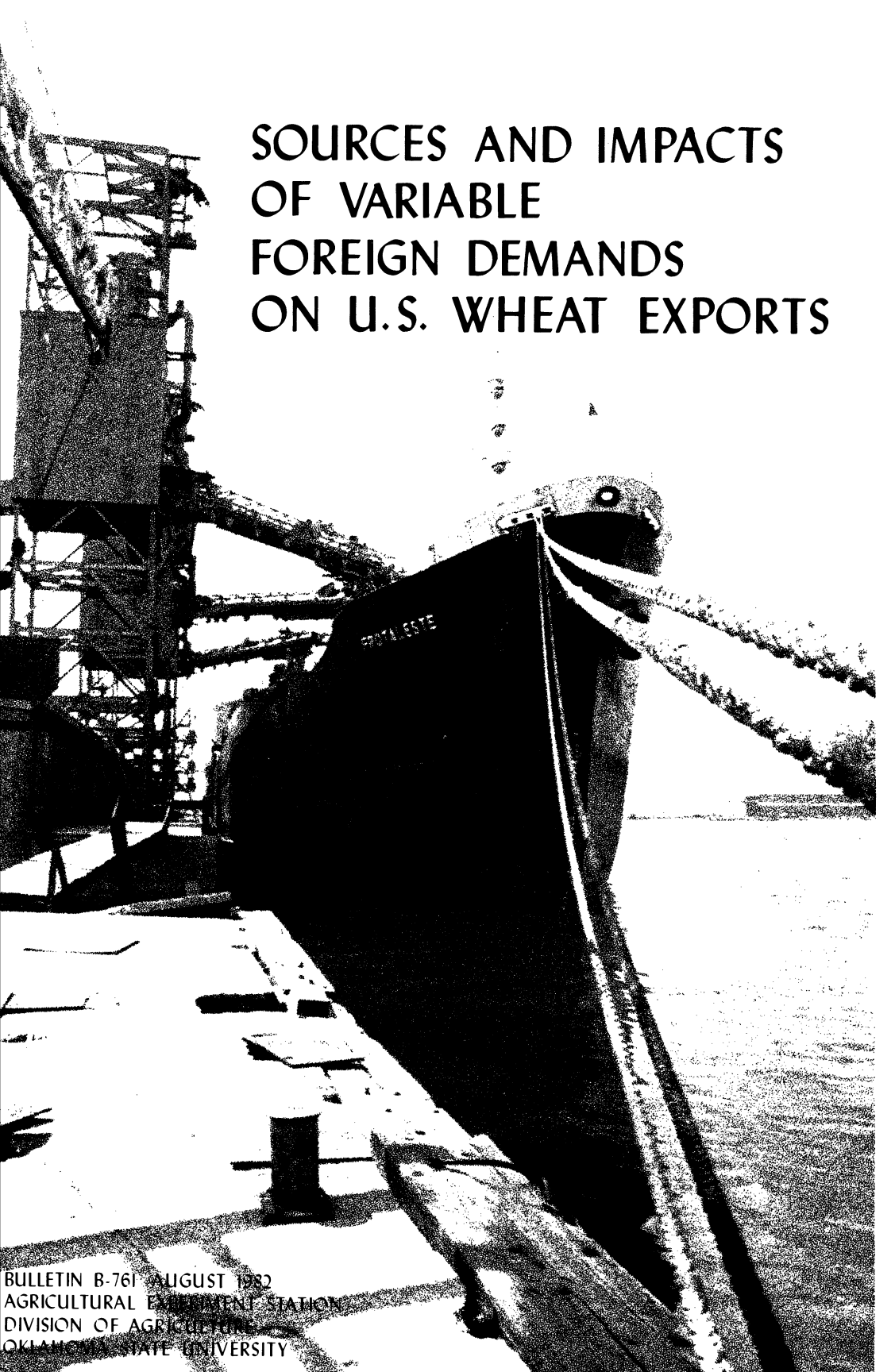
# SOURCES AND IMPACTS OF VARIABLE FOREIGN DEMANDS ON U.S. WHEAT EXPORTS



BULLETIN B-761 AUGUST 1982
AGRICULTURAL EXPERIMENT STATION
DIVISION OF AGRICULTURE
OKLAHOMA STATE UNIVERSITY

# Contents

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# Sources and Impacts of Variable Foreign Demands on U. S. Wheat Exports

**Alan J. Webb and Leo V. Blakley**[1]

## Introduction

The models and 1985 projections of wheat production-consumption balances for 1985 are reported in a previous report (Webb and Blakley, AE 80129). The methodology involved the estimation of regression equations for projecting production and consumption based on trend and other variables. Constant prices and no role for inventories are implicit in most of the projections.

Basic data for the projections covered the crop years from 1960-61 through 1976-77. After the mid 1970s, important changes appeared to have been made in the levels of production and consumption and in the quantities of imports permitted by some countries, particularly centrally planned economies. One method of verifying the sources and magnitudes of these changes is to compare projections with actual quantities for a recent crop year.

The year 1980-81 is halfway into the 10-year projection period used in Webb and Blakley (AE 80129). Projected quantities for 1980-81 based on interpolations from data in Tables 16 and 17 are presented in Table 1. Also shown are actual quantities for 1980-81 as reported in *World Agriculture* in September 1981. Production was modestly higher than projected for the world but there were large differences for individual countries. The U. S. production was higher by 6.0 mmt. while the three foreign exporters' production was lower by 1.7 mmt. Western Europe production was also higher. The large changes, however, occurred for the two aggregates—centrally planned economies and other foreign exporters. The former was 15.9 mmt. below the projection while the latter was 13.0 mmt. above the projection.

World consumption of wheat, in contrast to production, increased dramatically to 443.4 mmt. The increase of 38 mmt. over the projection should be decreased by some factor because of the underestimation of consumption by the equations. Comparisons of projections from the equations for 1976 with actual 1976 data revealed an underestimation of consumption of 14.7 mmt. Adjusting the increase in consumption by 14.7 mmt. would reduce the increase to 23.3 mmt., still almost five times greater than the increase in production.

The world production-consumption balance for 1980-81 was projected at 28.7 mmt. (14.0 mmt. if adjusted) as compared with an actual deficit of 4.5 mmt. The deficit was met with a decrease in carryover stocks by the three foreign exporters.

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Research reported herein was conducted under Oklahoma Station Project No. 1639.

