



AgEcon SEARCH
RESEARCH IN AGRICULTURAL & APPLIED ECONOMICS

The World's Largest Open Access Agricultural & Applied Economics Digital Library

This document is discoverable and free to researchers across the globe due to the work of AgEcon Search.

Help ensure our sustainability.

Give to AgEcon Search

AgEcon Search
<http://ageconsearch.umn.edu>
aesearch@umn.edu

*Papers downloaded from **AgEcon Search** may be used for non-commercial purposes and personal study only. No other use, including posting to another Internet site, is permitted without permission from the copyright owner (not AgEcon Search), or as allowed under the provisions of Fair Use, U.S. Copyright Act, Title 17 U.S.C.*

Estimation of Export Demand Functions for U.S. Wheat

Panos Konandreas, Peter Bushnell and Richard Green

Export demand functions for U.S. wheat were estimated for five world regions. Estimates of the effects of income, price, and nonprice variables on U.S. wheat exports were obtained using various econometric procedures. The major finding of the paper indicates that exchange rate changes have had a substantial impact on U.S. wheat exports. This result, conditioned on the aggregative nature of the study, supports the belief expressed by some researchers in recent years.

Some economists have suggested that dollar devaluations were important factors in the increased demand for U.S. grain during the early 1970's.¹ Furthermore, Schuh (1974) argues that an important share of the income problems of U.S. agriculture in the post-World War II period resulted from persistent over-valuation of the U.S. dollar. The argument goes as follows: over-valuation of the dollar implies higher U.S. prices in terms of foreign currencies. This, in turn, reduces the demand for U.S. grain exports, and therefore reduces the total demand (domestic and foreign) for U.S. grain. Consequently, U.S. domestic prices are depressed below those that would apply under correct valuation of the U.S. dollar. Schuh (1974, p. 2) expresses this result as "... an *under*-valuation of our agricultural resources in relation to their world opportunity costs." When the opposite event occurs, namely, devaluation of the U.S. dollar, the reverse sequence of events take place. The end result in this case is both an increase in U.S. exports and domestic prices.

The propositions advanced by Schuh have been challenged by some researchers. Vellianitis-Fidas (1975) and Kost (1975) suggest that currency realignments have had only a small impact on agricultural trade. A debate on these two conflicting views emerged [Greenes (1975), Vellianitis-Fidas (1975) and Schuh (1975a, 1975b)]. The purpose of this paper is to provide some additional empirical evidence on this issue. Although recent exchange rates have been fairly stable, there is greater potential for instability now that many countries have adopted flexible exchange rates and considering the current large U.S. trade deficit.

The paper is organized as follows: first, a model of export demand for U.S. wheat is specified; then, the model is estimated by various econometric methods incorporating extraneous information on the income coefficients of export demand; finally, price and exchange-rate elasticities are derived and the policy implications of the results are analyzed.

Panos Konandreas is a Research Associate, International Food Policy Research Institute, Washington, D.C., Peter Bushnell is a graduate student, and Richard Green is an Assistant Professor, Department of Agricultural Economics, University of California, Davis.

Giannini Foundation Research Paper No.496. The authors are indebted to Alex McCalla, the editor, and anonymous reviewers for their comments on an earlier draft of this paper.

¹In August 1971, the U.S. dollar was devalued by 8 percent in relation to gold and later in February 1973

by another 10 percent. During this period revaluation of several other currencies important to the world trade market (notably the German mark and the French franc) took place. Magnitudes of the effective devaluation of the U.S. dollar during this period from both U.S. devaluation and other countries' revaluation of their currencies have been estimated. Schuh [1974] cites references reporting these magnitudes from 8 percent to as high as 27 percent depending on the purpose of the measurement and the methodology used.

The Model

Total commercial export demand for U.S. wheat is the aggregate of individual countries' import demands. Thus, as a first step in the specification of a U.S. export demand function, the variables that enter the import demand function of individual importing countries must be analyzed. Commercial import demand for U.S. wheat by the k th country (M_t^k) is assumed to be a function of that country's domestic wheat price (P_t^k), U.S. export price (P_t^{US}), world price of wheat (P_t^w), the world price of a substitute commodity for wheat, e.g., rice (P_t'), and the country's per capita real income (Y_t^k). Expressed by a linear relationship and in terms of relative prices, commercial import demand for U.S. wheat by the k th country is

$$(1) \quad M_t^k = a_0 + a_1 \frac{P_t^{US}}{P_t^w} + a_2 \frac{P_t'}{P_t^w} + a_3 \frac{P_t^k}{P_t^w} + a_4 Y_t^k + u_t$$

with expected signs as follows:

$$a_1 < 0, \text{ and } a_2, a_3, a_4 > 0.$$

This model formulation needs to be modified in light of the following observations. First, high correlations exist among past export prices of major wheat exporters.² Similarly, a high correlation exists between past export wheat and rice price series.³ Thus, relative prices, P_t^{US}/P_t^w and P_t'/P_t^w have been rather stable over time, and for estimation purposes only U.S. export wheat prices will be included in the import demand specification.⁴ Second, it is essential when

considering different countries to have prices and income specified in common units. Thus monetary variables are expressed on a common currency basis which combines exchange rates and prices. Although this need for currency commonality has been often cited in the literature, it is commonly overlooked in econometric estimation [e.g., Bjarnason *et al.*].

