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The level and variability of agricultural exports

by

Donald Orville Mitchell

A Dissertation Submitted to the  
Graduate Faculty in Partial Fulfillment of  
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## CHAPTER I. INTRODUCTION

In 1974 agricultural products accounted for 23 percent of the value of United States exports. Total U.S. exports had a value of 97.14 billion dollars, and agricultural products accounted for 22 billion of this total (U.S. Department of Commerce, 1975). Table 1 shows exports and imports by major commodity group for selected years from 1960 to 1974. Agricultural products which have always been a major export commodity have shown the greatest increase in value over the period from 1970 to 1974. Exports of agricultural commodities increased 298 percent from 1970 to 1974 while chemicals, the commodity group with the second largest growth, increased 230 percent.

The largest import group for the 1960-1974 period was manufactured goods. However, mineral fuels and related products became a major import commodity in recent years. In 1970, imports of mineral fuels and related products had a value of 3.08 billion dollars, and in 1974 the U.S. imported 25.35 billion dollars of mineral fuels and related materials. The growth in the value of mineral fuel imports along with the overall growth in imports has created a potential problem in the U.S. balance of payments. The United States has been fortunate to have large agricultural exports to balance the petroleum imports during the last several years.

The level of agricultural exports is important to the balance of payments, and the income of the entire economy as well as representing

a major source of income for the U.S. farmer. In 1974, the value of all farm output was 103.1 billion dollars, and 21 percent of this value came from exports (U.S. Department of Commerce, 1975, p. 621). Sixty-one percent of U.S. wheat production was sold as exports in 1974. Twenty-one percent of the 1974 U.S. corn harvested for grain was exported, and 42 percent of the 1974 U.S. soybeans for beans crop was exported.

Table 1. United States imports and exports by commodity group for selected years in billions of dollars<sup>a</sup>

Commodity Group	1960	1965	1970	1974
(billion dollars)				
Exports:				
Agricultural products	4.52	6.23	7.36	22.00
Mineral fuels and related material	.84	.95	1.60	3.44
Chemicals	1.78	2.40	3.83	8.82
Machinery and transport equipment	6.99	10.14	17.88	38.19
Other manufactured goods	3.82	4.89	7.64	16.52
Other transactions	2.46	2.57	4.28	8.17
Total Exports	20.41	27.18	42.59	97.14
Imports:				
Agricultural products	4.01	3.99	5.59	9.55
Mineral fuels and related material	1.59	2.22	3.08	25.35
Chemicals	.81	.77	1.45	3.99
Machinery and transport equipment	1.47	2.95	11.17	24.71
Other manufactured goods	4.57	7.53	13.29	27.51
Other transactions	2.62	3.97	5.37	9.86
Total Imports	15.07	21.43	39.95	100.97

<sup>a</sup>Source: (U.S. Department of Commerce, 1975, pp. 630, 632, 818, and 820).

Table 2 shows the value of U.S. agricultural exports by commodity group for selected years from 1960 to 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 1974. These three commodity groups also represented 47, 49, and 48 percent of the value of agricultural exports, respectively, in 1960, 1965, and 1970. In addition to being the major export commodities in value terms, these three commodities were of similar magnitude in 1974. The value of wheat and wheat product exports was 4,739 million dollars in 1974; the value of feed grains and feed grain exports was 4,696 million dollars in 1974; and the value of soybeans and soybean product exports was 4,633 million dollars in 1974.

The relative importance of commodity groups to the total value of agricultural exports has shown several changes over the period from 1960 to 1974. Cotton and cotton product exports were 22 percent of total export receipts in 1960 but only 7 percent in 1974. Soybean and soybean products were 11 percent of total export receipts in 1960 and 22 percent in 1974. The value of wheat and wheat products exports has held relatively stable at 22 percent, and feed grains and feed grain products have increased from 12 to 22 percent between 1960 and 1974. Tobacco has shown an increase in value from 385 million dollars in 1960 to 814 million dollars in 1974. However, the value of tobacco exports relative to total exports has decreased from 8 percent to 4 percent from 1960 to 1974.

Table 2. Value of U.S. agricultural exports by commodity group for selected years 1960-1974 in millions of dollars<sup>a</sup>

Commodity	1960 <sup>b</sup>	1965 <sup>c</sup>	1970 <sup>d</sup>	1974 <sup>e,f</sup>
	(million dollars)			
Animals and animal products	429	527	817	1,760
Cotton and cotton products	996	666	407	1,444
Fruits and preparations	254	289	341	589
Nuts and preparations	17	33	60	158
Feed grains and products	546	957	1,016	4,696
Wheat and products	1,082	1,185	965	4,739
Soybeans and products	487	939	1,520	4,633
Other grains and preparations	143	227	349	909
Feeds and fodder, excluding oil cake and meal	31	33	123	280
Other oilseeds and products	60	82	112	478
Tobacco leaf	385	390	561	814
Vegetables and preparations	127	152	231	407
Total Exports for Commodity Groups	4,557	5,480	6,502	20,907

<sup>a</sup>Uninflated dollars.

<sup>b</sup>Source: (U.S. Department of Agriculture, 1965, pp. 596-598).

<sup>c</sup>Source: (U.S. Department of Agriculture, 1968, pp. 609-611).

<sup>d</sup>Source: (U.S. Department of Agriculture, 1974a, pp. 576-578).

<sup>e</sup>Source: (U.S. Department of Agriculture, 1975a, pp. 581-583).

<sup>f</sup>Preliminary.

#### Historical Levels of Agricultural Exports

Historical levels for U.S. exports of wheat, feed grains, and soybeans are shown in Table 3. Exports of all three commodities have shown increases during the 1972-1974 period. Wheat exports increased from 16.90 million metric tons in the 1971-1972 crop year to 31.75

million metric tons in the 1972-1973 crop year. This was an increase of 88 percent. Prior to the 1972-1973 crop year, wheat exports had fluctuated between 14.67 million metric tons in 1968-1969 and 23.34 million metric tons in 1965-1966. The average net wheat export over the 1960-1971 period was 19 million metric tons. Wheat exports did not show a clear trend of change over the 1960-1971 period. The export levels of 1972-1974 appear to be essentially unrelated to the prior observations.

Table 3. Net U.S. exports of wheat, feed grains, and soybeans in millions of metric tons for 1960-1974<sup>a</sup>

Crop Year	Wheat	Feed Grains <sup>b</sup>	Soybeans <sup>c</sup>
(million metric tons)			
1960/61	17.74	10.40	6.64
1961/62	19.52	14.38	5.33
1962/63	17.17	14.28	7.40
1963/64	22.99	15.86	7.50
1964/65	19.31	18.94	8.87
1965/66	23.34	24.85	9.19
1966/67	19.94	19.01	8.81
1967/68	20.18	20.02	9.98
1968/69	14.67	15.92	10.35
1969/70	16.40	18.59	10.65
1970/71	19.80	17.89	15.54
1971/72	16.90	23.68	15.79
1972/73	31.75	37.78	15.21
1973/74	30.96	39.05	15.61
1974/75	28.25	32.38	18.10

<sup>a</sup>Source: (U.S. Department of Agriculture, 1975b; FAO, 1974b).

<sup>b</sup>Measured in corn equivalent units.

<sup>c</sup>Includes soybeans and soy oil measured in bean equivalent units.

Feed grain<sup>1</sup> exports increased from 23.68 million metric tons in 1971-1972 crop year to 37.78 million metric tons in 1972-1973. This represented an increase of 60 percent. The period from 1960 to 1971 was similar for feed grain and wheat exports. Both crops had fluctuations with the highest export level in 1965-1966. Feed grain exports ranged from 10.40 million metric tons in 1960-1961 to 24.85 million metric tons in 1965-1966. Both wheat and feed grains had dramatic increases in the 1972-1973 crop year and both commodities have maintained most of this increase in the 1973-1974 and 1974-1975 crop years.

Soybean exports, unlike wheat and feed grain exports, have shown steady growth over the period from 1960-1974. The 1960-1961 export of soybeans was 6.42 million metric tons of beans and bean equivalent and the 1974-1975 export was 17.74 million metric tons. This is an increase of 276 percent. The 1972-1973 export of soybeans did not increase over the previous year. This is substantially different than the case of wheat and feed grains. Soybean exports showed their major increase in 1970-1971. In 1969-1970 soybean exports were 10.47 million metric tons and in 1970-1971 exports of soybeans increased by 45 percent to 15.19 million metric tons of beans and bean equivalent products.

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<sup>1</sup>Feed grains is the 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. One corn equivalent feed unit is defined as one bushel of corn, .9 bushels of barley, .95 bushels of grain sorghum, or .9 bushels of oats.

The changes in the export market which were first observed in 1972 are persistent in the data during the next two crop years. The three year average export of wheat for the period 1972-1974 is 30.32 million metric tons. This export level is almost 50 percent above the 1960-1971 average of 20.41 million metric tons. Feed grain exports increased from a 1960-1971 average of 17.82 to a 1972-1974 average of 36.40 million metric tons. Soybeans show less of a jump in exports, although exports grew by almost 400 percent during the 15-year period from 1960 to 1974.

#### P.L. 480 Agricultural Exports

Public Law 480 is the law that has provided the legal authority for sharing the abundant agricultural production of the United States with the developing countries that have food deficits. It was initiated in 1954 and has been in effect since that time. The Agriculture and Consumer Protection Act of 1973 extended P.L. 480 through 1977. P.L. 480 has been used to assist needy countries and to remove surplus agricultural commodities from the United States. The program has developed into a tool to stimulate economic development and carry out foreign policy (U.S. Department of Agriculture, 1974c).

P.L. 480 provides for agricultural exports under several programs. The major type of food aid provided by P.L. 480 has been the Title I-- Sales for Foreign Currencies. This provision authorized the sale of U.S. agricultural commodities under government agreement with payment in the currency of the foreign country. Currencies generated under this

provision were then used as loans or grants to the foreign country to further economic development. This type of sale accounted for nearly two-thirds of all P.L. 480 exports during the period between 1955 and 1973. A second method of food aid provided by P.L. 480 is the Title II--Foreign Donations. This provision provides the authority for the donations program of P.L. 480. Food was provided for alleviating famine, combating malnutrition, providing economic and community development, and for assisting needy persons and nonprofit school lunch and preschool feeding programs abroad. During 1955-1973, food aid donations accounted for one-fifth of all P.L. 480 shipments. The authority to barter agricultural exports was also extended under P.L. 480. Barter transactions for overseas procurement have been classified as commercial exports since 1963, and are considered equivalent to cash sales. From July 1, 1954, through June 30, 1969, barter transactions accounted for 10 percent of P.L. 480 exports and about 2 percent of total agricultural exports. The barter program was temporarily suspended in 1973 because the strong demand for U.S. exports made it necessary to continue the export incentives provided by the program.

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 has been the major commodity affected by the P.L. 480 programs. During the early 1960s, 70 percent of wheat exports were affected by P.L. 480 programs.

This percentage decreased to 30-40 percent in the late 1960s and zero in 1973-1975. Feed grains exported under P.L. 480 were approximately 10-15 percent during the decade of the 1960s, and decreased to zero in 1973-1975. Soybean exports under P.L. 480 have been zero since 1965. Prior to that time, P.L. 480 exports were less than 5 percent of total soybean exports.

Table 4. U.S. wheat 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 <sup>a</sup>	Commercial Exports <sup>b</sup>	Total U.S. Exports <sup>c</sup>
(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

<sup>a</sup>Source: (U.S. Department of Agriculture, 1974c).

<sup>b</sup>Calculated as the residual of total U.S. exports minus P.L. 480 exports.

<sup>c</sup>Source: (U.S. Department of Agriculture, 1975b).

Table 5. U.S. feed grain 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 <sup>a</sup>	Commercial Exports <sup>b</sup>	Total U.S. Exports <sup>c</sup>
(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

<sup>a</sup>Source: (U.S. Department of Agriculture, 1974c).

<sup>b</sup>Calculated as the residual of total U.S. exports minus P.L. 480 exports.

<sup>c</sup>Source: (U.S. Department of Agriculture, 1975b).

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

Recipients of P.L. 480 exports are shown in Table 7. Data are presented for countries which received greater than one million metric tons of wheat, feed grains, or soybeans. Total wheat exports under P.L. 480 totaled 112 million metric tons. The bulk of this wheat went to India and Pakistan. India received 38 percent of all P.L. 480 wheat exports and Pakistan received 13 percent. Brazil and the Republic of Korea were the next largest recipients with 7 percent each. Feed grain exports under P.L. 480 totaled 23 million metric tons. India was the

largest recipient with 23 percent and Israel was the second largest recipient at 21 percent. Egypt and Japan each received less than 5 percent. All other countries imported less than one million metric tons each of feed grains under the P.L. 480 programs. Soybean exports under P.L. 480 totaled approximately 440 thousand metric tons. The Republic of China received 86 percent of these exports.

Table 7. Total P.L. 480 exports during 1960-1975 in millions of metric tons for countries with P.L. 480 imports greater than one million metric tons<sup>a</sup>

Country	Wheat <sup>b</sup>	Feed Grains <sup>c</sup>	Soybeans <sup>d</sup>
(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	

<sup>a</sup>Source: (U.S. Department of Agriculture, 1974c).

<sup>b</sup>Countries listed received approximately 90 percent of P.L. 480 wheat exports.

<sup>c</sup>Countries listed received approximately 60 percent of P.L. 480 feed grains exports.

<sup>d</sup>No country received one million metric tons during this period. The Republic of China was the largest P.L. 480 participant with imports of 375 thousand metric tons.

### The Export Problem

Export levels of the last several years have increased our awareness of the magnitude and volatility of the demand for U.S. agricultural exports. The average level of exports which we can expect in the future appears to be growing, however, this is only part of the problem caused by exports. Studies done at Iowa State University and elsewhere indicate that the United States can satisfy all domestic consumption requirements and anticipated export levels. Several studies have shown the U.S. production potential far exceeding even the more optimistic export demands. If we possess this productive capability, then how do we explain the high prices and low grain reserves following the larger exports of the last several years? The answer to this question forms the basis for this study.

The problem which the United States faces in producing for a world market is not the magnitude of the export demand. The problem is the volatility of the demand. As long as we have time to adjust, we have the capability of producing for potential export markets. But, we cannot meet these peak levels of demand unless we are producing at full capacity. When we do produce at full capacity and exports are low, we face the problem of storage and give-away programs.

Exports are such a large part of the market for U.S. production that any major fluctuations will disrupt agriculture and the entire U.S. economy. The current need is to understand, anticipate, and guard against export volatility. The problem is not just a matter of stabilizing U.S. exports. This could be done by export quotas. The real

complexities come from our desires to benefit from the sale of agricultural production abroad while maintaining a stable domestic price level in the United States. Even this goal would not find total agreement. A volatile export market generates disagreement among consumer groups, farmers, and administrators. Consumers have come to expect low prices. Farmers have recently been exposed to the benefits of high prices and large exports. Administrators of the U.S. Department of Agriculture are caught between the two groups. Consumers are justifiably concerned about government programs to support agriculture through subsidy payments when agricultural prices reach high levels.

Many books have been written about the farm problem. One of the current farm problems is that of exports. They are large, profitable, and volatile. An important need for policy makers is a better understanding of this topic. The basic determinants of the export market must be understood. Not only do we need to understand what causes fluctuations in the demand for exports, but we also need to gauge the potential volatility in these underlying variables. In a broad sense this is the intent of this study.

#### Objectives of This Study

The primary objective of this study is to increase the level of understanding about the international market for the primary export commodities of the United States--wheat, feed grains, and soybeans. This study will attempt to identify factors which influence the quantities of these crops which importing nations purchase, and specify

the quantitative nature of these relationships. The stochastic nature of these determinants of import levels will be quantified to provide a foundation for examining the stochastic nature of a country's import demand. Using this foundation of import levels by countries and groups of countries, U.S. export levels will be projected. Magnitudes of export demand as well as statistical parameters of volatility will be developed.

Efforts will also be made to predict levels of exports to the year 2000. The basis of these projections will be the projections of import determinants by countries and groups of countries. Statistical confidence intervals will also be used to bound the stochastic aspects of exports about the projected mean levels.

Volatility of exports will be considered from both an individual country level and the entire world. Parameters for variation in import demand of an individual country will be based on the assumption of independence between all countries' demand for imports. A second case will develop the observed correlation between the import levels for all pairs of countries and regions and use this information to develop a statistical distribution function for the import levels for all countries.

Specifically, the objectives of this study are:

1. To econometrically estimate net import equations by importing countries or regions for wheat, feed grains, and soybeans.

2. To develop statistical parameters to characterize the stochastic aspects of the major determinants of import levels for all countries and regions, both independently and simultaneously, for wheat, feed grains, and soybeans.
3. To employ a Monte Carlo simulation procedure to explore levels of net imports for all importing countries and groups of countries when the correlation between import levels between countries conforms to the observed correlations described above in objective 2.
4. To project mean levels of imports by crop for all importing countries to the year 2000 for wheat, feed grains, and soybeans.
5. To provide statistical confidence intervals for projected import levels from the results in objective 3.
6. To quantify the relationship between world net imports for wheat, feed grains, and soybeans and U.S. export of these crops.

## CHAPTER II. THE INTERNATIONAL MARKET FOR AGRICULTURAL PRODUCTS

In order to understand the market for agricultural exports, it is necessary to examine the components of this market. The first section of this chapter considers the structure of the wheat, feed grains, and soybean markets. The second section examines the characteristics of imports, and the third section examines export supply. The final section reviews the previous work done in this area.

### Market Structure

Market structure refers to the economic atmosphere in which exchange takes place. The primary characteristic of market structure is the number and size of the participants involved in exchange. A second factor which determines how exchange takes place is the behavior of various market participants. Some countries represent a large enough part of the market for agricultural products to influence price, while other countries act as price takers.

### Wheat market

The international wheat market is comprised of two major exporters, the United States and Canada, who provide approximately 60 to 70 percent of all wheat exports (Table 8). As shown in Table 8, the United States has been the major wheat exporter during the 15-year period from 1960 to 1974. Canada has maintained a consistent second place in terms of

Table 8. Net exports of major wheat exporting countries in millions of metric tons for the period from 1960-1974. Percent of total exports is shown in parentheses for each country<sup>a,b</sup>

Crop Year	United States	Canada	Argentina	France	Australia	U.S.S.R.	Total Exports of Major Exporting Countries
(million metric tons)							
1960/61	17.74 (45)	9.30 (23)	1.94 (5)	1.14 (3)	4.99 (13)	4.44 (11)	39.55
1961/62	19.52 (44)	9.94 (22)	2.37 (6)	1.43 (3)	6.25 (14)	5.10 (11)	44.61
1962/63	17.17 (42)	9.01 (22)	1.83 (4)	2.38 (6)	4.79 (12)	5.50 (14)	40.68
1963/64	22.99 (45)	15.02 (30)	2.79 (6)	1.91 (4)	7.76 (15)	- <sup>c</sup>	50.47
1964/65	19.31 (42)	11.83 (26)	4.27 (9)	3.90 (9)	6.44 (14)	- <sup>c</sup>	45.80
1965/66	23.34 (42)	14.86 (27)	7.86 (14)	4.03 (7)	5.65 (10)	- <sup>c</sup>	55.74
1966/67	19.94 (41)	14.82 (31)	3.11 (6)	2.35 (5)	6.93 (14)	1.31 (3)	48.46
1967/68	20.18 (45)	8.92 (20)	1.25 (3)	3.77 (8)	7.04 (16)	3.79 (8)	44.95
1968/69	14.67 (35)	8.71 (20)	2.71 (6)	5.45 (13)	5.38 (13)	5.61 (13)	42.53
1969/70	16.40 (36)	8.99 (20)	1.69 (4)	5.65 (12)	7.37 (16)	5.29 (12)	45.39
1970/71	19.80 (37)	12.65 (24)	1.63 (3)	2.89 (5)	9.52 (18)	6.72 (13)	53.21
1971/72	16.91 (33)	15.82 (31)	1.34 (3)	5.37 (11)	8.67 (17)	2.39 (5)	50.50
1972/73	31.75 (50)	15.63 (24)	3.03 (5)	7.77 (12)	5.61 (9)	- <sup>c</sup>	63.79
1973/74	30.96 (55)	11.36 (20)	1.10 (2)	7.55 (13)	5.32 (9)	.55 (1)	56.84
1974/75	28.25 (49)	10.33 (18)	2.20 (4)	7.50 (13)	8.40 (14)	1.50 (2)	58.18

<sup>a</sup>Source: (U.S. Department of Agriculture, 1975b).