**Table 1. Wheat Production, Consumption, and Supply-Demand Balances for Selected Foreign and United States Aggregations, Actual and Baseline Projections for 1980-81.**

| | Projected | | | Actual | | | Error (Actual - Projected) | | |
|---|---|---|---|---|---|---|---|---|---|
| | Prod. | Cons. | Balance | Prod. | Cons. | Balance | Prod. | Cons. | Balance |
| | (million metric tons) | | | | | | | | |
| Centrally Planned Econ. | 202.7 | 201.3 | 1.4 | 186.8 | 221.9 | -35.1 | -15.9 | 20.6 | -36.5 |
| USSR | (115.8) | (111.5) | (4.3) | (98.1) | (116.1) | (-18.0) | (-17.7) | (4.6) | (-22.3) |
| China | (52.6)[a] | (52.6) | (-0-) | (54.2) | (67.7) | (-13.5) | (1.6) | (15.1) | (-13.5) |
| East Europe | (34.3) | (37.2) | (-2.9) | (34.5) | (38.1) | (-3.6) | (.2) | (.9) | (-.7) |
| Three Foreign Exporters[b] | 39.4 | 12.9 | 26.5 | 37.7 | 12.9 | 24.8 | -1.7 | -0- | 1.7 |
| Western Europe | 60.8 | 56.6 | 4.2 | 64.2 | 52.5 | 11.7 | 3.4 | -4.1 | 7.5 |
| Other Foreign[a] | 72.7 | 111.0 | -38.3 | 85.7 | 135.1 | -49.4 | 13.0 | 24.1 | -11.1 |
| Total Foreign | (375.6) | (381.8) | (-6.2) | (374.4) | (422.4) | (-48.0) | (-1.2) | (40.6) | (-41.8) |
| United States | 58.5 | 23.6 | 34.9 | 64.5 | 21.0 | 43.5 | 6.0 | -2.6 | 8.6 |
| World | 434.1 | 405.4[c] | 28.7 | 438.9 | 443.4 | -4.5 | 4.8 | 38.0 | -33.2 |

[a] Supply-demand balances assumed zero at projected consumption in China, Brazil, and India. Simple projections resulted in surplus production in these countries.
[b] Canada, Australia, and Argentina
[c] Excludes 14.7 mmt. for underestimation of the intercept terms calculated for 1976.

The supply-demand balance for the foreign sector changed from a projected deficit of 6.2 mmt. to an actual deficit of 48.0 mmt., a change of 41.8 mmt. Much of this change, 36.5 mmt., can be attributed to the centrally planned economies with China consuming much more (15.1 mmt.) and the USSR producing much less (15.9 mmt.) than projected. The magnitudes of the errors in projected consumption would be lower if the adjustments for underestimates of consumption were made. Nevertheless, the errors would remain large and were partially anticipated. The basic data for the centrally planned economies appeared to reflect only trends emanating from decisions concerning the allocation of resources in production and the rationing of products in consumption from 1960 to the mid 1970s. Thereafter, new decisions appear to have been made concerning the quantities available for consumption through importation of quantities to supplement domestic production.

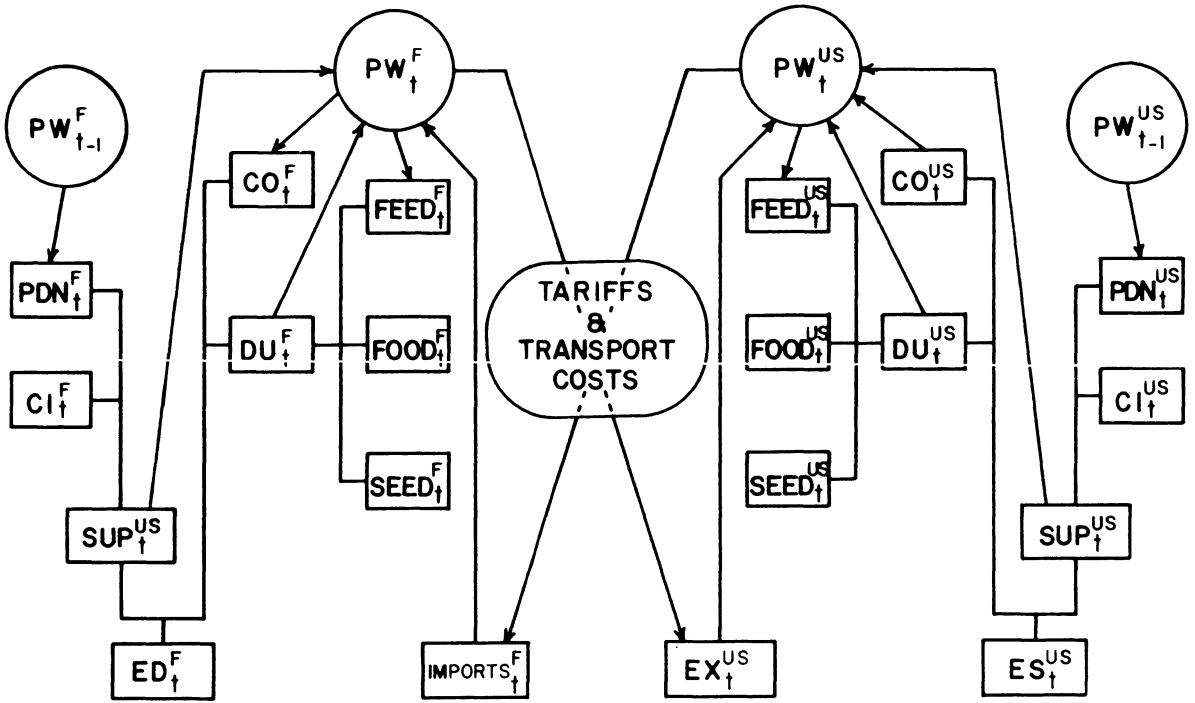
Western Europe had more surplus wheat than was projected. Both larger production and smaller consumption contributed to the larger balance of 11.7 mmt. In contrast, the other foreign aggregate had a greater deficit than was projected. Consumption increased more than production increased to result in a balance of −49.4 mmt. As for the centrally planned economies, however, some downward adjustment is needed to correct for the underestimate of consumption by the estimating equations.

The sources and types of the errors appear to be relaxed more to a shift in policy affecting quantity than to a price response as such. Therefore, the projections to 1985 which contain an allowance for the underestimate of consumption may be satisfactory for analyzing equilibrium conditions and evaluating the impacts of changes in production and consumption. If the centrally planned economies continue to permit consumption to be above production, the equilibrium prices would be higher than if approximate balances are required.

A more dynamic view of the world wheat market would recognize the interdependence between price and quantity produced or consumed and would involve international trade. For example, U. S. production could increase substantially above the 1980-81 level if prices were favorable. In this paper, an econometric model is developed to reflect the interdependence of variables. The balance sheet projections along with other data are then used in the model to analyze the magnitude and duration of potential instability in the U. S. wheat economy coming from such sources as production variability in particular countries.

## An Econometric Model

The relationships for the United States in the world wheat market are illustrated in Figure 1. A theoretical mathematical model developed from these relationships is a simple interregional trade model with the "world less the United States" comprising the import or excess demand sector and the United States representing the export or excess supply sector. The econometric model is divided into two sections—a recursive block and a simultaneous block.




*Terms are defined in Table 2.

Figure 1. A Flow Chart of Trade between the Wheat Economy of the United States and the Wheat Economy of the Rest of the World

## Recursive Block

The equations for production, food use and seed use of wheat are included in the recursive block. These variables are required in the solution of excess supply and excess demand but they are not themselves affected by that solution in the current period. The equations are as follows:

$$PD_t^F = -51624 + 61.9\ PW_{t-1}^F + 214981\ YLD_t^F \qquad R^2 = .97$$
$$(1.24) \qquad (18.39) \qquad DW = .80$$

$$PD_t^{US} = -54897 + 2713\ PW_{t-1}^{US} + 1322YR \qquad R^2 = .90$$
$$(2.97) \qquad (7.12) \qquad DW = 1.93$$

$$FO_t^{US} = 12599 + .49Y_t^{US} \qquad R^2 = .81$$
$$(7.98) \qquad DW = 1.18$$

$$SE_t^{US} = -33.52 + .081\ APL_t^{US} \qquad R^2 = .66$$
$$(5.35) \qquad DW = 1.74$$

where the "F" superscript denotes the "foreign" sector which includes the total for the world excluding the United States and the "US" superscript refers to United States' variables. A list of all the variables used in this model is given in Table 2 along with their definitions and their classification within the model as either endogenous or predetermined. All of the signs of the coefficients in the recursive block are expected to be positive except for the coefficient on income ($Y_t$) in the United States' food use equation ($FO_t^{US}$). The coefficient for income had a positive sign. Wheat prices appear to have had little impact on food consumption of wheat, based on past relationships.