Also in order to make estimation manageable, importing countries have been aggregated into five regions: developed countries, Latin America, Asia, Africa, and the U.S.S.R. and Eastern Europe.⁵ Assume that the j th region consists of K_j individual countries, each having an import demand for U.S. wheat, as specified by equation (1). Thus, a specification of the U.S. export demand to the j th region as a whole would generally involve the individual variables of equation (1) for all K_j countries. Such a function would be impossible to estimate and clearly some aggregation of the variables of the K_j countries is needed. Furthermore the U.S. has exported considerable quantities of wheat under concessional terms during the period under analysis. These exports have influenced commercial sales, either by substituting for commercial exports, or alternately, by facilitating the development of U.S. commercial markets. In order to measure these impacts, concessional exports were included as an explanatory variable in the above specification.

Domestic wheat production was also included as another shift variable. In addition,

²This specification assumes that other wheat exporters follow the United States with respect to price changes. That is, any changes by the U.S. are matched by other major wheat exporters. Thus equation (2) below explicitly reflects the competition between that country's imports and its domestic output rather than the competition between the suppliers to that country.

³The simple correlation coefficients between export prices (c.i.f. at Rotterdam or Antwerp) of major wheat suppliers are as follows: USA-Canada: 0.93; USA-Australia: 0.96; USA-Argentina: 0.94; Canada-Australia: 0.96; Canada-Argentina: 0.90; and Australia-Argentina: 0.93 [Hurtado 1976].

⁴The simple correlation coefficient between world wheat and rice prices has been estimated as 0.95.

⁵The selection criteria for the five regions involved geographic, economic, and political factors similar to those used by the United Nations classification. Japan and Israel are excluded from Asia and South Africa from Africa and consequently included in the developed countries region. Centrally planned economies in Asia (Peoples Republic of China, Mongolia, North Korea, and North Vietnam) are excluded from the analysis.

a lagged dependent variable was included, to reflect the continuation of existing patterns in wheat trade. Some trade is expected to flow between the U.S. and an importing country due to past established trade connections and trade agreements, regardless of the direction of changes in current factors. Alternatively, the inclusion of the lagged variable could be justified within a Nerlovian framework, in which a country's current wheat imports from the U.S. adjust to desired imports only by a certain proportion within a year. Trade agreements with other exporters, political affiliations, etc., could prevent a country from reaching the desired level of wheat imports from the U.S. within a year.

Therefore, the following U.S. commercial wheat export demand of the j th region as a whole is postulated:

$$(2) \quad M_t = \beta_0 + \beta_1 Q_t + \beta_2 PE_t + \beta_3 YE_t + \beta_4 C_t + \beta_5 M_{t-1} + u_t$$

where M_t is total U.S. commercial wheat exports to that region;

Q_t is per capita wheat production in the region;

C_t is U.S. concessional wheat exports to the region;

$PE_t = \sum_k^{K_j} (w^k)(PE_t^k)$ is the "effective" U.S. export price of wheat in that region;

$PE_t^k = p_t^{US}/(p_t^k/ER_t^k)$ is defined as the "effective" U.S. export price of wheat in the k th country, expressed as the U.S. export price over the domestic price in the k th country (expressed in U.S. currency);

$YE_t^k = Y_t^k/ER_t^k$ is defined as the "effective" per capita real income of the k th country expressed in U.S. currency;

$YE_t = \sum_k^{K_j} (w^k)(YE_t^k)$ is the "effective" per capita real income of that region;

and

w^k is the k th country's average import share (within the imports of its region) of U.S. wheat.

Data Availability and Use of Prior Information

Annual observations from 1954-1972 for U.S. wheat exports are used in the estimation.⁶ However, since consistent series for domestic grain prices and incomes for the importing countries were not available, some adjustments to the outlined model were necessary. For domestic wheat prices in the importing countries, the food price index, expressed with a base of 1958 = 100, was used as a proxy variable.⁷ Thus the price variable is defined as:⁸

$$PE_t = \sum_{k=1}^{K_j^*} w^k p_t^{US} / [(FPI_t^k/100)/(ER_t^k/ER_0^k)]$$

⁶For the various sources and a detailed listing of the data, see Konandreas.