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

<sup>c</sup>Russia was a net importer of wheat in these years.

quantities of wheat exported and share of the market. France has been exporting a larger volume of exports and has been capturing a growing portion of the market over the entire period. In 1960, France exported only 3 percent of all wheat exports, but in the 1972-1974 period, France exported 13 percent of all exports. Argentina and Australia have been stable exporters over the period considered. Australia has exported between 4.76 and 9.52 million metric tons each year, which represents 9 to 18 percent of all wheat exports. Argentina has been a relatively small exporter with average exports of 2.61 million metric tons per year. Exports have fluctuated between 1.10 and 7.86 million metric tons. The U.S.S.R. has also been an erratic exporter during the 1960-1974 period. . In 1968-1970, the U.S.S.R. provided 13 percent of all world wheat exports, however, in the last four years the U.S.S.R. was a net importer. The U.S.S.R. and the United States appear to compete for the same grain sales. When the U.S.S.R. is exporting large amounts of wheat, the United States has a reduction in exports, and when the U.S.S.R. is not a major exporter, the United States is able to increase its exports. Other countries which export wheat constitute approximately 5 percent of all wheat exports. In crop year 1974-1975, the net exports of wheat for all other countries totaled 2.82 million metric tons. This was 5 percent of the total wheat exports of 61 million metric tons.

The major wheat importing countries are listed in Table 9. The average net imports during the three-year period from 1972-1974 are listed in millions of metric tons. Japan and the People's Republic of China were the largest net importers during this period. Japan

imported an average of 5.55 million metric tons and the People's Republic of China imported 5.38 million metric tons per year. Japan had very stable net imports with approximately equal imports in each of the three years. The People's Republic of China also showed stable net wheat imports over the three-year period. The U.S.S.R. was the third largest net importer of wheat for the three-year period, however, this is obscured by the large imports in 1972 and small exports in the other two years. In crop year 1972-1973, the U.S.S.R. imported 13.6 million metric tons of wheat. This was 20 percent of all wheat exported in that year. The following two years, Russia was a net exporter of wheat. Several other countries and regions were large importers of wheat during the 1972-1974 period. The United Kingdom (excluding Northern Ireland) and Egypt each imported more than 3 million metric tons. An additional 8 countries had net wheat imports of 1 to 3 million metric tons.

The structure of the wheat import market is a matter which is important to the understanding of the role of price and competition in the international wheat market. On the demand side, several countries are major purchasers and many more regularly purchase wheat. On the supply side, two dominant exporters, the United States and Canada, and several additional countries supply wheat exports. This combination of buyers and sellers could lead to several types of market structures depending on the market behavior of the participants.

The countries which comprise the importers are larger in number and each takes a relatively small part of the total wheat purchased.

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<sup>a</sup>

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
U.S.S.R.	3.85 <sup>b</sup>
Iran	1.21

<sup>a</sup>Source: (U.S. Department of Agriculture, 1975b).

<sup>b</sup>The U.S.S.R. was a net importer in 1972-1973 and a net exporter in 1973-1974 and 1974-1975. Net wheat imports were 13.6 million metric tons in 1972-1973, and net wheat exports were .55 and 1.5 million metric tons, respectively, in 1973-1974 and 1974-1975.

These countries are price takers when they purchase wheat. However, the individual country may alter this structure under certain conditions.

Suppose an individual country purchases all its imports from only one of the exporting countries. It now has greater market power because its purchase represents a larger share of the exports of the selling country. Under this situation, the importing country may develop bargaining power.

The supply of wheat available for export in any individual country is represented by  $S$  in Figure 1. Supply is price responsive because of the storage and transportation characteristics of wheat. When wheat exports are low, supplies of wheat can be drawn from storage facilities which are located near the shipping ports. Transportation costs for moving this grain are low. However, as more grain is exported, it becomes necessary to transport grain over greater and greater distances (Meinken, 1955, p. 28). The result is a supply curve which takes a shape as shown.

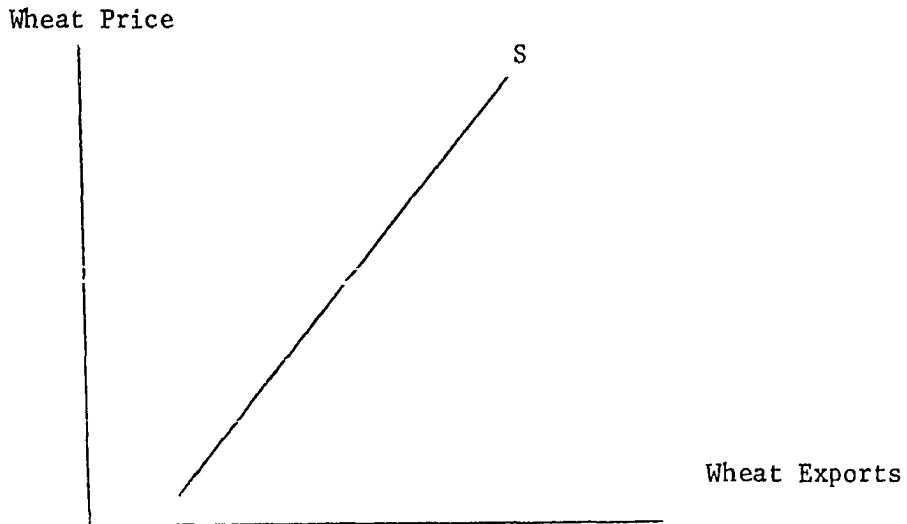


Figure 1. World wheat supply

Net wheat imports in each country should be a function of domestic supply, per capita income levels, wheat price, and other factors which may be primarily political or institutional in nature. When all countries act as price takers, the world demand for wheat imports is the horizontal summation of the demand of individual countries.

Combining with the world supply of wheat,<sup>1</sup> we have the situation shown by Figure 2. The equilibrium price of wheat is  $P_1$  and the equilibrium quantity is  $Q_1$ .

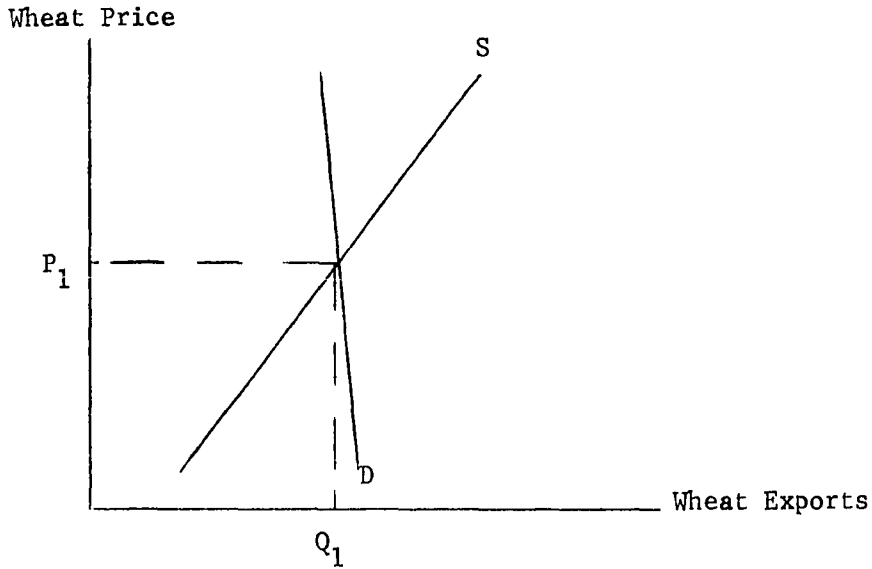


Figure 2. World demand and supply for wheat

#### Feed grains market

The United States is the major world exporter of feed grains. During the period from 1960 to 1974 the United States exported approximately 50 percent of all exports of feed grains in the world (Table 10). Argentina ranked second with approximately 12 percent of all world exports and France was third with 10 percent. The Republic of South

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<sup>1</sup>It is well known that the aggregate supply curve is equal to the summation of individual country supply curves only under certain restrictive assumptions. However, the nature of the production of agricultural commodities closely approaches these restrictions. In particular, we need only assume that input prices do not change as all countries vary production. Since acreage is the major input which varies, we do not overestimate aggregate supply by horizontally summing the individual country supplies.

Table 10. Net exports of major feed grain exporting countries in millions of metric tons for the period 1960-1974.<sup>a</sup> Percent of total exports are shown in parentheses for each country <sup>b</sup>

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

<sup>a</sup>Source: (U.S. Department of Agriculture, 1975b). Feed grains is the combined crops corn, barley, oats, and grain sorghum.

<sup>b</sup>Countries not included exported approximately 5 percent of total world exports. In 1974-1975 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.

Africa, Canada, Australia, Thailand, and Brazil each supply less than 5 percent of world exports and form the remainder of the major exporting countries. The remaining 8 to 10 percent of world exports was supplied by over 20 countries.

The market share of the major exporting countries has remained stable over the period from 1960 to 1974. In 1960, the United States supplied 59 percent of exports of the major exporting countries; and in 1974, the United States supplied 55 percent. The lowest market share was 44 percent in 1970 and the largest market share was 72 percent in 1965. Argentina supplied between 13 and 17 percent of the exports of the major exporting nations, however, exports dropped as low as 7 percent and reached as high as 19 percent. France also maintained its market share. Exports ranged from a low of 4 percent to a high of 17 percent of the exports of the major exporting countries. Other major exporting nations were able to hold their shares over the period.

Feed grain exports showed steady increase over the period from 1960 to 1974. In 1960, the major exporting nations exported 18.78 million metric tons of feed grains. By 1973 this figure had reached 63.66 million metric tons. Exports increased 339 percent over the period. United States exports increased 359 percent over the same period.

The major feed grains importing countries are listed in Table 11. During the three-year period from 1972 to 1974, Japan was the major importer of feed grains. Japan imported an average of 12.87 million metric tons of feed grains in 1972, 1973, and 1974. This was approximately 20 percent of the average world export of feed grains over this

period. It also equals 35 percent of U.S. exports of feed grains in these three years. Italy was the second largest importer of feed grains during the 1972-1974 period. Italy imported an average of 6.02 million metric tons. West Germany and Russia imported an average of 4.32 and 4.21 million metric tons, respectively, during this period. Other major importers of feed grains include Spain, United Kingdom (excluding Northern Ireland), and the Netherlands with an average 3.59, 3.45, and 3.06 million metric tons, respectively, during the three years from 1972-1974. Seven other countries had average feed grain imports in excess of one million metric tons per year over this period.

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<sup>a</sup>

Country	Average 1972-1974 Net Feed Grain Imports
	(million metric tons)
Mexico	1.88
United Kingdom (excluding Northern Ireland)	3.45
Netherlands	3.06
Belgium/Luxembourg	2.56
West Germany	4.32
East Germany	1.35
Poland-Danzig	1.41
U.S.S.R.	4.21
Spain	3.59
Portugal	1.17
Italy	6.02
People's Republic of China	1.14
Taiwan	1.08
Japan	12.87

<sup>a</sup>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 and several other countries supply significantly smaller amounts of feed grains for export. Many countries purchase feed grains, but only one or two purchase significant percentages of the total. Japan is the largest single importer and purchased 21 percent of the 1972-1974 average exports of the seven major exporting countries. The next largest importer in the 1972-1974 period was Italy with purchases of 10 percent of exports of the seven major exporting countries.

#### Soybean market

Soybean production is concentrated in three countries: United States, Brazil, and The People's Republic of China. Table 12 shows the yearly production of these major soybean producing countries. The United States has produced approximately 75 percent of all world production in recent years. However, Brazil has had rapid increases in production since 1969, and produced 9 percent of the world production in 1973-1974. The People's Republic of China has produced approximately 6.5 million metric tons per year for the past 10 years. Several other countries are soybean producers of smaller importance. Mexico, U.S.S.R., Indonesia, Canada, North Korea, Republic of Korea, and Argentina each produced between .25 and .50 million metric tons of soybeans in 1973-1974.

Soybean exports are shown in Table 13. The United States is the major exporter of soybeans and soybean oil. Brazil is the only major

competitor for the U.S. export of soybeans. Brazil exported 2.75 million metric tons of soybeans and soybean oil expressed in soybean equivalent in 1974. The United States exported 18.10 million metric tons.

Table 12. Soybean production in major producing countries in millions of metric tons for the period 1960-1974<sup>a</sup>

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

<sup>a</sup>Source: (FAO, 1964a; 1974a). The United States, Brazil, and The People's Republic of China represent 90 to 95 percent of all world soybean production.

Table 13. Soybean exports by country, 1960-1974, in millions of metric tons<sup>a,b</sup>

Year <sup>c</sup>	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

<sup>a</sup>Sources: (FAO, 1964b; 1974b).

<sup>b</sup>Data is 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.

<sup>c</sup>Exports are listed by calendar year.

Soybean imports by country are shown in Table 14. Japan and West Germany are the largest importers of soybeans and soybean oil. Each country imported approximately 15-20 percent of all soybean exports during the 1972-1974 period. A total of six countries had average imports exceeding one million metric tons per year from 1972-1974.

Table 14. Soybean imports of countries which have average imports of .3 million metric tons or more during the three years 1972-1974<sup>a</sup>

Country	Average 1972-1974 Soybean Imports <sup>b</sup>
	(million metric tons)
Canada	.31
Mexico	.35
People's Republic of China	1.10
Israel	.43
Japan	3.47
Belgium	.59
Denmark	.48
France	.83
West Germany	3.09
Italy	1.32
Netherlands	1.73
Norway	.30
Poland	.16
Spain	1.31
United Kingdom	.92
U.S.S.R.	.33

<sup>a</sup>Source: (FAO, 1974b). Data is for soybeans and soybean oil expressed as soybean equivalent. The conversion factor to convert soybean oil to soybeans is 5.49.

<sup>b</sup>Imports are listed by calendar year.

The export of soybeans and soybean products had been an unchallenged market for the United States during the 1960s and early 1970s. This situation may be changing if Brazil continues to increase production and exports at rates comparable to the last three years. However, the demand for soybeans appears to be expanding and may be able to absorb increased sales from both the United States and Brazil.

The structure of the international soybean market is that of a single seller and many buyers. The largest importer of soybeans and

soybean oil over the three years from 1972-1974 was Japan with average yearly purchases of 3.47 million metric tons. This was 21 percent of U.S. exports over the same period. A market structure comprised of many buyers and one seller is referred to as a monopoly situation. Figure 3 shows the demand and supply situation. Market demand is composed of many firms each acting as a price taker. Market supply is the export supply curve for the United States. If the United States did not behave as a monopolist, the equilibrium price and quantity would be where demand equals supply at  $P_1$  and  $Q$ . However, if the United States acts as a monopoly and equates marginal revenue and marginal cost, then price would be  $P_2$  and quantity would be  $Q_2$ . Several factors may explain why the United States might not act as a monopoly and sell the quantity which equates marginal cost and marginal revenue. First, the United States may have political interests which overshadow the increased revenue to be obtained from monopoly prices. Secondly, it may be more profitable in the long run to keep prices low and discourage countries from producing soybeans or substitute products. Third, the United States may not have a monopoly in the sale of soybeans and soybean oil because of the marketing methods used. Many private U.S. companies are engaged in the sale of soybean exports and compete for the foreign market. This may lead to a situation approximating perfect competition on the selling side and result in a quantity sold which equates demand and supply.

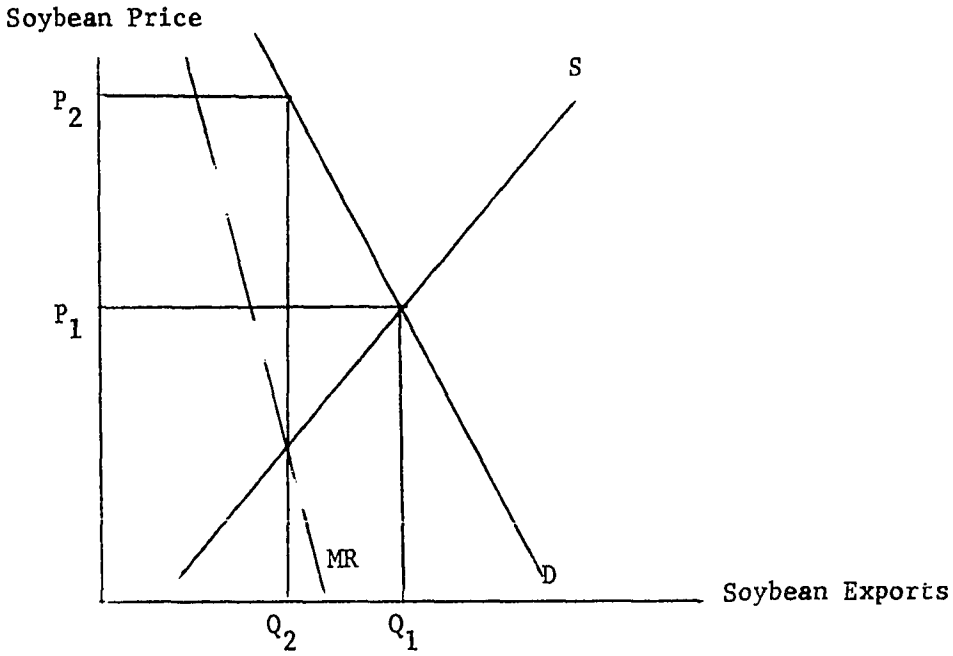


Figure 3. Structure of the soybean and soybean oil international market

#### Characteristics of Imports

The net imports of agricultural commodities by an individual country should be based on several factors. The consumptive demand for a commodity takes the form

$$D_{i,t} = f(P_{i,t}, I_t, P_{1,t}, \dots, P_{i-1,t})$$

where  $D_{i,t}$  is the demand for a particular commodity  $i$  in year  $t$ .  $P_{i,t}$  is the price of commodity  $i$  in year  $t$ ;  $I_t$  is the level of per capita income in year  $t$ ; and  $P_{1,t}, \dots, P_{i-1,t}$  are the prices of all other commodities in year  $t$ . If supply of the commodity,  $S_{i,t}$ , is fixed, price would equate demand and supply. If the supply is not perfectly inelastic, both price and quantity are determined by the interaction of demand and supply.

Demand for agricultural products unlike the demand for most other consumer commodities, should tend to fluctuate widely over time. This premise is based on the characteristics of the demand for agricultural products and on the nature of these products. A country would import a commodity primarily as a response to production shortage within the country. In the absence of this event, imports would be low or zero. Demand for imports to store for future consumption or for resale at a higher price in future periods would not be common because of high storage and transportation costs inherent in a bulky commodity such as grain.

Countries would also seem reluctant to import and store agricultural commodities for future use because of the fixed nature of resource commitments in agriculture. Agricultural land, machinery, and labor have little value in alternative employment. A country may not make short-run adjustments in domestic production policies or capabilities due only to favorable prices in the world market for agricultural commodities. A long-run adjustment to a favorable world market would seem to be more probable. Over a long period of time it is possible to adjust the resource commitment to agricultural production and move the less fixed factors of production into alternative areas of employment. These types of adjustment would appear as gradual changes in a country's level of imports over time.

Price may not be the major determinant affecting the import demand of a country. In the absence of a domestic shortage, import demand may be zero or even negative. Price may not play a significant role

in this situation. Even when import prices are low, the demand for imports to hold for future consumption or for eventual resale appears low. When domestic production is lower than expected and stock levels are not large enough to offset this production, imports will be increased. The amount which a country will import is influenced by many economic variables such as import prices, transportation costs, balance of payments positions, per capita income levels, and political influences. However, the maximum level which a country would be expected to import should equal the quantities of grain needed to make up for the lower than expected production. A country would have very little reason to attempt to import more than this amount; since such action would provide consumption above those levels available in an average year from domestic production. If a country had a growing level of imports over time, this would tend to show up as additional imports above levels required to supplement the lower than expected domestic production.

Price should affect the percent of production shortfall which is imported. If a country has lower production than usual, then price may effect the percent of this deviation from production which is purchased in the world market. Due to this unusual characteristic concerning price, we could almost refer to this response as the conditional price elasticity of demand. Only when production is low would a country have a price responsive import demand equation.

The level of per capita income would also influence the price responsiveness of a country to import an agricultural commodity. When levels of per capita income are high, the price elasticity of demand for agricultural imports should be low. That is, an affluent country would be more responsive to production shortages than to world price. Even when world prices are high, an affluent country would maintain consumption through higher imports. A lower income country would have a greater response to higher prices and would tend to reduce its demand for imports.

Other factors which would affect level of agricultural imports include the political and institutional characteristics of a country. Trade barriers and protectionism would tend to reduce a country's responsiveness to market prices and also domestic supply. Countries may tend to make large grain purchases in exchange for other concessions in trade or politics. Such factors contribute to the overall problems of a stable import demand function.

