U.S. Agricultural Exports and Foreign Economic Growth

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THE EXPORT MARKET is becoming increasingly important to U.S. agriculture. From calendar 1957 to 1966, total agricultural exports increased 53 percent, from $4.5 to $6.9 billion. Commercial agricultural exports were responsible for 98 percent of the total increase. Exports under Government programs increased only slightly (fig. 1).

The rapid growth of commercial exports has increased the stake of the American farmer in the export market. The factors responsible for the upsurge of commercial exports are ill defined, making explanations of the past and predictions of future levels of exports difficult. Need for research in this area is strongly indicated.

Lack of detailed knowledge of the export market has increased the difficulty of evaluating U.S. domestic and foreign policies. More knowledge about economic forces in the commercial agricultural export market will provide a basis for improved policies and programs. This paper attempts to fill some of the informational gaps by analyzing the propensity of foreign countries to import U.S. farm products, the characteristics of their aggregate import function, and some of the problems in predicting the aggregate demand for U.S. commercial agricultural exports.

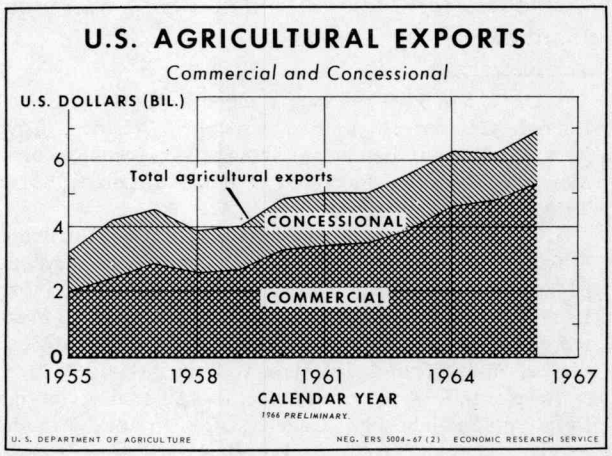

Figure 1

Previous research has demonstrated that there is a definite and positive relationship between income and imports of foreign countries. One study (6),[1] using 1959-61 data, estimated import elasticities of 1.1 for all commodities and 1.3 for commercial agricultural products from the United States. A separate study by Chenery (2), which used 1952-54 data, obtained an elasticity approaching 1.0 for all imports.

Increases in imports are directly related to the income level in importing countries, but the nature of this relationship may change with income level. Two well-known economic concepts suggest that the import-income relationship may not be constant for all income levels. Keynesian economics implies, in terms of consumption, that the marginal propensity to consume decreases as incomes increase. This theory, as well as a portion of "Engel's Law" (a declining percentage of income is expended for food as incomes increase), has possible implications for an import-income relationship. In addition, in the above-mentioned empirical studies, linear equations in logarithms were used to estimate the income coefficients. This suggests that the income-import relationship varies with level of income and that it may be nonlinear in actual values.

The writings of several economists (1, 4, 5, 7) suggest a declining marginal propensity to import as per capita incomes rise, but a precise statement of this hypothesis and an empirical evaluation of it are lacking. In this

[1] Underscored numbers in parentheses refer to items in the Literature Cited, p. 59.

paper, we test the hypothesis that the marginal propensity to import agricultural products commercially declines as foreign per capita incomes rise. Imports of U.S. products are used as an example.

A declining marginal propensity to import agricultural products might exist as a result of the development of a self-sufficient agriculture, or as a result of slower growth in demand for food and fiber at high levels of income. We only attempt to determine whether there is a declining marginal import propensity. We did not study possible factors which may cause such a relationship. The results should be useful in predicting aggregate demand for imports and lend more credibility to the estimate than mere extrapolation. The paper does not attempt to completely define the import function nor does it investigate individual country variations which might result from such factors as price differences, domestic supply, balance of payments positions, distance, and domestic and foreign government policies.