⁷This situation is admittedly nonoptimal. The appropriateness of the proxy depends on how closely domestic wheat prices are correlated with the food price index. In addition, the proxy should be approximately uncorrelated with the error terms (representing omitted variables). A high correlation was assumed between domestic wheat prices and the food price index, especially in developing regions.

⁸Only the major importers of U.S. wheat (their number designated by K_j^* , where $K_j^* \leq K_j$) are considered within each region in computing PE_t and YE_t . The importers considered and the actual weights used are as follows: developed countries (Germany 12.57 percent, Italy 6.89 percent, Japan 41.59 percent, Netherlands 11.86 percent, United Kingdom 13.20 percent, and Yugoslavia 13.88 percent); Latin America (Brazil 47.21 percent, Chile 7.34 percent, Columbia 9.41 percent, Mexico 7.24 percent, Peru 10.28 percent, and Venezuela 18.52 percent); Asia (India 58.66 percent, South Korea 15.73 percent, Pakistan 18.91 percent, and the Philippines 6.70 percent); Africa (Egypt 55.36 percent, Morocco 21.75 percent, Nigeria 10.82 percent, and Tunisia 12.07 percent); and Eastern Europe (Poland 100 percent).

where FPI_t^k : Food Price Index of the k th country;

ER_0^k : Exchange Rate (foreign currency per U.S. dollar) in the k th country in the base year (1958), and

K_j^* : number of major importing countries in the j th region.

In the case of income, the income variable is defined as:

$$YE_t = \sum_{k=1}^{K_j^*} w^k YI_t^k / [(ER_t^k / ER_0^k)]$$

where YI_t^k : per capita real income index of the k th country in year t with base year 1958 = 100.

Available estimates of income elasticities were incorporated in the estimation process. This was done after several preliminary estimations produced incorrect signs for the income parameters. A fuller discussion of this approach is in the following section. The analytical expressions involved in obtaining income coefficients from corresponding income elasticities are presented in Appendix A. The process involved the compilation of income elasticities for total wheat demand for regions of the analysis from elasticity estimates provided by Rojko, *et al.*⁹ Then, from these income elasticities of total demand, income elasticities of import demand were calculated using expression (2) in Appendix A, with Q_t and MT_t replaced by their averages over the period of analysis. Finally, income coefficients of import demand for U.S. wheat were computed from

the income elasticities using expression (4) in Appendix A, where again M_t and YE_t were replaced by their averages over the period of analysis.

Results

Export demand functions were estimated by ordinary least squares (OLS), a mixed estimation procedure developed by Theil and Goldberger which allows various degrees of uncertainty for the extraneous value of the income coefficient, and conditional least squares (CLS) with the extraneous information being introduced as if it were known with certainty.¹⁰

Table 1 presents the estimated export demand functions for the five regions of the analysis. From Table 1 the overall fit varies from a high ($R^2 = 0.90$) for Latin America using an OLS estimation procedure to a low ($R^2 = 0.44$) for Africa, again using OLS. For all regions the χ^2 test also indicates that the extraneous information is compatible with the sample data. When the variance of the extraneous estimate was increased and decreased by a factor of ten, the mixed estimates changed little indicating that they were insensitive to the degree of confidence placed in the extraneous information. These sensitivity analysis results are not reported here. However, the estimates of the extreme case, when complete uncertainty is assumed with respect to extraneously introduced information, are quite different from both the mixed estimates and the CLS estimates where the extraneous information is incorporated as if it were known with certainty. Thus, the "gains" of incorporating extraneous information may be significant as compared to the OLS procedure. Additional improvements by incorporating also the degree

⁹Their income elasticities were weighted by each country's or country-group's average import share within the regional classification of the analysis. For each individual country or country-group it was assumed that the income elasticity of total demand had a standard deviation of 0.2. The variance of the regional elasticities is obtained by the rule for the variance of a weighted sum, assuming zero covariances. Elasticities reported by Rojko *et al.* were assumed unbiased and statistically independent across countries.

¹⁰Brook and Wallace have shown that the mixed estimation procedure yields ordinary least-squares estimates when the extraneous information is introduced with complete uncertainty, while it yields conditional least-squares estimates when the extraneous information is introduced with complete certainty. Thus OLS and conditional least-squares are limiting cases of the mixed estimation procedure.