The long-run net import equation may not be of the same nature as the short-run net import equation. The major determinant of the short-run net import equation is the level of domestic production and grain reserve policies. Since production fluctuates with weather, we could expect the short-run net imports to be stochastic and highly correlated with weather fluctuations. (Grain reserve policies would tend to moderate this fluctuation.) Long-run net imports would take a different structure based on changes in a country's import policies

and agricultural structure. Long-run structural changes in productivity, resource commitments, and levels of affluence would tend to show a pattern of long-run adjustment. Within this long-term pattern of net imports, we would also expect to see a price elasticity of demand. Over a period of years, a country could respond to world commodity prices and alter its basic production capability. This type of long-term price elasticity would seem to be greater than the short-run price elasticity of demand. Political factors would play a greater role in this long term price elasticity than in the short-term price elasticity because of the greater dependency created by a reduction in agricultural productive ability. In the short run a country faces very little dependence when it makes a single purchase of an agricultural commodity. The continual purchase from world markets creates the type of dependence which a country may wish to avoid. In this case, political factors affect importing decisions. Large imports over a number of years will tend to diminish the productive machinery within a country or will raise consumption levels above those which can be supported by domestic production.

Several other factors tend to complicate net imports of a particular country. In addition to the hypothesized stochastic nature of short-run imports due to weather variability, we could also expect short and long term weather trends. Countries in a particular region would have correlations in production caused by correlations in weather. They also exhibit long-run patterns of production which are due to weather patterns of a longer nature. These weather cycles create periods of time when the domestic production of the majority of countries is higher

than normal and when production is lower than normal. Consequently, cycles may cause combined world net imports to be higher than normal followed by periods when world imports are lower than normal.

### Characteristics of Export Supply

Export supply or the availability of a commodity for sale to foreign countries should be primarily determined by levels of production, stocks, and export prices. Levels of grain available for export are determined by production, domestic demand, and reserve levels. When production is large enough to satisfy domestic consumption requirements and maintain desired reserve levels, the balance is available for export. The type of marketing system may affect the level of domestic consumption. A market economy such as the United States will usually allow prices to determine the desired consumption for domestic purposes. When export prices increase, this will cause domestic prices to also increase and reduce domestic consumption. In the process, the level of exports will increase because foreign buyers are bidding agricultural products away from U.S. consumers. A centrally planned economy may not allow this market activity to influence domestic consumption. The government planning authority may determine the level of domestic consumption independent of world price and only export grain in excess of specified quantity levels.

Export price may influence grain levels available for export in several ways. In the short run, quantity produced is fixed, however, export supply may still be price responsive. This will occur because of

the reduction of domestic consumption caused by higher prices and by the transportation costs involved in exporting grain. When grain export prices are low, the cost of moving grain from the center of a nation to the shipping ports prevents a profitable sale. Small quantities are profitably sold because some grain is produced and stored near the shipping ports. As export prices increase, the profitability of exporting grain covers the greater transportation costs incurred when grain is transported from the central producing areas (Meinken, 1955, p. 28). Export prices may also increase export supply in the long run. As export prices increase, countries may increase resource commitments and expand production. Profitable levels of imports such as fertilizer will increase and result in greater output.

#### Review of Previous Work

In view of the importance of exports to both the U.S. economy and the agricultural sector, it seems that very little work has been done in this area. Several publications have considered some aspect of foreign demand, however, most do not look directly at imports by country or region. Most of the work has been directed toward estimating country consumption functions and the price elasticity of demand as opposed to net import functions.

Several studies attempt to directly estimate the net import equations for selected agricultural commodities by countries. Capel and Rigaux estimated the import demand equations for wheat of selected countries in 1974 (Capel and Rigaux, 1974). Osman, Morrison, and Bender

estimated import demand equations for soybeans for the major soybean importing countries in 1966 (Osman, Morrison, and Bender, 1966). Jones and Morrison estimated import demand functions for soybean meal for selected countries in Eastern Europe (Jones and Morrison, 1976). A number of other studies have estimated some aspect of commodity demand by country or export equations.

### Meinken

Meinken studied the demand and price structure for wheat in 1955. He considered both the domestic and foreign aspects of the U.S. wheat economy. His work found a relationship between the quantity of wheat exported from the United States and the spread between U.S. wheat price and wheat prices in importing countries. A least-squares analysis for the period 1921-1929 and 1931-1938 indicated that 80 percent of the variation in the volume of net exports was associated with this price spread, after adjusting for factors such as ocean freight rates, the tariff in the United Kingdom, and the average export subsidy.

Meinken fitted the following relationship

$$C_e = B_0 + B_1 P_s$$

where

$C_e$  = domestic exports and shipments to United States territories of wheat and flour on a wheat equivalent basis, millions of bushels, and

$P_s$  = price spread between the average wholesale price of wheat at Liverpool, England, and the average wholesale price of

wheat at Kansas City minus the transportation costs from the United States to Liverpool and other tariff and export subsidy adjustments.

The resulting equation was estimated using Limited Information and Least Squares procedures over the period from 1924-1938. The Ordinary Least Squares procedure gave

$$C_e = 100 + 6.4 P_s \quad R^2 = .81$$

(.8)

These results suggest that wheat exports are a function of relative prices between the United States and other world market prices (Meinken, 1955, pp. 37-41).

#### Brandow

Brandow, in 1961, estimated elasticities of demand for export for selected agricultural commodities. He noted the difficulties in the following statement:

Statistically estimated elasticities of demand for export are almost wholly lacking. Foreign trade in farm products has been so greatly influenced for two decades or more by war, its after effects, tariffs, quotas, price supports, and a variety of subsidy arrangements that little firm bases exists for stating how commercial, unsubsidized exports or imports would be affected by changes in prices in the United States (Brandow, 1961, p. 52).

After noting some of the difficulties of estimation, Brandow obtained the following estimates: the price elasticity of commercial export demand for soybean oil was approximately -1.0; the price elasticity of commercial export demand for feed grains was -1.3; and the price

elasticity of commercial export demand of oilseed meal exports, including the meal equivalent of soybeans, was -1.5.

### Tweeten

Tweeten estimated the price elasticity of demand for all farm output combined in 1967 (Tweeten, 1967). Tweeten argued that the estimation of the price elasticity of demand for individual farm commodities is a very misleading measure of the aggregate price elasticity of demand for farm output because of the wide opportunities for substitution of one commodity for another in consumption. Estimates are developed for the domestic demand for food and the long-run demand for feed and food exports.

Export demand elasticity is estimated by the following approach. The price elasticity of demand for U.S. food and feed exports can be expressed as:

$$E_{ef} = \sum_{i=1}^m \left[ E_{di} E_{pi} \frac{Q_{di}}{O_{ef}} - E_{si} E_{pi} \frac{Q_{si}}{O_{ef}} \right]$$

where  $E_{di}$  is the price elasticity of domestic demand of food in country  $i$ ;  $E_{si}$  is the price elasticity of domestic supply of food in country  $i$ ;  $E_{pi}$  is the elasticity of prices in country  $i$  with respect to the market price of U.S. farm commodities;  $Q_{di}$  and  $Q_{si}$  are, respectively, the domestic demand and supply quantities in country  $i$ ; and  $O_{ef}$  is the U.S. farm output of food and feed for export. Results of the study show that price elasticity of demand for U.S. exports are very elastic. Depending on the assumptions about institutional impediments and market imperfections, the estimates range from -6.4 to -16.

Schmitz and Bawden

Schmitz and Bawden estimated per capita demand equations for all wheat uses by country (Schmitz and Bawden, 1973). Their work in 1973 appears to be the first effort to estimate country per capita wheat demand equations for a large number of countries. Ordinary least squares was used to estimate the equation:

$$\frac{Q_d}{L} = B_0 + B_1 P_m + B_2 N + B_3 T$$

where  $Q_d$  is the total consumption of all classes of wheat for food, feed, seed, and industrial purposes;  $L$  is population (millions);  $P_m$  is the weighted price paid by millers for all classes of wheat (U.S. dollars undeflated except for Argentina where the deflator used is the consumer price index, 1965 = 100);  $N$  is a measure of per capita income in U.S. dollars undeflated except for Argentina where the deflator used is the consumer price index 1965 = 100; and  $T$  is time in years. The results of their work are summarized in Table 15.

Osman, Morrison, and Bender

Osman, Morrison, and Bender estimated import demand equations for soybeans in 1966 (Osman, Morrison, and Bender, 1966). Their study included soybean import demand equations for Japan, Canada, Netherlands, Western Germany, France, Belgium-Luxembourg, and the United Kingdom. These seven countries represented 60 percent of the value of U.S. soybean exports in 1961. Data used in their study was 15 years of annual data.

Table 15. Price elasticities of demand for all wheat uses by country

Country	Price Elasticities	R <sup>2</sup>
United States	-.15	.88
Canada	-.08	.77
Australia	-.55	.76
Argentina	-1.48	.77
Japan	-3.03	.95
United Kingdom	-.01	.36
France	-.46	.16
Italy	-.02	.76
West Germany	-.56	.61
Belgium-Luxembourg	-.08	.61
Netherlands	-.03	.70

Capel and Rigaux

Capel and Rigaux in 1974 estimated import demand equations for China, United Kingdom, European Economic Community, Japan, U.S.S.R., West Germany, India, Poland, Brazil, Hong Kong, Philippines, and Taiwan (Capel and Rigaux, 1974). Ordinary least squares was used to estimate the following demand equation:

$$\log Q_t = a + b_1 \log P_t + b_2 \log S_{t-1} + b_3 T$$

where  $Q_t$  is the quantity of wheat imported in year  $t$  in thousands of metric tons;  $P_t$  is the average price of wheat imported from all suppliers in year  $t$  in thousands of dollars per metric tons;  $S_{t-1}$  is the domestic production in year  $t-1$  in thousands of metric tons; and  $T$  is the time in years. Their results are presented in Tables 16 and 17. Explanatory

Table 16. Demand for wheat imports by selected countries<sup>a</sup>

Importer (And Time Period Analyzed)	Regression Coefficients				R <sup>2</sup>
	Constant	Price	Lagged Production	Time	
China (1961-1970)	8.55	3.19 (1.78) <sup>b</sup>	-0.33 (0.45)	0.26* (0.11)	.56
United Kingdom (1959-1970)	1.64	-1.76*** (0.45)	-0.01 (0.15)	0.02 (0.03)	.68
European Economic Community (1963-1970)	3.85	3.02 (9.62)	0.55 (1.53)	0.05 (0.47)	.83
Japan (1959-1970)	-0.42	-0.07 (0.07)	-0.19** (0.06)	0.02** (0.003)	.94
U.S.S.R. (1959-1970)	2.46	-13.19* (6.75)	-3.31 (2.62)	1.53 (0.65)	.54
West Germany (1963-1970)	1.30	1.83 (2.30)	0.96 (0.55)	-0.06 (0.15)	.61
India <sup>c</sup> (1959-1970)	9.00	0.08 (1.75)	-1.38** (0.49)	0.45** (0.16)	.55
Poland (1959-1970)	-0.67	-0.06 (0.12)	-1.08 (0.89)	0.02 (0.02)	.55
Brazil (1959-1970)	3.66	-0.53 (0.80)	-0.37** (0.14)	0.14** (0.03)	.73
Hong Kong (1960-1970)	0.28	-0.76 (1.03)		0.02** (0.01)	.53
Philippines (1963-1969)	-0.94	-1.64 (1.50)		0.02 (0.01)	.67
Taiwan <sup>d</sup> (1963-1969)	-7.80	-4.86*** (1.15)			.78

<sup>a</sup>Using the equation  $\log Q_1 = a + b_1 \log P_1 + b_2 \log S_{t-1} + b_2 T$  (see definition of terms of this equation on page 43).

<sup>b</sup>Standard errors shown in parentheses.

<sup>c</sup>Import levies added to price.

<sup>d</sup>Correlation between price and time = 0.81. This may invalidate the price coefficient for the purpose of projection.

\*Significant at the 10 percent level.

\*\*Significant at the 5 percent level.

\*\*\*Significant at the 1 percent level.

variables were import price, lagged production, and time. Economic theory suggests an inverse relationship between price and quantity, however, the sign on the price coefficient was positive for China, European Economic Community, West Germany, and India. Of the remaining eight price coefficients which had the correct sign, only two were significant at the 5 percent level. Lagged production was used as an independent variable in nine of the twelve equations. Only three of the nine equations had a significant coefficient with the expected sign at the 5 percent level. Time was the third variable used to explain imports, and it was significant at the 5 percent level in only four of the eleven equations estimated.

Table 17. Estimated price elasticities of demand for wheat imports by selected countries<sup>a</sup>

Importer	Logarithmic Specification		Linear Specification	
	Elasticity	R <sup>2</sup>	Elasticity	R <sup>2</sup>
China	3.19	.56	3.67	.46
United Kingdom	-1.76***	.68	-1.62***	.70
European Economic Community	3.02	.83	-1.65	.86
Japan	-0.07	.94	0.03	.95
U.S.S.R.	-13.19*	.54	-4.52*	.55
West Germany	1.83	.61	0.88	.64
India	0.08	.55	-0.53	.47
Poland	-0.06	.55	-0.16	.53
Brazil	-0.53	.73	0.38	.76
Hong Kong	-0.76	.53	-0.79	.51
Philippines	-1.64	.67	-1.43	.66
Taiwan	-4.86***	.78	-5.93	.81

<sup>a</sup>Based on regression results reported in Table 1 and for the equivalent linear specifications (not reported).

<sup>b</sup>Elasticities calculated at the means.

\*Significant at the 10 percent level.

\*\*\*Significant at the 1 percent level.

Jones and Morrison

Import demand equations for soybeans and soybean products in Eastern Europe were estimated by Jones and Morrison in 1976 (Jones and Morrison, 1976). Ordinary least squares was applied to 13 years of data from 1960 to 1972. Import demand functions were specified for soybean meal imports for Poland, Yugoslavia, and Hungary. Similar efforts were unsuccessful for Czechoslovakia. Efforts to estimate import demand functions for soybean oil were also unsuccessful. Independent variables included in the analysis included prices of soybean products, prices and outputs of alternative oilseeds, per capita income, population, foreign exchange, reserve availability, production of livestock and poultry, and foreign trade institutional mechanisms peculiar to the Eastern European Socialist economics.

Results of the study indicated that livestock inventories was the dominant variable which explains the increase in soybean imports over the study period. Soybean price as given by U.S. wholesale prices was not statistically significant or had the opposite sign from the expected sign for all countries except Yugoslavia.

### CHAPTER III. RESEARCH METHODS

The objectives of this study are outlined in Chapter I. Briefly, they involve predicting the level and variability of combined world imports of wheat, feed grains, and soybeans. And, from these results the level and variability of U.S. exports are estimated by a market share analysis. The emphasis is on imports; major exporting nations are not included in the analysis.

The procedure is to econometrically estimate import equations for all countries of the world which have historically been net importers of the specified commodities. The analysis is carried out independently for each commodity. The estimated import equations are primarily developed for prediction purposes. Based on these 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, denoted as (OLS), and ordinary least squares corrected for autocorrelation, denoted as (ALS). Both techniques are common and are explained in econometric texts such as Econometric Methods by J. Johnston (Johnston, 1972). A Monte Carlo simulation technique is used to estimate the variation in import demand. This procedure will be explained later in this chapter.

#### Delineation of Regions

Importing countries are grouped into regions based on geographic location, per capita income, and conformity with previous studies (see

Blakeslee, Heady, and Framingham, 1973). Regions differ for each commodity because the major exporting countries for wheat, feed grains, and soybeans are different. The countries included in each region are presented for each crop in the results chapters.

Major exporting countries are not included in this study. Several factors have led to the concentration on only the importing countries. First, the primary focus of this study is on the commercial demand for agricultural products. This can be developed independently of supply since we know the flow of commodities. If we could not establish the movement of commodities and observed only the final transaction, as is true in most market transactions, then a simultaneous system would be required to estimate demand and supply together. Secondly, the analysis of supply is an entire topic separate from the intent and methods used in this analysis. To fully consider supply, an analysis of the productive capability, storage capacity, and ability to shift production between crops for each exporting country would be necessary. This is a very important topic for analysis, but not one I wish to include at this time. Thirdly, it is possible to make assumptions about supply which relegates it to secondary importance. Specifically we can assume that supply continues to grow at trend rates and that the excess capacity which existed during the period of the 1960s and early 1970s will return. If this is true, then the quantity of commercial exports will be determined by demand, since supply will be perfectly elastic.

### Estimating Import Equations

Import equations are estimated for each importing region for wheat, feed grains, and soybeans. 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, usefulness for projecting imports, and usefulness for evaluating the variability in imports.

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. However, this variable does not allow for changes in the monetary unit of the importing region. 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. This variable expresses the price of wheat, feed grains, and soybeans on a real basis with domestic commodities.

### Projecting Imports

Imports are projected for each region from the estimated import equations. Trend growth in imports is projected by incrementing the time variable. Alternative levels of commodity price provide a range of projected imports corresponding to different price levels. And finally,

trend estimates of production are combined with historical average levels of production plus stocks needed to complete the list of variables needed for import projections. The projected explanatory variables are evaluated in the estimated equation and a projection of imports is obtained. The resulting projections are based on trends and are valid only to the extent that the trends remain intact.

#### Methodology for Estimating Import Variability of Wheat and Feed Grains

The variability of net wheat and feed grain imports is derived from the variability in each commodity's production. A Monte Carlo procedure is used to randomly generate wheat and feed grain production in each region. The generated observations are based on the 1960-1974 actual observed production, and they have the same statistical properties as the original data. In other words, the variances of the randomly generated observations of wheat production for each region are the same as the variances of the original wheat data. And, the covariances of wheat production for each set of regions are the same for the generated and original data. The same properties also apply for feed grains. The generated observations of production are used to generate observations on net imports for each region. This allows net imports to be examined for many years of generated data instead of just the 15 years of actual data used in this study. A total of 200 observations were generated for this study. This number proved adequate to determine the statistical properties of net imports. Wheat and feed grains were analyzed separately.

The variability in wheat or feed grain production for each region was calculated as the variance of the deviations of the respective production about the linear time trend. The alternate method for calculating the variance is to calculate the variance about the mean of the observations. This procedure was unsatisfactory because some regions are reducing production over time and others are increasing production over time. For example, Japan has been decreasing wheat production and acreage planted over the entire period. Calculation of the variance of production about the mean overstates variance. The intent of this analysis is to consider the variation in production around the trend, and this can be done by calculating the variance of the residuals of a multiple regression of production on time.

The variability in production around the trend in a single region provides the basis for estimating the variability of net imports by that region. However, the simultaneous variability of net imports may not be equal to the sum of the variability of individual regions. This results from the correlation of deviations in production about the trend between regions. If weather patterns affect many regions at the same time, we could expect correlation in production. When this correlation is present, the variability in total world net imports will not be the same as the summation of individual regions.

The procedure used in this study to randomly project events subject to a specified correlation matrix is reported in "A Procedure for Correlating Events in Farm Firm Simulation Models" (Clements, Mapp, and Eidman, 1971).

The procedure is used to generate outcomes having the desired variance and covariance values assuming the outcomes for each event are normally distributed. In matrix notation, the problem can be expressed as

$$P = \bar{P} + AW$$

where  $P$  is a  $k \times n$  matrix of  $k$  productions to be generated for  $n$  years.  $\bar{P}$  is a  $k \times 1$  matrix of expected productions for the  $k$  regions,  $A$  is a  $k \times k$  matrix of derived coefficients and  $W$  is a  $k \times n$  matrix of random normal deviates.

The  $A$  matrix is generated subject to the following condition

$$AA' = \sum_p$$

where  $\sum_p$  is the  $k \times k$  variance-covariance matrix of production deviations from trend for the  $k$  regions. The result is a  $k \times n$  matrix of generated productions with variance-covariance matrix  $\sum_p$ .

## CHAPTER IV. DEMAND FOR WHEAT EXPORTS

United States wheat exports during the 1960s and early 1970s 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 disposal rather than exports for cash. Importing countries were able to purchase as much wheat as they wanted at low prices. Much of the U.S. export of wheat went to countries that would not have been importing if all sales were for cash.

This situation makes the historical export data a poor basis on which to evaluate future export potentials. An alternative method of viewing the market for U.S. exports is to concentrate on the import side of the international wheat market. Import equations 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 which purchased imports and the countries which obtained large imports under P.L. 480 aid programs. Although it may be impossible to completely eliminate the effects of the oversupply situation of the 1960s, concentrating on imports instead of historical exports appears to contain fewer distortions. This procedure also provides useful information about the determinants of individual country imports and allows the study of individual as well as simultaneous volatility of imports.

### 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 114 individual countries. The primary data source is a computer data tape containing information assembled by the Foreign Agricultural Service of the United States Department of Agriculture (United States Department of Agriculture, 1975b).

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.

### Delineation of Import Regions

A total of 108 countries were included in the wheat import demand portion of this study. In order to facilitate computations, these countries were grouped into 14 importing regions. The importing regions and the countries included are contained in Table 19.

