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Feed grain imports and their effect on feed grain prices in the importing country

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Feed grain imports and their effect on feed
grain prices in the importing country

by

Michael Robert Reed

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

Trade in Feed Grains

World trade in feed grains¹ has been increasing for quite some time. From 1958/59² to 1973/74, world trade in feed grains increased from 20.8 million metric tons to 76.0 million metric tons, a 265% increase. Corn accounted for 62% of world trade in feed grains during the 1958/59-1973/74 period while barley and sorghum accounted for 19% and 14% of world trade in feed grains, respectively, in the 1958/59-1973/74 period. Very little oats or rye are traded internationally as they accounted for only 4% and 2% of world trade in feed grains, respectively, in the period. Table 1-1 gives world trade in the five feed grains by year. Though trade in all feed grains has increased, trade in corn and sorghum has increased much more rapidly than the other three feed grains.

Exporters of Feed Grains

Table 1-2 shows the five leading exporters of feed grains and the volume of feed grains they shipped by year. The distribution of feed grain exports is very concentrated, with the five leading exporters accounting for 80% of total world trade in the period shown in Table 1-2.

The United States has been the leading feed grain exporter for many years. In the 1958/59-1973/74 period, the U.S. exported 317.2 million metric tons of feed grains or about 49% of the total world exports of feed

¹Barley, corn, oats, rye, and sorghum are feed grains.

²1958/59 stands for the year beginning on July 1, 1958, and ending on June 31, 1959. This notation will be used throughout the paper.

Table 1-1. World trade in feed grains (in thousands of metric tons)^a

	Corn	Barley	Sorghum	Oats	Rye	Total
1958/59	9,350	6,400	3,020	1,300	775	20,845
1959/60	10,870	6,090	3,151	1,510	840	22,461
1960/61	12,130	5,820	2,830	1,200	1,020	23,000
1961/62	16,660	7,150	3,300	1,410	930	29,450
1962/63	18,160	4,600	3,770	1,310	1,040	28,880
1963/64	21,100	6,820	3,570	1,190	580	33,260
1964/65	22,200	6,470	4,170	1,480	500	34,820
1965/66	26,110	6,670	7,320	1,580	525	42,205
1966/67	25,170	6,250	9,390	1,270	580	42,660
1967/68	27,350	6,255	6,050	1,180	430	41,265
1968/69	27,020	6,210	4,640	1,135	300	39,305
1969/70	28,050	8,330	5,345	940	340	43,005
1970/71	28,775	10,280	7,505	1,900	770	49,230
1971/72	32,895	13,155	5,770	1,960	620	54,400
1972/73	41,310	11,190	7,335	1,495	1,340	62,670
1973/74	50,470	11,805	10,810	1,675	1,225	75,985
1958/59- 1973/74 Total	397,620	123,495	87,976	22,535	11,815	643,441

^aSource: FAO (1958d through 1976d).

grains in the period. Most of the U.S. exports were corn, 228.5 million metric tons in the period. The U.S. is always the leading exporter of corn and sorghum and usually among the top three exporters of barley, oats, and rye. In 1958/59 the U.S. was the leading exporter of each of the five feed grains.

U.S. feed grain producers have become more reliant on foreign markets for feed grains in recent years. In 1958/59 only 6% of the corn produced in the U.S. was exported, but in 1973/74 nearly 25% of the corn produced in the U.S. was exported. The U.S. exports feed grains to all corners of the world because the price of U.S. feed grains is almost always competitive with the feed grains of other exporters. But from 1958-1962 the U.S.

Table 1-2. Leading exporters of feed grains (in thousands of metric tons)^a

	U.S.	Argentina	France	Canada	South Africa	5 country total	Total
1958/59	10,639	2,978	86	1,801	678	16,182	20,845
1959/60	10,965	4,055	532	1,515	424	17,491	22,461
1960/61	11,196	2,606	1,758	970	855	17,385	23,000
1961/62	14,221	3,551	2,011	1,056	1,725	22,564	29,450
1962/63	15,347	3,276	1,092	740	2,307	22,762	28,880
1963/64	15,824	3,794	3,180	1,290	2,411	26,499	33,260
1964/65	17,629	5,185	2,847	1,038	696	27,395	34,820
1965/66	25,544	3,798	2,780	1,184	220	33,526	42,205
1966/67	21,241	6,543	3,804	1,310	654	33,552	42,660
1967/68	19,687	4,264	4,054	1,207	3,318	32,530	41,265
1068/69	15,960	5,817	6,109	596	2,212	30,694	39,305
1969/70	19,067	6,307	5,993	1,573	859	33,799	43,005
1970/71	19,047	7,868	5,629	4,232	871	37,647	49,230
1971/72	20,930	6,256	8,124	4,825	3,047	43,182	54,400
1972/73	35,732	4,320	6,972	4,214	3,302	54,540	62,670
1973/74	44,503	8,544	9,815	2,785	371	66,018	75,985
1958/59- 1973/74 Total	317,543	79,162	64,786	30,336	23,950	515,777	643,441

^aSource: FAO (1958d through 1976d).

government felt it was necessary to pay a subsidy to U.S. feed grain exporters to keep U.S. feed grains competitive with other feed grains on the international market.

Western Europe is the best market for U.S. feed grains, where large amounts of U.S. corn, sorghum, and barley are imported by the United Kingdom, the Netherlands, Italy, West Germany, and Spain. Japan imports more U.S. feed grains than any single country. Most U.S. feed grain exports to Japan are corn and sorghum.

Table 1-2 shows that Argentina was the second leading feed grain exporter in 1958/59-1973/74 with 79.2 million metric tons. Most feed

grain exports by Argentina were corn and sorghum, 70% and 21% of total Argentine feed grain shipments, respectively. But Argentina does export barley, oats, and rye. Italy is by far the leading importer of Argentine feed grains, and the imports are almost all corn. Prior to 1962 Italy had a trade agreement with Argentina where Italian import licensing preferences for Argentine corn were given in return for Argentine preferences for some Italian manufactured goods (USDA-ERS-FDCD, 1967), so Argentina has been a traditional, long-term supplier of corn to Italy.

But the biggest reason that Italy is such a good market for Argentine corn is the type of corn Argentina grows. Most of the corn Argentina exports is of the flint-type. Flint corn has a relatively high concentration of carotene, which causes dark yoked eggs and yellow skinned meat when fed to poultry. These are characteristics that Italians prefer, so they buy Argentine corn. Argentine suppliers also like to ship corn to Italy because their corn commands a higher price in Italy relative to other markets because of the carotene content.

Spain is another major market for Argentine corn. In Spain, Argentine corn seems to have an advantage over other corn because of a "combination of normal freight and pricing factors and certain Spanish regulations affecting freight and levies on corn" (USDA-FAS, 1970). Argentina also ships a lot of sorghum to Spain. But Spain and Italy do import large amounts of corn from other exporting countries, especially the U.S. This is because Argentine corn and sorghum exports are usually heavily concentrated in the first six months of the marketing year because of limited storage capacity and a lack of adequate financial facilities to encourage producers to hold stocks (USDA-FAS, 1978).

Japan is the best market for Argentina's sorghum exports. During the 1958/59-1973/74 period, shipments of sorghum to Japan accounted for over 34% of Argentine sorghum exports. Other substantial markets for Argentine sorghum are in Western Europe.

France was the third leading exporter of feed grains from 1958/59-1973/74, as shown in Table 1-2. France is almost always the world's largest barley exporter and is usually among the leaders in corn exports. In 1958/59 France exported only 86,000 metric tons of feed grains, while in 1973/74 France exported over 9.8 million metric tons of feed grains. The main reason for this increase is the formation of the European Economic Community. The EEC system, which will be examined later in this chapter, became fully effective in 1967. The EEC pricing system caused the producer price of all feed grains in France to increase substantially, so French feed grain production and exports increased. Almost all of France's feed grain exports go to other EEC member countries.

Most of Canada's feed grain exports are barley (85%). Though Canada is always one of the leading rye exporters, the quantity involved is rather small relative to barley. Canada's chief markets for barley are Italy, the United Kingdom, and Japan. Canada benefited from preferential tariff rates in the U.K. because of its Commonwealth status before the U.K. joined the EEC in 1973. Canada also benefits from West Coast sea ports that are fairly accessible to Canadian barley-producing areas by rail. This gives Canada an edge in the Japanese market for imported barley. Canada is usually a net importer of corn and sorghum.

South African feed grain exports are almost exclusively corn. Some sorghum is exported, but it is a relatively small amount. South Africa has

a hard time building traditional markets because of its variable export level. Precipitation in South Africa varies significantly from year to year. Couple variable weather with the marginal land that is used for much of the corn produced and the result is extremely variable corn production and exports as can be seen in Table 1-2. Because its quantity of corn exports fluctuates radically from year to year, South Africa finds it difficult to establish itself as a reliable long-term export supplier. Major purchasers of South African corn are Japan, the United Kingdom, and the Netherlands.

Thailand is a growing exporter of corn. Thai production of corn was very small until 1960/61. That year some Thai farmers switched from planting rice to corn because of an improved corn price. This has continued in more recent years, too. But uses of corn in Thailand are minimal, so almost 90% of the corn produced is exported. Therefore, as corn production increases, almost all of the increase is exported. Virtually all Thai corn that is exported goes to Far Eastern countries. Major markets for Thai corn are Japan, Taiwan, Singapore, and Hong Kong. Thailand has had corn agreements to supply Japan with corn since 1966/67. Thailand has also had corn agreements with Taiwan in the past.

Importers of Feed Grains

The distribution of feed grain imports is also very concentrated. The five leading importers of feed grains accounted for 58% of total imports from 1958/59 to 1973/74 as can be seen in Table 1-3. Most feed grain importing countries are more developed, higher income countries. The reason is that feed grains are primarily used to feed livestock. Since meat

Table 1-3. Leading importers of feed grains (in thousands of metric tons)^a

	Japan	Italy	West Germany	U.K.	Nether- lands	5 country total	Total
1958/59	1,556	1,088	2,784	4,885	2,328	12,641	20,570
1959/60	1,388	2,094	3,069	4,674	2,909	14,134	22,396
1960/61	2,090	2,442	1,939	4,511	2,834	13,816	23,396
1961/62	2,451	2,674	4,628	5,178	2,920	17,851	29,080
1962/63	3,140	3,888	3,066	4,676	3,129	17,899	28,710
1963/64	4,912	5,208	3,145	4,226	3,164	20,655	33,120
1964/65	5,100	4,645	4,098	3,922	2,840	20,605	34,000
1965/66	5,811	6,712	5,196	4,275	3,195	25,189	41,535
1966/67	7,770	6,255	4,543	4,159	2,986	25,713	42,660
1967/68	8,050	4,210	4,749	4,076	3,078	24,163	41,085
1968/69	8,651	6,215	4,252	4,065	2,632	25,815	39,285
1969/70	10,013	5,473	3,947	4,173	2,665	26,271	42,795
1970/71	10,383	5,987	6,076	4,071	3,572	30,089	48,505
1971/72	10,207	5,356	5,576	4,377	2,886	28,402	53,580
1972/73	12,164	6,016	5,190	4,132	3,489	30,991	61,145
1973/74	14,375	6,651	5,908	3,999	5,253	36,186	75,305
1958/59- 1973/74 Total	108,061	74,914	68,166	69,399	49,880	370,420	636,901

^aSource: FAO (1958d through 1976d).

is more expensive than other food, only more developed countries have large inventories of livestock. So the more developed countries use more feed grains, and many of them are forced to import feed grains.

Japan was the largest importer of feed grains in the 1958/59-1973/74 period. In Japan feed grains are primarily used to feed poultry and hogs. In fact, swine and poultry operations account for 80% of mixed feed consumption in Japan (USDA-FAC, 1977). Beef production is not heavily reliant on feed grains in Japan. This is the case in most countries of the world, except in the United States and Argentina where grain-fed cattle are very common.

The Japanese government has direct control over domestic barley prices and imports, and for most years there has been a quota on barley imports. Corn and sorghum are imported by private firms, but the Japanese government does purchase part of these feed grains for price and market stabilization purposes. There are no trade barriers for sorghum imports, but corn imports are taxed and restricted by quotas at times. Other aspects of Japanese feed grain trade are discussed in Chapter IV.

The other four leading importers of feed grains listed in Table 1-3 are currently members of the European Economic Community. In most years, EEC countries import over one-third of the feed grains traded. The EEC system became fully effective in 1967, at which time Belgium, France, Italy, Luxemburg, the Netherlands, and West Germany were members. As of January 1, 1978, Denmark, Ireland, and the United Kingdom were also full members.

The EEC has a common agricultural policy for all member countries. The key element to the common agricultural policy is the pricing system. I will describe this system in relation to feed grains. The EEC fixes the price ruling in the marketing center of the area with the largest deficit for production of feed grains, which is Duisburg, West Germany. Derived prices of feed grains are differentiated by region throughout the EEC in order to favor the movement of feed grains from surplus regions to deficit regions. The price differentials between regions are determined by the cost of transportation and handling between regions.

To make sure the target price of feed grains is achieved, the EEC must control the importation of foreign feed grains that may be less expensive. This is handled by a variable levy system. A threshold price is set at the

terminal where feed grains are imported. The threshold price is derived from the target price. At Rotterdam, the chief port for all grains imported by the EEC countries, the threshold price is about 99% of the target price. This is because Duisburg is close and easily accessible from Rotterdam. The variable levy or tax on imported corn, for instance, is the difference between the threshold price and the lowest price that includes cost, insurance, and freight (c.i.f. price) for imported corn. This puts the cost of all imported corn at or above the threshold price. If the c.i.f. price is above the threshold price, the variable levy is zero. But most of the time the variable levy is greater than zero.

EEC countries import most of their feed grains from France and the United States. Even with the variable levy, which at times is equal to the c.i.f. price of U.S. feed grains, the U.S. still exports large amounts of feed grains to EEC member countries.

CHAPTER II. PREVIOUS WORK AND OBJECTIVES OF THIS STUDY

Review of the Literature

Previous work in general economics

Much of the empirical work in international trade has focused on total imports and/or total exports of a country. The most asked question in these works is how does a change in the exchange rate affect the volume of imports and exports of a country. International trade theory derives from postulates that if the price of a country's currency decreases, the quantity of imports to the country will fall and the quantity of exports from the country will increase (Heller, 1968; Kreinin, 1971; Leamer and Stern, 1970). For illustration I will use a two country-two good world example where the first country is the United States and the second country is the United Kingdom. For simplicity transportation costs are assumed to be zero.

The price of the dollar in this example is denominated in pounds per dollar (£/\$). If the price of the dollar decreases by 50%, then a good which the U.K. exports that costs £2 in the U.K. will be 50% higher in price in the U.S. after the depreciation of the dollar. If the original exchange rate is one pound per dollar, the original price of the good in the U.S. is \$2. But after the dollar depreciation, the exchange rate is one-half pound per dollar, so the price of the good in the U.S. is \$4. Because the price has increased in the U.S., the demand for the good should fall in the U.S., causing U.S. imports (U.K. exports) to fall. This ignores the possible price effects of the diminished U.S. demand, but even if the pound price falls some, the quantity of U.S. imports will still

decrease. This can be seen graphically in Figure 2-1. In Figure 2-1, P_1 is the price of the good in pounds, X_1 is the quantity of the good imported by the U.S., S_1 is the U.K. export supply curve, D_{10} is the original U.S. import demand curve, X_{10} is the original quantity of U.S. imports of the good, and P_{10} is the original pound price of the good. If the price of the dollar falls, money and real income effects ignored, the demand for imports by the U.S. will shift to D_{11} because the demand for imports by the U.S. is derived from a dollar price, not a pound price. U.S. imports of the good will fall to X_{11} , and the pound price of the good will decrease to P_{11} . Both the quantity and the value of U.S. imports for the good decrease.

With respect to a good that the U.S. exports, the depreciation will cause the quantity of U.S. exports to increase. If the price of the good in the U.S. is \$2, then the pound price for U.K. importers with the original exchange rate is £2. When the dollar depreciates by 50%, the U.S. exporters will still be able to sell the good for £2 in the U.K. because no variables that influence the U.K.'s demand or supply for the good have changed, but the £2 U.K. price translates into \$4 for the U.S. exporter. Because of the higher dollar price the U.S. exporters receive, the quantity of U.S. exports will increase. This can be seen graphically in Figure 2-2. In Figure 2-2, P_2 is the pound price of the good, X_2 is the quantity of U.S. exports of the good, D_2 is the U.K. import demand curve for the good, S_{20} is the original U.S. export supply curve for the good, X_{20} is the original quantity of U.S. exports of the good, and P_{20} is the original pound price of the good. If the price of the dollar falls, money and real income effects ignored, the supply of exports from the U.S. will shift to S_{21} because the supply curve is derived from a dollar price, not a pound

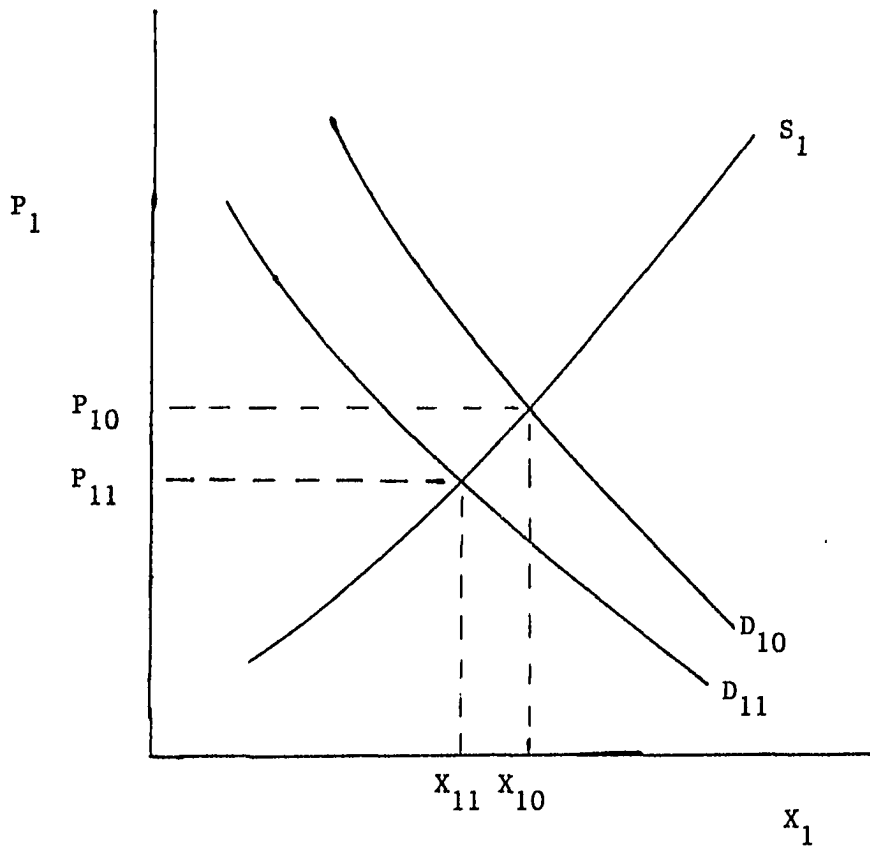


Figure 2-1. The effect of an exchange rate change on U.S. imports

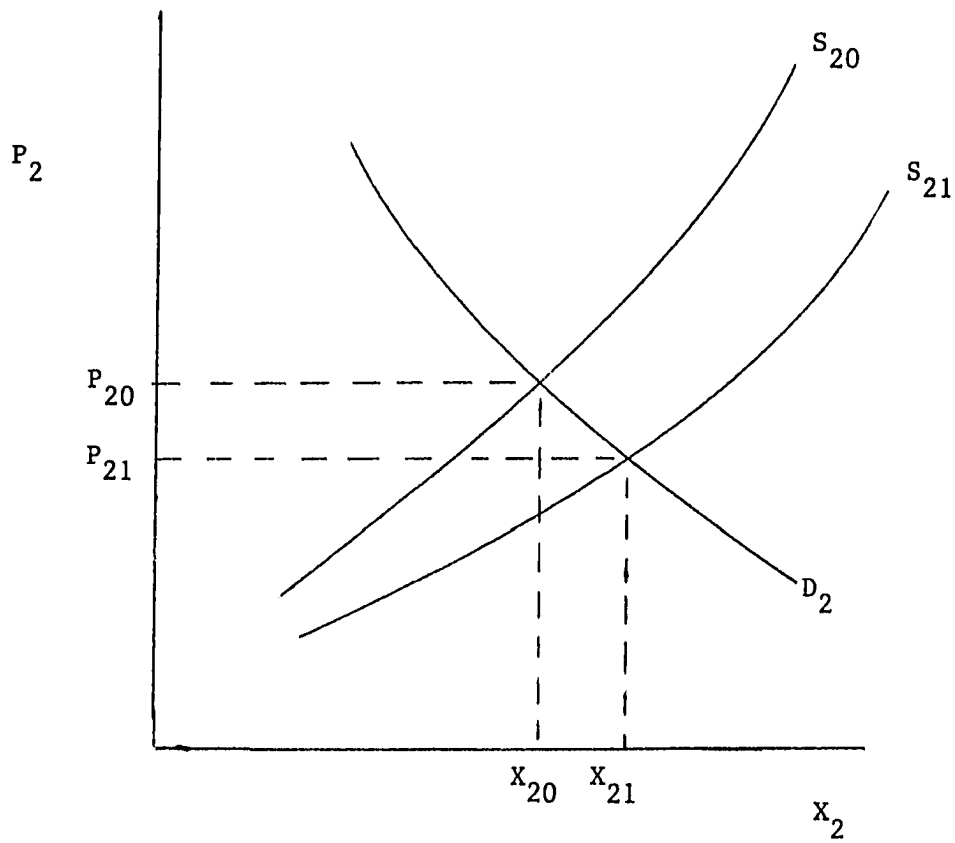


Figure 2-2. The effect of an exchange rate change on U.S. exports

price. U.S. exports of the good will increase to X_{21} , and the pound price of the good will decrease to P_{21} . The quantity of U.S. exports will definitely increase, but the value of exports could increase, decrease, or remain the same after the depreciation of the dollar depending on the U.K. import elasticity of demand for the good. If the U.K. import elasticity of demand is greater than one, the value of U.S. exports will increase. If the import elasticity of demand is less than one, then the value of U.S. exports will decrease.

So it is possible that a dollar depreciation (or a devaluation under a system of fixed exchange rates) could cause the U.S. trade balance with respect to a commodity to worsen if the U.K. import demand elasticity is very inelastic. The trade balance worsens if the value of exports minus the value of imports decreases. If X_1 is expanded to include all goods that the U.S. imports and X_2 is expanded to include all goods that the U.S. exports, then if the rest of the world's import demand elasticity for U.S. exports is very low, a depreciation of the dollar may worsen the U.S.'s balance of trade. This is a very important outcome, since a devaluation is used many times, under a system of fixed exchange rates, to improve a country's balance of trade.

Characteristic of the recent work in determining the effects of exchange rate changes on the quantity and value of a country's total imports and exports are studies by Bautista (1977), Bhagwat and Onitsuka (1974), Branson (1972), and Deppler (1974). Some work has focused on the effects of exchange rates on particular groups of commodities. Junz and Rhomberg (1973) did a study in this latter area. But for the most part, trade in specific individual commodities is not analyzed. The exception to

this last statement is the international trade studies by agricultural economists.

Previous work in agricultural economics

The work in agricultural commodities is different. Research is usually conducted on an individual commodity with the main objective being to explain the U.S. export pattern. Jones and Morrison (1976), Mitchell (1976), and Ryan and Houck (1976) estimated import demands for U.S. soybeans and soybean products. They used a world price model. By this it is meant that they assumed the price of imported soybeans was the same for all the countries they studied. This price was the U.S. price of soybeans. They ignored transportation costs and trade barriers and were not specific on how they included exchange rates.

Jones and Morrison (1976) explained imports of soybean meal and soybean equivalents for some Eastern European countries using a two equation recursive model. The first equation explained the livestock inventory with population lagged one year and a per capita product index lagged one year as predetermined variables. The second equation explained imports of soybean meal plus meal equivalents of soybeans as a function of the U.S. wholesale price of soybean meal, protein meal as a percentage of concentrates, the importing country's production of soybean meal, time, and the estimated size of the livestock inventory (from the first equation). The results showed that the size of the livestock inventory explained most of the variation in soybean meal imports. The price of soybean meal was significantly different from zero in only one of the three equations reported.

The estimation technique was ordinary least squares on each of the two equations for each country.

Mitchell (1976) ran separate equations to explain net imports of wheat, feed grains, and soybeans by various regions of the world using ordinary least squares (corrected for autocorrelation). The independent variables for these equations were the importing country's domestic supply, time, and the U.S. export price adjusted for the 1971 and 1973 dollar devaluations. The results for wheat and feed grains showed that net imports are not responsive to price. The coefficient on the U.S. export price was never significantly different from zero for wheat or feed grains in any of the 14 regions studied. Three separate equations explained soybean imports of each region. The three were for soybean meal, soybean oil, and soybeans. The U.S. export price of soybeans was significantly different from zero for some of the regions.

Ryan and Houck (1976) explained U.S. exports of soybeans and soybean meal using ordinary least squares. The independent variables for the soybean equations were the U.S. wholesale price of soybeans divided by the U.S. price of soybean meal, foreign production of oilseeds, and an income index for the European Economic Community and Japan. The results, as measured by \bar{R}^2 , were quite good. The price variables were significantly different from zero over most of the time periods studied. The income index consistently had the highest t value. The independent variables for the soybean meal equations were the price of fish meal at European ports, the number of hogs in the six countries of the EEC (EC6), the number of poultry in the EC6, exports of soybean meal from Brazil, and either the U.S. price of soybean meal and the U.S. price of soybeans or the ratio of the two

prices. The coefficients for the price variables were insignificant in most equations for soybean meal.

Abbott (1976) modeled separate equations to explain net imports of wheat and feed grains by 33 countries of the world using instrumental variable estimation techniques. Abbott tried to account for the existence of trade barriers by allowing the domestic price in the importing country to partially respond to changes in the world price. The prices in the model are cif prices so transportation costs are incorporated, but exchange rates and tariffs are omitted. The independent variables for the equations were the domestic price, domestic income, time, domestic production, aid in kind received of the commodity, the foreign exchange position of the importing country, the domestic stock of animals, and the domestic population. The coefficient for the price variable was significantly different from zero in only 5 of 33 equations for both wheat and feed grains.

A reason why price coefficients tend to be significant for soybeans and soybean products and insignificant for wheat and feed grains may be because of trade barriers. There are few trade barriers for soybeans and soybean products relative to wheat and feed grains. So the U.S. price of soybeans will reflect the important country's price of soybeans better than the U.S. price of feed grains will reflect the importing country's price of feed grains. Jones and Morrison's study (1976) was probably hampered by the fact that Eastern Europe is characterized by central planners. So the role of price is probably diminished. If trade barriers are considered, the coefficient for the domestic price of feed grains could be significant.

Johnson (1971) and others have used a market share analysis to explain international trade in some commodities. The market share analysis allows

a commodity produced in one country to be an imperfect substitute for the same commodity produced in another country. In that case, imports of a particular commodity should be distinguished by origin. Johnson et al. see the fact that countries import the same commodity from different countries as a rationale for their view. The emphasis of the market share approach is to estimate the elasticity of substitution between different import-supplying countries.

Needed Extensions on Previous Work

Three important aspects of international trade have not been properly handled in any one study yet. These three aspects are: 1) ocean shipping costs, 2) exchange rates, and 3) trade barriers. Some studies consider one or two of these three aspects, but no study has considered all three.

Ocean shipping costs

Ocean shipping costs exist and have not been constant through time. There has not been a substantial trend in shipping costs either. For example, the average shipping costs from the U.S. gulf ports to Tilbury, U.K., was \$8.78 per long ton in 1966/67 and was \$6.78 per long ton in 1975/76. But ocean shipping rates have varied widely in the 1966-1976 period with a high of \$16.52 per long ton in 1973/74 and a low of \$3.30 per long ton over the Tilbury route in 1971/72 (IWC, 1973/74). Ocean shipping costs definitely have an effect on the cost of imported feed grains to the importing country, too. During the 1966-74 period, ocean shipping costs averaged 11.5% of the cost of imported U.S. corn at the border of the U.K. (this excludes any import duties). A large proportion of the models find that the quantity of feed grain imports by a country are not responsive to the

price incorporated in the model. The exclusion of the cost of ocean shipping from the feed grain price could be part of the reason for those surprising results.

Incorporation of exchange rates

If a buyer in the U.K. wishes to buy feed grains, he is concerned with the pound price of feed grains. An American seller is concerned with the dollar price of the feed grains he sells. If the American and the Englishman wish to make a transaction, someone must change currencies. Let's assume the buyer must exchange his country's currency for the currency of the seller. Then the Englishman must exchange his pounds for dollars. This transaction must take place because the American seller wants to be paid in dollars. So the exchange rate between the pound and the dollar is a part of the cost of U.S. feed grains the Englishman purchases. If the dollar price remains the same, the cost of U.S. feed grains to the Englishman can still change if the exchange rate changes. Therefore, the exchange rate must be incorporated into the international trade model.

Ryan and Houck (1976) and Jones and Morrison (1976) did not incorporate the exchange rate at all in their studies. The prices they used were all dollar prices. Since the value of currencies change periodically, even under a system of fixed exchange rates, these studies have omitted an important factor. For instance, the U.S. devalued the dollar in 1971 and 1973 when the world monetary system was under a regime of fixed exchange rates. These devaluations made U.S. feed grains less expensive in terms of foreign currencies. So the exchange rate must be considered in some manner.

Deppler (1974) used intercept dummy variables to capture the effects of exchange rate changes on the total value of imports and exports for various countries. The dummy variables were used to allow the intercept for the aggregate import demand and export supply functions to change when the exchange rate changed. But a devaluation will do more than simply change the intercepts of these two functions. It will also change the price elasticities and slopes. Assume that total U.K. imports are a function of variables including some aggregate dollar price index for imports, P_a . By holding the other variables constant and varying P_a , an aggregate import demand function for the U.K. can be obtained that would look something like D_1 in Figure 2-3. Q_a is the quantity of total imports by the U.K.

