-.01	.21*
	(1.0)	(-2.5)	(-1.4)	(-3.5)	(-.3)	
Groundnuts	.01	.06	-.04	-.14	.01*	.52*
	(1.1)	(.5)	(-.3)	(-1.4)	(8.3)	

NA = Not available.

Note: The coefficients on GDPPC, DAF, DAS, DLA, and FERPC are expressed in scientific notation, E-03. An asterisk on the coefficient denotes significance at the 5-percent level; an asterisk on the adjusted R-squared statistic denotes a significant equation using the F statistic at the 5-percent level.

the apparent utilization equation for soybeans suggests that soy products are not directly important in diets of low-income groups.

As was the case for apparent utilization, the production equations which employ ALTDEV have less explanatory power than those which use GDPPC (tables 14 and 15). The exception is, again, the aggregated food grain production equation, for which the ALTDEV variable rivals the performance of GDPPC in earlier equations. The ALTDEV variable is not correlated with either the production of feed grains or oilseeds, again indicating that improvement in the social indicators does not rely, directly, on increases in either commodity group. For the individual food grains, the domestic production of rice is positively correlated with improvements in ALTDEV, while production of wheat is not. This is the opposite result obtained when GDPPC was used in the earlier equations. The only other commodities for which there is a correlation between ALTDEV and production changes are sunflower seeds and oats.

Earlier it was noted that the consumption of oats, maize, rice, and sunflower seeds increased at the same time ALTDEV did. Similarly, production of each of these commodities, and only these commodities, increased in association with rises in the level of the ALTDEV components. Maize was the only one of these commodities that recorded an increase in imports in association with increases in ALTDEV. Soybean imports were also correlated with increases in ALTDEV. This increase in soybeans is presumably related to the expansion of domestic meat production because soybeans can serve as an input to the meat industry. Finally, the consumption of meat increases along with improvements in ALTDEV. This rise in consumption is met largely through increased domestic production accompanied by small increases in meat imports.

On balance, the ALTDEV variable behaves as expected. Its formulation emphasizes improvements in health and education rather than increases in per capita income. Although per capita income can translate into improved health care and higher levels of education, this is not always the case as is borne out by the correlation coefficient for GDPPC and ALTDEV.

ALTDEV improvements tend to be more closely associated with increased levels of rice consumption than was the case for GDPPC. Conversely, the strong correlation between GDPPC and soybean utilization is not evident when the ALTDEV variable is used. As was the case for the equations which employed GDPPC, the rise in food grain consumption was supplied by increases in domestic production. While caution needs to be exercised when constructing generalizations out of the results presented here, it appears that improvements in ALTDEV are largely based on the increased consumption of a few commodities (oats, rice, maize, and meats). Supplies of these commodities come in large measure from increases in domestic production rather than from imports. The partial exception to this is the importation of soybeans, which are used as an input in meat production.

On the basis of this analysis, we conclude that the consumption, production, and trade patterns associated with increases in ALTDEV are consistent with those for GDPPC, even though the range of commodities that are correlated with ALTDEV is narrower than for GDPPC.

SOURCES OF SUPPLY FOR LDC AGRICULTURAL IMPORTS

The results presented here demonstrate that development, whether measured by income growth or a mix of basic needs indicators, does yield an increase in

demand for a wide range of agricultural commodities. This demand is met via increased domestic production of some commodities and expanded imports of others. This expansion of trade opportunities is what we have termed the "development growth market." Simply put, it is the market for agricultural commodities that arises from economic development. It is not the result of any other factors that can lead to an increase in demand of agricultural products. As a straightforward empirical problem, it would be interesting to know how the United States has fared in the competition for these markets.

This section addresses that problem by comparing two equations. The first equation regresses the per capita volume of developing country agricultural imports from the United States on GDPPC and the other independent variables used in the previous sections. The second equation regresses the per capita volume of developing country imports from the rest of the world on the same set of independent variables. By comparing the coefficients on the GDPPC variables in the two equations, the relative share of the United States as compared with the rest of the world can be approximated.

Table 20 presents the results of regressing the total value of agricultural imports from the United States and the rest of the world (ROW).35/ Three features are striking about these equations. First, there are considerable differences in the results for the two years. The coefficient on GDPPC in the ROW equation was 50 percent larger than the same coefficient in the U.S. equation in 1977. A $1 increase in per capita income in the sample countries resulted in an increase in the value of agricultural imports per capita from the ROW of $0.011 and an increase from the United States of $0.0073 per capita.36/ The difference may seem trivial, but not when the results are expressed in per capita and per annum terms. These data should also be viewed broadly. Collectively, 1.7 percent of the increase in per capita income is channeled into imports of agricultural commodities. If a country with a population of 25 million and a per capita income of $400 grew by 2.5 percent per year (GDPPC increased by $10 per capita), the value of agricultural imports would increase by $4.5 million. Thus, even modest growth poor countries can have a substantial impact on the value of agricultural imports.

The United States exported a record volume of agricultural commodities in 1980. This dominance in world markets is shown in the results for 1980 as a much larger coefficient for GDPPC in the U.S. export equation than in the ROW equation. This

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35/ The data set for this analysis was constructed by subtracting the volume of U.S. exports to the developing countries from the recorded volume of total imports by developing countries. This method caused some problems because of the different treatment accorded noncommercial agricultural trade. The data on U.S. exports include food aid and other forms of agricultural assistance. The FAO data on developing country agricultural imports do not treat these noncommercial transactions in a consistent manner. The result is that U.S. exports to some countries are greater than the total volume of agricultural imports recorded by that country. This result was found in only a few cases. Rather than tamper with the data set, we left the negative values in place.

36/ The data set used in this section required the merger of two separate data banks. The inconsistent treatment of noncommercial agricultural trade causes some problems in interpretation. It must be concluded that these estimates overstate the commercial import response to income growth. It is recommended that these estimates be regarded as maximum values.

means that U.S. exporters captured the entire "development growth market." (Note that the coefficient on GDPPC for the ROW equation is not significant, and, therefore, cannot be assumed to be different from zero.)