### Estimated Import Equations

Wheat import equations are estimated for each of the 14 importing regions. Equations are presented for each region along with definitions and interpretations. Two estimation methods are used and complete results are presented in Appendix A. Only the estimates used in the model are included in this chapter. 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. 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 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 1973.
Time	Time--integer variable with 1960 equal 1 and 2000 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.

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, Ecuador, Paraguay, Peru, Venezuela, Guyana
3	Brazil	Brazil
4	Northern Europe	Austria, Belgium 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, Czechoslovakia, East Germany, Hungary, Poland-Danzig, Rumania, Yugoslavia, Albania
7	U.S.S.R.	U.S.S.R.
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

Table 19. Continued

Region Number	Region Name	Countries Included in this Region
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

Equations reported in the text are used in a later part of this study. Economic relationships are considered to overrule statistical results and an equation must conform to economic theory before it is included. In several cases the equation which is selected for later use is not the statistically "best," but is more amenable to requirements imposed by the remainder of the study.

#### Mexico--Region 1

The estimated wheat import equation for Mexico is:

$$WNI_{1,t} = -1321.6 - .704WDS_{1,t} + 214.586 \text{ TIME}$$

(.173)\*\*\*, t (328.404)

$$\text{ALS } \rho = .896 \quad d = 1.87 \quad R^2 = .92 \quad \text{S.E.E.} = 130.3$$

(.238)\*\*\*

Wheat imports are inversely related to domestic supply and growing over time. The estimated coefficient on domestic supply is  $-.704$ . This indicates that Mexico would import 70 percent of a reduction in domestic wheat supply. If 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 would cause a 19.6 percent increase in wheat imports with other things constant. This formulation explained 92 percent of the variation in Mexico's net wheat imports. The standard error of the estimate is 130.3 million metric tons. This is a substantial reduction from the standard deviation of wheat imports which is 390.1 million metric tons.

Several alternative variables and equations were estimated and these estimates are presented in Appendix A. United States wheat export price was found to be insignificant or of the wrong sign in all specifications. In an effort to correct this disturbing conclusion, the U.S. wheat export price was deflated by the consumer price index of the region as suggested by (Bjarnason, McGarry, and Schmitz, 1969). This converts price to a 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 which resulted in the correct sign was able to explain only 13 percent of the variation in net wheat imports. Several conclusions could be supported from the results obtained. First, it is possible that the U.S. wheat export price does not reflect the import price, and that the constructed import price also differs from the actual import price. Secondly, the tendency for import and price to move together may dominate the response of quantity to price.

Thirdly, price may play a minor or insignificant role in decisions to import. This may also be supported by the relative stability of U.S. export price during most of the period analyzed.

### Central America--Region 2

The wheat import demand equation for Central America is:

$$WNI_{2,t} = 3798.8 - .538WDS_{2,t} - 142.751WUSP_t + 174.27 TIME$$

(.578)                      (160.924)                      (60.459)\*\*

$$ALS \quad \rho = .573 \quad d = 1.74 \quad R^2 = .93 \quad S.E.E. = 270.04$$

(.362)

Net wheat imports are inversely related to U.S. wheat export price and growing over time. Only time is statistically significant at the 10 percent level.

The estimated equation explains 93 percent of variations in net wheat imports for Central American and has a standard error of the estimate of 270.4 million metric tons. The standard deviation of net wheat imports is 921.2 million metric tons.

The coefficient of net import demand elasticity relative to wheat domestic supply calculated at the 1972-1974 average net imports and domestic supply is  $-.19$ . As production decreases 10 percent the quantity of net wheat imports will increase 1.9 percent, other things equal. The price elasticity of net imports calculated for U.S. wheat export price over the 1972-1974 average and wheat net imports over the 1972-1974 period is  $-.32$ . This suggests that a 10 percent increase in U.S. export price would reduce net wheat imports in Central America by 3.2 percent. The estimated coefficient on domestic wheat supply is

-.538. This coefficient indicates 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:

$$WNI_{3,t} = 2414.90 - .646WDS_{3,t} + 98.812 TIME$$

$$(.127)*** \quad (22.412)***$$

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

Net wheat imports are growing 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 supply. The estimated coefficient on domestic wheat supply is -.646. This suggests that Brazil will import approximately 65 percent of a decrease in domestic supply, other things equal. The estimated equation explains 69 percent of the variation in net imports.

Several alternative specifications and variables were considered and are presented in Table A-3 of the Appendix. United States 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 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, U.S. export price increases. Brazil imports approximately 5 percent of world wheat imports so this should not influence 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 very high that many other countries are also experiencing the same reduced production. The correlation 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 from 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
U.S.S.R.	.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

Wheat production in Brazil is highly correlated with wheat production in other regions. However, wheat net imports between Brazil and other regions are not highly correlated. This may result from several factors. First, wheat stocks are not considered and may augment production in some countries. Secondly, not all countries respond in the same magnitude to a change in domestic wheat supply. Thirdly, the simultaneous fluctuations in production may cause many countries to pursue the same export supply and drive up prices. This could cause further differences in actual imports as the richer countries bid wheat away from poorer countries.

#### Northern Europe--Region 4

The estimated net wheat import equation for Northern Europe is:

$$\begin{aligned} \text{WNI}_{4,t} = & 19816.0 - .583\text{WDS}_{4,t} - 664.157\text{WUSP}_t + 189.225 \text{ TIME} \\ & (.193)** \quad (398.182) \quad (103.961)* \\ \text{OLS} \quad d = & 1.79 \quad R^2 = .67 \quad \text{S.E.E.} = 850.61 \end{aligned}$$

The estimated equation explains 67 percent of the variation in net imports. Wheat net imports are inversely related to U.S. wheat export price and domestic wheat supply. Net imports are also growing 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  $-.41$ . This indicates an inelastic response of quantity imported to a change in U.S. export price. The coefficient of net wheat import elasticity with respect to domestic wheat supply is  $-2.28$ , when 1972-1974 average values are used in the calculation.

Several alternative specifications and variables were estimated and are included in Table A-4 in Appendix A. Similar results were obtained for all specifications. None of the equations estimated explains more than 68 percent of the variation in net wheat imports. The price variable obtained by deflating 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 import to United States exports, and this is best done when U.S. price is used directly.

#### Southern Europe--Region 5

The estimated net wheat import equation for Southern Europe is:

$$WNI_{5,t} = 14000.0 - .74WDS_{5,t} + 105.16 \text{ TIME}$$

$$(.09)*** \quad (34.44)**$$

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

The estimated equation explains 86 percent of the variation in net imports, and both estimated coefficients are statistically significant at the 1 percent level. Net wheat imports are growing over time and 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. This indicates a 5.56 percent increase in net wheat imports would be caused by 1 percent decrease in domestic wheat production plus stocks.

Several alternative specifications and variables were estimated and are included in Appendix Table A-5. United States 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:

$$WNI_{6,t} = 12040.2 - .388WDS_{6,t} + 294.258 \text{ TIME}$$

$$(.189)^* \quad (291.521)$$

$$\text{ALS} \quad \rho = .456 \quad d = 1.72 \quad R^2 = .63$$

$$(.287)$$

$$\text{S.E.E.} = 1067.4$$

Net wheat imports are inversely related to domestic wheat supply and increasing 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, assuming other factors remained 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. This indicates a 3.57 percent reduction in net imports would be caused by a 1 percent increase in domestic supply.

Alternative specifications and variables are shown in Appendix Table A-6. United States wheat export price and U.S. wheat export price deflated by a constructed consumer price index for Eastern Europe were both found to be statistically nonsignificant in all specifications. The overall inability of any estimated equation to explain more than 63 percent of the variation in net imports indicates that important variables may have been omitted from the analysis.

#### U.S.S.R.--Region 7

The estimated net wheat import equation for the U.S.S.R. is:

$$\text{WNI}_{7,t} = 19488.4 - .320\text{WDS}_{7,t} + 1133.796 \text{ TIME}$$

$$(.130)^{**} \quad (574.696)^*$$

$$\text{ALS} \quad \rho = .353 \quad d = 1.62 \quad R^2 = .53$$

$$(.521)$$

$$\text{S.E.E.} = 4580.6$$

The estimated equation explains 53 percent of the variation in net wheat imports. The low  $R^2$  may indicate that relevant economic variables have been omitted 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 growing 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. This indicates that a 1 percent decrease in wheat domestic supply would cause net imports of wheat to decrease 8.49 percent.

Several alternative specifications were estimated and are included in Appendix Table A-7. United States wheat export price is not significant in any specification, although the sign is correct in some equations. The overall lack of explanatory 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:

$$WNI_{8,t} = 5111.5 - .799WDS_{8,t} + 631.157 TIME$$

(.162)\*\*\*      (116.527)\*\*\*

$$ALS \quad \rho = .574 \quad d = 1.87 \quad R^2 = .93$$

(.301)\*

$$S.E.E. = 502.28$$

The estimated equation explains 93 percent of the variation in net wheat imports and shows a negative relationship between net wheat imports and domestic wheat supply and a positive growth in net wheat imports over time. 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 assuming other things constant. The coefficient of elasticity for net wheat imports relative to domestic wheat supply is -.87 when 1972-1974 averages are used in the calculations.

The U.S. wheat export price does not contain the correct sign in any specification estimated. Even when U.S. export price is deflated by a constructed consumer price index for Africa, the estimated coefficient does not contain the correct sign. All estimates of price result in positive coefficients and several specifications give 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:

$$WNI_{9,t} = 627.1 - .733WDS_{9,t} + 65.820 \text{ TIME}$$

(.163)\*\*\*                      (23.473)\*\*

$$\text{OLS} \quad d = 2.20 \quad R^2 = .72 \quad \text{S.E.E.} = 158.5$$

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.

United States wheat export price has the correct sign but is not statistically significant in several alternative equations. The standard error of the estimate is also higher for all alternative specifications. The results of alternative estimated equations are shown in Appendix Table A-9.

#### West Asia--Region 10

The estimated net wheat import equation for West Asia is:

$$\begin{aligned} \text{WNI}_{10,t} = & 12008.2 - .668\text{WDS}_{10,t} - 703.556\text{WUSP}_t + 596.141 \\ & (.157)^{***} \quad (433.866) \quad (137.920)^{***} \\ \text{ALS} \quad \rho = & .360 \quad d = 2.25 \quad R^2 = .78 \\ & (.353) \\ \text{S.E.E.} = & 743.3 \end{aligned}$$

The estimated net wheat import equation explains 78 percent of West Asia's variation in wheat net imports. The equation's standard error is 743.3 which 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 third parameter lacks being significant at the 10 percent level by only a small amount. The net wheat import coefficient of elasticity with respect to domestic wheat supply is -4.12 when 1972-1974 average values are used in the calculations.

Several alternative specifications are shown in Appendix Table A-10. The inclusion of U.S. wheat export price is shown to have 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, but 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:

$$\begin{aligned} \text{WNI}_{11,t} &= 11004.7 - .459\text{WDS}_{11,t} + 894.160 \text{ TIME} \\ &\quad (.127)^{***} \quad (229.638)^{***} \\ \text{ALS} \quad \rho &= .481 \quad d = 1.42 \quad R^2 = .83 \\ &\quad (.372) \\ \text{S.E.E.} &= 1014.2 \end{aligned}$$

The equation explains 83 percent of the variation in net wheat imports, and has the desired sign on both time and domestic wheat supplies. United States wheat export price does not have the correct sign and is not included in the final equation. When 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. The alternative specification are shown in Appendix Table A-11.

India and Other South Asia is a particularly important region for a study of net imports because this region received 56 percent of all P.L. 480 wheat exports during the 1960-1975 period (United States Department of Agriculture, 1974c). 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. The ability of the estimated equation to predict net imports during the last three years (when P.L. 480 sales were substantially reduced) provides an indication of the relevance of an equation estimated from historical data.

The P.L. 480 supported and commercial wheat imports for India and Other South Asia are presented in Table 21. Residuals from the estimated import equation are also presented.

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<sup>a</sup>

Year	P.L. 480 Imports <sup>b</sup>	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	4.32	-.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

<sup>a</sup>P.L. 480 exports are listed by calendar 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.

<sup>b</sup>Source: (United States Department of Agriculture, 1974c).

The residuals for the years that P.L. 480 exports are low, 1971-1974, are lower than the average residual for other crop years. This suggests that the estimated equation is not influenced by P.L. 480 imports and can be used in its estimated form.

### Japan--Region 12

The estimated net wheat import equation for Japan is:

$$\text{WNI}_{12,t} = 4597.6 - .844\text{WDS}_{12,t} + 134.450 \text{ TIME}$$

$$(.145)^{***} \quad (15.541)^{***}$$

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

The estimated equation explains 98 percent of the variation in net wheat imports over the 1960-1974 period. 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 growing at a linear rate over time. The estimated coefficient on domestic wheat supply is  $-.844$ , and indicates that 84 percent of a decrease in production would be offset by imports, assuming other things constant. The coefficient of net wheat import elasticity with respect to domestic wheat supply is  $-.21$  when the 1972-1974 average net imports and domestic supply are used in the calculation.

A number of alternative specifications and variables are reported in Appendix Table A-12. 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 is deflated by the consumer price index for Japan, the resulting variable has the expected sign and is significant at the 10 percent level.

### Other East Asia--Region 13

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

$$\text{WNI}_{13,t} = 761.7 + 358.188 \text{ TIME} \\ (75.941)***$$

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 implies the willingness of this region to import over two times as much as production decreases.

### People's Republic of China--Region 14

An estimated equation is not used to predict the net wheat imports for the People's Republic of China. A number of variables and specifications were considered and are reported in Appendix Table A-14. Although statistical significance was obtained in several specifications, the estimated parameters did not agree with results suggested by economic theory. 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 will provide an indication of the degree of interdependence of wheat imports. If wheat production is correlated between regions, then this has major implications for wheat imports. Assuming other factors remain constant, wheat imports would be correlated and the fluctuations in total world imports would be greater. When one region experiences a lower than expected production, the probability increases that other regions will also have reduced production and, therefore, larger imports.

#### Correlation of wheat production

Table 22 shows the correlation matrix for wheat production in all importing regions. Of the 91 nondiagonal correlation coefficients, 59 are significant at the 5 percent level and only 43 of these are significant at the 1 percent level (Snedecor and Cochran, 1972, pp. 184-185, 557). Table 23 shows the correlation matrix for deviations from trend wheat production between regions. Of these 91 nondiagonal correlation coefficients, only 11 are significant at the 5 percent level and only 3 of these are significant at the 1 percent level (Snedecor and Cochran, 1972, pp. 184-185, 557).

These two correlation matrices indicate that wheat production is highly correlated between many of the wheat importing regions. But, fluctuations in wheat production about the trend are not highly

Table 22. Correlation matrix of wheat production for the wheat importing regions for 1960-1974<sup>a</sup>

Region	1	2	3	4	5	6	7	Region 8	9	10	11	12	13	14
1	1.00													
2	0.02	1.00												
3	0.62	-0.36	1.00											
4	0.65	-0.59	0.81	1.00										
5	0.68	0.12	0.30	0.47	1.00									
6	0.67	-0.56	0.73	0.92	0.56	1.00								
7	0.39	-0.32	0.58	0.53	0.39	0.66	1.00							
8	0.45	-0.49	0.55	0.79	0.43	0.76	0.43	1.00						
9	0.54	-0.67	0.72	0.85	0.28	0.83	0.61	0.81	1.00					
10	0.57	-0.39	0.42	0.73	0.68	0.86	0.53	0.81	0.76	1.00				
11	0.54	-0.58	0.75	0.83	0.37	0.87	0.66	0.86	0.94	0.79	1.00			
12	-0.68	0.47	-0.69	-0.78	-0.41	-0.85	-0.58	-0.79	-0.84	-0.76	-0.85	1.00		
13	0.46	0.39	-0.15	-0.03	0.71	0.01	0.16	0.00	-0.13	0.18	-0.13	-0.05	1.00	
14	0.75	-0.34	0.60	0.80	0.57	0.87	0.63	0.73	0.71	0.79	0.76	-0.88	0.26	1.00

<sup>a</sup> A correlation coefficient is statistically significant at the 5 percent level if  $|r| \geq .514$  and is statistically significant at the 1 percent level if  $|r| \geq .641$  (Snedecor and Cochran, 1972, pp. 184-185, 557).

Table 23. Correlation matrix of deviations from trend wheat production for the wheat importing regions for 1960-1974<sup>a</sup>

Region	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	1.00													
2	0.64	1.00												
3	0.11	-0.14	1.00											
4	-0.04	-0.29	0.44	1.00										
5	0.49	0.52	-0.19	0.02	1.00									
6	-0.30	-0.42	-0.00	0.52	0.07	1.00								
7	-0.45	-0.26	0.13	-0.21	0.00	-0.06	1.00							
8	-0.32	-0.23	-0.14	0.36	-0.09	0.07	-0.11	1.00						
9	-0.33	-0.61	0.13	0.24	-0.50	0.04	0.31	0.32	1.00					
10	-0.19	0.03	-0.68	-0.05	0.32	0.31	0.05	0.47	0.16	1.00				
11	-0.41	-0.32	0.16	0.28	-0.31	0.06	0.26	0.71	0.53	0.28	1.00			
12	0.04	0.29	0.06	0.16	0.43	0.25	0.26	-0.29	-0.31	0.08	0.04	1.00		
13	0.46	0.45	-0.29	-0.29	0.68	-0.41	0.05	-0.33	-0.32	-0.03	-0.56	0.17	1.00	
14	0.24	0.12	-0.34	-0.01	0.05	-0.04	-0.37	0.11	-0.29	0.08	-0.14	-0.29	0.01	1.00

<sup>a</sup>A correlation coefficient is statistically significant at the 5 percent level if  $|r| \geq .514$  and is statistically significant at the 1 percent level if  $|r| \geq .641$  (Snedecor and Cochran, 1972, pp. 184-185, 557).

correlated. The high correlation in production is caused by a growth in wheat production in most regions over the 1960-1974 period. The lack of correlation in deviations from trend suggests that not all countries have above or below trend production at the same time.

#### Projected wheat production

Estimated wheat production equations as a function of time are presented in Table 24. These equations are used to predict production for each wheat importing region. The estimated equation for wheat production for Japan predicts a negative production in 1976. To overcome this problem, wheat production is held constant at the last observed wheat production which is .23 million metric tons in crop year 1974-1975. All other regions' wheat production is predicted by the estimated equations.

Projected wheat productions for each importing region and the sum of projected production for all regions are presented in Table 25. 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 1974 and 2000. Japan is projected to hold production unchanged, and all other regions are projected to increase production of wheat by the year 2000. Based on historical production

Table 24. Estimated equations for wheat production as a function of time, 1960-1974

Region	Estimation Technique	Constant	Time	$\rho$	$R^2$	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

Table 24. Continued

Region	Estimation Technique	Constant	Time	$\rho$	$R^2$	d	S.E.E.
13. Other East Asia	ALS	387.27	-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

patterns, the U.S.S.R. is projected to increase production from 83.84 to 181.77 million metric tons from 1974 to 2000. India and Other South Asia is also projected to have a large increase in wheat production between 1974 and 2000.

Table 25. 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
U.S.S.R.	83.84	119.66	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	<sup>a</sup>
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	

<sup>a</sup> An equation was not used to project production for Japan.

### Variation in production

The variation in wheat production is the primary determinant of variations in net wheat imports. Table 26 shows the standard deviations of wheat production about the trend for each region and the combined standard deviation for all regions. The summation of the standard deviations of all 14 regions yields a standard deviation on world wheat production of 22.78 million metric tons. However, when the correlation of wheat production between regions is included, the standard deviation is 12.00 million metric tons. The variation of wheat production about the trend is very large for the U.S.S.R. The standard deviation is almost 11 million metric tons. This value is almost 50 percent of the individual variability in all other regions combined.

Table 26. Standard deviations of wheat production for individual wheat importing regions and all regions combined

Region	Standard Deviation	1960-1974 Average Production
	(million metric tons)	
Mexico	.20	1.80
Central America	.17	1.10
Brazil	.50	1.49
Northern Europe	1.25	14.57
Southern Europe	1.13	16.08
Eastern Europe	1.68	23.93
U.S.S.R.	10.97	80.97
Africa	.80	6.00
Republic of South Africa	.21	1.16
West Asia	1.17	16.44
India and Other South Asia	2.55	21.76
Japan	.22	.91
Other East Asia	.08	.66
People's Republic of China	1.85	25.28
Total All Region	12.00	

The variation in total wheat production in all wheat importing countries has a standard deviation of 12 million metric tons when fluctuations in production are allowed to cancel. However, when fluctuations are not allowed to cancel the fluctuations in production have a standard deviation which is approximately twice as large. This implies a tendency for good and bad years in one region to be offset by the opposite result in another region.