If the U.S. devalues the dollar in terms of the pound by 10% and an intercept dummy variable is used to capture the effect of the exchange rate change, the new estimated aggregate import demand function would look like D_2 . But what the 10% devaluation actually causes is a 10% decrease in the pound price. This causes the intercept and the slope of the aggregate import demand function to change, since P_a is a dollar price. The new aggregate import demand function would be D_3 , but by using intercept dummy variables to capture the exchange rate change, one would get an estimate like D_2 . What should be done is to divide the dollar price by the exchange rate denominated in dollars per pound to obtain the pound price for all observations. Some of the agricultural studies state that they have "adjusted" for the exchange rate in their model. The adjustment should not be handled with intercept dummy variables only, though.

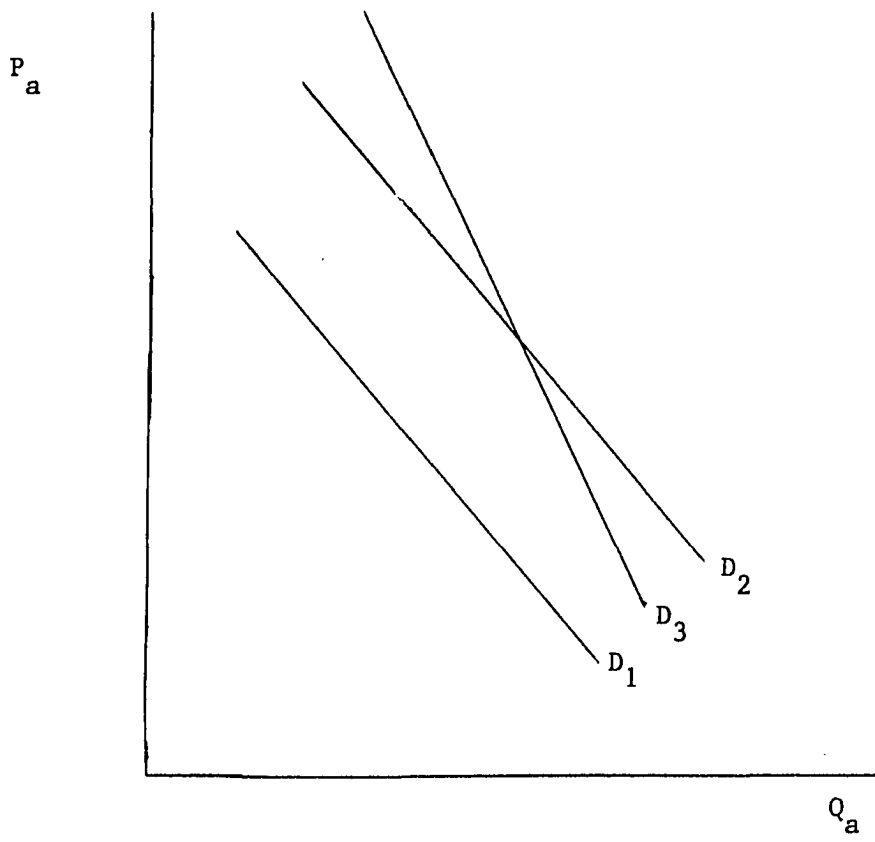


Figure 2-3. The effect of an exchange rate change on aggregate imports

Trade barriers

Some studies use the U.S. price as the importing country's price, others go on and take into consideration ocean shipping costs and exchange rates in the cost of importing the commodity. But no study that I have seen explicitly accounts for tariffs or quotas. One reason for this may be the lack of reliable published data on these trade barriers for most countries. Grain import policies of many countries are reported by FAO (1958b through 1976b) each year. But the government of the reporting country is in charge of submitting the information, and the information is very incomplete for most countries. A large proportion of the reporting countries issue import licenses to importers of grains. But the publication does not give the price of the licenses, how many are issued, or other information that is needed to get an idea of the country's true import policies. These import licenses could be a disguised quota in many instances. So the data limitations are great when it comes to import policies of most countries.

Abbott (1976) tried to incorporate import policies by allowing the importing country's domestic price to partially adjust to the cost of importing the commodity. But there was no specific rationale for this specification. Abbott recognized the effects that tariffs and quotas have on imports but didn't consider them in the estimation.

Problem Statement

A challenge in the area of international marketing is to discover the structure of international trade in various commodities. The policy makers would know the effects of their policy decisions. Planners, including

producers, importers, and consumers, would be more certain about the final outcome of production, consumption, and trade, and other benefits could emanate from the discovery.

If a complete model of the world feed grain market was constructed, the total effects of a change in one country's tariff rates could be examined. Future trade patterns could be predicted which could help transportation systems and other infra-structure adapt to the future changes in the international market for feed grains. This would improve efficiency in trade. There is little doubt that an accurate model of the world feed grain market would be useful. So that is an ultimate goal of world trade models in feed grains.

Objectives of This Study

The aim of this study is to investigate factors that have been overlooked in previous work on international trade in agricultural commodities and discover their influence on trade in feed grains. These factors are trade barriers, ocean shipping costs, and exchange rates. The specific objectives of the study are:

- 1) to obtain import demand equations for feed grains by certain feed grain-importing countries of the world.
- 2) to investigate factors that influence the domestic price of feed grains in these importing countries.
- 3) to extend the analysis to determine the effects of the model for foreign sales of U.S. feed grains.

Other factors in the importing country are investigated, but they are considered to make the analysis for feed grains more accurate in order to achieve the three objectives listed.

Following Chapters

Chapter III presents a six equation simultaneous model for each country in the study. The purpose of this six equation model is to explain the determination of the importing country's domestic price of feed grains and the importing country's imports of feed grains.

Chapter IV presents an equation for each importing country in the study. The purpose of the equation is to explain the country's importation of U.S. feed grains.

Chapter V explains the sources of data used in the study and how aggregate variables were obtained.

Chapter VI describes the statistical procedures used in the study.

Chapter VII presents the results of the study.

Chapter VIII gives some concluding remarks for the study.

CHAPTER III. A MODEL FOR TOTAL IMPORTS OF FEED GRAINS

The Import Demand Function

In a world with no trade barriers or transportation costs, the dollar price of a good will be the same in every country because of arbitrage, if there is perfect competition. If the dollar price is higher in some countries, an individual could buy the good in a country where the dollar price was low and sell the good in a country with a high dollar price, thus earning positive profits. Therefore, the supply of the good in the countries with the high dollar price will increase because of arbitrage. This will tend to decrease the dollar price in those high-priced countries. The supply of the good in the countries with a low dollar price will decrease because of arbitrage. This will tend to increase the dollar price in those low-priced countries. Arbitrage will be profitable until there is no difference in the dollar price between countries.

In a world with no trade barriers, perfect competition in the markets, but positive transportation costs, there can be different dollar prices for the same good depending on its location. But the difference in the dollar price between two countries will be no greater than the cost of transporting the good between the two countries. Suppose the dollar cost of imported feed grains into a particular importing country is P_I . If feed grains are not distinguishable by their country of production, then the domestic price of feed grains in the importing country, P_D , will equal the dollar cost of imported feed grains divided by an exchange rate, k , denominated in dollars per unit of the importing country's currency, $P_D = \frac{P_I}{k}$.

If the importing country does not import a large share of the feed grains that are traded internationally, the country will be able to import any amount of feed grains it wants at a cost of P_I , or $\frac{P_I}{k}$ in its own currency units. This is the small country assumption of international trade. Any price lower than P_I for the importing country will result in no feed grains being supplied from exporting countries because the costs of importing the feed grains would not be covered. No dollar price above P_I will last because the importing country will be able to find some importer who will be willing to supply feed grains at a price of P_I . So the cost of imported feed grains is exogenous to the importing country and fixed at P_I .

Figure 3-1 shows the domestic feed grain market. The vertical axis is the domestic price of feedgrains. The horizontal axis is the quantity of feed grains. S_{DF} is the domestic supply of feed grains. It is obtained by varying the domestic price of feed grains while holding all other supply variables constant. D_F is the domestic demand for feed grains. It is obtained by varying the domestic price of feed grains while holding all other demand variables constant. If there was no international trade in feed grains, the domestic price of feed grains would be P_N , where domestic supply equals domestic demand. Assuming that feed grain inventories of the importing country remain the same, domestic production of feed grains would equal domestic consumption. In Figure 3-1 this amount would be Q_1 .

But the country depicted imports feed grains, so the cost of imported feed grains must be lower than P_N . The import price has been labeled $\frac{P_I}{k}$. The import supply curve for feed grains is perfectly elastic at that price.

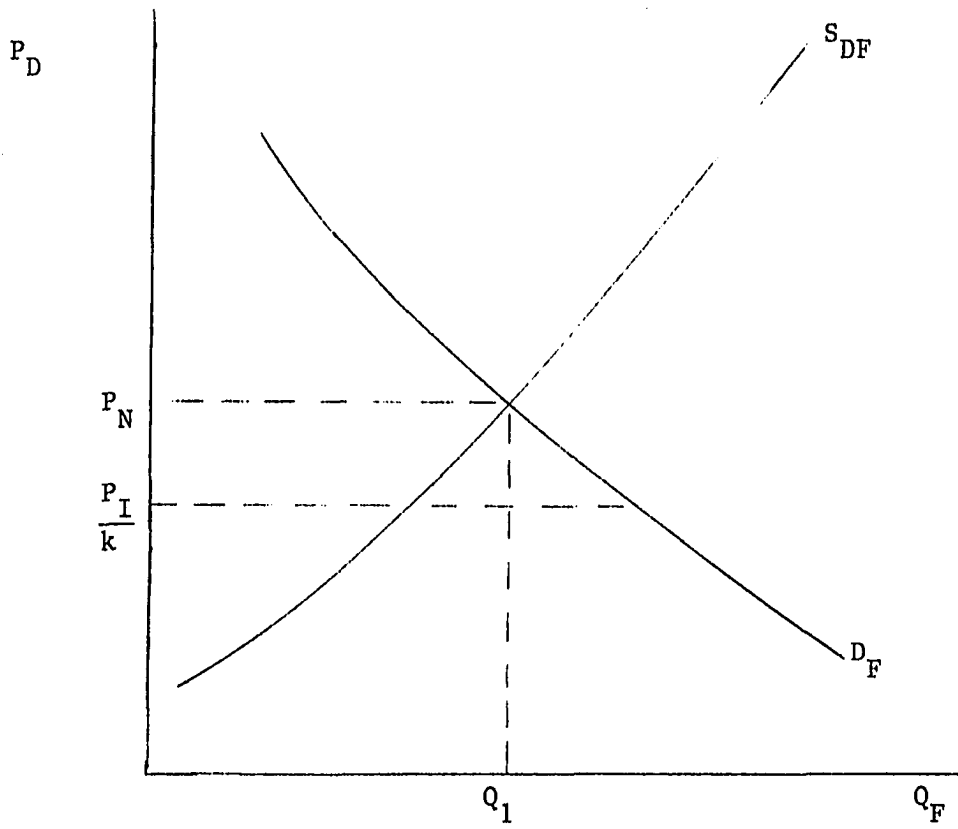


Figure 3-1. The domestic feed grain market with no trade

So the actual supply-demand situation for feed grains is depicted in Figure 3-2.

The demand curve is the same as in Figure 3-1, but the supply curve, S_F , is the portion of the domestic supply curve, S_{DF} , below $\frac{P_I}{k}$ and at $\frac{P_I}{k}$ the supply curve is perfectly elastic, reflecting the import supply curve. One can think of S_F as the lower envelope of the domestic supply and import supply curves. The domestic supply and demand curves do not determine the domestic price of feed grains in the importing country. The domestic price of feed grains is determined by the outside world. The domestic supply and demand curves determine the demand for imports. In Figure 3-2, Q_2 is domestic supply, Q_3 is domestic consumption, and $Q_3 - Q_2$ is the quantity of imports.

So under the assumptions of perfect competition in the domestic and international feed grain market and the assumption that foreign-produced feed grains are a perfect substitute for domestically-produced feed grains, the import demand for feed grains is an excess demand. Therefore, the demand for imported feed grains should be a function of the same variables that affect domestic supply and demand.

Figure 3-3 shows the import demand function, I_F . It is derived by subtracting S_{DF} from D_F at each domestic price. So in the diagram $Q_I = Q_3 - Q_2$. P_N is the domestic price of feed grains at which there are no imports of feed grains. It is the same as P_N in Figure 3-1. There are domestic prices that are high enough to cause the country depicted to be an exporter of feed grains, but the quantities exported at these prices have not been shown.

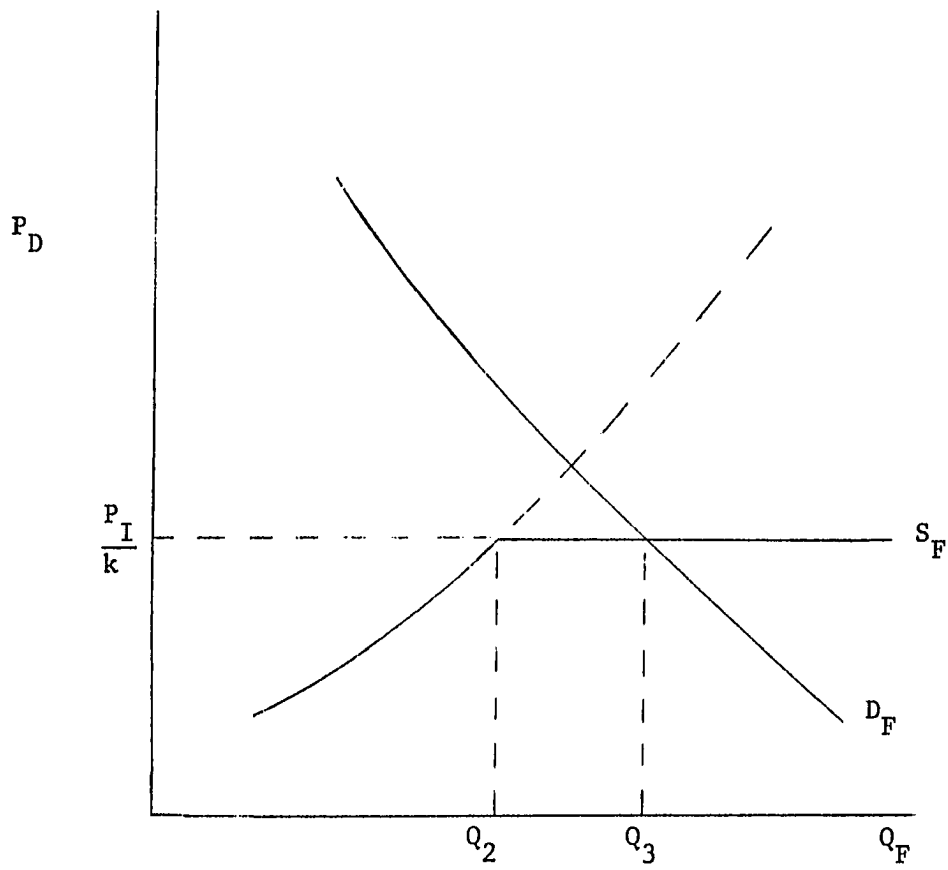


Figure 3-2. The domestic feed grain market with trade

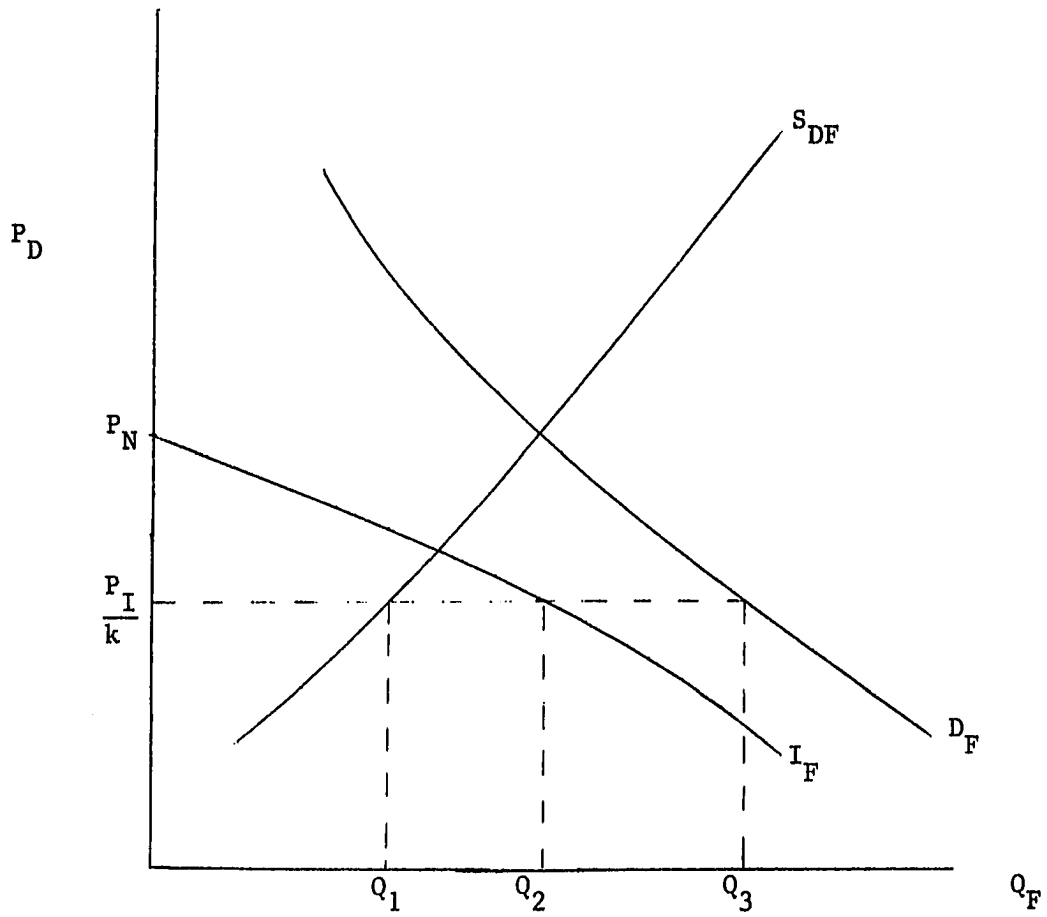


Figure 3-3. The import demand function

The supply function

The domestic supply function for feed grains is derived from the assumption of profit maximization by producers. The domestic supply function will be specified as a function of present and past values of the domestic price of feed grains and the present price of inputs for feed grain production. Lagged values of the domestic price influence supply since planting decisions must be made 6-12 months prior to the time the crop is harvested. If the functional form of the domestic supply curve is linear, we have:

$$S_{DFt} = a_0 + a_1 P_{Dt} + a_2 P_{Dt-1} + a_3 P_{ot} \quad \text{Eq. 3-1}$$

The t subscripts denote time, so P_{ot} is the price of inputs for feed grain production in period t . Only one lagged price variable has been included in the equation. This can be viewed as a representative lagged price, since longer lags may be included. From profit maximization, one would expect that a_1 and a_2 would be greater than zero. As the domestic price of feed grains increases, the supply of feed grains should also increase. a_3 should be less than zero. As the price of inputs for feed grain production increases, the supply of feed grains should decrease.

The demand function

The domestic demand function for feed grains is derived from the assumptions of utility maximization by consumers and profit maximization by producers of products that use feed grains as an input. The demand for feed grains is a function of the domestic price of feed grains, domestic per capita income, and the size of the domestic livestock industry. If the functional form of the demand function is linear, we have:

$$D_{Ft} = b_0 + b_1 P_{Dt} + b_2 \left(\frac{Y}{N}\right)_t + b_3 L_t \quad \text{Eq. 3-2}$$

In Eq. 3-2, $\left(\frac{Y}{N}\right)_t$ is the real domestic per capita income in period t, and L_t is the size of the domestic livestock inventory in period t. Economic theory indicates that b_1 should be less than zero. As the price of feed grains increases, the demand for feed grains should decrease. Since feed grains are used as a factor of production in the livestock industry, b_3 should be greater than zero. If there is more livestock, more feed grains must be used to feed them. The sign of b_2 is ambiguous. In less developed countries, one would expect that as real per capita income increases, part of the increased income will be used to purchase feed grains for the diet. But in more developed countries, there may be a substitution of higher priced commodities for feed grains in the diet when per capita income increases. For instance, beef may be substituted for corn bread when a family's income rises. So b_2 could be positive or negative. This study uses real income because the prices of all other goods have an effect on the demand for feed grains.

The excess demand function

Now that the domestic supply and demand functions have been specified, the import demand function has also been specified.

$$\begin{aligned} I_{Ft} &= D_{Ft} - S_{DFt} \\ &= (b_0 - a_0) + (b_1 - a_1) P_{Dt} - a_2 P_{Dt-1} + b_2 \left(\frac{Y}{N}\right)_t + b_3 L_t - a_3 P_{ot} \\ &= c_0 + c_1 P_{Dt} + c_2 P_{Dt-1} + c_3 \left(\frac{Y}{N}\right)_t + c_4 L_t + c_5 P_{ot} \end{aligned} \quad \text{Eq. 3-3}$$

$$c_1 < 0, c_2 < 0, c_4 > 0, c_5 > 0$$

Note that the domestic price of feed grains has two effects on imports. The first effect is the supply effect. As the domestic price increases, domestic supply should increase, therefore, decreasing the demand for imports. The second effect is the demand effect. As the domestic price increases, domestic demand should fall, therefore, decreasing the demand for imports also. Both the supply and demand effects tend to decrease import demand, so their combined effect is negative.

The import demand function used in this study

This import demand function, Eq. 3-3, has been derived under the assumption of perfect competition in the markets for feed grains. But are there perfect markets in the importing country? Probably not. The government of the importing country usually has some control over how the market operates. If the government is concerned with the trade balance of the country, it may follow policies to improve the balance of trade. There are two ways to improve a country's balance of trade. One is to increase the value of exports, and the other is to decrease the value of imports. The value of exports is largely determined by other countries, but the value of imports can be influenced by the government. A common way of holding down or decreasing the value of imports of a certain commodity is by imposing foreign exchange restrictions. The government may dictate that only X units of the country's currency may be exchanged for the purchase of imported feed grains. Since the cost of imported feed grains is exogenous to the importing country, this affects the quantity of feed grains imported. Foreign exchange restrictions affect neither domestic supply nor domestic demand, but they do affect imports. To handle this situation, a

measure of the amount of foreign exchange in period t , FE_t , will be added as an independent variable to the import demand function.

$$I_{Ft} = c_0 + c_1 P_{Dt} + c_2 P_{Dt-1} + c_3 \left(\frac{Y}{N}\right)_t + c_4 L_t + c_5 P_{ot} + c_6 FE_t \quad \text{Eq. 3-4}$$

The Equation for the Domestic Price of Feed Grains

Foreign exchange restrictions are not the only restrictions present in international feed grain trade. Import tariffs and variable levies are imposed on feed grain imports by the governments of various countries. These duties drive a wedge between the cost of imported feed grains and the domestic price of feed grains in the importing country. Import licensing is also common in feed grain trade. Quotas on feed grain imports are rare, but import licensing can be handled so that it is essentially a quota on imports. Restrictions on the quantity of feed grains imported will also drive a wedge between the domestic price and the cost of importing feed grains.

Arguments for tariffs

Why do governments impose these trade barriers? Free trade is the situation that maximizes the net welfare of the world economy (net welfare of the world being measured by the sum of consumer and producer surplus and government tax revenues over all goods for all countries). There are many arguments for trade barriers. The most popular claim is the infant-industry argument. This claim asserts that some industries may be more efficient in large-scale operations, but the industry must be allowed to develop. If competition is kept from foreign industries, the domestic

industry will not be able to develop and enjoy the benefits of a large scale. So the government will impose a tariff or quota on imports from foreign countries. This will allow the domestic industry to develop and reach the optimal size. The future benefits from the development of the domestic industry will exceed the start-up costs.

Another argument is that trade barriers will allow domestic production to increase, due to the higher domestic price for the product. This will increase employment in the domestic industry. Also, if the good is important for national security, the reliance on foreign sources for supply of the product will diminish when domestic production increases. The importing country will become more self-sufficient and independent.

Many countries have a problem with overcrowded cities. If farm income is increased, more people will choose to live in rural areas. This will lessen the pressures on the overcrowded cities. A tariff or quota on agricultural products will raise the price of farm products to domestic producers and, therefore, increase farm output. So protective trade policies are a means of combating some urban problems and encouraging a rural way of life for more people. Many countries do need to keep food prices in the city low, though. This is accomplished many times by subsidizing food in the large cities to soothe the masses. The money needed for the subsidies could be obtained from the trade barrier.

Trade barriers can be used to improve a country's balance of payments situation. Imports of a good will fall if a tariff or quota is imposed, but the price that the foreign importer receives will not change under the small country assumption. Therefore, if the price the foreign importer receives remains the same, and the quantity of the good imported decreases,

then the outflow of currency from the importing country will decrease. So the balance of payments situation improves.

When import duties are collected or quota licenses are sold, the government of the importing country receives revenue. For some countries, money from trade barriers is the major source of government revenue. Trade barrier revenues are easy to collect and are more indirect than other methods of taxation, so there is less opposition to trade barriers than to other methods of taxation. When personal income taxes increase, people know the tax has increased because they pay directly to the government. But if a tariff on a good increases, the people will still pay the tax, through a higher price for the product, but they may not know the reason why the price of the good increased. They don't pay for a tariff directly. Import barriers can serve as an invisible tax if they are not announced.

The welfare effects of tariffs

All of these effects from trade barriers have benefits to some individuals in the importing country. But net social welfare decreases because of the imposition of trade barriers. This can be seen with respect to one commodity for one country in Figure 3-4. Figure 3-4 depicts the usual upward sloping supply curve, S , and downward sloping demand curve, D , for the good. Initially, there are no trade barriers, and the price of the good is P_1 . P_1 is determined by the cost of importing the good. Domestic sales of the good are Q_1' and consumption is Q_1 , therefore, imports are $Q_1 - Q_1'$. Now assume a tariff is imposed on imports of the good in the amount t per unit. The new price of the good is $P_2 = P_1 + t$, so domestic sales increase to Q_2' , consumption decreases to Q_2 , therefore, imports fall

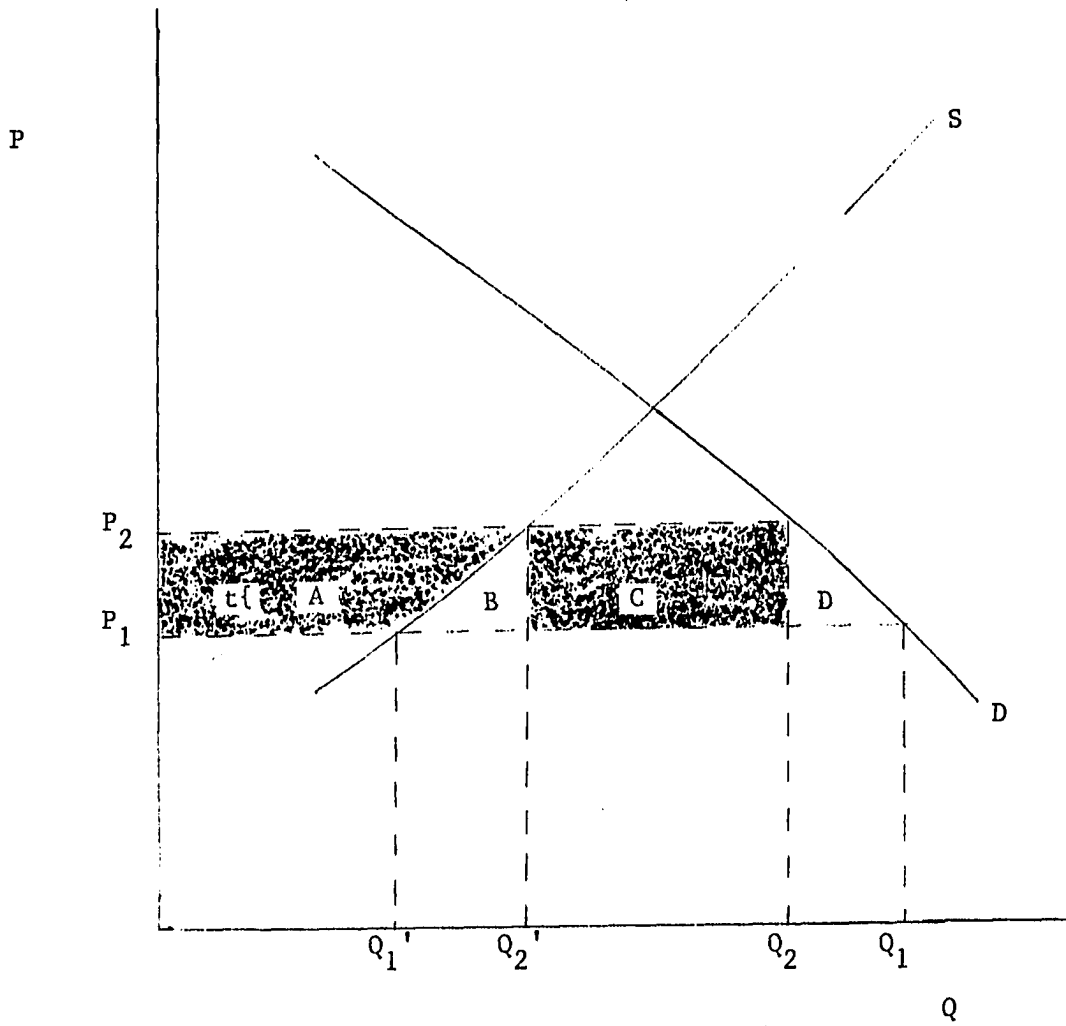


Figure 3-4. The welfare effects of a tariff

to $Q_2 - Q_2'$. Because of the tariff, producer surplus increases by the area of the shaded trapezoid labeled A, government revenue from the tariff is the area of the shaded rectangle labeled C, but consumer surplus decreases by the sum of the areas of A, C, and the two nonshaded triangles B and D. Therefore, the net social welfare of the country falls by the area of B plus D. So the costs of the tariff outweigh the benefits measured in welfare terms.

The only claim for trade barriers where the benefits outweigh the costs in terms of net social welfare for the country is the optimum tariff argument. This argument is relevant for countries whose importing decisions can influence the price foreign importers receive for the commodity. A country which has some market power can impose a tariff which will lower the cost of importing the good since world demand has been affected significantly. It is possible that the cost of importing the good would decrease enough so that the net social welfare of the country imposing the tariff could increase.

The government's utility function

Nevertheless, governments have imposed trade restrictions on many commodities, including feed grains. Probably the two biggest reasons for trade barriers in feed grain trade are to increase farm income and to become more self-sufficient in production. By imposing trade barriers on feed grain imports, the government of the importing country has some degree of control over the domestic price of feed grains. If the tariff on imported corn increases, at least a part of this duty will be passed on to the people who purchase the corn in the importing country. In fact, if the

governmental policies are the only restriction in the feed grain market, the government of the importing country can actually control the domestic price of feed grains. The government knows that if the tariff increases by \$5 per metric ton, the domestic price will increase by \$5 per metric ton.

