# U.S. Exports, Farm Employment, and Income Simulated under Alternative Export Demands



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# U.S. EXPORTS, FARM EMPLOYMENT AND INCOME SIMULATED UNDER ALTERNATIVE EXPORT DEMANDS

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# I. INTRODUCTION

Exports have become a major share of U.S. agricultural markets in recent years. They brought great profits to agriculture in the period 1973-76. Agricultural products accounted for 23 percent of the value of total U.S. exports in 1974 (Table 1). Exports of agricultural commodities increased 297 percent from 1970 to 1974 while chemicals, the commodity group with the second largest growth, increased 232 percent.

Table 1. United States imports and exports by commodity group for selected years in billions of dollars

| Commodity group | 1960 | 1965 | 1970 | 1974 | 1975 |
|---|---|---|---|---|---|
| | | | (Billion dollars) | | |
| Exports: | | | | | |
| Agricultural products | 4.5 | 6.2 | 7.4 | 22.0 | 23.0 |
| Petroleum and petroleum products | .8 | .9 | 1.6 | 3.4 | 4.4 |
| Chemicals | 1.7 | 2.4 | 3.8 | 8.8 | 8.7 |
| Machinery and transport equipment | 6.9 | 10.1 | 17.8 | 38.1 | 45.7 |
| Other manufactured goods | 3.8 | 4.9 | 7.6 | 16.5 | 16.5 |
| Other transactions | 2.5 | 2.6 | 4.3 | 8.1 | 3.1 |
| Total Exports | 20.4 | 27.1 | 42.5 | 97.1 | 106.1 |
| Imports: | | | | | |
| Agricultural products | 4.0 | 3.9 | 5.5 | 9.5 | 8.2 |
| Petroleum and petroleum products | 1.5 | 2.2 | 3.1 | 25.3 | 26.4 |
| Chemicals | .8 | .7 | 1.4 | 3.9 | 3.7 |
| Machinery and transport equipment | 1.4 | 2.9 | 11.1 | 24.7 | 24.2 |
| Other manufactured goods | 4.5 | 7.5 | 13.2 | 27.5 | 24.1 |
| Other transactions | 2.6 | 3.9 | 5.3 | 9.8 | 2.5 |
| Total Imports | 15.0 | 21.4 | 39.9 | 100.9 | 96.9 |

[a]SOURCE: [31]

Manufactured goods represented the largest import group for the 1960-75 period. However, petroleum and petroleum products became a major import commodity in recent years. Imports of petroleum and petroleum products increased in value by 750 percent between 1970 and 1975. The growth in import of petroleum, along with the overall growth in imports, has created a potential problem in the U.S. balance of payments. The nation has been fortunate to have large agricultural exports to balance against petroleum imports during the last several years.

As well as representing a major source of U.S. farm income, agricultural exports are important to the balance of payments and the income of the entire economy. In 1974, 21 percent (103.1 billion dollars) of the total value of U.S. output was exported. Sixty-one percent of U.S. wheat production, 21 percent of corn harvested for grain, and 42 percent of soybeans were exported in 1974.

Three commodity groups, wheat and wheat products, feed grains and feed grain products, and soybeans and soybean products, accounted for 64 percent of the value of all agricultural exports in 1976 (Table 2). These three commodity groups also represented 47, 49, and 48 percent of the value of agricultural exports, respectively, in 1960, 1965, and 1970.

The relative importance of various commodity groups in the total value of agricultural exports changed considerably over the period 1960-76. Exports of cotton and cotton products were 22 percent of total exports in 1960 but only 5 percent in 1976. Soybean and soybean products were 11 percent of total 1960 export receipts and 20 percent in 1976. The value of wheat and wheat products exports held relatively stable at 22 and 17 percent respectively and feed grains and feed grain products increased



Table 2. Value of U.S. agricultural exports by commodity group for selected years 1960-76 in millions of dollars[a]

| Commodity group | 1960[b] | 1965[c] | 1970[d] | 1974[e] | 1976[f,g] |
|---|---|---|---|---|---|
| Animals and animal products | 429 | 527 | 817 | 1,760 | 2,380 |
| Cotton and cotton products | 996 | 666 | 407 | 1,444 | 1,049 |
| Fruits and preparations | 254 | 289 | 341 | 589 | 770 |
| Nuts and preparations | 17 | 33 | 60 | 158 | 198 |
| Feed grains and products | 546 | 957 | 1,016 | 4,696 | 6,023 |
| Wheat and products | 1,082 | 1,185 | 965 | 4,739 | 4,087 |
| Soybeans and products | 487 | 939 | 1,520 | 4,633 | 4,582 |
| Other grains and preparations | 143 | 227 | 349 | 909 | 765 |
| Feeds and fodder, excluding oil cake and meal | 31 | 33 | 123 | 280 | 449 |
| Other coilseeds and products | 60 | 82 | 112 | 478 | 488 |
| Tobacco leaf | 385 | 390 | 561 | 814 | 939 |
| Vegetables and preparations | 127 | 152 | 231 | 407 | 674 |
| Total exports for commodity groups | 4,557 | 5,480 | 6,502 | 20,907 | 22,995 |

[a]Undeflated dollars

[b]SOURCE: [20]

[c]SOURCE: [21]

[d]SOURCE: [25]

[e]SOURCE: [28]

[f]SOURCE: [30]

[g]Preliminary

from 12 to 26 percent between 1960 and 1976. Although tobacco increased in value from 385 million dollars in 1960 to 939 million dollars in 1976, the percentage value of tobacco in exports declined during the period.

## Historical Levels of Agricultural Exports

Historical levels of U.S. exports for wheat, feed grains,[1] and soybeans are shown in Table 3. Both wheat and feed grains exports increased dramatically in the 1972-73 crop year and maintained most of the increase (Table 3). Unlike wheat and feed grain exports, soybean exports grew rather steadily over the period 1960-1975.

Table 3. Net U.S. exports of wheat, feed grains, and soybeans in millions of metric tons for 1960-1974[a]

| Crop year | Wheat | Feed grains[b] | Soybeans[c] |
|---|---|---|---|
| | | (Million metric tons) | |
| 1960/61 | 17.7 | 10.4 | 6.6 |
| 1961/62 | 19.5 | 14.4 | 5.3 |
| 1962/63 | 17.2 | 14.3 | 7.4 |
| 1963/64 | 23.0 | 15.9 | 7.5 |
| 1964/65 | 19.3 | 18.9 | 8.8 |
| 1965/66 | 23.3 | 24.9 | 9.1 |
| 1966/67 | 19.9 | 19.0 | 8.8 |
| 1967/68 | 20.1 | 20.0 | 10.0 |
| 1968/69 | 14.7 | 15.9 | 10.4 |
| 1969/70 | 16.4 | 18.6 | 10.7 |
| 1970/71 | 19.8 | 17.9 | 15.5 |
| 1971/72 | 16.9 | 23.7 | 15.8 |
| 1972/73 | 31.8 | 37.8 | 15.2 |
| 1973/74 | 31.0 | 39.0 | 15.6 |
| 1974/75 | 28.2 | 32.4 | 18.1 |

[a]SOURCE: [12,29]

[b]Measured in corn equivalent units

[c]Includes soybeans and soy oil measured in bean equivalent units

[1]Feed grains is a commodity group composed of corn, oats, barley, and grain sorghum. The unit of measure is corn equivalent units, which expresses all crops on the basis of their feed value relative to corn.



## P.L. 480 Agricultural Exports

Public Law 480 (P.L. 480) provided the legal authority for U.S. food aid programs with developing countries which had food deficits. Initiated in 1954, it still is in effect although on a greatly reduced scale. P.L. 480 has been used to assist needy countries and to remove surplus agricultural commodities from U.S. markets.

The major type of food aid provided by P.L. 480 has been the Title I, Sales for Foreign Currencies. Currencies so generated were used as loans or grants to foreign countries for further economic development. A second method of food aid provided by P.L. 480 is Title II, Foreign Donations, provided to alleviate famine and malnutrition and stimulate economic and community development. The barter of agricultural exports also was possible under P.L. 480 and after 1963 were classified as commercial exports equivalent to cash sales.

Total P.L. 480 sales under all provisions are shown in Tables 4, 5, and 6. Table 4 compares total exports under all P.L. 480 programs with commercial exports for wheat; Table 5 considers feed grains, and Table 6 considers soybeans. Of the three commodities, wheat was the major commodity affected by the P.L. 480 programs. During the early 1960s, 70 percent of wheat exports were assisted by P.L. 480 programs. Countries which received more than a million metric tons of wheat under P.L. 480 are shown in Table 7. The bulk of P.L. 480 wheat exports went to India and Pakistan.

Table 4. U.S. wheat exports by P.L. 480 and commercial sales for 1960-74 in millions of metric tons

| Crop year | Total exports all P.L. 480 programs[a] | Commercial exports[b] | Total U.S. exports |
|---|---|---|---|
| | (Million metric tons) | | |
| 1960/61 | 11.00 | 6.74 | 17.74 |
| 1961/62 | 11.45 | 8.07 | 19.52 |
| 1962/63 | 11.24 | 5.93 | 17.17 |
| 1963/64 | 11.23 | 11.76 | 22.99 |
| 1964/65 | 13.42 | 5.89 | 19.31 |
| 1965/66 | 12.78 | 10.56 | 23.34 |
| 1966/67 | 7.13 | 12.81 | 19.94 |
| 1967/68 | 9.39 | 10.79 | 20.18 |
| 1968/69 | 5.26 | 9.41 | 14.67 |
| 1969/70 | 5.78 | 10.62 | 16.40 |
| 1970/71 | 5.09 | 14.71 | 19.80 |
| 1971/72 | 5.20 | 11.70 | 16.90 |
| 1972/73 | 2.96 | 28.79 | 31.75 |
| 1973/74 | 0 | 30.96 | 30.96 |
| 1974/75 | 0 | 28.25 | 28.25 |

[a]SOURCE: [27]

[b]Calculated as the residual of total U.S. exports minus P.L. 480 exports.

[c]SOURCE: [29]

Table 5. U.S. feed grain exports by P.L. 480 and commercial sales for 1960-74 in millions of metric tons

| Crop year | Total exports all P.L. 480 programs[a] | Commercial exports[b] | Total U.S. exports[c] |
|---|---|---|---|
| | (Million metric tons) | | |
| 1960/61 | 2.98 | 7.42 | 10.40 |
| 1961/62 | 3.32 | 11.06 | 14.38 |
| 1962/63 | 1.57 | 12.71 | 14.28 |
| 1963/64 | 1.21 | 14.65 | 15.86 |
| 1964/65 | 1.04 | 17.90 | 18.94 |
| 1965/66 | 2.02 | 22.83 | 24.85 |
| 1966/67 | 3.51 | 15.50 | 19.01 |
| 1967/68 | 1.71 | 18.31 | 20.02 |
| 1968/69 | .79 | 15.13 | 15.92 |
| 1969/70 | 1.20 | 17.39 | 18.59 |
| 1970/71 | 1.17 | 16.72 | 17.89 |
| 1971/72 | 1.39 | 22.29 | 23.68 |
| 1972/73 | 1.45 | 36.33 | 37.78 |
| 1973/74 | 0 | 39.05 | 39.05 |
| 1974/75 | 0 | 32.38 | 32.38 |

[a]SOURCE: [27]

[b]Calculated as the residual of total U.S. exports minus P.L. 480 exports.

[c]SOURCE: [29]



Table 6. U.S. soybean exports by P.L. 480 and commercial sales for 1960-1974 in millions of metric tons

| Crop year | Total exports all P.L. 480 programs | Commercial exports | Total U.S. exports |
|---|---|---|---|
| | | (Million metric tons) | |
| 1960/61 | .20 | 6.22 | 6.64 |
| 1961/62 | .11 | 5.07 | 5.33 |
| 1962/63 | .10 | 7.62 | 7.40 |
| 1963/64 | .01 | 7.24 | 7.50 |
| 1964/65 | .02 | 8.58 | 8.87 |
| 1965/66 | 0 | 8.90 | 9.19 |
| 1966/67 | 0 | 8.64 | 8.81 |
| 1967/68 | 0 | 9.77 | 9.98 |
| 1968/69 | 0 | 10.16 | 10.35 |
| 1969/70 | 0 | 10.47 | 10.65 |
| 1970/71 | 0 | 15.19 | 15.54 |
| 1971/72 | 0 | 15.42 | 15.79 |
| 1972/73 | 0 | 14.94 | 15.21 |
| 1973/74 | 0 | 15.44 | 15.61 |
| 1974/75 | 0 | 17.74 | 18.10 |

Table 7. Total P.L. 480 exports during 1960-75 in millions of metric tons to countries with P.L. 480 imports greater than one million metric tons[a]

| Country | Wheat[b] | Feed grains[c] | Soybeans[d] |
|---|---|---|---|
| | | (Million metric tons) | |
| Brazil | 8.04 | | |
| Poland | 2.80 | | |
| Yugoslavia | 5.81 | | |
| Turkey | 4.85 | | |
| Iran | 1.40 | | |
| Israel | 2.30 | 4.93 | |
| India | 42.68 | 5.44 | |
| Pakistan | 13.97 | | |
| Korea, Republic of | 7.67 | 1.43 | |
| Republic of China | 1.68 | | .38 |
| Morocco | 2.89 | | |
| Tunisia | 1.99 | | |
| Egypt | 4.57 | 1.10 | |
| Japan | | 1.09 | |

[a]SOURCE: [27]

[b]Countries listed received approximately 90 percent of P.L. 480 wheat exports.

[c]Countries listed received approximately 60 percent of P.L. 480 feed grain exports.

[d]No country received one million metric tons of soybeans during this period. The Republic of China was the largest P.L. 480 participant with imports of 375 thousand metric tons.

### Objectives of This Study

The primary objective of this study is to evaluate the impacts of alternative international outcomes for the primary agricultural export commodities of the United States--wheat, feed grains, and soybeans. Factors influencing import quantities of these crops by foreign countries are estimated quantitatively. Based on these import estimates by countries and groups of countries, U.S. export levels are projected to the year 2000. The projected export levels then are included in the CARD simulation model to evaluate impacts on U.S. agriculture.[2] Finally, alternative export scenarios are developed to explore a range of possible export alternatives and their impacts on U.S. agricultural prices, incomes, production levels, and the acreage.

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[2]The CARD (Center for Agricultural and Rural Development) Simulation Model is a recursive econometric model of U.S. agriculture. The initial model is reported in Ray [17] and Ray and Heady [18]. This model was modified and extended for long-range forecasting purposes by Reynolds and Mitchell and reported in Reynolds, Heady, and Mitchell [19]. This revised model is the CARD Simulation Model used in this study.



## II. THE INTERNATIONAL MARKET FOR AGRICULTURAL PRODUCTS

The first part of this section considers the structure of the wheat, feed grains, and soybean markets. The second part examines the characteristics of imports, and the third part examines export supply.

### Market Structure

#### Wheat market

The United States and Canada supply 60 to 70 percent of the world's wheat exports (Table 8). Argentina, Australia, France and the USSR are other major exporters, but their volume is small compared to that of the United States and Canada. France has had a growing volume of exports while Argentina and the USSR are sporadic exporters.

The major wheat importing countries are listed in Table 9. Japan and the People's Republic of China, price takers when they purchase wheat, were the largest net importers during the period 1972-74.

#### Feed grains market

The United States also is the major feed grains exporter. It exported approximately 50 percent of all feed grains sold in international markets during the period 1960-74 (Table 10). Argentina was second with approximately 12 percent of world exports and France was third with 10 percent. South Africa, Canada, Australia, Thailand, and Brazil each supply less than 5 percent of world exports and form the remainder of the major

Table 8. Net exports of major wheat exporting countries in millions of metric tons for the period from 1960-74. Percent of total exports is shown in parentheses for each country[a,b]

| Crop year | United States | Canada | Argentina | France | Australia | USSR | Total exports of major exporting countries |
|---|---|---|---|---|---|---|---|
| | | | | (Million metric tons) | | | |
| 1960/61 | 17.7 (45) | 9.3 (23) | 1.9 (5) | 1.1 (3) | 5.0 (13) | 4.4 (11) | 39.4 |
| 1961/62 | 19.5 (44) | 9.9 (22) | 2.4 (6) | 1.4 (3) | 6.3 (14) | 5.1 (11) | 44.6 |
| 1962/63 | 17.2 (42) | 9.0 (22) | 1.8 (4) | 2.4 (6) | 4.8 (12) | 5.5 (14) | 40.7 |
| 1963/64 | 23.0 (45) | 15.0 (30) | 2.8 (6) | 1.9 (4) | 7.8 (15) | -[c] | 50.5 |
| 1964/65 | 19.3 (42) | 11.9 (26) | 4.3 (9) | 3.9 (9) | 6.4 (14) | -[c] | 45.8 |
| 1965/66 | 23.3 (42) | 14.9 (27) | 7.9 (14) | 4.0 (7) | 5.7 (10) | -[c] | 55.7 |
| 1966/67 | 19.9 (41) | 14.8 (31) | 3.1 (6) | 2.4 (5) | 6.9 (14) | 1.3 (3) | 48.4 |
| 1967/68 | 20.2 (45) | 8.9 (20) | 1.3 (3) | 3.8 (8) | 7.0 (16) | 3.8 (8) | 45.0 |
| 1968/69 | 14.7 (35) | 8.7 (20) | 2.7 (6) | 5.5 (13) | 5.4 (13) | 5.6 (13) | 42.6 |
| 1969/70 | 16.4 (36) | 9.0 (20) | 1.7 (4) | 5.7 (12) | 7.4 (16) | 5.3 (12) | 45.5 |
| 1970/71 | 19.8 (37) | 12.7 (24) | 1.6 (3) | 2.9 (5) | 9.5 (18) | 6.7 (13) | 53.2 |
| 1971/72 | 16.9 (33) | 15.8 (31) | 1.3 (3) | 5.4 (11) | 8.7 (17) | 2.4 (5) | 50.5 |
| 1972/73 | 31.8 (50) | 15.6 (24) | 3.0 (5) | 7.8 (12) | 5.6 (9) | -[c] | 63.8 |
| 1973/74 | 31.0 (55) | 11.4 (20) | 1.1 (2) | 7.6 (13) | 5.3 (9) | .6 (1) | 57.0 |
| 1974/75 | 28.3 (49) | 10.3 (18) | 2.2 (4) | 7.5 (13) | 8.4 (14) | 1.5 (2) | 58.2 |
| 1975/76 | 31.5 | 12.1 | 3.2 | NA[d] | 7.9 | .5 | NA[d] |
| 1976/77 | | 12.8 | 5.6 | NA[d] | 8.4 | 1.0 | NA[d] |

[a]SOURCE: [29]

[b]Several countries were net exporters in selected years, but were not major exporters continuously. These countries include Mexico, Sweden, Finland, Uruguay, Denmark, Hungary, Spain, Greece, Bulgaria, Kenya, and the Republic of South Africa and, combined, constitute about 5 percent of all world wheat exports.