Table 20--Value of developing country agricultural imports, United States and the rest of the world

Dependent variable	Independent variables					Adjusted R-squared
	GDPPC	DAF	DAS	DLA	FERPC	
1977:						
United States	0.007*	-1.32	-1.42	-3.70	-0.01	0.50*
	(3.9)	(-.4)	(-.4)	(1.2)	(0.7)	
Rest of World	.011*	-25.20*	-26.39*	-34.92*	.08*	.80*
	(3.1)	(-4.1)	(-4.1)	(-6.7)	(8.1)	
1980:						
United States	.007*	-4.51	-3.06	5.26	.03*	.64*
	(3.4)	(-.8)	(-.5)	(1.1)	(3.7)	
Rest of World	.006	-41.38*	-36.77*	-48.38*	.08*	.74*
	(1.6)	(-4.2)	(-3.5)	(-5.6)	(7.2)	

Note: The coefficients on GDPPC, DAF, DAS, DLA, and FERPC are expressed in scientific notation of E-03. An asterisk on the coefficient denotes significance at the 5-percent level; an asterisk on the adjusted R-squared statistic denotes a significant equation using the F statistic at the 5-percent level.

Second, the explanatory power of the ROW equations is appreciably higher than that for the U.S. equations. The interpretation of this difference must be undertaken with some caution, but the results seem to suggest that the ROW is a more consistent supplier to the growth market than the United States. Such an interpretation is consistent with the widely held notion that the United States is a residual supplier in world markets.

Third, the significance of the negative regional dummies in both ROW equations confirms our knowledge that the United States is a larger exporter of agricultural commodities than the ROW. The difference in the size of the coefficients on regional variables for the two periods confirms that 1980 was a very good year for U.S. agricultural exports.

Table 21 presents results for commodity groups (feed grains, oilseeds, and meat) and individual commodities (maize and soybeans), respectively, that were found to display some import responsiveness to income growth. The results for the aggregated and individual commodities are consistent. The United States performed relatively well in feed grains and oilseeds, but significantly less well in meats. The United States dominated the markets in traded maize and soybeans in both 1977 and 1980. For maize, this dominance was by a factor of at least 3 to 1. The FERPC variable, which typically is significant and of the opposite sign of the GDPPC variable, is insignificant in the U.S. equation for 1980 and in the ROW equation for 1977 and 1980. This may well be due to increased food relief shipments to drought areas, which were not paid for with foreign exchange. The dominance of U.S. soybean shipments to the developing countries was again on the order of 3 to 1. These results suggest that U.S. agricultural export performance is very sensitive to the year chosen. The results also indicate that

Table 21--Developing country agricultural imports by commodity groups, United States and rest of the world

Dependent variable		Independent variables					Adjusted R-squared
		GDPPC	DAF	DAS	DLA	FERPC	
Feed grain--							
1977:	United States	0.04*	-7.48	-8.40	-12.50	-0.05*	0.45*
		(5.4)	(-.6)	(-.6)	(-1.1)	(-2.5)	
	Rest of World	.01	4.69	5.34	-2.25	.01	-.05
		(.7)	(.5)	(.5)	(-.3)	(.7)	
1980:	United States	.01*	-13.96	-15.89	-11.31	-.01	.42*
		(4.3)	(-.9)	(-.9)	(-.8)	(.9)	
	Rest of World	.01	-4.81	-3.53	-10.32*	.01	.10*
		(1.2)	(-.8)	(-.6)	(-2.0)	(.7)	
Oilseed--							
1977:	United States	.01	.07	.07	.24*	-.01	.06
		(.8)	(.6)	(.5)	(2.3)	(-1.2)	
	Rest of World	.01*	-1.77	-1.22	-5.58*	-.02*	.62*
		(7.8)	(-.7)	(-.5)	(-2.8)	(-5.5)	
1980:	United States	.01	.01	.01	.02*	-.01	.09*
		(1.6)	(.4)	(.6)	(2.1)	(-1.6)	
	Rest of World	.01*	1.61	3.43	-2.80	-.03*	.01
		(8.4)	(.5)	(.9)	(-.9)	(-6.1)	
Meat--							
1977:	United States	.01	.30	.27	.70	-.01	-.01
		(.9)	(.6)	(.5)	(1.5)	(-.3)	
	Rest of World	.01*	.63	.39	-.72	.01	.69*
		(9.8)	(1.2)	(.7)	(-1.7)	(.1)	
1980:	United States	-.01	-.34	-.44	.52	.01	.14*
		(-.7)	(-.6)	(-.7)	(1.0)	(2.2)	
	Rest of World	.01	-1.18	-.81	-2.00*	.01*	.43*
		(1.9)	(-1.5)	(-.9)	(-2.8)	(3.8)	
Maize--							
1977:	United States	.03*	-2.34	-3.93	-8.46	-.05*	.50*
		(6.3)	(-.2)	(-.4)	(-1.0)	(-2.9)	
	Rest of World	.01*	8.16	8.57	-.34	-.01	.08
		(2.6)	(1.1)	(1.1)	(-.1)	(-.2)	
1980:	United States	.02*	-17.16	-18.59	-15.21	-.01	.40*
		(3.9)	(-1.1)	(-1.1)	(-1.1)	(-.5)	
	Rest of World	.01*	3.25	5.53	-2.80	-.01	.24*
		(3.4)	(.8)	(1.2)	(-.7)	(-.8)	
Soybean--							
1977:	United States	.01*	.51	.97	-1.58	-.01*	.49*
		(6.1)	(.3)	(.5)	(-1.0)	(-3.4)	
	Rest of World	.01*	.79	.70	-.72	-.01*	.37*
		(5.5)	(.9)	(.8)	(-1.0)	(-3.7)	
1980:	United States	.01*	1.61	2.82	.04	-.01*	.53*
		(6.8)	(.6)	(1.0)	(1.8)	(-4.0)	
	Rest of World	.01*	-.06	.42	-.88	-.01*	.76*
		(5.8)	(-.1)	(.4)	(-1.1)	(-6.9)	

Note: The coefficients on GDPPC, DAF, DAS, DLA, and FERPC are expressed in scientific notation of E-03.

while the United States has been competitive, its performance could be improved by strengthening trade relations with those countries having the greatest growth potential.

CONCLUSIONS

The issue of agricultural production by and trade with developing countries is a controversial one. Many have argued that the commercial interests of major agricultural exporting (developed) countries are endangered by growth in developing countries. The essence of that argument is, when the initial stages of economic development are based on expanded agricultural production, this expansion leads to displacement of agricultural imports and eventually results in agricultural exports that compete directly with those of the established major exporters. The other side of this issue consists of three parts. First, the key to expanded agricultural exports by developed countries is growth in the developing countries. Schuh (26) makes this point:

> It is important [to] understand where the true interests of U.S. agriculture lie and especially where future U.S. markets are likely to be.... These markets are likely to grow most rapidly in the developing countries (including China) rather than in the industrialized countries or even the centrally planned economies.... The developing countries will constitute a growing market for U.S. producers only if their economies expand and their living standards rise.

