Wheat marketing

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An Econometric Model of World Wheat Trade With Emphasis on U.S. Exports

by

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Abstract

An econometric model of the international wheat market is developed and evaluated for forecasting U.S. wheat exports over a one year period. The model attempts to capture the essential elements of the demand for U.S. wheat exports by explaning the linkages between wheat importing and exporting regions. A total of 112 countries are aggregated into fourteen importing regions and five exporting regions. Net import demand equations are estimated for each of the fourteen importing regions using data from 1960-74. Export supply equations are also estimated for the five major exporting regions. These equations are combined with equations which project wheat production to develop a forecasting model of net wheat imports by each region. A market share approach is then used to obtain U.S. wheat exports.

AN ECONOMETRIC MODEL OF WORLD WHEAT TRADE WITH EMPHASIS ON U.S. EXPORTS

The experience of the last several years suggests the need for a better understanding of the factors which determine the level of world wheat trade and the nature of U.S. participation in this trade. Prior to a 1972-73 crop year, U.S. wheat exports were characterized by concessionary sales and low prices. The average net wheat export over the 1960-71 period was 19 million tons. However, beginning in the 1972-73 crop year, the level of wheat exports increased sharply. U.S. wheat exports for the period from 1972 to 1974 were 30.32 million metric tons. These higher exports of wheat have had major effects on all sectors of U.S. agriculture and the economy. They also cause uncertainty about the future path of U.S. wheat exports and highlight the importance of being able to anticipate export levels.

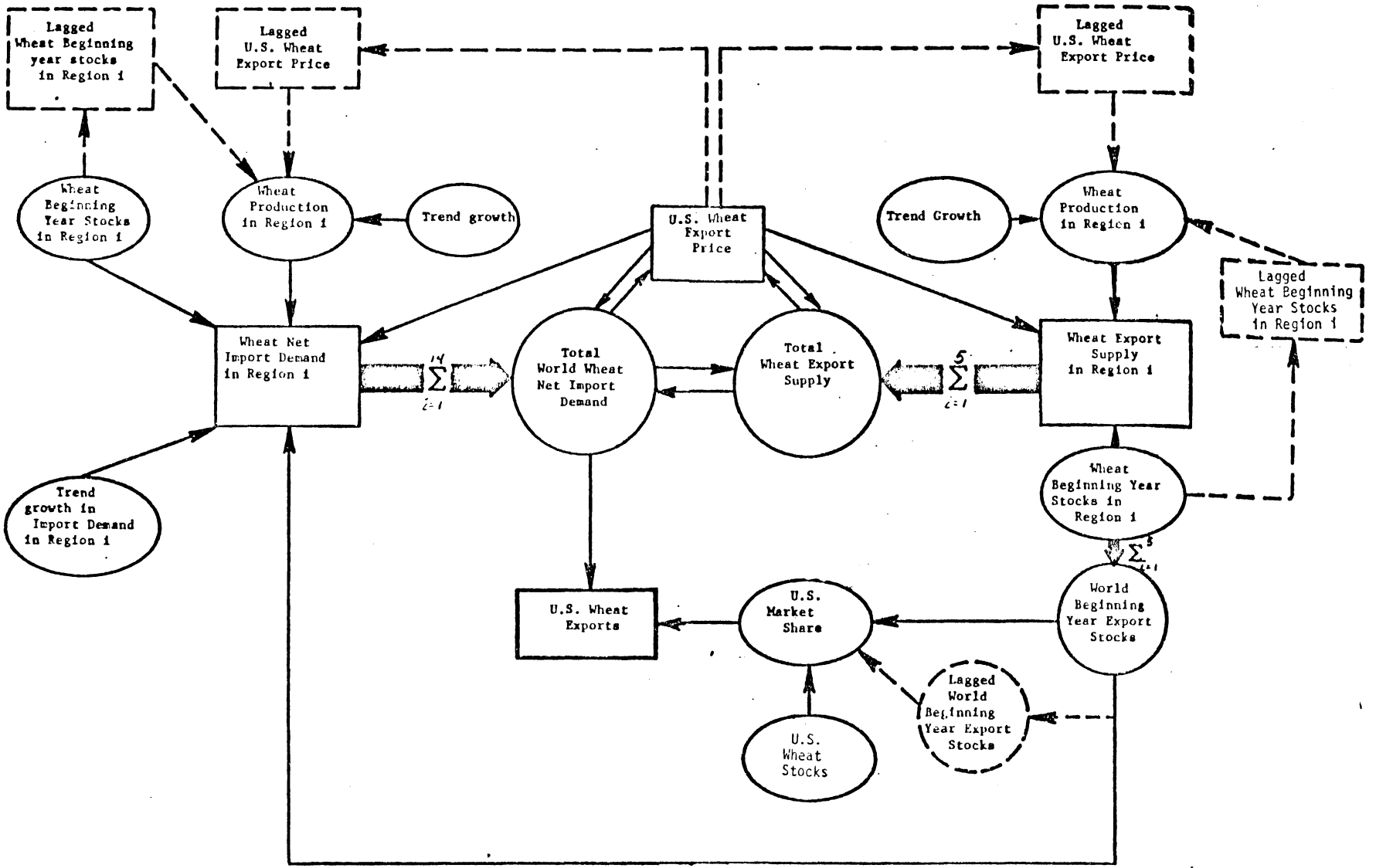
This paper presents the results of an econometric modeling effort of the international wheat economy. The model attempts to capture the essential elements of the demand for U.S. wheat exports by estimating the relationship within and among wheat importing and exporting countries. World importing and exporting regions are identified and equations are econometrically estimated to represent regional import demand and supply. A market share approach is used to link the exports of wheat from the U.S. to the world market. U.S. wheat export price is assumed to represent the world price.[1]