#### Wheat stocks

Stocks of wheat on hand at the beginning of each crop year is used as a component of the explanatory variable domestic wheat supply. When stocks are large, they provide a cushion against low production and are used to substitute for imports. The average level of beginning wheat stocks in each region are presented in Table 27. The U.S.S.R. has the largest average level of stocks of the importing regions. However, this is due primarily to the level of production which is also the greatest of the importing regions. In terms of the ratio of the average wheat stocks over the 1960-1974 period to the average production, the U.S.S.R. has average beginning period stocks equal to 14 percent of average production. Eastern Europe, Africa, and Mexico have the lowest ratio of average stocks to average production with ratios of 6, 7, and 8 percent, respectively. Japan has the highest ratio, but this is misleading because production is very low relative to imports and consumption. The data for the People's Republic of China is not available.

Table 27. Average wheat stocks at the beginning of each crop year for the period from 1960-1974

Region	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
U.S.S.R.	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	<sup>a</sup>	<sup>a</sup>

<sup>a</sup>Data on beginning stocks is not available for the People's Republic of China.

#### Wheat Imports

Wheat import equations are estimated for individual importing countries and regions. Explanatory variables used in the estimated equations are wheat production in the importing region, level of wheat stocks in the importing region, U.S. wheat export price, and a trend variable which is assumed 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. Appendix Table A-16 contains projected net imports when U.S. wheat export price is \$3.40 and stocks are constant at the 1960-1974 average levels.

The variability of net wheat imports can be obtained as 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 leads to the more elaborate Monte Carlo procedure used in this study.

#### Projected net wheat imports

Projected values for net wheat imports are presented for each region and all regions combined in Table 28. 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 Africa and Asia. The European countries shown 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 average net imports of 71.2 million

metric tons 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 in the net wheat imports and approximately doubles its imports between 1974 and 2000. Brazil's net imports remain relatively constant near its 1960-1974 average. Northern Europe is projected to decrease the level of net wheat imports. Northern Europe imported an average of 3.38 million metric tons of wheat in 1960-1963. By 1972-1974, the average imports were 6.19 million metric

Table 28. 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 value for the 1960-1974 period and U.S. wheat export price is \$3.00

Region	Actual 1972-1974 <sup>a</sup>	1980	1990	2000
(million metric tons)				
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
U.S.S.R.	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	5.54	4.59	4.59	4.59
Total All Regions	57.79	65.94	82.62	99.29

<sup>a</sup> Average U.S. wheat export price was \$3.78.

tons, and the projected net wheat imports in the year 2000 are 3.96 million metric tons. Southern Europe is projected to increase its net wheat imports by 74 percent between 1974 and the year 2000. Eastern Europe is projected to become a net exporter by the year 2000. During the period from 1960 to 1974, Eastern Europe has been decreasing its net wheat imports. This trend is projected to continue and result in net exports by the early 1990s. The average net wheat imports during the 1960-1974 period were 4.56 million metric tons. By 2000, Eastern Europe is projected to have net exports of 1.47 million metric tons. The U.S.S.R. is projected to become a net wheat importer over the remainder of the century. This is reflected by decreasing exports during the 1960-1974 period and net imports in 1972. By the year 2000, the U.S.S.R. is projected to import 4.29 million metric tons of wheat compared with average net exports of 1.04 million metric tons during the 1960-1974 period.

Africa is projected to become the largest net wheat importer by the year 2000. Imports of wheat increased steadily from 1960 to 1974, and 1974 imports were 8.36 million metric tons. This trend is projected to continue and increase imports to 20.22 million metric tons by the year 2000. The Republic of South Africa is projected to have average net imports of less than .1 million metric tons during the remainder of the century. West Asia is projected to become a major wheat importer by the year 2000. The 1960-1974 average net imports of 2.62 million metric tons are projected to increase to 13.21 million metric tons by the year 2000. India and Other South Asia is projected to have a small increase in net wheat imports. The 1960-1974 average imports were 6.46

and are projected to increase to 10.22 million metric tons by the year 2000. Japan is projected to have an increase in net wheat imports of 69 percent over the 1974 level. Other East Asia is projected to increase net wheat imports from an average of 3.79 to 15.45 by the year 2000. This region is projected to become the second largest net wheat importer by the year 2000. Net wheat imports for the People's Republic of China is projected to remain at the 1960-1974 average of 4.59 million metric tons.

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.

#### Variability in net wheat imports

The variability in net wheat imports is primarily dependent upon the variability in domestic wheat supply, and will be less variable than production. This results from a country's observed tendency to import only a portion of a reduction in production. For example, Africa has historically imported 79.9 percent of a reduction in production. This suggests the relationship between variability in production and variability in net imports is that 80 percent of the variability in wheat production in Africa will be converted into imports, assuming other things equal.

The estimated standard deviations of net wheat imports and wheat production are shown for individual regions and countries and for all wheat importing regions combined in Table 29 (Steel and Torrie, 1960, p. 47).

Table 29. Standard deviations of net wheat imports and wheat production for individual importing regions and countries and for all regions combined, with 1980 projected net wheat imports for comparison

Region	Projected 1980 Net Wheat Imports	Standard Deviation of Net Wheat Imports	Standard Deviation of Production Deviations
(million metric tons)			
Mexico	1.34	.15	.23
Central America	6.24	.10	.17
Brazil	2.26	.29	.50
Northern Europe	5.96	.78	1.25
Southern Europe	1.42	.90	1.13
Eastern Europe	2.04	.68	1.68
U.S.S.R.	.82	3.42	10.97
Africa	10.99	.68	.80
Republic of South Africa	.09	.15	.21
West Asia	6.71	.73	1.17
India and Other South Asia	7.87	1.26	2.55
Japan	6.32	.16	.22
Other East Asia	8.28	.06	.08
People's Republic of China	4.59	<sup>a</sup>	1.85
Total All Regions	64.93	4.81	12.00

<sup>a</sup>The standard deviation was not estimated for The People's Republic of China.

As expected, the variability in wheat production provides an upper bound on the variability in net wheat imports. Countries and regions which have the greatest variability in wheat production also have the greatest variability in net wheat imports. The U.S.S.R. has the largest

standard deviation for wheat production and net wheat imports. India and Other South Asia, Eastern Europe, and The People's Republic of China also have large standard deviations in wheat production. These countries and regions also have the highest standard deviations in net wheat imports. Table 30 shows the range of wheat production and net wheat imports defined by a 95 percent confidence interval about the projected 1980 values. The results of this table show the extreme variability in wheat production and net imports. The 1980 total net wheat imports will lie between 54.27 and 75.59 million metric tons in 95 out of 100 years.

Table 30. Confidence intervals for net wheat imports and wheat production for 1980 when  $\alpha = .05$

Region	95 Percent Confidence Interval on Wheat Imports	95 Percent Confidence Interval on Wheat Production
Mexico	( 1.01 - 1.67)	( 2.02 - 2.90)
Central America	( 6.02 - 6.46)	( .70 - 1.46)
Brazil	( 1.62 - 2.90)	( 1.88 - 4.10)
Northern Europe	( 4.23 - 7.69)	( 18.34 - 23.88)
Southern Europe	( -.57 - 3.41)	( 15.05 - 20.05)
Eastern Europe	( .53 - 3.55)	( 36.19 - 43.63)
U.S.S.R.	(-6.76 - 8.40)	( 95.36 - 143.96)
Africa	( 9.48 - 12.50)	( 7.01 - 10.55)
Republic of South Africa	( -.24 - .42)	( 1.83 - 2.77)
West Asia	( 5.09 - 8.32)	( 19.09 - 24.27)
India and Other South Asia	( 5.08 - 10.66)	( 37.10 - 48.40)
Japan	( 5.97 - 6.67)	( 0. - .71)
Other East Asia	( 8.15 - 8.41)	( .28 - .64)
People's Republic of China	— <sup>a</sup>	( 33.05 - 41.25)
Total All Regions	(54.27 - 75.59)	(291.51 - 344.67)

<sup>a</sup> A confidence interval on net wheat imports is not calculated for The People's Republic of China because an import demand equation was not obtained for this region.

### United States Wheat Exports

The percentage of total world exports which the United States supplies has been relatively stable over the 1960-1974 period. The average market share has been 42.7 percent of total exports by the major exporting countries,<sup>1</sup> and the range of market shares has been between 33 and 55 percent. Based on the historical market share of 42.7 percent, Table 31 shows the projected U.S. wheat exports for 1980, 1990, and 2000. The 95 percent confidence interval about the projected exports are also shown for 1980, 1990, and 2000. The confidence interval assumes that U.S. wheat exports remain at 42.7 percent of total world imports.

Table 31. Projected U.S. wheat exports for selected years with 1972-1974 actual exports for comparison<sup>a</sup>

Year	Projected U.S. Wheat Exports	95 Percent Confidence Interval on U.S. Wheat Exports
	(million metric tons)	
1972-1974 Actual <sup>b</sup>	30.32	
1980	28.16	(23.61 - 32.71)
1990	35.28	(30.73 - 39.83)
2000	42.40	(37.85 - 46.95)

<sup>a</sup>United States wheat export price is held constant at \$3.00 per bushel in 1972 dollars.

<sup>b</sup>Actual U.S. wheat export price averaged \$3.78 per bushel in 1972 dollars.

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<sup>1</sup>  
The major exporting countries are: United States, Canada, Brazil, Argentina, Australia, France, and the U.S.S.R.

## CHAPTER V. DEMAND FOR FEED GRAINS

The United States is the major supplier of feed grains to the world market. During the 1960-1974 period, the United States supplied 50 percent of all feed grains exported. This chapter will consider the characteristics of feed grain imports for all of the importing countries and regions of the world. From this analysis, the export market for the United States can be more clearly understood.

### 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 a computer data tape containing information assembled by the Foreign Agricultural Service of the United States Department of Agriculture (U.S. Department of Agriculture, 1975b).

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 32 contains a list of variable names and definitions.

## Delineation of Import Regions

A total of 111 countries were included in the feed grain import portion of this study. The major feed grain exporting countries: the United States, Argentina, France, Republic of South Africa, Canada, Australia, Thailand, and Brazil, were excluded from the analysis. These countries supplied approximately 95 percent of the feed grain exports during the 1960-1974 period.

The importing countries are divided into 12 importing regions. The importing regions and the countries included are given in Table 33.

Table 32. 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 $i = 1, \dots, 12$ .
$FGNI_{it}$	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 $t$ .

Table 33. 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, Ecuador, 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	U.S.S.R.	U.S.S.R.
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, Jordan, Lebanon, Syria, Turkey, Saudi Arabia, So Yemen, 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

### Estimated Import Equations

Import equations for feed grains are estimated for each of the 12 importing regions. Equations are presented for each region along with definitions and interpretations. Two estimation methods are used and complete results are presented in Appendix B. Only the estimates used for projecting imports are included in this chapter. 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 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. 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 indicate that the coefficient was not significant at the 10 percent level or higher.

Equations reported in the text are used in the later part of this study. Economic relationships are considered to overrule statistical results and an equation must conform to economic theory before it is included. In several cases the equation which is selected for later use is not the statistically "best," but is more amenable to requirements imposed by the remainder of the study.

Mexico--Region 1

The estimated feed grain import equation for Mexico is:

$$\text{FGNI}_{1,t} = 4381.4 - .791 \text{ FGDS}_{1,t} + 420.383 \text{ TIME}$$

(.066)\*\*\*                      (30.444)\*\*\*

OLS              d = 1.31              R<sup>2</sup> = .94              S.E.E. = 302.1

Feed grain imports are inversely related to domestic feed grain supply and growing over time. The estimated coefficient for domestic feed grain supply implies that Mexico would import 79 percent of a reduction in production plus stocks or it would decrease imports by 79 percent of an increase in feed grain production plus stocks. The coefficient estimated for TIME implies that net feed grain imports are growing over time. The variable time can be interpreted to represent the combination of factors which increase imports. Two of these factors are expected to be the growth in population and the increase in per capita income.

The coefficient of elasticity of net feed grain imports to a change in domestic feed grain supply is -4.32, when calculated at the 1972-1974 average values of net feed grain imports and domestic supply. This implies that a decrease of 10 percent in domestic production plus stocks would cause a 43.2 percent increase in net feed grain imports.

A number of alternative equations were estimated and are presented in Appendix Table B-1. Several specifications resulted in good statistical fits based on summary statistics, however, the estimated coefficient on U.S. feed grain export price had the opposite sign from that suggested by economic theory. Two definitions of feed grain price were used in the estimated equations: 1) U.S. corn export value at gulf

ports deflated to 1972 dollars and adjusted for the dollar devaluation of 1971 and 1973 and 2) the above variable deflated by the consumer price index for the importing region or a constructed index when several countries comprised a region. Both price variables gave similar results. Feed grain price was not found to be a significant variable influencing the quantity of net feed grain imports which a country had in the 1960-1974 period. The observed positive and significant results are contrary to those suggested by economic theory and indicate the difficulty of estimation rather than the causality of the relationship.

The estimated equation with the highest  $R^2$  was able to explain 98 percent of the variation in net feed grain imports by Mexico, but had positive and significant coefficient on U.S. feed grain export price. This implies that Mexico increases exports as the U.S. feed grain export price increases. This same problem was observed in several of the estimated net import equations for wheat. This result may be explained by several factors. First, the U.S. feed grain export price may not be correctly defined due to the exchange rates between Mexico and the United States. Secondly, the simultaneous increase in net feed grain imports by all importing countries may cause a positive correlation of net feed grain imports and price. This correlation may disguise the negative impact of higher prices on net feed grain imports. This would be particularly true if the price elasticity of imports is very low.

Because of the difficulty caused by including price in the estimated equation, a specification was chosen which included domestic feed grain

supply and time as the explanatory variables. The resulting equation explained 94 percent of the variation in net feed grain imports.

### Central America--Region 2

The estimated feed grain net import equation for Central America is:

$$\text{FGNI}_{2,t} = 3720.9 - .768 \text{ FGDS}_{2,t} + 251.893 \text{ TIME}$$

(.223)\*\*\*                      (35.144)\*\*\*

ALS       $\rho = .087$        $d = 2.31$        $R^2 = .94$       S.E.E. = 156.6

The estimated equation explains 94 percent of the variation in net feed grain imports over the 1960-1974 period. Net feed grain imports are increasing over time and inversely related to domestic feed grain production plus stocks of feed grains at the beginning of the crop year. According to the estimated equation, 76.8 percent of a reduction in feed grain production plus stocks was made up by increased imports during the 1960-1974 period. The elasticity of net feed grain imports with respect to the domestic supply of feed grains is -2.87 when calculated for the 1972-1974 period. This implies a 10 percent reduction in domestic feed grain supply would cause a 28.7 percent decrease in net feed grain imports.

Several alternative equations were estimated and are presented in Appendix Table B-2. Feed grain price was not significant and of the expected sign in any specification.

Northern Europe--Region 3

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

$$\text{FGNI}_{4,t} = 32164.0 - .829 \text{ FGDS}_{4,t} + 1157.679 \text{ TIME}$$

$$(.218)^{***} \quad (269.217)^{***}$$

$$\text{OLS} \quad d = 1.81 \quad R^2 = .66 \quad \text{S.E.E.} = 852.2$$

The estimated relationship shows that Northern Europe has 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 are also growing over time as shown by the estimated equation. The estimated coefficient on time is also 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.

The estimated equation explains only 66 percent of the variation in net feed grain imports over the 1960-1974 period. Several other specifications and variables were estimated and are shown in Appendix Table B-3. None of the alternate specifications resulted in a substantial improvement over the reported equation. Feed grain price was not found to be both significant at the 10 percent level or greater and of the expected sign. The lack of explanatory power of the estimated equation suggests that one or more important variables have been omitted from the analysis.

Southern Europe--Region 4

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

$$\begin{aligned} \text{FGNI}_{4,t} &= 4728.9 + 459.247 \text{ TIME} \\ &\quad (149.166)*** \\ \text{ALS} \quad \rho &= .412 \quad d = 2.11 \quad R^2 = .79 \\ &\quad (.261) \\ \text{S.E.E.} &= 1224.2 \end{aligned}$$

The estimated equation explains 79 percent of the variation in net feed grain imports over the 1960-1974 period. An equation which used domestic supply as the explanatory variable was able to explain 80 percent of the variation in net imports, but did not work well for projections.

Appendix Table B-4 presents alternative specifications of the estimated import equation. U.S. feed grain export price was not found to be a significant variable affecting net feed grain imports. In all specifications, U.S. feed grain export price had a positive sign, which disagrees with economic theory, and was statistically not different from 0 at the 10 percent level. A number of specifications resulted in a negative coefficient less than one for the domestic supply variables. These equations are unacceptable because the implication is that exports would increase more than domestic supply decreases.

Eastern Europe--Region 5

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

$$\text{FGNI}_{5,t} = 112.3 - .012 \text{ FGDS}_{5,t} + 228.497 \text{ TIME}$$

(.153) (204.583)

OLS      d = 2.13      R<sup>2</sup> = .47      S.E.E. = 1104.7

The estimated equation for Eastern Europe explains 47 percent of the variation in net feed grain imports. Neither 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, and that Eastern Europe does not respond to the same variables that affect import decisions in other regions. Several alternative specifications are presented in Appendix Table B-5.

#### U.S.S.R.--Region 6

The estimated net feed grain import equation for the U.S.S.R. is:

$$\text{FGNI}_{6,t} = -3266.7 - .025 \text{ FGDS}_{6,t} + 566.381 \text{ TIME}$$

(.088) (354.037)

ALS      ρ = .413      d = 1.49      R<sup>2</sup> = .70

          (.344)

S.E.E. = 1565.2

The estimated equation explains 70 percent of the variation in net feed grain imports, however, neither estimated coefficient is statistically significant at the 10 percent level or higher. Additional equations are shown in Appendix Table B-6. All other specifications estimated resulted in a positive estimate for the coefficient on domestic supply. This relationship is not reasonable, but perhaps shows that another relationship not included in the equation is important. The estimated coefficient on U.S. feed grain export price had the correct sign in all equations, but was insignificant in all but one specification at the

10 percent level or higher. 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:

$$\begin{array}{rcll} \text{FGNI}_{7,t} & = & 4566.4 & - .232 \text{ FGDS}_{7,t} + 131.945 \text{ TIME} \\ & & (.123) & (57.900)*** \\ \text{OLS} & d = & 1.83 & R^2 = .33 \quad \text{S.E.E.} = 328.5 \end{array}$$

The estimated equation explains 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 feed grain domestic supply and growing over time. The coefficient of elasticity of net feed grain imports to domestic supply is -22.95. The lack of explanatory ability of the estimated equation shows that significant variables may have been excluded from the analysis.

Several alternative equations were estimated and are contained in Appendix Table B-7. As shown by these equations, U.S. feed grain export price and 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:

$$\begin{array}{rcll} \text{FGNI}_{8,t} & = & 2742.2 & - .326 \text{ FGDS}_{8,t} + 116.396 \text{ TIME} \\ & & (.073)*** & (11.527)*** \\ \text{OLS} & d = & 1.84 & R^2 = .91 \quad \text{S.E.E.} = 191.4 \end{array}$$

The estimated equation explains 91 percent of the variation in net feed grain imports and both estimated coefficients are statistically significant at the 1 percent level. Net feed grain imports are increasing over time and 32.6 percent of a reduction in domestic feed grain supply would be offset by increased imports. The coefficient of elasticity of feed grain net imports to domestic feed grain supply is -1.79 when calculated for the 1972-1974 period.

Several alternative equations are presented in Appendix Table B-8. United States feed grain export price had the desired sign in several equations, but was not statistically significant at the 10 percent level or greater. Deflating the U.S. feed grain export price by a consumer price index for West Asia resulted in one specified equation which had the correct sign on the price variable and statistical significance at the 1 percent level. However, the resulting equation explained only 70 percent of the variation in net feed grain imports and had extreme autocorrelation due to the exclusion of the trend variable. When the trend variable was included, the price coefficient was no longer significant.

#### India and Other South Asia--Region 9

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

$$\text{FGNI}_{9,t} = 1834.4 - .049 \text{ FGDS}_{9,t} - 17.240 \text{ TIME}$$

$$(\text{.186}) \quad (132.456)$$

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

$$(\text{.451})$$

The estimated equation explains 28 percent of the variation in net feed grain imports. None of the estimated coefficients are significant at the 10 percent level or higher. 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 shipments of feed grain under P.L. 480. If a dummy variable is introduced for these three years, we get the following equation:

$$\begin{aligned} \text{FGNI}_{9,t} = & 604.0 - .027 \text{ FGDS}_{9,t} + 30.603 \text{ TIME} + 1437.398 \text{ DUM}_9 \\ & (.042) \quad (21.920) \quad (229.384)*** \\ \text{OLS} \quad d = & 2.37 \quad R^2 = .79 \quad \text{S.E.E.} = 344.47 \end{aligned}$$

where  $\text{DUM}_9$  is the dummy variable. This equation explains 79 percent of the variation in net feed grain imports. It shows that feed grain imports are growing over time and are inversely related to domestic supply. Additional equations are included in Appendix Table B-9.