Second, growth in the developing country economies, and therefore their import demand, must initially be based on expansion of their agricultural production. As income in developing countries increases, demand for imported agricultural commodities will also increase. Again, Schuh makes the same point and argues:

> The bulk of their [developing countries'] resources is invested in, and derived from agriculture. The level of productivity in this sector is generally very low. Increasing productivity and incomes in agriculture is thus the key to raising per capita incomes in the economy as a whole. These higher incomes are the source of a strong demand for agricultural imports.

Finally, it is asserted that much of the income growth from agricultural export expansion is based on commodities for which the developing countries have a comparative advantage, typically tropical crops.

Recognizing that a distinction can be made between the determinants of agricultural imports and exports, the present study was largely confined to investigating the impact of development on agricultural imports. However, to gain an understanding of the determinants of agricultural imports, it was necessary to gauge the response of apparent utilization and domestic agricultural production during development. The development process is characterized by increased productivity and structural change of the economy. From a neoclassical point of view, this typically means that resources are transferred out of subsistence agriculture to more productive applications as production in all sectors becomes more specialized. Income growth gives rise to increased demand for agricultural commodities and, when coupled with increased specialization, should engender an increase in a broad range of agricultural imports. Again, in

the neoclassical view, this should hold true for all commodities except those for which a country holds a comparative advantage. Although this scenario may be valid in some situations, it cannot be regarded as the general rule because it can be overshadowed by the impact of policy interventions. Therefore, we have argued, especially for food grains, that there exists the potential for domestic policy to stimulate local production and thereby offset some of the anticipated, growth-stimulated increases in agricultural imports. While the question of the impact of policy on agricultural production and trade is an interesting one, it is not directly tested and is offered more as an explanation for the observed results.

The investigation concentrated on the relationship between measures of development and agricultural demand and supply. Sources of supply for agricultural consumption were grouped into three categories: production, imports, and exports. Each was represented as a function of some measure of development, either income or an average of social infrastructure measures.

There is a strong, and we believe causal, relationship between each of the two measures of development and the value of agricultural imports. This relationship does not exist to the same degree for agricultural exports. Both measures of development proved to be far more highly correlated with agricultural imports than with agricultural exports. This suggests that expanding exports of the commodities used in this study are not inexorably linked to the development process. Further, this result demonstrates that development creates more import opportunities in developing countries, for the agricultural commodities studied, than it does export competition.

Income growth is associated with increased utilization of a number of agricultural commodities, such as feed grains (barley, oats, and maize), certain oilseeds (soybeans and sunflower seeds), and meat products. Somewhat surprisingly, the utilization of food grains does not respond to income growth. Rather than accept this result at face value, we are inclined to place more emphasis on the correlation between per capita income of the components parts of apparent utilization. Food grain production demonstrated a positive association with income growth, while exports of food grains showed essentially no reaction to income changes, and imports of food grains decreased as income increased. When the increase in production of food grains is larger than the reduction in imports, we infer that domestic utilization of food grains increases, as income does.

The apparent utilization of food grains is more responsive to improvements in the alternative measure of development than to growth in per capita income. This implies a stronger link between increased consumption of food grains and a social measure of development than there is between consumption and a simple income measure. In other words, food consumption is more likely to increase when social indicators increase than when income alone increases.

The correlation of feed grain utilization with either measure of development is greater than that for the food grains. (This differential is difficult to measure given our uncertainty about the coefficient on GDPPC in the apparent utilization equation.) This presumably reflects the move of consumer preferences toward foodstuffs requiring feeds as an input.

There is a comparatively strong correlation between income growth and increased production of certain food grains (wheat), feed grains, and meat. For feed grains, this correlation is based upon the behavior of barley, oats, and maize

production. Part of the increased production of maize is probably for use as food, rather than as feed. The increased production of meat most likely reflects the realities of transporting and storing meat imports. It is more cost effective to raise livestock locally than to import it. The extent to which the behavior of food grain production is the result of "self-sufficiency" policies as opposed to local productive advantages cannot be determined with certainty. However, it is our conjecture that the former plays a large role in explaining the results for domestic food production performance.

The increased utilization of food grains and some feed grains is met through increased domestic production. The increased demand for other feed grains, specifically maize, gives rise to increased levels of imports of those grains. This point can be extended to the oilseeds as well. Two oilseeds, sunflower seed and soybean, showed an increase in utilization as development occurred. Sunflower seed was supplied largely through increased domestic production, while demand for soybeans was met through increased imports.

Corresponding to the results of the value equations, there is little correlation between the volume of agricultural exports and growth of per capita income or the alternative measure of development.

The results of the bilateral value equations indicate that relative trade shares (United States versus the rest of the world) in the growth market are sensitive to the time period chosen. Although the United States is competitive, its performance in the "developing country growth market" is less consistent than that for other suppliers.

The results of this study are generally in agreement with those in earlier works. Income growth in developing countries resulted in more rapid growth of agricultural imports than exports. These expanded market opportunities are more likely to be for selected feed grains and oilseeds than for food grains.

Earlier, we referred to the issue of developing countries' growth and the implications thereof for competition in the traditional agricultural export markets of developed countries. The evidence presented here indicates that there is not a systematic relationship between the value of agricultural exports or the volume of selected commodities and development. This is not to say that developing countries will not export agricultural commodities as part of their development strategy, but rather that exports of the commodities studied herein will not be the mainstay of sustained economic growth. Further, the results presented here demonstrate that for the commodities most important to U.S. exporters, maize and soybeans, developing countries will increase their imports as development proceeds.

Further, the evidence indicates that successful development efforts by the developing countries are the strongest catalysts for expanding developed country agricultural exports. For better or worse, the prospects of the two seem to be inextricably joined.

FUTURE RESEARCH

As a result of this study, we recommend that two types of additional research be prepared. The first type is a result of the particular methodology employed. The goal was to gain a perspective on agricultural trade and economic development. The methodology was designed to facilitate this goal. Since we have acquired a perspective on this aspect of development and trade issues, it

would be appropriate to pursue individual country studies to ascertain the extent to which they conform to the general patterns we have observed. For such a study to be complete, it would need to consider the causes of deviation from the established pattern and offer a judgment about the benefits, in terms of development prospects, of such deviations.