[c]Russia was a net importer of wheat in these years.

[d]Not available



Table 9. Net wheat imports of countries which had average net imports of one million metric tons or more during the three-year period 1972-1974[a]

| Country | Average 1972-1974 net wheat imports |
|---|---|
| | (Million metric tons) |
| Brazil | 2.34 |
| United Kingdom (minus Northern Ireland) | 3.50 |
| East Germany | 1.30 |
| Italy | 1.34 |
| India | 3.27 |
| Pakistan | 1.29 |
| Bangladesh | 1.89 |
| People's Republic of China | 5.55 |
| Korea, Republic of | 1.70 |
| Japan | 5.38 |
| Algeria | 1.24 |
| Egypt | 3.20 |
| USSR | 3.85[b] |
| Iran | 1.21 |

[a]SOURCE: [29]

[b]The USSR was a net importer in 1972-73 and a net exporter in 1973-74 and 1974-75. Net wheat imports were 13.6 million metric tons in 1973-74, and net wheat exports were .55 and 1.5 million metric tons, respectively, in 1973-74 and 1974-75.

exporting countries. In 1960, the major exporting nations exported 18.78 million metric tons. Their exports increased to 63.66 million metric tons or by 139 percent by 1973. United States exports increased 359 percent over the period.

The major countries importing feed grains are in Table 11. During the three-year period 1972-74, Japan, the major importer, purchased about 20 percent of the average world exports of feed grains. Japan's imports were 35 percent of U.S. feed grains exports in these three years. Italy, West Germany, Russia, Spain, United Kingdom, and the Netherlands were other major exporters.

Table 10. Net exports of major feed grain exporting countries in millions of metric tons for the period 1960-1974.[a] Percent of total exports is shown in parentheses for each country [b]

| Crop year | United States | Canada | Argentina | France | Australia | Republic of South Africa | Thailand | Brazil | Total |
|---|---|---|---|---|---|---|---|---|---|
| 1960/61 | 11.09 (59) | .88 (5) | 2.48 (13) | 1.57 (8) | 1.16 (6) | 1.08 (6) | .52 (3) | 0 (0) | 18.76 |
| 1961/62 | 14.34 (60 | .90 (4) | 3.51 (15) | 1.55 (6) | 1.12 (5) | 1.95 (8) | .59 (2) | 0 (0) | 23.96 |
| 1962/63 | 14.75 (62) | .55 (2) | 3.26 (14) | .99 (4) | .56 (2) | 2.69 (11) | .72 (3) | .65 (3) | 24.17 |
| 1963/64 | 15.97 (54) | 1.15 (4) | 3.74 (13) | 4.28 (15) | .72 (2) | 2.65 (9) | .90 (3) | 0 (0) | 29.41 |
| 1964/65 | 18.51 (61) | .91 (3) | 5.09 (17) | 2.27 (8) | .74 (2) | 1.00 (3) | 1.13 (4) | .50 (2) | 30.15 |
| 1965/66 | 24.81 (72) | .99 (3) | 3.75 (11) | 2.15 (6) | .55 (2) | .44 (1) | 1.27 (4) | .57 (1) | 24.53 |
| 1966/67 | 20.22 (59) | 1.07 (3) | 6.53 (19) | 3.22 (10) | .83 (2) | .77 (2) | 1.34 (4) | .38 (1) | 34.36 |
| 1967/68 | 20.46 (58) | 1.10 (3) | 4.03 (11) | 3.50 (10) | .39 (1) | 3.28 (10) | 1.34 (4) | 1.20 (3) | 35.30 |
| 1968/69 | 16.60 (49) | .45 (1) | 5.61 (17) | 5.56 (17) | .76 (2) | 2.42 (7) | 1.55 (5) | .59 (2) | 33.54 |
| 1969/70 | 18.58 (51) | 1.26 (5) | 5.98 (16) | 5.52 (15) | 1.13 (3) | .63 (2) | 1.73 (5) | 1.72 (5) | 36.55 |
| 1970/71 | 18.79 (44) | 3.98 (10) | 7.62 (18) | 5.17 (12) | 2.79 (7) | 1.07 (2) | 2.23 (5) | .90 (2) | 42.55 |
| 1971/72 | 23.45 (48) | 4.34 (9) | 6.15 (13) | 7.65 (16) | 2.90 (6) | 3.07 (6) | 1.19 (2) | .13 (0) | 48.88 |
| 1972/73 | 37.66 (63) | 3.98 (7) | 4.18 (7) | 6.62 (11) | 1.54 (3) | 3.31 (5) | 2.23 (4) | 0 (0) | 59.52 |
| 1973/74 | 39.85 (61) | 2.67 (4) | 8.20 (13) | 9.36 (14) | 2.10 (3) | .37 (1) | 1.11 (2) | 1.28 (2) | 64.94 |
| 1974/75 | 32.26 (55) | 2.51 (4) | 8.25 (14) | 4.72 (8) | 2.68 (5) | 4.07 (7) | 2.13 (4) | 2.09 (3) | 58.71 |

[a]SOURCE: [29]. Feed grains is the combined crops of corn, barley, oats, and grain sorghum.

[b]Countries not included exported approximately 5 percent of total world exports. In 1974-75 total world exports were 61.49 million metric tons. Five percent of these exports were sold by 26 countries not included in this table. Denmark was the largest net exporter in this group with exports of .76 million metric tons of feed grains.



Table 11. Net imports of feed grains of countries which had an average net import of one million metric tons or more during the three years 1972-1974[a]

| Country | Average 1972-1974 net feed grain imports |
|---|---|
| | (Million metric tons) |
| Mexico | 1.88 |
| United Kingdom (exluding Northern Ireland) | 3.45 |
| Netherlands | 3.06 |
| Belgium/Luxemburg | 2.56 |
| West Germany | 4.32 |
| East Germany | 1.35 |
| Poland-Danzig | 1.41 |
| USSR | 4.21 |
| Spain | 3.59 |
| Portugal | 1.17 |
| Italy | 6.02 |
| People's Republic of China | 1.14 |
| Taiwan | 1.08 |
| Japan | 12.87 |

[a]Feed grains is the combination of corn, barley, grain sorghum, and oats.

The structure of the feed grain market is similar to the international wheat market. The United States is the major exporter of feed grains. Several other countries supply significantly smaller amounts of feed grains for export.

Soybean market

Soybean production is concentrated in the United States, Brazil, and The People's Republic of China (Table 12). The United States produces approximately 75 percent of world output. Brazil rapidly increased production after 1969 and produced 9 percent of the world's supply in 1973-74. Production by the People's Republic of China has been relatively stable for the past 10 years.

Table 12. Soybean production in major producing countries in millions of metric tons for the period 1960-1974[a]

| Crop year | United States | Brazil | People's Republic of China |
|---|---|---|---|
| | | (Million metric tons) | |
| 1960/61 | 15.11 | .21 | 8.20 |
| 1961/62 | 18.47 | .27 | 7.90 |
| 1962/63 | 18.21 | .35 | 7.70 |
| 1963/64 | 19.03 | .32 | 7.04 |
| 1964/65 | 19.08 | .30 | 6.94 |
| 1965/66 | 23.01 | .52 | 6.84 |
| 1966/67 | 25.27 | .60 | 6.80 |
| 1967/68 | 26.58 | .72 | 6.95 |
| 1968/69 | 30.13 | .65 | 6.48 |
| 1969/70 | 30.84 | 1.51 | 6.20 |
| 1970/71 | 30.68 | 1.06 | 6.90 |
| 1971/72 | 32.00 | 2.08 | 6.70 |
| 1972/73 | 34.58 | 3.67 | 6.30 |
| 1973/74 | 42.11 | 5.00 | 6.70 |

[a]SOURCE: [10,11]. Production by the United States, Brazil, and The People's Republic of China represents 90 to 95 percent of all world soybean production.

Soybean exports are shown in Table 13. The United States dominates in the export of soybeans and soybean oil. Brazil is the only major competitor. As Table 14 indicates, Japan and West Germany are the largest importers of soybeans and soybean oil. The structure of the international soybean market approximates that of a single seller and many buyers. Japan purchased 21 percent of U.S. exports from 1972-1974.



Table 13. Soybean exports by country, 1960-1974, in millions of metric tons[a,b]

| Crop year | United States | Brazil | People's Republic of China |
|---|---|---|---|
| | | (Million metric tons) | |
| 1960 | 6.66 | .01 | NA |
| 1961 | 5.33 | .07 | NA |
| 1962 | 7.40 | .10 | NA |
| 1963 | 7.50 | .03 | .35 |
| 1964 | 8.87 | .00 | .51 |
| 1965 | 9.19 | .08 | .60 |
| 1966 | 8.81 | .12 | .57 |
| 1967 | 9.98 | .30 | .58 |
| 1968 | 10.35 | .07 | .59 |
| 1969 | 10.65 | .31 | .51 |
| 1970 | 15.54 | .31 | .43 |
| 1971 | 15.79 | .24 | .47 |
| 1972 | 15.21 | 1.37 | .37 |
| 1973 | 15.61 | 2.29 | .31 |
| 1974 | 18.10 | 2.75 | .34 |

[a]SOURCES: [10,11]

[b]Data and for soybean exports and soybean oil exports expressed as soybean equivalent. The conversion factor used to convert soybean oil to soybean equivalent is 5.49.

Table 14. Net soybean imports of countries which have average imports of .3 million metric tons or more during the three years 1972-1974[a]

| Country | Average 1972-1974 soybean imports | Country | Average 1972-1974 soybean imports |
|---|---|---|---|
| | (Million metric tons) | | (Million metric tons) |
| Canada | .31 | West Germany | 3.09 |
| Mexico | .35 | Italy | 1.32 |
| People's Republic of China | 1.10 | Netherlands | 1.73 |
| Israel | .43 | Norway | .30 |
| Japan | 3.47 | Poland | .16 |
| Belgium | .59 | Spain | 1.31 |
| Denmark | .48 | United Kingdom | .92 |
| France | .83 | USSR | .33 |

[a]SOURCE: [11]. Data are for soybeans and soybean oil expressed as soybean equivalent. The conversion factor to convert soybean oil to soybeans is 5.49.

# III. RESEARCH PROCEDURE

This study projects world levels of imports for wheat, feed grains, and soybeans. Based on these import levels, U.S. exports are then estimated by a market share analysis. The emphasis is on imports; major exporting nations are not included in the analysis.

Import equations are estimated econometrically for all countries of the world which historically have been net importers of the specified commodities. The analysis is conducted independently for each commodity. Based on the estimated equations, future import levels are projected and the variability of imports is estimated. The procedures for estimating the import equations are ordinary least squares regression (OLS) and ordinary least squares corrected for autocorrelation (ALS) as outlined in Johnston [13]. A Monte Carlo simulation technique is used to estimate the variation in import demand.

## Delineation of Regions

Importing countries are grouped into regions based on geographic location, per capita income, and conformity with previous studies (see [2]). Different regions are used for the different commodities because the major exporting countries for wheat, feed grains, and soybeans also are different.

Several factors led to concentration on importing countries. First, the primary focus of this study is on the commercial demand for agricultural products. This demand can be developed independently of supply when



the flow of commodities is known. If it were impossible to establish the movement of commodities and observe only the final transactions, as is true in most market transactions, then a simultaneous system would be required to estimate demand and supply. Second, the analysis of supply is a topic separate from the intent and methods used in this analysis. To consider all aspects of supply, an analysis of the productive capability, storage capacity, and ability to shift production among crops would be necessary for each exporting country. Third, it is possible to make certain assumptions about supply which places it in secondary importance. It can be assumed that (a) supply continues to grow at trend rates and (b) that as excess capacity, which existed during the period of the 1960s and early 1970s, returns it will be absorbed by government programs. In this case, the quantity of commercial exports will be determined mainly by demand because supply will be highly elastic.

## Estimating Import Equations

Import equations are estimated for each importing region for wheat, feed grains, and soybeans. Although many alternatives in variables were examined, the explanatory variables used in the analysis are production plus beginning stocks of the commodity in the importing region (denoted as domestic supply), commodity price, and time. These variables were selected on the basis of economic theory, the usefulness for projecting imports, the usefulness for evaluating the variability in imports, on the basis of other variables examined and on statistical tests of significance.

Two definitions of commodity price were considered. The U.S. commodity export price adjusted for export subsidies, deflated by the consumer price index, and adjusted for the 1971 and 1973 devaluation of the dollar is the primary price variable. This variable is the most useful definition of price for applying the results to the United States. This variable does not allow for changes in the monetary unit of the importing region, however. To allow for this type of change, the consumer price index for each country, or a weighted average index for each region, was used to deflate the U.S. price. The resulting variable expresses the price of wheat, feed grains, and soybeans on a real basis with domestic commodities.

### Projected Imports

Imports are projected for each region from the estimated import equations. Trend growth in imports is estimated by incrementing the time variable. Alternative levels of commodity prices provide a range of projected imports corresponding to different price levels. Finally, trend estimates of production are combined with historical average levels of production and stocks needed to complete the list of variables needed for import projections. The projected explanatory variables are evaluated in the estimated equation and projection of imports is obtained. The resulting projections are based on trends and are valid only to the extent that the trends remain intact.

### Simulation Models

The econometric simulation model of U.S. agriculture described later is used to evaluate the projected levels of U.S. exports. Alternative assumptions about the international production, consumption, and trade of wheat and feed grains are explored through a series of future scenarios. Forecasts are made for each year between 1975 and 2000. Based on the results of these scenarios, the impacts on U.S. farm prices, incomes, production, and resource use are examined.



## IV. DEMAND FOR WHEAT EXPORTS

United States wheat exports during the 1960s and early 1970s may provide a poor indication of both the levels and volatility of future wheat exports. During this period, the United States had an oversupply of wheat for export and the emphasis was on exports for surplus disposal rather than exports for cash sales. Importing countries were able to purchase as much wheat as they wanted at low prices. Much of the U.S. wheat exports went to countries that would not have imported under cash sales.

This situation causes historical export data to serve as a poor basis for evaluting future export potentials. An alternative method of viewing the U.S. export market is to concentrate on the import side of the international wheat market. Import equations then can be estimated for individual countries and regions. This procedure allows a country-by-country view of imports and makes possible the separation of countries with cash imports and those which obtained large P.L. 480 imports. Although it may be impossible to completely eliminate the effects of the oversupply situation of the 1960s, concentrating on imports instead of historical exports would appear to allow fewer distortions. This procedure also provides useful information about the determinants of individual country imports.

### Data and Definition of Variables

Time series data on production, imports, stocks, and other related variables for 114 individual countries for a period of 15 years were used in this study. The primary data source was a computer data tape containing information assembled by the Foreign Agricultural Service of the United States Department of Agriculture [29].

Additional variables were collected for the consumer price indexes, balance of payments, and exchange rates from various sources. Data are defined on a crop year basis unless otherwise designated. A crop year begins on July 1 and ends on June 30. Table 18 contains a list of variable names and definitions used in the estimation.

Table 18. List of variables, definitions, and symbols used for wheat

| Variable symbol | Variable name and definition |
|---|---|
| $WP_{it}$ | Wheat Production--thousands of metric tons of wheat produced in country or region i in year t, where i = 1,...,14. |
| $WNI_{it}$ | Wheat Net Imports--thousands of metric tons of wheat imports minus wheat exports by country or region i in year t. |
| $WBS_{it}$ | Wheat Beginning Stocks--thousands of metric tons of wheat stocks at the start of the crop year in country or region i in year t. |
| $WUSP_t$ | Wheat Price--U.S. export price of wheat in constant 1972 dollars after adjusting for a dollar devaluation in 1970 and 1972. |
| Time | Time--integer variable with 1960 equal 1 and 200 equal 41. |
| $WDS_{i,t}$ | Wheat Domestic Supply--thousands of metric tons of wheat production plus wheat beginning stocks in region i in year t. |
| $WRIP_{i,t}$ | Wheat Real Import Price--U.S. wheat export price in constant 1972 dollars adjusted for devaluation and divided by the consumer price index in region i in year t. |



## Delineation of Import Regions

One hundred eight countries were included in the wheat import demand portion of this study. To facilitate computations, these countries were grouped into 14 importing regions. The importing regions and the countries are in Table 19. Wheat import equations are estimated for each of the 14 importing regions.

## Estimated Import Equations

Wheat import equations are presented for each region along with definitions and interpretations. Only the estimates used later in the simulation model are included. A complete listing of estimated equations and alternative specifications is available in [15]. Each fitted equation is presented using the abbreviated variable names with the regression coefficients, standard errors (in parentheses), estimation technique (OLS, ALS), the Durbin-Watson d statistic (d), the $R^2$ value, the standard error of the estimate (S.E.E.) and for the ALS estimation technique the first-order autocorrelation coefficient, $\rho$, and its standard error. The statistical significance of each estimated coefficient is also indicated by asterisks on the standard error.[1]

Economic relationships are considered to overrule statistical results. Equations must conform to economic theory before they are included in the later analysis. In several cases the equation selected for use is not "statistically best," but is more amenable to requirements imposed by the remainder of the study.