The model flows are presented in Figure 1. The importing region's net import demand are dependent upon each region's wheat production, stocks, the U.S. export price, a trend variable, and the level of wheat stocks in the major exporting countries. Wheat production responds to lagged wheat export price and lagged regional wheat stocks. The total import demand for all countries is obtained by the summation of import demand in all fourteen importing regions.

Wheat export supply in each of the exporting countries is a function of wheat production, wheat stocks, and the export price of wheat. Total world production and total world stocks are obtained as a summation over the exporting regions. World wheat net import demand, world export supply, and the U.S. wheat export price (used as a proxie for world price) are simultaneously determined. The U.S. share of the world exports is obtained from a market share equation which is estimated from the level of stocks in the U.S., the five major exporting regions and the U.S.S.R.

A total of 107 countries are aggregated into 14 importing regions to represent the world market for wheat imports. Countries designated as importing countries are on balance net importers of wheat in any given year. However, some countries such as the U.S.S.R. are also net wheat exporters in some years. Since wheat imports are calculated on a regional basis, a country which has net exports in a given year would reduce the net imports of the region. It is also possible for a region which is designated as an importing region to have net exports in some years. When the situation occurs, the imports of other regions would be balanced by these exports. Appendix Table 1 shows the countries included in each region.

Figure 1. World Wheat Trade Model



The five major wheat exporting countries represent the supply side of the international wheat market. These five countries are the United States, Canada, Australia, France, and Argentina. The U.S.S.R. has also been a major exporter during selected periods. During the period from 1966-71, the U.S.S.R. exported approximately 10 percent of world wheat exports. The last several years the U.S.S.R. has been a net importer or a marginal net exporter. The five major exporting countries plus the U.S.S.R. have accounted for approximately 95 percent of world wheat exports over the 1960-74 period. The remaining 5 percent of world wheat exports was contributed by countries which are occasional exporters. The average market share for the five major exporting countries during the three year period from 1972-74 are: United States (51%), Canada (21%), France (13%), Australia (11%), and Argentina (4%).