A possible extension of this type of analysis would be an investigation of what constitutes a successful agricultural trade policy for developing countries. What are the economic and political characteristics of countries that have managed to foster development on the basis of an agricultural export strategy? How do these characteristics compare with cases that have been notable failures?

Another area of research is engendered by the questions that were left unanswered by the results of the present report. For example, to what extent have policy interventions affected food production and trade in developing countries? Is there scope for adopting food security programs that would allow developing countries to turn their agricultural potential more in the direction of their comparative advantages? Another question that comes out of this report centers on the factors which affect domestic production and importation decisions. For example, why are oats and barley produced locally, while maize is imported?

This report has answered some questions, but Mellor's observation that our understanding of the nature of relations between agriculture and the rest of the developing economy is weak, especially in the area of the macroeconomy, is still valid.

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Appendix I--Component Parts of Alternative Development Measure for 1977

Country	Life expectancy at birth		Child death rate		Pct. of school age children enrolled in primary school		ALTDEV variable
	Value	Index	Value	Index	Value	Index	
Afghanistan	42.0	8.8	27.0	27.8	20.0	3.6	13.4
Algeria	56.0	50.0	16.0	58.3	99.0	98.8	69.0
Angola	41.0	5.9	34.0	8.3	59.0	50.6	21.6
Bangladesh	47.0	23.5	23.0	38.9	72.0	66.3	42.9
Benin	46.0	20.6	27.0	27.8	60.0	51.8	33.4
Bolivia	52.0	38.2	22.0	41.7	86.0	83.1	54.3
Brazil	62.0	67.6	9.0	77.8	88.0	85.5	77.0
Cameroon	46.0	20.6	27.0	27.8	100.0	100.0	49.5
Cent. African Rep.	46.0	20.6	27.0	27.8	78.0	73.5	40.6
Chile	67.0	82.4	5.0	88.9	100.0	100.0	90.4
Colombia	62.0	67.6	9.0	77.8	100.0	100.0	81.8
Congo	46.0	20.6	27.0	27.8	100.0	100.0	49.5
Costa Rica	70.0	91.2	3.0	94.4	100.0	100.0	95.2
Dominican Rep.	60.0	61.8	10.0	75.0	96.0	95.2	77.3
Ecuador	60.0	61.8	10.0	75.0	100.0	100.0	78.9
Egypt	54.0	44.1	18.0	52.8	74.0	68.7	55.2
El Salvador	63.0	70.6	8.0	80.6	79.0	74.7	75.3
Ethiopia	39.0	0	37.0	0	38.0	25.3	8.4
Ghana	48.0	26.5	23.0	38.9	71.0	65.1	43.5
Greece	73.0	100.0	1.0	100.0	100.0	100.0	100.0
Guatemala	57.0	52.9	15.0	61.1	64.0	56.6	56.9
Guinea	44.0	14.7	30.0	19.4	34.0	20.5	18.2
Honduras	57.0	52.9	14.0	63.9	85.0	81.9	66.3
Indonesia	48.0	26.5	19.0	50.0	94.0	92.8	56.4
Ivory Coast	46.0	20.6	27.0	27.8	71.0	65.1	37.8
Jamaica	70.0	91.2	3.0	94.4	98.0	97.6	94.4
Jordan	56.0	50.0	16.0	58.3	100.0	100.0	69.4
Kenya	53.0	41.2	14.0	63.9	99.0	98.8	68.0
Korea, South	63.0	70.6	5.0	88.9	100.0	100.0	86.5
Liberia	48.0	26.5	23.0	38.9	64.0	56.6	40.7
Madagascar	46.0	20.6	27.0	27.8	94.0	92.8	47.0
Malawi	46.0	20.6	27.0	27.8	59.0	50.6	33.0
Malaysia	67.0	82.4	3.0	94.4	94.0	92.8	89.9
Mali	42.0	8.8	32.0	13.9	28.0	13.3	12.0
Mauritania	42.0	8.8	32.0	13.9	26.0	10.8	11.2
Mexico	65.0	76.5	6.0	86.1	100.0	100.0	87.5
Morocco	55.0	47.1	17.0	55.6	72.0	66.3	56.3
Nepal	45.0	17.6	23.0	38.9	69.0	62.7	39.7
Nicaragua	55.0	47.1	17.0	55.6	85.0	81.9	61.5
Niger	42.0	8.8	32.0	13.9	23.0	7.2	10.0
Nigeria	48.0	26.5	24.0	36.1	62.0	54.2	38.9
Pakistan	51.0	35.3	17.0	55.6	51.0	41.0	43.9
Panama	70.0	91.2	3.0	94.4	88.0	85.5	90.4
Papua N. Guinea	48.0	26.5	19.0	50.0	60.0	51.8	42.8

Appendix I--Component Parts of Alternative Development Measure for 1977--con.

Country	Life expectancy at birth		Child death rate		Pct. of school age children enrolled in primary school		ALTDEV variable
	Value	Index	Value	Index	Value	Index	
Paraguay	63.0	70.6	8.0	80.6	85.0	81.9	77.7
Peru	56.0	50.0	16.0	58.3	100.0	100.0	69.4
Philippines	60.0	61.8	7.0	83.3	100.0	100.0	81.7
Portugal	69.0	88.2	2.0	97.2	100.0	100.0	95.2
Rwanda	46.0	20.6	27.0	27.8	64.0	56.6	35.0
Senegal	42.0	8.8	32.0	13.9	41.0	28.9	17.2
Sierra Leone	46.0	20.6	27.0	27.8	37.0	24.1	24.2
South Africa	60.0	61.8	10.0	75.0	99.0	98.8	78.5
Spain	73.0	100.0	1.0	100.0	100.0	100.0	100.0
Sri Lanka	69.0	88.2	2.0	97.2	94.0	92.8	92.7
Sudan	46.0	20.6	31.0	16.7	50.0	39.8	25.7
Syria	57.0	52.9	14.0	63.9	89.0	86.7	67.9
Tanzania	51.0	35.3	20.0	47.2	70.0	63.9	48.8
Thailand	61.0	64.7	6.0	86.1	82.0	78.3	76.4
Togo	46.0	20.6	27.0	27.8	100.0	100.0	49.5
Trin. and Tob.	70.0	91.2	3.0	94.4	99.0	98.8	94.8
Upper Volta	42.0	8.8	32.0	13.9	17.0	0	7.6
Uruguay	71.0	94.1	3.0	94.4	100.0	100.0	96.2
Venezuela	66.0	79.4	5.0	88.9	100.0	100.0	89.4
Yemen Arab Rep.	47.0	23.5	31.0	16.7	29.0	14.5	18.2
Yugoslavia	69.0	88.2	2.0	97.2	99.0	98.8	94.8
Zaire	46.0	20.6	27.0	27.8	90.0	88.0	45.4
Zambia	48.0	26.5	23.0	38.9	98.0	97.6	54.3

Appendix I--Component Parts of Alternative Development Measure for 1980--con.