[1] A coefficient which is significant at the 1 percent level is denoted by ***, a 5 percent level is denoted by **, a 10 percent level is denoted by *, and no asterisks indicates that the coefficient was not significant at the 10 percent level or higher.

Table 19. Wheat importing regions and countries included in the analysis

| Region number | Region name | Countries included in this region |
|---|---|---|
| 1 | Mexico | Mexico |
| 2 | Central America | Costa Rica, Cuba, Dominican Republic, El Salvador, Guatemala, Haiti, Honduras, Jamaica and Dependents, Nicaragua, Panama, Trinidad and Tobago, Bolivia, Chile, Colombia, Equador, Paraguay, Peru, Venezuala, Guyana |
| 3 | Brazil | Brazil |
| 4 | Northern Europe | Austria, Belguim and Luxembourg, Denmark, Finland, Ireland, Netherlands, Norway, Sweden, Switzerland, United Kingdom-North Ireland, West Germany, Iceland |
| 5 | Southern Europe | Greece, Italy, Portugal, Spain, Malta-Gozo |
| 6 | Eastern Europe | Bulgaria, Czechoslavakia, East Germany, Hungary, Poland-Danzig, Rumania, Yugoslavia, Albania |
| 7 | USSR | USSR |
| 8 | 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 |
| 9 | Republic of South Africa | Republic of South Africa |
| 10 | West Asia | Cyprus, Iran, Iraq, Israel, Jordan, Lebanon, Syria, Turkey, Saudi Arabia, So Yemen, Kuwait, Afghanistan |
| 11 | India and other South Asia | Sri Lanka (Ceylon), Pakistan, Bangladesh, Nepal |
| 12 | Japan | Japan |
| 13 | Other East Asia | Burma, Khmer Republic (Cambodia), Taiwan, Indonesia, Philippines, Hong Kong, South Korea, South Vietnam, Thailand, North Vietnam, North Korea, Outer Mongolia |
| 14 | People's Republic of China | People's Republic of China |



Mexico--Region 1

The estimated wheat import equation for Mexico is:

$$WNI_{1,t} = -1321.6 - \underset{(.173)^{***}}{.704WDS_{1,t}} + \underset{(328.404)}{214.586TIME}$$

ALS $\quad \underset{(.238)^{***}}{\rho = .896} \quad d = 1.87 \quad R^2 = .92 \quad S.E.E. = 130.3$

Wheat imports are inversely related to domestic supply and are growing over time. The estimated coefficient on domestic supply, -.704, indicates that Mexico would import 70 percent of a shortfall domestic wheat production. If the domestic wheat supply decreased 10 million metric tons, imports would increase 7 million metric tons, assuming other things equal. The elasticity of net imports with respect to domestic supply calculated at the 1972-1974 average net import and domestic supply is -1.96. Thus, a 10 percent decrease in domestic supply causes a 19.6 percent increase in wheat imports with other things constant. This formulation explains 92 percent of the variance in Mexico's net wheat imports.

The U.S. wheat export price was found to be insignificant or of the wrong sign in all specifications. In an effort to correct this disturbing result, the U.S. wheat export price was deflated by the consumer price index of the region [1]. Price was thus converted to real import price in relation to other commodities consumed. This variable had the correct sign but was not statistically significant and did not have the correct sign when included in any equation which contained time. The only specification with price that had the correct sign explained only 13 percent of the variation in net wheat imports. Several conclusions are supported from these results. First, the U.S. wheat export price may not reflect the true import price and the constructed import price also may differ from the actual import price. Second, the tendency for imports and price to move together may dominate the response of quantity to price. Third, price may play a somewhat minor or insignificant role in decisions to import. This conclusion was supported by the relative stability of U.S. export prices during most of the period analyzed.

Central America--Region 2

The wheat import demand equation for Central America is:

$$WNI_{2,t} = 3798.8 - \underset{(.578)}{.538WDS_{2,t}} - \underset{(160.924)}{142.751WUSP_t} + \underset{(60.459)^{**}}{174.27TIME}$$

ALS $\rho = \underset{(.362)}{.573}$ $d = 1.74$ $R^2 = .93$ S.E.E. = 270.04

Net wheat imports are inversely related to U.S. wheat export price and growing over time. Time has the only statistically significant coefficient at the 10 percent level of probability. The estimated equation explains 93 percent of the variance in net wheat imports for Central America.

The coefficient of net import demand elasticity relative to wheat domestic supply calculated at the 1972-1974 average net imports and domestic supply is -.19. The price elasticity of net imports calculated for U.S. wheat export price over the 1972-1974 average and net wheat imports over the 1972-1974 period is -.32. The estimated regression coefficient for domestic wheat supply is -.538. This coefficient predicts that 54 percent of a reduction in wheat domestic supply, production plus beginning period stocks, would be imported, assuming other things equal.



Brazil--Region 3

The estimated wheat import equation for Brazil is:

$$WNI_{3,t} = 2414.90 - \underset{(.127)^{***}}{.646WDS_{3,t}} + \underset{(22.412)^{***}}{98.812TIME}$$

OLS $d = 1.72$ $R^2 = .69$ S.E.E. = 236.5

Net wheat imports grow over time and are negatively related to domestic supply. The elasticity of net imports with respect to domestic supply is -.50 when calculated at the average 1972-1974 net imports and domestic supplies.

Several alternative specifications and variables were considered. The U.S. export price had the wrong sign in all specifications. The variable obtained by deflating U.S. export price by the consumer price index for Brazil has the correct sign and is statistically significant at the 5 percent level. However, the equation which contained price only explains 34 percent of the variation in imports. The fact that the U.S. wheat export price was significant but had the wrong sign in all specifications may indicate the nature of the difficulty in estimating the price coefficient. When Brazil increases its imports, the U.S. export price increases. Brazil imports approximately 5 percent of world wheat imports so this should not influence the wheat price significantly. However, the explanation may come from the correlation of world production and the resulting correlation in wheat imports. When Brazil has lower production than normal, the probability is high that other countries also are experiencing reduced production. Correlations between Brazil and other countries in wheat production and imports are shown in Table 20.

Table 20. Correlation of domestic wheat supply and net wheat imports for Brazil and other importing regions for the period 1960-1974

| Region | Correlation of wheat production | Correlation of wheat imports |
|---|---|---|
| Mexico | .62 | .32 |
| Central America | -.36 | .24 |
| Northern Europe | .81 | -.10 |
| Southern Europe | .30 | -.03 |
| Eastern Europe | .73 | -.22 |
| USSR | .58 | .70 |
| Africa | .55 | .19 |
| Republic of South Africa | .72 | -.28 |
| West Asia | .42 | -.36 |
| India and Other South Asia | .75 | .09 |
| Japan | -.69 | .19 |
| Other East Asia | -.15 | .06 |
| People's Republic of China | .60 | .52 |

While production in Brazil is correlated with production in other regions, net wheat imports between Brazil and other regions are not highly correlated. This result may be explained by several factors. First, wheat stocks are not considered and may augment production in some countries. Second, not all countries respond in the same magnitude to a change in domestic wheat supply. Third, the simultaneous fluctuations in production may cause many countries to pursue the same import action and drive up prices. Thus the time series data tend to show imports and wheat prices to increase in tandem. Of course, richer countries may bid wheat away from poorer countries under these conditions.

Northern Europe--Region 4

The estimated net wheat import equation for Northern Europe is:

$$WNI_{4,t} = 19816.0 - \underset{(.193)^{**}}{.583WDS_{4,t}} - \underset{(398.182)}{664.157WUSP_t} + \underset{(103.961)^{*}}{189.225TIME}$$

OLS $d = 1.79$ $R^2 = .67$ S.E.E. = 850.61



Wheat net imports are inversely related to U.S. wheat export price and domestic wheat supply. Net imports also grow over time. The relatively low $R^2$ may indicate that significant variables have been omitted from the estimated equation.

The coefficient estimated for domestic wheat supply indicates that 58 percent of a reduction in domestic wheat supply would be imported, other things constant. The coefficient on U.S. wheat export price indicates the expected response of imports to a change in price. The calculated price elasticity of imports with respect to U.S. export price is -.41. When 1972-1974 average values are used in the calculation, the coefficient of net wheat import elasticity with respect to domestic wheat supply is -2.28.

Several other specifications and variables were estimated. Similar results were obtained for all specifications. None of the equations estimated explained more than 68 percent of variance in net wheat imports. The price variable obtained by deflating the U.S. wheat export price by a constructed consumer price index for Northern Europe gave slightly better results than the U.S. wheat export price variable. However, this equation was not selected for later use because of the additional complexity created by this constructed price variable. One of the goals of this study is to relate imports to U.S. exports, and this is best done when the U.S. price is used directly.

Southern Europe--Region 5

The estimated net wheat import equation for Southern Europe is:

$$WNI_{5,t} = 14000.0 - \underset{(.09)^{***}}{.74WDS_{5,t}} + \underset{(34.44)^{**}}{105.16TIME}$$

OLS $d = 2.04$ $R^2 = .86$ S.E.E. = 482.3

Net wheat imports grow over time and are inversely related to domestic wheat supply. The coefficient of elasticity of net wheat imports with respect to domestic supply is -5.56 when the 1972-1974 average domestic wheat supply and net imports are used.

Several alternative specifications and variables were estimated. The U.S. wheat export price had the wrong sign in all specifications. The price variable obtained by deflating U.S. wheat export price by a constructed consumer price index for Southern Europe had the correct sign in one specification. However, the equation did not explain a greater portion of the variation in import demand than the specification selected.

Eastern Europe--Region 6

The estimated net wheat import equation for Eastern Europe is:

$$WNI_{6,t} = \underset{}{12040.2} - \underset{(.189)^{*}}{.388WDS_{6,t}} + \underset{(291.521)}{294.258TIME}$$

$$\text{ALS} \quad \underset{(.287)}{\rho = .456} \quad d = 1.72 \quad R^2 = .63 \quad \text{S.E.E.} = 1067.4$$

Net wheat imports are inversely related to domestic wheat supply and increase over time. The estimated coefficient on domestic wheat supply indicates that approximately 39 percent of a reduction in production plus beginning wheat stocks would be imported, other factors remaining constant. The net wheat import elasticity with respect to domestic wheat supply is -3.57 when 1972-1974 average values of domestic wheat supply and net wheat imports are used.

Alternative specifications indicated that the U.S. wheat export price and the U.S. wheat export price deflated by a constructed consumer price index for Eastern Europe were both statistically nonsignificant. The



overall inability of any estimated equation to explain more than 63 percent of the variation in net imports in Eastern Europe indicates that this region is difficult to predict and other variables may have to be devised.

USSR--Region 7

The estimated net wheat import equation for the USSR is:

$$WNI_{7,t} = 19488.4 - \underset{(130)^{**}}{.320WDS_{7,t}} + \underset{(574.696)^{*}}{1133.796TIME}$$

$$\text{ALS} \quad \underset{(.521)}{\rho = .353} \quad d = 1.62 \quad R^2 = .53 \quad \text{S.E.E.} = 4580.6$$

The low $R^2$ may indicate that economic variables relevant elsewhere may not apply in the USSR or that net imports have been influenced by variables other than economic variables. The estimated equation shows that net wheat imports are negatively related to domestic wheat supply and grow over time. Thirty-two percent of a reduction in domestic wheat supply would be imported, other things equal, according to the estimated results. The coefficient of net wheat import elasticity with respect to domestic supply is -8.49 when 1972-1974 average values of domestic supply and net wheat imports are used as the basis of calculation.

Alternative specifications indicated that the U.S. wheat export price is not significant in any estimation, although the sign is correct in some equations. The lack of significant predictive power of the estimated equations is probably attributed to the influences of political factors on the decision to import.

Africa--Region 8

The estimated net wheat import equation for Africa is:

$$WNI_{8,t} = 5111.5 - .799WDS_{8,t} + 631.157TIME$$
$$\qquad\qquad (.162)^{***} \qquad (116.527)^{***}$$

ALS $\rho$ = .574 d = 1.87 $R^2$ = .93 S.E.E. = 502.28
(.301)*

The coefficient estimated for domestic wheat supply is -.799, and indicates that approximately 80 percent of a reduction in domestic wheat supply would be covered by wheat imports, other things being equal. The elasticity for net wheat imports relative to domestic wheat supply is -.87 when calculations are based on 1972-1974 averages.

The U.S. wheat export price does not contain the correct sign in any specification estimated. Even when the U.S. export price is deflated by a constructed consumer price index for Africa, the estimated coefficient does not have the expected sign. All estimates of price result in positive coefficients and several specifications gave significant results. The positive and significant results on wheat export price may indicate a correlation of net wheat imports and wheat import price which dominates the expected price responsiveness of quantity to a change in price.

Republic of South Africa--Region 9

The estimated net wheat import equation for the Republic of South Africa is:

$$WNI_{9,t} = 627.1 - .733WDS_{9,t} + 65.820TIME$$
$$\qquad\qquad (.163)^{***} \qquad (23.473)^{**}$$

OLS d = 2.20 $R^2$ = .72 S.E.E. = 158.5



Wheat net imports are inversely related to domestic wheat supply and growing over time. The net wheat import elasticity with respect to the domestic supply of wheat is -6.15 when the 1972-1974 average net imports and domestic supply are used.

The U.S. wheat export price has the correct sign but is not statistically significant in several alternative equations estimated. The standard error of the estimate also was higher for all alternative specifications.

West Asia--Region 10

The estimated net wheat import equation for West Asia is:

$$WNI_{10,t} = 12008.2 - .668WDS_{10,t} - 703.556WUSP_t + 596.141TIME$$
$$\qquad\qquad (.157)^{***} \qquad (433.866) \qquad (137.920)^{***}$$

ALS $\rho$ = .360 d = 2.25 $R^2$ = .78 S.E.E. = 743.3
(.353)

The equation's standard error, 743.3, is approximately 40 percent of the standard deviation of wheat import demand. The expected signs are obtained for all variables and wheat domestic supply and time are significant at the 1 percent level. The net wheat import of elasticity with respect to domestic wheat supply is -4.12 when calculations are based on 1972-1974 average values.

The inclusion of the U.S. wheat export price had a very small effect on the estimated equation. The standard error of the equation decreased approximately 5 percent. The coefficient on U.S. wheat export price had the wrong sign and was insignificant before the estimated equation was corrected for autocorrelation. After the correction the estimated coefficient had a lower standard error and the correct sign as suggested by economic theory.

India and Other South Asia--Region 11

The estimated net wheat import equation for India and Other South Asia is:

$$WNI_{11,t} = 11004.7 - \underset{(.127)^{***}}{.459WDS_{11,t}} + \underset{(229.638)^{***}}{894.160TIME}$$

$$\text{ALS} \quad \underset{(.372)}{\rho = .481} \quad d = 1.42 \quad R^2 = .83 \quad \text{S.E.E.} = 1014.2$$

The U.S. wheat export price does not have the correct sign and is not included in the final equation. When the U.S. wheat export price is deflated by the constructed consumer price index for the region, price had the desired sign. However, the resulting equation had an $R^2$ of .25, compared to an $R^2$ of .83 when the adjusted U.S. wheat export price was replaced with a time variable.

India and Other South Asia is a particularly important region for a study of net imports. This region received 56 percent of all P.L. 480 wheat exports during the 1960-1975 period [27]. The difficult, perhaps impossible, task is to develop an import equation which accounts for this historical data but is an acceptable estimate of future net import responses. It is difficult to predict net imports during the years when P.L. 480 sales were substantially reduced. The P.L. 480 supported and commercial wheat imports for India and Other South Asia are presented in Table 21.



Table 21. P.L. 480 wheat imports, total wheat imports, and residuals from the import equation for India and Other South Asia for 1960-1974[a]

| Year | P.L. 480 imports[b] | Total wheat imports | Estimated residuals |
|---|---|---|---|
| 1960 | 4.42 | 5.74 | - |
| 1961 | 3.01 | 4.14 | -1.18 |
| 1962 | 4.97 | 5.38 | 1.01 |
| 1963 | 6.13 | 6.06 | .24 |
| 1964 | 7.70 | 8.26 | .68 |
| 1965 | 8.04 | 8.63 | .66 |
| 1966 | 4.88 | 10.53 | 1.03 |
| 1967 | 7.38 | 9.04 | -1.40 |
| 1968 | 2.49 | 5.67 | -1.20 |
| 1969 | 3.03 | 4.82 | -.58 |
| 1970 | 2.13 | 4.57 | -.76 |
| 1971 | 1.52 | 4.45 | .04 |
| 1972 | 1.46 | 4.04 | .81 |
| 1973 | .0 | 6.63 | .89 |
| 1974 | .0 | 8.94 | -.23 |

[a]P.L. 480 exports are listed by calandar year and total imports and residuals are reported by crop year. To overcome part of this difference, P.L. 480 exports are lagged one year to correspond to the part of the year when imports are purchased.

[b]SOURCE: [27]

Japan--Region 12

The estimated net wheat import equation for Japan is:

$$WNI_{12,t} = 4597.6 - \underset{(.145)^{***}}{.844WDS_{12,t}} + \underset{(15.541)^{***}}{134.450TIME}$$

$$\text{OLS} \quad d = 1.82 \quad R^2 = .98 \quad \text{S.E.E.} = 147.2$$

Both parameter estimates obtained in the equation have the correct sign and are statistically significant at the 1 percent level. Wheat net imports are inversely related to production plus wheat stocks at the beginning of the crop year and grow linearly over time. The estimated coefficient on domestic wheat supply is -.844. The coefficient of net wheat import elasticity with respect to domestic wheat supply is -.21 based on 1972-1974 average net imports and domestic supplies.

A number of alternative specifications and variables were tried. These results indicate that U.S. wheat export price is not statistically significant in explaining the variation in net wheat imports, and does not have the expected sign. When the U.S. wheat export price was deflated by the consumer price index for Japan, the resulting variable had the expected sign and was significant at the 10 percent level.