TABLE 1. Estimated Export Demand Functions of U.S. Wheat by Five World Regions

	Constant	Lagged ^a exports (M_{t-1})	Effective U.S. export price (PE_t)	Conces- sional exports (C_t)	Domestic produc- tion (per capita) (Q_t)	Effective per capita income (YE_t)	χ^2	R ²	Number of observa- tions (T)
Developed Countries ^b									
OLS ^c	16381.7 (6129.5) ^f	-0.30 (0.29)	-103.52 (56.40)	-0.44 (0.49)	-43.35 (38.29)	7.82 (63.65)		0.52	18
Mixed ^d ($r=-7.96$, $v_0=106$)	17867.8 (6126.0)	-0.30 (0.29)	-105.25 (55.96)	-0.47 (0.47)	-40.71 (36.75)	-7.56 (10.16)	0.06		18
CLS ^e	15529.7 (1525.3)	-0.28 (0.26)	-90.00 (53.54)	-0.44 (0.42)	-31.22 (34.13)	-7.96		0.46	18
Latin America ^b									
OLS ^c	1087.0 (1323.9)	0.66 (0.26)	-12.31 (19.58)	-0.54 (0.20)	-12.78 (12.25)	13.71 (7.64)		0.90	18
Mixed ^d ($r=12.12$, $v_0=34.7$)	1121.8 (1263.8)	0.68 (0.23)	-11.46 (18.88)	-0.53 (0.19)	-13.18 (12.02)	12.71 (4.67)	0.03		18
CLS ^e	2809.9 (270.4)	0.26 (0.17)	-37.00 (11.55)	-0.41 (0.14)	-15.11 (8.69)	12.12		0.87	18
Asia ^b									
OLS ^c	-4478.8 (3715.2)	0.57 (0.30)	19.15 (28.94)	0.02 (0.09)	28.41 (53.39)	20.58 (11.18)		0.85	18
Mixed ^d ($r=8.21$, $v_0=8.33$)	-6037.1 (2712.6)	0.77 (0.23)	35.15 (24.77)	0.08 (0.07)	71.93 (34.61)	8.98 (2.79)	1.15		18
CLS ^e	-180.7 (399.1)	0.81 (0.22)	-11.08 (25.01)	0.05 (0.06)	-3.48 (42.70)	8.21		0.72	18
Africa ^b									
OLS ^c	5771.7 (1572.2)	-0.27 (0.29)	-25.13 (11.09)	-0.16 (0.17)	-85.86 (56.13)	-21.23 (24.19)		0.44	17
Mixed ^d ($r=5.73$, $v_0=1.69$)	3220.7 (1567.4)	-0.22 (0.29)	-27.23 (10.93)	-0.25 (0.15)	-79.35 (55.82)	5.65 (1.29)	1.24		17
CLS ^e	3630.1 (405.4)	-0.31 (0.25)	-26.85 (9.34)	-0.23 (0.13)	-104.14 (50.57)	5.73		0.45	17
USSR and Eastern Europe ^b									
OLS ^c	29239.1 (17884.2)	-0.31 (0.82)	-456.87 (346.13)	1.86 (58.93)	21.57 (23.30)	-72.49 (103.13)		0.78	7
Mixed ^d ($r=.13$, $v_0=0.858$)	10237.5 (6472.0)	-0.59 (0.72)	-246.92 (175.81)	26.68 (47.24)	8.91 (14.83)	0.13 (0.93)	0.50		7
CLS ^e	10247.6 (745.2)	-0.60 (0.62)	-247.36 (151.63)	26.87 (40.74)	8.93 (12.76)	0.13		0.67	7

^aUnits of measurement of the various variables are as follows: M_t and C_t in 1,000 metric tons; PE_t in U.S. dollars/metric ton; Q_t in Kg/person; and YE_t is expressed in an index form with 1958 = 100.

^bFor the specific countries involved, see Footnote 2.

^cThe OLS estimation is equivalent to mixed estimation with $v_0 = \infty$ (complete uncertainty on the value of the extraneous information).

^dMixed estimation with the *a priori* "most accurate" value of v_0 . No values were available for the variance of the point estimates used in the mixed estimation, so subjective estimates were used. The "most accurate" estimate of the variance was based on the assumption of about 67 percent certainty that any particular elasticity was within ± 2 units of the true elasticity.

^eConditional least squares estimation is equivalent to mixed estimation with $v_0 = 0$ (complete certainty on the value of the extraneous information).

^fValues in parentheses are standard errors.

of uncertainty associated with extraneous information are very minor. Therefore, unless this degree of uncertainty is known with some confidence, mixed estimation may serve only as a measure of the sensitivity of the estimated coefficients.

OLS estimates of the coefficient of the income variable did not agree with *a priori* expectations for three of the five regions considered, namely, developed countries, Africa, and U.S.S.R. and Eastern Europe.¹¹ This inability of the OLS procedure to provide sensible and significant estimates provided the motivation for the incorporation of extraneous information. The estimated income coefficients using extraneous information are in conformity with *a priori* expectations. Furthermore, they become significant at a five percent level in seven out of fifteen cases, thus improving the efficiency in comparison to the OLS estimates.