If the government can control the domestic price of feed grains, then how does it decide what the price should be? One possible explanation is that the government simply maximizes its utility function. The variables in the utility function stem from the arguments for trade barriers presented in the previous section. With respect to the feed grain industry, the arguments that seem most likely to concern the government are to increase farm employment, to increase national security or self-sufficiency, to improve the balance of payments situation, and to increase government revenues.

The infant-industry argument was eliminated because operations that produce feed grains are relatively small throughout the world. The economies-of-scale in production are probably small or nonexistent. Even if there are substantial economies-of-scale in production of feed grains, it doesn't appear that foreign governments are encouraging producers to capture their benefits. The other argument that was eliminated was the idea of an optimum tariff. This is because it was assumed that the importing country modeled could not influence the cost of imported feed grains, therefore, the country's optimal tariff is zero.

One way to increase farm employment and keep people out of the city is to increase farm income. Then more people will move to or stay on farms. So with respect to the feed grain industry, the government's utility

function would be positively influenced by the value of domestic sales of feed grains.

A good measure for how self-sufficient or independent the importing country is with respect to feed grains is the total amount of feed grains imported. The balance of payments situation in the feed grain market would be represented by the value of feed grain imports. As the quantity and value of feed grain imports decrease, the government's utility function should increase.

The amount of revenue the government receives will be the difference between the domestic price of feed grains and the cost of imported feed grains, multiplied by the quantity of feed grains imported. As these government revenues increase, the government's utility function should also increase.

The utility function for the government of the importing country has four variables that have been mentioned thus far. They are the value of domestic feed grain sales, the quantity of feed grain imports, the value of feed grain imports, and the revenue the government receives from trade barriers for feed grains. If these four variables were the only variables in the government's utility function, the country would always have some trade barrier to feed grains. The trade barrier would allow domestic feed grain production to increase, the quantity and value of feed grain imports to fall, and the government revenues to increase. All these changes would result in a higher level of utility for the government. But not all importing countries have trade barriers according to FAO (1958a through 1976b). So some other variables must be in the government's utility function that would cause trade barriers to have a negative influence on

utility. That variable could be the amount of consumer surplus derived from the domestic feed grain market.

Consumer surplus for a particular commodity measures the benefits that accrue to buyers of that commodity. Consumer surplus is positive if a buyer purchases a good at a price lower than the value the good has for him. With respect to a particular good, it is the area below the demand curve and above the price line, as shown in Figure 3-5 by the shaded area. If the price of the good increases, consumer surplus will decrease. Therefore, as the domestic price of feed grains increases, consumer surplus derived from the domestic feed grain market will decrease. So if trade barriers on imported feed grains are imposed, the domestic price of feed grains will increase and consumer surplus will fall. Since the government represents the people of the country, an increase in consumer surplus or the welfare of the citizens will increase the government's utility. Inclusion of consumer surplus as a variable in the utility function takes into consideration the changes in welfare that occur because of trade barriers. The greater the weight that consumer surplus has in the government's utility function, the less restrictive trade barriers will be.

Therefore, the government's utility function is:

$$U_t = f(P_{Dt} \cdot S_{Ft}, I_{Ft}, \left(\frac{P}{k}\right)_t I_{Ft}, TT_t, CS_t) \quad \text{Eq. 3-5}$$

Where U_t is the government's utility from the domestic feed grain market in period t .

$P_{Dt} S_{Ft}$ is domestic farm income from feed grain sales in period t .

I_{Ft} is the quantity of feed grains imported in period t .

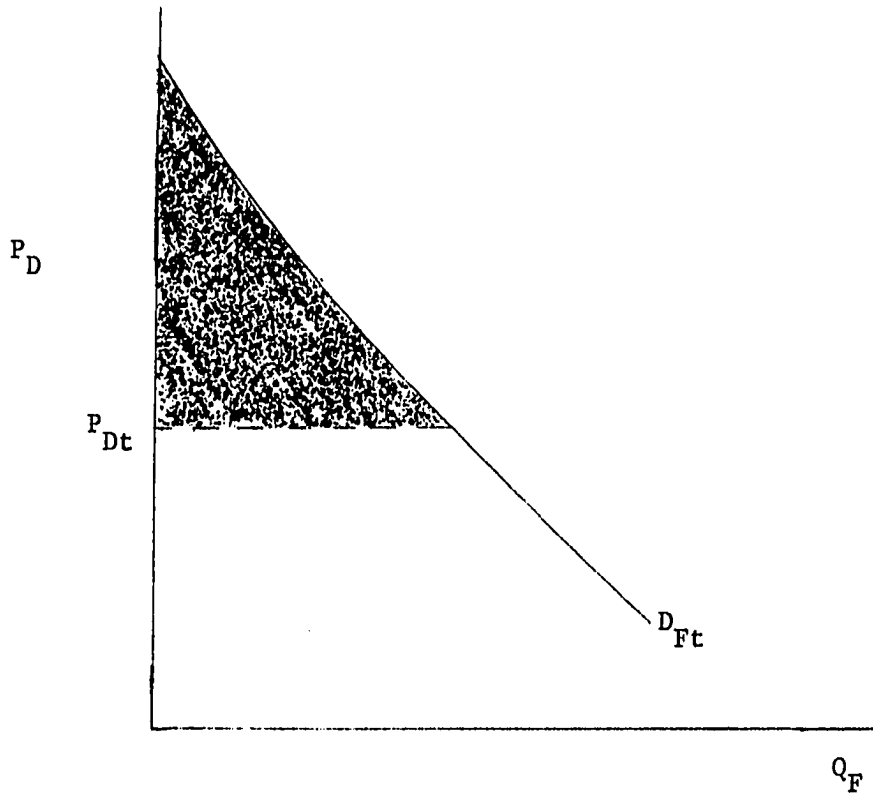


Figure 3-5. Consumer surplus

$\left(\frac{P_I}{k}\right)_t \cdot I_{Ft}$ is the value of feed grains imported in period t.

TT_t is the government's revenue from feed grain trade barriers in period t.

CS_t is consumer surplus from the domestic feed grain market in period t.

Maximization of the government's utility function

If the function f is linear we have:

$$U_t = d_1 P_{Dt} \cdot S_{Ft} + d_2 \cdot I_{Ft} + d_3 \left(\frac{P_I}{k}\right)_t \cdot I_{Ft} + d_4 TT_t + d_5 CS_t \quad \text{Eq. 3-6}$$

$$d_1, d_4, d_5 > 0 \quad d_2, d_3 < 0$$

Since the government's instrument for maximizing its utility is the domestic price of feed grains, the utility function will be differentiated with respect to P_{Dt} , set equal to zero, then solved for the government's utility maximizing value of P_{Dt} .

First order conditions

$$\begin{aligned} \frac{\partial U_t}{\partial P_{Dt}} &= d_1 S_{Ft} + d_1 P_{Dt} \frac{\partial S_{Ft}}{\partial P_{Dt}} + d_2 \frac{\partial I_{Ft}}{\partial P_{Dt}} + d_3 \left(\frac{P_I}{k}\right)_t \frac{\partial I_{Ft}}{\partial P_{Dt}} + d_4 \frac{\partial TT_t}{\partial P_{Dt}} \\ &+ d_5 \frac{\partial CS_t}{\partial P_{Dt}} = 0 \end{aligned} \quad \text{Eq. 3-7}$$

Because

$$TT_t = (P_{Dt} - \left(\frac{P_I}{k}\right)_t) I_{Ft}$$

it follows that

$$\frac{\partial TT_t}{\partial P_{Dt}} = I_{Ft} + (P_{Dt} - \left(\frac{P_I}{k}\right)_t) \frac{\partial I_{Ft}}{\partial P_{Dt}}$$

Or substituting for $\frac{\partial I_{Ft}}{\partial P_{Dt}}$ from Eq. 3-4

$$\frac{\partial TT_t}{P_{Dt}} = I_{Ft} + c_1 \left(P_{Dt} - \left(\frac{P_I}{k} \right)_t \right) \quad \text{Eq. 3-8}$$

Since the demand for feed grains is linear, we can see from Figure 3-6 that:

$$CS_t = \frac{1}{2}(P_{NDt} - P_{Dt}) D_{Ft} \quad \text{Eq. 3-9}$$

Where P_{NDt} is the domestic feed grain price at which the domestic demand for feed grains is zero.

From Eq. 3-2:

$$P_{NDt} = \frac{-b_0}{b_1} - \frac{b_2 \left(\frac{Y}{N} \right)_t}{b_1} - \frac{b_3}{b_1} L_t \quad \text{Eq. 3-10}$$

Differentiating Eq. 3-9 with respect to P_{Dt} :

$$\frac{\partial CS_t}{\partial P_{Dt}} = -\frac{1}{2} D_{Ft} + \frac{1}{2} (P_{NDt} - P_{Dt}) \frac{\partial D_{Ft}}{\partial P_{Dt}}$$

or by substituting for P_{NDt} from Eq. 3-10

$$\begin{aligned} \frac{\partial CS_t}{\partial P_{Dt}} &= -\frac{1}{2} (b_0 + b_1 P_{Dt} + b_2 \left(\frac{Y}{N} \right)_t + b_3 L_t) - \frac{1}{2} \left(\frac{b_0}{b_1} + \frac{b_2 \left(\frac{Y}{N} \right)_t}{b_1} + \frac{b_3}{b_1} L_t \right. \\ &\quad \left. + P_{Dt} \right) b_1 \\ &= -b_0 - b_1 P_{Dt} - b_2 \left(\frac{Y}{N} \right)_t - b_3 L_t \end{aligned} \quad \text{Eq. 3-11}$$

So by substituting Eqs. 3-1, 3-8, and 3-11 into Eq. 3-7:

$$\begin{aligned} \frac{\partial U_t}{\partial P_{Dt}} &= d_1 (a_0 + a_1 P_{Dt} + a_2 P_{Dt-1} + a_3 P_{ot}) + d_1 a_1 P_{Dt} + d_2 c_1 \\ &\quad + d_3 c_1 \left(\frac{P_I}{k} \right)_t + d_4 \left[I_{Ft} + c_1 \left(P_{Dt} - \left(\frac{P_I}{k} \right)_t \right) \right] + d_5 (-b_0 - b_1 P_{Dt} \\ &\quad - b_2 \left(\frac{Y}{N} \right)_t - b_3 L_t) = 0 \end{aligned}$$

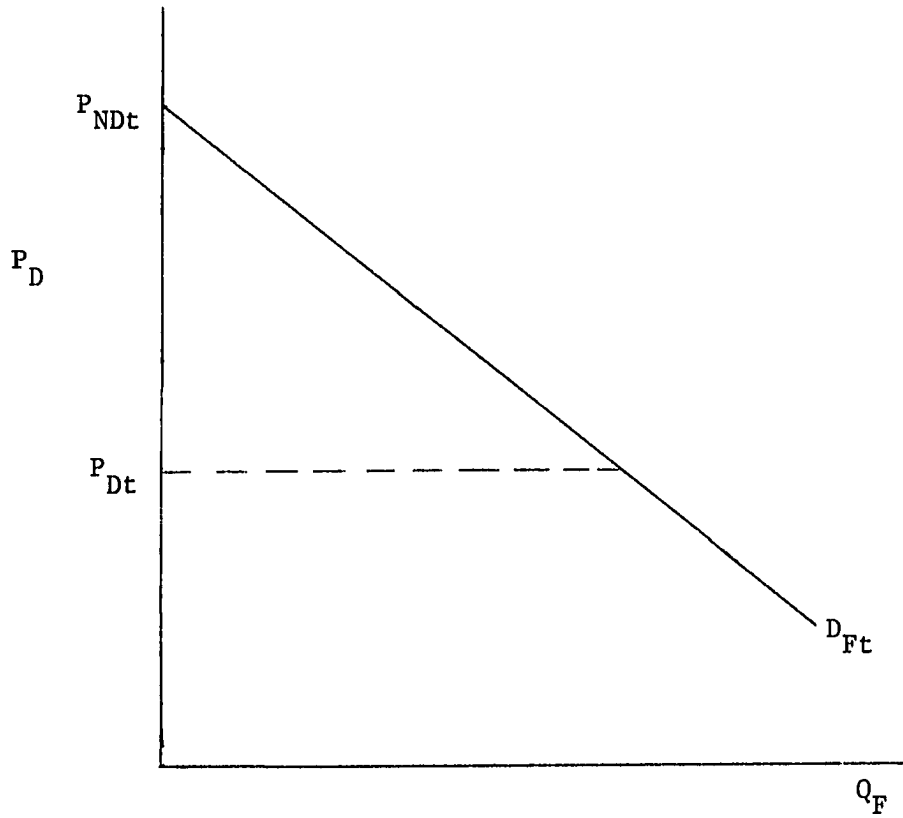


Figure 3-6. The determination of consumer surplus with a linear demand curve

$$\begin{aligned} \frac{\partial U_t}{\partial P_{Dt}} = & (2d_1 a_1 + d_4 c_1 - d_5 b_1) P_{Dt} + (d_1 a_0 + d_2 c_1 - d_5 b_0) \\ & + d_1 a_2 P_{Dt-1} + a_3 d_1 P_{ot} - d_5 b_2 \left(\frac{Y}{N}\right)_t - d_5 b_3 L_t + d_4 I_{Ft} \\ & + (d_3 c_1 - d_4 c_1) \left(\frac{P_I}{k}\right)_t = 0 \end{aligned}$$

Now by solving for P_{Dt} we obtain:

$$\begin{aligned} P_{Dt} = & \frac{(-d_1 a_0 - d_2 c_1 + d_5 b_0)}{\Delta} - \frac{d_1 a_2}{\Delta} P_{Dt-1} + \frac{d_5 b_2}{\Delta} \left(\frac{Y}{N}\right)_t + \frac{d_5 b_3 L_t}{\Delta} \\ & - \frac{a_3 d_1}{\Delta} P_{ot} - \frac{d_4 I_{Ft}}{\Delta} - \frac{(d_3 c_1 - d_4 c_1)}{\Delta} \left(\frac{P_I}{k}\right)_t \end{aligned} \quad \text{Eq. 3-12}$$

Where

$$\Delta = 2 d_1 a_1 + d_4 c_1 - d_5 b_1$$

$$\text{Or } P_{Dt} = \gamma_0 + \frac{\gamma_1}{\Delta} P_{Dt-1} + \frac{\gamma_2}{\Delta} \left(\frac{Y}{N}\right)_t + \frac{\gamma_3}{\Delta} L_t + \frac{\gamma_4}{\Delta} I_{Ft} + \frac{\gamma_5}{\Delta} \left(\frac{P_I}{k}\right)_t + \frac{\gamma_6}{\Delta} P_{ot}$$

$$\gamma_1, \gamma_4 < 0 \quad \gamma_2, \gamma_3, \gamma_5 > 0 \quad \gamma_6 > 0$$

The sign of Δ is indeterminate. But if the utility weights for the value of domestic feed grain sales, government revenue from feed grain trade barriers, and consumer surplus derived from the domestic feed grain market in Eq. 3-6 are equal, then

$$d_1 = d_4 = d_5 = d \quad \text{and}$$

$$\Delta = 2 a_1 d + c_1 d - b_1 d, \text{ but } c_1 = b_1 - a_1 \quad \text{so}$$

$$\Delta = a_1 > 0$$

If Δ is positive, as would be the case if $d_1 = d_4 = d_5$, then we have:

$$\begin{aligned} P_{Dt} = & e_0 + e_1 P_{Dt-1} + e_2 \left(\frac{Y}{N}\right)_t + e_3 L_t + e_4 I_{Ft} + e_5 \left(\frac{P_I}{k}\right)_t \\ & + e_6 P_{ot} \end{aligned} \quad \text{Eq. 3-12a}$$

$$e_1, e_4 < 0 \qquad e_2, e_3, e_5 > 0 \qquad e_6 < 0$$

In this case, if variation in $\left(\frac{Y}{N}\right)_t$ or L_t caused the domestic demand for feed grains to increase, the domestic price of feed grains would also increase. If variation in P_{Dt-1} or P_{ot} caused the domestic supply of feed grains to increase, the domestic price of feed grains would decrease. If the cost of imported feed grains increases, the domestic price of feed grains would also increase. It seems that if Δ were positive, the domestic price of feed grains would tend to move in a more plausible direction given changes in the predetermined variables. By the term "plausible direction," it is meant that the domestic price movement is in the direction that is usually expected by economists. If variables change such that domestic demand increases, the domestic price should also increase. It seems unlikely that as the cost of imported feed grains increases, the domestic price of feed grains should decrease (which would be the case if $\Delta < 0$).

But in the general case, since $\Delta = (2 d_1 - d_4) a_1 + (d_4 - d_5) b_1$, the larger the utility weights for the value of domestic feed grain sales and for the consumer surplus derived from the domestic feed grain market relative to the utility weight for the government revenue from feed grain trade barriers, the larger Δ will be.

Second order conditions The second order condition for utility maximization is that $\frac{\partial^2 U_t}{\partial P_{Dt}^2} < 0$. For the utility function specified

$$\begin{aligned} \frac{\partial^2 U_t}{\partial P_{Dt}^2} &= 2 d_1 a_1 + d_4 c_1 - d_5 b_1 + d_4 \frac{\partial I_{FT}}{\partial P_{Dt}} \\ &= 2 d_1 a_1 + 2 d_4 c_1 - d_5 b_1 \end{aligned}$$

$$= 2 a_1 (d_1 - d_4) + b_1 (2 d_4 - d_5)$$

The sign of $\frac{\partial^2 U_t}{\partial P_{Dt}^2}$ is also indeterminate. But if $d_1 = d_4 = d_5 = d$,

$$\frac{\partial^2 U_t}{\partial P_{Dt}^2} = db_1 < 0. \text{ Actually, } \frac{\partial^2 U_t}{\partial P_{Dt}^2} = \Delta + d_4 c_1. \text{ Since } d_4 c_1 < 0, \text{ all that}$$

the second order conditions tell concerning Δ is that $\frac{\partial^2 U_t}{\partial P_{ot}^2} < \Delta$.

So the model for the importing country has two equations, Eqs. 3-4 and 3-12, and it is simultaneous. The government of the importing country relies on the outside world to determine the price of feed grains at its border, then the government imposes the utility maximizing tariff or quota on imported feed grains.

A Note on Consumer and Producer Surplus

Producer surplus was not included in the government's utility function, but consumer surplus was included. This seems inconsistent. But the objective is to measure the way in which the government will react to changes in variables, not how the government should react theoretically. The government is more likely to base its trade policies on a more concrete concept such as farm income than on the theoretical concept of a producer surplus. So excluding producer surplus from the utility function can be justified. Consumer surplus is included in the utility function because it is a proxy for the concern the government has for the benefits that accrue to domestic consumers from low prices in the feed grain market. The government probably doesn't explicitly consider surplus per se, but the

government's decision process incorporates concepts that are analogous to consumer surplus. What variables the government actually uses in its decision process are unknown, but consumer surplus will provide an approximation.

Hicks (1939) has argued that the true measure of consumer surplus must be made with the compensated demand curve, not the ordinary demand curve. The reason is that points along the ordinary demand curve are not points of equal real income. If the price of the good goes up, the consumer's real income falls. Consumer surplus should be derived with real income fixed because it is measured at a point in time. The compensated demand curve is the demand for the good with real income of the consumer fixed, so it should be used to derive consumer surplus. The ordinary demand curve will be used for derivation of consumer surplus for feed grains in this study. The difference between the ordinary and compensated demand curves for feed grains should be small for most countries because the income elasticity of demand for feed grains should be relatively small, and the proportion of consumer income spent on feed grains is small, too. The relationship between the price elasticity of the ordinary and compensated demand curve is quite well known.

$$E_{11} = e_{11} - \alpha_1 N_1$$

Where E_{11} is the own-price elasticity of the ordinary demand curve, e_{11} is the own-price elasticity of the compensated demand curve, α_1 is the proportion of total income spent on the good, and N_1 is the income elasticity of demand for the good. As α_1 or N_1 approach zero, E_{11} approaches e_{11} . If

$E_{11} = e_{11}$, then it does not matter which demand curve one uses to derive consumer surplus.

The Livestock Industry

The model, as it is specified, assumes that the size of the domestic livestock inventory helps determine imports of feed grains and the domestic price of feed grains for the importing country. But since feed grains are an input in the production of livestock, the domestic price of feed grains should influence the size of the domestic livestock inventory, too. In order to avoid simultaneous equation bias, a simple model will be used to explain the domestic livestock industry.

International trade in livestock products is rather limited. Transportation costs are high and trade barriers are very restrictive in most countries. For these reasons, it will be assumed that the livestock industry is closed to foreign supplies. This means that the domestic price of livestock is determined by domestic supply and demand. The domestic livestock industry model involves four equations. They are an equation for the production of livestock products, a demand for livestock products, an inventory equation, and a supply-demand relationship for livestock products.

The equation for the production of livestock products

The first equation is the equation for the production of livestock products. This equation is really a reduced form of two structural relationships. The first structural relationship is a production function for livestock. The quantity of livestock products produced in period t , Q_{PLt} , is a function of the quantity of feed grains fed to livestock, Q_{FLt} , and the beginning domestic livestock inventory in period t .

$$Q_{PLt} = h(Q_{FLt}, L_t) \quad \text{Eq. 3-13}$$

Eq. 3-13 is both biological and technological in nature. As the quantity of feed grains fed to livestock increases, the quantity of livestock produced should also increase. As the domestic livestock inventory increases, more livestock production can take place.

The second structural relationship used to obtain the equation for the production of livestock products is the determination of the quantity of feed grains fed to livestock. The demand for feed grains fed to livestock is derived from profit maximization by livestock producers. The quantity of feed grains fed to livestock in period t is a function of the domestic price of feed grains in period t , the price of livestock in period t , the beginning inventory of livestock in period t , and the price of other inputs for livestock production in period t (P_{Lot}).

$$Q_{FLt} = i(P_{Dt}, P_{Lt}, L_t, P_{Lot}) \quad \text{Eq. 3-14}$$

As the domestic price of feed grains increases, less feed grains should be fed to livestock. As the price of livestock products increases, the demand for feed grains by livestock producers should increase. The larger the inventory of livestock, the more feed grains needed to feed livestock. As the price of other inputs for livestock production increases, the demand for feed grains by livestock producers should decrease.

It was assumed that the quantity of livestock production was identical to the quantity of livestock sold. This assumption was made because production is not distinguishable from sales in the agricultural statistics for the livestock sector of foreign countries.

By combining Eqs. 3-13 and 3-14 we have:

$$Q_{PLt} = j(P_{Dt}, P_{Lt}, L_t, P_{Lot}) \quad \text{Eq. 3-15}$$

If the functional form of Eq. 3-15 is linear:

$$Q_{PLt} = h_0 + h_1 P_{Dt} + h_2 P_{Lt} + h_3 L_t + h_4 P_{Lot} \quad \text{Eq. 3-16}$$

$$h_1 < 0 \quad h_2, h_3 > 0 \quad h_4 < 0$$

Eq. 3-16 is the first equation of the importing country's domestic livestock industry.

The demand for livestock products

The demand for livestock products is derived from utility maximization by consumers. The demand for livestock products in period t , D_{Lt} , is a function of the domestic price of livestock in period t , P_{Lt} , and domestic per capita income in period t . Economic theory indicates that as the price of livestock increases, the demand for livestock products should increase. As per capita income increases, more livestock products should be consumed by people, so the demand for livestock products should increase. If the functional form is linear, we have:

$$D_{Lt} = f_0 + f_1 P_{Lt} + f_2 \left(\frac{Y}{N}\right)_t \quad \text{Eq. 3-17}$$

The livestock inventory equation

The livestock inventory equation is derived from expected profit maximization by producers. The word "expected" is used because producers do not know what the value of the production from an additional unit of inventory will be when the additional unit is added. Time elapses between inventory accumulation and a change in the production of livestock

products. This time lag differs between different types of livestock. Poultry inventory changes can affect production of broilers and eggs in less than three months, but cattle inventory changes may not affect production of beef or milk for over nine months.

When an animal is mature enough to produce livestock products, the current cost of production and the current price of the livestock products obtained from that animal influence the decision on whether the animal should be kept in inventory or not. But until the animal is mature enough to produce livestock products, the inventory decision must be based on expected profits.

The decision to hold inventory differs depending on the type of livestock, but there are two general cases. The first case is when livestock production can occur without inventory depletion. This is the case with milk and egg production. There is a time lag between the birth of dairy cattle and hens and their ability to produce, so expected revenue or profit from each animal is used to make the decision on inventory changes. But after the animal starts producing, the question is whether revenues from the production of the livestock product exceed costs. If revenue exceeds costs, the animal is kept in inventory, and its production continues.

Animals produced for meat are another case. In this case the only way production can take place, remember supply and production cannot be distinguished, is by inventory depletion. But again, the animal must mature before it can be slaughtered. So expected profits are relevant before the animal is mature. Expected profits are also considered when a decision whether an animal should be slaughtered or not is made. After the animal reaches a weight at which it can be slaughtered, it may be kept because the

costs of further weight gains are less than the revenues from the weight gain. So expected profits still enter into the decision.

So expected profit and current profit potential are relevant to the decision concerning the size of the livestock inventory. With these considerations in mind, the livestock inventory equation is:

$$L_t = \varepsilon_0 + \varepsilon_1 P_{Dt} + \varepsilon_2 P_{Lt} + \varepsilon_3 P_{LOt} + \varepsilon_4 P_{Dt-1} + \varepsilon_5 P_{Lt-1} + \varepsilon_6 P_{LOt-1} \quad \text{Eq. 3-18}$$

As the cost of holding a given livestock inventory increases, i.e., P_{Dt} and P_{LOt} increase, the size of the livestock inventory should decrease. As the price of livestock products increases, the size of the livestock inventory should increase because expected future profits from livestock production are expected to increase. One period lagged values of these variables are also included because of the lag between inventory changes and production changes. The one period lagged costs helped determine expected costs for last period's inventory change. The same can be said about last period's price of livestock products.

The supply-demand relationship for livestock products

The final equation for the domestic livestock industry is the supply-demand relationship for livestock products. In most models this equation is the familiar supply, or production as defined in this study, equals demand identity. This is not the case for this model.

Because the livestock production equation, Eq. 3-16, is included to help explain feed grain utilization, production from different types of livestock was weighted by the amount of feed grain consumed per ton of production in order to form the aggregate variable Q_{PLt} . But the relative

prices of livestock products were used to form the aggregate demand variable D_{Lt} . Chapter V describes the aggregations of Q_{PLt} and D_{Lt} in more detail.

Therefore, Eq. 3-19 is the equation used for the supply-demand relationship for livestock products:

$$D_{Lt} = k_0 + k_1 Q_{PLt} \quad \text{Eq. 3-19}$$

The General Model

So the general model that will be investigated in this study is simultaneous and involves six equations for each importing country. The general model is:

$$I_{Ft} = c_0 + c_1 P_{Dt} + c_2 P_{Dt-1} + c_3 \left(\frac{Y}{N} \right)_t + c_4 L_t + c_5 FE_t + c_6 P_{Ot} \quad \text{Eq. 3-4}$$

$$P_{Dt} = e_0 + e_1 P_{Dt-1} + e_2 \left(\frac{Y}{N} \right)_t + e_3 L_t + e_4 I_{Ft} + e_5 \left(\frac{P_I}{k} \right)_t + e_6 P_{Ot} \quad \text{Eq. 3-12a}$$

$$Q_{PLt} = h_0 + h_1 P_{Dt} + h_2 P_{Lt} + h_3 L_t + h_4 P_{LOt} \quad \text{Eq. 3-16}$$

$$D_{Lt} = f_0 + f_1 P_{Lt} + f_2 \left(\frac{Y}{N} \right)_t \quad \text{Eq. 3-17}$$

$$L_t = g_0 + g_1 P_{Dt} + g_2 P_{Lt} + g_3 P_{LOt} + g_4 P_{Dt-1} + g_5 P_{Lt-1} + g_6 P_{LOt-1} \quad \text{Eq. 3-18}$$

$$D_{Lt} = k_0 + k_1 Q_{PLt} \quad \text{Eq. 3-19}$$

The endogenous variables of the general model are I_{Ft} , P_{Dt} , D_{Lt} , P_{Lt} , Q_{PLt} , and L_t . The predetermined variables are P_{Dt-1} , $\left(\frac{Y}{N} \right)_t$, FE_t , $\left(\frac{P_I}{k} \right)_t$, P_{Ot} , P_{LOt} , and P_{LOt-1} .

Criteria Used in Choosing the Countries Studied

The countries that were chosen for the study had to meet certain criteria. Because the model is derived from the "small country" assumption, each country's imports of feed grains could have no effect on its cost of imported feed grains. This assumption is a close approximation for every individual country in the world. But the way this model is constructed, all European Economic Community member countries need to be treated as a single country because of their common agricultural policy. EEC countries import approximately one-third of the feed grains traded. So the "small country" assumption is probably violated for the EEC as a whole. Neither the EEC as a whole nor individual countries of the EEC will be analyzed.

The countries modeled should have reliable data sources on variables needed for the analysis. Some data needed for the study can be estimated or assumed to be the same as in the U.S. or some other country. But data on feed grain prices, livestock prices, livestock production, livestock inventories, and other variables which must be unique for each country need to be available. This limits the analysis to more developed countries that can afford to spend money collecting and publishing data. But most substantial feed grain importers are more developed countries. Finally the countries must be net importers of feed grains throughout the observation period. The model is constructed to explain the importation of feed grains, not exportation of feed grains.

The Specific Model Used for Each Country Studied

Greece

Because of data limitations, the general model, presented in this chapter, could not be fitted for Greece. Data limitations and sources are discussed in Chapter V. The model fitted for Greece had P_{Ot} deleted from Eqs. 3-4 and 3-12a, P_{LOt} from Eqs. 3-16 and 3-18, and P_{LOt-1} deleted from Eq. 3-18.

$$I_{Ft} = c_0 + c_1 P_{Dt} + c_2 P_{Dt-1} + c_3 \left(\frac{Y}{N}\right)_t + c_4 L_t + c_5 FE_t \quad \text{Eq. 3-4g}$$

$$P_{Dt} = e_0 + e_1 P_{Dt-1} + e_2 \left(\frac{Y}{N}\right)_t + e_3 L_t + e_4 I_{Ft} + e_5 \left(\frac{P_I}{k}\right)_t \quad \text{Eq. 3-12g}$$

$$Q_{PLt} = h_0 + h_1 P_{Dt} + h_2 P_{Lt} + h_3 L_t \quad \text{Eq. 3-16g}$$

$$D_{Lt} = f_0 + f_1 P_{Lt} + f_2 \left(\frac{Y}{N}\right)_t \quad \text{Eq. 3-17}$$

$$L_t = g_0 + g_1 P_{Dt} + g_2 P_{Lt} + g_3 P_{Dt-1} + g_4 P_{Lt-1} \quad \text{Eq. 3-18g}$$

$$D_{Lt} = k_0 + k_1 Q_{PLt} \quad \text{Eq. 3-19}$$

The observation period for Greece was from 1958 through 1976.