The main objective of this paper is to investigate the relationships between per capita income of importing countries and per capita commercial agricultural imports from the United States for different levels of development. More specifically this main objective includes the following:

1. To determine the absolute level of per capita agricultural imports (all agricultural, commercial agricultural, and imports under Government programs) of U.S. exports for low-, medium-, and high-income countries;

2. To measure the expenditure for commercial agricultural products of U.S. products in relation to income (import elasticities), both cross-sectionally and over time;

3. To test the hypothesis that the commercial import expenditures for agricultural products from the United States, in relation to per capita income, decline as income increases;

4. To indicate the use of the estimated elasticities for predicting aggregate exports of U.S. farm products for some future period.

Method of Analysis

Countries and time periods.--The period from 1957 to 1964 was chosen for analysis. Both 1957 and 1964 are points in time when world economic conditions were fairly similar and stable. Also, 1957 represents a peak period, relative to 1958 and 1959, in agricultural exports (see fig. 1), consequently insuring an element of conservatism in the analysis. Specifically, 1957 represents (1) a period 3 years after the beginning of the P.L. 480 program, (2) the highest level of P.L. 480 exports prior to 1961, and (3) a period of transition from food aid programs designed primarily to assist developed countries to those aimed at helping the less developed countries. The year 1964 is the most recent period for which adequate trade and income data are available.

The 66 countries included in this study, in both 1957 and 1964, accounted for more than 82 percent of total U.S. agricultural exports. Also these countries represented 84.8 percent of U.S. commercial exports in 1957 and 81.4 percent in 1964. In both 1957 and 1964, these 66 countries participated in approximately 80 percent of total world agricultural trade (8).

Determination of income levels.--The 66 countries were arbitrarily divided into three income categories, based on their 1964 income positions which represent developmental levels.[2] The income or developmental levels chosen were low (less than $200 per capita income), medium ($200 to $600 per capita income), and high (more than $600 per capita income). An analysis of variance was performed for 1957 and 1964 to determine whether the level of imports was significantly different for each developmental level. This test showed that for both time periods, the difference in level of imports for each income category was highly significant.

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[2] Less than $200 per capita income--Bolivia, Brazil, Burma, Ceylon, Dominican Republic, Ecuador, Egypt (U.A.R.), Ghana, Honduras, India, Iran, Jordan, Korea, Morocco, Pakistan, Paraguay, Peru, Philippines, Sudan, Taiwan, Thailand.

$200 to $600 per capita income--Argentina, Barbados, British Guiana, Chile, Colombia, Costa Rica, Cyprus, El Salvador, Greece, Guatemala, Iraq, Jamaica, Japan, Lebanon, Libya, Malta & Gozo, Malaya, Mauritius, Mexico, Nicaragua, Panama, Portugal, Republic of South Africa, Spain, Trinidad, Uruguay, Yugoslavia.

More than $ 600 per capita income--Australia, Austria, Belgium-Luxembourg, Canada, Denmark, Finland, France, Iceland, Ireland, Israel, Italy, New Zealand, Norway, Sweden, Switzerland, United Kingdom, Venezuela, West Germany.

Two methods of calculating the average per capita income and imports for each development level were considered:

$$\frac{1}{N}\sum_{i}^{N}\frac{Y_i}{P_i} \quad \text{and} \quad \frac{\sum_{i}^{N} Y_i}{\sum_{i}^{N} P_i}$$

with Y being either imports or income and P being population. The latter method was used to insure that population units were of equal importance in the development level.

Calculation of elasticities.--Three methods of calculating import elasticities were used. In the cross-sectional analysis, the income coefficient was calculated by using the function $y = \alpha x^b$ computed in logarithmic form. This function was used because of the ease of obtaining the point elasticity estimate and because it provided a better fit to the data than any of the other functions tried.

An arc elasticity measure was used to estimate the import elasticity by income level for the interval from 1957 to 1964. Also, elasticities were measured by income level using a time series approach. The point elasticity estimates were obtained from linear equations in logarithms. Countries were categorized into income levels on the basis of their relative income positions in 1964. Thus, the country composition of each income level in a particular year was identical to the country composition in any other year.

Analytical Results

One way of viewing U.S. agricultural exports is by studying foreign countries' imports of U.S. products. The data in table 1 provide the reader with some idea of the magnitude of changes in foreign countries' imports of U.S. agricultural products over time as they undergo economic growth.