Regional Wheat Net Import Estimates

Wheat net import[2] demand is estimated for each of the fourteen importing regions. The estimated equations are shown in Table 1. Wheat net import demand equations are estimated over the fifteen year period from 1960-74. Quantity data is on a crop year basis expressed in thousands of metric tons. The estimated equation is:

$$WNI_{i,t} = \beta_o + \beta_1 WDS_{i,t} + \beta_2 WUSP_t + \beta_3 Time_t + \beta_4 WES_t + e_{i,t}$$

where:

$WNI_{i,t}$ is net wheat imports in region i in year t

$WDS_{i,t}$ is wheat production plus carryover wheat stocks in region i in year t

$WUSP_t$ is the U.S. wheat export price in year t in 1972 dollars

$TIME_t$ is a trend variable with 1960 = 1

WES_t is the beginning stock of wheat in the five major exporting countries (U.S., Canada, Argentina, Australia, and France) in year t

The estimated equations reported in Table 1 show that the level of domestic wheat supply, WDS, is the major determinant of net wheat imports. Coefficient estimates range from -.388 to -1.044 and indicate the portion of a change in domestic wheat supply which would be imported from the international grain markets. The expected range of coefficient estimates is between 0.0 and -1.0 Of the twelve coefficients reported, only Japan is outside of this expected range, and that coefficient is not significantly outside the expected range. Two regions, East Asia and China had positive estimated coefficients on the WDS variable. Nine of the estimated coefficients were statistically significant at the one percent level, and only one coefficient failed to be significant at the ten percent level. The magnitudes of the estimated coefficients are similar and this increases our confidence in the importance of this relationship. The estimated coefficients are also remarkably stable when alternative specifications are used.

A second factor which emerges from the estimation results is the relative insignificance of U.S. wheat export price as a determinant of net wheat imports. Several definitions of U.S. wheat export price were specified. Both deflated and undeflated prices were estimated.

Table I. Wheat Net Import Equations for Major World Importing Regions for the Fifteen Year Period from 1960 to 1974.[a/]

Region	C	$WDS_{i,t}$	$WUSP_t$	$TIME_t$	WES_t	$\hat{\rho}$	R^2	DW	S.E.
Mexico	-1321.6	-.704 (.173)***		214.586 (328.404		.896 (.238)***	.92	1.37	130.30
Central America	3798.8	-.538 (.578)	-142.751 (160.924)	174.270 (60.459)**		.573 (.362)	.93	1.74	270.04
Brazil	2414.9	-.646 (.127)***		98.812 (22.412)***			.69	1.72	236.50
Northern Europe	19816.0	-.583 (.193)**	-664.157 (398.182)	189.225 (103.961)*			.67	1.79	850.61
Southern Europe	14000.0	-.740 (.090)***		105.160 (34.44)***			.86	2.04	482.30
Eastern Europe	12040.2	-.388 (.189)*		294.258 (291.521)		.456 (.287)	.63	1.72	1067.40
USSR	52894.3	-.407 (.061)***	-5956.311 (1465.041)***	1529.491 (279.378)***	-.335 (.080)***	-.453 (.238)*	.80	2.34	3141.37
Africa	5111.5	-.799 (.162)***		631.157 (116.527)***		.574 (.301)*	.93	1.87	502.28
Republic of South Africa	1276.8	-.644 (.156)***	-125.689 (66.666)*	47.556 (24.362)*	-.008 (.004)*	-.252 (.259)	.81	2.19	150.02
West Asia	12008.2	-.668 (.157)***	-703.556 (433.866)	596.141 (137.920)***		.360 (.353)	.78	2.25	743.3
India South Asia	11004.7	-.459 (.127)***		894.160 (229.638)***		.481 (.372)	.83	1.42	1014.20
Japan	6095.4	-1.044 (.101)***	-110.734 (31.771)***	100.617 (11.847)***	-.013 (.002)***	.568 (.220)**	.99	2.46	89.20
East Asia	761.7			358.188 (75.941)***			.91	1.56	531.20
China[b/]	4590.0								

a/ *** indicates the estimated coefficient is significantly different from zero at the 1 percent level of significance
** indicates the estimated coefficient is significantly different from zero at the 5 percent level of significance
* indicates the estimated coefficient is significantly different from zero at the 10 percent level of significance
The estimated coefficient of first order autocorrelation is denoted by $\hat{\rho}$, the coefficient standard errors of each coefficient are given in parenthesis, the durbin watson statistic is denoted as DW and the standard error of the equation is denoted as S.E.