Israel

The Israeli data set had the same limitations as the Greek data set, therefore, the general model could not be fitted for Israel. The Israeli model was the same as the Greek model: Eqs. 3-4g, 3-12g, 3-16g, 3-17, 3-18g, and 3-19. The observation period for Israel was also from 1958 through 1976.

Japan

The main crop that Japan produces is rice. Since 1969 Japan has been a major exporter of rice. In 1971 large stockpiles of rice became a

problem for Japan, so the government adopted policies aimed at encouraging depletion of the stocks. The Japanese government heavily subsidized the use of stockpiled rice in animal feeds to encourage disposal of the surplus rice. "Since rice will replace feedgrains on a one-to-one basis, the use of surplus rice stocks for feed will reduce the feedgrain import potential of a like amount" (USDA-FAS, 1972b, p. 4). To capture this policy, the quantity of rice stocks at the beginning of period t , R_t , will be included in the import demand for feed grains, Eq. 3-4 from the general model, by Japan. As the quantity of rice stocks at the beginning of period t increases, the import demand for feed grains by Japan should fall. Including the stock of rice in the import demand function for feed grains allows the stock of rice to affect the domestic price of feed grains by the mechanisms outlined in the second section of this chapter. If the coefficient for the stock of rice in the Japanese domestic demand equation, Eq. 3-2, is b_4 , then the coefficient for the stock of rice in the equation for the domestic price of feed grains, Eq. 3-12, is $\frac{d_5 b_4}{\Delta}$. Now $d_5 b_4 < 0$ but the sign of Δ is indeterminate.

Chapter V outlines the data limitations for Japan. So the Japanese model had R_t added to Eqs. 3-4 and 3-12a and P_{pt} substituted for P_{Ot} in Eqs. 3-4 and 3-12a, P_{LOt} in Eqs. 3-16 and 3-18, and P_{LOt-1} in Eq. 3-18.

$$I_{Ft} = c_0 + c_1 P_{Dt} + c_2 P_{Dt-1} + c_3 \left(\frac{Y}{N}\right)_t + c_4 L_t + c_5 FE_t + c_6 P_{pt} + c_7 R_t \quad \text{Eq. 3-4j}$$

$$P_{Dt} = e_0 + e_1 P_{Dt-1} + e_2 \left(\frac{Y}{N}\right)_t + e_3 L_t + e_4 I_{Ft} + e_5 \left(\frac{P_I}{k}\right)_t + e_6 P_{pt} + e_7 R_t \quad \text{Eq. 3-12j}$$

$$Q_{PLt} = h_0 + h_1 P_{Dt} + h_2 P_{Lt} + h_3 L_t + h_4 P_{pt} \quad \text{Eq. 3-16j}$$

$$D_{Lt} = f_0 + f_1 P_{Lt} + f_2 \left(\frac{Y}{N}\right)_t \quad \text{Eq. 3-17}$$

$$L_t = g_0 + g_1 P_{Dt} + g_2 P_{Lt} + g_3 P_{pt} + g_4 P_{Dt-1} + g_5 P_{Lt-1} \\ + g_6 P_{pt-1} \quad \text{Eq. 3-18j}$$

$$D_{Lt} = k_0 + k_1 Q_{PLt} \quad \text{Eq. 3-19}$$

where P_{pt} is a price index of commodities necessary for production by farmers in period t .

The observation period for Japan was from 1960 through 1976.

Portugal

The Portuguese data set had the same limitations as the Greek and Israeli data sets. Therefore, the Portuguese model was the same as the Greek and Israeli models: Eqs. 3-4g, 3-12g, 3-16g, 3-17, 3-18g, and 3-19. The observation period for Portugal was from 1958 through 1976.

Spain

The Spanish model was the same as the Greek, Israeli, and Portuguese models because of the same data limitations. The observation period was also from 1958 through 1976.

United Kingdom

One aspect of the livestock industry in the U.K. may cause the general model to be inaccurate. Livestock producers in the U.K., as in many other Western European countries, feed a substantial amount of wheat to livestock. The general model does not include wheat at all, so some adjustment must be made. It is not known if wheat is substituted for feed grains in

the U.K. livestock industry. According to the USDA-FAS (1977, p. 5): "Since wheat can only be fed up to a certain proportion of total grain intake, it is often used only to supplement rather than replace coarse grains in livestock rations." If this is the case, then wheat is not a substitute for feed grains, and the general model could be revised without incorporating the entire U.K. wheat market. For this study, it was assumed that wheat was not a substitute for feed grains in livestock rations. The revision was in the equation for the production of livestock products and the inventory equation.

The production function for livestock has the quantity of wheat fed to livestock in period t , Q_{WLt} , in addition to the quantity of feed grains fed to livestock in period t and the size of the domestic livestock inventory:

$$Q_{PLt} = h'(Q_{FLt}, Q_{WLt}, L_t) \quad \text{Eq. 3-13uk}$$

So, Eq. 3-13uk replaced Eq. 3-13 for the U.K. The second structural relationship, the quantity of feed grains fed to livestock, is unchanged:

$$Q_{FLt} = i(P_{Dt}, P_{Lt}, L_t) \quad \text{Eq. 3-14}$$

But a third structural relationship was added to determine the quantity of wheat fed to livestock in period t :

$$Q_{WLt} = i'(P_{Wt}, P_{Lt}, L_t) \quad \text{Eq. 3-20uk}$$

The quantity of wheat fed to livestock in period t is a function of the price of wheat in period t , P_{Wt} , the price of livestock in period t , and the size of the livestock inventory in period t .

$$\frac{\partial Q_{WLt}}{\partial P_{Wt}} < 0; \quad \frac{\partial Q_{WLt}}{\partial P_{Lt}} > 0; \quad \frac{\partial Q_{WLt}}{\partial L_t} > 0$$

Therefore, the equation used to estimate the quantity of livestock produced in period t for the U.K., obtained from assuming Eqs. 3-13uk, 3-14, and 3-20uk are linear, was:

$$Q_{PLt} = h_0 + h_1 P_{Dt} + h_2 P_{Lt} + h_3 L_t + h_4 P_{Wt} \quad \text{Eq. 3-16uk}$$

$$h_1, h_4 < 0; \quad h_2, h_3 > 0$$

The price of wheat in period t , P_{Wt} , and the one period lagged price of wheat, P_{Wt-1} , was added to the U.K. inventory equation.

The United Kingdom joined the European Economic Community in 1972 along with Ireland and Denmark. In 1972 the internal price of feed grains in the U.K. was substantially lower than the target prices in the EEC member countries. The membership agreement called for U.K. import levies to equal the levies of other EEC member countries by January 1, 1978. To attain this goal, a transition period began on February 1, 1973. U.K. import levies increased slowly during the transition period until the U.K. levies were comparable to the other EEC members on January 1, 1978. To handle this situation, a dummy variable was inserted in Eqs. 3-4 and 3-12a for the U.K. The dummy variable was constant during the period that the U.K. was not a member of the EEC. The dummy variable was also constant after the U.K. was a full member of the EEC but with a higher value than when the U.K. was not a member. For observations in the transition period, the value of the dummy variable increased linearly from the value before membership in the EEC to the value after full membership. For further explanation of the dummy variable and examples of its value, see Chapter V.

Chapter V also outlines the data limitations for the U.K. The model that was fitted for the U.K. deleted P_{Ot} from Eqs. 3-4 and 3-12a, P_{LOt} from

Eqs. 3-16 and 3-18, and P_{L0t-1} from Eq. 3-18. The U.K. model also had D_t added to Eqs. 3-4 and 3-12a, P_{Wt} added to Eqs. 3-16 and 3-18, and P_{Wt-1} added to Eq. 3-18.

$$I_{Ft} = c_0 + c_1 P_{Dt} + c_2 P_{Dt-1} + c_3 \frac{Y}{N} t + c_4 L_t + c_5 FE_t + c_6 D_t \quad \text{Eq. 3-4uk}$$

$$P_{Dt} = e_0 + e_1 P_{Dt-1} + e_2 \frac{Y}{N} t + e_3 L_t + e_4 I_{Ft} + e_5 \frac{P_I}{k} t + e_6 D_t \quad \text{Eq. 3-12uk}$$

$$Q_{PLt} = h_0 + h_1 P_{Dt} + h_2 P_{Lt} + h_3 L_t + h_4 P_{Wt} \quad \text{Eq. 3-16uk}$$

$$D_{Lt} = f_0 + f_1 P_{Lt} + f_2 \frac{Y}{N} t \quad \text{Eq. 3-17}$$

$$L_t = g_0 + g_1 P_{Dt} + g_2 P_{Lt} + g_3 P_{Wt} + g_4 P_{Dt-1} + g_5 P_{Lt-1} + g_6 P_{Wt-1} \quad \text{Eq. 3-18uk}$$

$$D_{Lt} = k_0 + k_1 Q_{PLt} \quad \text{Eq. 3-19}$$

The observation period for the U.K. was from 1958 through 1974.

CHAPTER IV. A MODEL FOR IMPORTS OF U.S. FEED GRAINS

The six countries that have been chosen for the study are given in this section. A short explanation of their import pattern will be given, and a model to explain imports of U.S. feed grains will also be given for that country. The focus will be on barley, corn, and sorghum since relatively little rye or oats are traded internationally.

The general equation used to study a country's imports of a U.S. good (in this study the good will always be a feed grain of some kind) is:

$$\text{CUSG}_t = f^0 (\text{CG}_t, \text{USG}_t, \text{COSG}_t) \quad \text{Eq. 4-1}$$

Where CUSG_t is the quantity of the good imported by the country from the U.S. in period t , CG_t is the total quantity of the good imported by the country in period t , USG_t is the quantity of the good available for export by the U.S. in period t , and COSG_t is the quantity of the good available for export from other countries that compete with the U.S. in the particular importing country in period t .

As the total quantity of the good imported increases, the country's imports of the good from the U.S. should also increase. The U.S. is a supplier of the good to the country, so if imports increase, some of the increase should come from the U.S. As the amount of the good available for export by the U.S. increases, the amount of the good imported by the country from the U.S. should also increase. If more of the U.S. good is available for export, the U.S. should be able to supply more of the good to the importing country. As the amount of the good available for export by countries that compete with the U.S. increases, the importing country's imports of the U.S. good should fall. More is available through other sources of

supply, so it is likely that the importing country will take advantage of this.

For some countries the U.S. is the only main supplier of a particular feed grain. In this case the export availability of the U.S. and its competitors are really not important. What is important is the total quantity of the good imported by the country. For other countries, the U.S. is not a major supplier of a particular feed grain, so the availability of the good from the U.S. is not important. The general model is given in Eq. 4-1. The specific country models given in the next sections are adaptations of the general model.

Greece

Greece imported over 100,000 metric tons of feed grains in every year during the 1958/59-1973/74 period except in 1959/60. The average for the 1958/59-1973/74 period was 307,000 metric tons. Almost 90% of the feed grains imported during that period was corn. The United States supplied 89% of the feed grains imported during that period. In 1966/67 and 1971/72 Greece imported large amounts of corn from exporters other than the U.S. In 1966/67 and 1971/72 the U.S.'s share of the feed grains imported by Greece was less than 50% (49% and 47%, respectively). In 1966/67, 1971/72, and possibly 1962/63, Greece probably imported feed grains from Eastern European countries, such as Romania and Yugoslavia. 1966/67 and 1971/72 were years when Romania and Yugoslavia exported feed grains. Most other years Romania and Yugoslavia imported feed grains. Greece has purchased over 96% of their feed grain imports from the U.S. if 1966/67, 1971/72, and 1962/63 are excluded.

Greece does import barley from France occasionally, but most barley imports come from the U.S. All Greek imports of sorghum come from the U.S. Table 4-1 shows Greek feed grain imports from 1958/59 to 1973/74.

Table 4-1. Greek feed grain imports (quantities are in thousands of metric tons)

	U.S.	U.S. % of total	Total
1958/59	101	79	128
1959/60	66	93	71
1960/61	162	99	164
1961/62	127	100	127
1962/63	154	83	186
1963/64	242	98	247
1964/65	298	97	307
1965/66	346	98	353
1966/67	137	49	279
1967/68	188	94	200
1968/69	290	95	305
1969/70	373	94	397
1970/71	191	100	191
1971/72	206	47	439
1972/73	431	100	431
1973/74	1,072	99	1,087

Since Greece purchases such a large percentage of its imported feed grains from the U.S., the equation used to study Greek imports of U.S. feed grains is:

$$GUSFG_t = i_0 + i_1 GFG_t \quad i_1 > 0$$

where $GUSFG_t$ is the quantity of Greek imports of U.S. feed grains in period t and GFG_t is the quantity of total Greek feed grain imports in period t .

Israel

Israel is a big importer of feed grains. From 1958/59 to 1973/74 Israel averaged 607,000 metric tons of feed grain imports per year. Most of the feed grains imported were corn and sorghum. The U.S. supplies about 90% of the feed grains imported by Israel. From 1966/67 to the present Israel has imported most of its barley from Canada. But Canadian barley is the only significant competition the U.S. faces in the Israeli feed grain import market.

The average Israeli consumed 412 eggs and 65.6 pounds of poultry meat in 1970 (USDA-FAS, 1972a). This is one reason why Israel has such a large demand for imported feed grains. Israeli production of feed grains has not been increasing as fast as demand, so the demand for imports has been increasing. Table 4-2 shows Israeli feed grain imports from 1958/59 to 1973/74.

The equation used to explain imports of U.S. feed grains by Israel reflects the fact that Canadian barley is the only significant competition that the U.S. faces in the Israeli feed grain import market. The Israeli demand for U.S. barley is:

$$IUSB_t = j^1(IB_t, USB_t, CB_t) \quad \text{Eq. 4-2}$$

$$\frac{\partial IUSB_t}{\partial IB_t} > 0; \quad \frac{\partial IUSB_t}{\partial USB_t} > 0; \quad \frac{\partial IUSB_t}{\partial CB_t} < 0$$

where $IUSB_t$ is the quantity of Israeli barley imports from the U.S. in period t , IB_t is the quantity of total Israeli barley imports in period t , USB_t is the quantity of U.S. barley available for export in period t , and CB_t is the quantity of Canadian barley available for export in period t .

Table 4-2. Israeli feed grain imports (quantities are in thousands of metric tons)

	U.S.	U.S. % of total	Canada	Canadian % of total	Total
1958/59	318	99	-	-	322
1959/60	352	99	-	-	355
1960/61	341	95	-	-	358
1961/62	386	93	-	-	413
1962/63	302	73	-	-	411
1963/64	398	82	-	-	486
1964/65	328	85	14	4	384
1965/66	494	92	26	5	535
1966/67	475	76	95	15	625
1967/68	516	76	64	9	681
1968/69	493	86	28	5	570
1969/70	696	85	84	10	822
1970/71	686	89	89	10	875
1971/72	701	79	183	21	891
1972/73	702	75	178	19	932
1973/74	811	77	167	16	1,052

The Israeli demand for U.S. feed grains other than barley is:

$$IUSO_t = j^2 (IO_t, USO_t) \quad \text{Eq. 4-3}$$

$$\frac{IUSO_t}{IO_t} > 0; \quad \frac{IUSO_t}{USO_t} > 0$$

where $IUSO_t$ is the quantity of U.S. feed grains other than barley imported by Israel in period t , IO_t is the total quantity of Israeli nonbarley feed grain imports in period t , and USO_t is the quantity of U.S. feed grains other than barley available for export in period t .

If Eqs. 4-2 and 4-3 are linear:

$$IUSFG_t = j_0 + j_1 IB_t + j_2 IO_t + j_3 USB_t + j_4 CB_t + j_5 USO_t \quad \text{Eq. 4-4}$$

$$j_1, j_2, j_3, j_5 > 0; \quad j_4 < 0$$

where $IUSFG_t$ is the quantity of Israeli imports of U.S. feed grains in period t . Eq. 4-4 will be used to study Israeli imports of U.S. feed grains.

Japan

Japan imported more feed grains than any other country during the 1958/59-1973/74 period. During that period Japan averaged over 6.7 million metric tons of feed grain imports per year. Table 4-3 shows Japanese imports of feed grains by source from 1958/59-1973/74. Because Japan has very little cultivable land relative to its population, very little corn and no sorghum is produced in Japan. So virtually all corn and sorghum consumed in Japan is imported. Japan does produce large quantities of barley but not enough to satisfy domestic demand.

During the 1958/59-1973/74 period, the U.S. supplied 58% of Japan's feed grain imports. Competition for the Japanese market is rather stiff most of the time. One reason is that Japan is such a big market. Many exporting countries want a share of the Japanese market because Japan is consistently a heavy importer of feed grains. Another reason that competition is stiff is that the Japanese government is trying to diversify feed grain import sources, especially sources of corn and sorghum. By diversifying sources, Japan can reduce its reliance on the U.S. as a source of supply. Individual Japanese trading companies have started joint ventures in Thailand to provide technical and material assistance for feed grain production (USDA-FAS, 1969). Also, Japan can correct trade imbalances with some countries by diversifying feed grain imports.

Table 4-3. Japanese imports of feed grains (in thousands of metric tons)

	U.S.	U.S. % of total	Argentina	Thailand	Australia	Other 3 % of total	Total
1958/59	734	47	229	?	279	33	1,556
1959/60	258	19	421	224	33	49	1,388
1960/61	812	39	280	408	143	40	2,090
1961/62	1,163	47	182	?	3	8	2,451
1962/63	1,395	44	95	420	10	17	3,140
1963/64	2,511	51	133	?	126	5	4,912
1964/65	3,163	62	314	729	172	24	5,100
1965/66	4,433	76	152	776	52	17	5,811
1966/67	4,553	59	264	858	188	17	7,770
1967/68	4,394	55	97	631	102	10	8,050
1968/69	4,491	52	909	484	271	19	8,651
1969/70	6,460	65	1,612	?	273	19	10,013
1970/71	5,908	57	1,415	843	525	27	10,383
1971/72	3,835	38	1,316	1,002	1,240	35	10,207
1972/73	8,410	69	348	384	1,090	15	12,164
1973/74	10,224	71	643	927	1,277	20	14,375

One country that has a trade imbalance with Japan is Thailand. "Since the trade deficit with Japan accounts for as much as 60% of Thailand's total trade deficit, the Thai government is making a particular effort to correct this part of the trade imbalance" (USDA-FDCD, 1972). The Japanese have agreed to increase their purchases of several Thai agricultural commodities. One of these Thai commodities is corn. Since 1966/67 Thailand has had a corn agreement with Japan. The annual agreements usually call for 800,000 to 1,000,000 metric tons of Thai corn to be shipped to Japan during the year. The price used in these agreements is usually based on the price of U.S. #2 yellow corn on the Chicago futures market.

Traditional sources of imported corn for Japan are the U.S., Thailand, and South Africa. Minor sources of corn for Japan are Argentina, Brazil,

and Mexico. The equation that will be used to study Japan's demand for U.S. corn is:

$$JUSC_t = k^1(JC_t, USC_t, JTS_t, JMS_t, R_t) \quad \text{Eq. 4-5}$$

$$\frac{\partial JUSC_t}{\partial JC_t} > 0; \quad \frac{\partial JUSC_t}{\partial USC_t} > 0; \quad \frac{\partial JUSC_t}{\partial JTS_t} < 0; \quad \frac{\partial JUSC_t}{\partial JMS_t} < 0; \quad \frac{\partial JUSC_t}{\partial R_t} < 0$$

where $JUSC_t$ is the quantity of U.S. corn imported by Japan in period t , JC_t is the total quantity of Japanese corn imports in period t , USC_t is the quantity of U.S. corn available for export in period t , JTS_t is the quantity of corn available for export by traditional suppliers to Japan other than the U.S. in period t , and JMS_t is the quantity of corn available for export by minor suppliers to Japan in period t . Japan wants to diversify its sources of corn supply, so as the availability of corn from these non-U.S. sources increases, Japanese imports of U.S. corn should fall.

The quantity of rice stocks in Japan, R_t , is included as a variable because, even though one ton of rice may substitute for one ton of feed grains, feed grains may not be substituted equally. It may be that rice is substituted for some feed grains and not others. To allow for differential substitution among feed grains, the quantity of rice stocks in Japan will be included in each equation that will be used to explain Japan's demand for U.S. feed grains.

Japan obtains virtually all of its sorghum from three sources: the U.S., Argentina, and Australia. From 1958/59 to 1973/74 the U.S. supplied over two-thirds of Japan's sorghum imports. Australia has become a major source of Japanese sorghum imports since 1970/71. The equation that will be used to study Japanese imports of U.S. sorghum is:

$$JUSS_t = k^2(JS_t, USS_t, JOSS_t, R_t) \quad \text{Eq. 4-6}$$

$$\frac{\partial JUSS_t}{\partial JS_t} > 0; \quad \frac{\partial JUSS_t}{\partial USS_t} > 0; \quad \frac{\partial JUSS_t}{\partial JOSS_t} < 0; \quad \frac{\partial JUSS_t}{\partial R_t} < 0$$

where $JUSS_t$ is the quantity of U.S. sorghum imported by Japan in period t , JS_t is the total quantity of Japanese sorghum imports in period t , USS_t is the quantity of U.S. sorghum available for export in period t , and $JOSS_t$ is the quantity of sorghum available for export by other Japanese sorghum suppliers (Argentina and Australia) in period t .

Most of Japan's barley imports come from Canada, Australia, France, and the U.S. Canada has been the largest and most consistent source of barley for Japan since 1958/59. The equation for the Japanese demand of U.S. barley is:

$$JUSB_t = k^3(JB_t, USB_t, JOSB_t, R_t) \quad \text{Eq. 4-7}$$

$$\frac{\partial JUSB_t}{\partial JB_t} > 0; \quad \frac{\partial JUSB_t}{\partial USB_t} > 0; \quad \frac{\partial JUSB_t}{\partial JOSB_t} < 0; \quad \frac{\partial JUSB_t}{\partial R_t} < 0$$

where $JUSB_t$ is the quantity of U.S. barley imported by Japan in period t , JB_t is the total quantity of Japanese barley imports in period t , USB_t is the quantity of U.S. barley available for export in period t , and $JOSB_t$ is the quantity of barley available for export by other countries that export barley to Japan (France, Australia, and Canada) in period t .

Rye and oat imports of Japan are extremely small relative to corn, barley, and sorghum imports. So the equation to explain U.S. rye and oat imports by Japan will be a single equation. The Japanese demand for U.S. rye and oats is:

$$JUSO_t = k^4 (JO_t, R_t) \quad \text{Eq. 4-8}$$

$$\frac{JUSO_t}{JO_t} > 0; \quad \frac{JUSO_t}{R_t} < 0$$

where $JUSO_t$ is the quantity of U.S. rye and oats imported by Japan in period t , and JO_t is the quantity of total rye and oat imports of Japan in period t .

If Eqs. 4-5, 4-6, 4-7, and 4-8 are linear:

$$\begin{aligned} JUSFG_t = & k_0 + k_1 JC_t + k_2 USC_t + k_3 JTS_t + k_4 JMS_t + k_5 JS_t + k_6 USS_t \\ & + k_7 JOSS_t + k_8 JB_t + k_9 USB_t + k_{10} JOSB_t + k_{11} JO_t \\ & + \sum_{i=1}^4 k_{12}^i R_t \end{aligned} \quad \text{Eq. 4-9}$$

$$k_1, k_2, k_5, k_6, k_8, k_9, k_{11} > 0; \quad k_3, k_4, k_7, k_{10} < 0$$

where $JUSFG_t$ is the quantity of U.S. feed grains imported by Japan in period t . Eq. 4-9 will be used to explain U.S. feed grain exports to Japan.

$\sum_{i=1}^4 k_{12}^i$ is the sum of the coefficients on the quantity of Japanese rice stocks. This summation could be other than zero because the U.S. has a different competitive position in each feed grain. If stockpiled rice tends to be substituted for barley, the quantity of Japanese rice stocks may have little effect on the Japanese demand for U.S. feed grains because most of Japan's imported barley is from Canada. But if stockpiled rice tends to be substituted for sorghum or corn, the quantity of Japanese rice stocks may have a great effect on the Japanese demand for U.S. feed grains.

If $k_1 = k_5 = k_8 = k_{11} = k$, then $\sum_{i=1}^4 k_{12}^i = 0$ because the effects of the

quantity of Japanese rice stocks on the Japanese demand for U.S. feed grains are captured through total Japanese imports of feed grains ($JC_t + JS_t + JB_t + JO_t$). When rice stocks increase, Japan's imports of feed grains will fall, and Japan's demand for each individual feed grain from the U.S. will fall by k .

Portugal

Portugal has increased its imports of feed grains from 29,000 metric tons in 1958/59 to 1,084,000 metric tons in 1973/74. That is an increase of 3638% over 16 years. U.S. exports of feed grains to Portugal have increased from virtually zero in 1958/59 to 526,000 metric tons in 1973/74, as can be seen in Table 4-4. These astounding increases are two reasons Portugal was included in this study. It will be interesting to see if the model can account for their occurrence. During the 1958/59-1973/74 period, Portugal imported 358,000 metric tons of feed grains, on average, per year. About 77% of the feed grains imported were corn. Portugal has traditionally relied on two of its overseas states, Angola and Mozambique, to supply imported corn. But because of Portugal's rapid increase in demand for corn and increased uses of corn in the two overseas states, Portugal has had to go to other sources for its imported corn. The U.S. has been the main source for these increased corn imports. South Africa and Argentina also supply corn to Portugal.

The Portuguese demand for U.S. corn that will be used in the study is:

$$PUSC_t = L^1(PC_t, CC_t, POC_t, USC_t) \quad \text{Eq. 4-10}$$

$$\frac{\partial PUSC_t}{\partial PC_t} > 0; \quad \frac{\partial PUSC_t}{\partial CC_t} < 0; \quad \frac{\partial PUSC_t}{\partial POC_t} < 0; \quad \frac{\partial PUSC_t}{\partial USC_t} > 0$$

Table 4-4. Portuguese imports of feed grains (in thousands of metric tons)

	U.S.	U.S. % of total	France	French % of total	Argentina	Argentina % of total	Total
1958/59	?	?	?	?	?	?	29
1959/60	?	?	1	4	?	?	28
1960/61	?	?	7	11	?	?	62
1961/62	?	?	1	3	?	?	39
1962/63	-	-	1	1	-	-	82
1963/64	9	10	2	2	-	-	93
1964/65	-	-	5	6	-	-	81
1965/66	132	47	10	4	-	-	281
1966/67	121	42	15	5	-	-	287
1967/68	86	27	-	-	-	-	314
1968/69	44	11	15	4	11	3	405
1969/70	179	21	49	6	24	3	844
1970/71	368	70	16	3	93	18	527
1971/72	420	51	84	10	148	18	816
1972/73	577	55	8	1	196	19	1,043
1973/74	526	49	35	3	418	39	1,084

where $PUSC_t$ is the quantity of U.S. corn imported by Portugal in period t , PC_t is the total amount of corn imported by Portugal in period t , CC_t is the amount of corn available for export by the two overseas colonial states of Portugal, Angola and Mozambique, in period t , POC_t is the quantity of corn available for export by other competitors of the U.S. (South Africa and Argentina) in period t , and USC_t is the amount of corn available for export by the U.S. in period t . Angola and Mozambique have been distinguished from South Africa and Argentina as suppliers. The reason is that South Africa and Argentina have only recently exported corn to Portugal, while Angola and Mozambique have exported corn to Portugal for a long time.

Portugal is usually self-sufficient in rye and oat production, but small amounts of barley and sorghum are imported. Because imports of other

feed grains are usually small, all feed grains other than corn will be included in a single equation:

$$PUSO_t = L^2(PO_t) \quad \frac{\partial PUSO_t}{\partial PO_t} > 0 \quad \text{Eq. 4-11}$$

where $PUSO_t$ is the quantity of U.S. feed grains other than corn imported by Portugal in period t and PO_t is the total quantity of feed grains other than corn imported in period t .

If Eqs. 4-10 and 4-11 are linear:

$$PUSFG_t = L_0 + L_1 PC_t + L_2 PO_t + L_3 CC_t + L_4 POC_t + L_5 USC_t \quad \text{Eq. 4-12}$$

$$L_1, L_2, L_5 > 0; \quad L_3, L_4 < 0$$

where $PUSFG_t$ is the quantity of U.S. feed grains imported by Portugal in period t . Eq. 4-12 will be used to study U.S. feed grain exports to Portugal.

Spain

Spain is one of the leading feed grain importers in the world. It is also one of the best markets for U.S. corn. In the period 1958/59-1973/74, Spanish feed grain imports averaged over 2.1 million metric tons per year. Forty-one percent of that total came from the U.S. Spanish imports of feed grains have risen dramatically from 1958/59 when 221,000 metric tons were imported to 1973/74 when almost 4.3 million metric tons were imported. This can be seen in Table 4-5.