The coefficient for lagged imports is between zero and one for Latin America and Asia for all estimations.¹² However, it is negative for developed countries, Africa, and the U.S.S.R. and Eastern Europe. This result indicates an adjustment coefficient greater than one, implying some countries in these regions overreact with respect to their imports from the U.S. as a response to changes in the world market. However, in none of the negative cases is the lagged import coefficient significantly different from zero at the five percent level.

Effects of Nonprice Variables

The coefficient of concessional imports is

¹¹Expectations on the effect of income on wheat demand were based on several sources. See, for example, Rojko *et al.* (pp. 35-37).

¹²It is well known that the effects of autocorrelation together with a lagged dependent variable as an explanatory variable make the OLS and mixed estimates inconsistent. The large-sample test suggested by Durbin [Johnston, p. 313] was used to test for autocorrelation. For the developed countries, Latin America, Asia, Africa, and U.S.S.R. and Eastern Europe the *t*-values for the estimated coefficient of $\hat{\epsilon}_{t-1}$ were 0.25, 0.39, 0.18, 0.54, and 0.42, respectively. Thus, the test statistic indicates that the estimates are consistent.

negative for developed countries, Latin America, and Africa, and positive for Asia, and the U.S.S.R. and Eastern Europe for all estimation procedures. For example, in the case of mixed estimation for each additional 1,000 metric tons of wheat imported under concessional terms, commercial imports dropped by 470 metric tons for developed countries, 530 metric tons for Latin America, and 250 metric tons for Africa. These results are consistent with the conclusion reached by Abbott that, in general, P.L. 480 food aid has been a substitute for commercial imports by recipient countries rather than an addition to commercial imports. The opposite conclusion is suggested from the estimates for Asia and the U.S.S.R. and Eastern Europe. However, no great significance should be placed in these latter estimates due to their very high standard errors.

An increase in domestic per capita production of wheat in an importing region is estimated to have a negative effect on U.S. wheat exports for developed countries, Latin America, and Africa. This result is as anticipated. However, for Asia, and the U.S.S.R. and Eastern Europe it has a positive influence in all cases, except for Asia in the CLS case. This positive influence may be due to the partial nature of this analysis. Changes in current production constitute only one component of total supply within a region during a given time period. They do not reflect changes in export volumes and stock levels which are also elements of total supply and thus determinants of the level of imports. On the other hand, this analysis is partial because it considers only U.S. supplies of imports for the respective regions. This observed linkage between domestic per capita wheat production in Asia, the U.S.S.R. and Eastern Europe, and their respective imports from the U.S. does not necessarily imply that a similar relation exists with respect to their total imports from all sources. The U.S. may have been more competitive in its behavior other than pricing. The positive linkage between concessional imports from the U.S. and commercial imports, observed

previously for exactly the same regions, is some evidence for this conjecture. Concessional U.S. exports to these regions might have resulted in the establishment of marketing channels and consequently a competitive advantage for U.S. commercial wheat exports.

Price-, Income-, and Exchange-Rate Elasticities

The price coefficient was negative as anticipated in every estimation procedure for all regions except Asia. For Asia the price coefficient takes a negative sign when the income coefficient is introduced with certainty (CLS case). In addition, about half of the negative price coefficients differ from zero at a ten percent level of significance. These results are similar to those obtained by other investigators [e.g., Houthakker and Magee, and Khan and Ross].

"Effective" price (PE_t) and "effective" income (YE_t) variables in the specification of export demand functions include two variables (U.S. export price P_t^{US} , and exchange rates, ER_t^k) whose effects on exports would be of interest to isolate.

As shown in Appendix B (expressions (1) and (2)), U.S.-export-price elasticities $\eta(P^{US})$, and exchange-rate elasticities $\eta(ER)$ of export demand can be obtained as¹³

¹³Exchange-rate elasticity of import demand $\eta(ER)$ is defined here as the change in wheat imports from the U.S. (expressed by the elasticity measure) caused by a unilateral and unbiased exchange rate adjustment of the U.S. dollar vis-a-vis the currencies of all countries within a region. By the term "unbiased" we

$$(3) \quad \eta(P^{US}) = \eta(PE).$$

and

$$(4) \quad \eta(ER) = \eta(PE) - \eta(YE)$$

where $\eta(PE)$ and $\eta(YE)$ are the elasticities of export demand with respect to "effective" price and "effective" income, respectively. These elasticities can be computed directly from the respective estimated coefficients of the export demand relationships.