#### Japan--Region 10

The estimated net feed grain import equation for Japan is:

$$\begin{aligned} \text{FGNI}_{10,t} = & 2023.0 - .532 \text{ FGDS}_{10,t} + 792.595 \text{ TIME} \\ & (.469) \quad (48,595)*** \\ \text{OLS} \quad d = & 2.29 \quad R^2 = .98 \quad \text{S.E.E.} = 592.2 \end{aligned}$$

The estimated equation explains 98 percent of the variation in net feed grain imports over the 1972-1974 period. The estimated relationship indicates that Japan's net feed grain imports are growing over time and that historically Japan has increased imports to offset 53.2 percent of a reduction in domestic supply. The high explanatory power of the estimated equation is largely due to the low feed grain production in Japan.

This reduces the fluctuations in net imports due to production variations. The result is a stable growth in net feed grain imports as population and other factors change.

Several alternative equations and variables were estimated and are included in Appendix Table B-10. United States feed grain export was not significant at the 10 percent level or of the expected sign in any 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. However, the resulting equation had extreme autocorrelation. When this was corrected by including a trend variable the price variable no longer had the correct sign nor was it significant at the 10 percent level or greater.

The results with Japan clearly show that price was not a significant variable explaining the net quantity of feed grains imported. Domestic feed grain supply and time explain 98 percent of the variation in net feed grain imports. These results were derived over a period of time when price was relatively stable, and different results might be obtained if price increased substantially.

#### Other East Asia--Region 11

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

$$\begin{aligned} \text{FGNI}_{11,t} = & -5203.5 - .058 \text{ FGDS}_{11,t} - 930.411 \text{ FGUSP}_t \\ & (.103) \quad (571.690) \\ & + 635.155 \text{ TIME} \\ & (1186.849) \end{aligned}$$

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

The estimated equation explains 92 percent of the variation in net feed grain imports. Net feed grain imports are inversely related to domestic feed grain supply and price and growing over time. The estimated coefficient on 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 0 at the 10 percent level. The coefficient of price elasticity of demand is -2.07 for the 1972-1974 period. This indicates that a 10 percent decrease in U.S. feed grain export price will cause net feed grain imports to increase 20.7 percent assuming other things remain constant.

A number of alternate equations are presented in Appendix Table B-11. Several 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 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:

$$\text{FGNI}_{12,t} = 3747.9 - .150 \text{ FGDS}_{12,t} + 185.918 \text{ TIME} \\ (.057)*** \quad (68.554)*** \\ \text{OLS} \quad d = 1.95 \quad R^2 = .38 \quad \text{S.E.E.} = 497.8$$

Feed grain net imports are growing over time and inversely related to domestic feed grain supply. Both coefficients are statistically different from 0 at the 1 percent level and 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 will only increase imports 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. This implies that a 10 percent decrease in domestic feed grain supply would cause net feed grain imports to increase 48.2 percent.

Alternate specifications are presented in Appendix Table B-12. In all specifications, U.S. feed grain export price has a positive sign rather than the negative sign which is expected from economic theory.

#### Feed Grain Production

The level and variability of feed grain production has major implications for the level and variability of net feed grain imports. 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.

Efforts to quantify the variability in feed grain production for world regions provides a base on which to evaluate the variability in

feed grain imports. The following section concentrates on feed grain production for the importing regions specified in this study. Production levels are projected to the year 2000 based on historical trends. The variability of production is also examined for individual regions and all regions combined.

#### Correlation of feed grain production

The correlation matrix for feed grain production in all regions is shown in Table 34. Of the 66 nondiagonal correlation coefficients, 43 are significantly different from 0 at the 5 percent level and 39 are significantly different from 0 at the 1 percent level. This suggests a high degree of correlation in feed grain production between world regions.

Table 35 shows the correlation matrix for deviations in production from the trend. Of the 66 nondiagonal correlation coefficients, 4 coefficients are significantly different from 0 at the 5 percent level and one additional coefficient is significant at the 1 percent level. These results indicate a low correlation in the deviations of feed grain production between importing regions.

#### Projected feed grain production

Estimated equations for feed grain production estimated as a function of time are presented in Table 36. 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. The estimated equations

Table 34. Correlation matrix of feed grain production between importing regions for the period 1960-1974<sup>a</sup>

Region	1	2	3	4	5	6	7	8	9	10	11	12
1	1.00											
2	0.91	1.00										
3	0.87	0.91	1.00									
4	0.75	0.84	0.92	1.00								
5	0.71	0.80	0.90	0.88	1.00							
6	0.70	0.81	0.82	0.90	0.83	1.00						
7	0.87	0.91	0.89	0.79	0.75	0.74	1.00					
8	0.23	0.23	0.45	0.30	0.29	0.13	0.45	1.00				
9	0.37	0.37	0.35	0.26	0.18	0.40	0.44	0.37	1.00			
10	-0.84	-0.82	-0.89	-0.81	-0.78	-0.72	-0.93	-0.52	-0.25	1.00		
11	0.70	0.67	0.56	0.40	0.44	0.60	0.56	-0.01	0.50	-0.45	1.00	
12	0.92	0.89	0.86	0.69	0.65	0.66	0.90	0.45	0.40	-0.90	0.67	1.00

<sup>a</sup>A correlation coefficient,  $r$ , is significantly different from 0 at the 5 percent level if  $|r| \geq .514$  and is significantly different from 0 at the 1 percent if  $|r| \geq .641$  (Snedecor and Cochran, 1972, pp. 184-185, 557).

Table 35. Correlation matrix of deviations of feed grain production from trend for the feed grain importing regions from 1960-1974<sup>a</sup>

Region	1	2	3	4	5	6	7	8	9	10	11	12
1	1.00											
2	0.49	1.00										
3	-0.07	-0.08	1.00									
4	-0.28	0.17	0.27	1.00								
5	-0.46	-0.25	0.27	0.37	1.00							
6	-0.42	-0.03	-0.23	0.46	0.37	1.00						
7	0.25	0.33	0.10	-0.17	-0.43	-0.42	1.00					
8	-0.04	-0.29	0.46	-0.29	-0.18	-0.67	0.44	1.00				
9	0.13	0.16	0.18	-0.14	-0.24	0.06	0.34	0.27	1.00			
10	-0.10	0.19	0.17	0.38	0.26	0.36	-0.40	-0.46	0.03	1.00		
11	0.52	0.53	0.10	-0.20	-0.28	-0.04	0.25	-0.02	0.53	0.26	1.00	
12	0.45	0.32	0.04	-0.61	-0.58	-0.49	0.46	0.36	0.40	-0.48	0.51	1.00

<sup>a</sup>A correlation coefficient,  $r$ , is significantly different from 0 at the 5 percent level if  $|r| \geq .514$  and is significantly different from 0 at the 1 percent level if  $|r| \geq .641$  (Snedecor and Cochran, 1972, pp. 184-185, 557).

Table 36. 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 (63.081)		.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

for West Asia and India and Other South Asia did not have significant time trends and were able to explain only a small part of the variation in production. The 1960-1974 average production level was projected to continue for these regions. The estimated equation for Japan is able to explain 88 percent of the variation in production, however, 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 of .257 million metric tons.

Table 37 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 from 287.88 million metric tons in 1974 to 480.65 million metric tons by 2000. This is an increase of 77 percent from 1974 to 2000. The U.S.S.R. is projected to provide 37 percent of this total increase. Production is projected to increase from 74.62 million metric tons in 1974 to 145.05 million metric tons by 2000. Large increases are also projected for Mexico (118 percent) and Southern Europe (105 percent). West Asia and India and Other South Asia did not show a definite trend and production is assumed to remain at the 1960-1974 average. Japan has shown rapid declines in feed grain production over the 1960-1974 period and is projected to continue production at the 1974 level.

Table 37. 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	72.12	.87
U.S.S.R.	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	— <sup>a</sup>
India and Other					— <sup>a</sup>
South Asia	18.84	18.00	18.00	18.00	— <sup>a</sup>
Japan	.26	.26	.26	.26	— <sup>a</sup>
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	— <sup>a</sup>

<sup>a</sup>An estimated equation was not used to project production for this region.

#### Variation in production

The 1960-1974 average feed grain production and standard deviation of deviations of feed grain production from projected trends are given in Table 38. The standard deviations refer to fluctuation from the production trend obtained from the estimated equations of Table 34. The variability of production in individual regions is large, but the total variability of all regions combined is low. For example, the variability of feed grain production in the U.S.S.R. has a standard deviation of 7.18 million metric tons. This exceeds the variability of all

regions combined which is 6.68 million metric tons. This result is surprising. It suggests that the fluctuations in imports tend to cancel between regions.

Table 38. Average feed grain production and standard deviation of deviations of feed grain production from projected trends for individual feed grain importing regions and all regions combined

Region	Standard Deviation	1960-1974 Average Production
(million metric tons)		
Mexico	1.06	8.79
Central America	.22	5.90
Northern Europe	.98	28.37
Southern Europe	.65	10.70
Eastern Europe	2.11	32.11
U.S.S.R.	7.18	43.57
Africa	.77	23.55
West Asia	.60	8.45
India and Other South Asia	1.27	17.90
Japan	.21	1.18
Other East Asia	.61	6.18
People's Republic of China	1.63	31.30
Total All Regions	6.68	320.63

#### Feed grain stocks

Average stocks of feed grain and the ratio of average stocks to average production are presented in Table 39 for all importing regions for the period for 1960-1974. Several characteristics of the average level of feed grain stocks available at the beginning of each crop year are interesting. Several regions have maintained very low levels of stocks. Africa had average production of 23.55 million metric tons

but stocks of only .03 million metric tons. The same relationship is also true for Central America, Eastern Europe, and West Asia. The developed countries such as Northern Europe maintain a higher ratio of stocks to production. Northern Europe had average stocks of 14 percent of production. Japan has a high ratio of stocks to production, but this figure is misleading because of the low production and high imports.

Table 39. 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
U.S.S.R.	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.	---

## Feed Grain Imports

Projected net feed grain imports

Projected feed grain imports for each importing region and all importing regions combined are presented in Table 40 for selected years. During the remainder of the century, feed grain imports by all countries and regions which are currently net importers are projected to increase from the 1972-1974 average of 56.2 million metric tons to 141.25 million metric tons. This is an increase of 151 percent. Most of this increase comes from a growth in feed grain imports in Northern Europe, Southern Europe, the U.S.S.R., 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. Southern Europe is projected to increase feed grain imports from an average of 11.4 million metric tons during 1972-1974 to 23.56 million metric tons by 2000. The U.S.S.R. is projected to increase imports from the 1972-1974 average of 4.13 million metric tons to 16.25 million metric tons by 2000. Japan is projected to increase net imports of feed grains from 12.53 to 34.01 million metric tons and the region designated as Other East Asia shows the largest percentage increase in net feed grains imports with projected imports to increase from 2.81 million metric tons to 17.88 million metric tons by 2000.

Several regions are projected to have small increases in net feed grain imports. India and Other South Asia, The People's Republic of China, Africa, Mexico, and West Asia are all projected to have import

increases between one and four million metric tons. These increases are large in percentage terms, but small compared to the total of all world imports.

Table 40. Projected net feed grain imports for 1980, 1990, and 2000 with average 1972-1974 net imports for comparisons. 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

Region	Actual 1972-1974 <sup>a</sup>	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
U.S.S.R.	4.13	6.47	11.36	16.25
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

<sup>a</sup> Average U.S. feed grain export price was \$2.54.

#### Variability in net feed grain imports

The estimated confidence intervals for feed grain imports and feed grain production are shown in Table 41. The confidence interval is calculated about the 1980 projected value of feed grain imports and production. The 95 percent confidence interval shows the range of values

which will contain 95 out of 100 future import levels on levels of production.

World feed grain imports are projected to lie between 71.37 million metric tons and 77.75 million metric tons in 95 out of 100 times for 1980. Individual countries are projected to have high variability in both feed grain net imports and feed grain production. However, because of the lack of correlation of feed grain production between most countries, fluctuations in feed grain production and net imports tend to cancel and cause total world imports and production to have small confidence intervals.

Table 41. Confidence intervals for net feed grain imports and feed grain production for 1980 when  $\alpha = .05^a$

Region	95 Percent Confidence Interval on Feed Grain Imports	95 Percent Confidence Interval on Feed Grain Production
Mexico	( .06 - 3.74)	( 11.45 - 16.15)
Central America	( 2.56 - 3.27)	( 7.34 - 8.32)
Northern Europe	(15.39 - 18.80)	( 41.96 - 46.30)
Southern Europe	(12.98 - 15.77)	( 17.95 - 20.83)
Eastern Europe	( 4.26 - 4.39)	( 43.98 - 53.32)
U.S.S.R.	( 6.09 - 6.88)	( 67.00 - 98.82)
Africa	( .24 - 1.00)	( 27.29 - 30.71)
West Asia	( 1.93 - 2.73)	( 7.04 - 9.70)
India and Other South Asia	( .57 - .74)	( 15.19 - 20.81)
Japan	(17.74 - 18.40)	( 0. - .73)
Other East Asia	( 5.25 - 5.38)	( 6.52 - 9.22)
People's Republic of China	( .31 - 2.13)	( 39.71 - 46.93)
Total All Regions	(71.37 - 77.75)	(308.72 - 338.32)

<sup>a</sup> SOURCE: (Steel and Torrie, 1960, pp. 47).

The U.S.S.R. has the largest confidence interval about feed grain production. In 1980 feed grain production is projected to be between 67.0 million metric tons and 98.82 million metric tons. This implies that 5 times out of 100 feed grain production would lie outside these bounds. Surprisingly, feed grain imports do not have a proportionately wide confidence interval. This reflects the historical tendency for the U.S.S.R. to import only a small percent of a decrease in domestic supply.

All of the communist regions have large confidence intervals for feed grain production, but this is not reflected in imports. Eastern Europe is projected to have feed grain production in 1980 between 43.98 to 53.32 million metric tons in 95 out of 100 cases, and The People's Republic of China has a 1980 confidence interval from 39.71 to 46.93 million metric tons. These variabilities are not reflected in imports, but suggest the potential for increased variability in feed grain imports. If the communist countries change their import policies, this would have major effects on the variability in imports.

Mexico, Northern Europe, and Southern Europe have the largest confidence intervals for 1980 feed grain imports. Feed grain imports for Mexico are projected to lie between .06 and 3.74 million metric tons in 95 out of 100 cases. These figures reflect the variability in production and also the tendency for Mexico to import a major portion of a decrease in domestic feed grain supply. Northern Europe has a 95 percent confidence interval for 1980 net feed grain imports of 15.39 to

18.80 million metric tons. Southern Europe is projected to have feed grain imports between 18.44 and 21.23 million metric tons for 1980 in 95 out of 100 cases.

#### 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 1960-1974 period, the United States supplied an average of 57.1 percent of total feed grain imports. The range of market share reached a low of 44 and a high of 72 percent (see Table 10, Chapter II). Based on an average market share of 57.1 percent, Table 42 contains projected feed grain exports for the United States for selected years. 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 42. Projected U.S. feed grain exports for selected years with 1972-1974 actual exports for comparison<sup>a</sup>

Year	Projected U.S. Feed Grain Exports	95 Percent Confidence Interval on U.S. Feed Grain Exports
(million metric tons)		
1972-1974 Actual <sup>b</sup>	36.59	
1980	42.57	(40.75 - 44.39)
1990	61.62	(59.80 - 63.44)
2000	80.65	(78.83 - 82.47)

<sup>a</sup>United States feed grain export prices is held constant at \$2.50 per bushel in 1972 dollars.

<sup>b</sup>Actual U.S. grain export price averaged \$2.54 per bushel in 1972 dollars.

## CHAPTER VI. DEMAND FOR SOYBEANS

The demand for soybeans has several characteristics which distinguish it from the demand for wheat or feed grains. First, soybean production is concentrated in only three countries: the United States, Brazil, and The People's Republic of China. Both wheat and feed grains are produced all over the world including most importing 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. This suggests that soybean imports should be less volatile than wheat or feed grain imports. A second characteristic of soybean demand that distinguishes it from wheat or feed grains is the role of P.L. 480 exports. Historical data about soybean exports is much more relevant to future exports because of the small role of P.L. 480. United States exports of soybeans have not been supported by P.L. 480 programs to the degree that both wheat and feed grains exports have.

The primary variable which influenced imports of both wheat and feed grains was the level of domestic supply--production plus beginning

period stocks in each importing region. However, since 95 percent of all world soybean production is concentrated in three countries: the United States, Brazil, and The People's Republic of China (FAO, 1964a; 1974b), production in the importing region is not a determinant of soybean imports. In the case of wheat and feed grains, imports were used to supplement production. When production plus beginning period stocks were high, imports decreased. However, soybean imports do not have this characteristic. Soybean imports are not influenced by domestic production in each importing region and, therefore, are not subject to the random fluctuations caused by fluctuations in production. This is a very important difference and may partially explain the relative stability of growth in soybean exports (see Table 3 of Chapter I).

Soybean exports under P.L. 480 have been zero since 1965 and were less than four percent of total exports at their peak in 1960 (U.S. Department of Agriculture, 1974c). This differs markedly from the case of wheat and feed grains where P.L. 480 exports reached maximum levels of 69 and 29 percent of total exports, respectively. Because of this difference, the historical data about soybean exports has more value for predicting future imports than historical data for wheat or feed grains. Historical exports represent export sales on a commercial basis and are not distorted by government programs to encourage trade.

These two characteristics of soybean trade make the problem of projecting soybean imports by other countries much less complex than for wheat or feed grains. They eliminate the necessity of concentrating on imports in order to project U.S. exports. In the case of both wheat

and feed grains, exports were not projected directly because of the bias in historical data. Concentration on imports as a method to determine the level of exports provided fewer problems. However, with soybean export data this problem does not exist. The historical data on soybean exports by the United States is relevant.

The analysis of soybean exports will involve several steps. Soybean exports by the United States will be projected to the year 2000. The imports of soybean oil and meal will also be projected for each of the major world importing regions. Trends in the imports by individual countries will be examined and the responsiveness of imports to the U.S. soybean export price will be estimated for each importing region.

#### Delineation of Import Regions

A total of 10 regions and 14 countries import soybean or soybean oil. The list of regions and the countries included in each are shown in Table 43.

#### 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 (FAO, 1964a; 1974a), and the U.S. Foreign Agricultural Trade Statistical Report, Fiscal Year 1975 (U.S. Department of Agriculture, 1975d). These definitions and variables are shown in Table 44.

Table 43. 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, U.S.S.R., South Africa, Tanzania
8	Asia	Brunei, Hong Kong, China (Taiwan), India, Indonesia, Iran, Israel, South Korea, North Korea, Kuwait, Lebanon, Macau, Maldives, Malawi, Poland, Saudi Arabia, Singapore, South Vietnam, North Vietnam, Thailand
9	Japan	Japan
10	Oceania	Australia, French Polynesia, New Zealand

#### United States Soybean Exports

Exports of soybean and soybean products expressed in bean equivalents are estimated for the United States by the following equation:

$$USSE_t = 3.024 + .099 USSP_t + .916 TIME$$

(.621)                      (.117)

$$ALS \quad \rho = .159 \quad d = 1.81 \quad R^2 = .92 \quad S.E.E. = 1.28$$

The estimated equation explains 92 percent of the variation in soybean exports over the 1960-1974 period. Soybean exports are increasing over time and are positively influenced by export price. The estimated equation can be used to project U.S. exports at alternative price levels. Table 45 presents projected U.S. soybean exports for 1980, 1990, and 2000 at various price levels.

Table 44. 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 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.
$SMI_{i,t}$	Soymeal 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 45. Projected U.S soybeans and soybean products exports expressed in bean equivalent for selected years with 1972-1974 actual exports for comparison

United States Soybean Export Price	Actual 1972-1974 Soybean Exports	1980	1990	2000
(dollar/bushel)	(million metric tons)			
4.00	16.31 <sup>a</sup>	22.66	31.82	40.98
6.00	16.31 <sup>a</sup>	22.85	32.01	41.17
8.00	16.31 <sup>a</sup>	23.05	32.31	41.37

<sup>a</sup> Actual soybean export price averaged \$5.90 over the 1972-1974 period.

#### 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 46. 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 were included only for completeness.