Country	Life expectancy at birth		Child death rate		Pct. of school age children enrolled in primary school		ALTDEV variable
	Value	Index	Value	Index	Value	Index	
Algeria	56.0	48.6	19.0	64.0	95.0	93.8	68.8
Angola	42.0	8.6	34.0	34.0	59.0	49.4	30.7
Bangladesh	46.0	20.0	20.0	62.0	62.0	53.1	45.0
Benin	47.0	22.9	34.0	34.0	62.0	53.1	36.6
Bolivia	50.0	31.4	25.0	52.0	84.0	80.2	51.6
Brazil	63.0	68.6	7.0	88.0	93.0	91.4	82.6
Cameroon	47.0	22.9	21.0	60.0	100.0	100.0	61.0
Cent. African Rep.	46.0	20.6	27.0	27.8	78.0	73.5	40.6
Chile	67.0	80.0	2.0	98.0	100.0	100.0	92.7
Colombia	63.0	68.6	4.0	94.0	100.0	100.0	87.5
Congo	59.0	57.1	27.0	48.0	100.0	100.0	68.4
Costa Rica	70.0	88.6	1.0	100.0	100.0	100.0	96.2
Dominican Rep.	61.0	62.9	6.0	90.0	100.0	100.0	84.3
Ecuador	61.0	62.9	8.0	86.0	100.0	100.0	83.0
Egypt	57.0	51.4	14.0	74.0	76.0	70.4	65.3
El Salvador	63.0	68.6	7.0	88.0	74.0	67.9	74.8
Ethiopia	40.0	2.9	32.0	38.0	43.0	29.6	23.5
Ghana	49.0	28.6	19.0	64.0	69.0	61.7	51.4
Greece	74.0	100.0	1.0	100.0	100.0	100.0	100.0
Guatemala	59.0	57.1	6.0	90.0	69.0	61.7	69.6
Guinea	45.0	17.1	37.0	28.0	33.0	17.3	20.8
Honduras	58.0	54.3	10.0	82.0	89.0	86.4	74.2
Indonesia	53.0	40.0	11.0	80.0	98.0	97.5	72.5
Ivory Coast	47.0	22.9	26.0	50.0	76.0	70.4	47.7
Jamaica	71.0	91.4	2.0	98.0	99.0	98.8	96.1
Jordan	61.0	62.9	6.0	90.0	100.0	100.0	84.3
Kenya	55.0	45.7	15.0	72.0	100.0	100.0	72.6
Korea, South	65.0	74.3	2.0	98.0	100.0	100.0	90.8
Liberia	54.0	42.9	34.0	34.0	66.0	58.0	45.0
Madagascar	47.0	22.9	11.0	80.0	100.0	100.0	67.6
Malawi	44.0	14.3	39.0	24.0	62.0	53.1	30.5
Malaysia	64.0	71.4	2.0	98.0	92.0	90.1	86.5
Mali	43.0	11.4	31.0	34.0	27.0	9.9	18.4
Mauritania	43.0	11.4	31.0	40.0	33.0	17.3	22.9
Mexico	65.0	74.3	4.0	94.0	100.0	100.0	89.4
Morocco	56.0	48.6	15.0	72.0	76.0	70.4	63.6
Nepal	44.0	14.3	23.0	56.0	91.0	88.9	53.1
Nicaragua	56.0	48.6	10.0	82.0	100.0	100.0	76.9
Niger	43.0	11.4	31.0	40.0	23.0	4.9	18.8
Nigeria	49.0	28.6	28.0	46.0	98.0	97.5	57.4
Pakistan	50.0	31.4	18.0	66.0	57.0	46.9	48.1
Panama	70.0	88.6	1.0	100.0	100.0	100.0	96.2

Appendix I--Component Parts of Alternative Development Measure for 1980--con.

Country	Life expectancy at birth		Child death rate		Pct. of school age children enrolled in primary school		ALTDEV variable
	Value	Index	Value	Index	Value	Index	
Papua N. Guinea	51.0	34.3	14.0	74.0	62.0	53.1	53.8
Paraguay	65.0	74.3	3.0	96.0	100.0	100.0	90.1
Peru	58.0	54.3	9.0	84.0	100.0	100.0	79.4
Philippines	64.0	71.4	4.0	94.0	100.0	100.0	88.5
Portugal	71.0	91.4	2.0	98.0	100.0	100.0	96.5
Rwanda	45.0	17.1	29.0	44.0	70.0	63.0	41.4
Senegal	43.0	11.4	32.0	28.0	44.0	30.9	26.8
Sierra Leone	47.0	22.9	50.0	2.0	39.0	24.7	16.5
South Africa	61.0	62.9	18.0	66.0	99.0	98.8	75.9
Spain	73.0	97.1	1.0	100.0	100.0	100.0	99.0
Sri Lanka	66.0	77.1	3.0	96.0	100.0	100.0	91.0
Sudan	46.0	20.0	22.0	58.0	51.0	39.5	39.2
Syria	65.0	74.3	5.0	92.0	100.0	100.0	88.8
Tanzania	52.0	37.1	19.0	64.0	100.0	100.0	67.0
Thailand	63.0	68.6	4.0	94.0	96.0	95.1	85.9
Togo	47.0	22.9	21.0	60.0	100.0	100.0	65.1
Trin. and Tob.	72.0	94.3	1.0	100.0	94.0	92.6	95.6
Upper Volta	39.0	0	51.0	0	19.0	0	0
Uruguay	71.0	91.4	2.0	98.0	100.0	100.0	96.5
Venezuela	67.0	80.0	2.0	98.0	100.0	100.0	92.7
Yemen Arab Rep.	42.0	8.6	50.0	2.0	47.0	34.6	15.0
Yugoslavia	70.0	88.6	2.0	98.0	99.0	98.8	95.1
Zaire	47.0	22.9	22.0	58.0	90.0	87.7	56.2
Zambia	49.0	28.6	20.0	62.0	95.0	93.8	61.5