Table 2 provides price, income and exchange-rate elasticities computed from the mixed estimates of Table 1. These figures indicate that import demand is responsive to U.S. export price and currency realignments. In general, the less developed a region the greater its response to price or currency changes. The exception is the U.S.S.R. and Eastern Europe which demonstrates the highest responsiveness. Perhaps noneconomic factors uncaptured by this analysis are responsible for this behavior. In addition, the limited degrees of freedom for the U.S.S.R. and Eastern Europe reduce the reliability of the price elasticity estimate.

The high values of exchange-rate elasticities obtained here support the notion that currency realignments have had a substantial impact on U.S. agricultural trade [Schuh (1974)] and on wheat in particular. In particu-

mean that the changes in exchange rates, expressed as $\Delta ER^k/ER^k$, are the same for all countries (k) in that region.

TABLE 2. U.S.-Export-Price, Income, and Exchange-Rate Elasticities of Regional Import Demand

Region	Elasticities		
	Export Price $\eta_j(P^{US}) \equiv \eta_j(PE)^a$	Income $\eta_j(YE)^b$	Exchange-Rate $\eta_j(ER)^c$
Developed	-1.47	-0.297	-1.17
Latin America	-0.37	1.52	-1.89
Asia	3.46	4.57	-1.11
Africa	-3.35	6.07	-9.42
USSR and Eastern Europe	-34.01	0.40	-33.61

^aObtained from price coefficient estimates (mixed estimation case of Table 1).

^bExtraneous estimates of income elasticities obtained from Rojko, *et al.* as described in the text.

^cComputed by expression (4).

lar, these estimates of exchange-rate elasticities for wheat are compatible with those reported by Fletcher and Just. Their reported elasticity of -1.096 for Western Europe compares with the estimate here of -1.17 for developed countries; for Africa they report -15.219 compared with the -9.42 obtained in this study.

Conclusions and Limitations

The problems associated with simultaneous-equation bias in single equation models are too well known to need much elaboration here. However, the use of ordinary and mixed least-squares procedures to estimate single equation export demand functions may be free of some of these problems in the present case. If shifts in the supply schedule are relatively large in comparison to those of the demand schedule, the regression line would have a negative slope close to that of the actual demand schedule. Moreover, should the elasticity of the supply curve be infinite — which was perhaps the case in the wheat market during the time period of this analysis due to the large North American stocks — the regression line would be parallel to the actual demand schedule and therefore the calculated price parameter would exactly represent the true one. This case is worth elaborating. It suggests that where price is taken as given and the importing country adjusts the quantity demanded, the traditional least-squares model provides reasonable results.¹⁴

In view of the above discussion and the aggregative nature of the study, the paper's results should be viewed as having a diagnostic rather than a policy emphasis. For example, the positive price elasticity estimate of export demand to Asia contradicts *a priori* reasoning.

Specification bias could be the reason. Another explanation could be along the lines of Tryfos' [1975] reservations about the length of time covered by observations in prices and quantities imported, and the length of the adjustment process to changes in the price variable. Annual time series in prices and quantities, based on averages of these variables, might not reflect the particular fluctuations that are responsible for the observed average responses. "If the adjustment in prices . . . can be completed within a period of time shorter than the one to which the available data refer, then clearly the recorded exports or imports and price differences will have no relationship to each other" [Tryfos (1975, p. 689)]. This observation suggests that semi-annual or quarterly data would have been more appropriate in our estimation.¹⁵ However, problems in data availability and large volume of data needs made it impossible to effectively use semi-annual or quarterly data in this study.

In general, the results of this study suggest that U.S. export demand for wheat is responsive to price and exchange rate changes. However, a U.S. policy of price cuts to stimulate increased commercial exports might be less effective than the estimates suggest. The oligopolistic nature of the world wheat market has long been recognized [McCalla, 1966], but is submerged with the effective U.S. price in this study, where any action by the U.S. is assumed to be matched by that of other exporters.¹⁶ On the other hand, exchange rate changes, which to a great extent originate from adjustments outside the agricultural sector and for that matter outside the power of the U.S., have had a substantial impact on agricultural exports in general and wheat in particular, a conclusion which supports the belief expressed by many researchers in recent years.

¹⁴Characteristic of acceptance of the least-squares norm by researchers in international trade problems is the well-quoted paper by Houthakker and Magee [1969], which appeared almost two decades after the first attacks against traditional approaches.

¹⁵Capel and Rigaux [1974, p. 13] also make the same point with respect to the aggregative nature of annual data.

¹⁶The relatively stable movements of wheat prices among major wheat exporters mentioned earlier supports this conjecture.