The results from the estimated equations show that soybean imports are explained for the major importing regions, but not for the minor regions. Northern Europe is the largest soybean importer and the

Table 46. 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	$\rho$	$R^2$	d	S.E.E.
Canada	386	OLS	536.26	-26.070 (30.070)	-2.775 (4.518)		.13	1.78	70.0
Central America	72	OLS	-274.33	55.944 (37.953)	9.476 (5.702)		.40	1.72	88.4
South America	51	OLS	-86.97	15.690 (6.681)	7.700 (1.003)		.88	1.74	15.6
Northern Europe	3,933	ALS	-3,183.62	751.477 (286.009)	420.444 (85.417)	.394 (.285)	.95	1.80	503.3
Southern Europe	1,320	OLS	520.97	-172.331 (98.859)	204.028 (14.853)		.94	2.19	230.2
Eastern Europe	242	OLS	-246.65	89.519 (140.507)	7.023 (21.111)		.06	2.28	327.2
Africa	9	OLS	-15.01	5.993 (1.684)	-.636 (.253)		.54	2.10	3.9
Asia	785	ALS	-29,556.50	-20.023 (55.480)	2,075.780 (76,857.252)	.994 (.224)	.97	1.62	81.9
Japan	2,311	OLS	1,199.30	-95.373 (78.570)	196.532 (11.805)		.96	1.90	183.0
Oceania	11	OLS	-32.67	6.409 (.4068)	.762 (.611)		.32	2.05	9.5

estimated equation explains 95 percent of the variation 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

Import equations for soy oil are presented in Table 47. Asia is the largest importer of soy oil. The estimated equation for soy oil importers in Asia explains 87 percent of the variation in imports over the 1960-1974 period. The estimated coefficient on U.S. soybean price has the desired 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 desired 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.

#### Soymeal imports

Northern Europe is the major world importer of soymeal. Over the 1960-1974 period, Northern Europe imported more than 70 percent of all world imports of soymeal. The estimated soymeal import equation explains 97 percent of the variation in soymeal imports by Northern Europe. The

Table 47. Soy oil import equations for the 10 importing regions, 1960-1974

Region	Average 1960-1974 Soy Oil Imports (thousand metric tons)	Estimation Technique	Constant	U.S. Soybean Export Price	TIME	$\rho$	$R^2$	d	S E E.
Canada	16	ALS	-6.569	2.507 (2.602)	1.18 (.540)	.174 (.334)	.57	1.65	5.4
Central America	34	OLS	-63.028	12.088 (8.056)	4.801 (1.210)		.69	1.61	18.8
South America	58	ALS	-79.657	16.399 (9.985)	6.935 (3.125)	.475 (.389)	.86	1.93	14.8
Northern Europe	151	ALS	-24.808	-25.940 (39.187)	32.958 (21.093)	.632 (.327)	.80	1.44	51.7
Southern Europe	90	ALS	-25.574	36.632 (24.934)	-8.419 (6.482)	.322	.59	1.92	45.3
Eastern Europe	58	OLS	4.09	8.925 (19.880)	1.330 (2.987)		.05	1.76	46.3
Africa	72	OLS	11.88	4.714 (10.093)	4.626 (1.517)		.50	1.92	23.5
Asia	261	ALS	121.519	-15.178 (41.556)	27.065 (9.864)	.607	.87	1.27	51.1
Japan	2	ALS	-21.751	3.985 (2.119)	.591 (.400)	.153	.59	1.42	3.8
Oceania	7	OLS	10.99	-1.779 (.840)	.526 (.126)		.59	2.17	1.96

estimated equation has the desired sign on 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 48).

The next largest soymeal 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 48. Soymeal import equations for the 10 importing regions, 1960-1974

Region	Average 1960-1974 Soymeal Imports (million metric tons)	Estimation Technique	Constant	U.S. Soybean Export Price	TIME	$\rho$	$R^2$	d	S.E.E.
Canada	217	OLS	191.87	1.072 (11.943)	2.486 (1.794)		.16	1.92	27.8
Central America	50	ALS	-72.00	12.676 (11.427)	7.375 (3.333)	.458 (.354)	.76	1.80	19.6
South America	12	OLS	-96.99	20.673 (8.707)	1.193 (1.308)		.44	1.95	20.3
Northern Europe	2,632	ALS	283.06	-19.392 (122.510)	300.313 (21,887)	.205 (.304)	.97	1.66	228.1
Southern Europe	281	OLS	-1,207.30	217.020 (60.915)	54.892 (9.152)		.86	2.01	141.8
Eastern Europe	395	ALS	-163,160.75	185.028 (59.249)	10,915.487 (955,506.209)	.998 (.145)	.98	1.88	90.8
Africa	3	ALS	-6,239	.729 (.610)	.682 (.141)	.400 (.240)	.90	2.26	1.1
Asia	46	ALS	2,917	-3.205 (14.403)	7.119 (2.765)	.194 (.331)	.54	1.79	29.7
Japan	50	ALS	-275.76	55.271 (19.143)	7.346 (2.825)	-.331 (.315)	.59	1.94	53.5
Oceania	16	OLS	32.64	-7.599 (2.626)	2.452 (.394)		.76	2.01	6.1

## CHAPTER VII. SUMMARY, CONCLUSIONS, AND LIMITATIONS

This study estimates the level and variability of U.S. agricultural exports of wheat, feed grains, and soybeans through the year 2000. Results are presented for 1980, 1990, and 2000. World demand for wheat and feed grain imports is estimated and used as a basis for estimating U.S. exports. Soybean exports are projected directly from historical U.S. exports. Variability estimates are based on estimated demand for wheat and feed grains and the historical exports for soybeans.

The analysis is conducted for the 15-year period from 1960 to 1974 for 14 wheat importing regions, 12 feed grain importing regions, and 10 soybean importing regions. Import equations are econometrically estimated for each importing region for each commodity. Based on the estimated equations, projections of world import levels and variabilities are made for each importing region for wheat and feed grains. United States export levels and variabilities are estimated on the basis of historical market shares. United States soybean exports are projected directly from historical data.

Wheat and feed grain imports are estimated as functions of three explanatory variables; domestic commodity supply, U.S. export price, and time. Domestic commodity supply is equal production plus commodity stocks at the beginning of the crop year in the importing region. United States export price is a constant dollar export price adjusted

for export subsidies and dollar devaluations. Wheat and feed grain imports are found to respond to domestic supply in almost all regions. This variable is the major factor explaining imports of wheat and feed grains over the historical period used in this analysis. United States export price was not found to be an important explanatory variable in most importing regions. The reasons for this are not clear, but a possible explanation is that the variable used, U.S. export price, is not the import price which an importing country pays. This reasoning seems to be supported by the constant restructuring of the monetary units of various countries. Another possible explanation involves the relative stability of U.S. commodity export prices during the period included in this analysis. A period of more volatile export price data would probably lead to a different conclusion.

Soybean imports are estimated for each region by product form. Soybeans are imported as soybeans, soybean oil, and soybean meal. The estimated equations specify the soybean product imported as a function of U.S. soybean export price and time. The time variable is included to represent the growth in imports due to changes in import patterns, per capita income, and population. The estimated equations perform reasonably well for the major importing regions, but are not able to explain imports by the small importing regions.

Estimated import equations for wheat and feed grains show that imports of wheat are more responsive to a reduction in domestic supply than is true of feed grains. This relationship indicates that a

country would increase wheat imports more than it would increase feed grain imports if domestic supply of both decreased by a proportionate amount. This distinction may reflect the tendency to use wheat for direct human consumption and feed grains as livestock feed.

The estimated coefficient for the domestic supply indicates the willingness of a country to import in response to a reduction in domestic supply. The 10 wheat importing regions which include domestic supply as one of the explanatory variables in the import equation have an average coefficient on domestic supply of  $-.62$ . The feed grain import equations have an average coefficient of  $-.34$ .

The communist regions, Eastern Europe and the U.S.S.R., have smaller than average coefficients on domestic supply. The estimated coefficient on domestic supply in the wheat import equation for these two regions is  $-.35$ . In the feed grain import equation the estimated coefficient is  $-.02$ . These coefficients are well below the average for all regions and reflect a more restrictive stance toward imports. The People's Republic of China has a coefficient of  $-.15$  on domestic supply in the feed grains equation and was not included in the wheat import equation.

United States wheat exports are projected to be 28.16 million metric tons in 1980, 35.28 million metric tons in 1990, and 42.40 million metric tons in 2000. These values are based on a U.S. wheat export price of \$3.00, and a U.S. market share of 42.7 percent of all world imports. The 1972-1974 actual U.S. wheat exports averaged 30.32 million metric tons. The projected exports in 2000 are 40 percent above the 1972-1974 average. A 95 percent confidence interval about

the projected export level in 2000 is (37.85 - 46.95) million metric tons. United States wheat exports are expected to be between 37.85 and 46.95 million metric tons in 95 out of 100 cases.

Projected feed grain exports for the United States are 42.57 million metric tons in 1980, 61.62 million metric tons in 1990, and 80.65 million metric tons in the year 2000. (Assuming that U.S. feed grain export price is \$2.50 per bushel and that U.S. exports remain at 57.1 percent of all world imports of feed grains.) These figures compare with an average of 36.59 million metric tons of feed grain exports in 1972-1974. The increase in feed grain exports between 1972-1974 and 2000 is 120 percent. A 95 percent confidence interval about the projected exports includes a range of exports within 1.82 million metric tons above or below the projected export level. The confidence interval for the year 2000 is (98.83 - 82.47). This indicates that in 95 out of 100 cases, U.S. feed grain exports will be between 78.83 and 82.47 million metric tons in the year 2000.

United States exports of soybeans and soybean products are projected to increase to 22.85 million metric tons in 1980, 32.01 million metric tons in 1990, and 41.17 million metric tons by the year 2000. (These projections are based on a U.S. soybean export price of \$6.00 per bushel in 1972 dollars.) The projected exports for the year 2000 are 154 percent above the 1972-1974 average exports of 16.31 million metric tons. A 95 percent confidence on projected U.S. soybean exports for the year 2000 is (38.33 - 44.01). The projected exports

will be between 38.33 and 44.01 million metric tons in 95 out of 100 cases.

A comparison of projected U.S. export levels of wheat, feed grains, and soybeans to the year 2000 shows that soybeans are projected to increase 152 percent above their 1972-1974 average. Feed grain exports are projected to increase 120 percent and wheat exports are projected to increase 40 percent. In terms of the variability of U.S. exports, the ranking almost reverses. Wheat has the greatest projected variability followed by soybeans and feed grains. The variability in exports, as defined by the bounds of a 95 percent confidence interval, shows that wheat can fluctuate 10.73 percent above or below the projected export level in the year 2000. Soybeans can fluctuate 6.79 percent, and feed grains can fluctuate only 2.02 percent and still remain within a 95 percent confidence interval.

Wheat production was found to be highly correlated among the importing regions, however, deviations of wheat production about the trend are not highly correlated. This indicates a correlation exists in the overall direction of production, but not in the year-to-year fluctuations of production. Similar results were also observed for feed grains. The quantity and quality of the data do not support a strong conclusion about the correlation of year-to-year fluctuations in production; however, these results may serve as a first approximation. In order to clearly show the relationship between production in world regions, it would be necessary to examine yields instead of final production. The type and quality of data required does not

exist for most of the underdeveloped countries according to Arthur Mackie of the Foreign Demand and Competition Division of the Economic Research Service of the U.S. Department of Agriculture (Mackie, 1974, p. 22).

A definite conclusion about the degree of correlation of production between regions has major implications for export volatility, storage policies, and grain reserves. If we are certain that droughts do not occur in many regions of the world simultaneously, we can expect low variability in world production and imports, but if droughts do occur in many countries, we would expect wide fluctuations in production and imports.

A number of limitations of the data and procedures should be acknowledged. Since this was a study of world demands for wheat, feed grains, and soybeans, data was used which has a lower degree of accuracy than would be necessary for a study involving only the United States. Much of the data for the underdeveloped countries is of low quality. Although the amount of error in the data cannot be estimated, it is certain that the amount exceeds that for the developed countries. Data for the communist countries are also of low or unknown quality. Information for selected variables were not available for certain countries.

Lack of data made it necessary to do all analysis in terms of crop production instead of crop yields and acreages. This limitation makes the correlation in wheat and feed grains production among regions difficult to evaluate. The correlation in production could be caused by a growth in crop yields, or by increased acreage in some regions

and increased production in other regions. More complete data on acreage and yields would make it possible to evaluate the correlation in both short- and long-term yields. This type of data would also allow an investigation of weather patterns over time.

An additional topic which was not included, but which constitutes a limitation of this study, is the exclusion of fertilizer as a factor influencing world grain production. During the high petroleum prices of the last several years, fertilizer prices have increased substantially. This may have a significant affect on world production and imports. Such a relationship would be a useful addition to the knowledge about world food production.

The import equations estimated for wheat, feed grains, and soybeans do not include several variables which seem theoretically important. Population and per capita income are not included, however, a trend variable was included, and this is believed to serve as a proxy for these two variables. Complete information on population and per capita income may have greater explanatory ability than the proxy variable used in this study. Several other variables also have theoretical merit for explaining commodity imports. Complete information on exchange rates, international monetary conditions, and the balance of payments in each importing country may contribute to the explanation of commodity imports.

The delineation of import regions may also provide a limitation to the quality and usefulness of the results. Because of computational

considerations, import regions are large and often cover large geographic areas. This makes the application of results to a specific region difficult and may have distorted the import response obtained in some regions.

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APPENDIX A

Table A-1. Wheat import equations for Mexico

Estimation Technique	Constant	$WDS_{i,t}$	$WUSP_t$	$WRIP_{i,t}$	Time	$\hat{\rho}$	$R^2$	d	S.E.E.
OLS	758.66	-.986 (.185)	167.580 (65.665)		93.227 (11.934)		.90	1.55	141.19
OLS	1,617.3	-.38 (.45)		-260.10 (192.61)			.13	.45	393.2
OLS	1,411.3	-1.12 (.21)			104.70 (13.35)		.84	.92	170.6
ALS	-445.4	-.668 (.184)	60.363 (71.221)		157.711 (154.920)	.843 (.270)	.93	1.80	132.0
OLS	751.7	-1.054 (.209)		141.930 (95.191)	117.149 (15.216)		.86	1.28	162.5
ALS	1,516.5	-.652 (.190)		60.928 (76.530)	214.497 (295.232)	.889 (.252)	.93	1.86	132.5
OLS	-888.9	-.009 (.341)	325.898 (146.129)				.29	.50	354.9
ALS	-1,321.6	-.704 (.173)			214.586 (328.404)	.896 (.238)	.92	1.87	130.3
ALS	118.4	-.690 (.157)	51.587 (60.733)			1.093 (.096)	.92	2.15	132.8
ALS	363.1	-.697 (.153)		54.589 (66.496)		1.128 (.098)	.92	2.09	133.1
ALS	375.1	-.709 (.149)	50.047 (58.358)			1.113 (.106)	.92	2.05	133.1

Table A-2. Wheat import equations for Central America

Estimation Technique	Constant	WDS <sub>i,t</sub>	WUSP <sub>t</sub>	WRIP <sub>i,t</sub>	Time	$\hat{\rho}$	R <sup>2</sup>	d	S.E.E.
OLS	2,408.3	-.051 (.395)	-79.415 (154.368)		201.711 (20.151)		.93	1.20	283.92
OLS	-1,707.9	1.875 (1.052)	645.167 (415.167)				.25	.59	864.26
OLS	1,997.7	.065 (.315)			196.849 (17.245)		.92	1.28	275.08
OLS	3,568.5	-.288 (.523)		-137.011 (161.195)	154.589 (52.692)		.93	1.11	278.32
OLS	8,644.3	-1.344 (.578)		-583.251 (68.227)			.87	.96	355.76
ALS	3,798.8	-.538 (.578)	-142.751 (160.924)		174.270 (60.459)	.573 (.362)	.93	1.74	270.04
ALS	3,024.8	-.333 (.482)			169.037 (51.313)	.524 (.334)	.92	1.83	272.3

Table A-3. Wheat import equations for Brazil

Estimation Technique	Constant	WDS <sub>i,t</sub>	WUSP <sub>t</sub>	WRIP <sub>i,t</sub>	Time	$\hat{\rho}$	R <sup>2</sup>	d	S.E.E.
OLS	1,814.30	-.598 (.108)	222.405 (89.863)		84.091 (19.681)		.80	2.89	197.95
OLS	2,861.80	-.33 (.14)		-6.16 (3.65)			.34	1.20	344.0
OLS	2,414.90	-.646 (.127)			98.812 (22.412)		.69	1.72	236.5
ALS	1,718.61	-.577 (.098)	268.330 (64.923)		76.110 (16.308)	-.520 (.287)	.85	1.98	183.0
OLS	2,125.7	-.700 (.129)		4.985 (3.684)	132.353 (32.927)		.73	2.07	228.7
OLS	1,686.0	-.226 (.107)	313.401 (129.188)				.45	1.86	313.5
ALS	2,421.2	-.632 (.144)			96.247 (29.746)	.103 (.339)	.67	1.78	257.5
ALS	3,596.1	-.573 (.140)		50.311 (37.807)		.725 (.054)	.55	2.87	298.2

Table A-4. Wheat import equations for Northern Europe

Estimation Technique	Constant	$WDS_{i,t}$	$WUSP_t$	$WRIP_{i,t}$	Time	$\hat{\rho}$	$R^2$	d	S.E.E.
OLS	19,816.0	-.583 (.193)	-664.157 (398.182)		189.225 (103.961)		.67	1.79	850.61
OLS	15,392.0	-.280 (.107)	-756.684 (431.307)				.57	1.89	928.98
OLS	19,670.0	-.679 (.197)			211.363 (110.502)		.58	1.74	911.59
OLS	21,867.0	-.599 (.185)		-875.878 (470.958)	80.776 (122.738)		.68	1.90	830.47
OLS	21,014.0	-.499 (.101)		-1,053.194 (377.043)			.67	1.99	810.62

Table A-5. Wheat import equations for Southern Europe

Estimation Technique	Constant	WDS <sub>i,t</sub>	WUSP <sub>t</sub>	WRIP <sub>i,t</sub>	Time	$\hat{\rho}$	R <sup>2</sup>	d	S.E.E.
OLS	13,020.00	-.701 (.109)	152.006 (268.904)		92.012 (42.415)		.87	2.03	496.58
OLS	15,411.00	-.71 (.14)		-360.54 (319.74)			.78	1.43	611.30
OLS	14,000.00	-.74 (.09)			105.16 (34.44)		.86	2.04	482.30
OLS	12,926.0	-.707 (.113)		140.697 (322.877)	116.454 (44.087)		.86	2.06	499.5
OLS	9,966.5	-.539 (.092)	431.313 (249.798)				.80	1.34	575.4
ALS	12,687.8	-.671 (.093)			112.645 (33.964)	-.066 (.288)	.83	2.20	471.4
ALS	13,843.6	-.638 (.185)		-264.421 (395.021)		.228 (.343)	.68	1.87	641.8
ALS	7,555.4	-.432 (.140)	551.389 (298.656)			.234 (.279)	.75	2.06	562.0

Table A-6. Wheat import equations for Eastern Europe

Estimation Technique	Constant	WDS <sub>i,t</sub>	WUSP <sub>t</sub>	WRIP <sub>i,t</sub>	Time	$\hat{\rho}$	R <sup>2</sup>	d	S.E.E.
OLS	13,238.00	-.498 (.195)	243.213 (504.341)		406.569 (239.976)		.55	1.30	1,120.7
OLS	8,658.4	-.18 (.06)	165.20 (512.55)				.43	.99	1,207.3
OLS	13,699.0	-.49 (.19)			402.27 (232.02)		.54	1.19	1,084.3
OLS	13,315.0	-.497 (.195)	209.232 (477.360)		408.009 (240.600)		.55	1.29	1,122.8
ALS	12,200.9	-.392 (.213)	-48.132 (651.991)		302.392 (343.284)	.463 (.343)	.63	1.73	1,124.7
ALS	12,040.2	-.388 (.189)			294.258 (291.521)	.456 (.287)	.63	1.72	1,067.4
ALS	11,007.6	-.240 (.172)	-38.428 (609.458)			.549 (.328)	.59	1.56	1,117.3
ALS	10,354.6	-.233 (.109)	105.957 (578.648)			.539 (.311)	.59	1.54	1,115.5

Table A-7. Wheat import equations for U.S.S.R.