Because Spain is such a large market, competition is quite keen. Competition for corn import supplies to Spain, which account for about 81% of Spain's total feed grain imports, comes from Argentina and France for the most part, but Mexico, Brazil, and South Africa are occasional or minor

Table 4-5. Spanish imports of feed grains (in thousands of metric tons)

	U.S.	U.S. % of total	Argentina	Argentine % of total	France	French % of total	Total
1958/59	218	99	3	1	-	-	221
1959/60	146	84	-	-	-	-	173
1960/61	475	70	-	-	81	12	683
1961/62	349	65	8	1	26	5	538
1962/63	848	43	54	3	70	4	1,953
1963/64	768	38	48	2	600	30	2,000
1964/65	861	50	196	11	512	30	1,711
1965/66	1,947	62	287	9	483	15	3,138
1966/67	916	24	1,230	32	625	17	3,785
1967/68	1,065	39	796	29	502	18	2,758
1968/69	198	9	801	36	450	20	2,253
1969/70	896	38	690	29	299	13	2,371
1970/71	163	6	1,547	57	324	12	2,699
1971/72	499	19	1,370	53	61	2	2,571
1972/73	2,060	70	445	15	-	-	2,928
1973/74	2,571	60	1,075	25	43	1	4,284

suppliers. The equation which will be used to study Spanish imports of U.S. corn is:

$$SUSC_t = m^1(SC_t, USC_t, STS_t, SMS_t) \quad \text{Eq. 4-13}$$

$$\frac{\partial SUSC_t}{\partial SC_t} > 0; \quad \frac{\partial SUSC_t}{\partial USC_t} > 0; \quad \frac{\partial SUSC_t}{\partial STS_t} < 0; \quad \frac{\partial SUSC_t}{\partial SMS_t} < 0$$

where $SUSC_t$ is the quantity of U.S. corn imported by Spain in period t , SC_t is the total quantity of corn imported by Spain in period t , USC_t is the amount of U.S. corn available for export in period t , STS_t is the amount of corn available for export by traditional supplier to Spain (Argentina and France) in period t , and SMS_t is the amount of corn available for export by minor suppliers to Spain (Brazil, Mexico, and South Africa) in period t .

The U.S. occasionally supplies sorghum and barley to Spain, but Spain's chief source of sorghum imports is Argentina, and most of Spain's imported barley is from France. So the U.S. is a minor supplier of feed grains other than corn for Spain. Therefore, all feed grains other than corn will be included in a single equation for Spain:

$$\text{SUSO}_t = m^2 (\text{SO}_t, \text{AS}_t, \text{FB}_t, \text{USNC}_t) \quad \text{Eq. 4-14}$$

$$\frac{\partial \text{SUSO}_t}{\partial \text{SO}_t} > 0; \quad \frac{\partial \text{SUSO}_t}{\partial \text{AS}_t} < 0; \quad \frac{\partial \text{SUSO}_t}{\partial \text{FB}_t} < 0; \quad \frac{\partial \text{SUSO}_t}{\partial \text{USNC}_t} > 0$$

where SUSO_t is the quantity of U.S. feed grains other than corn imported by Spain in period t , SO_t is the total quantity of feed grains other than corn imported by Spain in period t , AS_t is the amount of Argentine sorghum available for export in period t , FB_t is the amount of French barley available for export in period t , and USNC_t is the amount of U.S. feed grains other than corn available for export in period t .

If Eqs. 4-13 and 4-14 are linear:

$$\begin{aligned} \text{SUSFG}_t = m_0 + m_1 \text{SC}_t + m_2 \text{USC}_t + m_3 \text{STS}_t + m_4 \text{SMS}_t + m_5 \text{SO}_t + m_6 \text{AS}_t \\ + m_7 \text{FB}_t + m_8 \text{USNC}_t \end{aligned} \quad \text{Eq. 4-15}$$

$$m_1, m_2, m_5, m_8 > 0; \quad m_3, m_4, m_6, m_7 < 0$$

where SUSFG_t is the quantity of U.S. feed grains imported by Spain in period t . Eq. 4-15 will be used in the study.

United Kingdom

The United Kingdom was the third leading importer of feed grains during the 1958/59-1973/74 period, behind Japan and Italy. The U.K. averaged over 4.3 million metric tons of feed grain imports annually during that

period. This can be seen in Table 4-6. The U.S. supplied 44% of the feed grains imported by the U.K. The U.K. imports large amounts of corn and substantial amounts of barley and sorghum.

Table 4-6. British imports of feed grains (in thousands of metric tons)

	U.S.	U.S. % of total	Argen- tina	Aus- tralia	France	Canada	Other 4 % of total	Total
1958/59	2,399	49	300	221	37	1,159	35	4,885
1959/60	2,396	51	434	181	72	690	29	4,674
1960/61	2,193	49	194	214	309	248	21	4,511
1961/62	2,589	50	310	233	171	175	17	5,178
1962/63	2,030	43	240	130	15	157	12	4,676
1963/64	1,699	40	190	109	130	241	16	4,226
1064/65	1,804	46	233	51	30	204	13	3,922
1965/66	2,547	60	97	52	16	137	7	4,275
1966/67	1,954	47	342	42	275	213	21	4,159
1967/68	1,644	40	64	11	106	63	6	4,076
1968/69	1,437	35	150	188	216	220	19	4,065
1969/70	2,064	49	218	265	436	393	31	4,173
1970/71	1,328	33	194	277	551	730	43	4,071
1971/72	1,290	29	89	255	139	704	27	4,377
1972/73	1,600	39	39	53	322	294	17	4,132
1973/74	1,258	31	219	56	1,465	60	45	3,999

The U.S. is the main supplier of corn to the U.K., but South Africa also exports a lot of corn to the U.K. Argentina and France export small amounts of corn to the U.K., too. The equation that will be used to study the U.K.'s imports of U.S. corn is:

$$BUSC_t = n^1(BC_t, USC_t, BTS_t, BMS_t) \quad \text{Eq. 4-16}$$

$$\frac{\partial BUSC_t}{\partial BC_t} > 0; \quad \frac{\partial BUSC_t}{\partial USC_t} > 0; \quad \frac{\partial BUSC_t}{\partial BTS_t} < 0; \quad \frac{\partial BUSC_t}{\partial BMS_t} < 0$$

where $BUSC_t$ is the quantity of U.S. corn imported by the United Kingdom in period t , BC_t is the total quantity of corn imported by the U.K. in period t , USC_t is the quantity of U.S. corn available for export in period t , BTS_t is the quantity of corn available for export by traditional British suppliers (South Africa) in period t , and BMS_t is the quantity of corn available for export by minor British suppliers (Argentina and France) in period t .

Most sorghum imports of the U.K. originate from Argentina and the U.S. The U.K. has not been a big sorghum importer during the 1958/59-1973/74 period, but imports were rather large in the early years of the period. The equation that will be used to study the U.K.'s imports of U.S. sorghum is:

$$BUSS_t = n^2(BS_t, USS_t, AS_t) \quad \text{Eq. 4-17}$$

$$\frac{\partial BUSS_t}{\partial BS_t} > 0; \quad \frac{\partial BUSS_t}{\partial USS_t} > 0; \quad \frac{\partial BUSS_t}{\partial AS_t} < 0$$

where $BUSS_t$ is the quantity of U.S. sorghum imported by the U.K. in period t , BS_t is the total quantity of sorghum imported by the U.K. in period t , USS_t is the quantity of U.S. sorghum available for export in period t , and AS_t is the quantity of Argentine sorghum available for export in period t .

The U.K. does import a little barley in most years. But the U.S.'s share of British barley imports is small. The U.K. gets most of its barley from Canada. Both Australia and France export more barley to the U.K. than the U.S. So barley, oats, and rye will be grouped together because U.S. exports of these goods to the U.K. is so small. The equation that will be used to study British imports of U.S. barley, oats, and rye is:

$$\text{BUSO}_t = n^3 (\text{BO}_t) \qquad \frac{\partial \text{BUSO}_t}{\partial \text{BO}_t} > 0 \qquad \text{Eq. 4-18}$$

where BUSO_t is the quantity of U.S. barley, rye, and oats imported by the U.K. in period t and BO_t is the total quantity of British barley, rye, and oat imports in period t .

If Eqs. 4-16, 4-17, and 4-18 are linear:

$$\begin{aligned} \text{BUSFG}_t = n_0 + n_1 \text{BC}_t + n_2 \text{USC}_t + n_3 \text{BTS}_t + n_4 \text{BMS}_t + n_5 \text{BS}_t + n_6 \text{USS}_t \\ + n_7 \text{AS}_t + n_8 \text{BO}_t \end{aligned} \qquad \text{Eq. 4-19}$$

$$n_1, n_2, n_5, n_6, n_8 > 0; \qquad n_3, n_4, n_7 < 0$$

where BUSFG_t is the quantity of U.S. feed grains imported by the U.K. in period t . Eq. 4-19 will be fitted for the U.K. in the study.

CHAPTER V. DATA

Many of the variables presented in Chapters III and IV are not directly measurable. Because feed grains and livestock are not homogenous commodities, a way must be developed to measure the price, quantity of production, and other observations needed for these commodities. So assumptions must be made to obtain these observations because aggregate measures are needed. This chapter will describe the aggregations for feed grains and livestock for each country and give the sources of data used.

Aggregations

One the best ways to aggregate heterogenous products is to use rates of substitution between the products. If one wants to compare barley and corn production, one could use the rate of product transformation to transform the barley into corn equivalents. Unfortunately, the rate of product transformation is not directly observable. But economic theory postulates that if barley and corn are substitutes in production, the marginal rate of product transformation between barley and corn will equal the ratio of their prices.

The aggregation for feed grains

The way feed grains were aggregated in this study is similar to the method described in the preceding paragraph. The ratio of average prices for each feed grain throughout the observation period was used to estimate the marginal rates of substitution between each feed grain and corn. Then all feed grains were transformed into corn equivalent, using these estimated rates of substitution, so they could be aggregated. For example, if

the price of barley averaged 9 currency units per 100 lbs. in some country during the observation period and the price of corn averaged 10 currency units per 100 lbs. in the same country during the observation period, then 0.9 would be the factor used to transform barley into corn equivalents. If this country imported 1.0 million metric tons of barley, this would be the same as 0.9 million metric tons of corn for aggregation purposes. In this way a single aggregate quantity of feed grain imports, in corn equivalents, can be obtained.

The factor used to convert the g^{th} feed grain into corn equivalents for the i^{th} country was:

$$\frac{P_{gi}}{P_{ci}}$$

Eq. 5-1

where P_{gi} is the average price of the g^{th} feed grain in country i during the study period and P_{ci} is the average price of corn in country i during the study period.

If the feed grain imports for a particular country were aggregated into corn equivalents, the price of corn was used as the price of feed grains in the model, P_{Dt} . If feed grains were aggregated into equivalents of some other feed grain, the price of that feed grain was used as the price of feed grains. The price of feed grains was always consistent with the aggregation.

Table 5-1 shows the factors used to transform each type of feed grain into corn equivalents. Note that feed grain imports were transformed into barley equivalents for Japan. Barley equivalents were used because no quarterly price of corn was available for Japan.

Table 5-1. Factors used in feed grain transformations

	Barley	Corn	Oats	Rye	Sorghum
Greece	0.95	1.00	0.99	0.94	1.00
Israel	1.00	1.00	1.05	1.00	1.00
Japan	1.00	0.77	0.86	1.00	0.74
Portugal	1.03	1.00	0.91	0.96	1.00
Spain	0.84	1.00	0.82	1.00	0.81
U.K.	0.89	1.00	0.87	0.78	0.99

Eq. 5-2 shows how feed grain imports were aggregated for the i^{th} country when corn was used as the equivalent measure:

$$I_{Fti} = \sum_g \frac{P_{gi}}{P_{ci}} I_{gti} \quad \text{Eq. 5-2}$$

where I_{gti} is the imports of the g^{th} feed grain in period t and I_{Fti} is the variable that appears in Chapter III.

The aggregation of livestock inventories, L_t

Because the livestock sector was included in this study to explain the feed grain sector, the relationship between livestock and feed grains is of primary importance. In most countries poultry consume much more feed grains than cattle or sheep per pound of body weight. In fact, it is not unusual for a four-pound layer to consume more feed grains than a 900-pound steer in many foreign countries. Therefore, the inventory of each type of livestock was adjusted for their feed grain consumption to obtain the inventory in feed grain equivalents. After inventories were transformed

into feed grain equivalents, the aggregate livestock inventory was obtained by summing the inventory of each type of livestock in feed grain equivalents.

The adjustment factor for feed grain consumption was calculated by dividing the amount of feed grains consumed by a particular type of livestock per animal by the amount of feed grains consumed by the average hog. The livestock inventory for that type of livestock was then multiplied by this adjustment factor to yield the livestock inventory in feed grain equivalents for that type of livestock.

The factor used to convert the number of the a^{th} type of livestock into feed grain equivalents for the i^{th} country was:

$$FGE_{ai} = \frac{\left(\frac{CF_{ai}}{L_{ai}} \right)}{\left(\frac{CF_{hi}}{L_{hi}} \right)} \quad \text{Eq. 5-3}$$

where FGE_{ai} is the number of feed grain equivalents per animal of the a^{th} type of livestock. CF_{ai} is the annual average amount of concentrated feed consumed by the inventory of the a^{th} type of livestock. CF_{hi} is the annual average amount of concentrated feed consumed by the inventory of hogs, L_{ai} is the annual average inventory of the a^{th} type of livestock (in number of head), and L_{hi} is the annual average inventory of hogs (in number of head).

Eq. 5-4 shows how livestock inventories were aggregated for the i^{th} country:

$$L_{ti} = \sum_a FGE_{ai} L_{ati} \quad \text{Eq. 5-4}$$

where L_{ti} is the inventory of livestock in feed grain equivalents in period

t and L_{ati} is the inventory of the a^{th} type of livestock in period t . L_{ti} is the livestock inventory variable that appears in Chapter III.

Table 5-2 shows FGE_{ai} for all types of livestock by country.

Table 5-2. Aggregation factors for livestock inventories

	Beef cattle	Dairy cattle	Hogs	Sheep	Poultry
Greece	0.25	1.00	1.00	0.07	0.35
Israel ^a	0.71	2.86	-	0.20	1.00
Japan	0.18	0.97	1.00	1.00	0.10
Portugal	0.25	1.00	1.00	0.07	0.35
Spain	0.25	1.00	1.00	0.07	0.35
U.K.	1.00	1.00	1.00	0.13	0.13

^aBecause few hogs are in inventory in Israel, the amount of concentrated feed consumed per fowl was used as the equivalent measure. Therefore, in Eq. 5-3, CF_{hi} is the amount of concentrated feed consumed by poultry and L_{hi} is the inventory of poultry (in number of fowl).

The aggregation of the production of livestock products, Q_{PLt}

The aggregation used to form Q_{PLt} was different from the aggregation used to form D_{Lt} . The aggregation used to form Q_{PLt} was very similar to the aggregation used to form L_t . The quantity of feed grains consumed by the a^{th} type of livestock (the type of livestock that produce the p^{th} product) was used to adjust for feed grain use in the production of livestock products.

The adjusted factor for feed grain consumption was calculated by dividing the amount of feed grains consumed by the a^{th} type of livestock by

the quantity of production of the p^{th} product from the a^{th} type of livestock. For the i^{th} country the factor used to convert tons of livestock production into tons of feed grain equivalents for the p^{th} product was:

$$FGE_{pai} = \frac{\left(\frac{CF_{ai}}{Q_{Ppai}} \right)}{\left(\frac{CF_{hi}}{Q_{Pphi}} \right)} \quad \text{Eq. 5-5}$$

where FGE_{pai} is the number of feed grain equivalents per ton of production of the p^{th} product, CF_{ai} is the annual average amount of concentrated feed consumed by the a^{th} type of livestock (the type of livestock which produces the p^{th} product), CF_{hi} is the annual average amount of concentrated feed consumed by hogs, Q_{Ppai} is the annual average production of the p^{th} product in tons, and Q_{Pphi} is the annual average production of pork in tons.

Eq. 5-6 shows how livestock production was aggregated for the i^{th} country:

$$Q_{PLti} = \sum_{pa} FGE_{pai} Q_{Ppati} \quad \text{Eq. 5-6}$$

where Q_{PLti} is the quantity of livestock products produced in period t and Q_{Ppati} is the quantity of the p^{th} livestock product produced in period t . Q_{PLti} is the livestock production variable that appears in Chapter III.

Table 5-3 shows FGE_{pa} for all types of livestock products by country.

The aggregation of the demand for livestock products, D_{Lt}

The aggregation of the demand for livestock products was accomplished in two steps: 1) form a consistent price series for livestock products and 2) transform the amount of livestock products sold into hog carcass equivalents. The demand for livestock products, D_{Lt} , and the quantity of

Table 5-3. Aggregation factors for livestock production, Q_{PLt}

	Beef	Pork	Mutton	Poultry meat	Milk	Eggs
Greece	0.18	1.00	0.64	1.50	0.05	1.50
Israel ^a	0.12	-	0.42	1.00	0.03	1.00
Japan	0.36	1.00	1.00	1.04	0.08	1.04
Portugal	0.18	1.00	0.64	1.50	0.05	1.50
Spain	0.18	1.00	0.64	1.50	0.05	1.50
U.K.	0.36	1.00	0.20	0.72	0.04	0.72

^aBecause Israel produced very little pork, the amount of concentrated feed consumed per ton of poultry products was used as the equivalent measure. Therefore, in Eq. 5-5, CF_{hi} is the annual average amount of concentrated feed consumed by poultry, and Q_{pphi} is the tons of poultry products produced (poultry meat and eggs).

livestock products produced, Q_{PLt} , are both derived from the same data source as explained later in this chapter.

Formation of a consistent price series The first step for aggregating the amounts of livestock products was to obtain prices that took into consideration yield differences between livestock products. This was important because aggregating cattle by carcass weight and milk by total weight would not be accurate if the relative prices used were producer prices on a liveweight basis. If production figures are on a carcass weight basis, the prices used in aggregation must be on a carcass weight basis also. There must be product-price consistency.

The data on livestock production collected for each country, except Israel, were on a carcass weight basis. Production figures were for tons

of pork, not the liveweight of hogs slaughtered. The same was true for beef, poultry meat, and mutton production. But the prices for all livestock products were producer prices on a liveweight basis. The producer prices for milk and eggs are approximately equal to the wholesale prices because the yield of these two livestock products is 100%. One pound of eggs at the producer level yields one pound of eggs at the wholesale level. But a 1100 lb. steer will not yield 1100 lbs. of beef. Therefore, the wholesale price of beef must be above the producer price on a liveweight basis. The way this situation was handled was that the average yield of livestock products from the farm level to the wholesale level was used to obtain a producer price on a carcass weight basis. This was how much the producer received per pound of carcass weight of the animal.

The producer price on a carcass weight basis was obtained by multiplying the producer price on a liveweight basis by the inverse of the yield percentage. So if the producer price of the p^{th} livestock product per unit is P_{pa} on a liveweight basis, Y_{pa} is the average yield of production of the p^{th} product from the farm level to the wholesale level, and PW_{pa} is the producer price on a carcass weight basis, then for the i^{th} country:

$$PW_{pai} = \frac{P_{pai}}{Y_{pa}} \quad \text{Eq. 5-7}$$

Y_{pa} is the weight of the p^{th} product from the a^{th} type of livestock at the wholesale level divided by the weight of the p^{th} product from the a^{th} type of livestock at the farm level. With animals used for meat, the weight at the wholesale level is the carcass weight, and the weight at the farm level is the liveweight. For production of beef from cattle, the yield of production is the average carcass weight of a beef cow divided by

the average liveweight of a slaughtered beef cow. For milk and eggs the weight at the wholesale level and the farm level is equal, so the yield percentage for both livestock products is 100%.

The yields for other livestock products used in this study were: 56% for cattle, 69% for hogs, 72% for poultry, and 49% for sheep. These yield figures were obtained from USDA-ERS-SRS (1965) and are for the United States. Yield figures were not available for any of the countries in this study, so figures for the U.S. were used as a first approximation. For cattle, hogs, and sheep the yield percentages were a weighted average for 1954-1963, and for poultry the yield percentage was a weighted average for 1961-63. The a is used as a subscript because the p^{th} livestock product is derived from the a^{th} type of livestock.

Conversion into hog carcass equivalents After a consistent series of prices were obtained, the price of each livestock product relative to hogs was calculated. This relative price is an estimate of the rate of substitution between the livestock product and the product from hogs (pork), which was used to aggregate production data to form D_{Lt} . So the factor used to convert production of the p^{th} livestock product into hog carcass equivalents for the i^{th} country was:

$$PE_{pai} = \frac{PW_{pai}}{PW_{phi}} \quad \text{Eq. 5-8}$$

where PE_{pai} is the number of hog carcass equivalents per pound of production of the p^{th} livestock product, PW_{phi} is the average producer price of the product from hogs (pork) on a carcass weight basis (calculated from Eq. 5-7), and PW_{pai} is from Eq. 5-7.

Table 5-4 shows PE_{pa} for all types of livestock products by country.

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III. The models presented in Chapter III were constructed to be fitted with quarterly data. However, quarterly data were impossible to obtain for many of the variables for Greece, Israel, and Portugal, therefore, the models for these three countries were changed to a yearly basis. The models for Japan, Spain, and the U.K. were on a quarterly basis because quarterly data were available.

Data sources for the models in chapter III

The domestic price of feed grains, P_{Dt} Yearly prices of feed grains used to aggregate feed grain imports were found in FAO-ECE (1960/61 through 1975/76) for Greece, Portugal, Spain, and the United Kingdom. Yearly prices of feed grains used to aggregate feed grain imports for Japan were from the Institute of Developing Economies (1969). Yearly unit values for feed grains were used to aggregate feed grain imports for Israel. A unit value is the total value of production divided by the total quantity of production. The data for these unit values for feed grains were found in the Central Bureau of Statistics (1958a through 1976a).

The price of sorghum in Greece, Portugal, and Spain and the price of rye in Israel and Japan could not be found. Missing prices for each country were assumed to be equal to the price of corn for the country.

The yearly price of corn obtained from these sources for Greece, Israel, and Portugal was used as the price of feed grains for the yearly models. The quarterly price of corn for Spain was collected from the Instituto Nacional de Estadística (1958 through 1976). The quarterly price of corn for the United Kingdom came from the Ministry of Agriculture, Fisheries, and Food (1958/59a through 1973/74a). The U.K. price was for

corn imported from the U.S. that has already passed through the port of entry.

The price of barley was the only feed grain price available on a quarterly basis for Japan. Therefore, feed grain imports were aggregated into barley equivalents. The Japanese barley price was published by the FAO (1958a through 1976a). This price was the government-fixed price of barley exclusive of premiums.

Imports of feed grains, I_{Ft} The FAO (1958a through 1976a) published quarterly imports of barley, corn, oats, and rye for Japan; barley and corn for Spain; and barley, corn, and oats for the U.K. Quarterly imports of sorghum by Japan were published in the Ministry of Finance-Japan (1958 through 1976).

Yearly imports of feed grains for Greece, Israel, and Portugal came from the FAO (1958d through 1976d). Also imports of oats, rye, and sorghum for Spain and imports of rye and sorghum for the U.K. were obtained from FAO (1958d through 1976d). These yearly totals were divided by four to obtain quarterly observations. The imports of sorghum were not directly observable from FAO (1958d through 1976d), but sorghum and millet imports were published. So sorghum and millet imports were considered feed grain imports, too.

Livestock production, Q_{PLt} Observations on the production of beef, pork, mutton, poultry meat, milk, and eggs were needed to form the aggregate livestock production variable. Yearly observations on production of these livestock products for Greece, Israel, and Portugal came from the FAO (1958c through 1976c). Quarterly observations for Japanese livestock production came from the Ministry of Agriculture--Statistics and Information

Department, Japan (1958 through 1976). Quarterly livestock production figures for Japan were not available before 1960. All livestock production in the U.K. by quarters was available through the Great Britain Central Statistical Office (1958 through 1976). Spanish production of beef, pork, and mutton by quarters was available from the FAO (1958a through 1976a), and Spanish production of poultry meat was available from the Instituto Nacional de Estadística (1958 through 1976).

Spanish production of milk and eggs was available on a yearly basis only through the FAO (1958c through 1976c). So, the yearly totals were divided by four to get quarterly observations.

The livestock inventory, L_t Data on the size of livestock inventories were available on a quarterly basis for the United Kingdom only. Inventories were published by the Ministry of Agriculture, Fisheries, and Food (1958b through 1976b). For England and Wales, sheep inventories were not given for the first quarter but were included for the other three quarters. For Scotland and Northern Ireland, the other territories that make up the United Kingdom, all livestock inventory figures were given biannually, in June and December. In order to have quarterly data for Scotland and Northern Ireland, the missing observations for March and September were estimated by averaging the previous quarter and the following quarter. For instance, the inventory values for March, 1969, would be the average of December, 1968, and June, 1969. The same procedure was followed to estimate sheep inventories in England and Wales for the first quarter of each year. Quarterly livestock figures for the U.K. ended in 1974.

Observations on the livestock inventories of all other countries were on a yearly basis and were gathered from the FAO (1958c through 1976c). A

missing value procedure, which is outlined in the last section of this chapter, was used to calculate the missing quarterly inventories of livestock for Japan and Spain.

The price of livestock products, P_{Lt} Yearly prices of livestock products used to aggregate livestock inventories and livestock production were published by the FAO-ECE (1960/61 through 1975/76 for Greece, Portugal, Spain, and the U.K. The Institute of Developing Economics (1969) had Japanese livestock product prices on a yearly basis. Yearly unit values of Israeli livestock production were calculated from quantity and value of production data published by the Central Bureau of Statistics (1958a through 1976a). The price of sheep was only available for Israel, so for other countries it was assumed that the price of sheep was equal to the price of hogs.

The quarterly price of hogs in Japan was published by the Ministry of Agriculture-Statistical Information Department (1958 through 1976). The quarterly price of hogs in the U.K. was published by the Ministry of Agriculture, Fisheries, and Food (1958/59a through 1973/74a). The quarterly price of hogs in Spain was published by the Ministry of Agriculture (1958 through 1976).

Real domestic per capital income, $\left(\frac{Y}{N}\right)_t$ Real domestic per capita income of the country was calculated from data published by the IMF (1958 through 1976). It was obtained by dividing private consumption of the country by the consumer price index and population of the country. Unfortunately, no consistent disposable income figure was available for any of the countries in the study. Population figures were given annually only for every country in the study. In order to obtain quarterly population

figures, a time trend was fitted to the yearly population figures. Then the predicted quarterly population figures were used in calculating the real domestic per capita income of the country. Private consumption in Spain was only available on a yearly basis, too. Quarterly observations were obtained by interpolating between yearly observations. Spanish private consumption was 1,730 billion pestatas in 1970 and 1,953 billion pestatas in 1971. These figures are annual averages so they were assumed to be the levels of private consumption as of midyear, July 1. The level of private consumption in the third quarter of 1970 was estimated to be: $1730 + \frac{1.5}{12} (1953-1730)$. This gives the level of private consumption as of midquarter, August 15. The level of private consumption in 1970 IV was estimated to be: $1730 + \frac{3.5}{12} (1953-1730)$. In this way quarterly observations of private consumption in Spain were obtained.

The amount of foreign exchange available, FE_t The value of exports by the importing country was used as the measure for FE_t . Observations on the value of exports were published by the IMF (1958 through 1976).

The cost of imported feed grains, $\left(\frac{P_I}{k}\right)_t$ The cost of imported feed grains to the importing country in dollars, P_I , was equal to the price of #2 yellow corn free on board (f.o.b.) gulf ports, minus any subsidy paid by the U.S. government to corn exporters, plus ocean transportation costs for all countries except Japan. The price of #2 yellow corn f.o.b. gulf ports was published by the USDA-AMS (1958 through 1976). U.S. government subsidy payments to corn exporters were gathered from the USDA-ERS-FDCD (1958 through 1962). Ocean transportation costs from the U.S. gulf ports to the U.K. were collected from the IWC (1958 through 1976).

The cost of imported feed grains for Japan was equal to the price of #2 barley f.o.b. tracks in Portland, Oregon, minus any government subsidy paid to barley exporters, plus ocean transportation costs. The Portland barley price was used because much of the U.S. barley exported to Japan is shipped from the Pacific Northwest.

The price of #2 barley f.o.b. tracks in Portland was published by the USDA-AMS (1958 through 1976). U.S. government payments to barley exporters were collected from the USDA-ERS-FDCD (1958 through 1962). Ocean transportation costs from the Pacific ports to Japan were collected from the IWC (1958 through 1976).

The cost of imported feed grains did not include the cost of unloading the feed grains at the port of the importing country. Also, for Japan, the cost of imported feed grains did not include loading costs at Portland. No data were available on these loading and unloading costs.

Ocean transportation costs were not available for grain shipped to Greece, Israel, Portugal, or Spain, so these ocean transportation costs were estimated from rates to the U.K. It was assumed ocean transportation costs to Portugal and Spain were the same as to the U.K. and costs to Greece and Israel were 1.25 and 1.50 times the costs to the U.K., respectively. These factors were decided on by comparing distances from the U.S. gulf to those countries. It is approximately the same distance from the U.S. gulf to Portugal, Spain, or the U.K. The route from the U.S. gulf to Greece is approximately 1.25 times the distance from the gulf to the U.K. The route from the U.S. gulf to Israel is approximately 1.50 times the distance from the gulf to the U.K.

The cost of imported feed grains in dollars was then divided by the exchange rate to obtain $\left(\frac{P_I}{k}\right)_t$. The exchange rate was published by the IMF (1958 through 1976).

The cost of imported feed grains was higher than the domestic price of feed grains for the entire period with one exception. The exception was the period around 1973 and 1974. These two years saw a very rapid increase in the cost of imported feed grains. The domestic price of feed grains in all countries rose also, but the cost of imported feed grains was above the domestic price of feed grains for all countries for at least one observation. It did not take long before the domestic price passed the import price though.

The price index of commodities necessary for production by farmers,

P_{pt} Observations on this variable were only available for Japan. They were compiled by the Ministry of Agriculture-Department of Statistics and Information (1958 through 1976). No other country had this variable compiled at all. For this reason, the variables on the cost of production for feed grains and livestock were dropped from the general model in Chapter III. P_{pt} was added for Japan because it was available.

The price of wheat, P_{wt} The price of wheat, which was used only in the model for the U.K., was collected from the FAO (1958a through 1976a).

The dummy variable for the U.K. D_t The purpose of the dummy variable for the United Kingdom, D_t , was to capture the fact that the U.K. joined the European Economic Community in 1972, and the transition period started in February, 1973. The dummy variable had a value of 0.00 for all observations prior to 1973. For the first quarter of 1973, the dummy

variable had a value of 0.67. The reason for that value was that the transition period had lasted 0.67 quarters at the end of 1973 I. The dummy variable increased by 1.0 each quarter until the transition period ended in January, 1978. So the dummy variable actually measured the number of quarters the U.K. had been in the transition period. The values of the dummy variable through 1973 were:

<u>Quarter</u>	<u>D_t</u>
1972 IV and earlier	0.00
1973 I	0.67
1973 II	1.67
1973 III	2.67
1973 IV	3.67

The quantity of rice stocks, R_t The quantity of rice stocks, a variable that was used only in the model for Japan, was gathered from the Ministry of Agriculture-Statistics and Information Department (1958 through 1976).