Table 1.--Per capita value of agricultural imports from the United States, 66 countries by per capita income level, 1957 and 1964 [1]

(U.S. dollars)

Item	Low-income countries [2]		Medium-income countries [2]		High-income countries [2]	
	1957	1964	1957	1964	1957	1964
All agricultural imports	0.93	1.59	3.66	4.18	7.59	8.33
Commercial agricultural imports	.20	.30	2.35	3.48	6.14	7.88
Concessional imports (under U.S. Government export programs)	.73	1.29	1.31	.70	1.45	.45
Income	88	100	262	460	831	1,261

[1] Trade data adjusted for transhipments through Canada. Transhipment data were obtained from Thomas A. Warden, "Transshipments of U.S. Agricultural Products Through Canada," Foreign Agricultural Trade of the United States, December 1966.

[2] Countries were categorized according to 1964 income levels as follows: Low level of development or income, less than $200 per capita income; medium level of development or income, $200 to $600 per capita income; high level of development or income, more than $600 per capita income.

Sources: U.S. Dept. Agr., Foreign Agricultural Trade of the United States; Internatl. Monetary Fund, International Financial Statistics; and United Nations, Statistical Yearbook, 1964.

In 1957 and 1964, the high-income countries had the largest per capita imports for all agricultural products and for commercial products. The medium-income countries had the second largest per capita imports, while the low-income countries imported the least in both years. Concessional imports (imports under U.S. Government programs) were important for all income groups in 1957, but the magnitude of these imports decreased in the medium-and high-income countries in 1964.

In terms of absolute changes in imports from 1957 to 1964, the high-income countries had the largest per capita increase ($0.74) in all agricultural imports, while the medium- and low-income countries had increases of $0.52 and $0.66 per capita, respectively. In terms of commercial agricultural imports from the United States, the high-income countries increased their imports by $1.74 per capita, and the medium- and low-income countries increased imports by $1.13 and $0.10 per capita, respectively. The low-income countries increased their concessional imports by $0.56 per capita while the medium- and high-income countries decreased their concessional imports by $0.61 and $1, respectively. Consequently, the increase in all agricultural imports in the low-income countries was primarily through concessional sales, whereas commercial imports were of primary importance in the medium- and high-income countries. In fact, the large increases in commercial imports and the substantial decreases in concessional imports per capita in the middle- and high-income countries suggest that countries with these levels of income have been able to substitute commercial for concessional imports, as the latter were phased out.

Import Elasticity Estimates [3]

The elasticity estimates were obtained by using the equation $m = \alpha y^b$ in logarithmic form computed by simple least squares. In this instance, the estimated b is also an elasticity estimate (ϵ). The relation of the elasticity estimate (b) to the marginal propensity to import (mpm) is shown below:

$$\frac{d}{dy}(\alpha y^b) = b\alpha y^{b-1} = \text{mpm}$$

$$\frac{d}{dy}(\text{mpm}) = b\alpha(b-1)\ y^{b-2}$$

$$= \text{rate of change in mpm.}$$

By simply substituting alternative values for b (or in this case ϵ) it can be shown that if:

$0<\epsilon<1$	the mpm is decreasing at a decreasing rate
$1<\epsilon<2$	the mpm is increasing at a decreasing rate
$2<\epsilon<\infty$	the mpm is increasing at an increasing rate
$\epsilon=0$	the mpm = 0
$\epsilon=1$	the mpm $=\alpha$ and is independent of the income level
$\epsilon=2$	the mpm $= 2\alpha y$ or increases at a constant rate

Thus, by knowing the sign and magnitude of the elasticity, one can make a statement regarding the marginal propensity to import.

The cross-sectional analysis suggests that the import function increases at a decreasing rate as per capita income rises. Both the arc and time series elasticity estimates indicate that the marginal propensity to import declines with rising per capita incomes. The three elasticity estimates strongly suggest that the proposed hypothesis of a declining marginal propensity to import is correct. Furthermore, there is an implication that a cross-sectional elasticity estimate for all countries will understate the true import elasticity for the less developed countries and overstate the true import elasticity for the highly developed countries. These implications mean that the cross-sectional elasticity estimate for all countries has limitations for predictive purposes, especially if the period for which the predictions are being made is very distant from the period from which the cross-sectional estimate was derived.