## Simultaneous Block

The simultaneous block is a set of equations for which the values of seven interdependent endogenous variables are solved simultaneously. This block can be specified with five stochastic equations and two identities as follows:

$$DU_T^F = -205419 - 182\ PW_t^F + 144\ POPW_t$$
$$(-2.24) \qquad (12.40)$$

$$CO_t^F = 7067 - 52\ PW_t^F + .47\ CI_t^F + .076\ PD_t^F$$
$$(-1.19) \quad (1.86) \qquad (1.49)$$

$$FE_t^{US} = -34177 - 3325\ PW_t^{US} + .47\ LVN_t^{US} + 6893\ PC_t^{US}$$
$$(-3.05) \qquad (3.80) \qquad (3.32)$$

$$CO_t^{US} = -26339 - 2679\ PW_t^{US} + 1.06\ CI_t^{US} + .74\ PD_t^{US}$$
$$(-1.52) \qquad (5.09) \qquad (2.19)$$

$$PW_t^{US} = .0456 + .0199\ PW_t^F$$
$$(13.74)$$

$$EX_t^{US} = DU_t^F + CO_t^F - PD_t^F - CI_t^F$$

$$DU_t^{US} = FO_t^{US} + FE_t^{US} + SE_t^{US} + CO_t^{US}$$

**Table 2. Listing, Classification and Definition of Simultaneous Equation Model Variables**

| Variable | Definition |
|---|---|
| | **Endogenous Variables** |
| $DU_t^F$ | Utilization of wheat, world less the U.S., 1000 metric tons. |
| $CO_t^F$ | Carry-out wheat stocks, world less the U.S., 1000 metric tons |
| $FE_t^{US}$ | Feed use of wheat, U.S., 1000 metric tons. |
| $CO_t^{US}$ | Carry-out wheat stocks, U.S., 1000 metric tons. |
| $PW_t^{US}$ | Wheat price, U.S. season average, dollars per bushel. |
| $PW_t^F$ | Wheat import price, United Kingdom season average, dollars per metric ton. |
| $EX_t^{US}$ | Wheat exports, U.S. 1000 metric tons. |
| | **Predetermined Variables** |
| $PD_t^F$ | Wheat production, world less the U.S., 1000 metric tons. |
| $PD_t^{US}$ | Wheat production, U.S., 1000 metric tons. |
| $FO_t^{US}$ | Food use of wheat, U.S., 1000 metric tons. |
| $SE_t^{US}$ | Seed use of wheat, U.S., 1000 metric tons. |
| $YLD_t^W$ | Wheat yields, world excluding China, metric tons per hectare. |
| YR | Year or trend, last two digits of the year. |
| $Y_t$ | Per capita disposable income, U.S., dollars |
| $APL_t^{US}$ | Wheat area planted, U.S., 1000 hectares. |
| $POPW_t$ | World population, millions of persons. |
| $CI_t^F$ | Carry-in wheat stocks, world less the U.S., equal to $CO_{t-1}^F$. |
| $LVN_t^{US}$ | Grain consuming animal units, U.S., year beginning October 1, 1000 units. |
| $PC_t^{US}$ | Price of competitive feed grains (barley, corn and sorghum), U.S., weighted average in dollars per bushel. |
| $CI_t^{US}$ | Carry-in wheat stocks, U.S., equal to $CO_{t-1}^{US}$. |
| $DU_t^{US}$ | Domestic utilization of wheat, U.S., 1000 metric tons. |
| $PW_{t-1}^F$ | Wheat import price, United Kingdom season average, dollars per ton. |
| $PW_{t-1}^{US}$ | Wheat price, U.S. season average, dollars per bushel. |

In the first four equations, the expected sign on the price coefficients should be negative since these are all demand relationships. The remaining independent variables are expected to have positive signs with the exception of carry-in stocks ($CI_t^F$ and $CI_t^{US}$) in the foreign and U.S. carry-out equations. In these equations, carry-in could have either a positive or a negative sign depending on whether beginning stocks followed a steady trend or were cyclical from year to year.

## The Estimation Results

Estimates for the recursive block were obtained using ordinary least squares and the values for the simultaneous block were the result of using a two-stage least squares procedure. The results for both blocks are given above. The Student's t statistics are listed in parentheses below the appropriate variables and the multiple correlation coefficient and the Durbin-Watson statistics are listed to the right of the estimated equation when they are appropriate.

Although all the signs for the estimated coefficients in the model meet expectations based on economic theory, a few of the coefficients are not different from zero at the ten percent level of significance. Non-significant coefficients included the coefficient $PW_{t-1}^F$ in the foreign production equation, the coefficients on $PW_t^F$ and the $PD_t^F$ in the foreign carry-out relationship, and the $PW_t^{US}$ coefficient in the U.S. carry-out equation. These variables were kept in the model because they were deemed desirable in maintaining the simultaneity of the model.

## Elasticities

In order to obtain an idea of the interaction of prices and quantities in this model, a set of elasticities was derived using the appropriate coefficients and the variable means given in Table 3. The elasticities are reported in Table 4 along with similar elasticities from selected other studies. For this model, most of the price elasticities tend to have an absolute value less than unity for both demand and supply. There are two notable exceptions. The first is feed use demand which has a price elasticity of $-2.41$. However, feed use makes up less than 10 percent of the demand for wheat for all purposes in the United States. The price elasticity of domestic demand for wheat for all uses is only $-.31$.

A second important exception is the price elasticity of demand for U.S. wheat exports which is shown to be slightly larger than unity ($-1.05$). As shown in Table 4, there is substantial disagreement in the literature over the price elasticity of demand for U.S. wheat exports. Gallagher et al. (1978) estimated an elasticity of only $-.41$ given the current restrictive trade policies in the EEC and Japan whereas P. R. Johnson (1977, p. 736) calculated an excess demand elasticity for U. S. exports of $-6.72$. A major part of the discrepancy lies in the assumptions regarding supply and demand elasticities for individual countries and regions of the world. Johnson assumes supply and demand elasticities that are three to 10 times greater than those generated above. In fact, using the elasticities from this model in Johnson's formula yields an elasticity of excess demand for U.S. exports of only $-1.03$.