The quantity of feed grains fed to livestock Data on the amount of feed grains fed to each type of livestock were not available for any country. But the amount of concentrated feed consumed by particular types of livestock was available. Concentrated feed consumed by each type of livestock in the U.K. was published by the Great Britain Statistical Office (1958 through 1976). For Japan concentrated feed consumption was published by the Ministry of Agriculture and Forestry (1958 through 1976). Concentrated feed consumption was available in 1970 only for Spain. This data were published by the USDA-FAS (1971). It was assumed these consumption

figures for Spain accurately reflected consumption throughout the 1958-1976 period.

Data on concentrated feed consumption for Greece, Israel, and Portugal were not available. Because of the similar livestock structure among these countries and Spain, the factors used to convert hog equivalents into hog-feed grain consuming equivalents for Greece, Israel, and Portugal were assumed to be the same as the factors for Spain.

Data sources for the models in chapter IV

The model presented in Chapter IV was on a yearly basis. All variables used in the model from Chapter IV were collected from the FAO (1958e through 1976e), except the quantity of rice stocks in Japan. The variable used to reflect the export availability of feed grains by a certain feed grain exporter was the total quantity of exports by that country in the same period.

The source for the quantity of rice stocks in Japan was given under data sources for the models in Chapter III. The rice stocks at the beginning of the third quarter (July 1) were used as the observation because all the data collected for Chapter IV were on a trade year basis.¹

The Procedure Used to Estimate Missing Values of Endogenous Variables

The livestock inventory figures for Japan and Spain were available on a yearly basis only. Both inventory figures were during the first quarter of the year (Japan's inventory was taken in February and Spain's was in

¹The trade year begins on July 1 and ends on June 30.

January and February). So the second, third, and fourth quarter livestock inventories are missing for both countries. In order to obtain inventory observations for the missing quarters, the first quarter livestock inventories were regressed on all exogenous variables (using the observations from the first quarters only). The coefficients obtained from this regression equation and the second, third, and fourth quarter observations on the exogenous variables were then put into the regression equation to get estimated inventories for the respective quarters.

CHAPTER VI. PROCEDURES

Estimation Procedures for the Models in Chapter III

Each model presented in Chapter III contains six simultaneous equations. The estimation procedure that was chosen to analyze the Chapter III models was autoregressive three stage least squares. This first section of Chapter VI will: 1) explain the assumptions of the general linear statistical model, 2) explain what serial correlation is, how it violates the assumptions of the general linear statistical model, and how it can be corrected, 3) explain simultaneous equation estimation procedures, the use of three stage least squares, and why 3SLS is needed for the models in Chapters III, and 4) present the autoregressive 3SLS statistical model and explain the procedures involved in its application.

Assumptions of the general linear statistical model

Suppose we have an equation

$$Y = XB + U \quad \text{Eq. 6-1}$$

where Y is a vector of observations for the variable which is determined by this equation. Suppose there are n observations for all variables in this equation, so Y is $n \times 1$.

X is a matrix of observations on variables which determine the value of Y . Suppose there are k variables that influence Y , so X is $n \times k$.

B is a vector of structural parameters for X , so B is $k \times 1$.

U is a vector of disturbance or error terms, so U is $n \times 1$.

The assumptions of the general linear statistical model are:

$$1) \quad E(U) = 0$$

$$2) \quad E(UU') = \sigma^2 I_n$$

$$3) E(X'U) = 0$$

$$4) X \text{ has rank } k < n$$

Under these assumptions, the ordinary least squares (OLS) estimator, which is

$$\hat{B}_{OLS} = (X'X)^{-1} (X'Y)$$

\hat{B}_{OLS} is the best linear unbiased estimate of B.

Serial correlation

Positive serial correlation often occurs when time series data are used. Probably the most common reason is the effects of omitted variables in the regression model. Because economic variables tend to be autocorrelated, omitted relevant variables sometimes cause the error term to be autocorrelated also. Positive serial correlation causes the estimated standard errors obtained from OLS to be smaller than the true standard errors. The estimated parameters are not efficient.

Serial correlation violates the assumption that $E(UU') = I\sigma^2$. If first order serial correlation is present, then

$$u_t = \rho u_{t-1} + \varepsilon_t \quad \text{Eq. 6-2}$$

Eq. 6-1 can be written with time subscripts as:

$$Y_t = B_0 + B_1 X_{1t} + \dots + B_k X_{kt} + u_t \quad \text{Eq. 6-3}$$

If Eq. 6-3 is lagged one period, multiplied by ρ , and subtracted from

Eq. 6-3, we have:

$$Y_t^* = B_0(1-\rho) + B_1 X_{1t}^* + \dots + B_k X_{kt}^* + \varepsilon_t \quad \text{Eq. 6-4}$$

where

$$\begin{aligned} Y_t^* &= Y_t - \rho Y_{t-1} \\ X_{1t}^* &= X_{1t} - \rho X_{1t-1} \\ &\vdots \\ X_{kt}^* &= X_{kt} - \rho X_{kt-1} \end{aligned}$$

If ε_t is distributed $N(0, \sigma^2)$, which is assumed for this study, Eq. 6-4 does not violate the assumption that $E(\varepsilon\varepsilon') = 0$.

The procedure that corrects for first order serial correlation fits Eq. 6-3 and obtains the estimated errors, \hat{u}_t 's. Then the estimated errors are lagged and fitted in Eq. 6-5 to obtain an estimate of ρ .

$$\hat{u}_t = \rho \hat{u}_{t-1} + \varepsilon_t \quad \text{Eq. 6-5}$$

The estimate of ρ from Eq. 6-5 is then used to transform the independent and dependent variables as shown in Eq. 6-4. Then Eq. 6-4 is fitted using OLS. These parameter estimates are the best linear unbiased estimates.

The error term for the first observation must be handled differently from the other observations. The reason is that the error for the first observation is a function of errors in the previous time period for which no data are available. But the variance of u_t can be shown to equal

$$\frac{\sigma^2}{1-\rho^2}, \text{ therefore, the first observation for all variables is multiplied by } \sqrt{1-\rho^2}.$$

Simultaneous equation estimation

The model presented in Chapter III is a system of simultaneous equations for each country. Kmenta (1971, p. 532) states: "A model is said to

constitute a system of simultaneous equations if all of the relationships involved are needed for determining the value of at least one of the endogenous variables included in the model." If X from Eq. 6-1 is partitioned into two parts, Y_1 and X_1 , and B is partitioned into two parts, β_1 and γ_1 , we have:

$$y_1 = Y_1 \beta_1 + X_1 \gamma_1 + U_1 \quad \text{Eq. 6-6}$$

where y_1 is a vector of observations on the endogenous variable determined in this structural equation. y_1 is $n \times 1$.

Y_1 is the matrix of observations on other endogenous variables in the equation that influences y_1 . If there are k_1 other endogenous variables in this equation, then Y_1 is $n \times k_1$.

X_1 is the matrix of observations on predetermined variables in the equation that influences y_1 . If there are k_2 predetermined variables in this equation, then X_1 is $n \times k_2$.

β_1 is the vector of structural parameters for Y_1 and is $k_1 \times 1$.

γ_1 is the vector of structural parameters for X_1 and is $k_2 \times 1$.

U_1 is the vector of disturbance or error terms and is $n \times 1$. It will be assumed that no serial correlation is present and $E(U_1 U_1') = 0$.

If OLS is applied to Eq. 6-6, the parameter estimates, $\hat{\beta}_1$ and $\hat{\gamma}_1$, will be biased and inconsistent. The reason is that the other endogenous variables in the equation, Y_1 , are correlated with the disturbance term, U_1 . If U_1 is positive, y_1 tends to be large. Because y_1 influences other endogenous variables in the system through other equations, this will cause all endogenous variables in the system to change, including endogenous

variables in the equation that influence y_1 . So $E(Y_1'U_1) \neq 0$ which violates the more general assumption that $E(X'U) = 0$.

Two-stage least squares (2SLS) use the predetermined variables of the simultaneous equation system as instruments to form a new matrix, \hat{Y}_1 , which is purged of the correlation with U_1 . \hat{Y}_1 is a weighted average of the predetermined variables in the system. The weights are chosen so as to maximize the correlation between \hat{Y}_1 and Y_1 .

In 2SLS each endogenous variable is regressed on all the predetermined variables, and the predicted endogenous variables are the matrix \hat{Y}_1 . These predicted variables are purged of the correlation with U_1 . For Eq. 6-6, \hat{Y}_1 replaces Y_1 , and ordinary least squares is then used to estimate the structural equation. Parameters estimated with 2SLS are consistent, but they are not asymptotically efficient if there is correlation among disturbances of different equations of a simultaneous system.

Three stage least squares (3SLS) yields parameter estimates that are consistent and asymptotically efficient because cross-equation correlation is considered. Suppose we have the following simultaneous system after the first stage has been performed:

$$\begin{aligned} y_1 &= \hat{Y}_1 \beta_1 + X_1 \gamma_1 + U_1 \\ y_2 &= \hat{Y}_2 \beta_2 + X_2 \gamma_2 + U_2 \\ &\vdots \\ Y_G &= \hat{Y}_G \beta_G + X_G \gamma_G + U_G \end{aligned}$$

Eq. 6-7

where

y_g is $n \times 1$

Y_g is $n \times (G_g - 1)$

x_g is $n \times k_g$

β_g is $(G - 1) \times 1$

γ_g is $k_g \times 1$

U_g is $n \times 1$

G_g is the number of endogenous variables in the g^{th} equation, and k_g is the number of predetermined variables in the g^{th} equation $g = 1, 2, \dots, G$.

Alternatively, Eqs. 6-7 can be written as:

$$y_1 = \hat{Z}_1 \alpha_1 + U_1$$

$$y_2 = \hat{Z}_2 \alpha_2 + U_2$$

⋮

⋮

$$y_G = \hat{Z}_G \alpha_G + U_G$$

Eq. 6-8

where

$$\hat{Z}_g = \begin{bmatrix} \hat{Y}_g & X_G \end{bmatrix}$$

$$\alpha_g = \begin{bmatrix} \beta_g \\ \gamma_g \end{bmatrix}$$

or

$$\begin{bmatrix} y_1 \\ y_2 \\ \cdot \\ \cdot \\ \cdot \\ y_G \end{bmatrix} = \begin{bmatrix} \hat{Z}_1 & 0 & \dots & 0 \\ 0 & \hat{Z}_2 & \dots & 0 \\ \cdot & \cdot & & \cdot \\ \cdot & \cdot & & \cdot \\ \cdot & \cdot & & \cdot \\ 0 & 0 & \dots & \hat{Z}_G \end{bmatrix} \begin{bmatrix} \alpha_1 \\ \alpha_2 \\ \cdot \\ \cdot \\ \cdot \\ \alpha_G \end{bmatrix} + \begin{bmatrix} U_1 \\ U_2 \\ \cdot \\ \cdot \\ \cdot \\ U_G \end{bmatrix}$$

or

$$y = \hat{Z} \alpha + U$$

Eq. 6-9

let

$$E(UU') = \Omega \sigma^2$$

where Ω is a known symmetric positive definite matrix of order nG . Because Ω is a positive definite matrix, it can be expressed in the form:

$$\Omega = PP'$$

where P is nonsingular.

Therefore

$$P^{-1} \Omega P^{-1'} = I_{nG}$$

Premultiplying Eq. 6-9 by P^{-1} will give:

$$y_* = \hat{Z}_* \alpha + U_* \quad \text{Eq. 6-10}$$

where $y_* = P^{-1} y$, $\hat{Z}_* = P^{-1} \hat{Z}$, and $U_* = P^{-1} U$

From Eq. 6-10, $E(U_* U_*') = \sigma^2 I_{nG}$ so Eq. 6-10 satisfies all the assumptions of OLS. The OLS estimator after these transformations is performed as:

$$\hat{\alpha} = (\hat{Z}' \Omega^{-1} \hat{Z})^{-1} (\hat{Z}' \Omega^{-1} y) \quad \text{Eq. 6-11}$$

Because Ω is not known, it must be estimated. In 3SLS, 2 SLS estimates of α are obtained. These estimates are used to estimate Ω , and the resulting $\hat{\Omega}$ is used in Eq. 6-11 to obtain a new estimator $\hat{\alpha}_*$:

$$\hat{\alpha}_* = (\hat{Z}' \hat{\Omega}^{-1} \hat{Z})^{-1} (\hat{Z}' \hat{\Omega}^{-1} y)$$

α_* is Aitken's generalized least squares estimator.

Autoregressive 3SLS

In autoregressive 3SLS the first step is a regression of each endogenous and each lagged endogenous variable on all the exogenous variables. This is different from the usual first step in 3SLS because lagged endogenous variables are treated as if they were endogenous variables rather than

predetermined variables. The reason lagged endogenous variables are treated as endogenous variables is that the lagged endogenous variables are correlated with the error terms if serial correlation is present. Therefore, each lagged endogenous variable is regressed on all exogenous variables to form an instrumental variable that is not correlated with the error term.

In the second step the structural coefficients are estimated by instrumental variables. The instruments are the estimated endogenous and lagged endogenous variables formed in the first step and the exogenous variables. In the third step the estimated errors from each equation, the u_t 's from Eq. 6-3, are gathered, lagged one period, and the u_t 's are regressed on the u_{t-1} 's for each equation, thus estimating a ρ for each equation. If the $\hat{\rho}$ for a particular equation is significantly different from zero, all variables are transformed using $\hat{\rho}$ and the procedure to correct for serial correlation. If the $\hat{\rho}$ for a particular equation is not significantly different from zero,¹ the variables in that equation are not transformed.

In the fourth step the endogenous and predetermined variables that have been corrected for serial correlation are used. The corrected endogenous variables are regressed upon all corrected predetermined variables. This time the lagged endogenous variables are treated as predetermined variables because they should not be correlated with the error terms.

¹The 0.05 level of significance was used throughout for all hypothesis tests.

The fifth step uses the transformed predetermined variables and the estimated values of the endogenous variables from the fourth step, plus the one period lagged values of the estimated errors used in estimating ρ for each equation. These instruments are used to obtain preliminary estimates of the structural parameters. The lagged errors, u_{t-1} 's, are inserted into this step because the estimation problem for ρ is an adaptation of the one-step Gauss-Newton procedure for estimating equations with serial correlation to the simultaneous equation case (Amemiya, 1966; Fuller, 1978). The coefficient on the lagged error is an estimate of $\Delta\rho$.

The sixth step uses the estimated structural parameters from the fifth step to estimate Ω . The seventh step uses the transformed variables and $\hat{\Omega}$ to obtain asymptotically efficient estimates of the structural parameters for the simultaneous system. The estimator is Eq. 6-12.

The procedure is iterative, so if $\hat{\Delta\rho}$ is significantly different from zero, a new $\hat{\rho}$ is formed by adding $\hat{\Delta\rho}$ to the $\hat{\rho}$ used to transform the data. Then the fifth, sixth, and seventh steps are performed again using this new $\hat{\rho}$. This procedure continues until $\hat{\Delta\rho}$ is not significantly different from zero. So autoregressive 3SLS actually has at least seven steps (or stages) instead of three.

Autoregressive 3SLS was applied to each country separately.

Estimation Procedures for the Models in Chapter IV

The models in Chapter IV can be written as:

$$\begin{array}{rcl}
 Y_1 & = & X_1 \theta_1 + U_1 \\
 \cdot & & \cdot \\
 \cdot & & \cdot \\
 \cdot & & \cdot \\
 Y_6 & = & X_6 \theta_6 + U_6
 \end{array}
 \qquad \text{Eq. 6-13}$$

where Y_i is a vector of observations for the dependent variable in the i^{th} equation. The i^{th} equation is for the i^{th} country, so for this study $i = 6$. If there are n_i observations for the variables in the i^{th} equation, Y_i is $n_i \times 1$.

X_i is a matrix of observations on the independent variables in the i^{th} equation. If there are k_i independent variables in the i^{th} equation, X_i is $n_i \times k_i$.

θ_i is a vector of structural parameters for X_i and is $k_i \times 1$.

U_i is a vector of disturbance terms for the i^{th} equation and is $n_i \times 1$.

$i = 1, \dots, I$

Because time series observations were used to estimate Eqs. 6-13, serial correlation could be present. Therefore, the procedure used to correct for serial correlation was implemented. After the transformations involved in the method are executed, Eqs. 6-13 may be written as:

$$\begin{aligned} Y_1^* &= X_1^* \theta_1 + U_1^* \\ \cdot & \quad \quad \quad \cdot \\ \cdot & \quad \quad \quad \cdot \\ \cdot & \quad \quad \quad \cdot \\ Y_I^* &= X_I^* \theta_I + U_I^* \end{aligned} \tag{Eq. 6-14}$$

It is assumed that

$$E(U_i^*) = 0$$

$$E(U_i^* U_i^{*'}) = \sigma_i^2 I_{n_i}$$

$$E(X_i^{*'} U_i^*) = 0$$

X_i has rank $k_i < n_i$

So

$$\hat{\theta}_i = (X_i^{*'} X_i^*)^{-1} (X_i^{*'} Y_i^*)$$

Hypotheses tested

As noted earlier, barley, corn, oats, rye, and sorghum are all feed grains. In the model from Chapter IV, these feed grains are aggregated to form the dependent variable, which is the quantity of U.S. feed grains imported, but are not always aggregated for independent variables. For instance, Japanese barley, corn, and sorghum imports are all separate independent variables in Eq. 4-4. It may be useful to know if there is a significantly different relationship depending upon the type of feed grain. In order to investigate this kind of possibility, several hypotheses were tested.

In Chapter IV there were three general types of independent variables for each country: export availability of the United States, export availability of principal competitors of the U.S. for the country, and the total imports of the country. For some countries these variables were for total feed grains, but sometimes these variables were broken up into particular subsets of feed grains, e.g., imports of corn.

For the first hypothesis, those importing countries where export availability of U.S. feed grains was divided among particular feed grains (i.e., Japan, Spain, and the U.K.), the export availability of all U.S. feed grains was substituted for the export availability of each feed grain. For Japan the equation set forth in Chapter IV was Eq. 4-4:

$$\begin{aligned} \text{JUSFG}_t = & k_0 + k_1 \text{JC}_t + k_2 \text{USC}_t + k_3 \text{JTS}_t + k_4 \text{JMS}_t + k_5 \text{JS}_t + k_6 \text{USS}_t \\ & + k_7 \text{JOSS}_t + k_8 \text{JB}_t + k_9 \text{USB}_t + k_{10} \text{JOSB}_t + k_{11} \text{JO}_t \\ & + \sum_{i=1}^4 k_{12}^i R_t \end{aligned}$$

In order to test the hypothesis that the effect of export availability from the U.S. is the same for all feed grains, this reduced model was fitted:

$$\begin{aligned} \text{JUSFG}_t = & k_0 + k_1 \text{JC}_t + k_3 \text{JTS}_t + k_4 \text{JMS}_t + k_5 \text{JS}_t + k_7 \text{JOSS}_t + k_8 \text{JB}_t \\ & + k_{10} \text{JOSB}_t + k_{11} \text{JO}_t + \sum_{i=1}^4 k_{12}^i R_t + k_{13} (\text{USC}_t + \text{USS}_t + \text{USB}_t) \end{aligned}$$

where USFG_t is the amount of U.S. feed grains available for export in period t . After serial correlation was eliminated, OLS was used to test the hypothesis that $k_2 = k_6 = k_9$.

The general test for a reduced model is:

$$\frac{\frac{(R_F^2 - R_r^2)}{r}}{\frac{(1 - R_F^2)}{n - q}} = F(r, n - q) \quad \text{Eq. 6-15}$$

where R_F^2 is the R^2 from the full model, R_r^2 is the R^2 from the reduced model, r is the change in the number of parameters estimated from the full model to the reduced model, n is the number of observations, and q is the number of parameters estimated in the full model.

R_F^2 and R_r^2 are obtained from the estimates of $\hat{\theta}$ for the full model and reduced model, respectively. If the calculated F exceeded the tabled F with r and $n - q$ degrees of freedom, the hypothesis was rejected.

For some importing countries, competitive sources of feed grains¹ were classified into two or more groups. A separate export availability

¹Corn was the only feed grain where competitors were divided into different categories.

variable was included for each group of sources. As an alternative, these export availabilities by competitors were aggregated to form one independent variable on export availability of all principal competitors for that feed grain. This hypothesis for Japan can be stated from Eq. 4-4 as:

$$H_0: k_3 = k_4$$

$$H_1: k_3 \neq k_4$$

Eq. 4-4 was fitted under H_0 , and Eq. 6-15 was used as the test statistic.

From some importing countries, a separate explanatory variable was included to measure the amount of one feed grain available from all sources. As an alternative, these variables were aggregated over feed grains to obtain one measure of total feed grain availability. This hypothesis for Japan can be stated from Eq. 4-4 as:

$$H_0: k_3 = k_4 = k_7 = k_{10}$$

$$H_1: \text{Not } H_0$$

Eq. 4-4 was fitted under H_0 , and, again, Eq. 6-15 was used as the test statistic.

Almost every country had imports broken down into two or more kinds of feed grains as independent variables. Imports of all feed grains were aggregated to form the total imports of feed grains as an independent variable. For Japan this hypothesis can be stated from Eq. 4-4 as:

$$H_0: k_1 = k_5 = k_8 = k_{11}$$

$$H_1: \text{Not } H_0$$

Again, Eq. 4-4 was fitted under H_0 , and Eq. 6-15 was used as the test statistic.

After these tests were made, Eqs. 6-14 had variables obtained from these hypotheses. If it was found that an aggregation hypothesis could not be rejected, the aggregated variable was kept as an independent variable in Eq. 6-14. If the aggregation hypothesis was rejected, the disaggregated variables were kept in Eq. 6-14.

The seemingly unrelated regression model

Eqs. 6-14 can also be written as:

$$Y = X \theta + U$$

Eq. 6-16

Let $k = k_1 + k_2 + \dots + k_I$ and

$$n = \sum_{i=1}^I n_i$$

It is assumed that

$$E(U) = 0$$

$$E(X'U) = 0$$

X has rank $k < n$

$$E(UU') = \Omega$$

Eqs. 6-14 have no apparent connection with each other except for their similar structure. But it is possible that OLS would not yield the most efficient parameter estimates possible. Disturbance terms among equations could be correlated which would lead to inefficient parameter estimates. When estimates of U.S. feed grain exports to the U.K. are low, estimates of U.S. feed grain exports to Japan or some other country may tend to be low (or high). If disturbance terms between equations tend to be mutually correlated, the Aitken generalized least squares estimator, outlined earlier

in this chapter in reference to 3SLS, will provide parameter estimates with greater asymptotic efficiency than OLS.

The Aitken estimator for Eq. 6-16 is:

$$\theta = (X' \Omega^{-1} X)^{-1} (X' \Omega^{-1} Y)$$

Ω is estimated from preliminary estimates of the structural parameters. $\hat{\theta}$ was the estimator used for the model in Chapter IV.

CHAPTER VII. RESULTS

This chapter presents the results of the statistical analyses of the models from Chapters III and IV. In the first section of this chapter, the results of the Chapter III models are given by equation. The signs of the resultant coefficients are discussed, and some intercountry comparisons are made. Two model results are given for Chapter III: 1) the full model which was derived in Chapter III and 2) the final reduced model which is obtained by deleting variables from the full model. The second section of this chapter discusses the results of the Chapter III models by country. The experiments undertaken to obtain the final reduced model are outlined in this second section. The third and final section of this chapter presents the results of the models from Chapter IV. As with the Chapter III models, the full and final reduced models are presented. The experiments undertaken to obtain the final reduced models and discussion of the signs of the coefficients are also included in the third section.

The Chapter III Models Discussed by Equation

The full model, as presented in Chapter III, and other reduced models for Japan did not perform well. After a few experiments were performed, where variables were deleted from particular equations, it was decided that the Japanese domestic price of feed grains, P_{Dt} and P_{Dt-1} , may be the cause of the problem. As indicated in Chapter V, the domestic price of feed grains collected for Japan was a government-fixed producer price of barley exclusive of premiums. In most years this price was constant throughout the fiscal year and was changed at the start of the third quarter. This price was not an average price of barley received by farmers but was the

price at which the government would purchase barley. It was a support-type price set by the government.

According to the FAO (1958b through 1976b) and the USDA-ERS-FDCD (1972), imports of all feed grains are duty-free for Japan. There has been a quota on barley imports but no other trade barrier on feed grain trade. Therefore, the price of imported feed grains should be close to the domestic price of feed grains, since over 90% of Japan's feed grain imports face no trade barriers. For these reasons the Japanese models were fitted with the import price of barley as P_{Dt} . The results of the full model with the government-fixed price of barley as P_{Dt} are presented in the first section of this chapter. Experiments performed on the Japanese model with the government-fixed price of barley as P_{Dt} are also reported. But the final reduced model is presented with the import price of barley as P_{Dt} .

Seasonal dummy variables were added to the quarterly models, for Japan, Spain, and the U.K., to account for seasonal variation. D_1 is a dummy variable that has a value of 1.0 for the first quarter of the year, a value of 0.0 for the second and third quarters of the year, and -1.0 for the fourth quarter. D_2 has a value of 1.0 for the second quarter, 0.0 for the first and third quarters, and -1.0 for the fourth quarter. D_3 has a value of 1.0 for the third quarter, 0.0 for the first and second quarters, and -1.0 for the fourth quarter. D_1 , D_2 , and D_3 are orthogonal variables.

The main objectives of this study relate to the feed grain sector of the importing country. When the results of different models for a given country are compared, the weights for the explanatory power of the import demand equation and the equation for the domestic price of feed grains were greater than the weights for the explanatory power of the four livestock

equations. So in many cases, the two feed grain equations of a particular country were improved at the expense of the four livestock industry equations.

The import demand equation

The import demand equation from the full model is Eq. 3-4g for Greece, Israel, Portugal, and Spain; Eq. 3-4j for Japan; and Eq. 3-4uk for the U.K.

The full model The coefficient estimates and their standard deviations for the import demand equation from the full model are given in Table 7-1 for each of the countries studied. The estimates of and for the coefficients of seasonal dummies are presented in the Appendix for all equations. Seasonal dummies are only in the quarterly models: Japan, Spain, and the U.K. Of the 33 parameters estimated for the six countries (this number excludes intercepts, seasonal dummies, and the Japanese model with the government-fixed price of barley as P_{Dt}), only seven are significantly different from zero at the 5% level. Of those seven significant coefficients, two have the wrong sign: the coefficient for P_{Dt} for Greece and L_t for the U.K. Two countries, Israel and Portugal, had no significant coefficients at the 5% level.

The Japanese import demand equation in which the government-fixed price of barley is used as P_{Dt} had two coefficients that were significantly different from zero at the 5% level. The coefficient for FE_t was of the incorrect sign, though. A negative coefficient for foreign exchange earnings is not surprising for Japan, though, because Japan has not had balance of payments problems for a long time. Japan consistently runs a surplus in

Table 7-1. The import demand equations from the full model. The dependent variable is I_{Ft}

	Intercept	P_{Dt}	P_{Dt-1}	L_t	$\left(\frac{Y}{N}\right)_t$	FE_t	P_{pt}	D_t	R_t
Greece	-644** (296) ^a	7.1* (2.8)	-4.6* (1.6)	0.10 (0.07)	-51.4 (32.0)	0.01 (0.65)			
Israel	77 (317)	-0.93 (1.31)	0.57 (0.60)	0.02 (0.04)	11.2 (11.5)	0.08 (0.07)			
Japan ^b	-1268** (415)	-2.60 (6.60)	-6.61** (2.35)	0.05 (0.05)	-7.14 (9.48)	-0.11 (0.11)	7.64** (2.76)		-0.02 (0.02)
Portugal	-134 (423)	0.01 (0.53)	-0.17 (0.77)	0.12 (0.20)	-0.67 (0.53)	0.03 (0.02)			
Spain	-1459 (780)	-0.14 (0.17)	0.23 (0.15)	0.02 (0.03)	45.5** (14.9)	-5.67 (3.82)			
U.K.	4403** (632)	-0.64 (15.43)	-10.7 (17.8)	-0.14* (0.05)	14.4 (15.6)	0.61** (0.15)		-135 (94)	
Japan	-1972** (469)	0.98 (8.80)		0.07 (0.06)	-10.2 (9.9)	-0.28* (0.13)	9.9** (3.1)		-0.01 (0.02)

^aStandard deviations are in parentheses.

^bThe Japanese model using the import price as P_{Dt} .

*Significantly different from zero at the 5% level.

**Significantly different from zero at the 1% level.

their balance of payments, so foreign exchange availability probably doesn't restrict imports of feed grains.

The lagged domestic price of feed grains, P_{Dt-1} , was not included in the import demand equation for the model where P_{Dt} was the government price of barley because the government price changed only once per year. Therefore, the correlation between P_{Dt} and P_{Dt-1} is very large. So P_{Dt-1} was omitted from the Japanese import demand equation for the full model.

The final reduced model The parameter estimates and their standard deviations for the import demand equation from the final reduced model are given in Table 7-2 for each country. In the final reduced import demand equation, 16 slope coefficients are significantly different from zero at the 5% level. Japan had six of the 16 significant coefficients, while Portugal and Spain had only one significant coefficient each. But both Spain and Portugal had two other coefficients that were significantly different from zero at the 10% level.

Only one of the 16 significant coefficients was of the wrong sign. The livestock inventory in the U.K. had a negative influence on feed grain imports. It could be that the method of aggregating livestock inventories was not appropriate for the U.K. In applying the aggregation procedure for livestock inventories, it was assumed that concentrated feed consumption reflected feed grain consumption. But for the U.K., where a substantial quantity of wheat is fed to livestock, concentrated feed consumption may change through increased feed uses of wheat.

One might expect a high degree of correlation between a price and its lagged value. So the fact that only Japan had both the domestic price of feed grains, P_{Dt} , and the lagged domestic price of feed grains, P_{Dt-1} , in

Table 7-2. The import demand equation from the final reduced model. The dependent variable is I_{Ft} .

	Intercept	P_{Dt}	P_{Dt-1}	L_t	$\left(\frac{Y}{N}\right)_t$	FE_t	P_{pt}	D_t	R_t
Greece	-386 (406) ^a		-1.66 (1.56)	0.27** (0.08)	-125** (36)	0.021** (0.004)			
Israel	254** (68)	-2.92** (0.37)		0.03** (0.01)		0.29** (0.03)			
Japan ^b	-1477** (198)	-22.6** (7.2)	-8.2** (2.4)	0.26** (0.07)	-42.6** (11.3)		4.44** (1.63)		-0.12** (0.03)
Portugal	-126 (299)		-0.24 (0.13)	0.14 (0.09)	-63.0 (31.0)	0.032** (0.004)			
Spain	-1978** (630)	0.12 (0.07)		0.04 (0.03)	36.3** (13.5)	-6.40 (3.70)			
U.K.	3846** (572)	-27.2** (8.3)		-0.07** (0.02)		0.53** (0.14)			

^aStandard deviations are in parentheses.