Cross-sectional analysis.--The cross-sectional analysis yielded results which were consistent with previous research, in that per

[3] The authors wish to thank W. Y. Mo for his help in developing the ideas in this section.

capita income was found to be an important variable in explaining per capita commercial agricultural imports from the United States. However, all the point elasticity estimates were greater than 1.0 (see unadjusted data, table 2) and fail to substantiate a hypothesis of declining marginal propensity to import. But these elasticity estimates do state that even if the marginal propensity to import (mpm) is increasing, it is increasing at a decreasing rate. Since many of the elasticity estimates are less than 1.5, it can be expected that the rate of increase in the mpm will drop rather quickly at high income levels.

It was felt that the way in which the commercial export values are derived might be partly responsible for the failure to substantiate the hypothesis of declining marginal propensity to import when using cross-sectional data. Commercial agricultural exports are derived as follows: (Total agricultural exports to $country_i$) - (exports under Government programs to $country_i$) = commercial agricultural exports to $country_i$. This determination of commercial exports may create a downward bias in the commercial export estimates, as donations under Title II of P.L. 480 are valued at Commodity Credit Corporation costs which are generally above market value (3).

This downward bias could affect an elasticity estimate, particularly since countries receiving concessional shipments are at the lower end of the income scale.

An attempt was made to overcome these problems in the following way. In each cross section, a line was fitted for total exports and commercial exports (as defined above) for all countries whose commercial agricultural imports accounted for less than 95 percent of total agricultural imports. The expected import levels were predicted by using the estimated total and commercial export equations. The average of these predictions for each country was then used as an adjusted import figure. The entire cross-section was then reestimated in a linear equation in logarithms. The results of this estimation are shown in table 2 (adjusted data). The elasticity estimates obtained by using

Table 2.--Estimates of imports elasticities, unadjusted and adjusted data, 1957-64

Year	Unadjusted data			Adjusted data[1]		
	[2] B	α	R^2	[2] B	α	R^2
1957.....	1.51552 (0.20186)	-3.64675	0.49	1.18907 (0.09374)	-2,68062	0.73
1958.....	1.48745 (0.19788)	-3.68146	0.48	1.26651 (0.10736)	-2.96809	0.70
1959.....	1.55869 (0.18256)	-3.83579	0.54	1.19213 (0.11466)	-2.78694	0.64
1960.....	1.43802 (0.15708)	-3.46367	0.57	1.24111 (0.08955)	-2.85609	0.75
1961.....	1.47238 (0.15734)	-3.54194	0.59	1.23058 (0.11956)	-2.81980	0.63
1962.....	1.25530 (0.14493)	-2.95415	0.54	1.12334 (0.09119)	-2.51939	0.71
1963.....	1.43229 (0.15604	-3.46793	0.58	1.03794 (0.09344)	-2.32051	-0.66
1964.....	1.24295 (0.15252)	-2.92013	0.48	1.01250 (0.06374)	-2.16401	0.80

[1] See text for adjusting procedures.
[2] Standard errors appear in parentheses.

the adjusted data are greater than 1.0, but less than the estimates obtained by using unadjusted data. The adjusted data do indicate that lower elasticities would result if the bias were removed. Since the elasticity estimates obtained with the adjusted data are still greater than 1.0 and because the adjustment is crude, no further use was made of the data.

Table 2 shows that the cross-sectional elasticity estimates tend to decrease over time. Since the mean incomes increase over time, an inverse relationship is suggested between the magnitude of the elasticity and the mean income. Correlation of the mean income to the estimated elasticity with both adjusted and unadjusted data resulted in a negative correlation coefficient and a small but significant regression coefficient.[4] These results suggest that, with continuing increases in per capita incomes, the import elasticity and consequently the marginal propensity to import will decrease.

Arc elasticity estimates.--Arc elasticity estimates were calculated by income level for the interval between 1957 and 1964. The estimates, 3.13 for low levels of development and 0.74 and 0.60 for middle and highly developed countries, indicate that the import elasticity decreases as development occurs and strongly suggest a declining marginal propensity to import.