**Table 3. Actual and Projected Values, and Means for Variables Used in the Econometric Model**

| Variable Names | Units | Mean | 1976 Value | Projected 1985 Value |
|---|---|---|---|---|
| $PD^F$ | mmt | 270.0 | 359.0 | 390.4 |
| $YLD^F$ | mt/ha | 1.48 | 1.82 | 2.01 |
| $PD^{US}$ | mmt | 40.8 | 58.3 | 65.4 |
| YR | last two digits of year | 68 | 76 | 85 |
| $FO^{US}$ | mmt | 14.2 | 16.0 | 17.8 |
| $Y^{US}$ | $/person | 3212 | 5511 | 10581 |
| $SE^{US}$ | mmt | 1.9 | 2.5 | 2.8 |
| $APL^{US}$ | mha | 24.0 | 32.5 | b |
| $DU^F$ | mmt | 283.0 | 349.3 | a |
| $PW^F$ | $/mt | 100.0 | 145 | a |
| POPW | m. people | 3510 | 4104 | 4816 |
| $CO^F$ | mmt | 42.2 | 62.7[c] | a |
| $CI^F$ | mmt | 43.2 | 44.3 | 43.2 |
| $FE^{US}$ | mmt | 2.8 | 1.9 | a |
| $PW^{US}$ | $/bu | 2.03 | 2.85 | a |
| $LVN^{US}$ | m. animal units | 76.4 | 74.7 | 72.6 |
| $PC^{US}$ | $/bu | 1.16 | 1.77 | 1.84 |
| $CO^{US}$ | mmt | 20.6 | 30.3 | a |
| $CI^{US}$ | mmt | 21.5 | 18.1 | 21.5 |
| $EX^{US}$ | mmt | 22.3 | 26.4 | a |

A definition of these variables can be found in Table 2.
[a]1985 values are not given for endogenous variables.
[b]The 1985 value of $APL^{US}$ is not used to project $SE^{US}$ since the result would be inconsistent with projected $PD^{US}$. A ratio of $SE^{US}$ to $PD^{US}$ is used to project $SE^{US}$.
[c]Approximate.

## Long Run Equilibrium for the 1976 World Wheat Market

The trade model can be collapsed into a set of wheat price and quantity relationships which can be used to derive a long-run equilibrium for the system. This long-run equilibrium will be the point of departure for analyzing the response of the U.S. and world wheat markets to changes in supply and demand. The results will provide insights into the potential variation of prices and quantities of wheat for a given shift in supply or demand.

The trade model using 1976 values for all the predetermined variables in the system except for the lagged U.S. and foreign wheat prices ($PW^{US}_{t-1}$ and $PW^{F}_{t-1}$) results in the following set of equations with units expressed in million metric tons for quantities, dollars per metric ton for foreign prices, and dollars per bushel for U.S. prices:

U.S. Supply:

$$PD^{US}_t = 45.6 + 2.7\ PW^{US}_{t-1}$$

$$CI^{US}_t = 18.1$$

U.S. Demand:

$$CO^{US}_t = 33.7 - 2.7\ PW^{US}$$

$$FE^{US}_t = 13.2 - 3.3\ PW^{US}_t$$

$$FO^{US}_t = 15.3$$

$$SE^{US}_t = 2.6$$

Foreign Supply:

$$PD^{F} = 339.6 + .0619\ PW^{F}_{t-1}$$

$$CI^{F} = 44.3$$

Foreign Demand:

$$CO^{F}_t = 54.6 - .052\ PW^{F}_t$$

$$DU^{F} = 40.0 - .182\ PW^{F}_t$$

The last equation has an adjustment for the intercept term of 14.747 million tons to compensate for underestimation of foreign consumption. These equations can be aggregated into one supply and one demand relationship for each of the U.S. and the foreign sectors.

The system of equations provides a reasonable realistic model of American wheat trade with the rest of the world. A major drawback is that it represents only the short run equilibrium which exists when the quantity supplied equals the quantity demanded at the prevailing market price for a given time period. Long run equilibrium further requires that both prices and stocks be at equilibrium levels for lagged as well as current levels.

It is in this latter regard that adjustments had to be made. Since the large Russian wheat purchase of 1972, the United States and the world have been rebuilding depleted stocks. In the model, projected U.S. carry-out at 1976 prices was 26 million metric tons—eight million tons greater than carry-in stocks. Similarly, world carry-out stocks, in 1976 were 47 million tons at prevailing prices compared with a carry-in of only 44.3 million tons. From initial carry-in stocks for the U.S. and the rest of the world at their mean values of 21.0 and 43.2 million tons, the intercepts on the carry-out equations were adjusted downward in an iterative process until ending stocks were equal to beginning stocks. The adjusted carry-out equations are:

$$CO^{US} = 28.0 - 2.7\ PW^{US}_t$$

and

$$CO^{F} = 50.0 - .052\ PW^{F}_t$$

The adjustment of these equations and stocks resulted in a corresponding shift in the aggregate demand and supply equation intercepts.

**Table 4. A Comparison of Model Elasticities With Those of Previous Studies**

| Elasticity of: | With Respect to: | Elasticity | Similar Elasticities from Other Studies | Source | Time Period and Comments |
|---|---|---|---|---|---|
| $PD^{US}$ | $PW^{US}_{t-1}$ | .12 | .13 | Gallagher, et al., 1978 | 1952-1974 |
| | | | .06 | Lattimore and Zwart, 1978 | 1950-1976 |
| $FE^{US}$ | $PW^{US}_{t}$ | -2.41 | -3.29 | Gallagher, et al., 1978 | |
| | | | -1.71 | Mo, 1970 | |
| | | | -1.86 | Lattimore and Zwart, 1978 | |
| $CO^{US}$ | $PW^{US}_{t}$ | -.26 | -1.70 | Gallagher, et al., 1978 | 1956-1974. Privately owned stocks. |
| | | | -.38 | Zwart and Lattimore, 1977 | 1950-1976. Total stocks. |
| | | | -.57 | Lattimore and Zwart, 1978 | 1950-1976. Government stocks. |
| | | | -1.26 | Lattimore and Zwart, 1978 | 1950-1976. Privately owned stocks. |
| $FO^{US}_{t}$ | $Y_t$ | .11 | -.31 | Gallagher, et al., 1978 | 1952-1974 |
| | | | .35 | Hutchinson, et al., 1970 | 1950-1970 |
| | | | -.35 | Schmitz and Bawden, 1973 | 1950-1962 |
| $PD^{F}$ | $PW^{F}_{t-1}$ | .022 | .09 | Zwart and Lattimore, 1977 | Average of selected country and region elasticities. |
| $CO^{F}_{t}$ | $PW^{F}_{t}$ | -.13 | -.15 | Zwart and Lattimore, 1977 | Average of stock elasticities of other four major exporters. |
| $DU^{F}_{t}$ | $PW^{F}_{t}$ | -.06 | | Not available or not comparable. | |
| $EX^{US}_{t}$ | $PW^{F}_{t}$ | -1.05 | -.71 | Gallagher, et al., 1979 | 1960-1974. Only for LDC's. |
| | | | -.41 | Gallagher, et al., 1978 | 1956-1974 |
| | | | -6.72 | P.R. Johnson, 1977 | Assumes very high internal price elasticities. |

Given the new demand and supply equations and a relationship between $PW^{US}$ and $PW^{F}$, a long-run equilibrium can be obtained by setting United States' excess supply equal to the excess demand of the rest of the world. The equations are:

$ES^{US} = 7.5 + 8.7\ PW^{US}$

$ED^{F} = 67.4 - .296\ PW^{F}$

$PW^{US} = .0456 + .0199\ PW^{F}$

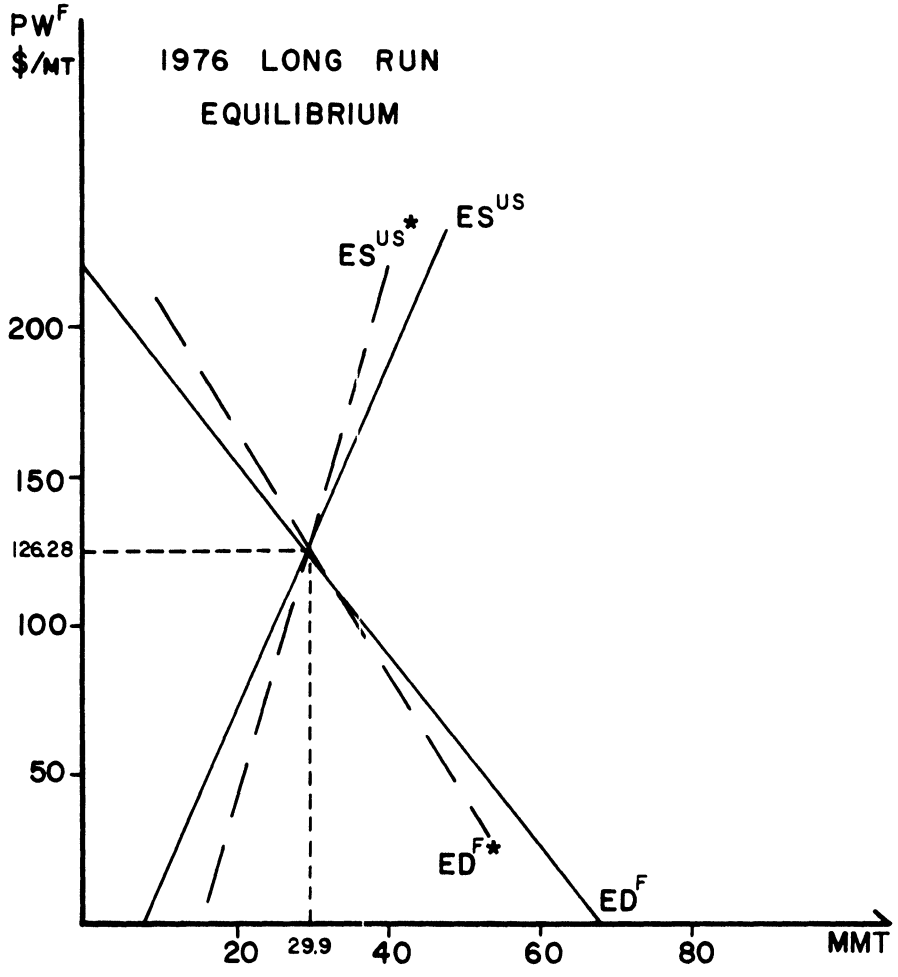
The supply, demand, carry-out, excess supply, and excess demand equations for long-run equilibrium are given in Table 5 and a graph of the equilibrium solution is shown in Figure 2. Equilibrium prices are $126.78 per mt. at the world level and $2.56 per bu. for the U.S. The short run excess supply and excess demand curves (dashed lines in Figure 2) are less elastic than their long-run counterparts because supply is assumed to be fixed and changes are made only along the U.S. and foreign aggregate wheat demand schedules.

The long-run equilibrium shown in Figure 2 as depicted by the equations in Table 5 will be used as a benchmark against which shifts in supply and demand over time can be measured. It also provides a starting point from which the dynamics of the international wheat market can be depicted.

**Table 5. Original and Long-Run Equilibrium Equations for 1976**

| Variable (units in mmt) | Intercept | | Regression Coefficients for Long-Run Equilibrium | |
|---|---|---|---|---|
| | Original | Equilibrium | $PW_t^{US}$ | $PW_t^{F}$ |
| $SUP^{US}$ | 63.7 | 66.6 | 2.7[a] | — |
| $CI^{US}$ | 18.0 | 21.0 | — | — |
| $PD^{US}$ | 45.6 | 45.6 | 2.7[a] | — |
| $DMD^{US}$ | 64.8 | 59.0 | -6.0 | — |
| $FO^{US}$ | 15.3 | 15.3 | — | — |
| $SE^{US}$ | 2.6 | 2.6 | — | — |
| $FE^{US}$ | 13.2 | 13.2 | -3.3 | — |
| $CO^{US}$ | 33.7 | 28.0 | -2.7 | — |
| $ES^{US}$ | -1.1 | 7.5 | 8.7[b] | — |
| $SUP^{F}$ | 383.9 | 382.8 | — | .062[c] |
| $CI^{F}$ | 44.3 | 43.2 | — | — |
| $PD^{F}$ | 339.6 | 339.6 | — | .062[c] |
| $DMD^{F}$ | 440.1 | 450.3 | — | -.234 |
| $CO^{F}$ | 54.6 | 50.0 | — | -.052 |
| $DU^{F}$ | 385.6 | 400.3 | — | -.182 |
| $ED^{F}$ | 56.2 | 67.4 | — | -.296[d] |

[a]Coefficient for $PW_{t-1}^{US}$ in original equation
[b]Coefficients in original equation are $PW_t^{US} = 6.0$ and $PW_{t-1}^{US} = 2.7$
[c]Coefficient for $PW_{t-1}^{F}$ in original equation
[d]Coefficient in original equation is $ED^{F} = -.062$ for the short run




*Indicates price elasticity of supply equals zero for one year.

Figure 2. 1976 Long Run Equilibrium

## Long Run Equilibrium for the 1985 World Wheat Market

The 1985 equations for the simultaneous model are derived using the 1985 values of the exogenous variables in Table 3. In general, a 1972-1976 five-year average was assumed for variables which showed no clear trend. Though carry-in (both foreign and U.S.) is a constant, it is adjusted upward using the product of its ratio to production in 1976 and the projected 1985 production level. The determination of the initial values of the rest of the variables used in the 1985 model is unambiguous except for total foreign wheat demand ($DMD^F$). The location of this curve was established by adding the baseline projection of foreign demand for American wheat given a constant U.S. market share of 54 percent (Webb p. 99) to the projected foreign supply at the 1972-1976 average world wheat price of $163 per metric ton.

The same procedure was used for 1985 as for 1976 to handle the problem of carry-out not equal to carry-in at the still undetermined long run equilibrium price. The equations were determined through an iterative process which adjusted the intercepts of the carry-out functions to equal their respective carry-in levels first at an initial price (in this case, the average world or U.S. price for 1972-1976) then iteratively to an equilibrium price.

Beginning with a set of initial prices of $163/mt. at the world level and $3.24/bu. for the U.S., it took three iterations to solve for the 1985 long-run equilibrium. The final set of equations is given in Table 6. The final equilibrium prices—$126.15/mt. for the world and $2.56/bu. for the U.S.—are remarkably close to the 1976 long-run prices. These prices are in terms of 1976 dollars. Hence, with continued inflation, actual prices would be higher. The quantities, however, are much higher. Equilibrium excess demand for American wheat in 1985 is projected to approach to 40 mmt.—an increase of about 33 percent over the 1976 long-run equilibrium level. This compares with actual exports of 41.9 mmt. in 1980-81 with prospects for even larger potential exports by 1985.

## Impacts of World Supply Instability on the U.S. Wheat Economy in 1985

The previous analysis does not consider the impact of short-run variations in world supplies—an element which has caused wide gyrations in world wheat markets in the 1970's.

In this section, short-run decreases and increases in world supplies will be traced through the model to show the response of prices and export quantities to these supply changes. The procedure will be similar to that followed in previous analyses except that the effect of the initial shocks will be carried out over a two-year period to show how the system responds over time.