^bThe Japanese model using the import price as P_{Dt} .

**Significantly different from zero at the 1% level.

the final reduced model is not surprising. By dropping one of the feed grain price variables, the t value for the coefficient of the remaining feed grain price increased and usually became significant.

As mentioned earlier, Portugal and Spain had only one significant coefficient each at the 5% level, other than intercepts and seasonal dummies. But Portugal did have two other coefficients that were significant at the 10% level, the coefficients for P_{Dt-1} and $\left(\frac{Y}{N}\right)_t$. All three of these coefficients which were significant at the 10% level for Portugal were of the correct sign.¹

Spain also had three coefficients that were significant at the 10% level. But two of the three coefficients were of the wrong signs (for P_{Dt} and FE_t). The coefficient on $\left(\frac{Y}{N}\right)_t$ was positive, which is a bit unexpected given the results for other countries. The sign for $\left(\frac{Y}{N}\right)_t$ was not hypothesized in Chapter III because of the fact that direct consumption of feed grains by individuals may decrease as income increases. A positive coefficient on $\left(\frac{Y}{N}\right)_t$ for Spain is not by itself surprising, but all other countries had negative coefficients for $\left(\frac{Y}{N}\right)_t$. Even Greece and Portugal, which are generally considered less developed than Spain, had negative coefficients for $\left(\frac{Y}{N}\right)_t$ which were significantly different from zero at the 10% level at least. So the positive coefficient on the real per capita income variable in the Spanish equation is a bit of a surprise.

¹Though the sign of the coefficient for $\left(\frac{Y}{N}\right)_t$ was not postulated, a negative coefficient was not unexpected.

The equation for the domestic price of feed grains

The equation for the domestic price of feed grains from the full model is Eq. 3-12g for Greece, Israel, Portugal, and Spain; Eq. 3-12j for Japan; and Eq. 3-12uk for the U.K.

The full model The coefficient estimates and their standard deviations for the equation for the domestic price of feed grains from the full model are given in Table 7-3. The equation for the domestic price of feed grains was omitted from the Japanese model when the import price of barley was used as P_{Dt} . In that case, $P_{Dt} = \left(\frac{P_I}{k} \right)_t$. Because the models for all countries are built on the small country assumption, fitting the equation for the domestic price of feed grains would have no theoretical background for this study. Japanese domestic factors, such as the livestock inventory or real per capita income, cannot affect the import price of feed grains.

Twenty-five slope parameters were estimated for the remaining five countries for this equation (excluding the equation for Japan where the government-fixed price of barley was used as P_{Dt}). Nine of these coefficients were significant at the 5% level.

In Chapter III the expected signs of the variables in the equation for the domestic price of feed grains could not be determined. Even though the expected signs of the variables in this equation could not be determined, it is logical to believe that factors which increase the demand for feed grains or decrease the supply of feed grains should increase the domestic price of feed grains. But many of the coefficients in Table 7-3 do not bear out that logic.

Table 7-3. The equation for the domestic price of feed grains from the full model. The dependent variable is P_{Dt}

	Intercept	I_{Ft}	P_{Dt-1}	L_t	$\left(\frac{Y}{N}\right)_t$	$\left(\frac{P_I}{k}\right)_t$	P_{pt}	D_t	R_t
Greece	-28.6 (101.2) ^a	0.001 (0.013)	0.65* (0.26)	0.001 (0.013)	-2.26 (5.87)	0.25 (0.24)			
Israel	157 (166)	0.61 (0.40)	0.45 (0.41)	-0.02 (0.03)	-9.9 (8.8)	0.51** (0.20)			
Japan ^b	-7.1 (6.1)	-0.008 (0.004)		-0.001 (0.001)	0.19 (0.14)	-0.28** (0.10)	0.53** (0.04)		0.009* (0.003)
Portugal	-1762 (13,435)	-0.58 (9.32)	0.72 (4.94)	0.58 (4.69)	-150 (1042)	0.10 (3.13)			
Spain	9294** (1,995)	0.02 (0.41)	1.59** (0.12)	-0.53** (0.12)	230** (48)	-0.63** (0.19)			
U.K.	-19.6** (3.2)	0.003** (0.001)	0.56** (0.10)	0.004 (0.003)	0.10 (0.09)	0.63** (0.07)		0.89 (0.59)	

^aStandard deviations are in parentheses.

^bThe Japanese model using the government price as P_{Dt} .

*Significantly different from zero at the 5% level.

**Significantly different from zero at the 1% level.

The sign of the coefficient for P_{Dt-1} was always positive, though a larger value of P_{Dt-1} should increase feed grain supply and, therefore, decrease the price of feed grains. But, as stated earlier in this chapter, one expects a high degree of positive correlation between a price and its lagged value. So it is understandable that the coefficient for P_{Dt-1} was always positive.

The coefficient for the cost of imported feed grains for the Japanese model where the government-fixed price of barley was used as P_{Dt} was of the wrong sign. This is one of the reasons that the validity of the government-fixed price of barley was challenged as an accurate measure for P_{Dt} .

The final reduced model The results of the final reduced equation for the domestic price of feed grains are given in Table 7-4. In the final reduced model, 15 slope coefficients from the equation for the domestic price of feed grains were significantly different from zero at the 5% level.

The results of the equation for the domestic price of feed grains for Spain look different from the other countries. The sign of the coefficients for L_t and $\left(\frac{P_I}{k}\right)_t$ are negative, which is contrary to the logic espoused earlier in this chapter and in Chapter III. As the cost of imported feed grains for Spain increases, the domestic price of feed grain falls. This is possible, but it seems to indicate that something is amiss in the Spanish model. The coefficient for P_{Dt-1} is also much larger than 1.0. For all other countries this coefficient is less than 1.0.

Table 7-4. The equation for the domestic price of feed grains from the final reduced model. The dependent variable is P_{Dt}

	Intercept	I_{Ft}	P_{Dt-1}	L_t	$\frac{Y}{N} t$	$\left(\frac{P}{k}\right)_t$	P_{pt}	D_t	R_t
Greece	-51 (50) ^a		0.66** (0.20)	0.01 (0.01)	-3.78 (4.27)	0.28** (0.07)			
Israel	59** (10)	0.29** (0.05)	0.43** (0.13)		-8.33** (1.83)	0.60** (0.09)			
Portugal	-876 (767)		0.54 (0.47)	0.31* (0.11)		0.02 (0.18)			
Spain	9154** (1793)		1.60** (0.11)	-0.52** (0.11)	228** (43)	-0.63** (0.17)			
U.K.	-17.5** (3.2)	0.002* (0.001)	0.65** (0.07)		0.20** (0.03)	0.70** (0.06)			

^aStandard deviations are in parentheses.

*Significantly different from zero at the 5% level.

**Significantly different from zero at the 1% level.

The equation for the production of livestock products

The equation for the production of livestock products from the full model is Eq. 3-16g for Greece, Israel, Portugal, and Spain; Eq. 3-16j for Japan; and Eq. 3-16uk for the U.K.

The full model The results of the equation for the production of livestock products from the full model are given in Table 7-5. All countries had the coefficient for the size of the domestic livestock significantly different from zero at the 1% level, and the coefficient was of the correct sign. Spain and Japan had all variables included in this equation significantly different from zero at the 5% level, but no country had all variables included significant and of the correct sign.

For Spain the coefficient for P_{Dt} was of the wrong sign. For the Japanese equation, where the government price of barley was used, coefficients of both P_{Dt} and P_{Lt} were of the incorrect sign. In the Japanese equation, where the import price of barley was used, coefficients of both P_{Lt} and P_{pt} were of the wrong sign.

In general, the full equation for the production of livestock products was plagued by incorrect signs. If the coefficients of L_t are not counted, there were nine slope coefficients which were significantly different from zero at the 5% level. Five of these nine significant coefficients had incorrect signs.

The final reduced model The results of the final reduced equation for the production of livestock products are given in Table 7-6. The difference between the equation for the production of livestock products in the full model and in the final reduced model is small for most countries. The equation for the production of livestock products for Japan, Portugal,

Table 7-5. The equation for the production of livestock products from the full model. The dependent variable is Q_{PLt}

	Intercept	P_{Dt}	P_{Lt}	L_t	P_{pt}	P_{wt}
Greece	-136** (21) ^a	-0.07 (0.17)	0.08** (0.02)	0.039** (0.003)		
Israel	-61 (29)	-0.07 (0.15)	0.03 (0.03)	0.017** (0.003)		
Japan ^b	-130** (26)	-5.12** (1.19)	-0.04** (0.02)	0.0038** (0.0002)	2.85** (0.50)	
Portugal	48 (41)	-0.003 (0.010)	-0.05 (0.03)	0.05** (0.01)		
Spain	-530** (64)	0.03** (0.01)	5.48 (0.86)	0.019** (0.003)		
U.K.	-115** (27)	0.24 (1.33)	-0.07 (0.09)	0.019** (0.001)		-0.27 (1.26)
Japan	-136** (23)	9.68** (1.53)	-0.06* (0.02)	0.0038** (0.0002)	-1.80** (0.52)	

^aStandard deviations are in parentheses.

^bThe Japanese model using the import price as P_{Dt} .

*Significantly different from zero at the 5% level.

**Significantly different from zero at the 1% level.

and Spain is the same as in the full model, while Greece and Israel had P_{Dt} eliminated for the final reduced model. The U.K. final reduced model had P_{Dt} and P_{Wt} eliminated from the production of livestock products equation.

The domestic livestock inventory is definitely the most prominent variable in this equation with t values ranging from 6.6 for Spain to 24.6 for the U.K.

Table 7-6. The equation for the production of livestock products from the final reduced model. The dependent variable is Q_{PLt}

	Intercept	P_{Dt}	P_{Lt}	L_t	P_{pt}	P_{Wt}
Greece	-141** (17) ^a		0.07** (0.01)	0.039** (0.003)		
Israel	-54** (10)		0.045** (0.004)	0.009** (0.001)		
Japan ^b	-122** (26)	-5.51** (1.19)	-0.06** (0.02)	0.0038** (0.0002)	3.11** (0.49)	
Portugal	34 (36)	-0.005 (0.012)	-0.05* (0.02)	0.05 (0.01)		
Spain	-530** (64)	0.03** (0.01)	5.45 (0.85)	0.019** (0.003)		
U.K.	-146** (25)		-0.13** (0.04)	0.021** (0.001)		

^aStandard deviations are in parentheses.

^bThe Japanese model using the import price as P_{Dt} .

*Significantly different from zero at the 5% level.

**Significantly different from zero at the 1% level.

The demand for livestock products

The demand for livestock products from the full model is Eq. 3-17 for all countries in the study.

The full model The results of the demand for livestock products from the full model are presented in Table 7-7. Every slope coefficient is significant at the 1% level except the coefficient for P_{Lt} in the Greek equation. But most of the coefficients on P_{Lt} are of the wrong sign. Only

Table 7-7. The demand for livestock products from the full model. The dependent variable is D_{Lt}

	Intercept	P_{Lt}	$\left(\frac{Y}{N}\right)_t$
Greece	55** (21) ^a	0.10** (0.03)	14.9** (2.1)
Israel	-36** (15)	0.017** (0.003)	9.87** (0.75)
Japan ^b	-121** (26)	0.03** (0.01)	0.72** (0.03)
Portugal	32 (59)	-0.03 (0.04)	40.3** (4.6)
Spain	-341* (132)	32.5** (4.9)	30.8** (6.3)
U.K.	-766* (340)	-1.11** (0.33)	40.4** (4.0)
Japan	-126** (26)	0.03** (0.01)	0.71** (0.03)

^aStandard deviations are in parentheses.

^bThe Japanese model using the import price as P_{Dt} .

*Significantly different from zero at the 5% level.

**Significantly different from zero at the 1% level.

the U.K. had a negative coefficient for P_{Lt} which was significantly different from zero at the 5% level.

This demand for livestock products is very simple, and some variables may be left out that should be included. If these variables increase over time, as P_{Lt} does, it may be that the coefficient on P_{Lt} reflects a spurious relationship. The true relationship is between the demand for

livestock products and a variable X, for instance. Both X and P_{Lt} are increasing through time, so they are related through time. So the coefficient on P_{Lt} is a false relationship. This is one possibility.

Another possible explanation is that there is little or no substitution between livestock products and other commodities. If the equation was, instead, a demand for beef, the coefficient on the price of beef may be negative because of substitution among other livestock products. But aggregating livestock products hides these substitution effects.

Real per capita income explains most of the variation in the demand for livestock products. The coefficient for $\left(\frac{Y}{N}\right)_t$ is significant at the 1% level and of the correct sign for all countries. The t values for $\left(\frac{Y}{N}\right)_t$ range from 4.9 for Spain to 24.1 for Japan.

The final reduced model The results of the demand for livestock products are given in Table 7-8. There is little difference between the full model equation and the final reduced model equation for all countries. No variable was eliminated, so the only change in the parameter estimates and standard deviations came through changes in the specification of other equations in the model.

The livestock inventory equation

The livestock inventory equation from the full model is Eq. 3-18g for Greece, Israel, Portugal, and Spain; Eq. 3-18j for Japan; and Eq. 3-18uk for the U.K.

The full model The results of the livestock inventory equation from the full model are presented in Table 7-9. Of the 28 slope parameters estimated for the six countries (not including the Japanese model using the

Table 7-8. The demand for livestock products from the final reduced model. The dependent variable is D_{Lt}

	Intercept	P_{Lt}	$\left(\frac{Y}{N}\right)_t$
Greece	54* (21) ^a	0.10** (0.03)	14.7** (2.2)
Israel	-57** (12)	0.024** (0.003)	10.0** (0.6)
Japan ^b	-120** (26)	0.03* (0.01)	0.71** (0.03)
Portugal	11.9 (47.1)	-0.04 (0.03)	43.4** (4.1)
Spain	-336* (132)	32.4** (4.9)	30.8** (6.3)
U.K.	-872* (342)	-1.23** (0.35)	41.8** (4.1)

^aStandard deviations are in parentheses.

^bThe Japanese model using the import price as P_{Dt} .

*Significantly different from zero at the 5% level.

**Significantly different from zero at the 1% level.

government-fixed barley price as P_{Dt}), 16 were significant at the 5% level.

Of the 16 significant coefficients, only five are of the incorrect sign.

The Portuguese equation did not have any significant coefficients for the livestock inventory equation and the Israeli equation had only one significant coefficient.

The livestock inventory equation for Spain had all four slope coefficients significant, but two had the wrong sign. The coefficient for P_{Dt}

Table 7-9. The livestock inventory equation from the full model. The dependent variable is L_t

	Intercept	P_{Dt}	P_{Lt}	P_{Dt-1}	P_{Lt-1}	P_{pt}	P_{pt-1}	P_{Wt}	P_{Wt-1}
Greece	2078 (2040) ^a	-51.4** (17.6)	5.91** (1.92)	26.6 (17.6)	2.63 (2.17)				
Israel	6436** (1887)	29.8 (22.9)	-8.49 (6.02)	-4.1 (23.8)	7.77** (3.14)				
Japan ^b	90,182** (13,351)	-4421 (935)	44.2 (25.0)	-1664* (661)	-65.0** (19.1)	4754** (1070)	-2634* (1154)		
Portugal	17,529 (26,855)	11.2 (9.1)	-15.3 (34.3)	-12.8 (12.7)	10.9 (23.4)				
Spain	23,976** (1914)	4.02* (1.68)	2095** (438)	-5.66** (1.91)	-1806** (414)				
U.K.	22,338 (1652)	146 (332)	41.9* (18.8)	595* (293)	25.7 (15.4)			-547** (201)	-419* (202)
Japan	122,604** (20,904)	24,070** (4,124)	130* (50)	-9267 (3175)	-118** (37)	4748** (1499)	-11,196* (2192)		

^aStandard deviations are in parentheses.

^bThe Japanese model using the import price as P_{Dt} .

*Significantly different from zero at the 5% level.

**Significantly different from zero at the 1% level.

was positive, and the coefficient for P_{Lt-1} was negative. The equation has both current and one-period lagged prices of livestock products and feed grains. If the coefficients of the two feed grain prices are added for Spain, the result is a negative number, which is the correct sign for the effect of the price of feed grains. Similarly, if the two livestock price coefficients are added, the result is a positive number, so the livestock price has the correct effect also.

For the U.K. the coefficient for P_{Dt-1} is positive, but the coefficients for both P_{Wt} and P_{Wt-1} are negative. All three variables reflect the costs of holding livestock inventories, so it is not surprising that one is of the wrong sign.

The two Japanese equations are the only equations where the relationships are of the wrong sign. In both equations the effect of the index of commodities necessary for production was of the wrong sign. In the equation where the import price of barley was used as P_{Dt} , the effect of the livestock price on the livestock inventory was negative, which is not consistent with the model. In the equation where the government-fixed price of barley was used as P_{Dt} , the effect of the feed grain price on the livestock inventory was positive. This may be the case because livestock production is not distinguishable from supply. As the price of feed grains increases, the production of livestock products should fall, but the supply of livestock products could increase because the producer depletes the livestock inventory.

The final reduced model The results of the livestock inventory equation from the final reduced model are shown in Table 7-10. The livestock inventory equation from the final reduced model is the same as in the

Table 7-10. The livestock inventory equation from the final reduced model. The dependent variable is L_t

	Intercept	P_{Dt}	P_{Lt}	P_{Dt-1}	P_{Lt-1}	P_{pt}	P_{pt-1}	P_{Wt}	P_{Wt-1}
Greece	2224 (2011) ^a	-50.9* (17.4)	6.03** (1.85)	25.2 (17.7)	2.55 (2.16)				
Israel	5035 (2516)	2.11 (16.79)	3.54 (3.18)		15.43 (20.01)				
Japan ^b	91,211** (13,394)	-4217** (941)	45.0 (25.8)	-1799** (666)	-67.4** (19.6)	4859** (1082)	-2731* (1169)		
Portugal	1544 (2423)	2.62 (1.07)		-0.82 (1.94)	0.31 (0.56)				
Spain	24,030** (1910)	3.99** (1.65)	2112 (434)	-5.66** (1.88)	-1821** (410)				
U.K.	21,769** (1414)		57.2** (19.3)	670** (195)	12.7 (17.1)			-582** (144)	-305 (203)

^aStandard deviations are in parentheses.

^bThe Japanese model using the import price as P_{Dt} .

*Significantly different from zero at the 5% level.

**Significantly different from zero at the 1% level.

full model for Greece, Japan, and Spain. Only one variable was eliminated from the livestock inventory equation of the full model for Israel, Portugal, and the U.K.

The Japanese equation still has two coefficients of the wrong sign. Portugal has only one coefficient that is significantly different from zero at the 5% level and that coefficient is of the wrong sign. The Israeli livestock inventory equation, which had P_{Lt-1} significant and of the correct sign in the inventory equation from the full model, had no significant coefficients. This was because of changes in the structure of other equations between the full and the final reduced model.

The main intent of this study was to investigate the feed grain market in these six importing countries. Some of the livestock equations, especially the livestock inventory equation for some countries, suffered because of this objective. There is little doubt that the results of the livestock inventory equations could be better, especially for Israel and Portugal. But the import demand and domestic price of feed grains equations would have suffered. Variable deletions for reduced models were chosen to improve all six equations, but sometimes a variable deletion improved the fit for some equations and worsened the fit for other equations. The weight placed on improving the import demand and domestic price of feed grains equations was higher than the weight placed on improving the livestock equations.

The demand-supply relationship for livestock

The demand-supply relationship for livestock was Eq. 3-19 for all countries in the study. Table 7-11 gives the results of this equation for

Table 7-11. The demand-supply relationship for livestock from the full model. The dependent variable is D_{Lt}

	Intercept	Q_{PLt}
Greece	41.5 (65.0) ^a	2.20** (0.17)
Israel	4.7 (7.2)	1.61** (0.04)
Japan ^b	45.7** (5.1)	0.887** (0.007)
Portugal	-20 (16)	1.27** (0.06)
Spain	20 (139)	5.00** (0.31)
U.K.	145 (173)	3.42** (0.29)
Japan	45.7** (5.1)	0.887** (0.007)

^aStandard deviations are in parentheses.

^bThe Japanese model using the import price as P_{Dt} .

**Significantly different from zero at the 1% level.

the full model, and Table 7-12 gives the results of this equation for the final reduced model.

The results of the demand-supply relationship for livestock differ very little between the full model and the final reduced model. As expected, the coefficient for Q_{PLt} is positive and significantly different from zero at the 1% level for all countries. The t value on the coefficient for Q_{PLt} ranges from 12.7 for Greece to 121.4 for Japan.

Table 7-12. The demand-supply relationship for livestock products from the final reduced model. The dependent variable is D_{Lt}

	Intercept	Q_{PLt}
Greece	41.4 (64.1) ^a	2.20** (0.17)
Israel	-32.5** (8.5)	1.84** (0.05)
Japan ^b	47** (5)	0.88** (0.01)
Portugal	-17.5 (16.2)	1.26** (0.06)
Spain	19 (132)	5.00** (0.31)
U.K.	116 (174)	3.47** (0.29)

^aStandard deviations are in parentheses.

^bThe Japanese model using the import price as P_{Dt} .

**Significantly different from zero at the 1% level.

The Chapter III Models Discussed by Country

The main intent of this section is to outline the experiments or variable eliminations that resulted in the final reduced model.¹ It will be seen that even though a variable is insignificant in a particular equation, the variable was not always deleted. Some variables are important enough that they are left in the final reduced form, though their coefficients may

¹The author apologizes for the fact that the reader must reexamine six tables to see the six equation models for each country.

indicate that the variable should not be in. The best example is the price of feed grains in the import demand equation. Either P_{Dt} or P_{Dt-1} was kept in the import demand equation for each country, even though the coefficient may have a small t value. The same treatment was given to L_t in the import demand and both L_t and $\left(\frac{P_I}{k}\right)_t$ in the domestic price of feed grains equation.

Greece

The equations for feed grain imports and the domestic price from the full Greek model appeared to be the equations that needed the most improvement. The first experiment was to examine the effects of deleting P_{Dt} from the import demand equation. The coefficient for P_{Dt} was significant at the 5% level but of the wrong sign. It was hoped that deleting P_{Dt} would increase the explanatory power of P_{Dt-1} , which had a negative coefficient. The result of eliminating P_{Dt} was that the coefficients for L_t , $\left(\frac{Y}{N}\right)_t$, and FE_t became significant at the 1% level, while the coefficient for P_{Dt-1} turned insignificant.

If a variable elimination, or experiment, was judged successful, the variable was eliminated in investigating the effects of other variable eliminations. This procedure was followed for all countries. So it was decided to leave P_{Dt} out of the import demand equation.

The aim of the next experiment was to improve the equation for the domestic price of feed grains. I_{Ft} was deleted from the equation for the domestic price of feed grains because the t value on its coefficient was only 0.26. The result of deleting I_{Ft} was that the coefficients for P_{Dt-1} and $\left(\frac{P_I}{k}\right)_t$ in the equation for the domestic price of feed grains were significant at the 1% level. The t values for other variables in the equation

for the price of feed grains also increased, so I_{Ft} was kept out of the equation for the domestic price of feed grains.

P_{Dt} was deleted from the equation for the production of livestock products for the fourth computer run. The coefficient for P_{Dt} was of the correct sign, but the t values were only -0.38 . The result of dropping P_{Dt} was a slight improvement in the t values in the equation for the production of livestock products.

Three other experiments were tried, but the results of the fourth computer run were judged the best. One of the experiments involved dropping P_{Dt-1} from the livestock inventory equation. Dropping P_{Dt-1} resulted in a lower t value for the coefficient on L_t in the import demand equation and lower t values for all coefficients in the equation for the domestic price of feed grain. Deleting P_{Dt-1} from the livestock inventory equation did cause the t value of P_{Lt-1} to become significant at the 10% level, though.

Deleting P_{Lt-1} from the livestock inventory equation was also tried. This experiment changed the sign of the coefficient for L_t in the import demand equation and also decreased the t value of the coefficient for P_{Lt} in the demand for livestock products. Eliminating P_{Lt-1} had little effect on the t values of coefficients in the livestock inventory equation.

The final experiment involved deleting $\left(\frac{Y}{N}\right)_t$ from the equation for the domestic price of feed grains. This deletion improved the t values of the coefficients for other variables in the equation for the price of feed grains but also changed the sign of the coefficient for L_t in the import demand equation.

Israel

The import demand equation for Israel had no significant coefficients after the first run (the full model). The first experiment was, therefore, aimed at improving the import demand equation. P_{Dt-1} was deleted from the import demand equation because its coefficient was positive. Surprisingly, dropping P_{Dt-1} did little to the t values of coefficients in the import demand equation, but the deletion did increase the t values of the coefficients for P_{Dt-1} and $\left(\frac{P_I}{k}\right)_t$ in the equation for the price of feed grains. Dropping $\left(\frac{Y}{N}\right)_t$ from the import demand equation did cause the t values of coefficients to increase. The coefficients for both L_t and FE_t turned significant at the 5% and 10% levels, respectively.

P_{Dt} was then eliminated from the equation for the production of livestock products because of its low t value, -0.09. This experiment improved all t values in the equation for the production of livestock products, turning the coefficient for P_{Lt} significant at the 1% level. The livestock inventory equation was also improved by the deletion.

L_t was then deleted from the equation for the price of feed grains because the coefficient was of the wrong sign. This experiment increased the t value of the coefficients for FE_t in the import demand equation and for P_{Dt-1} in the equation for the price of feed grains.

The final reduced model was then obtained by deleting P_{Lt-1} from the livestock inventory equation. Even though dropping P_{Lt-1} made the livestock inventory equation a bit worse, it increased the t values of coefficients for L_t in the import demand equation and P_{Dt-1} in the equation for the price of feed grains.

Two other experiments were attempted but were judged unsuccessful. Dropping P_{Dt} and P_{Dt-1} from the livestock inventory equation failed to improve any equation, while both experiments hurt the import demand equation and the equation for the domestic price of feed grains.

Japan

Results when the government-fixed price of barley was used as P_{Dt}
As can be seen from examining the six tables of results from the equations of the full model, the simultaneous system for Japan needed much work. Over one-half of the coefficients that were significantly different from zero at the 5% level were of the wrong sign. The first experiment applied in the hope of remedying this situation was dropping P_{Dt} from the import demand equation. This deletion turned the coefficient for P_{pt} in the import demand equation significant at the 1% level and in general helped the import demand equation slightly.

Leaving FE_t out of the import demand equation hurt the explanatory power of the import demand equation and the equation for domestic price of grains equations. When FE_t was dropped from the import demand equation, the only equation it appeared in, FE_t was also dropped as a predetermined variable. This caused many changes in signs of coefficients and level of significance for variables throughout system.

In the three equations where P_{Dt} was a right-hand side variable, the coefficient was of the wrong sign in each. The equation for the domestic price of feed grains did not perform well either. So it was decided that the government-fixed price of barley should be replaced by the import price of barley as the measure of the domestic price of feed grains. Most

imported feed grains enter Japan duty-free, so the import price of feed grains should be very close to the variable desired.

The results when the import price of barley was used as P_{Dt} When the import price of barley was used as P_{Dt} in the full model, the system improved. In each of the three equations where P_{Dt} was a right-hand side variable, the coefficient was of the correct sign. In two of the three equations, the coefficient was significant at the 5% level.

The first and only experiment on this revised Japanese model was to leave FE_t out of the import demand equation. The coefficient for FE_t was of the incorrect sign in the full model. The result of this reduction was that the coefficients for P_{Dt-1} , L_t , $\left(\frac{Y}{N}\right)_t$, and R_t in the import demand equation became at the 1% level. So the final reduced model for Japan has only one deleted variable, FE_t .

Portugal

The Portuguese import demand equation from the full model had no significant coefficients. The aim of the first experiment was to improve the import demand equation. It was decided that P_{Dt} should be dropped from the equation because of its incorrect sign. This deletion helped all the t values of coefficients in the import demand equation and turned the coefficient for FE_t significant at the 1% level.

Because the t value on the coefficient for I_{Ft} in the equation for the domestic price of feed grains was -0.01 , I_{Ft} was dropped from that equation. The result was an increase in the t values on all coefficients in the equation for the domestic price of feed grains, but there were still no significant coefficients at the 5% level. Therefore, $\left(\frac{Y}{N}\right)_t$ was also dropped

from the equation for the domestic price of feed grains. Eliminating $\left(\frac{Y}{N}\right)_t$ turned the coefficient for P_{Dt-1} in the equation for the price of feed grains significant at the 10% level. The livestock inventory equation also improved, though no coefficients turned significant at the 10% level.

After this second deletion, the coefficient for P_{Dt} in the equation for the production of livestock products had the lowest t value, -0.27 . Therefore, an experiment was performed by dropping P_{Dt} from that equation. The result of the experiment helps one realize the sensitivity of this six equation simultaneous system to changes in equation structure. Almost every t value in the whole system decreased. Because of the interconnection of the six equations, changes in the specification of one equation can drastically change all six equations. The domestic price of feed grains, P_{Dt} , was left in the equation for the production of livestock products despite its insignificant coefficient.

The final reduced model was ultimately obtained by deleting P_{Lt} from the livestock inventory equation. This deletion of P_{Lt} improved all the t values of coefficients in the import demand equation. The coefficients for P_{Dt-1} and $\left(\frac{Y}{N}\right)_t$ in the import demand equation became significantly different from zero at the 10% level. In general, t values throughout the system were increased.

Other experiments were performed after the final reduced model was obtained, but the results were judged less favorable than the final reduced model. P_{Dt} , P_{Dt-1} , and P_{Lt-1} were all deleted from the livestock inventory equation (one at a time), but these deletions hurt other equations, especially the import demand equation, without helping the livestock inventory equation. The final experiment was elimination of P_{Dt-1} from the equation

for the domestic price of feed grains. This experiment decreased all the t values in the livestock inventory equation without helping the t values in any equation.