Appendix II--Country List of Supply Sources

Afghanistan (1977 only)
Algeria
Bangladesh
Benin
Bolivia
Brazil
Cameroon
Central African Republic
Chile
Colombia
Congo
Costa Rica
Dominican Republic
Ecuador
Egypt
El Salvador
Ethiopia
Greece
Guatemala
Guinea
Honduras
Indonesia
Ivory Coast
Jamaica
Jordan
Kenya
Korea, Republic of
Liberia
Madagascar
Malawi
Malaysia
Mexico
Morocco
Nepal
Nicaragua
Niger
Nigeria
Pakistan
Papua New Guinea
Paraguay
Peru
Philippines
Portugal
Senegal
Sierra Leone
Spain
Sri Lanka
Sudan
Syria
Tanzania
Thailand
Togo
Trinidad and Tobago
Upper Volta
Venezuela
Yemen Arab Republic
Yugoslavia
Zaire

Appendix III--Time Series Analysis of Import Demand in Korea, Kenya, and Colombia

A cross-sectional methodology imposes some limitations on the model employed in the main part of this report. In an effort to address some of these issues, a time series analysis was conducted for selected countries and agricultural commodities. The selection of countries was based largely on the extent of U.S. bilateral aid involvement and the availability of data. The commodities examined were those which accounted for a significant share of agricultural imports. As was the case with the cross-sectional study, our concern is with the impact of development on agricultural imports, therefore in the model that is specified, we concentrate on the impact of macroeconomic factors of imports.

Since imports are assumed to be a device for filling the gap between domestic production and demand, the model should take into consideration the factors that influence domestic production. Following the logic of a two-stage maximization process, prices are assumed to affect output through planting (acreage) and harvesting (yield) decisions. Equation (1) presents acreage planted to the ith commodity as a function of the relative price of the ith and jth commodity (PR_{it}/PR_{jt}), the real price of the ith commodity (PR_{it}/CPI_t), and the cost of factor inputs (FOP_t). As the price of the ith commodity increases relative to that of other commodities, the number of acres planted to the ith commodity should increase. The real price variable represents the terms of trade between traded goods produced in the agricultural sector and those produced in other sectors. If, for example, the price of goods from other sectors increased relative to those for the agricultural sector, the incentive to produce agricultural commodities will decrease. The terms of trade effect can be affected by decisions ranging from marketing board pricing decisions to the level of the exchange rate. The input cost variable (FOP_t) is included to represent another factor in determining the profitability of agricultural production. We assume there are no government sponsored acreage restriction programs in effect.

$$AC_{it} = a_0 + a_1PR_{it}/PR_{jt} + a_2PR_{it}/CPI_t + a_3FOP_t \qquad (1)$$

Similarly, the yield (YD) equation (2) depicts agricultural productivity as a function of the same set of factors and posits the same relationship between dependent and independent variables. In essence, incentives will operate in such a way that producers will attempt to increase yield in the face of higher agricultural output prices, lower prices in other sectors, or lower input prices.

$$YD_{it} = b_0 + b_1PR_{it}/PR_{jt} + b_2PR_{it}/CPI_t + b_3FOP_t \qquad (2)$$

Agricultural production of the ith commodity at time t (PD_{it}) is assumed to be a function of acres planted, yield, and the level of external (typically public sector) resources channeled to the sector. As a proxy for resources received by the agricultural sector, we use the level of official development assistance spent on agricultural projects ($ODAAG_t$).

$$PD_{it} = c_0 + c_1AC_{it} + c_2YD_{it} + c_3ODAAG_t \qquad (3)$$

The specification of an import-demand equation follows the examples provided by Leamer and Stern (16). Typically, import demand is a function of income, the price of imports, and the price of alternative consumable commodities. As noted by Leamer and Stern (16, pp. 10-12), this specification assumes that imports and domestic goods are not perfect substitutes. In most situations where agricultural commodities are concerned, this assumption cannot be comfortably

made.37/ The solution to the problem is to make some consideration for the capacity of domestic import-competing industries as an explanatory variable in the import-demand function. In addition to the world price of the commodity (WP_{it}) and real income ($RGDPPC_t$) variables, the level of production (PD_{it}) from equation (3) is included in the import-demand equation. It is assumed that the level of commodity imports will be negatively related to international commodity prices and that imports will be positively related to real income. Since domestic production is assumed to be a near-perfect substitute for imports, the relationship with imports is hypothesized to be negative. Finally, the level of foreign exchange reserves as a share of total merchandise imports ($FER/MERM_t$) is included as a proxy for the strictness of controls affecting imports. This being the case, we assume that relatively large foreign exchange reserves, compared with import demand, will cause import restrictions to be relaxed and be positively related to the level of imports.

$$M_{it} = d_0 + d_1PD_{it} + d_2RGDPPC_t + d_3WP_{it} + d_4FER/M_ERMt \qquad (4)$$

A number of issues had to be resolved with regard to the data required to estimate the above set of equations. Wherever possible, variables were expressed in terms of local currency in order to avoid problems over the appropriate exchange rate for conversion. The exception to this is the world price variable which was initially expressed in dollars. In order to capture the effects of exchange rate changes, this variable was converted to local currency units. The issue of whether to express the above set of equations in linear or log-linear form is one for which there is no obvious a priori answer. Leamer and Stern (16, p. 18) make the following observation on this question:

> There are unfortunately no clear-cut criteria that can be relied on in choosing a functional form. The researcher is more or less left to select a functional form according to his own theoretical leanings with the hope that his choice does not adversely affect his result. One drawback of the linear form is that the price elasticity will diminish as income grows. Under such circumstances the log-linear form, which constrains the elasticities to be constant, might be preferred.

With this advice in mind, the equations were estimated in both linear and log-linear form. To avoid scale problems, all measures of agricultural volume (production, imports, and apparent utilization) and gross domestic product were expressed in per capita terms.