### A Short Run Decrease in World Supplies

The impact of a crop shortfall upon U.S. wheat trade with the rest of the world is shown graphically in Figure 3. Initially, in frame A, both long- and short-run equilibrium conditions exist in the world wheat market: 1) excess demand equals excess supply, 2) the world wheat price is equivalent to the U.S. wheat price plus transfer

**Table 6. Intercepts for 1985 Projected and Long-Run Equilibrium Equations**

| Variable (units in mmt) | Projected Intercept | Long-Run Equilibrium Intercept |
|---|---|---|
| $SUP^{US}$ | 81.0 | 81.0 |
| $CI^{US}$ | 23.6 | 23.6 |
| $PD^{US}$ | 57.5 | 57.5 |
| $DMD^{US}$ | 65.5 | 63.7 |
| $FO^{US}$ | 17.8 | 17.8 |
| $SE^{US}$ | 2.8 | 2.8 |
| $FE^{US}$ | 12.6 | 12.6 |
| $CO^{US}$ | 32.3 | 30.4 |
| $ES^{US}$ | 15.6 | 17.4 |
| $SUP^{F}$ | 428.6 | 428.6 |
| $CI^{F}$ | 48.1 | 48.1 |
| $PD^{F}$ | 380.5 | 380.5 |
| $DMD^{F}$ | 505.6 | 505.6 |
| $CO^{F}$ | 56.6 | 54.7 |
| $DU^{F}$ | 449.0 | 450.9 |
| $ED^{F}$ | 77.0 | 77.0 |

costs OT and 3) there is no incentive for producers or consumers to make production or consumption adjustments in subsequent years given their current supply and demand schedules.

Frame B shows a departure from long-run equilibrium in the form of a short-run decrease in supply in the foreign sector. This increases excess demand for wheat which dictates an increase in prices. Since foreign and U.S. supplies are fixed in the short run (having been determined by the previous year's price), short-run equilibrium can only be attained by decreases in the quantity of wheat demanded on both markets. In practice the demand adjustments will be made in the areas of feed use and carry-out stocks. Users of wheat for feed will substitute other cheaper grains and holders of stocks will sell wheat believing that future wheat prices are likely to decline.

Though a short-run equilibrium is reached at price $P_2$ in Figure 3-B, long-run equilibrium does not exist because there is an incentive for producers to make adjustments in supply. Therefore, in the following years, producers on both sides of the market will plan to increase their quantity supplied to a level that is consistent with price $P_2$.

Assuming that the world crop shortfall was only a one year departure from the long run supply function $S^F$, producers in the foreign sector in Figure 3-C will harvest an amount of wheat consistent with short run supply $S_3^f$—a substantial increase over the previous year. Likewise, American producers will increase their quantity supplied from $S_1^{us}$ to $S_2^{us}$. The result is a short-run increase in supply which causes the price to fall below the long-run equilibrium level. Price $P_3$, however, is closer to the equilibrium price than was price $P_2$ indicating that there will be a gradual but oscillating return to long run equilibrium.

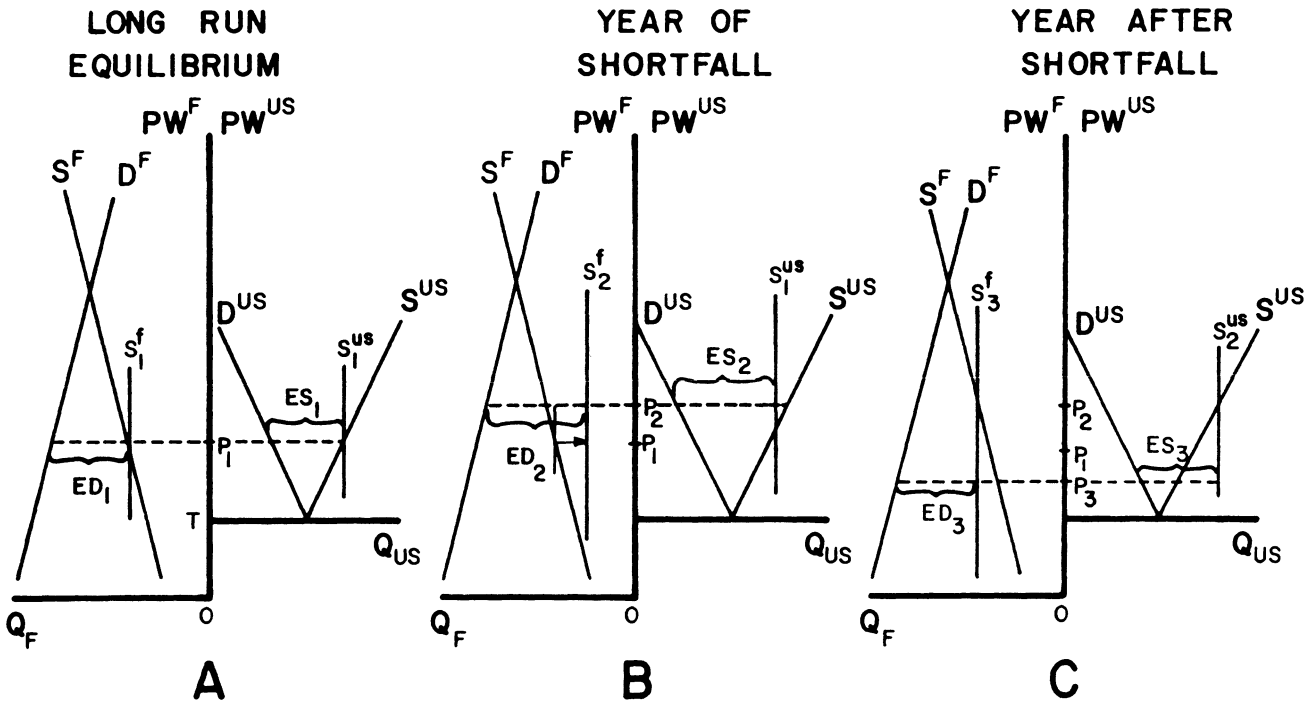



Figure 3. The Two-Year Impact of a Single Year Shortfall in World Supply on Wheat Trade and Prices

The process outlined above can be traced more precisely using the set of equations from Table 6 and an assumed shortfall of 33 million metric tons. The effects of this shortfall on world wheat market prices and quantities over a period of two years for 1985 are shown in Table 7. The 1976 values are also given as a basis for comparison. The initial impact of the shortfall was to cause a sharp increase in prices (from $126 to $229 a metric ton on the world level) and to sharply reduce U.S. and world demand for wheat.[2]

In the United States, these changes are viewed as a shift in export demand. As shown in the table, only a portion of the total change in world supply was translated into a change in U.S. exports because the resulting change in prices brought about changes in the quantity of wheat demanded for both the United States and the rest of the world. The 33 million ton world supply shortfall increased American wheat exports by 8.9 million tons in the year of the shortfall. The additional U.S. exports were obtained from a decrease in feed use (3.3 mmt.) and a decrease in normal carry-out stocks (5.5 mmt).[3] The other 24.1 million tons of the shortfall was made up by decreases in world stocks (5.4 mmt.) and in consumption. Presumably, the largest part of the decrease in stocks from the rest of the world would come from the other major world wheat exporters as they increase exports to meet the demand.

In keeping with the assumption of fixed supply in the short run, all the adjustments to the 33 million ton world supply shortfall in the first year were made on the demand side. In the second year, the production of wheat in the United States and abroad increased in response to the previous year's high prices. U.S. production increased by 5.6 million tons while foreign producers recovered from the previous year's disasterous crop and pushed their output to 11.7 million tons above equilibrium. Under normal circumstances, this big an increase in world production would cause prices to drop sharply below equilibrium, but the rebuilding of depleted stocks absorbs most of additional output. As a result, the U.S. price was only seven cents below its equilibrium level (though it was less than half of what it was only one year earlier).

The change in U.S. carry-out stocks was the same as the change in stocks for the rest of the world. This indicates the importance of the United States as the world's major wheat reserve and as the primary wheat exporter.