Time series.--In the time series analysis by income levels, a linear equation in logarithms was again used for estimation purposes. The results of this series of estimations support a hypothesis of declining marginal propensity to import. The low-income group had an import elasticity of 2.49, the middle-income group 1.05, and the high-income group 0.78. These results (shown in table 3) are consistent with the declining marginal propensity hypothesis, since imports would increase at an increasing rate at the low level of development (2.49), increase at a decreasing rate at the medium level of development (1.05), and decrease at a decreasing rate at the high-income level of development (0.78).

[4] $\overline{Y} = 2.23 - \underset{(0.0008)}{0.0026}\, b$ (unadjusted) $R^2 = 0.62$

$\overline{Y} = 1.935 - \underset{(0.0004)}{0.0025}\, b$ (adjusted) $R^2 = 0.81$

Table 3.--Results of time series analysis, unadjusted data, 1957-64

Income level	Estimates of --		R^2
	α	b	
Low.....	-5.53100	2.48717 (0.84731)	0.59
Medium.....	-2.23632	1.04806 (0.20438)	0.81
High.....	-1.52452	0.77978 (0.16515)	.79

Estimates of U.S. Commercial Agricultural Exports

The analysis in this paper can be used to predict aggregate commercial agricultural exports for the United States. Results of two methods of prediction are presented here. One method uses the time series functional relationships shown in table 3. The other method uses the following predictive formula:

$$M^*_{t+1} = \left[\left(\frac{Y_{t+1} - Y_t}{Y_t}\right) E\, M_t + M_t\right] P_{t+1}$$

where:

Y = income per capita
E = elasticity estimate
M = commercial agricultural imports per capita
M*= aggregate commercial imports
P = population

The above formula was used, with both cross-sectional and time series elasticity estimates and a different assumption concerning population and income growth for each income level, to predict U.S. commercial agricultural exports.

Actual and predicted 1965 exports are shown in table 4. The export estimate ($4.88 billion) obtained with cross-sectional elasticities most nearly approached actual exports ($4.78 billion). The second best estimates ($4.93 billion) were

Table 4.--U.S. commercial agricultural exports, predicted and actual for 1965

(Billion U.S. dollars)

Method used to make predictions	Predicted commercial exports to--		Actual[2]	Difference[3]
	66 countries	All countries[1]		
Predictive formula:				
With 1964 cross-sectional elasticity estimates[4]	3.98	4.88	4.78	+.10
With arc elasticity estimates	4.02	4.93	4.78	+.15
With time series estimates	4.06	4.98	4.78	+.20
Time series function	4.02	4.93	4.78	+.15

[1] The 66 countries included in the study accounted for 81.5 percent of all commercial imports of U.S. commercial agricultural exports in 1964. It was assumed that these countries maintained this share in 1965. The estimate for all countries was calculated by dividing the estimates for 66 countries by 0.815.

[2] Foreign Agricultural Trade of the United States, U.S. Dept. Agr., July 1966 issue.

[3] Difference calculated by subtracting actual exports from predicted exports.

[4] Mean per capita income and population predicted on an aggregate basis.

obtained by using the arc elasticities and the time series function.

Estimated exports for 1970.--Estimates of U.S. commercial agricultural exports were made for 1970 assuming the same rate of (1) population growth as occurred from 1963 to 1964, and (2) per capita income growth as occurred from 1957 to 1964, slightly modified.

The 1966 and 1970 population estimates were made assuming the same annual growth rate by income level as occurred from 1963 to 1964. The average population growth was assumed to be 2.61 percent per year in the low-income countries, 1.25 percent in the medium-income countries, and 1.24 percent in the high-income countries.

Cross-sectional elasticities were used in the predictive formula with the mean per capita income estimated on an aggregate rather than a country-by-country basis.

Income growth per capita per year was assumed to be 2.0 percent in low-income countries, 6.0 percent in medium-income countries, and 5.0 percent in high-income countries. These assumed rates are somewhat different from the actual growth rates, which were 1.82 percent for the low-income group, and 8.4 and 6.2 percent for the medium and high groups.