Other East Asia--Region 13

The estimated net wheat import equation for Other East Asia is:

$$WNI_{13,t} = 761.7 + \underset{(75.941)^{***}}{358.188}TIME$$

ALS $\rho = .535$ $d = 1.56$ $R^2 = .91$ S.E.E. = 531.2

The estimated net wheat import equation is specified as a function of time. Other specifications are unsatisfactory from a theoretical viewpoint. Several specifications had higher $R^2$s than the above equation, but all contained a coefficient exceeding 2 for the wheat domestic supply variables. This magnitude implies that the region's imports will be double its production decrease.

People's Republic of China--Region 14

An estimated equation is not used to predict net wheat imports for the People's Republic of China. A number of variables and specifications were tried but were not acceptable. Although statistical significance was obtained in several specifications, the estimated parameters did not agree with results suggested by economic theory. Hence, for the People's



Republic of China, net wheat imports are assumed to equal the 1960-1974 average value of 4.59 million metric tons.

## Wheat Production

Wheat production is a major determinant of wheat imports in most regions of the world. The degree of interdependence in wheat production between regions provides an indication of the degree of interdependence of wheat imports. If wheat production is correlated among regions, this condition has major implications for wheat imports. When one region experiences production lower than expected, the probability increases that other regions also will have reduced production and, therefore, larger imports.

Projected wheat production

Estimated wheat production equations as a function of time are presented in Table 22. These equations predict production for each wheat importing region. The estimated equation for wheat production for Japan predicts a negative output in 1976. To overcome this problem, wheat production is held constant at the last observed production quantity (.23 million metric tons in crop year 1974-1975). Wheat production in all other regions is predicted by the estimated equations.

Projected wheat production for each importing region and the sum of projected production for all regions are presented in Table 23. The actual 1974 production and the $R^2$ of the projecting equation are also presented for each region. Total world wheat production of the importing countries is projected to increase from 250.55 million metric tons in 1974 to 485.78 million metric tons in 2000. Two regions, Central America and Other East Asia, are projected to decrease production of wheat between

Table 22. Estimated equations for wheat production as a function of time, 1960-1974

| Region | Estimation technique | Constant | Time | ρ | $R^2$ | d | S.E.E. |
|---|---|---|---|---|---|---|---|
| 1. Mexico | OLS | 1,404.5 | 50.046 (12.139) | | .57 | 1.80 | 203.13 |
| 2. Central America | ALS | 1,815.8 | -34.908 (25.857) | .533 (.240) | .50 | 1.76 | 165.10 |
| 3. Brazil | ALS | -140.06 | 148.941 (42.726) | .124 (.338) | .63 | 1.85 | 503.07 |
| 4. Northern Europe | OLS | 10,555. | 502.371 (74.526) | | .78 | 1.84 | 1,247.1 |
| 5. Southern Europe | ALS | 15,622.46 | 91.689 (103.021) | .218 (.243) | .23 | 2.33 | 1,133.17 |
| 6. Eastern Europe | OLS | 14,102.0 | 1,228.757 (100.460) | | .92 | 1.83 | 1,681.0 |
| 7. U.S.S.R. | ALS | 56,917.42 | 3,045.267 (447.908) | -.633 (.273) | .66 | 1.65 | 10,969.424 |
| 8. Africa | OLS | 4,291.3 | 213.511 (48.049) | | .60 | 2.15 | 804.01 |
| 9. Republic of South Africa | ALS | 399.278 | 90.602 (23.188) | .397 (.270) | .80 | 1.73 | 210.62 |
| 10. West Asia | OLS | 13,205. | 403.775 (69.990) | | .72 | 1.86 | 1,171.2 |
| 11. India and Other South Asia | ALS | 6,679.60 | 1,723.355 (444.665) | .617 (.224) | .90 | 1.48 | 2,545.8 |
| 12. Japan | OLS | 1,758.6 | -106.379 (12.889) | | .84 | 2.21 | 215.67 |
| 13. Other East Asia | ALS | 887.27 | -20.267 (15.621) | .546 (.185) | .47 | 2.46 | 75.48 |
| 14. People's Republic of China | OLS | 18,779. | 874.786 | | .83 | 1.66 | 1,848.7 |



1974 and 2000. Japan is projected to maintain production, and all other regions are projected to increase production. Based on historical patterns, the USSR is projected to increase production from 83.84 to 181.77 million metric tons from 1974 to 2000. If trend is not dampened by other variables, the India and Other South Asia region also is projected to have a large increase in wheat production between 1974 and 2000.

Table 23. Projected wheat production for 1980, 1990, and 2000 with 1974-1975 actual wheat production for comparison and $R^2$ for the projecting equation

| Region | Actual 1974 production | 1980 | 1990 | 2000 | $R^2$ |
|---|---|---|---|---|---|
| | (Million metric tons) | | | | |
| Mexico | 2.20 | 2.45 | 2.95 | 3.45 | .57 |
| Central America | 1.28 | 1.08 | .73 | .38 | .50 |
| Brazil | 2.82 | 2.98 | 4.47 | 5.96 | .63 |
| Northern Europe | 20.37 | 21.10 | 26.12 | 31.15 | .78 |
| Southern Europe | 16.88 | 17.54 | 18.46 | 19.38 | .23 |
| Eastern Europe | 33.98 | 39.90 | 52.19 | 64.48 | .92 |
| USSR | 83.84 | 199.66 | 151.30 | 181.77 | .66 |
| Africa | 7.34 | 8.77 | 10.91 | 13.04 | .60 |
| Republic of South Africa | 1.61 | 2.30 | 3.20 | 4.11 | .80 |
| West Asia | 17.95 | 21.68 | 25.72 | 29.86 | .72 |
| India and Other South Asia | 30.26 | 42.74 | 60.10 | 77.33 | .90 |
| Japan | .23 | .23 | .23 | .23 | –[a] |
| Other East Asia | .54 | .46 | .25 | .05 | .47 |
| People's Republic of China | 31.20 | 37.15 | 45.89 | 54.64 | .83 |
| Total All Regions | 250.55 | 318.09 | 402.59 | 485.78 | |

[a]An equation was not used to project production for Japan.

## Wheat stocks

Table 24 includes the average level of beginning wheat stocks in each region. The USSR has the largest average level of stocks due primarily to its level of production, which also is the greatest of the importing regions. The USSR had average beginning period stocks equal to 14 percent of production. Eastern Europe, Africa, and Mexico have the lowest ratios of average stocks to average production. The high ratio for Japan is misleading because production is very low relative to imports and consumption.

Table 24. Average wheat stocks at the beginning of each crop year for the period from 1960-1974

| Region | Beginning year stocks 1960-1974 | Ratio of average stocks to production |
|---|---|---|
| | (Million metric tons) | |
| Mexico | .15 | .08 |
| Central America | .36 | .24 |
| Brazil | .38 | .35 |
| Northern Europe | 5.94 | .41 |
| Southern Europe | 2.32 | .14 |
| Eastern Europe | 1.44 | .06 |
| USSR | 11.00 | .14 |
| Africa | .44 | .07 |
| Republic of South Africa | .30 | .26 |
| West Asia | 1.87 | .11 |
| India and Other South Asia | 4.25 | .20 |
| Japan | .98 | 1.09 |
| Other East Asia | .28 | .43 |
| People's Republic of China | Not available | |

## Wheat Imports

Wheat import equations are estimated for individual importing countries and regions. Explanatory variables used in the estimated equations include wheat production in the importing region, level of wheat stocks in the importing region, U.S. wheat export price, and a trend variable to represent the change in demand due to income, population, and shifts in production patterns within each region. A deterministic projection of net wheat imports can be obtained for each region or country by first projecting



wheat production, wheat stocks, and wheat price. The projected net wheat import is then obtained from the estimated equation.

The variability of net wheat imports is a function of the variability of wheat production in each region or country and the estimated coefficient on domestic wheat supply in each country. The combined variability in total net wheat imports cannot be obtained as a summation of individual countries or regions because of the correlation between countries. This condition leads to the more elaborate Monte Carlo procedure used in this study.

### Projected net wheat imports

Projected values of net wheat imports are presented for each region and all regions combined in Table 25. Total net imports are projected to increase from an average of 57.79 million metric tons in 1972-1974 to 99.29 million metric tons in the year 2000. The bulk of this increase comes from the less developed countries such as those in Africa and Asia. The European countries had an overall decrease in net imports of approximately 60 percent over the 1972-1974 period. The communist countries show small overall changes in imports.

Mexico has projected imports of 4.94 million metric tons of wheat in the year 2000, compared with an average of 71.2 million metric tons of wheat over the 1960-1974 period. This change reflects the switch from net exporter to net importer during the 1960s and early 1970s. Central America shows a moderate growth rate in the net wheat imports and approximately doubles its imports between 1974 and 2000 (Table 25). Brazil's net imports remain relatively constant near its 1960-1974 average.

Table 25. Projected net wheat import demand for 1980, 1990, and 2000 with average 1972-1974 net imports for comparisons. Wheat stocks in each country or region are fixed at the average volume for the 1960-1974 period and U.S. wheat export price is $3.00

| Region | Actual 1972-1974[a] | 1980 | 1990 | 2000 |
|---|---|---|---|---|
| Mexico | .73 | 1.35 | 3.15 | 4.94 |
| Central America | 4.84 | 6.24 | 8.17 | 10.10 |
| Brazil | 2.63 | 2.33 | 2.35 | 2.38 |
| Northern Europe | 6.19 | 6.03 | 4.99 | 3.96 |
| Southern Europe | 1.88 | 1.51 | 1.88 | 2.25 |
| Eastern Europe | 3.59 | 2.18 | .35 | -1.47 |
| USSR | 3.85 | 1.10 | 2.70 | 4.29 |
| Africa | 7.58 | 11.01 | 15.61 | 20.22 |
| Republic of South Africa | -.28 | .10 | .10 | .09 |
| West Asia | 3.19 | 6.68 | 9.94 | 13.21 |
| India and Other South Asia | 6.53 | 8.15 | 9.18 | 10.22 |
| Japan | 5.38 | 6.40 | 7.74 | 9.09 |
| Other East Asia | 5.84 | 8.28 | 11.87 | 15.45 |
| People's Republic of China | 5.45 | 4.59 | 4.59 | 4.59 |
| Total All Regions | 57.79 | 65.94 | 82.62 | 99.29 |

[a]Average U.S. wheat export price was $3.78 FOB.

Northern Europe is projected to decrease the level of net wheat imports in the year 2000 to 3.96 million metric tons. Southern Europe is projected to increase net wheat imports by 74 percent. Eastern Europe is projected to continue its trend and become a net exporter by year 2000. By the year 2000, the USSR is projected to import 4.29 million metric tons, compared with average net exports of 1.04 million metric tons, during the 1960-1974 period.

Africa, where wheat has increased steadily from 1960 to 1974, is projected to become the largest net wheat importer and increase imports to



20.22 million metric tons by the year 2000. South Africa is projected to have only small net imports. West Asia, which averaged net imports of 2.62 million metric tons over the 1960-74 period, is projected to increase to 13.21 million metric tons by 2000. India and Other South Asia is projected to have a small increase in net wheat imports while Japan is projected to have an increase of 69 percent. Other East Asia, projected to increase net wheat imports from the 1960-74 average of 3.79 to 15.45 by 2000 (Table 25), would become the second largest net wheat importer.

Total imports by all wheat importing countries and regions combined are projected to increase from 54.52 million metric tons in 1974 to 99.29 million metric tons by the year 2000. This increase of 82 percent comes primarily from the less developed countries.

## United States Wheat Exports

The percentage of world exports supplied by the United States was relatively stable over the 1960-1974 period. The average market share was 42.7 percent of total exports by the major exporting countries,[2] and the range of market shares has been between 33 and 55 percent. Based on the historical market share of 42.7 percent, Table 26 shows the projected U.S. wheat exports for 1980, 1990, and 2000. The 95 percent confidence intervals about the projected exports are also shown for 1980, 1990, and 2000.

[2]The major exporting countries are: United States, Canada, Argentina, Australia, France, and the USSR.

Table 26. Projected U.S. wheat exports for selected years with 1972-1974 actual exports for comparison[a]

| Year | Projected U.S. wheat exports | 95 percent confidence interval on U.S. wheat exports |
|---|---|---|
| | (Million metric tons) | |
| 1972-1974 actual[b] | 30.32 | |
| 1980 | 28.16 | (23.61 - 32.71) |
| 1990 | 35.28 | (30.73 - 39.83) |
| 2000 | 42.40 | (37.85 - 46.95) |

[a]United States wheat export price is held constant at $3.00 per bushel in 1972 dollars.

[b]Actual U.S. wheat export price averaged $3.78 per bushel in 1972 dollars.



## V. DEMAND FOR FEED GRAINS

The United States supplied 50 percent of the world's feed grains during the 1960-1974 period. We now consider the characteristics of feed grain imports for all of the importing countries and regions of the world.

### Data and Definition of Variables

The data used in this study are 15 years of annual data on production, imports, exports, stocks, and other related variables for 111 individual countries. The primary data source is the computer data tape of information assembled by the Foreign Agricultural Service of the United States Department of Agriculture [26].

Additional variables were collected for the consumer price indexes, balance of payments, and exchange rates from various sources. Data are defined on a crop year basis unless otherwise designated. A crop year begins on July 1 and ends on June 30. Table 27 contains a list of variable names and definitions used in the analysis.

### Delineation of Import Region

The major feed grain exporting countries are the United States, Argentina, France, Republic of South Africa, Canada, Australia, Thailand, and Brazil which were excluded from the analysis. These countries supplied approximately 95 percent of the feed grain exports during the 1960-1974 period. The importing regions and the countries included in each are given in Table 28.

Table 27. List of variables, definitions, and symbols used for feed grains

| Variable symbol | Variable name and definition |
|---|---|
| $FGP_{it}$ | Feed Grain Production--thousands of metric tons of feed grains produced in country or region i in year t, where i = 1,...,12. |
| $FGNI_{it}$ | Feed Grain Net Imports--thousands of metric tons of feed grain imports minus exports by country or region i in year t. |
| $FGBS_{it}$ | Feed Grain Beginning Stocks--thousands of metric tons of feed grain stocks at the start of the crop year in country or region i in year t. |
| $FGUSP_{t}$ | Feed Grain Price--U.S. export price of corn in constant 1972 dollars after adjusting for a dollar devaluation in 1970 and 1973. |
| TIME | TIME--integer variable with 1960 equal 1 and 2000 equal 41. |
| $FGDS_{i,t}$ | Feed Grain Domestic Supply--thousands of metric tons of feed grain production plus beginning stocks in region i in year t. |
| $FGRIP_{i,t}$ | Feed Grain Real Import Price--U.S. corn export price in constant 1972 dollars adjusted for devaluation divided by the consumer price index in region i in year t. |

## Estimated Import Equations

Import equations for feed grains are estimated for each of the 12 importing regions. Two estimation methods and several alternative specifications were used. Only the estimates used for projecting imports are shown. A complete listing of estimated equations and alternative specifications are available in [15]. Each fitted equation is presented using the abbreviated variable names with the regression coefficients, standard errors (in parentheses), estimation technique (OLS, ALS), the Durbin-Watson d statistic (d), $R^2$ value, the standard error of the estimate (S.E.E.), and



Table 28. Feed grain importing regions and countries included in the analysis

| Region number | Region name | Countries included in this region |
|---|---|---|
| 1 | Mexico | Mexico |
| 2 | Central America | Costa Rica, Cuba, Dominican Republic, El Salvador, Guatemala, Haiti, Honduras, Jamaica and Dependents, Nicaragua, Panama, Trinidad and Tobago, Bolivia, Chile, Colombia, Equador, Paraguay, Peru, Venezuela, Guyana |
| 3 | Northern Europe | Austria, Belgium and Luxembourg, Denmark, Finland, Ireland, Netherlands, Norway, Sweden, Switzerland, United Kingdom--North Ireland, West Germany, Iceland |
| 4 | Southern Europe | Greece, Italy, Portugal, Spain, Malta-Gozo |
| 5 | Eastern Europe | Bulgaria, Czechoslovakia, East Germany, Hungary, Poland-Danzig, Rumania, Yugoslavia, Albania |
| 6 | USSR | USSR |
| 7 | Africa | Algeria, Ethiopia, Lybia, Morocco, Sudan, Tunisia, Egypt, Somali Republic, Angola, Cameroon, Zaire, Ghana, Guinea, Ivory Coast, Nigeria, Senegal, Sierra Leone, Upper Volta, Dahomey, Kenya, Malagasy Republic, Rhodesia, Zambia, Uganda, Tanzania, Mozambique |
| 8 | West Asia | Cyprus, Iran, Iraq, Israel, Jordon, Lebanon, Syria, Turkey, Saudi Arabia, So Yemem, Kuwait, Afghanistan |
| 9 | India and Other South Asia | Sri Lanka (Ceylon), Pakistan, Bangladesh, Nepal |
| 10 | Japan | Japan |
| 11 | Other East Asia | Burma, Khmer Republic (Cambodia), Taiwan, Indonesia, Philippines, Hong Kong, South Korea, South Vietnam, North Vietnam, North Korea, Outer Mongolia |
| 12 | People's Republic of China | People's Republic of China |

Northern Europe imported 82.9 percent of a reduction in domestic feed grain supply during the 1960-1974 period. The estimated coefficient is statistically significant at the 1 percent level and has the expected sign. Net feed grain imports grow over time as shown by the estimated equation. The estimated coefficient for time also is significant at the 1 percent level. The elasticity of net feed grain imports with respect to domestic supply is -2.28 when calculated for the 1972-1974 period.

Although the estimated equation explains only 66 percent of the variation in net feed grain imports over the 1960-1974 period, none of the alternative specifications resulted in improvement. Feed grain price was neither significant at the 10 percent level of probability or of the expected sign.

Southern Europe--Region 4

The estimated net feed grain import equation for Southern Europe is:

$$FGNI_{4,t} = 4728.9 + \underset{(149.166)^{***}}{459.247TIME}$$

$$\text{ALS} \quad \underset{(.261)}{\rho = .412} \quad d = 2.11 \quad R^2 = .79 \quad S.E.E. = 1224.2$$

The U.S. feed grain export price was not found to be a significant variable in any of the alternative specifications attempted. The U.S. feed grain export price had a positive sign in all specifications, and was statistically not different from 0 at the 10 percent level.