b/ An estimated equation was not able to satisfactorily represent the level of net wheat imports for the Peoples Republic of China. Consequently imports are projected to equal the average net imports over the 1960-74 period.

Source: (1) (2) (3) (4) (5) (6)

Adjustment for the U.S. monetary devaluations of 1971 and 1973 were also included. However none of these specifications produced results substantially different from the reported estimates. Only six of the fourteen wheat importing regions had an estimated coefficient with the expected negative sign. Three of these were not significantly different from zero at the ten percent level. Two regions, Japan and the U.S.S.R., have negative coefficients which are significant at the one percent level. The price elasticity of demand, estimated at the mean price and import quantity, for the six importing regions with negative estimated coefficients are: Central America (-.093), Northern Europe (-.215), U.S.S.R. (+13.815), Republic of South Africa (-3.729), West Asia (-.646), and Japan (-.065). The estimated price elasticity for the U.S.S.R. has a positive value because the U.S.S.R. has been a net exporter on balance over the period.

A final point which emerges from the estimation results is the significance of the level of wheat stocks in the major exporting countries as a determinant of wheat net imports. The combined level of wheat stocks held by the U.S., Canada, Argentina, France, and Australia at the beginning of the year significantly influences the level of imports in three of the importing countries. This may suggest a long range assessment of the world wheat market by importing countries and precautionary purchases to reduce the possibilities of lower than desired imports. It may also be indicative of the need for importing countries to make purchases early in the crop year before production is known.

Wheat Production Equations

Wheat production equations are estimated for the fourteen importing

regions and the five exporting countries. The results are shown in Table 2. The primary explanatory variable used to explain wheat production is the trend variable. Wheat stocks held at the beginning of the crop year and lagged U.S. wheat export price are also used as explanatory variables in selected equations. The estimated equations are used in the simulation model to project wheat production one year into the future. These projections are then incorporated into the estimated regional import demand and export supply equations.

The estimated equations are estimated over the fifteen year period from 1960-74. Data is on a crop year basis expressed in thousands of metric tons. The estimated equation is:

$$WP_{i,t} = \beta_o + \beta_1 \, Time_t + \beta_2 \, WST_{i,t} + \beta_3 \, WUSP_{t-1} + e_{i,t}$$

where:

$WP_{i,t}$ is wheat production in region i in year t

$Time_t$ is a trend variable with 1960 = 1

$WST_{i,t}$ is beginning year wheat stocks in region i in year t

$WUSP_{t-1}$ is the U.S. wheat export price in year t

Market Share Analysis

The U.S.'s market share of the world wheat imports is represented by the following market share equation:

$$USMS_t = 61.222 \underset{(.092)**}{-.191} \, TES6_t \underset{(.098)**}{-.198} \, TES6_{t-1} + \underset{(9.062)}{4.958} \, US/TES5_t$$

$$\hat{\rho} = \underset{(.596)}{-.157} \quad R^2 = .61 \quad D = 1.84 \quad S.E. = 4.38$$

Table 2. Wheat Production Equations for Major Wheat Importing and Exporting Regions for the Fifteen Year Period from 1960 to 1974.[a/]