References

- Abbott, P. C., "Developing Countries and International Grain Trade", Ph.D. Dissertation, Massachusetts Institute of Technology, 1976.
- Bjarnason, H. F., M. J. McGarry, and A. Schmitz, "Converting Price Series of Internationally Traded Commodities to a Common Currency Prior to Estimating National Supply and Demand Equations", *American Journal of Agricultural Economics*, 51, (1969): 189-191.
- Brook, R. and T. D. Wallace, "A Note on Extraneous Information in Regression", *Journal of Econometrics*, 1, (1973): 315-316.
- Capel, R. E. and L. R. Rigaux, "Analysis of Export Demand for Canadian Wheat", *Canadian Journal of Agricultural Economics*, 22: 1-14.
- Ferguson, C. E. and M. Polasek, "The Elasticity of Import Demand for Raw Apparel Wool in the United States", *Econometrica*, 30 (1962): 670-685.
- Fletcher, Stanley and R. E. Just, "The Impact of Currency Realignment on U.S. Wheat Export Demand", paper presented at the annual AAEA meeting Columbus, Ohio, August 1975.
- Greenes, T. "The Exchange Rate and U.S. Agriculture: Comment", *American Journal of Agricultural Economics*, 57 (1975): 134-135.
- Harberger, A. C., "A Structural Approach to the Problem of Import Demand", *American Economic Review*, 43 (May 1953): 148-160.
- Houthakker, H. S. and S. P. Magee, "Income and Price Elasticities in World Trade", *The Review of Economics and Statistics*, 51 (May 1969): 111-125.
- Hurtado, H., "EC Import Demand for Grains: Some Implications of the Common Agricultural Policy on U.S. Imports", Ph.D. Dissertation, University of California, Davis (1976).
- Johnston, J., *Econometric Methods*, 2nd ed., McGraw-Hill, 1972.
- Kahn, M. S. and K. Z. Ross, "Cyclical and Secular Income Elasticities of the Demand for Imports", *The Review of Economics and Statistics*, 57, (August 1975): 357-361.
- Konandreas, P. A., "An Econometric Analysis of U.S. Grain Exports with Policy Implications of Price Stabilization", Ph.D. Dissertation, University of California, Davis (1976).
- Kost, W. E., "The Effect of an Exchange Rate Change on Commodity Trade", paper presented at annual AAEA meeting, Columbus, Ohio, August (1975).
- Kreinin, M., "Price Elasticities in International Trade", *Review of Economics and Statistics*, 49, (1967): 510-516.
- McCalla, A. F., "A Duopoly Model of World Wheat Pricing", *Journal of Farm Economics*, 48, (1966): 711-727.
- Rojko, A. S., F. S. Urban, and J. J. Naive, *World Demand Prospects for Grain in 1980 with Emphasis on Trade by the Less Developed Countries*. Foreign Agricultural Economics Report No. 75, ERS, USDA (1971).
- Schuh, G. E., "Exchange Rates and U.S. Agriculture", *American Journal of Agricultural Economics*, 56 (1974): 1-13.
- , "The Exchange Rate and U.S. Agriculture: Reply", *American Journal of Agricultural Economics*, 57 (1975A): 136-137.
- , "The Exchange Rate and U.S. Agriculture: Reply", *American Journal of Agricultural Economics*, 57, (1975B): 136-137.
- Theil, H. and A. S. Goldberger, "On Pure and Mixed Statistical Estimation in Economics", *International Economic Review*, 2 (1961): 65-78.
- Tryfos, P., "The Measurement of Price Elasticities in International Trade", *American Journal of Agricultural Economics*, 57 (1975): 689-691.
- Vellianitis-Fidas, A., "The Exchange Rate and U.S. Agriculture: Comment", *American Journal of Agricultural Economics*, 56, (1975): 692-695.
- Yntena, T. O., *A Mathematical Formulation of the General Theory of International Trade*, Chicago: University of Chicago Press (1932).

Appendix A

Derivation of Extraneous Estimates of Income

As mentioned in the text, regional estimates of income elasticities of total demand were obtained as a weighted average of the income elasticities of total demand for countries or subregions within the main regions of the analysis. The weights were the country's average shares of total regional imports.

The total quantity of wheat consumed in region j in year t , D_t , consists of domestically produced grain, Q_t , and total imports from all sources of MT_t , i.e., $D_t = Q_t + MT_t$. Introducing income elasticities of the respective variables, total demand can be expressed as:¹⁷

$$1) \quad D_t \eta_t(D) = Q_t \eta_t(Q) + MT_t \eta_t(MT)$$

where $\eta_t(D) = \frac{\partial D_t}{\partial YE_t} \frac{YE_t}{D_t}$: the income elasticity of total demand for wheat in the j th region in year t :

$\eta_t(Q) = \frac{\partial Q_t}{\partial YE_t} \frac{YE_t}{Q_t}$: the income elasticity of domestic production for wheat in the j th region and year t ; and

$\eta_t(MT) = \frac{\partial MT_t}{\partial YE_t} \frac{YE_t}{MT_t}$: the income elasticity of import demand for wheat in the j th region in year t .