Eastern Europe--Region 5

The estimated equation for net feed grain imports for Eastern Europe is:

$$FGNI_{5,t} = 112.3 - \underset{(.153)}{.012FGDS_{5,t}} + \underset{(204.584)}{228.497TIME}$$

$$\text{OLS} \quad d = 2.13 \quad R^2 = .47 \quad S.E.E. = 1104.7$$

Neither regression coefficient is statistically significant at the 10 percent level or higher. The lack of explanatory power of the estimated equation suggests that relevant variables have been omitted, or that Eastern Europe does not respond to the same variables that affect import decisions in other regions.

USSR--Region 6

The estimated net feed grain import equation for the USSR is:

$$FGNI_{6,t} = -3266.7 - \underset{(.088)}{.025FGDS_{6,t}} + \underset{(354.037)}{566.381TIME}$$

$$\text{ALS} \quad \underset{(.344)}{\rho = .413} \quad d = 1.49 \quad R^2 = .70 \quad S.E.E. = 1565.2$$

Neither estimated coefficient is statistically significant at the 10 percent level or higher. However, all other specifications resulted in a positive coefficient for domestic supply. All equations which contained both U.S. feed grain export price and domestic supply resulted in the wrong sign on domestic supply.

Africa--Region 7

The estimated equation for net feed grain imports for Africa is:

$$FGNI_{7,t} = 4566.4 - \underset{(.123)}{.232FGDS_{7,t}} + \underset{(57.900)^{***}}{131.945TIME}$$

OLS d = 1.83 $R^2$ = .33 S.E.E. = 328.5

The estimated equation explains only 33 percent of the variation in Africa's net feed grain imports over the 1960-1974 period. Net feed grain imports are inversely related to domestic feed grain supply and grow over time. Alternative specifications did not improve the estimate. In alternative equations, the U.S. feed grain export price and the U.S. feed grain price deflated by the consumer price index for the region had the opposite sign from that expected.

West Asia--Region 8

The estimated net feed grain import equation for West Asia is:

$$FGNI_{8,t} = 2742.2 - \underset{(.073)^{***}}{.325FGDS_{8,t}} + \underset{(11.527)^{***}}{116.396TIME}$$

OLS d = 1.84 $R^2$ = .91 S.E.E. = 191.4

Net feed grain imports increase over time and 32.6 percent of a reduction in domestic feed grain supply would be offset by increased imports. The elasticity of feed grain net imports with respect to domestic feed grain supply is -1.79 when calculated for the 1972-1974 period.

United States feed grain export price had the expected sign in several alternative equations but was not statistically significant at the 10 percent level. Other specifications had a lower $R^2$ value.



India and Other South Asia--Region 9

The estimated net feed grain import equation for India and Other South Asia is:

$$FGNI_{9,t} = 1834.4 - \underset{(.186)}{.049FGDS_{9,t}} - \underset{(132.456)}{17.240TIME}$$

ALS $\rho$ = .558 d = 1.46 $R^2$ = .28 S.E.E. = 656.7

None of the estimated coefficients is significant at the 10 percent level. The results obtained are partially explained by the effects of feed grain sales under P.L. 480. During 1965, 1966, and 1967 this region received large P.L. 480 shipments of feed grain. When a dummy variable is introduced for these three years, the following equation is obtained:

$$FGNI_{9,t} = 604.0 - \underset{(.042)}{.027FGDS_{9,t}} + \underset{(21.920)}{30.603TIME} = \underset{(229.384)^{***}}{1437.398DUM_9}$$

OLS d = 2.37 $R^2$ = .79 S.E.E. = 344.47

where $DUM_9$ is the dummy variable. This equation explains 79 percent of the variation in net feed grain imports. Feed grain imports grow over time and are inversely related to domestic supply.

Japan--Region 10

The estimated net feed grain import equation for Japan is:

$$FGNI_{10,t} = 2023.0 - \underset{(.469)}{.532\ FGDS_{10,t}} + \underset{(48.595)^{***}}{792.595TIME}$$

OLS d = 2.29 $R^2$ = .98 S.E.E. = 592.2

The estimated relationship indicates that Japan's net feed grain imports are growing over time and that historically Japan increases imports to offset 53.2 percent of reductions in domestic supply. The high explanatory power of the estimated equation is due largely to the low feed grain production in Japan.

United States feed grain exports were not significant at the 10 percent level or of the expected sign in alternative specification. When U.S. feed grain export price was deflated by the consumer price index for Japan, the resulting variable was significant at the 1 percent level and had the expected negative sign. The resulting equation had extreme autocorrelation and when corrected by including a trend variable, the price variable neither had the correct sign or was significant at the 10 percent level.

Other East Asia--Region 11

The estimated net feed grain import equation for Other East Asia is:

$$FGNI_{11,t} = -5203.5 - \underset{(.103)}{.058}FGDS_{11,t} - \underset{(571.690)}{930.411}FGUSP_t + \underset{(1186.849)}{633.155}TIME$$

ALS $\rho = \underset{(.251)}{.897}$ $d = 2.19$ $R^2 = .92$ S.E.E. = 364.6

Net feed grain imports are inversely related to domestic feed grain supply and price and grow over time. The estimated coefficient on the U.S. feed grain export price has the correct sign but is not statistically significant at the 10 percent level or greater. The estimated coefficient on domestic feed grain supply is very small and not significantly different from zero at the 10 percent level.

Several alternate equations were approximately similar in overall explanatory ability. The equation presented was selected on the basis of its high $R^2$, low S.E.E., and the correct signs on the price and domestic supply variables.



People's Republic of China--Region 12

The estimated net feed grain import equation for the People's Republic of China is:

$$FGNI_{12,t} = 3747.9 - \underset{(.057)^{***}}{.150}FGDS_{12,t} + \underset{(68.554)^{***}}{185.918}TIME$$

OLS $d = 1.95$ $R^2 = .38$ S.E.E. = 497.8

Feed grain net imports grow over time and relate inversely to domestic feed grain supply. Both coefficients are statistically different from zero at the 1 percent level of probability. The estimated equation explains 38 percent of the variation in net feed grain imports. The estimated coefficient on domestic feed grain supply implies that the People's Republic of China increases imports only enough to offset 15.9 percent of a decrease in domestic feed grain production plus beginning crop year stocks of feed grains. The coefficient of elasticity of net feed grain imports with respect to feed grain domestic supply is -4.82.

## Feed Grain Production

All regions were found to have an inverse relationship between the level of feed grain production plus stocks and the level of net feed grain imports. This relationship creates a direct link between variables such as weather which influence production and the level of feed grain imports.

Quantification of feed grain production for world regions provides a base on which to evaluate feed grain import possibilities. The following section concentrates on feed grain production for the importing regions designated in this study. Production levels are projected to the year 2000.

## Projected feed grain production

Estimated equations for feed grain production estimated as a function of time are presented in Table 29. These equations are used to project feed grain production to the year 2000 for 9 of the 12 regions. The estimated equations for West Asia, India and Other South Asia, and Japan were not used for projecting production since they did not have significant time trends and were able to explain only a small part of the variance in production. Hence, the 1960-1974 average production level was projected to continue for these regions. Japan had a rapid decline in feed grain production over 1960-1974. While the estimation equation for Japan explains 88 percent of the variation in production, this equation results in a negative projected production by 1976. To overcome this problem, feed grain production is projected to remain at the 1974 level.

Table 30 contains actual 1974 production of feed grains for each region and 1980, 1990, and 2000 projected levels. The $R^2$ of the projecting equation is also included with each equation. World feed grain production is projected to increase by 77 percent from 287.88 million metric tons in 1974 to 480.65 million metric tons by 2000. The USSR is projected to provide 37 percent of this total increase. Large increases are also projected for Mexico (118 percent) and Southern Europe (105 percent). West Asia and India and Other South Asia do not show a definite trend and production is assumed to remain at the 1960-1974 average.

## Feed grain stocks

Stocks of feed grain and the ratio of stocks to average production are presented in Table 31 for all importing regions. Several regions



Table 29. Estimated equations for feed grains production as a function of time, 1960-1974

| Region | Estimation technique | Intercept | Time | $\rho$ | $R^2$ | d | S.E.E. |
|---|---|---|---|---|---|---|---|
| Mexico | OLS | 6,028.3 | 370.018 (63.018) | | .73 | 1.28 | 1,055.5 |
| Central America | OLS | 4,911.1 | 139.083 (13.206) | | .90 | 2.15 | 221.0 |
| Northern Europe | OLS | 20,414.8 | 1,129.266 (58.364) | | .97 | 2.46 | 976.6 |
| Southern Europe | ALS | 5,804.9 | 647.019 (132.116) | .599 (.230) | .94 | 2.11 | 652.4 |
| Eastern Europe | OLS | 24,000.0 | 1,173.585 (126.168) | | .87 | 2.03 | 2,111.2 |
| U.S.S.R. | ALS | 17,668.0 | 3,106.844 (641.699) | .212 (.298) | .78 | 2.14 | 7,180.6 |
| Africa | OLS | 20,728.0 | 393.842 (45.836) | | .85 | 1.66 | 767.0 |
| West Asia | OLS | 8,289.6 | 10.250 (36.040) | | .01 | 1.94 | 603.1 |
| India and Other South Asia | ALS | 17,040.5 | 115.857 (110.880) | .241 (.292) | .18 | 1.81 | 1,268.1 |
| Japan | ALS | 1,932.4 | -115.361 (19.674) | .247 (.257) | .88 | 2.16 | 208.1 |
| Other East Asia | ALS | 5,386.3 | 118.178 (27.669) | -.456 (.265) | .51 | 1.69 | 607.3 |
| People's Republic of China | ALS | 26,961.3 | 778.866 (224.302) | .452 (.189) | .88 | 2.12 | 1,634.7 |

Table 30. Projected feed grain production for 1980, 1990, and 2000 with 1974-1975 actual wheat production for comparison and $R^2$ for the projecting equation

| Region | Actual 1974 production | 1980 | 1990 | 2000 | $R^2$ |
|---|---|---|---|---|---|
| | (Million metric tons) | | | | |
| Mexico | 9.72 | 13.80 | 17.50 | 21.20 | .73 |
| Central America | 6.80 | 7.83 | 9.22 | 10.61 | .90 |
| Northern Europe | 37.71 | 44.13 | 55.42 | 66.72 | .97 |
| Southern Europe | 15.75 | 19.39 | 25.86 | 32.33 | .94 |
| Eastern Europe | 42.25 | 48.65 | 60.38 | 71.12 | .87 |
| USSR | 74.62 | 82.91 | 113.98 | 145.05 | .78 |
| Africa | 26.75 | 29.00 | 32.94 | 36.88 | .85 |
| West Asia | 8.48 | 8.37 | 8.37 | 8.37 | -[a] |
| India and Other South Asia | 18.84 | 18.00 | 18.00 | 18.00 | -[a] |
| Japan | .26 | .26 | .26 | .26 | -[a] |
| Other East Asia | 7.27 | 7.87 | 9.05 | 10.23 | .51 |
| People's Republic of China | 39.45 | 43.32 | 51.11 | 58.90 | .88 |
| Total all regions | 287.88 | 323.52 | 402.09 | 480.65 | -[a] |

[a]An estimated equation was not used to project production for this region.

Table 31. Average feed grain stocks at the beginning of each crop year for the period from 1960-1974

| Region | Average beginning feed grain stocks 1960-1974 | Ratio of average stocks to average production 1960-1974 |
|---|---|---|
| | (Million metric tons) | |
| Mexico | .67 | .08 |
| Central America | .16 | .03 |
| Northern Europe | 3.98 | .14 |
| Southern Europe | .76 | .07 |
| Eastern Europe | .94 | .03 |
| USSR | 3.30 | .08 |
| Africa | .08 | .00 |
| West Asia | .45 | .05 |
| India and Other South Asia | 3.93 | .22 |
| Japan | .72 | .61 |
| Other East Asia | .68 | .11 |
| People's Republic of China | 0. | - |



maintained very low levels of stocks over the 1960-74 period. Africa had average production of 23.55 million metric tons but stocks of only .08 million metric tons. The relationship was similar for Central America, Eastern Europe, and West Asia.

Developed countries such as Northern Europe maintained a higher ratio of stocks to production. While Japan had a high ratio of stocks to production, this figure is misleading because of its low production and high imports.

## Feed Grain Imports

### Projected net feed grain imports

Projected feed grain imports for importing regions are presented in Table 32 for specified years. During the remainder of the century, feed grain imports by all countries and regions which are currently net importers are projected to increase imports from the 1972-1974 average of 56.2 million metric tons to 141.25 million metric tons. Most of this increase comes from Northern Europe, Southern Europe, the USSR, Japan, and Other East Asia. Northern Europe is projected to increase feed grain imports from the 1972-1974 average of 14.78 million metric tons to 21.02 million metric tons by 2000 during the same period. Southern Europe is projected to increase by 11.16, the USSR by 12.12, Japan by 41.28 and Other East Asia by 15.07 million metric tons.

## United States Feed Grain Exports

The level of feed grain exports for the United States in future periods is assumed to be a constant share of total world imports. During the

Table 32. Projected net feed grain imports for 1980, 1990, and 2000 with average 1972-1974 net imports for comparison. Feed grain stocks in each country or region are constant at the average level for the 1960-1974 period and U.S. feed grain export price is constant at $2.50 per bushel

| Region | Actual 1972-1974[a] | 1980 | 1990 | 2000 |
|---|---|---|---|---|
| | (Million metric tons) | | | |
| Mexico | 1.96 | 1.76 | 3.04 | 4.32 |
| Central America | 1.88 | 2.87 | 4.32 | 5.77 |
| Northern Europe | 14.78 | 16.59 | 18.81 | 21.02 |
| Southern Europe | 11.40 | 14.37 | 18.97 | 23.56 |
| Eastern Europe | 3.00 | 4.32 | 6.46 | 8.60 |
| USSR | 4.13 | 6.47 | 11.36 | 16.26 |
| Africa | .27 | .59 | 1.00 | 1.40 |
| West Asia | 1.56 | 2.31 | 3.48 | 4.64 |
| India and Other South Asia | .74 | .66 | .96 | 1.27 |
| Japan | 12.53 | 18.15 | 26.08 | 34.01 |
| Other East Asia | 2.81 | 5.31 | 11.60 | 17.88 |
| People's Republic of China | 1.14 | 1.15 | 1.84 | 2.54 |
| Total all regions | 56.20 | 74.56 | 107.91 | 141.25 |

[a]Average U.S. feed grain export price was $2.54 per bushel.

1960-1974 period, the United States supplied an average of 57.1 percent of total feed grain imports. The market share ranged from 44 to 72 percent (Table 10). Based on an average market share of 57.1 percent, the projected feed grain exports for the United States for selected years are shown in Table 33. Confidence intervals are also presented for feed grain imports under the assumption that U.S. exports remain at 57.1 percent of world imports.



Table 33. Projected U.S. feed grain exports for selected years with 1972-1974 actual exports for comparison[a]

| Year | Projected U.S. feed grain exports | 95 percent confidence interval on U.S. feed grain exports |
|---|---|---|
| | (Million metric tons) | |
| 1972-1974 actual[b] | 36.59 | |
| 1980 | 42.57 | (40.75 - 44.39) |
| 1990 | 61.62 | (59.80 - 63.44) |
| 2000 | 80.65 | (78.83 - 82.57) |

[a]United States feed grain export prices are held constant at $2.50 per bushel in 1972 dollars.

[b]Actual U.S. grain export price averaged $2.54 per bushel in 1972 dollars.

# VI. DEMAND FOR SOYBEANS

Several characteristics distinguish the demand for soybeans from the demand for wheat or feed grain. First, soybean production is concentrated in only three countries. Countries that import wheat and feed grains also produce these commodities. This difference between soybeans and wheat or feed grains production causes several important differences in soybean imports. Unlike the imports of wheat or feed grains, soybean imports are independent of production in the importing region. Soybean imports are determined by more traditional variables of demand. Soybean imports do not have the volatility caused by fluctuations in production in the importing region. A second distinguishing characteristic of soybean demand is the role of P.L. 480 exports. Historical data for soybean exports is much more relevant to future exports because of the small role of P.L. 480 in U.S. previous soybean exports.

## Delineation of Import Regions

Ten regions and 74 countries import soybean or soybean oil. The list of regions and the countries included in each is shown in Table 34.

## Data and Definition of Variables

The data used in this study are 15 years of annual data on soybean imports, exports, and prices for 74 countries. The primary data sources are the FAO Production Yearbooks [9,11] and the U.S. Foreign Agricultural Trade Statistical Report, Fiscal Year 1975 [30]. These definitions and variables are shown in Table 35.



Table 34. Soybean and soy oil importing regions and the countries included in each region

| Region number | Region name | Countries included in this region |
|---|---|---|
| 1 | Canada | Canada |
| 2 | Central America | Costa Rica, Cuba, Dominican Republic, El Salvador, Guatemala, Honduras, Jamaica, Nicaragua, Panama, Trinidad, Mexico |
| 3 | South America | Argentina, Colombia, Guyana, Peru, Surinam, Uruguay, Venezuela |
| 4 | Northern Europe | Austria, Belgium, Denmark, Finland, France, Ireland, Netherlands, Norway, Sweden, Switzerland, United Kingdom, West Germany |
| 5 | Southern Europe | Greece, Italy, Portugal, Spain |
| 6 | Eastern Europe | Bulgaria, Czechoslovakia, East Germany, Hungary, Poland, Rumania, Yugoslavia |
| 7 | Africa | Kenya, Morocco, Mozambique, USSR, South Africa, Tanzania |
| 8 | Asia | Brunci, Hong Kong, China (Taiwan), India, Indonesia, Iran, Israel, South Korea, North Korea, Kuwait, Lebanon, Macau, Mol Salah, Mol Sarowak, Mol W Malays, Pakistan, Philippines, Saudi Arabia, Singapore, South Vietnam, North Vietnam, Thailand |
| 9 | Japan | Japan |
| 10 | Oceania | Australia, French Polynesia, New Zealand |

## United States Soybean Exports

Soybean and soybean meal export projections are available through 1985 in a USDA Economic Research Service Situation report [14]. These figures are extended to the year 2000 at the yearly rate included in the report. Soybean exports are projected to increase 38.07 million bushels per year from 1972 to 2000, and soybean meal exports are assumed to increase at the rate of 2.26 million bushels per year from 1972 to 2000 (Table 36).