Estimation Technique	Constant	WDS <sub>i,t</sub>	WUSP <sub>t</sub>	WRIP <sub>i,t</sub>	Time	$\hat{\rho}$	R <sup>2</sup>	d	S.E.E.
OLS	15,001.00	-.279 (.089)	-69.689 (2,112.330)		1,230.038 (445.932)		.50	1.41	4,563.2
OLS	1,678.00	-.09 (.07)	1,838.09 (2,343.17)				.15	1.61	5,697.6
OLS	14,770.00	-.278 (.082)			1,224.647 (398.299)		.50	1.41	4,369.1
OLS	14,807.0	-.279 (.089)	-11.140 (1,991.414)		1,225.473 (441.438)		.50	1.41	4,563.4
ALS	19,378.6	-.329 (.148)	452.471 (2,621.185)		1,095.493 (661.831)	.402 (.642)	.53	1.61	4,821.5
ALS	19,488.4	-.320 (.130)			1,133.796 (574.696)	.353 (.521)	.53	1.62	4,580.6

Table A-8. Wheat import equations for Africa

Estimation Technique	Constant	WDS <sub>i,t</sub>	WUSP <sub>t</sub>	WRIP <sub>i,t</sub>	Time	$\hat{\rho}$	R <sup>2</sup>	d	S.E.E.
OLS	4,508.0	-.763 (.185)	518.046 (228.918)		652.228 (63.532)		.96	1.41	505.44
OLS	-3,350.3	.885 (.284)	1,158.118 (685.983)				.55	1.63	1,574.1
OLS	5,561.5	-.772 (.201)			565.267 (61.741)		.92	.92	550.26
OLS	3,891.9	-.771 (.185)		591.387 (263.673)	703.701 (61.549)		.96	1.52	506.86
OLS	-1,780.0	1.009 (.340)		322.474 (902.517)			.45	1.58	1,741.9
ALS	5,111.5	-.799 (.162)			631.157 (116.527)	.574 (.301)	.93	1.87	502.28

Table A-9. Wheat import equations for Republic of South Africa

Estimation Technique	Constant	WDS <sub>i,t</sub>	WUSP <sub>t</sub>	WRIP <sub>i,t</sub>	Time	$\hat{\rho}$	R <sup>2</sup>	d	S.E.E.
OLS	692.48	-.717 (.174)	-27.376 (75.944)		64.765 (24.549)		.72	2.23	164.60
OLS	953.7	-.37 (.09)		-106.19 (93.28)			.58	1.70	193.6
OLS	627.1	-.733 (.163)			65.820 (23.473)		.72	2.20	158.5
ALS	708.11	-.720 (.193)	-27.235 (78.134)		63.735 (28.250)	-.127 (.338)	.73	2.05	179.4
OLS	636.61	-.732 (.174)		-2.590 (91.263)	65.433 (28.070)		.72	2.20	165.6
OLS	661.66	-.301 (.087)	-48.422 (86.699)				.55	1.60	201.4
ALS	643.4	-.734 (.181)			64.564 (27.030)	-.115 (.325)	.73	2.04	171.3

Table A-10. Wheat import equations for West Asia

Estimation Technique	Constant	WDS <sub>i,t</sub>	WUSP <sub>t</sub>	WRIP <sub>i,t</sub>	Time	$\hat{\rho}$	R <sup>2</sup>	d	S.E.E.
OLS	7,812.5	-.369 (.221)	446.761 (508.085)		616.841 (208.167)		.70	1.26	1,128.0
OLS	-3,517.6	.248 (.096)	760.382 (638.017)				.45	1.91	1,448.2
OLS	9,423.8	-.394 (.218)			658.971 (201.667)		.67	.93	1,117.3
OLS	8,717.8	-.389 (.227)		183.740 (706.939)	660.548 (211.084)		.68	1.02	1,163.4
OLS	-1,717.0	.270 (.112)		-41.146 (925.743)			.39	1.57	1,531.4
ALS	12,008.2	-.668 (.157)	-703.556 (433.866)		596.141 (137.920)	.360 (.353)	.78	2.25	743.3
ALS	9,480.6	-.597 (.184)			499.127 (117.005)	.081 (.356)	.73	2.09	787.5

Table A-11. Wheat import equations for India and Other South Asia

Estimation Technique	Constant	WDS <sub>i,t</sub>	WUSP <sub>t</sub>	WRIP <sub>i,t</sub>	Time	$\hat{\rho}$	R <sup>2</sup>	d	S.E.E.
OLS	8,488.0	-.435 (.055)	1,227.838 (375.914)		713.413 (110.003)		.87	1.75	839.92
OLS	4,721.5	-.120 (.074)	1,660.494 (777.920)				.39	.77	1,766.2
OLS	11,835.0	-.446 (.074)			777.177 (145.472)		.75	.98	1,128.7
OLS	4,733.3	-.474 (.054)		1,248.860 (352.422)	1,159.466 (149.726)		.88	1.87	805.54
OLS	13,827.0	-.178 (.091)		-717.517 (594.309)			.25	.64	1,959.0
ALS	11,004.7	-.459 (.127)			894.160 (229.638)	.481 (.372)	.83	1.42	1,014.2

Table A-12. Wheat import equations for Japan

Estimation Technique	Constant	WDS <sub>i,t</sub>	WUSP <sub>t</sub>	WRIP <sub>i,t</sub>	Time	$\hat{\rho}$	R <sup>2</sup>	d	S.E.E.
OLS	4,484.6	-.855 (.148)	53.723 (67.074)		131.513 (16.200)		.98	1.77	149.50
OLS	7,798.6	-1.51 (.27)		-250.83 (131.36)			.89	1.16	346.9
OLS	4,597.6	-.844 (.145)			134.450 (15.541)		.98	1.82	147.2
ALS	4,831.1	-.977 (.172)	75.124 (76.602)		111.619 (24.612)	.207 (.348)	.98	2.05	154.0
OLS	4,249.4	-.854 (.144)		76.295 (70.399)	147.588 (19.622)		.98	1.71	146.2
ALS	4,541.1	-.994 (.152)		113.356 (78.243)	131.540 (25.551)	.281	.98	2.14	146.6
OLS	7,104.0	-1.850 (.213)	162.494 (157.394)				.87	1.16	379.6
ALS	4,937.8	-.949 (.185)			118.720 (24.457)	.173 (.356)	.98	2.00	153.6
ALS	6,871.3	-1.028 (.122)		141.187 (80.918)		.894 (.975)	.98	2.82	168.1
ALS	6,482.0	-1.035 (.131)	107.739 (84.183)			.855 (.100)	.97	2.77	177.3

Table A-13. Wheat import equations for Other East Asia

Estimation Technique	Constant	WDS <sub>i,t</sub>	WUSP <sub>t</sub>	WRIP <sub>i,t</sub>	Time	$\hat{\rho}$	R <sup>2</sup>	d	S.E.E.
OLS	3,252.4	-2.361 (.952)	-295.593 (231.494)		454.837 (55.075)		.92	.56	515.7
OLS	-469.61	4.041 (1.421)	148.251 (578.485)				.42	.90	1,325.0
OLS	2,410.3	-2.245 (.972)			438.511 (54.959)		.91	.67	529.12
OLS	1,106.5	-2.234 (.956)		115.681 (97.522)	521.475 (88.392)		.92	.84	520.36
OLS	5,123.5	.546 (1.626)		-339.560 (116.507)			.66	.60	1,016.7
ALS	2,839.5	-2.503 (.838)	-408.877 (248.497)		533.221 (162.376)	.732 (.285)	.96	1.63	379.50
ALS	1,904.3	-1.967 (.747)			451.834 (92.382)	.655 (.241)	.95	1.36	424.45
OLS	-94.0	4.102 (1.350)					.42	.94	1,276.50
OLS	1,113.8				334.757 (36.506)		.87	.86	610.87
OLS	2,564.3		420.597 (709.257)				.03	.16	1,647.24
ALS	-7,831.3	-2.624 (.643)	-421.745 (198.930)			1.031 (.058)	.95	1.89	390.6
ALS	2,634.4	-1.364 (.862)	81.861 (234.216)			.813 (.227)	.88	1.70	120.0

Table A-14. Wheat import equations for People's Republic of China

Estimation Technique	Constant	WDS <sub>i,t</sub>	WUSP <sub>t</sub>	WRIP <sub>i,t</sub>	Time	$\hat{\rho}$	R <sup>2</sup>	d	S.E.E.
OLS	1,516.80	.029 (.171)	769.795 (507.890)		9.532 (164.660)		.23	1.74	1,136.5
OLS	1,383.50	.04 (.07)	731.92 (458.17)				.23	1.77	1,088.1
OLS	3,440.1	.03 (.18)			33.64 (172.52)		.06	1.38	1,196.4
ALS	1,420.38	.196 (.128)	981.901 (298.500)		-215.862 (118.726)	-.254 (.225)	.52	2.48	760.3
OLS	1,383.5	.042 (.061)	731.920 (458.170)				.23	1.77	1,088.1
ALS	3,153.0	.096 (.192)			-101.962 (181.142)	.079 (.302)	.07	1.52	1,005.9
OLS	2,058.84		771.494 (486.818)		34.928		.22	1.69	1,089.6

## APPENDIX B

Table B-1. Feed grain import equations for Mexico

Estimation Technique	Constant	FGDS <sub>i,t</sub>	FGUSP <sub>t</sub>	FG RIP <sub>i,t</sub>	Time	$\hat{\rho}$	R <sup>2</sup>	d	S.E.E.
OLS	2,105.9	-.720 (.040)	791.437 (153.088)		393.227 (17.956)		.98	2.02	170.4
OLS	1,483.6	-.791 (.054)		880.158 (327.997)	512.474 (42.295)		.96	1.91	245.3
OLS	-3,934.5	.00001 (.144)	1,772.240 (936.027)				.24	.53	1,089.2
OLS	10,532.0	-.483 (.172)		-2,344.596 (695.220)			.49	.53	889.4
OLS	4,381.4	-.791 (.066)			420.383 (30.444)		.94	1.31	302.1
ALS	1,023,098.3	-.633 (.064)			5,062.765 (337,071.529)	.995 (.346)	.96	1.81	273.8

Table B-2. Feed grain import equations for Central America

Estimation Technique	Constant	FGDS <sub>i,t</sub>	FGUSP <sub>t</sub>	FGRIP <sub>i,t</sub>	Time	$\hat{\rho}$	R <sup>2</sup>	d	S.E.E.
OLS	1,792.2	-.506 (.197)	307.395 (141.133)		200.795 (31.234)		.95	1.39	151.5
OLS	-160.7	-.334 (.171)		305.151 (81.576)	268.796 (25.014)		.97	1.98	120.3
OLS	-5,190.8	.708 (.120)	679.920 (268.733)				.76	.05	316.4
OLS	-2,303.9	.535 (.483)		-70.250 (239.322)			.64	.05	390.4
OLS	3,433.9	-.689 (.205)			228.726 (32.621)		.93	1.42	173.5
ALS	2,188.3	-.583 (.230)	263.530 (135.914)		221.789 (36.591)	.138 (.341)	.96	2.45	138.7
ALS	3,720.9	-.763 (.223)			251.893 (35.144)	.087 (.306)	.94	2.31	156.6

Table B-3. Feed grain import equations for Northern Europe

Estimation Technique	Constant	FGDS <sub>i,t</sub>	FGUSP <sub>t</sub>	FGRIP <sub>i,t</sub>	Time	$\hat{\rho}$	R <sup>2</sup>	d	S.E.E.
OLS	30,459.0	-.809 (.224)	534.215 (739.434)		1,131.924 (277.048)		.67	1.99	869.7
OLS	27,923.	-.792 (.219)		989.689 (908.256)	1,218.831 (272.971)		.69	2.16	845.6
OLS	8,600.9	.090 (.064)	922.942 (1,113.949)				.18	.02	1,321.1
OLS	9,875.5	.103 (.141)		155.936 (1,427.174)			.13	.02	1,357.7
OLS	32,164.0	-.829 (.218)			1,157.679 (269.217)		.66	1.81	852.2
ALS	70,804.3	-.935 (.222)	-219.770 (1,423.372)			.949 (.071)	.35	2.71	1,186.2
ALS	32,831.4	-.843 (.246)			1,142.813 (297.882)	.050 (.340)	.64	2.08	875.1

Table B-4. Feed grain import equations for Southern Europe

Estimation Technique	Constant	FGDS <sub>i,t</sub>	FGUSP <sub>t</sub>	FGRIP <sub>i,t</sub>	Time	$\hat{\rho}$	R <sup>2</sup>	d	S.E.E.
OLS	11,678.0	-1.214 (.250)	589.640 (672.974)		1,219.260 (144.149)		.94	2.63	795.9
OLS	10,668.0	-1.223 (.252)		692.402 (988.353)	1,308.487 (184.704)		.94	2.59	805.4
OLS	-3,571.9	.781 (.216)	1,017.150 (1,760.027)				.53	.03	2,087.3
OLS	16,591.0	.058 (.398)		-3,622.414 (1,757.625)			.64	.03	1,818.7
OLS	13,142.0	-1.230 (.247)			1,228.746 (142.344)		.93	2.33	788.1
ALS	15,015.6	-1.239 (.220)	861.076 (603.179)		1,229.753 (128.922)	-.379 (.318)	.92	2.15	816.1
ALS	33,930.1	-.823 (.518)	140.549 (1,567.420)			.938 (.112)	.80	2.98	1,267.2
ALS	24,536.0	-.849 (.434)				.944 (.086)	.80	2.97	1,208.7
ALS	4,728.9				459.247 (149.166)	.412 (.261)	.79	2.11	1,224.2

Table B-5. Feed grain import equations for Eastern Europe

Estimation Technique	Constant	FGDS <sub>i,t</sub>	FGUSP <sub>t</sub>	FGRIP <sub>i,t</sub>	Time	$\hat{\rho}$	R <sup>2</sup>	d	S.E.E.
OLS	-275.3	-.014 (.160)	190.523 (972.939)		230.658 (213.594)		.47	2.17	1,151.8
OLS	-3,917.1	.150 (.052)	136.257 (978.344)				.41	.52	1,159.7
OLS	112.3	-.012 (.153)			228.497 (204.583)		.47	2.13	1,104.7
OLS	-179.1				213.271 (63.443)		.47	2.14	1,061.6

Table B-6. Feed grain import equations for U.S.S.R.

Estimation Technique	Constant	FGDS <sub>i,t</sub>	FGUSP <sub>t</sub>	FGRIP <sub>i,t</sub>	Time	$\hat{\rho}$	R <sup>2</sup>	d	S.E.E.
OLS	-1,256.1	.076 (.087)	-1,753.001 (1,843.383)		216.535 (259.002)		.63	1.02	1,668.0
OLS	-904.6	.143 (.033)	-2,665.817 (1,466.496)				.61	.43	1,646.9
OLS	-3,661.4	.022 (.066)			362.421 (207.849)		.60	1.13	1,661.3
ALS	890.3	.039 (.079)	-2,991.281 (2,255.041)		464.687 (440.289)	.596 (.363)	.76	1.33	1,478.4
ALS	3,102.7	.104 (.064)	-3,550.741 (2,141.695)			.642 (.363)	.71	1.20	1,530.6
ALS	-3,266.7	-.025 (.088)			566.381 (354.037)	.413 (.344)	.70	1.49	1,565.2
OLS	-3,023.6				422.200 (95.814)		.60	1.10	1,603.3
ALS	-3,844.6				482.393 (165.961)	.400 (.271)	.70	1.40	1,501.7
OLS	-1,379.2		-724.107 (1,391.520)		422.950 (98.630)		.61	1.00	1,650.2
ALS	587.0		-2,448.305 (2,155.360)		584.904 (306.305)	.581 (.344)	.75	1.46	1,423.4

Table B-7. Feed grain import equations for Africa

Estimation Technique	Constant	FGDS <sub>i,t</sub>	FGUSP <sub>t</sub>	FGRIP <sub>i,t</sub>	Time	$\hat{\rho}$	R <sup>2</sup>	d	S.E.E.
OLS	3,242.5	-.212 (.118)	401.845 (264.738)		122.714 (55.325)		.44	2.09	312.0
OLS	2,731.4	-.202 (.126)		419.442 (403.277)	146.426 (59.360)		.39	2.10	327.4
OLS	-1,864.3	.034 (.046)	466.395 (303.078)				.19	1.80	359.4
OLS	-1,833.9	.059 (.083)		186.117 (467.769)			.05	1.80	390.7
OLS	4,566.4	-.232 (.123)			131.945 (57.900)		.33	1.83	328.5

Table B-8. Feed grain import equations for West Asia

Estimation Technique	Constant	FGDS <sub>i,t</sub>	FGUSP <sub>t</sub>	FGRIP <sub>i,t</sub>	Time	$\hat{\rho}$	R <sup>2</sup>	d	S.E.E.
OLS	2,894.2	-.333 (.083)	-39.249 (184.451)		116.581 (12.047)		.90	1.85	199.5
OLS	3,420.2	-.342 (.078)		-187.630 (268.690)	104.210 (21.055)		.91	1.89	195.6
OLS	2,510.0	-.217 (.243)	90.019 (543.270)				.09	.13	589.0
OLS	7,435.4	-.412 (.132)		-1,289.805 (258.592)			.70	.13	336.4
OLS	2,742.2	-.326 (.073)			116.396 (11.527)		.91	1.84	191.4
ALS	2,068,103.8	-.305 (.089)	-75.573 (304.686)			1.007 (.172)	.82	2.10	282.4
ALS	2,195.8	-.274 (.088)			124.261 (13.869)	.023 (.323)	.92	1.98	192.2

Table B-9. Feed grain import equations for India and Other South Asia

Estimation Technique	Constant	FGDS <sub>i,t</sub>	FGUSP <sub>t</sub>	FGRIP <sub>i,t</sub>	Time	$\hat{\rho}$	R <sup>2</sup>	d	S.E.E.
OLS	-1,805.7	.041 (.086)	539.049 (605.196)		27.004 (45.250)		.09	1.05	711.2
OLS	-1,305.2	.042 (.098)		145.280 (584.941)	62.353 (154.821)		.03	1.03	734.3
OLS	-1,175.9	.024 (.079)	527.289 (588.424)				.07	.55	691.8
OLS	312.9	.022 (.081)		-79.330 (170.164)			.02	.55	708.2
OLS	-339.9	.031 (.085)			25.692 (44.835)		.03	1.03	705.0
ALS	1,082.2	-.061 (.201)	583.681 (788.724)		-51.395 (214.884)	.609 (.524)	.33	1.43	2,003.4
ALS	813.7	-.044 (.203)		194.375 (811.237)	24.152 (192.776)	.577 (.552)	.29	1.43	689.3
ALS	303.5	-.039 (.141)	495.749 (647.087)			.558 (.380)	.32	1.40	638.7
ALS	1,834.4	-.049 (.186)			-17.240 (132.456)	.558 (.451)	.28	1.46	656.7

Table B-10. Feed grain import equations for Japan

Estimation Technique	Constant	FGDS <sub>i,t</sub>	FGUSP <sub>t</sub>	FGRIP <sub>i,t</sub>	Time	$\hat{\rho}$	R <sup>2</sup>	d	S.E.E.
OLS	1,596.6	-.630 (.519)	288.346 (552.403)		785.459 (52.022)		.98	2.18	611.0
OLS	-547.3	-.672 (.485)		710.683 (671.395)	902.340 (114.311)		.98	1.97	589.2
OLS	12,681.0	-.621 (1.625)	2,511.827 (2,375.907)				.55	.02	2,726.4
OLS	20,002.0	-.796 (1.198)		-4,091.643 (701.958)			.87	.02	1,456.3
OLS	2,023.0	-.532 (.469)			792.595 (48.595)		.98	2.29	592.2

Table B-11. Feed grain import equations for Other East Asia

Estimation Technique	Constant	FGDS <sub>i,t</sub>	FGUSP <sub>t</sub>	FGRIP <sub>i,t</sub>	Time	$\hat{\rho}$	R <sup>2</sup>	d	S.E.E.
OLS	1,741.8	-.486 (.219)	98.972 (451.594)		311.167 (55.807)		.82	1.45	520.0
OLS	-1,586.2	-.364 (.157)		315.904 (97.984)	476.547 (65.237)		.91	2.01	373.7
OLS	-1,770.3	.528 (.228)	-381.614 (830.199)				.31	.09	973.8
OLS	2,229.5	-.009 (.345)		-254.852 (136.935)			.45	.09	865.4
OLS	1,905.7	-.475 (.204)			308.833 (52.564)		.82	1.37	498.9
ALS	-582.6	-.140 (.124)			297.195 (94.034)	.667 (.216)	.89	1.72	410.5
ALS	-5,203.5	-.058 (.103)	-930.411 (571.690)		635.155 (1,186.849)	.897 (.251)	.92	2.19	364.6

Table B-12. Feed grain import equations for People's Republic of China

Estimation Technique	Constant	$FGDS_{i,t}$	$FGUSP_t$	$FGRIP_{i,t}$	Time	$\hat{\rho}$	$R^2$	d	S.E.E.
OLS	2,472.4	-.153 (.055)	597.091 (400.206)		188.973 (65.332)		.49	2.39	474.2
OLS	-525.3	-.011 (.030)	560.809 (508.168)				.10	.75	602.4
OLS	3,747.9	-.150 (.057)			185.918 (68.554)		.38	1.95	497.8
ALS	3,495.6	-.214 (.046)	826.321 (317.685)		244.616 (48.270)	-.459 (.316)	.65	2.23	433.1
ALS	279.1	-.021 (.069)	362.575 (836.015)			.380 (.418)	.21	1.88	617.1