The detailed price data required for equations (1) and (2) were not available for a sufficient length of time. Therefore, these equations could not be estimated. Yield data could not be found for use in equations (2) and (3), nor were data on the area planted consistently available. Consequently, the data on the area harvested were substituted for both the "area planted" and "yield" variables. This causes some problems because productivity growth would have been captured by the yield variable. This revised specification means it is not possible to

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37/ Leamer and Stern (16, pp. 11-12) assumed that the international supply of the good in question is perfectly elastic at the given price and that domestic investment increases the capacity of import-competing industries. The domestic and import prices must be the same as long as some quantity of both goods are being sold. No price change is observed; yet, at the same time, imports will be reduced if domestic production increases.

differentiate between increased production which is due to expanded acreage versus that which is attributable to improved productivity.

All data were downloaded from data banks maintained by Wharton Econometrics and indirectly were provided by either the IMF's International Financial Statistics or the Foreign Agricultural Service of USDA. Given the data problems associated with the first two equations, the exercise was reduced to estimating the influence of real per capita income, area harvested, and prices on import demand. Virtually all of the equations were characterized by evidence of multicollinearity, high adjusted R^2 values and low "t" statistics. Further, this problem was exacerbated in the log-linear form. A number of variations on the basic equations, consisting in large part of transformations of the variables, were run in an attempt to control for multicollinearity. One of these variations involved the use of a lagged dependent variable and real per capita GDP as independent variables. The results of this latter estimation and the original specification of the import equation for Korea, Kenya, and Colombia are presented in appendix tables 1 through 3, respectively. It should be remembered that per capita GDP was measured in local currency units.

Significant coefficients for Korea on real per capita GDP (RGDPPC) were obtained on at least one of the forms of the equation for barley, maize, soybeans, copra, palm oil, cocoa, cotton lint, sugar, and coffee (appendix table 1). There is no a priori reason to accept the coefficient on one form of an equation over another, when both are significant. The coefficients are of the same magnitude. The small size of the coefficient is somewhat misleading. A 6.6-percent increase in the sugar GDP for 1980 (the average annual rate of increase for 1960-82) will cause an increase in sugar imports of 25,000 metric tons. (This uses the smaller of the coefficients on income from the two sugar equations. The larger coefficient would increase sugar imports by nearly 50,000 metric tons.) Import data from 1980 suggest an income elasticity of between 0.5 and 0.92. (It should be warned that the figures are based solely on imports.) The results for Kenya are not as satisfactory as those for Korea. In general, the explanatory power of the equations is lower and multicollinearity is still a problem. However, the lower R-squared makes it more difficult to judge the severity of the collinearity problem. Only barley, rice, and coconut oil equations display a significant income variable.

The results for Colombia are somewhat better, with at least one equation for each of the five crops containing a significant income variable. An example of the interpretation of these coefficients is an increase in per capita GDP of 3.1 percent (the average annual growth rate for the 1960-82 period) would result in an annual increase in imports of roughly 15,000 metric tons.

In summary, the magnitude of the estimate generated in this exercise seems plausible. However, the problem of multicollinearity along with a specification that does not adequately deal with policy variables (marketing and pricing anomalies) means that the estimates should be treated with caution.

Appendix table 1--Korea: Import demand estimation, 1961-84

Dependent variable per capita imports	Independent variables	Adjusted R-squared
Wheat grain:		
	0.004 +0.10E-07 RGDPPC + 0.77 MHGPCLG*	
	(.7) (1.0) (5.2)	0.80*
	.070 + .24E-08 RGDPPC - 12.99 HHGPC -.96E-07DPRHGR	
	(1.9) (.1) (-1.7) (-.9)	.83*
Barley:		
	.003 - .24E-08 RGDPPC + .77 MBAPCLG*	
	(1.4) (-.8) (2.7)	.24*
	-.046* + .30E-07 RGDPPC* + 1.60 HBAPC*	
	(-2.3) (2.1) (2.8)	.47*
Maize:		
	-.019* + .49E-07 RGDPPC* + .53 MMAPCLG*	
	(-2.5) (3.1) (3.4)	.91*
	-.056 + .11E-06 RGDPPC* + 8.20 HMAPC - .36E-07 DPRMAR	
	(-1.9) (4.6) (.5) (-.2)	.91*
Soybean seed:		
	-.002* + .47E-08 RGDPPC* + .85 MSBSPCLG*	
	(-2.0) (2.7) (8.8)	.96*
	-.020 + .18E-07 RGDPPC* - .79 HSBSPC -.19E-07 DPRMAR	
	(-.2) (2.9) (-1.3) (-.2)	.93*
Copra:		
	.001 + .85E-08 RGDPPC + .25 MCPPCLG	
	(.6) (1.2) (1.2)	.11*
	.001 + .24E-09 RGDPPC* -.36E-09 DPRCPR	
	(.8) (2.2) (-1.7)	.22*
Palm oil:		
	-.002 + .46E-09 RGDPPC + .65 MPAOPCLG*	
	(-.3) (.7) (3.1)	.85*
	-.001 + .2E-08 RGDPPC* - .18E-08 DPRPAOR*	
	(-.6) (2.3) (-2.1)	.84*
Linseed:		
	.001 - .04E-10 RGDPPC + .56 MLNPCLG*	
	(1.5) (-.9) (3.1)	.31*
	.002 + .02E-09 RGDPPC - .57E-09 DPRLNR*	
	(1.9) (.2) (-2.0)	.42*

Appendix table 1--Korea: Import demand estimation, 1961-84--Continued

Dependent variable per capita imports	Independent variables	Adjusted R-squared
Cocoa:		
	-0.001* +0.04E-09 RGDPPC* + 0.30 MCAPCLG	0.87*
	(-2.6) (3.7) (1.4)	
	-.001* + .06E-09 RGDPPC* - .39E-10 DPRCAR	.87*
	(-4.0) (5.8) (-1.1)	
Cotton lint:		
	-.001 + .34E-08 RGDPPC* + .60 MCLPCLG*	.96*
	(-.8) (3.3) (4.7)	
	-.001 + .72E-08 RGDPPC* + .42E-08 DPRCLR	.95*
	(-.6) (6.4) (.6)	
Sugar:		
	-.002* + 0.10E-07 RGDPPC* + .11 MSUCPCLG*	.95*
	(-2.0) (3.2) (3.2)	
	-.005* + .19E-07 RGDPPC* + .45E-07 DPRSUCR	.95*
	(-2.5) (8.6) (1.7)	
Coffee:		
	-.001 + .29E-10 RGDPPC + 1.12 MCFPCLG*	.97*
	(-.7) (.9) (10.7)	
	-.001 + .43E-09 RGDPPC* - .59E-10 DPRCFR	.94*
	(-1.7) (4.0) (-.9)	