Table 35. List of variables, definitions, and symbols used for soybeans and soy oil

| Variable symbol | Variable name and definition |
|---|---|
| $USSE_t$ | U.S. Soybean Exports--thousands of metric tons of soybeans, soy meal, and soy oil expressed as soybean equivalent exported by the United States in year t. |
| $USSP_t$ | U.S. Soybean Export Price--the U.S. export price of soybeans in dollars per bushel expressed in constant 1972 dollars with adjustments for the dollar devaluation in 1970 and 1973. |
| $SBI_{i,t}$ | Soybean Imports--thousand metric tons of soybeans imported by region i in year t. |
| $SOI_{i,t}$ | Soy Oil Imports--thousand metric tons of soy oil imported by region i in year t. |
| $SMI_{i,t}$ | Soy Meal Imports--thousand metric tons of soy meal imported by region i in year t. |
| TIME | TIME--integer variable with 1960 equal to 1 and 2000 equal to 41. |

Table 36. Projected soybean products exports expressed in bean equivalent for selected years with 1969-73 actual exports for comparison

| Actual 1969-1973 soybean exports | 1985 | 2000 |
|---|---|---|
| | (Million bushels) | |
| 448.0 | 906.7 | 1477.8 |

## Soybean and Soybean Product Imports

Soybeans are imported in three forms: beans, oil, and meal. Separate equations are estimated for each region for each of the three products.

### Soybean imports

Estimated soybean import equations are presented for the 10 importing regions in Table 37. The equations estimate soybean imports for each



region as a function of U.S. soybean export price and time. Several of the regions, such as Africa and Oceania, are very small importers and are included only for completeness.

Results for the estimated equations show that soybean imports are explained by the regression specifications for the major importing regions, but not for the minor regions. Northern Europe is the largest soybean importer and the estimated equation explains 95 percent of variance in soybean imports. However, the estimated coefficient on U.S. soybean export price has the wrong sign. The next three largest soybean importing regions are Southern Europe, Asia, and Japan. The estimated equations for these regions have the correct sign on the price variable, and explain 94, 97, and 96 percent of the variation in soybean imports, respectively.

### Soy oil imports

The estimated equation for soy oil importers in Asia explains 87 percent of the variation in imports over the 1960-1974 period (Table 38). The estimated coefficient on U.S. soybean price has the expected sign but is not significant at the 10 percent level. The second largest importer of soy oil is Northern Europe. The estimated equation for Northern Europe explains 80 percent of the variation in soy oil imports and has the expected sign on the estimated price variable. Neither estimated coefficient is statistically significant at the 10 percent level or higher. Of the remaining eight importing regions, seven have the wrong sign on the price variable.

Table 37. Soybean import equations for the 10 importing regions, 1960-1974

| Region | Average 1960-1974 soybean imports (thousand metric tons | Estimation technique | Constant | U.S. soybean export price | TIME | ρ | $R^2$ | d | S.E.E. |
|---|---|---|---|---|---|---|---|---|---|
| Canada | 386 | OLS | 536.26 | -26.070 | -2.775 | | .13 | 1.78 | 70.0 |
| | | | | (30.070) | (4.518) | | | | |
| Central America | 72 | OLS | -274.33 | 55.944 | 9.476 | | .40 | 1.72 | 88.4 |
| | | | | (37.953 | (5.702) | | | | |
| South America | 51 | OLS | -86.97 | 15.690 | 7.700 | | .88 | 1.74 | 15.6 |
| | | | | (6.681) | (1.003) | | | | |
| Northern Europe | 3,933 | ALS | -3,183.62 | 751.477 | 420.444 | .394 | .95 | 1.80 | 503.3 |
| | | | | (286.009) | (85.417) | (.285) | | | |
| Southern Europe | 1,320 | OLS | 520.97 | -172.331 | 204.028 | | .94 | 2.19 | 230.2 |
| | | | | (98.859) | (14.853) | | | | |
| Eastern Europe | 242 | OLS | -246.65 | 89.519 | 7.023 | | .06 | 2.28 | 327.2 |
| | | | | (140.507) | (21.111) | | | | |
| Africa | 9 | OLS | -15.01 | 5.993 | -.636 | | .54 | 2.10 | 3.9 |
| | | | | (1.684) | (.253) | | | | |
| Asia | 785 | ALS | -29,556.50 | -20.023 | 2,075.780 | .994 | .97 | 1.62 | 81.9 |
| | | | | (55.480) | (76,857.252) | (.224) | | | |
| Japan | 2,311 | OLS | 1,199.30 | -95.373 | 196.532 | | .96 | 1.90 | 183.0 |
| | | | | (78.570) | (11.805) | | | | |
| Oceania | 11 | OLS | -32.67 | 6.409 | .762 | | .32 | 2.05 | 9.5 |
| | | | | (.4068) | (.611) | | | | |



Table 38. Soy oil import equations for the 10 importing regions, 1960-1974

| Region | Average 1960-1974 soybean imports (thousand metric tons | Estimation technique | Constant | U.S. soybean export price | TIME | ρ | $R^2$ | d | S.E.E. |
|---|---|---|---|---|---|---|---|---|---|
| Canada | 16 | ALS | -6.569 | 2.507 | 1.18 | .174 | .57 | 1.65 | 5.4 |
| | | | | (2.602) | (.540) | (.334) | | | |
| Central America | 34 | OLS | -63.028 | 12.088 | 4.801 | | .69 | 1.61 | 18.8 |
| | | | | (8.056) | (1.210) | | | | |
| South America | 58 | ALS | -79.657 | 16.399 | 6.935 | .475 | .86 | 1.93 | 14.8 |
| | | | | (9.985) | (3.125) | (.389) | | | |
| Northern Europe | 151 | ALS | -24.808 | -25.940 | 32.958 | .632 | .80 | 1.44 | 51.7 |
| | | | | (39.187) | (21.093) | (.327) | | | |
| Southern Europe | 90 | ALS | -26.574 | 36.632 | -8.419 | .322 | .59 | 1.92 | 45.3 |
| | | | | (24.934) | (6.482) | | | | |
| Eastern Europe | 58 | OLS | 4.09 | 8.925 | 1.330 | | .05 | 1.76 | 46.3 |
| | | | | (19.880) | (2.987) | | | | |
| Africa | 72 | OLS | 11.88 | 4.714 | 4.626 | | .50 | 1.92 | 23.5 |
| | | | | (10.093) | (1.517) | | | | |
| Asia | 261 | ALS | 121.519 | -15.178 | 27.065 | .607 | .87 | 1.27 | 51.1 |
| | | | | (41.556) | (9.864) | | | | |
| Japan | 2 | ALS | -21.751 | 3.985 | .591 | .153 | .59 | 1.42 | 3.8 |
| | | | | (2.119) | (.400) | | | | |
| Oceania | 7 | OLS | 10.99 | -1.779 | .526 | | .59 | 2.17 | 1.96 |
| | | | | (.840) | (.126) | | | | |

## Soy meal imports

Northern Europe is the major world importer of soy meal. For the 1960-1974 period, Northern Europe imported more than 70 percent of the world imports of soy meal. The estimated soy meal import equation explains 97 percent of the variation in soy meal imports by Northern Europe. The estimated equation has the expected sign for the U.S. soybean export price variable, but the estimated coefficient is not statistically significant at the 10 percent level or higher. The estimated coefficient on time is positive, indicating that imports are growing over time, and significant at the 1 percent level (Table 39).

The next largest soy meal importers are Eastern Europe, Southern Europe, and Canada. The estimated equation for these three regions does not have the correct sign on U.S. soybean export price.



Table 39. Soy meal import equations for the 10 importing regions, 1960-1974

| Region | Average 1960-1974 soy meal imports (thousand metric tons) | Estimation technique | Constant | U.S. soybean export price | TIME | ρ | $R^2$ | d | S.E.E. |
|---|---|---|---|---|---|---|---|---|---|
| Canada | 217 | OLS | 191.87 | 1.072<br>(11.943) | 2.486<br>(1.794) | | .16 | 1.92 | 27.8 |
| Central America | 50 | ALS | -72.00 | 12.676<br>(11.427) | 7.375<br>(3.333) | .458<br>(.354) | .76 | 1.80 | 19.6 |
| South America | 12 | OLS | -96.99 | 20.673<br>(8.707) | 1.193<br>(1.308) | | .44 | 1.95 | 20.3 |
| Northern Europe | 2,632 | ALS | 283.06 | -19.392<br>(122.510) | 300.313<br>(21.887) | .205<br>(.304) | .97 | 1.66 | 228.1 |
| Southern Europe | 281 | OLS | -1,207.30 | 217.020<br>(60.915) | 54.892<br>(9.152) | | .86 | 2.01 | 141.8 |
| Eastern Europe | 385 | ALS | -163,160.75 | 185.028<br>(59.249) | 10,915.487<br>(955,506.209) | .998<br>(.145) | .98 | 1.88 | 90.8 |
| Africa | 3 | ALS | -6.239 | .729<br>(.610) | .682<br>(.141) | .400<br>(.240) | .90 | 2.26 | 1.1 |
| Asia | 46 | ALS | 2.917 | -3.205<br>(14.403) | 7.119<br>(2.765) | .194<br>(.331) | .54 | 1.79 | 29.7 |
| Japan | 50 | ALS | -275.76 | 55.271<br>(19.143) | 7.346<br>(2.825) | -.331<br>(.315) | .59 | 1.94 | 53.5 |
| Oceania | 16 | OLS | 32.64 | -7.599<br>(2.626) | 2.452<br>(.394) | | .76 | 2.01 | 6.1 |

## VII. SIMULATION MODEL

A recursive econometric simulation model is used to evaluate the long range consequences of alternative levels of U.S. wheat and feed grain exports on U.S. agriculture. The model used is the CARD simulation model reported by Reynolds, Heady, and Mitchell [19]. The model depicts the sequential nature of the agricultural production cycle. It is an annual model which allows the time path for each endogenous variable to be generated by iterating the model for each year in the projection period. Alternative sets of futures for agriculture can be simulated by different sets of exogenous variables.

The simulation model is composed of five commodity submodels representing the major categories of agriculture. Commodity submodels are included for the livestock, feed grains, wheat, soybeans, and cotton sectors at the national level. Other commodities are included in an exogenous category. Within each commodity submodel agricultural production is represented by estimated econometric equations.

Each commodity submodel is divided into three categories corresponding to the planning, planting, and harvesting decisions in the production cycle. These three categories are referred to as the pre-input, input, and output sections of each commodity submodel. The pre-input section determines the levels of such fixed resources as machinery available, new machinery to be purchased, stock of productive assets, and the number of acres intended for harvest. Levels of the variable inputs such as



fertilizer, seed, machinery, and labor requirements are determined in the input section, based on information from the pre-input section and from previously determined variables. The output section provides the production, commodity price, and income estimates resulting from the resource levels committed in the pre-input and output sections.

The aggregate simulation model (Figure 1) results from combining the submodels. Interaction among the commodity submodels allows a change in one to have both direct and indirect impacts on the entire system. The livestock sector interacts directly with the feed grain and soybean sector through feed prices. Crop submodels also interact as changes in relative crop prices cause acreage to shift to more profitable crops. The feed grain, livestock, soybean, cotton, and wheat sectors form a network of recursive equations with dynamic interaction and feedbacks among the submodels. The U.S. sector aggregates the commodity submodels and exogenously determine values for other crops. National variables include total acres, farm assets, input use, gross farm income, farm production expenses, and net farm income.

The simulation model allows the time path for endogenous variables, such as production or net income, to be generated by iterating the model subject to a set of exogenous variables. Sixty-eight exogenous variables are used in the model. Exogenous variables include levels of U.S. exports and imports, aggregate crop land restrictions, levels of yields for the crop submodels, and domestic demand levels for commodities.

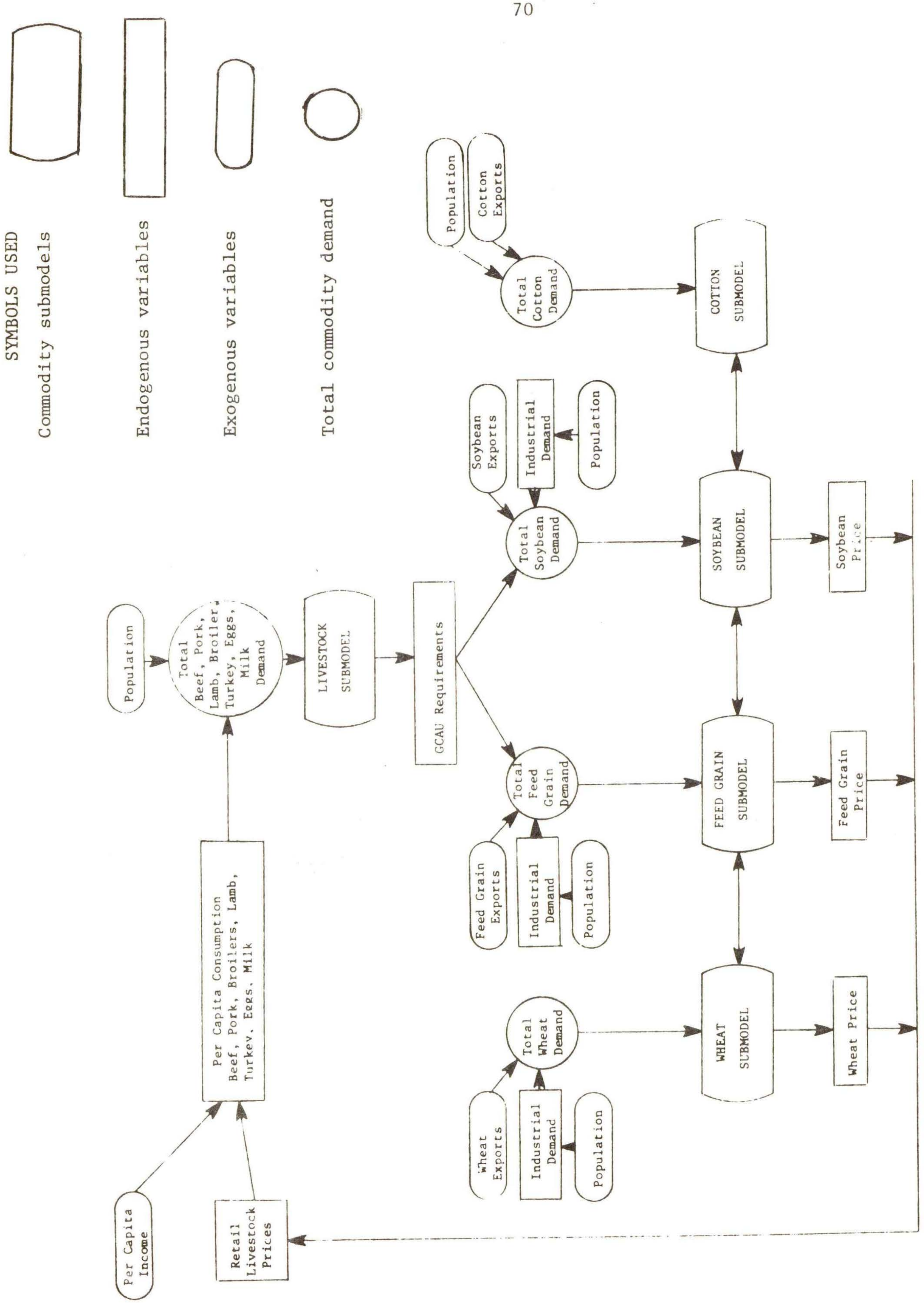


Figure 1. Aggregate simulation model of the agricultural sector.



Commodity Demands

Domestic demand for agricultural commodities is composed of agricultural demand and industrial demand. Commodities used for livestock feed and seed represent agricultural demand. Commodities used for cereals, flours, beverages (malt and distilled liquors), other food products, and industrial uses not for consumption (such as distilled spirits) can be classified as industrial demand. Industrial demand also includes the export of commodities in processed form [8].

Agricultural Demand

The demand for agricultural commodities to be used as seed is estimated from historical relationship between production and seed requirements. Seed demand is not estimated as a price responsive relationship, but instead is assumed to maintain the same ratio of seed demand to production in the future as the average over the last five years.

Livestock feed demand is estimated as a derived demand based on consumer demand for livestock for meat, poultry, dairy products, and livestock raised for nonconsumptive uses (horses, mules, and domestic pets). Per capita consumption of meat and poultry is estimated as a function of retail prices and per capita disposable income. Equations used to determine per capita consumption are available in [19]. Per capita consumption levels obtained for each year of the simulation are converted into grain-consuming animal units (GCAU) and are used to determine the feed units required to produce the corresponding quantities of livestock and poultry. Per capita consumption levels for dairy products and eggs are also projected for each time period. The feed units required to support their production are estimated accordingly. Feed unit requirements of all livestock categories are summed to estimate total livestock feed demand.

Per capita consumption levels (Table 40) of beef, pork, poultry, lamb, and mutton are functions of both per capita disposable income and commodity retail prices. Estimates of per capita disposable income are obtained from the OBERS projections up to 1985 and are presented with projected population in Table 41 [32]. Beyond 1985 a constant $4,000 per capita income is used in the demand estimates, assuming that the income elasticity of demand for these products is zero after a per capita income of $4,000. Retail livestock prices are calculated as a function of farm prices. In turn, farm prices are determined from the grain costs estimated in the simulation model. The livestock finishing feed price equation developed by Rahn [16] is used to develop a relationship between feed costs, livestock farm prices, and retail livestock prices. The livestock demand equations use these retail prices, along with disposable income, to determine consumption of livestock. Using this system as the estimated price of grain rises, the farm price of livestock also increases, causing retail prices to advance and consumption to decline.