Region	C	$Time_t$	$WST_{i,t}$	$WUSP_{t-1}$	$\hat{\rho}$	R^2	DW	S.E.
Mexico	1225.8	43.836 (15.638)*	- .028 (.836)	109.237 (74.249)		.64	1.99	200.96
Central America	1615.8	-34.909 (25.857)			.533 (.240)**	.50	1.76	165.10
Brazil	-1153.9	151.101 (32.961)***		429.038 (222.694)*	.126 (.265)	.72	2.22	435.00
Northern Europe	10484.5	503.781 (51.500)***	- .585 (.408)	1549.374 (462.736)***	-.224 (.260)	.90	2.02	912.44
Southern Europe	15619.1	91.982 (91.741)			.217 (.261)	.23	2.33	1084.94
Eastern Europe	17064.6	1245.257 (99.195)***	-2.337 (1.111)*		.011 (.267)	.94	2.25	1447.13
USSR	56901.9	3048.048 (426.214)***			-.634 (.207)***	.66	1.65	10498.7
Africa	4383.7	274.757 (67.446)***	-1.334 (1.054)			.65	2.07	786.05
Republic of South Africa	398.8	90.621 (22.294)***			.397 (.245)	.80	1.73	201.66
West Asia	13205.0	403.775 (69.990)***				.72	1.86	1171.20
India and South Asia	6666.0	1724.063 (425.190)***			.618 (.210)**	.90	1.48	2437.49
Japan	1758.6	-106.379 (12.889)***				.84	2.21	215.67
East Asia	881.9	- 19.794 (10.376)*				.47	2.45	72.27
China	18257.8	921.283 (144.119)***			.144 (.264)	.82	1.17	1854.66
United States	36816.7	893.101 (272.416)***	-.279 (.108)**		.328 (.252)	.89	2.52	2045.59
Canada	21747.6	-11.569 (329.603)	-.382 (.234)		.253 (.259)	.21	1.70	3703.51
Argentina	7999.2	-145.022 (133.000)			.211 (.261)	.14	2.10	1584.19
France	7489.2	519.278 (71.984)***		1094.298 (696.397)	-.396 (.245)	.74	2.11	1513.58
Australia*	8095.2	163.628 (135.278)			-.210 (.261)	.12	1.91	2463.48

a/ *** indicates the estimated coefficient is significantly different from zero at the 1 percent level of significance
** indicates the estimated coefficient is significantly different from zero at the 5 percent level of significance
* indicates the estimated coefficient is significantly different from zero at the 10 percent level of significance
The estimated coefficient of first order autocorrelation is denoted by $\hat{\rho}$, the coefficient standard errors of each coefficient are given in parenthesis, the durbin watson statistic is denoted as DW and the standard error of the equation is denoted as S.E.

Source: (1) (5)

where

$USMS_t$ is the U.S.'s share of world exports of the five major wheat exporting countries in year t times 100

$TES6_t$ is the beginning year wheat stocks in the five major wheat exporting countries plus the U.S.S.R. in year t times 100

$US/TES5_t$ is the ratio of U.S. wheat stocks at the beginning of the crop year to the level stocks in the five major wheat exporting countries times 100

The market share equation explains the U.S. share of exports of the five major exporting countries as a function of levels of beginning wheat stocks in the five major wheat exporting countries and the USSR. The USSR has been a major factor determining the U.S. market share over the historical period. Wheat exports from the U.S. and the USSR are inversely related. Since the USSR has been both a major wheat importer and exporter over the period much of this relationship is explained by U.S. exports to the USSR. But, a relationship also exists between U.S. exports to other communist countries and the exports of the USSR. When the USSR does not have wheat for export, the U.S. gains a large part of this market and consequently experiences a larger share of world exports. And, when the USSR does have wheat for export, the U.S. loses this market.

A number of variables and alternative specifications were used to try and improve the market share equation. Stocks were the only variables which explained any significant portion of the variability in the U.S. market share. Production of wheat in the major exporting countries did not perform as well as stocks, and relative prices of wheat exports by the major exporting countries did not improve the estimated equation.