The variation in American exports followed closely the variation in prices. The abnormally high level of exports in the first year when the shortfall occurred was followed by exports below equilibrium in the second year as foreign countries are able to meet more of their needs directly. Though exports were lower, the lower prices make American wheat consumption as feed more attractive. The additional feed use and the accumulation of stocks partly made up for the fall in export demand but only at lower prices.

[2]At prices above $3.55 per bushel in 1985 and $3.72 per bushel in 1976, American feed use of wheat ($FE^{US}$) is assumed to become price inelastic at a level of 800 thousand metric tons—the minimum amount of wheat used for feed over the 17-year study period.

[3]Due to round-off error, the sum of the elements may not equal the total in some cases.

### A Short Run Increase in World Supplies

The effects of extremely good crops in a few of the major world wheat producing countries using the same techniques are shown in Table 8. Beginning with a state of long-run equilibrium, prices and foreign excess demand for American wheat will decline with the 25 million ton above normal world crop posited in Scenario II in Webb and Blakley AE 80129.

The world supply increase caused U.S. exports to fall by 8.5 million tons as the price of wheat dropped to $1.15 per bushel. American feed use of wheat more than doubled as carry-out increased by 3.8 million tons. Consumption of wheat in the rest of the world increased with the lower prices and foreign wheat stocks rose to 3.7 million tons above equilibrium at the end of the year. Again, the change in American wheat stocks was comparable with the total change in stocks for the rest of the world.

There is one important difference between the shortfall and the increase in world supplies in the second year: the return to equilibrium is slower in the case of the world supply shortfall than for the case of the extra-large world wheat crop. This results because the feed use of wheat in the United States is restricted on the downside to a minimum of 800 thousand tons. Without this restriction, feed use would have taken on negative values at very high prices.

## The Impact of Model Assumptions on Price Variability

It is apparent from Tables 7 and 8 that there can be a high degree of variability present in the world wheat market. A decrease in supply of seven percent (33 mmt.) for 1985 caused prices to increase by nearly 80 percent while a five percent increase in supply (25 mmt.) resulted in a 55 percent decline in prices. It may be worthwhile to identify some of the forces which lay outside explicit specifications of the model but which are likely to have a significant impact on the actual level of wheat quantity and price variability. These forces will be divided into two sections—those which account for greater price variability than has shown up in the model and those which will result in a smaller range of price variations than specified in the model.

### Forces Which Increase Price Variability

Primary among the forces which are likely to account for greater world price variability are attempts by governments to thwart the operation of the internal price system. The policies vary from price supports to increase producers' income in major producing countries to price ceilings to insure a cheap food supply in some developing countries. Many of these policies have been implicitly included in the model already since they have influenced the actual levels of supply and demand from which the model was estimated. Yet a wide departure from normal market conditions, may stimulate a number of new policy responses.

The major exporters, particularly the United States, Canada, and Australia, all have policies designed to prevent prices from falling below a set minimum level. Given a 25 million ton increase in world supplies, these policies would take effect. By supporting a minimum level of prices, these governments would encourage a greater accumula-

**Table 7. A Short Run Decrease in World Supply of 33 Million Metric Tons**

| | | 1985 | | | 1976 | | |
|---|---|---|---|---|---|---|---|
| | Units | Equili-brium | First Year | Second Year | Equili-brium | First Year | Second Year |
| $SUP^{US}$ | mmt | 88.0 | 88.0 | 88.1 | 73.5 | 73.5 | 73.8 |
| $CI^{US}$ | mmt | 23.6 | 23.6 | 18.1 | 21.0 | 21.0 | 15.8 |
| $PD^{US}$ | mmt | 64.4 | 64.4 | 70.0 | 52.5 | 52.5 | 58.0 |
| $DMD^{US}$ | mmt | 48.3 | 39.5 | 48.7 | 43.7 | 34.5 | 45.8 |
| $FO^{US}$ | mmt | 17.8 | | | 15.3 | | |
| $SE^{US}$ | mmt | 2.8 | 20.6 | 20.6 | 2.6 | 17.9 | 17.9 |
| $FE^{US}$ | mmt | 4.1 | .8 | 4.3 | 4.6 | .8 | 5.8 |
| $CO^{US}$ | mmt | 23.6 | 18.1 | 23.7 | 21.1 | 15.8 | 22.1 |
| $EX^{US}(=ED^{F})$ | mmt | 39.7 | 48.6 | 39.4 | 29.9 | 39.1 | 27.9 |
| $PW^{US}$ | $/bu. | 2.56 | 4.60 | 2.50 | 2.57 | 4.59 | 2.20 |
| $SUP^{F}$ | mmt | 436.4 | 403.4 | 442.7 | 390.7 | 357.7 | 391.8 |
| $CI^{F}$ | mmt | 48.1 | 48.1 | 42.7 | 43.2 | 43.2 | 38.0 |
| $PD^{F}$ | mmt | 388.3 | 355.3 | 400.0 | 347.5 | 341.6 | 353.8 |
| $DMD^{F}$ | mmt | 476.0 | 452.0 | 476.7 | 420.6 | 396.8 | 424.9 |
| $CO^{F}$ | mmt | 48.1 | 42.7 | 48.2 | 43.3 | 38.0 | 44.3 |
| $DU^{F}$ | mmt | 427.9 | 409.3 | 428.5 | 377.3 | 358.8 | 380.6 |
| $PW^{F}$ | $/mt. | 126.15 | 228.86 | 123.11 | 126.78 | 228.36 | 108.26 |

**Table 8. A Short Run Increase in World Supply of 25 Million Metric Tons**

| | Units | 1985 | | | 1976 | | |
|---|---|---|---|---|---|---|---|
| | | Equilibrium | First Year | Second Year | Equilibrium | First Year | Second Year |
| $SUP^{US}$ | mmt | 88.0 | 87.9 | 87.9 | 73.5 | 73.5 | 73.5 |
| $CI^{US}$ | mmt | 23.6 | 23.6 | 27.4 | 21.0 | 21.0 | 24.9 |
| $PD^{US}$ | mmt | 64.4 | 64.4 | 60.5 | 52.5 | 52.5 | 48.7 |
| $DMD^{US}$ | mmt | 48.3 | 56.7 | 48.1 | 43.7 | 52.1 | 42.3 |
| $FO^{US}$ | mmt | 17.8 | | | 15.3 | | |
| $SE^{US}$ | mmt | 2.8 | 20.6 | 20.6 | 2.6 | 17.9 | 17.9 |
| $FE^{US}$ | mmt | 4.1 | 8.8 | 4.0 | 4.6 | 9.3 | 3.8 |
| $CO^{US}$ | mmt | 23.6 | 27.4 | 23.5 | 21.1 | 24.9 | 20.5 |
| $EX^{US}(=ED^{F})$ | mmt | 39.7 | 31.2 | 39.9 | 29.9 | 21.5 | 31.5 |
| $PW^{US}$ | $/bu. | 2.56 | 1.15 | 2.59 | 2.57 | 1.15 | 2.59 |
| $SUP^{F}$ | mmt | 436.4 | 461.4 | 435.7 | 390.7 | 415.7 | 390.2 |
| $CI^{F}$ | mmt | 48.1 | 48.1 | 51.8 | 43.2 | 43.2 | 47.0 |
| $PD^{F}$ | mmt | 388.3 | 413.3 | 383.9 | 347.5 | 372.5 | 343.2 |
| $DMD^{F}$ | mmt | 476.0 | 492.6 | 475.6 | 420.6 | 437.1 | 420.2 |
| $CO^{F}$ | mmt | 48.1 | 51.8 | 48.0 | 43.3 | 47.0 | 43.3 |
| $DU^{F}$ | $/mt. | 427.9 | 427.9 | 427.6 | 377.3 | 390.1 | 376.9 |
| $PW^{F}$ | $/mt. | 126.15 | 55.40 | 128.11 | 126.78 | 56.11 | 127.99 |

tion of stocks than would occur under the "normal" conditions shown in Table 8. In addition, the minimum prices would also prevent producers from decreasing production by a sufficient amount in the first year which means that the return to equilibrium would take longer. Producers would also have to accept lower than equilibrium prices in the second year in order to allow the market to clear the additional supplies which have resulted from government price supports.