## Industrial Demand

Industrial demands for feed grains, wheat, soybeans, and cotton are estimated on the basis of historical trends. Demand for industrial uses includes corn for cereal, dry processing, wet processing, and alcohol; oats for cereal; barley for malt and food products; wheat for flour and other uses; soybeans for soybean meal; and cottonseed for cottonseed meal.



Table 40. Per capita consumption levels for selected agricultural products in 1972

| Commodity | Actual[a] 1972 |
|---|---|
| Beef and veal (lbs. carc. wt.) | 118.30 |
| Pork (lbs. carc. wt.) | 67.4 |
| Broilers (lbs. ready to cook wt.) | 43.0 |
| Turkeys (lbs. ready to cook wt.) | 9.10 |
| Lamb and mutton (lbs. carc. wt.) | 3.30 |
| Dairy products (lbs. milk equiv.) | 560.00 |
| Eggs (number) | 307.00 |
| Wheat (bushels) | 2.50 |
| Cotton (lbs.) | 18.68 |

[a]SOURCES [23,24]

Table 41. Assumed population and OBERS per capita disposable income projections used to estimate livestock demands

| YEAR | POP | PCDY |
|---|---|---|
| | (Millions) | (1957-59 dollars) |
| 1975 | 213 | $3023 |
| 1980 | 223 | 3495 |
| 1985 | 232 | 3976 |
| 1990 | 242 | 4000 |
| 1995 | 253 | 4000 |
| 2000 | 264 | 4000 |

## Crop Yields

Crop yields are defined as the average crop production per crop acre planted and intended for harvest. Acres intended for harvest include estimates for harvested acreage plus an adjustment to include acreage abandoned due to flood, drought, and other natural disasters [17]. Planted acres intended for harvest are used to represent the planting decisions of farmers and are closely tied to their input decisions.

Per acre yields for crops in the model are projected on the basis of time series data. Yield equations for feed grains, wheat, and soybeans were estimated using data over the period 1930-72. All yields equations were estimated with an autoregressive model on time. The yield projections obtained from these equations (Table 42) are denoted as trend yield projections. These projections represent the yields expected if we assume that historical trends in technology, weather, and input use continue.

Table 42. Crop yields per acre projected to the year 2000[a]

| | Actual 1969-72 | Estimated 1985 | Estimated 2000 |
|---|---|---|---|
| Trend yields | | | |
| Feed grains (tons/acre) | 1.84 | 2.35 | 2.96 |
| Wheat (bu./acre) | 31.0 | 35.2 | 42.4 |
| Soybeans (bu./acre) | 27.0 | 31.2 | 36.0 |

[a]Crop yields per acre are calculated by dividing total production by acreage. Acreage figures are adjusted to exclude land used for forage, silage, or hay; but they do include crop acreages that are abandoned due to damage caused by floods, drought, insects, etc. [17]. The actual yield figures for 1969-72 will be lower than figures which are calculated using unadjusted yield figures.

### Cropland Base

Cropland available in the simulation model for wheat, feed grains, soybeans, and cotton is 250 million acres. The maximum acreage planted to the above crops between 1949 and 1974 was 241 million acres.



## VIII. SIMULATION RESULTS FOR U.S. AGRICULTURE

Simulation results for nine alternative levels of U.S. wheat and feed grain exports are now presented. Each simulation generates annual estimates for all endogenous variables for each of the years from 1975 to 2000. This allows the impacts of alternative levels of exports to be observed on the endogenous variables such as commodity prices, production levels, acreage requirements, net agricultural income, and production expenses for U.S. agriculture. Simulation results are presented for 1985 and 2000 in Tables 42-49.

### Simulation Alternatives

The nine simulation alternatives are grouped into three basic categories. The first category is the Trend Export Simulation which corresponds with historical trend levels of wheat, feed grain, and soybean exports. This simulation serves as the benchmark for comparisons with other export alternative simulations. The second category is the Market Shares Alternative. This category includes four simulations representing alternative assumptions about U.S. agriculture's share of world export markets. The third category is the Grain Production Alternatives which include four simulation models which explore alternative assumptions about grain production in importing countries.

Trend Exports

Simulation I. Projected exports of wheat, feed grains, and soybeans follow historical trend levels. This alternative supposes no major structural changes in import policies of the major importing nations, no major changes in world rates of growth in grain production, and no major changes in the relative share of the world export market which the U.S. captures. The alternative also serves as a basis for comparison with other alternatives.

Market Share Alternatives

Simulation II. The U.S. share of the world export for wheat and feed grains increases 20 percent over the period from 1975 to 2000. This increase does not occur in a single year but is spread over 26 years with a cumulative increase of 20 percent by 2000. The U.S. wheat export market share increases from the 1960-74 average of 42.7 to 51.2 percent. The increase is set at .328 percent per year. The U.S. feed grain market share increases from the 1960-74 average of 57.1 to 68.52 percent of world exports. The increase occurs at the rate of .439 percent per year. Soybean exports remain at trend levels. Cotton exports are held constant at 3.4 million bales per year.

Simulation III. The U.S. share of the world export market for wheat and feed grains is assumed to decrease 20 percent over the period from 1975 to 2000. This decrease is spread over



26 years with a cumulative increase of 20 percent by 2000. The U.S. wheat market share decreases from the 1960-74 average of 57.1 percent to 45.68 percent. This decrease accumulates over the 26 year period at the rate of .439 percent per year. Soybean exports remain at trend levels. Cotton exports are held constant at 3.4 million bales per year.

Simulation IV. The U.S. share of the world export market for wheat and feed grains increases by 40 percent over the period from 1975-2000. The U.S. wheat market share increases from 42.7 to 59.78 percent of world exports. The U.S. share of world feed grain exports increases from the historical average of 57.1 percent to 79.97. Soybean exports remain at trend levels. Cotton exports are held constant at 3.4 million bales per year.

Simulation V. The U.S. share of the world export market for wheat and feed grains decreases 40 percent over the period from 1975-2000. The U.S. wheat market share is assumed to decrease from 42.7 to 25.62 percent of world exports at the rate of .657 percent per year. The U.S. feed grain exports would decrease from 57.1 to 34.26 percent of world exports at the rate of .878 percent per year. Soybean exports remain at trend levels. Cotton exports are held constant at 3.4 million bales per year.

Grain Production Alternatives

Simulation VI. This alternative assumes a 20 percent slower than trend rate of increase in wheat and feed grain production in all importing countries. The U.S. market share of wheat and feed grain exports is assumed to remain constant at the 1960-74 average of 42.7 and 57.1 percent respectively. Soybean exports remain at trend levels. Cotton exports are held constant at 3.4 million bales per year.

Simulation VII. This alternative assumes a rate of increase in wheat and feed grain production 20 percent faster than trend in all importing countries. The U.S. market share of world wheat and feed grain exports is assumed to remain constant at the 1960-74 average of 42.7 and 57.1 percent respectively. Soybean exports remain at trend levels. Cotton exports are held constant at 3.4 million bales per year.

Simulation VIII. This alternative assumes production of wheat and feed grains will grow at less than historical rates in the LDC's. Production is increased at 50 percent of the trend growth rate. The U.S. market share of world wheat and feed grain exports is assumed to remain constant at the 1960-74 average of 42.7 and 57.1 percent respectively. Soybean exports remain at trend levels. Cotton exports are held constant at 3.4 million bales per year.

Simulation IX. It assumes production in the centrally planned countries grows at only 50 percent of the historical growth rate. This region includes the USSR and Eastern Europe. Mainland China was not included in this group because imports could not be explained and are held constant at 1960-74 average levels. The U.S. market share of wheat and feed grain exports is assumed to remain constant at the 1960-74 average of 42.7 and 57.1 percent respectively. Soybean exports remain at trend levels. Cotton exports are held constant at 3.4 million bales per year.



## Trend Export Simulation

Simulated results for the Trend Export Simulation are shown under Simulation I in Tables 43-49. Wheat, feed grain, and soybean export demands are projected to increase to 1,570 million bushels of wheat, 88.6 million tons of feed grains, and 1,478 million bushels of soybeans. These export demands represent increases of 40 percent, 140 percent, and 147 percent respectively over the 1972-74 average exports. The figures represent the maximum possible U.S. exports under the assumptions of Simulation I. The actual level of exports indicated by the simulation model are shown in Table 45. Wheat and feed grain exports are equal to export potentials for both 1985 and 2000. However, soybean exports are less than the export potential for both 1985 and 2000. This situation indicates that domestic and foreign crop demands exceed the productive capacity of U.S. agriculture under this simulation alternative. When this situation occurs in the simulation model, exports are reduced to production in excess of domestic demands.

Table 43. Simulation estimates of gross farm income, farm production expenses, and net farm income for each simulation alternative with 1969-72 averages for comparison (in 1972 real dollars)

| Model | Actual[a] 1969-72 | 1985 | 2000 |
|---|---|---|---|
| | | Gross farm income | (Million of 1975 dollars) |
| I | 83,539 | 104,023 | 132,243 |
| II | | 104,902 | 144,462 |
| III | | 103,841 | 123,169 |
| IV | | 104,506 | 149,493 |
| V | | 102,752 | 120,526 |
| VI | | 105,358 | 142,811 |
| VII | | 102,941 | 123,087 |
| VIII | | 105,513 | 140,589 |
| IX | | 105,550 | 140,860 |
| | | Production expenses | (Million of 1975 dollars) |
| I | 63,538 | 73,082 | 94,028 |
| II | | 73,600 | 96,534 |
| III | | 72,710 | 91,868 |
| IV | | 74,138 | 97,821 |
| V | | 72,305 | 91,106 |
| VI | | 73,666 | 96,273 |
| VII | | 72,592 | 93,244 |
| VIII | | 73,458 | 95,735 |
| IX | | 73,463 | 95,774 |
| | | Net farm income | (Millions of 1974 dollars) |
| I | 20,001 | 30,941 | 38,215 |
| II | | 31,302 | 47,928 |
| III | | 31,131 | 31,301 |
| IV | | 30,368 | 51,672 |
| V | | 30,447 | 29,420 |
| VI | | 31,692 | 46,538 |
| VII | | 30,349 | 29,843 |
| VIII | | 32,055 | 44,854 |
| IX | | 32,087 | 45,086 |

[a]SOURCE: [4]



Table 44. Simulated and actual prices received by farmers for wheat, feed grains, and soybeans expressed in constant 1972 dollars

| Simulation | Wheat Actual[a] 1969-72 | Wheat 1985 | Wheat 2000 | Feed grains Actual[ab] 1969-72 | Feed grains 1985 | Feed grains 2000 | Soybeans Actual[a] 1969-72 | Soybeans 1985 | Soybeans 2000 |
|---|---|---|---|---|---|---|---|---|---|
| | | | | ($ per bushel) | | | | | |
| I | 1.83 | 1.99 | 2.47 | 1.56 | 2.52 | 2.56 | 4.01 | 4.80 | 5.91 |
| II | | 2.06 | 2.95 | | 2.61 | 3.06 | | 4.86 | 6.83 |
| III | | 2.10 | 1.96 | | 2.50 | 2.47 | | 4.75 | 4.98 |
| IV | | 2.01 | 3.15 | | 2.68 | 3.29 | | 4.81 | 7.08 |
| V | | 2.02 | 1.99 | | 2.47 | 2.08 | | 4.70 | 5.06 |
| VI | | 2.02 | 2.83 | | 2.92 | 3.15 | | 4.84 | 6.69 |
| VII | | 2.02 | 2.05 | | 2.33 | 2.35 | | 4.72 | 5.15 |
| VIII | | 2.05 | 2.79 | | 2.92 | 3.13 | | 4.89 | 6.50 |
| IX | | 2.05 | 2.79 | | 2.95 | 3.20 | | 4.89 | 6.52 |

[a]SOURCE: [3]

[b]Corn price only.

Table 45. Estimated model exports for each simulation alternative with the 1969-72 average for comparison

| Simulation | Actual[a] 1969-72 | Wheat 1985 | Wheat 2000 | Feed grain Actual[b] 1969-72 | Feed grain 1985 | Feed grain 2000 | Soybeans Actual[c] 1969-72 | Soybeans 1985 | Soybeans 2000 |
|---|---|---|---|---|---|---|---|---|---|
| | | (Million bushels) | | | (Million tons) | | | (Million bushels) | |
| I | 781.5 | 1177.2 | 1569.7 | 25.7 | 57.1 | 88.6 | 439.4 | 808.4 | 1223.4 |
| II | | 1276.8 | 1676.4 | | 62.0 | 88.7 | | 789.7 | 1134.7 |
| III | | 1077.6 | 1255.8 | | 52.3 | 70.9 | | 813.7 | 1262.7 |
| IV | | 1376.4 | 1702.9 | | 66.8 | 91.6 | | 805.6 | 1111.2 |
| V | | 978.1 | 942.0 | | 47.5 | 53.2 | | 830.4 | 1354.0 |
| VI | | 1377.0 | 1676.5 | | 62.5 | 86.6 | | 806.3 | 1154.1 |
| VII | | 914.3 | 1155.1 | | 51.8 | 80.1 | | 829.8 | 1326.0 |
| VIII | | 1375.8 | 1676.0 | | 58.8 | 85.1 | | 798.7 | 1159.4 |
| IX | | 1378.5 | 1675.6 | | 58.8 | 85.1 | | 799.2 | 1157.2 |

[a]SOURCE: [7]

[b]SOURCE: [6]

[c]SOURCE: [5]



Table 46. Estimated export potential for each simulation alternative with 1969-72 average for comparison

| Simulation | Actual[a] 1969-72 | Wheat 1985 | Wheat 2000 | Feed grains Actual[b] 1969-72 | Feed grains 1985 | Feed grains 2000 | Soybeans Actual[c] 1969-72 | Soybeans 1985 | Soybeans 2000 |
|---|---|---|---|---|---|---|---|---|---|
| | | (Million bushels) | | | (Million tons) | | | (Million bushels) | |
| I | 781.5 | 1177.2 | 1569.7 | 25.7 | 57.1 | 88.6 | 439.4 | 906.7 | 1477.8 |
| II | | 1276.8 | 1883.5 | | 62.0 | 106.3 | | 906.7 | 1477.8 |
| III | | 1077.6 | 1255.8 | | 52.3 | 70.9 | | 906.7 | 1477.8 |
| IV | | 1376.4 | 2197.4 | | 66.8 | 124.1 | | 906.7 | 1477.8 |
| V | | 978.1 | 942.0 | | 47.5 | 53.2 | | 906.7 | 1477.8 |
| VI | | 1440.1 | 1984.2 | | 62.5 | 97.1 | | 906.7 | 1477.8 |
| VII | | 914.3 | 1155.1 | | 51.8 | 80.1 | | 906.7 | 1477.8 |
| VIII | | 1444.2 | 1990.6 | | 58.8 | 91.3 | | 906.7 | 1477.8 |
| IX | | 1473.2 | 2036.4 | | 58.8 | 91.3 | | 906.7 | 1477.8 |

[a]SOURCE: [7]

[b]SOURCE: [6]

[c]SOURCE: [5]

Table 47. Simulated production of selected commodities for each simulation alternative with the 1969-72 average for comparison

| Simula-tion | Actual[a] 1969-72 | Wheat 1985 | Wheat 2000 | Feed grain Actual[a] 1969-72 | Feed grain 1985 | Feed grain 2000 | Soybeans Actual[a] 1969-72 | Soybeans 1985 | Soybeans 2000 |
|---|---|---|---|---|---|---|---|---|---|
| | | (Million bushels) | | | (Million tons) | | | (Million bushels) | |
| I | 1489.2 | 1901.9 | 2468.1 | 186.3 | 274.3 | 335.6 | 1179.8 | 1808.1 | 2391.0 |
| II | | 2144.6 | 2557.0 | | 274.5 | 338.0 | | 1788.9 | 2278.3 |
| III | | 2017.6 | 2260.5 | | 259.0 | 347.4 | | 1815.7 | 2439.3 |
| IV | | 2158.7 | 2584.5 | | 278.6 | 339.0 | | 1807.2 | 2246.0 |
| V | | 1773.0 | 1803.0 | | 258.7 | 310.6 | | 1833.3 | 2541.3 |
| VI | | 2201.7 | 2557.2 | | 276.1 | 336.6 | | 1806.6 | 2301.2 |
| VII | | 1728.5 | 2031.1 | | 263.5 | 336.9 | | 1832.3 | 2510.5 |
| VIII | | 2200.4 | 2551.4 | | 271.6 | 336.2 | | 1798.1 | 2311.2 |
| IX | | 2203.1 | 2556.2 | | 271.3 | 336.1 | | 1798.7 | 2308.4 |

[a]SOURCE: [22]



Table 48. Simulation model acreage intended for harvests in millions of acres for wheat, feed grains, and soybeans for 1985 and 2000 for Model I thru IX[a]

| Simula-tion | Actual[b] 1969-72 | Wheat 1985 | Wheat 2000 | Feed grain Actual[b] 1969-72 | Feed grain 1985 | Feed grain 2000 | Soybeans Actual[b] 1969-72 | Soybeans 1985 | Soybeans 2000 |
|---|---|---|---|---|---|---|---|---|---|
| | | (Million bushels) | | | (Million tons) | | | (Million bushels) | |
| I | 48.00 | 54.0 | 58.3 | 101.00 | 116.5 | 113.5 | 43.6 | 60.0 | 66.5 |
| II | | 60.9 | 60.3 | | 116.6 | 114.3 | | 57.4 | 63.3 |
| III | | 57.3 | 53.4 | | 110.0 | 117.5 | | 58.2 | 67.8 |
| IV | | 61.3 | 61.0 | | 118.3 | 114.7 | | 57.9 | 62.4 |
| V | | 50.3 | 42.6 | | 109.9 | 105.1 | | 58.8 | 70.6 |
| VI | | 62.5 | 60.4 | | 117.3 | 113.9 | | 57.9 | 63.7 |
| VII | | 49.1 | 48.0 | | 111.9 | 114.0 | | 58.7 | 69.8 |
| VIII | | 62.4 | 60.2 | | 115.2 | 113.7 | | 57.7 | 64.2 |
| IX | | 62.5 | 60.4 | | 115.2 | 113.7 | | 57.7 | 64.2 |

[a]Crop acreages figures do not include land used for forage, silage, or hay but do include crop acres abandoned due to damage caused by floods, droughts, insects, etc. See [17] for details.