Model Results

Actual, simulated, and projected world net wheat imports and U.S. exports are shown in Figures 2 and 3. Simulated results are obtained by using actual historical values for the explanatory values, and provides a measure of the ability of the model to capture or explain historical results. Projected export levels were also made when exogenous variables were projected by the model equations. These results correspond to a series of one year forecasts of world and U.S. wheat exports. These results are denoted by the dotted line projections of Figures 2 and 3.

A significant constraint imposed on the model during development was the availability, timeliness, and projectability of the data required to make projections. Better simulated results could probably be obtained by explicitly incorporating additional variables such as per capita income, monetary reserves, and demographic variables. But, these relationships are difficult to project. In some cases, a weaker basis exists for projecting these variables than for projecting world trade. Imposing this data constraint makes it relatively easy to make a one year projection.

Conclusions and Implications

The demand for wheat imports is primarily determined by the level of domestic wheat supply, production plus stocks, in each importing region. The U.S. wheat export price was not found to be a significant determinant of the level of wheat imports in most regions. The demand for wheat imports was found to be increasing over time as indicated by a positive and significant trend variable for most regions. Wheat

imports in several regions were also found to be inversely related to the level of wheat stocks held by the major exporting countries. This relationship may indicate precautionary buying on the part of several major importing countries rather than risking lower than desired imports of wheat.

The implications of these results are particularly important as the United States and Canada engage in talks to explore a joint wheat-pricing policy. The unresponsiveness of wheat imports to price indicates little resistance would be found to a price increase, at least in the short-run. Further, these results also indicate that a reduction in wheat export price would not increase sales substantially. However, it must be recognized that an individual exporting nation could not raise its price above the export price of other nations without reducing its share of the total world wheat market.

In addition to being unresponsive to price, the demand for wheat imports is also found to be highly unstable from one year to the next. This instability is caused by the variability in wheat production and the resulting shift created in the import demand function. Although we are not yet able to accurately predict wheat production a year or more in advance we have seen substantial progress in forecasting production from current crops prior to harvest. As these estimates become available for various world regions, they can be evaluated to obtain advance estimates of purchasing intentions of major wheat importing nations. This information could then be used in trade negotiations.