Because both inflationary and real income changes are incorporated in the income growth rates, per capita incomes in foreign countries are estimated in current U.S. dollars.

Commercial and total agricultural exports for 1970 are shown in table 5. These estimates were calculated in the same way as the estimates in the preceding section. The estimates for commercial exports range from $5.15 billion to $5.47 billion for the 66 countries included in this study. The most conservative import estimate for 1970 ($5.15 billion) was obtained by using arc elasticity estimates. The predictive formula with time series elasticities gave a higher commercial export prediction ($5.47 billion). As indicated earlier, the use of a cross-sectional elasticity estimate may be inappropriate since we have shown that the import elasticity tends to decline at higher income levels, resulting in a declining marginal propensity to import. Thus, the use of time series elasticities in making long-term predictions would be less likely to overstate the projection level of U.S. commercial agricultural exports.

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Table 5.--U.S. agricultural exports predicted for 1970

(Billions of 1970 U.S. dollars)

Methods used to make predictions	Commercial exports to--		Concessional exports	Total[2]
	66 countries	All countries[1]		
Predictive formula:				
With arc elasticity estimates.....	5.15	6.31	1.94	8.25
With cross-sectional elasticity estimates.....	5.41	6.64	1.94	8.58
With time series elasticity estimates.....	5.47	6.71	1.94	8.65
Time series function.....	5.40	6.63	1.94	8.57

[1] The 66 countries included in the study account for 81.5 percent of all commercial imports of U.S. commercial agricultural exports. It was assumed that these countries maintained this share in 1970. The estimate for all countries was calculated by dividing the estimate for 66 countries by 0.815.

[2] Total exports consists of commercial plus concessional exports (exports under Government programs). For 1970, $1.94 billion was added to the commercial export estimate to obtain the total estimate. The concessional exports were $1.5 billion in 1957 and $1.72 billion in 1964. The increase in concessional exports represents a growth of approximately 2 percent per year. To estimate concessional exports for 1970, it was assumed that the 2 percent growth would continue.

If one wishes to estimate all agricultural exports from the United States, it is necessary to include concessional shipments. The level of concessional exports can be influenced by other than purely economic factors. Policy considerations are very important in determining levels of concessional exports and these are subject to change.[5] The concessional export number for 1970 was obtained by assuming that concessional exports will continue to increase at the same rate as they increased from 1957 to 1964, or approximately 2 percent per year. Assuming a 2 percent per year compound growth in concessional exports, an estimate of $1.94 billion was obtained for 1970. Thus, the sum of estimated commercial plus estimated concessional exports equals a predicted total for agricultural exports in 1970 of at least $8.25 billion and maybe as high as $8.65 billion.[6]

[5] For example, the Food for Peace Act of 1966.

[6] These estimates slightly exceed those made by Quentin M. West (9), who used a different methodology.

Conclusions

The analysis in this paper, though limited, agrees with previous analyses which emphasized the importance of per capita income in determining import levels. In addition, the analysis indicates that the marginal propensity to import commercial agricultural products declines as per capita incomes rise in importing countries. There is a need for further empirical testing to better define and specify import functions for aggregate agricultural products, as well as for commodity groups. Further research should be concerned with identifying those causal variables associated with per capita income growth that affect the propensity to import, and with developing more precise methods of categorizing and aggregating countries into development levels.

The commercial import response varies with per capita income levels, indicating a declining marginal propensity to import. The time series import response from 1957 to 1964 was 24.8 percent for the low, 10.5 percent for the

medium, and 7.8 percent for the high-income groups for each 10 percent increase in per capita income. However, in terms of absolute imports, the high-income countries will continue to be the best markets. But, given sustained economic growth, the lower-income countries will have tremendous potential as markets for U.S. commercial agricultural products.

If the relationships described in this paper prevail and foreign economic growth continues, the results obtained suggest that commercial U.S. agricultural exports will exceed $6.0 billion by 1970 and may reach $6.71 billion. These amounts are suggested regardless of the predictive methods used or the manner in which the elasticity was estimated. Any major increase in concessional shipments or trade with the Eastern Trade Area, or a major change in international trade policies, would affect these estimated amounts.

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