[b]SOURCE: [22]

Table 49. Estimated input expenses for U.S. agriculture for the nine simulation alternatives with 1970-72 averages for comparison

| Simulation | Actual[a] 1970-72 | 1985 | 2000 |
|---|---|---|---|
| | Fertilizer and Lime | (Millions of 1975 dollars) | |
| I | 3,141 | 4,640 | 6,079 |
| II | | 4,687 | 6,739 |
| III | | 4,396 | 6,003 |
| IV | | 4,719 | 7,067 |
| V | | 4,329 | 5,245 |
| VI | | 4,716 | 6,623 |
| VII | | 4,394 | 5,759 |
| VIII | | 4,641 | 6,487 |
| IX | | 4,636 | 6,493 |
| | Seed | (Millions of 1973 dollars) | |
| I | 1,321 | 1,399 | 1,630 |
| II | | 1,423 | 1,623 |
| III | | 1,402 | 1,618 |
| IV | | 1,435 | 1,620 |
| V | | 1,378 | 1,576 |
| VI | | 1,434 | 1,624 |
| VII | | 1,377 | 1,617 |
| VIII | | 1,427 | 1,623 |
| IX | | 1,427 | 1,623 |
| | Labor | (Millions of manhours) | |
| I | | 6,204 | 5,566 |
| II | | 6,364 | 5,506 |
| III | | 6,346 | 5,586 |
| IV | | 6,380 | 5,482 |
| V | | 6,343 | 5,588 |
| VI | | 6,371 | 5,513 |
| VII | | 6,345 | 5,608 |
| VIII | | 6,361 | 5,526 |
| IX | | 6,361 | 5,525 |



Table 49. Continued.

| Simulation | Actual[a] 1970-72 | 1985 | 2000 |
|---|---|---|---|
| | Machinery | (Millions of 1973 dollars) | |
| I | 10,640 | 12,155 | 15,531 |
| II | | 12,187 | 16,380 |
| III | | 12,112 | 15,207 |
| IV | | 12,213 | 16,879 |
| V | | 12,082 | 15,091 |
| VI | | 12,257 | 16,402 |
| VII | | 12,072 | 15,255 |
| VIII | | 12,244 | 16,171 |
| IX | | 12,248 | 16,194 |
| | Real Estate | (Millions of 1975 dollars) | |
| I | 19,392 | 29,734 | 37,834 |
| II | | 29,822 | 39,720 |
| III | | 29,343 | 37,612 |
| IV | | 29,929 | 40,998 |
| V | | 29,245 | 36,616 |
| VI | | 29,918 | 39,704 |
| VII | | 29,364 | 37,432 |
| VIII | | 29,809 | 39,103 |
| IX | | 29,806 | 39,146 |
| | Fuel, Oil, and Repairs | (Millions of 1975 dollars) | |
| I | 5,942 | 7,131 | 8,655 |
| II | | 7,162 | 8,870 |
| III | | 7,131 | 8,561 |
| IV | | 7,169 | 9,001 |
| V | | 7,101 | 8,502 |
| VI | | 7,187 | 8,884 |
| VII | | 7,093 | 8,556 |
| VIII | | 7,183 | 8,827 |
| IX | | 7,185 | 8,834 |

Table 49. Continued.

| Simulation | Actual[a] 1970-72 | 1985 | 2000 |
|---|---|---|---|
| | Miscellaneous Expenses | (Millions of 1973 dollars) | |
| I | 7,348 | 9,867 | 12,967 |
| II | | 9,901 | 13,186 |
| III | | 9,827 | 12,902 |
| IV | | 9,946 | 13,356 |
| V | | 9,789 | 12,831 |
| VI | | 9,923 | 13,189 |
| VII | | 9,800 | 13,002 |
| VIII | | 9,891 | 13,095 |
| IX | | 9,891 | 13,099 |
| | Interest on Stock | (Millions of 1974 dollars) | |
| I | 3,133 | 3,555 | 4,226 |
| II | | 3,589 | 4,263 |
| III | | 3,533 | 4,122 |
| IV | | 3,636 | 4,254 |
| V | | 3,503 | 4,022 |
| VI | | 3,610 | 4,240 |
| VII | | 3,516 | 4,211 |
| VIII | | 3,574 | 4,225 |
| IX | | 3,576 | 4,224 |
| | Real Estate Tax | (Millions of 1975 dollars) | |
| I | 4,109 | 4,454 | 5,738 |
| II | | 4,471 | 6,054 |
| III | | 4,391 | 5,702 |
| IV | | 4,488 | 6,272 |
| V | | 4,371 | 5,525 |
| VI | | 4,486 | 6,053 |
| VII | | 4,392 | 5,664 |
| VIII | | 4,469 | 5,951 |
| IX | | 4,468 | 5,958 |

[a]SOURCES: [4,22]



The export levels of the trend export simulation causes commodity prices to rise throughout the simulation period. Real wheat prices increase from $1.83 in 1969-72 to $2.47 in the year 2000. Real feed grain prices (in 1972 dollars) increase from $1.56 per bushel in 1969-72 to $2.56 in 2000, and real soybean prices increased from $4.01 in 1969-72 to $5.91 in 2000. The largest price increase occurs in soybeans because of the rapid increase of export demand. This is reflected in the increased acreage of soybeans as shown in Table 48. Soybean acreages increase by 52 percent over the 1969-72 period. Wheat and feed grain acreages increase by 21 and 12 percent respectively over the same period. These relationships are also reflected in the production estimates shown in Table 47. Soybean production increases slightly more than 100 percent over the 1969-72 to 2000 period. Wheat and feed grain production increase by 66 and 80 percent respectively.

Gross farm income, production expenses, and net farm income are shown for Simulation I in Table 43. A more detailed breakdown of production expenses is included in Table 49. Gross farm income is estimated to increase from 83.5 billion dollars in 1969-72 to 132.2 billion in the year 2000. This increase of 58 percent in gross farm income is accompanied by a 48 percent increase in production expenses. The resulting net farm income increases by 91 percent over the 1969-72 to 2000 simulation period. This is an increase of 18.2 billion dollars in net farm income over the simulation period.

Production expenses by category are shown in Table 49. Fertilizer and lime expenditures for agriculture are projected to increase by 94 percent over the 1970-72 actual expenditures by year 2000. This increase is caused by higher crop prices, higher gross income, and an increasing proportion of cropland which is fertilized. Fertilizer and limestone prices were not inflated over the simulation period and are equal to 1972 levels. Seed expenses are projected to increase 23 percent over the simulation period in response to increased cropland acreage and increased cropland acreage and increased crop prices. Labor requirements of U.S. agriculture are projected to decrease by 13 percent. Expenses, interest, and depreciation for machinery is projected to increase 46 percent. Real estate expense composed of interest on land and farm buildings, depreciation, repairs, and maintenance on farm buildings, is projected to increase 46 percent. This increase is caused by greater level of machinery use since inflation is not projected in prices. (Fuel, oil, and repair prices are held constant at their 1972 levels.) Miscellaneous expenses, interest on stocks, and real estate tax are projected to increase by 76 percent, 35 percent, and 40 percent, respectively, in real terms. Again, price levels, interest rates, and tax rates are projected in 1972 real levels.

## Market Share Simulations

Four simulations explore alternative U.S. shares of the world market for wheat and feed grains. The results are compared with the Trend Export Simulation of Simulation I. Simulations II and III explore respectively the effects of increased and decreased market share by 20 percent over 1975 in the 2000 simulation year. The total increase and decrease are assumed to occur in equal increments per year over the simulation period. Simulations IV and V assume a 40 percent increase and decrease, respectively, in market share.



The levels of export demand of Simulation I, combined with domestic demand, requires U.S. agriculture to use 242 million acres of cropland in 1985 and exhausts the land base in 1990. The 20 and 40 percent increase in market shares for wheat and feed grains, Simulations II and IV, respectively, exhaust the land base in 1986 and 1984, respectively. The decreased market shares in Simulation III exhaust the land base in 2000. Simulation V, a decrease in the U.S. share of world wheat and feed grains exports by 40 percent by the year 2000, does not exhaust the land base during the simulation period. Four of the five simulations require U.S. agriculture to produce at full production between the mid-1980s and 1990. Only Simulation V, a 40 percent decreased share of world export markets by the year 2000, does not fully exhaust the productive capacity of U.S. agriculture.

The larger share of the international wheat and feed grain exports shown by Simulation II and Simulation IV cannot be satisfied under the specifications of the simulation model. These higher export demands cause acreage to increase to the cropland limit of 250 million acres in 1986 and 1984 respectively. Crop prices, in 1972 real terms, rise considerably by the year 2000. Real wheat prices increase from $1.83 in 1969-72 to $2.06 and $2.01 in 1985 and $2.95 and $3.15 in 2000 for Simulation II and Simulation IV, respectively. Feed grain prices increase from $1.56 in 1969-72 to $2.61 and $2.68 in 1985 and $3.05 and $3.29 in 2000 for Simulation II and Simulation IV, respectively. Feed grain prices increase from $1.56 in 1969-72 to $2.61 and $2.68 in 1985 and $3.06 and $3.29 in 2000 for Simulation II and Simulation IV, respectively. Soybean prices increase from $4.01 in 1969-72 to $4.81 in 1985 and $6.83 and $7.08 in 2000 for Simulation II and Simulation IV, respectively.

Increased commodity prices and greater acreages combine to increase gross farm income. By 1985, projected gross income to agriculture is expected to increase by 25 percent over the 1969-72 level for both Simulation II and Simulation IV. By 2000, the gross income is projected to increase by 73 percent for Simulation II and 79 percent for Simulation IV. Net farm income is projected to increase 140 and 158 percent for Simulation II and Simulation IV, respectively, by the year 2000.

The decreased market shares assumed by Simulation III and Simulation V result in reduced prices, incomes, and resource use. Simulation III, a 20 percent reduction in wheat and feed grain market shares by 2000, causes wheat prices to increase to only \$1.96 by 2000. This price is only 7 percent above the 1969-72 average of \$1.83. Alternative V causes wheat price to increase 9 percent to \$1.99. The slightly higher wheat price in Simulation V is caused by the relationship of exports of wheat and feed grains to total consumption. Since a larger share of U.S. wheat production than feed grain production is exported, the 40 percent reduction in market share wheat demand is reduced more rapidly than is feed grain demand. Table 48 shows that wheat acreage for Simulation V decreases 27 percent over Simulation I. Feed grain acreage decreases only 7 percent for the same period. The simulation model causes a supply overreaction and creates a temporary price disequilibrium. This disequilibrium would be corrected if the model were extended over more years.

Gross and net incomes for Simulation III and Simulation V show the effects of lower alternative export levels and market shares. Net income in 2000 is \$31.3 billion for Simulation III and \$29.4 billion for Simulation V. Simulation I, the Trend Export Simulation, has a projected net



farm income of \$38.2 billion. Consequently, the 20 percent reduction in exports of wheat and feed grains by 2000 reduces net farm income by 23 percent. Gross income is reduced by 7 percent and production expenses decrease by only 2 percent. Therefore, a relatively small change in production expenses causes net income to change significantly more than gross income changes.

## Grain Production Simulations

Grain production historically has been a major determinant of the demand for grain imports. During the decade of the 1970s, grain production had increased variability because of climatic conditions. This pattern of world production brings forward the question of the effects alternative production levels might have on world demand for grain imports and on U.S. agriculture. The four simulations in this section address this question by exploring four alternative growth rates of grain production in the importing nations of the world. Simulation VI and Simulation VII change the rate of growth of wheat and feed grain production in all importing nations. These changes are then evaluated by observing their impacts on the model variables. Simulation VIII and Simulation IX consider changes in production in specific world regions. Simulation VIII assumes a 50 percent decrease in the growth rate of wheat and feed grain production in the less developed countries. Simulation IX assumes a 50 percent reduction in the growth rate of wheat and feed grain production in the centrally planned countries.

Commodity prices shown in Table 44 indicate that the rate of growth in world grain production is vitally important to U.S. agriculture.

Simulation VI assumes a growth rate 20 percent slower than trend in wheat and feed grain production by all importing nations. Simulation VII assumes a 20 percent faster rate of growth. The accelerated growth rates of Simulation VII cause real wheat price to be $2.05 in 2000. This compares with $2.47 under the projected trend growth rates of Simulation I, and $2.83 for the decreased growth rates assumes in Simulation VI. Feed grain prices show similar differences. The increased growth rates of Simulation VII cause feed grain price to equal only $2.35 per bushel in 2000. The trend growth rates of Simulation I result in a feed grain price of $2.56 in 2000 and the decreased growth rates of Simulation VI cause feed grain prices to increase to $3.15 by the year 2000. Soybean prices for Simulation VII are $5.15 per bushel in 2000 compared with $5.91 and $6.69 for Simulation I and Simulation VI respectively. These figures indicate a substantial reduction in commodity prices, in 1972 real terms, would accompany accelerated growth rates for wheat and feed grain production in the importing nations. Conversely, reduction in growth rates by 20 percent for wheat and feed grains in the importing countries (VII) would raise U.S. wheat, feed grains, and soybean real prices by 15, 23, and 13 percent respectively by the year 2000.

Reduced growth rates for wheat and feed grain production in less developed countries and the centrally planned countries are shown by Simulation VIII and Simulation IX, respectively. A reduction in the projected growth rate by 50 percent for these regions would lead to commodity prices which are higher than projected under the trend growth rates of Simulation I. Table 44 indicates that either of the assumptions (Simulation VIII and Simulation IX) would have almost identical effects on



commodity prices. Wheat prices are 13 percent above the levels of Simulation I in 2000. Feed grain prices are 22-25 percent higher and soybean prices would be 10 percent greater than for Simulation I.

Net farm income, gross farm income, and production expenses, in 1972 dollars, are shown for the grain production simulations in Table 43. The higher commodity prices caused by reduced growth rates of wheat and feed grain production are reflected in gross farm income and net farm income. The net farm income of Simulation VI and Simulation VII, a 20 percent decrease and 20 percent increase in production growth rates for wheat and feed grains respectively, result in net farm income of 46.5 and 29.8 billion dollars respectively in 2000. These figures compare with a net farm income of 38.2 billion dollars for the trend estimates of Simulation I. Simulation VIII and Simulation IX produce an estimated 44.9 and 45.1 billion dollars of net farm income in 2000.

Additional information is presented in Tables 43-49 for each of the simulation models.

## SUMMARY OF SIMULATION RESULTS

This study summarizes recent trends in world grain production and trade. It then explains the general world commodity markets surrounding wheat, feed grains and soybeans. Individual countries are then grouped into world regions. Import demands in each of these world regions are estimated for wheat, feed grains, and soybeans. Demand projections are based on domestic supplies, U.S. export prices, time or other variables which can be specified logically and provide statistically significant or reasonable results. Finally, production is projected for these world regions. These demand and production data then are used with an econometrically based simulation model to evaluate nine alternative futures for U.S. exports, agriculture and farm income.

The nine simulations explored a number of possible scenarios for agricultural exports. Simulation I represents ongoing trends for U.S. exports of wheat, feed grains, and soybeans. It assumes no major structural changes in import policies of the importing nations; no major changes in rates of growth in production of wheat, feed grains, and soybeans in importing nations; and no major changes in the relative share of the world export market which the U.S. captures. It also assumes moderate growth rates of U.S. population and agricultural productive capabilities. Based on these assumptions, the impacts on U.S. agriculture are simulated for the 1975 to 2000 period using an annual recursive model. The other eight simulations explore alternative assumptions about developments in



international export markets. The combined results from the simulations provide some notion of the ability of U.S. agriculture to satisfy both these levels of export demand and domestic demand requirements.

From Simulation I, domestic and foreign crop demands are projected to exceed the productive capacity of U.S. agriculture at the prices specified by the simulation model. Demands for wheat and feed grains are satisfied, but soybean production is not large enough to satisfy both domestic and foreign demand. Agriculture attains full resource use in 1990. It uses all 250 million acres available for wheat, feed grains, soybeans, and cotton. Commodity prices increase throughout the simulation period. In 1972 real price terms, wheat prices increase from $1.83 per bushel in 1969-72 to $1.99 in 1985 and $2.47 in the year 2000. Feed grain prices increase from $1.56 per bushel in 1969-72 to $2.52 in 1985 and $2.56 in 2000. Soybeans increase from $4.01 in 1969-72 to $4.80 in 1985 and $5.91 in 2000. Gross farm income is estimated to increase from 83.5 billion dollars in 1969-72 to 104 billion in 1985 and 132.2 billion in 2000. Net farm income is projected to increase from 20.0 billion in 1969-72 to 30.9 and 38.2 billion by 1985 and 2000, respectively.

Varying the U.S. market share of wheat and feed grain exports shows the importance of production and demand conditions of other major exporting nations to the resource use and returns to U.S. agriculture. If the United States were to experience a gradual decline of 20 percent in its share of wheat and feed grain exports by 2000, real prices of wheat, feed grain, and soybeans would be 21, 4, and 16 percent lower by the year 2000, respectively. A decline totaling 40 percent would lead to an even greater decrease in commodity prices. Increased shares of the international wheat and feed grain markets would cause higher commodity prices. A 20 percent larger share would cause prices to increase 19, 20, and 16 percent for wheat, feed grains, and soybeans by the year 2000, respectively.

Decreased growth rates for wheat and feed grain production in the major importing nations would also cause higher commodity prices. If the rate of growth of wheat and feed grain production were decreased 20 percent, wheat, feed grain, and soybean prices would increase by 15, 23, and 13 percent respectively by the year 2000. Parallel conclusions occur if the centrally planned countries or the less developed countries had lower rates of growth in agricultural production. Thus, the prosperity of American agriculture over the next 25 years hinges especially on the share of the export market it retains and the rate at which agricultural production increases in centrally planned and developing countries.



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