Appendix table 2--Kenya: Import demand estimation, 1961-84

Dependent variable per capita imports	Independent variables	Adjusted R-squared
Barley:		
	-0.00 + 0.98E-10 RGDPPC - 0.27 MBAPCLG	0.01
	(-.9) (1.2) (-1.1)	
	-.001 + .22E-09 RGDPPC* - .04 HBAPC	.14*
	(-1.9) (2.1) (-1.6)	
Rice:		
	-.001 + .27E-09 RGDPPC + .76 MRIPCLG*	.33*
	(-.5) (.7) (3.2)	
	.011* - .23E-08 RGDPPC* - 1.69 HRIPC - 0.11E-06 DPRRIR	.49*
	(2.5) (-2.0) (-.7) (-1.2)	
Soybean oil:		
	.001 - .53E-11 RGDPPC - .08 MSBOPCLG	-.11
	(.6) (-.1) (-.3)	
	.001 + .41E-11 RGDPPC - .13E-07 DPRSBOR	.01
	(1.2) (.1) (-1.3)	
Coconut oil:		
	.001* - .15E-09 RGDPPC* - .10 MCOOPCLG	.18*
	(2.9) (-2.4) (-.4)	
	.001* - .15E-09 RGDPPC* + .10E-07 DPRCOOR	.24*
	(2.8) (-2.6) (1.2)	
Palm oil:		
	-.002 + .91E-09 RGDPPC + .79 MPAOPCLG*	.84*
	(-1.2) (1.4) (6.0)	
	.004 + .82E-10 RGDPPC - .75E-07 DPRPAOR	.82*
	(.8) (.1) (-.7)	
Linseed oil:		
	.001 - .11E-10 RGDPPC + .41 MLNOPCLG	.16*
	(1.5) (-1.1) (1.9)	
	.001 - .95E-11 RGDPPC - .31E-09 DPRLNOR	.11*
	(1.0) (-.6) (-.2)	
Tobacco:		
	.001* - .12E-09 RGDPPC + .28 MTBPCLG	.18*
	(2.3) (-1.8) (1.2)	
	.001* - .25E-10 RGDPPC - .45E-06 PTBPC -.99E-08 DPRTBR	.48*
	(2.0) (-.4) (-1.2) (-1.2)	
Sugar:		
	.010 - .30E-08 RGDPPC + .59 MSUCPCLG*	.56*
	(1.6) (-1.5) (3.0)	
	.006 + .24E-08 RGDPPC - .6E-06 PSUCPC*+.2E-07 DPRSUCR	.70*
	(.9) (.9) (-4.3) (.8)	

Appendix table 3--Colombia: Import demand estimation, 1961-84

Dependent variable per capita imports	Independent variables	Adjusted R-squared
Wheat:		
	-0.016* + 0.54E-06 RGDPPC* + 0.18 MHGPCLG	0.58*
	(-2.0) (2.7) (.8)	
	.005 + .22E-06 RGDPPC - 1.50 HHGPC* +.29E-06 DPRHGR	.66*
	(.3) (.7) (-2.1) (.5)	
Maize:		
	-.005* + .16E-06 RGDPPC* - .17 MMAPCLG	.35*
	(-2.7) (3.3) (-.8)	
	-.009 + .26E-06 RGDPPC* - .01 HMAPC -.43E-06 DPRMAR*	.52*
	(-1.4) (3.0) (-.2) (-3.0)	
Oats:		
	.001* + .10E-08 RGDPPC + .27 MOAPCLG	.01
	(2.0) (.6) (1.2)	
	-.004* + .32E-07 RGDPPC* + 29.28 HOAPC*	.69*
	(-4.1) (3.9) (4.9)	
Cocoa:		
	.001* - .15E-07 RGDPPC* + .49 MCAPCLG*	.77*
	(2.4) (-2.4) (2.6)	
	.001* - .16E-07 RGDPPC - .9E-07 PCAPC - .13E-07 DPRCAR	.77*
	(3.5) (-1.1) (-.7) (-1.4)	
Soybean oil:		
	-.001 + .39E-07 RGDPPC + .70 MSBOPCLG*	.82*
	(-1.6) (1.8) (5.0)	
	-.004* + .12E-06 RGDPPC* - .50 HSBOPC +.44E-16 DPRSBOR	.65*
	(-2.4) (5.4) (-1.4) (.9)	

Appendix IV--Estimated Elasticities

The elasticities presented below must be treated with considerable caution. First, they are based on a very wide income range, and second, they have been computed without regard to the significance of the coefficient on which they are based.

Year and commodity	Estimated elasticity			
	AU	M	P	X
1977:				
Food grains	NS	-0.464	0.379	NS
Feed grains	0.764	1.713	.599	2.872
Oilseeds	.786	3.021	NS	NS
Meat	.674	7.111	.662	NS
Barley	2.301	-8.941	2.435	NS
Oats	6.171	NS	7.111	472.667
Wheat flour	NA	-1.790	NA	24.364
Wheat grain	NS	-.570	.852	7.551
Wheat flour/grain	NA	-.664	NA	7.471
Maize	.732	1.857	.605	3.269
Rice	NS	NS	NS	NS
Soybeans	1.605	4.105	NS	NS
Sunflower	5.821	NS	6.208	NS
Sesame	NS	NS	NS	NS
Groundnuts	NS	NS	NS	NS
1980:				
Food grains	NS	-.291	.429	2.545
Feed grains	.750	1.017	.653	3.451
Oilseeds	.547	2.750	NS	NS
Meat	.502	NS	.503	NS
Barley	1.591	NS	1.707	NS
Oats	7.432	NS	8.043	577.368
Wheat flour	NA	-2.332	NA	10.224
Wheat grain	NS	-.364	1.186	5.789
Wheat flour/grain	NA	-.425	NA	4.573
Maize	.600	1.085	.589	3.817
Rice	NS	NS	NS	NS
Soybeans	1.528	3.521	NS	NS
Sunflower	7.830	NS	11.240	NS
Sesame	NS	NS	NS	NS
Groundnuts	NS	NS	NS	NS

NA = Not available.
NS = Insignificant.

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