In the very short run (within the year) a change in income does not affect the grain produced in an importing region. Therefore one can write

$$\frac{\partial Q_t}{\partial YE_t} = 0 \quad \text{which implies } \eta_t(Q) = 0$$

and therefore, equation (1) yields

$$2) \quad \eta_t(MT) = \frac{Q_t + MT_t}{MT_t} \eta_t(D).$$

¹⁷Equation (2) was first derived by Yntena (1932) and has been rediscovered since then under different forms by Harberger, Ferguson and Polasek, and Kreinin among others.

This last relationship provides a means of obtaining the income elasticity of import demand, $\eta_t(MT)$, of a region, from a knowledge of the income elasticity of total demand, $\eta_t(D)$.

Total wheat imports of a region consist of imports from the U.S. (M_t) and imports from the rest of the world (M'_t), i.e.,

$$MT_t = M_t + M'_t.$$

Assume that the U.S. market share in that region is constant. Its imports from the U.S. can then be expressed as $M_t = cMT_t$, where c is a constant. Then,

$$3) \quad \eta_t(M) = \frac{\partial MT_t}{\partial YE_t} \frac{YE_t}{MT_t} = \eta_t(MT).$$

Therefore, the assumption of constant market share of the U.S. in a region implies that its income elasticity of import demand for U.S. wheat equals the income elasticity of total import demand for wheat from all sources. From expression (3), the coefficients of the income variables can be obtained as

$$4) \quad \frac{\partial M_t}{\partial YE_t} = \frac{M_t}{YE_t} \eta_t(MT).$$

Appendix B

Derivation of U.S.-Export-Price and Exchange-Rate Elasticities of Import Demand

Define $\eta(\cdot)$ as the elasticity of import demand with respect to the variable in parentheses. Subscripts and superscripts on η qualify further this notation in terms of the region and country concerned. The derivations that follow are based on the ordinary definition of the elasticity measure and the definitions of variables PE and YE as they appear in the text. Time subscripts have been dropped for simplicity.

The U.S.-export-price elasticity of import demand by a particular region can be derived as

$$\begin{aligned}
 (1) \quad \eta(P^{US}) &= \frac{\partial M}{\partial P^{US}} \frac{P^{US}}{M} = \frac{\partial M}{\partial PE} \frac{\partial PE}{\partial P^{US}} \frac{P^{US}}{M} \\
 &= \frac{\partial M}{\partial PE} \left(\sum_{k=1}^{K_j} w^k \frac{1}{P^k/ER^k} \right) \frac{P^{US}}{M} \\
 &= \frac{\partial M}{\partial PE} \frac{PE}{M} = \eta(PE).
 \end{aligned}$$

The effect of a change in the exchange rate between the U.S. and the k th country on its wheat imports from the U.S. measured in terms of the respective elasticity can be expressed as

$$\begin{aligned}
 \eta^k(ER) &= \frac{\partial M}{\partial ER^k} \frac{ER^k}{M} \\
 &= \left[\frac{\partial M}{\partial PE} \frac{\partial PE}{\partial ER^k} + \frac{\partial M}{\partial YE} \frac{\partial YE}{\partial ER^k} \right] \frac{ER^k}{M} \\
 &= \left[\frac{\partial M}{\partial PE} w^k \frac{P^{US}}{P^k/ER^k} \right. \\
 &\quad \left. - \frac{\partial M}{\partial YE} w^k \frac{Y^k}{ER^k} \right] \frac{1}{M}.
 \end{aligned}$$

Now assume that a major currency realignment takes place between the U.S. dollar and the currencies of the rest of the world such that changes in exchange rates, expressed as $\Delta ER^k/ER^k$, are the same for every country. Then, its impact on imports of the j th region, expressed by the elasticity measure, would be

$$\begin{aligned}
 (2) \quad \eta(ER) &= \sum_{k=1}^{K_j} \eta^k(ER) = \left[\frac{\partial M}{\partial PE} \sum_{k=1}^{K_j} w^k \frac{P^{US}}{P^k/ER^k} \right. \\
 &\quad \left. - \frac{\partial M}{\partial YE} \sum_{k=1}^{K_j} w^k \frac{Y^k}{ER^k} \right] \frac{1}{M} \\
 &= \frac{\partial M}{\partial PE} \frac{PE}{M} - \frac{\partial M}{\partial YE} \frac{YE}{M} \\
 &= \eta(PE) - \eta(YE).
 \end{aligned}$$