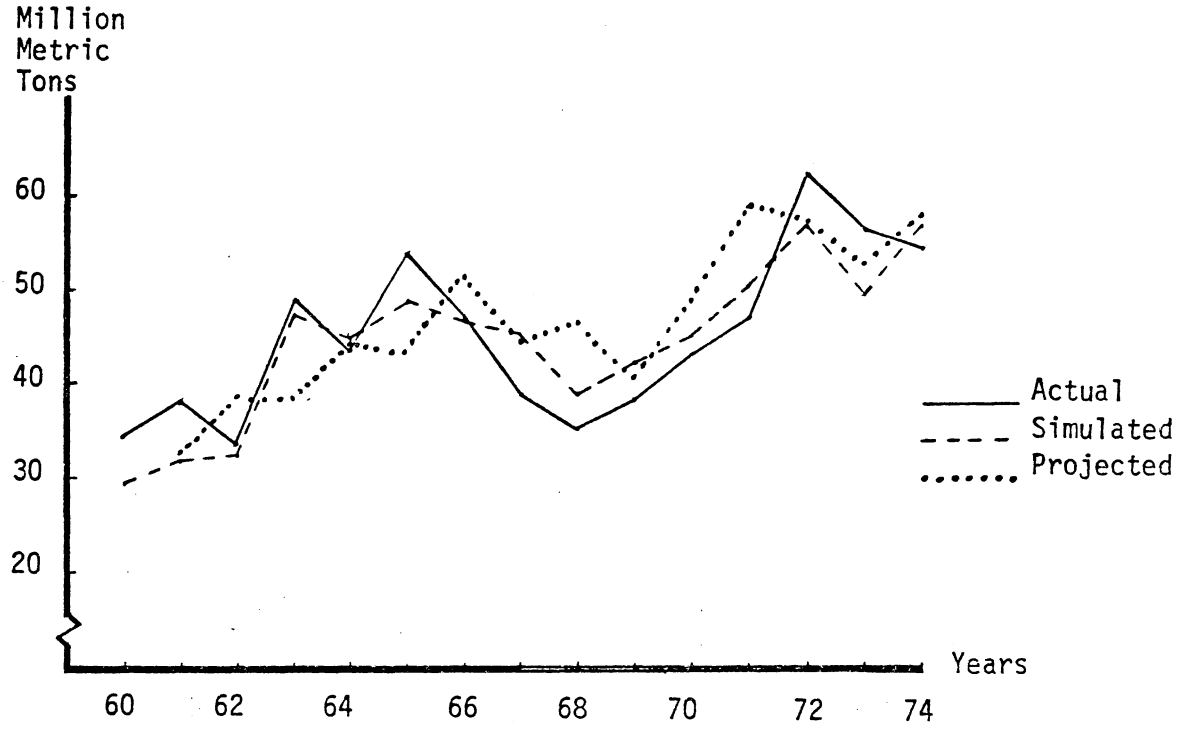


Figure 2. World Net Wheat Imports

Figure 3. U.S. Net Wheat Exports

FOOTNOTES

1/ This assumption is supported by high correlations between the U.S. export price and the export and import prices in other major wheat trading nations. The correlation between the U.S. wheat export price and the export price in the other major exporting countries are: U.S.-Canada (.965), U.S.-Argentina (.983), U.S.-France (.890). U.S.-Australia (.934). Of the major importing nations, the correlations between the U.S. export price and the wheat import price are: U.S.-Japan (.976), U.S.-United Kingdom (.974), U.S.-India (.974), U.S.-U.S.S.R. (.871). Source: (2) (6)

2/ All estimates are made for net wheat imports to avoid double counting for countries which both import and export in the same period.

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Appendix Table 1: World Wheat Importing and Exporting Regions and Countries Included in Each Region

Region Name	Countries Included in This Region
Importing Regions	
Mexico	Mexico
Central America	Costa Rica, Cuba, Dominican Republic, El Salvador, Guatemala, Haiti, Honduras, Jamica and Dependents, Nicaragua, Panama, Trinidad and Tobago, Bolivia, Chile, Colombia, Equador, Paraguay, Peru, Venezuala, Guyana
Brazil	Brazil
Northern Europe	Austria, Belguim and Luxembourg, Denmark, Finland, Ireland, Netherlands, Norway, Sweden, Switzerland, United Kingdom-North Ireland, West Germany, Iceland
Southern Europe	Greece, Italy, Portugal, Spain, Malta-Gozo
Eastern Europe	Bulgaria, Czechoslovakia, East Germany, Hungary, Poland-Danzig, Rumania, Yugoslavia, Albania
U.S.S.R.	U.S.S.R.
Africa	Algeria, Ethiopia, Lybia, Morocco, Sudan, Tunisia, Egypt, Somali Republic, Angola, Camaroon, Zaire, Ghana, Guinea, Ivory Coast, Nigeria, Senegal, Sierra Leone, Upper Volta, Dahomey, Kenya, Malagasy Republic, Rhodesia, Zambia, Uganda, Tanzania, Mozambique
Republic of South Africa	Republic of South Africa
West Asia	Cyprus, Iran, Iraq, Israel, Jordan, Lebanon, Syria, Turkey, Saudi Arabia, So Yemen, Kuwait, Afghanistan
India and Other South Asia	India, Sri Lanka (Ceylon), Pakistan, Bangladesh, Nepal
Japan	Japan
Other East Asia	Burma, Khmer Republic (Cambodia), Taiwan, Indonesia, Philippines, Hong Kong, South Korea, South Vietnam, Thailand, North Vietnam, North Korea, Outer Mongolia
People's Republic of China	People's Republic of China
Exporting Regions	
United States	United States
Canada	Canada
Argentina	Argentina
France	France
Australia	Australia