For a sharp decrease in world supplies, the policy response of some countries might be to impose an embargo on wheat exports as the EEC did in 1973. This policy would further increase the price of wheat and shift a greater proportion of the burden of the shortfall onto the rest of the world.

A second set of factors which could result in greater price variability than that predicted by the model are the physical limitations of the world wheat marketing system. A major crop failure in one part of the world, for example, may heavily tax the shipping and terminal capacity of the countries involved. Transportation costs would then increase sharply, resulting in a very large price difference between exporting and importing regions. Producer prices in major exporting countries would not increase as rapidly as they did in the model which would delay the supply response and lengthen the time required to return to equilibrium.

In the same way, a large crop in a major producing country could result in extremely low wheat prices in that country for a longer period of time than implicitly assumed in the model because the surplus cannot be exported or consumed quickly. Inadequate storage facilities may limit the amount of carry-over stocks which—as specified in the statistical model—would have been a key element in bringing a rapid return to equilibrium.

Finally, even if the marketing system did not have any capacity or transportation limitations, the economic agents in the system—consumers, wholesalers, producers, feed users, and others—might not be able to respond to major price changes as rapidly as portrayed in the model.

## Forces Which Tend to Diminish Price Variability

There are at least two major reasons the model may understate the true magnitude of price variability for large shifts in world supply. The first is the assumption that the prices of wheat substitutes in consumption and production remain constant. As with a number of other assumptions, this one may be valid for wheat prices near equilibrium but as prices begin to deviate by large amounts, price changes would spread out to other grains and foodstuffs. If, for example, the price of wheat were to rise sharply because of a major wheat crop failure, the full force of the shortfall would be cushioned by the substitution of rice, coarse grains, potatoes and other foods for wheat by the world's populations. Likewise, an extra large world wheat crop would result in the substitution of wheat for other grains, particularly in feed use, thus transmitting some of the impetus for a wheat price decline to those grains.

A final abstraction which tends to overstate the variability of the model is the assumption of fixed short run supply. With different harvest times for different latitudes, only a certain percentage of the world wheat supply is fixed at any given time of the year. For this reason, total world wheat supplies are never perfectly inelastic for a year's time.

## Summary and Conclusions

The central purpose of this study was to analyze the supply and demand relationships in the world wheat market and to develop models to assist in forecasting the future price of American wheat. This was accomplished by first dividing the world into major importing and exporting countries and regions with the results reported in Webb and Blakley AE 81029.

A simultaneous equation model was developed in this publication to link the wheat economy of the United States with the wheat economy of the rest of the world to estimate equilibrium for 1976 and projected 1985 conditions. The baseline 1985 long-run equilibrium pointed to an increase in American wheat exports but with almost no change in price—about $2.56 per bushel in 1976 dollars.

Prices and quantities in the United States and the rest of the world are closely interrelated. A comparative statics approach was used to demonstrate the effect of a 33 million metric ton decrease and a 25 million ton increase in world supplies. These changes in supplies correspond to the largest changes which occurred during the 1960-1976 study period. The shortfall in world production would cause U.S. prices in 1976 dollars to rise to $4.60 a bushel and a world bumper crop would depress prices to $1.15 a bushel in 1976 dollars. In both cases the return to equilibrium was rapid with prices only slightly below or above the long run equilibrium level in the year following the initial change.

One of the most significant and perhaps the most expected result of this study was the pivotal role of the Soviet Union in the international wheat market. As the world's largest and most variable producer of wheat, the effects of Russian agricultural policies and variable yields can have a very large impact on world demand and supply.

This model also illustrates the central role of the United States in providing stability to world wheat markets. The variations in carry-out stocks were the key to a quick return to equilibrium since the change in American stocks equalled the change in stocks for the rest of the world combined. To provide this stability to world wheat markets, the model assumes the United States is willing to accept wide variations in prices, stocks, feed use, and exports. This may be a valid assumption for a certain range of price variations, but American policy makers are likely to take action to mitigate the effects on producers and/or consumers for extreme deviations or disruptions similar to those experienced on world grain markets in the first half of the 1970's. By allowing for a few rigidities in the pricing and marketing system, it is not surprising that a one year supply shortfall could sustain higher wheat prices over two, three, or more years.

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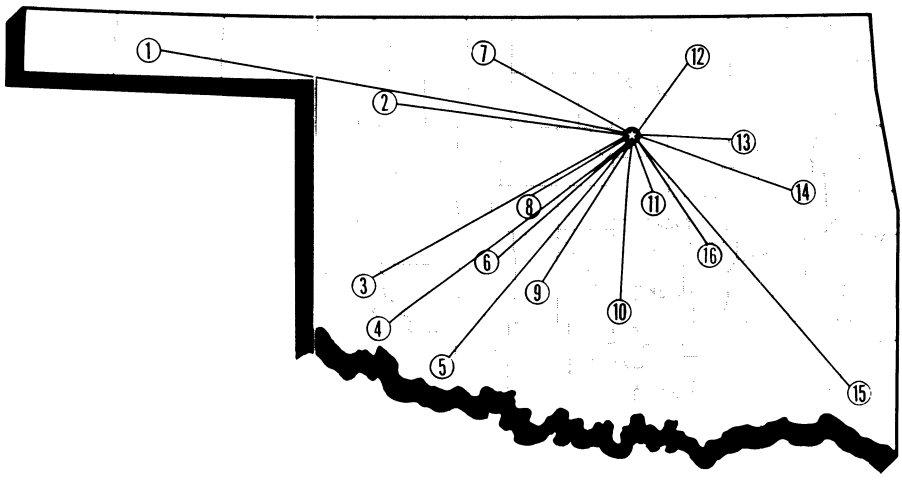
OKLAHOMA

# Agricultural Experiment Station

## System Covers the State




Main Station — *Stillwater, Perkins and Lake Carl Blackwell*

1. Panhandle Research Station — *Goodwell*
2. Southern Great Plains Field Station — *Woodward*
3. Sandyland Research Station — *Mangum*
4. Irrigation Research Station — *Altus*
5. Southwest Agronomy Research Station — *Tipton*
6. Caddo Research Station — *Ft. Cobb*
7. North Central Research Station — *Lahoma*
8. Southwestern Livestock and Forage Research Station — *El Reno*
9. South Central Research Station — *Chickasha*
10. Agronomy Research Station — *Stratford*
11. Pecan Research Station — *Sparks*
12. Veterinary Research Station — *Pawhuska*
13. Vegetable Research Station — *Bixby*
14. Eastern Research Station — *Haskell*
15. Kiamichi Field Station — *Idabel*
16. Sarkeys Research and Demonstration Project — *Lamar*