Spain

The equations for feed grain imports and the domestic price of feed grains needed the most work for the Spanish system. Only the coefficient for $\left(\frac{Y}{N}\right)_t$ was significant at the 5% level for the Spanish import demand equation. The first experiment was dropping P_{Dt-1} from the import demand equation, because the coefficient for P_{Dt-1} was of the wrong sign. It was hoped that dropping P_{Dt-1} would improve the t value for P_{Dt} in the same equation. Dropping P_{Dt-1} did help the t value for P_{Dt} in the import demand equation, but the sign of the coefficient changed to positive. So P_{Dt-1} was put back into the import demand equation, and P_{Dt} was dropped in the attempt to get a negative relationship between the price of feed grains and imports of feed grains. But the coefficient for P_{Dt-1} remained positive. In a further attempt to obtain a negative sign on the price of feed grains, FE_t was dropped from the import demand equation. Deleting FE_t hurt almost every t value in the entire system.

The only deletion that definitely improved upon the full model for Spain was dropping I_{Ft} from the equation for the price of feed grains. This increased the t values of the coefficients for P_{Dt-1} and L_t in the equation for the price of feed grains.

The final reduced model reported for Spain had P_{Dt-1} deleted from the import demand equation and I_{Ft} deleted from the equation for the domestic price of feed grains. The other reduced models described verbally for

Spain are probably equally good fits but were arbitrarily eliminated. No reduced model fit the Spanish fit feed grain import or feed grain price data very well. The problem could stem from the limitations of the study discussed in the next chapter. The assumptions made about the data used may not fit for Spain, too.

There also may be a lot of error in one or more of the data series. Unfortunately, it was not possible to get all the data from one source, so the time series used may not be consistent. But for some reason, the model was less successful for Spain than for any other country.

The U.K.

The first experiment for the U.K. was to delete P_{Dt} from the equation for the production of livestock products. The coefficient for P_{Dt} in that equation was of the incorrect sign but not significant. It was hoped that this deletion would help the t values for P_{Dt} and P_{Dt-1} in the import demand equation through the interrelationships of the model. The only effects of deleting P_{Dt} from the equation for the production of livestock products were in that same equation, where t values for P_{Lt} and L_t were increased somewhat.

P_{Dt-1} was then deleted from the import demand equation. This deletion turned the coefficient for L_t in the equation for the domestic price of feed grains significant at the 10% level. The absence of P_{Dt-1} in the import demand equation also increased the t value of coefficients for P_{Dt} and D_t , though neither coefficient turned significant.

At this point the t value of the coefficient for P_{Wt} in the equation for the production of livestock products was -0.05. So it was decided that

P_{Wt} should be dropped from that equation. This deletion caused the t value of the coefficient for P_{Lt} to be significant at the 5% level.

The next four experiments, dropping $\left(\frac{Y}{N}\right)_t$ and D_t from the import demand equation, D_t from the equation for the domestic price of feed grains, and P_{Dt} from the livestock inventory equation, all helped t values throughout the six equation system. Dropping D_t as a predetermined variable for the system was the major reason that P_{Dt} turned significant at the 1% level in the import demand equation. Because of the results of these four experiments, all four variables were deleted in the final reduced model.

The culmination of these seven experiments on the system for the U.K. was the final reduced model. After one other experiment was tried, deleting P_{Dt-1} from the livestock inventory equation, it was decided that the seven successful deletions would form the final reduced model.

The Results of the Models in Chapter IV

Tests of hypotheses

The results of hypothesis tests on the coefficients for a particular country are presented in this section. The outcome of these hypothesis tests are then used in the seemingly unrelated regressions model. The results of the hypothesis tests are presented by country.

Greece No hypothesis tests were performed on the Greek equation because only one independent variable, total Greek imports of feed grains, was used to explain Greek imports of U.S. feed grains. So the Greek equations remains the same as in Chapter IV:

$$GUSFG_t = i_0 + i_1 GFG_t$$

Eq. 7-1

Israel Two hypotheses were tested on the Israeli equation presented in Chapter IV, Eq. 4-4. The first test was that the coefficients on IB, Israeli imports of barley, and IO, Israeli imports of other feed grains, were equal. The F ratio calculated from Eq. 6-15 of Chapter IV was 3.79. The critical $F_{(1, 10)}$ value was 4.96, so the hypothesis could not be rejected. Therefore, IB and IO were summed to form the variable IFG, total Israeli feed grain imports.

The other hypothesis tested on the Israeli equation was that the coefficients for U.S. exports of barley, USB and U.S. exports of other feed grains, USO, were equal. The calculated F was 0.84, so this hypothesis could not be rejected. USB and USO were summed to obtain total U.S. exports of feed grains, USFG.

Because both hypotheses were rejected, the Israeli equation that results from the tests is:

$$IUSFG_t = j_0 + j_1 IFG_t + j_2 USFG_t + j_3 CB_t \quad \text{Eq. 7-2}$$

Japan Four hypotheses were tested for the Japanese equation presented in Chapter IV, Eq. 4-9. The first hypothesis was that the coefficients on USC, U.S. exports of corn; USS, U.S. exports of sorghum; and USB, U.S. exports of barley, were equal. The calculated F for this hypothesis was 0.43, which is not significant. So the hypothesis could not be rejected, and USC, USS, and USB were added to form USFG1.

The second hypothesis tested was that the coefficients on exports of corn by traditional suppliers to Japan, JTS, and exports of corn by minor suppliers to Japan, JMS, were equal. The calculated F for this hypothesis

was 0.57, which is not significant. So JTS and JMS were summed to obtain JOCS, exports of corn by Japanese suppliers other than the U.S.

The third hypothesis was that the coefficients for JC, Japanese corn imports; JS, Japanese sorghum imports; JB, Japanese barley imports; and JO, Japanese imports of oats and rye, were equal. The calculated F was 0.81, which means the hypothesis could not be rejected. So total Japanese imports of feed grains, JFG, were used as a variable instead of the separate variables on imports by type of feed grain.

The final hypothesis test performed for Japan was that the coefficients for JOCS; JOSS, sorghum exports of other sorghum suppliers to Japan; and JOSB, barley exports of other barley suppliers to Japan, were equal. The calculated F for this hypothesis was 0.09, so this hypothesis could not be rejected. Therefore, JOCS, JOSS, and JOSB were added to form JOFGS.

The Japanese equation that results from failing to reject the four hypotheses is:

$$JUSFG_t = k_0 + k_1 JFG_t + k_2 USFG1_t + k_3 JOFGS_t + \sum_{i=1}^4 k_{4i} R_t \quad \text{Eq. 7-3}$$

Portugal Two hypotheses were tested on the Portuguese equation presented in Chapter IV, Eq. 4-12. The first hypothesis was that the coefficients for PC, Portuguese imports of corn, and PO, Portuguese imports of other feed grains, were equal. The calculated F for this hypothesis was 7.15, which is greater than the critical $F_{(1, 11)}$ of 4.84. So PC and PO were left in the Portuguese equation separately because their coefficients are significantly different.

The second hypothesis was that coefficients for CC, corn exports by Angola and Mozambique, and POC, corn exports by other corn suppliers to

Portugal, were equal. The calculated F was 0.55, which is not significant at the 5% level. So CC and POC were added to obtain PCS, corn exports of Portuguese corn suppliers other than the U.S.

The Portuguese equation that results from the two hypothesis tests is:

$$\text{PUSFG}_t = L_0 + L_1 \text{PC}_t + L_2 \text{PO}_t + L_3 \text{PCS}_t + L_4 \text{USC}_t \quad \text{Eq. 7-4}$$

Spain Four hypotheses were tested on the Spanish equation presented in Chapter IV, Eq. 4-14. The first hypothesis was that the coefficients for SC, Spanish imports of corn, and SO, Spanish imports of other feed grains, were equal. The calculated F for this test was 0.41, which is not significant. Therefore, SC and SO were summed to form SFG, total Spanish imports of feed grains.

The second hypothesis was that the coefficients for STS, corn exports of traditional corn suppliers to Spain (other than the U.S.), and SMS, corn exports of minor corn suppliers to Spain, were equal. The calculated F for this test was 0.14, which is insignificant. So STS and SMS were added to form the variable SCS.

The third hypothesis was that the coefficients for SCS, AS, Argentine sorghum exports, and FB, French barley exports, were equal. The calculated F for this test was 1.57, which is also insignificant. Therefore, SCS, AS, and FB were summed to obtain SFGS, feed grain exports of other Spanish feed grain supplies.

The final hypothesis was the only hypothesis rejected for Spain. The hypothesis was that the coefficients for USC, U.S. corn exports, and USNC, U.S. feed grain exports other than corn, were equal. The calculated F was

20.53, which is much greater than the critical $F_{(1, 12)}$ of 4.75. So USC and USNC remained in the equation separately.

The Spanish equation that results from failing to reject the first three hypotheses and rejecting the last hypothesis is:

$$SUSFG_t = m_0 + m_1 SFG_t + m_2 USC_t + m_3 SFGS_t + m_4 USNC_t \quad \text{Eq. 7-5}$$

The U.K. Four hypotheses were also tested for the U.K. equation presented in Chapter IV, Eq. 4-19. The first hypothesis was that the coefficients for British corn imports, BC; British sorghum imports, BS; and British imports of other feed grains, BO, were equal. The calculated F from the hypothesis was 1.22, which is insignificant. So BC, BS, and BO were summed to form BFG, total British imports of feed grains.

The second hypothesis was that the coefficients for corn exports of traditional suppliers of corn to the U.K. (other than the U.S.), BTS, and corn exports of minor suppliers of corn to the U.K., BMS, were equal. The calculated F from this hypothesis was 0.50, which is not significantly different from zero. So BTS and BMS were added to form BCS, corn exports of British corn suppliers.

The third hypothesis was that the coefficients for BCS and AS, Argentine sorghum exports, were equal. The calculated F for this test was 0.80, which is insignificant. So BCS and AS were added to form BFGS, feed grain exports of British corn suppliers.

The final hypothesis was that the coefficients for USC, U.S. corn exports, and USS, U.S. sorghum exports, were equal. The calculated F for this test was 3.58, which is less than the critical $F_{(1, 10)}$ of 4.96, so

the hypothesis cannot be rejected. So USS and USC were summed to form USFG2, which was used in the U.K. equation.

The equation for the U.K. obtained by rejecting the four hypotheses is:

$$\text{BUSFG}_t = n_0 + n_1 \text{BFG}_t + n_2 \text{USFG2}_t + n_3 \text{BFGS}_t \quad \text{Eq. 7-6}$$

The results of the seemingly unrelated regressions model

The results of the final reduced seemingly unrelated regressions model are presented in Eqs. 7-7. The full model, Eqs. 7-1 through 7-6, is not presented for economy of space. In the final reduced model, all significant coefficients were of the correct sign. Every coefficient that was significantly different from zero at the 5% level in the final reduced model was also significantly different at the 5% level in the full model. So the variable deletions from the full model to the final reduced model failed to change any coefficients from insignificant to significant.

The variable with the lowest t in absolute value was deleted in each iteration of the seemingly unrelated regressions model. The first variable deleted was USFG_t from the Israeli equation. The other deletions in order were: USC_t from the Portuguese equation, PO_t from the Portuguese equation, USFG2 from the British equation, CB_t from the Israeli equation, PFGS_t from the Portuguese equation, and USNC_t from the Spanish equation.

Eqs. 7-7. The results of the seemingly unrelated regressions model for chapter IV

$$\begin{array}{l} \text{GUSFG}_t = -29.1 + 0.99 \text{GFG}_t \\ \quad \quad (26.3) \quad (0.07) \end{array} \quad \hat{\rho} = \begin{array}{l} 0.19 \\ (0.25) \end{array}$$

$$\begin{array}{l} \text{IUSFG}_t = 83.0 + 0.69 \text{IFG}_t \\ \quad \quad (21.4) \quad (0.03) \end{array} \quad \hat{\rho} = \begin{array}{l} 0.03 \\ (0.25) \end{array}$$

$$\begin{aligned}
 \text{JUSFG}_t &= 102.3 + 0.87 \text{JFG}_t + 0.07 \text{USFG1}_t + 0.31 \text{JFGS}_t + 0.14 \text{R}_t \\
 &\quad (272.3) \quad (0.06) \quad (0.02) \quad (0.04) \quad (0.05) \\
 &\qquad\qquad\qquad \hat{\rho} = 0.36 \\
 &\qquad\qquad\qquad (0.23) \\
 \\
 \text{PUSFG}_t &= -52.4 + 0.71 \text{PC}_t \\
 &\quad (24.8) \quad (0.06) \\
 &\qquad\qquad\qquad \hat{\rho} = 0.27 \\
 &\qquad\qquad\qquad (0.24) \\
 \\
 \text{SUSFG}_t &= 129.7 + 0.35 \text{SFG}_t + 0.09 \text{USC}_t - 0.12 \text{SFGS}_t \\
 &\quad (81.1) \quad (0.05) \quad (0.01) \quad (0.01) \\
 &\qquad\qquad\qquad \hat{\rho} = 0.01 \\
 &\qquad\qquad\qquad (0.25) \\
 \\
 \text{BUSFG}_t &= 39.6 + 0.58 \text{BFG}_t - 0.08 \text{BFGS}_t \\
 &\quad (574.2) \quad (0.08) \quad (0.02) \\
 &\qquad\qquad\qquad \hat{\rho} = 0.62^1 \\
 &\qquad\qquad\qquad (0.20)
 \end{aligned}$$

Standard deviations are in parentheses.

The coefficients for the imports of feed grains by the country range from 0.35 for Spain to 0.99 for Greece. If Greece increases its imports of feed grains, 99% of the increase should come from the U.S., other things equal. If 100 extra tons of U.S. corn are available for export, as measured by actual U.S. corn exports, 7 tons would go to Japan and 9 tons would go to Spain, other things equal. If 100 extra tons of Argentine corn were available for export, as measured by actual Argentine corn exports, U.S. feed grain exports to Japan would fall by 31 tons. U.S. exports of feed grains would also fall to Spain and the U.K. by 12 and 8 tons, respectively. All coefficients in the equations are significantly different from zero, of the correct sign, and appear to be of the right magnitude.

The results from the Japanese model in Chapter III showed that as R_t increased, feed grain imports would decrease. The coefficient for R_t in the Japanese equation from Chapter IV was significant and greater than

¹ $\hat{\rho}$ for the U.K. equation was significantly different from zero at the 5% level, so the procedure used to correct for autocorrelated errors was applied to the U.K. equation.

zero. These two results seem to indicate that as rice stock increase, imports of feed grains in which the U.S. has a strong competitive position do not fall as much as imports of feed grains in which the U.S. competitive position is less strong.

CHAPTER VIII. CONCLUDING REMARKS

Summary of Objectives

The objectives of this study were to investigate factors that influence: 1) the demand for imported feed grains, 2) the domestic price of feed grains, and 3) the importation of U.S. feed grains, for certain feed grain importing countries. The first two objectives were accomplished by fitting a six equation simultaneous system for each country. The last objective was accomplished by fitting a seemingly unrelated regressions model that included one equation for each country studied.

Limitations of the Study

There are limitations in almost every study performed. Both the researcher and the reader should be aware of them. In this study the biggest limitation is data. Lack of data meant that assumptions had to be made that might not be accurate for some of the countries.

The equations in Chapter IV have two main underlying assumptions that may not fit the situation in the importing country. It is assumed that trade barriers on imported U.S. feed grains by the country are the same as trade barriers on feed grains from other exporting countries. For instance, trade barriers for U.S. corn are assumed to be the same as trade barriers for Argentine corn in all the countries studied. The equations in Chapter IV cannot capture the effects of different trade barriers depending on the country of origin.

Another key assumption behind the equations in Chapter IV is that the importing country does not distinguish feed grains by their country of origin. #2 yellow corn from the U.S. is the same as #2 yellow corn from

France. Therefore, corn of given characteristics from the U.S. is a perfect substitute for corn with the same characteristics from any other country.

Data

The data chapter outlines how the data used in the study were collected. Chapter V has many instances where the actual data needed were unavailable. The aggregation procedures used to form the quantity of livestock products produced, Q_{PLt} , and the size of the domestic livestock inventory, L_t , needed data on the consumption of feed grains by each type of livestock. The only figures that were available were consumption of concentrated feed by type of livestock. So it was necessary to assume that concentrated feed consumption by a particular type of livestock reflected feed grain consumption by that same type of livestock. But feed grains are not the only ingredients in concentrated feed. Alfalfa, milling by-products, many types of meal, and other substances are also ingredients in concentrated feed. Changes in the content of concentrated feed would cause changes in the relationship between concentrated feed consumption and feed grain consumption.

Ocean transportation rates were available for the U.K. and Japan, but other transportation rates were calculated from the U.K. rates. This is not a good assumption, but it is unavoidable. Transportation rates vary widely due to backhaul rates, size of vessels which carry the grain, and other factors. Unfortunately, there was no way to obtain the actual ocean transportation rates for Greece, Israel, Portugal, and Spain.

These are just two examples of assumptions which had to be made to obtain the data needed to fit the models. No assumption is terribly damaging to the model by itself. But when numerous assumptions must be made, their cumulative effects may be undesirable.

Many quarterly observations that were needed for the quarterly models were unavailable. The size of the domestic livestock inventory for Spain and Japan was estimated from the predetermined variables of the simultaneous system. It is very possible that the true inventory figures would perform better in the model. Other missing quarterly observations were determined by various methods outlined in Chapter V. These missing value procedures are probably imperfect substitutes for the actual value of the variables.

Another problem in regard to the data collected is the accuracy of the figures reported in the publications cited. Sometimes the FAO figures and the figures reported by various government agencies of a country were not the same for the same variable. In cases where figures did not match, the differences were small, but it raises some doubt about the accuracy of the compilations and how consistent each source is. Unfortunately, it was not possible to obtain all the data needed for the study from the same source, except for the data used to fit the Chapter IV model. Therefore, it may have been more appropriate to use an errors-in-variables model rather than the autoregressive 3SLS model and seemingly unrelated regressions model.

The variable used to measure the amount of foreign exchange available was the value of exports for the country. There are many other variables that could be used to measure FE_t . One could argue that the stock of foreign exchange holdings should be used as the measure of FE_t . Another

possibility is to use the total outflow of the country's currency (other than for importation of feed grains) at time t to measure FE_t . These other measures may have performed better than the value of exports by the country. But for this study, FE_t was measured by the value of exports.

Multicollinearity, correlation between right-hand side variables in an equation, could be a problem with the results. The full model for each country had problems with multicollinearity because of the existence of both current and lagged prices in the same equation. It is possible that multicollinearity is present in the final reduced models, too.

The scope of the study

This study suffered from problems common to many studies in economics. The analysis is partial equilibrium, while the world economy is more likely general equilibrium in nature. The feed grain and livestock sectors of the importing country are modeled, but other sectors that probably affect the feed grain sector are disregarded. Soybeans, wheat, and other crops can be substituted for feed grains on the supply side. Some substitution for feed grains can occur on the demand side, too. But the analysis does not incorporate these possible substitution effects. The price of wheat is incorporated in the livestock sector for the U.K. but not in the feed grain sector.

Feeding of concentrates to livestock is not nearly as widespread in Greece, Israel, Portugal, and Spain as in the U.S. Alfalfa and hay are major factors in the maintenance of livestock inventories and production of livestock products, so some substitution between feed grains and these non-concentrated feeds is a real possibility. The same substitution probably

occurs in the U.K. and Japan but to a lesser extent because of their developed livestock industries.

For these reasons, the scope of the model is too narrow, but the scope can also be considered too broad. If individual feed grains were modeled instead of feed grains in general, the cross-price elasticities between feed grains could explain much about the importing pattern of feed grains for a particular country. If feed grains are modeled separately, the effects of other right-hand side variables could also be different. It is possible that some feed grains are used primarily in the livestock industry, e.g., corn, while others are used primarily for direct consumption by humans, e.g., barley for brewing beer. So a change in the size of the livestock inventory could have little effect on the demand for barley but a great effect on the demand for corn.

This same idea can be applied to the livestock sector of each country. Substitution among livestock and livestock products could do much to explain the livestock industry of the countries. But these substitution effects are lost when aggregate variables are used.

Implications of This Study and Future Research

Despite the limitations of the study, the models seem to explain much of the variation in the domestic price and imports of feed grains for most of the countries studied. Some of the variables that are not found in other studies were significant in this study. The coefficient for the domestic price of feed grains in the import demand equation was significant for three of the six countries studied. Two of the three quarterly models

had a significant coefficient for the domestic price of feed grains in the import demand equation.

The cost of imported feed grains, which incorporated ocean transportation costs and the exchange rate, was significant in the domestic price of feed grains equation for four of the five countries (though the coefficient was of the wrong sign for Spain). It is interesting to note that the coefficient for the cost of imported feed grains, which was less than one for each country, was always significantly different from one. So if the cost of imported feed grains changed, the domestic price of feed grains would change (except for Spain) but by a smaller magnitude. The importing country smoothes out fluctuations in the world price of feed grains.

It is hoped that one contribution of this study will be to increase the awareness of the significance of international trade concepts in feed grain trade. Trade barriers, exchange rates, transportation costs, and other factors should be incorporated in international trade models, instead of assumed away.

It would be interesting to see the results of the general Chapter III model for a country which has fewer data problems. This could be done by a researcher who is more familiar with the country studied and has access to more publications of the country studied. The research could be treated as a sort of case study. This approach could improve the results substantially.

The Western European countries have a wealth of information on variables needed for this study. So many of the assumptions needed in this

study would not be needed for Western European countries. But the European Economic Community would need to be treated as a single country for the general Chapter III model, so other problems are introduced. But the government's utility function and Eq. 3-12 of the general model may give an accurate portrayal of the EEC variable levy system.

BIBLIOGRAPHY

- Abbott, Philip. 1976. "Modelling international grain trade with government controlled markets." Unpublished manuscript. Department of Economics, Northeastern University.
- Amemiya, Takeshi. 1966. "Specification analysis in the estimation of parameters of a simultaneous equation model with autoregressive residuals." *Econometrica* 34(2):283-306.
- Bautista, Romeo. 1977. "Effects of major currency realignments on Philippine merchandise trade." *Review of Economics and Statistics* 69(2):152-160.
- Bhagwat, Avinash and Yusuke Onitsuka. 1974. "Export-import responses to devaluation: Experience of the nonindustrial countries in the 1960's." *International Monetary Fund Staff Papers* 21(2):414-462.
- Branson, William. 1972. "The trade effects of the 1971 currency realignments." *Brookings Papers on Economic Activity* No. 1:15-58.
- Central Bureau of Statistics. 1958a through 1976a. *Statistical Abstract of Israel* 19 through 27. Jerusalem: Author.
- Central Bureau of Statistics. 1958b through 1976b. *Statistical Bulletin of Israel*. Jerusalem: Author.
- Chiang, Alpha C. 1974. *Fundamental Methods of Mathematical Economics*. Second edition. New York: McGraw-Hill.
- Currie, John M., John A. Murphy, and Andrew Schmitz. 1971. "The concept of economic surplus and its use in economic analysis." *The Economic Journal* 81(324):741-799.
- Deppler, Michael. 1974. "Some evidence on the effects of exchange rate changes on trade." *International Monetary Fund Staff Papers* 21(3):605-636.
- Food and Agriculture Organization of the United Nations. 1958a through 1976a. *Monthly Bulletin of Agricultural Economics and Statistics*. Volumes 7(1) through 26(12).
- Food and Agriculture Organization of the United Nations. 1958b through 1976b. *National Grain Policies*. Rome: FAO.
- Food and Agriculture Organization of the United Nations. 1958c through 1976c. *Production Yearbook*. Volumes 12 through 30. Rome: FAO.
- Food and Agriculture Organization of the United Nations. 1958d through 1976d. *Trade Yearbook*. Volumes 12 through 30. Rome: FAO.

- Food and Agriculture Organization of the United Nations. 1958e through 1976e. World Grain Trade Statistics. Rome: FAO.
- Food and Agriculture Organization of the United Nations and the Economic Commission for Europe. 1960/61 through 1975/76. Price of Agricultural Products and Fertilizers in Europe. New York: United Nations.
- Fuller, Wayne A. 1978. Advanced econometric statistics. Unpublished class notes. Department of Statistics, Iowa State University.
- Great Britain Central Statistical Office. 1958 through 1976. Monthly Digest of Statistics. Numbers 150 through 372. London: Her Majesty's Stationary Office.
- Heller, H. Robert. 1968. International Trade: Theory and Empirical Evidence. Englewood Cliffs, New Jersey: Prentice-Hall.
- Henderson, James M. and Richard E. Quandt. 1971. Microeconomic Theory. Second edition. New York: McGraw-Hill.
- Hicks, J. R. 1939. Value and Capital. London: Oxford University Press.
- Hildreth, Clifford and F. G. Jarrett. 1955. A Statistical Study of Livestock Production and Marketing. New York: John Wiley and Sons.
- Hirshleifer, Jack. 1976. Price Theory and Applications. Englewood Cliffs, New Jersey: Prentice-Hall.
- Institute of Agricultural Economic Research. 1964. Japanese import requirement: Projections of agricultural supply and demand for 1965, 1970, and 1975. Department of Agricultural Economics, University of Tokyo.
- Institute of Developing Economics. 1969. 100 Years of Agricultural Statistics in Japan. Tokyo: Author.
- Instituto Nacional de Estadística. 1977. Anuario de Estadística Agrícola. Madrid: Author.
- Instituto Nacional de Estadística. 1958 through 1976. Boletín Mensual de Estadística. Volumes 157 through 384.
- International Monetary Fund. 1958 through 1976. International Financial Statistics. Volumes 11 through 29. Washington: IMF.
- International Wheat Council. 1958 through 1976. Review of the World Wheat Situation. London: IWC.
- Johnson, Paul R. 1971. Studies in the demand for U.S. exports of agricultural commodities. Department of Economics, North Carolina State University, Economic Research Report No. 15.

- Johnston, J. 1972. *Econometric Methods*. Second edition. New York: McGraw-Hill.
- Jones, James R. and W. R. Morrison. 1976. Import demand for soybeans and soybean products in Eastern Europe. *Arkansas Agricultural Experiment Station Bulletin* 803.
- Junckerstorff, H. K. 1963. *International Manual on the EEC*. St. Louis: St. Louis University Press.
- Junz, Helen B. and Rudolf Rhomberg. 1973. Price competitiveness in export trade among industrial countries. *American Economic Review* 63(2):412-418.
- Kmenta, Jan. 1971. *Elements of Econometrics*. New York: Macmillan Company.
- Kmenta, Jan and Roy F. Gilbert. 1970. Estimation of seemingly unrelated regressions with autoregressive disturbances. *Journal of the American Statistical Association* 65(329):186-197.
- Kreinin, Mordechai. 1971. *International Economics: A Policy Approach*. New York: Harcourt Brace Jovanovich.
- Leamer, Edward E. and Robert M. Stern. 1970. *Quantitative International Economics*. Chicago: Aldine Publishing Company.
- Ministry of Agriculture. *Agricultural and Settlement Planning and Development Center*. 1973. *Resources and uses of fodder in Israel*. Tel Aviv: Author.
- Ministry of Agriculture, Fisheries, and Food. 1958/59a through 1973/74a. *Agricultural Statistics of England and Wales*. London: Her Majesty's Stationary Office.
- Ministry of Agriculture, Fisheries, and Food. 1958/59b through 1975/76b. *Agricultural Statistics of the United Kingdom*. London: Her Majesty's Stationary Office.
- Ministry of Agriculture and Forestry. 1958 through 1976. *Abstract of Statistics on Agriculture, Forestry, and Fisheries*. Tokyo: Government of Japan.
- Ministry of Agriculture. *Statistics and Information Department*. 1958 through 1976. *Monthly Statistics of Agriculture, Forestry, and Fisheries*. Tokyo: Government of Japan.
- Ministry of Finance. 1958 through 1976. *Monthly Return of the Foreign Trade of Japan*. Tokyo: Government of Japan.

- Mitchell, Don O. 1976. The level and variability of agricultural exports. Unpublished Ph.D. thesis, Iowa State University.
- National Statistical Service of Greece. 1958 through 1976. Monthly Bulletin of External Trade Statistics. Athens: Kingdom of Greece.
- Organization for Economic Cooperation and Development of the United Nations. 1967. Agricultural Policies in 1966: Europe, North America, Japan. Paris: OECD.
- Pindyck, Robert S. and Daniel L. Rubinfeld. 1976. Econometric Models and Economic Forecasts. New York: McGraw-Hill.
- Ryan, Mary E. and James P. Houck. 1976. A study of U.S. exports of soybeans and soybean meal. Minnesota Agricultural Experiment Station Technical Bulletin 309.
- Samuelson, Paul A. 1952. Spatial price equilibrium and linear programming. American Economic Review 42(3):283-303.
- Schmitz, Andrew and D. Lee Bawden. 1973. The world wheat economy: An empirical analysis. Giannini Foundation Monograph No. 32. California Agricultural Experiment Station.
- United States Department of Agriculture. 1966. Projected exports and imports of selected agricultural commodities of South Africa. Report to the Economic Research Service and Foreign Agricultural Service. Washington: USDA.
- United States Department of Agriculture. Agricultural Marketing Service. 1958 through 1976. Grain Market News Volumes 6(1) through 24(52).
- United States Department of Agriculture. Agricultural Marketing Service. Statistical Reporting Service. 1973. Livestock and Meat Statistics. USDA Statistical Bulletin No. 522.
- United States Department of Agriculture. Economic Research Service. Foreign Demand and Competition Division. 1958 through 1962. Foreign Agricultural Trade of the U.S.
- United States Department of Agriculture. Economic Research Service. Foreign Demand and Competition Division. 1967. Foreign Agricultural Trade of the U.S. October:15.
- United States Department of Agriculture. Economic Research Service. Foreign Demand and Competition Division. 1972. Foreign Agricultural Trade of the U.S. November.
- United States Department of Agriculture. Economic Research Service. Foreign Demand and Competition Division. 1977. Foreign Agricultural Trade of the U.S. April:19.

- United States Department of Agriculture. Economic Research Service. Statistical Reporting Service. 1965. Conversion factors and weights and measures for agricultural commodities and their products. USDA Statistical Bulletin No. 362.
- United States Department of Agriculture. Foreign Agricultural Service. 1969. Foreign Agriculture 7(17):10.
- United States Department of Agriculture. Foreign Agricultural Service. 1970. Grain production and marketing in Argentina. USDA Bulletin M222.
- United States Department of Agriculture. Foreign Agricultural Service. 1971. Foreign Agriculture 9(43):15.
- United States Department of Agriculture. Foreign Agricultural Service. 1972a. Foreign Agriculture 19(42):12.
- United States Department of Agriculture. Foreign Agricultural Service. 1972b. Agricultural Trade Policy ATP 2-72:4.
- United States Department of Agriculture. Foreign Agricultural Service. 1977. Foreign Agricultural Circular FG 8-77:5.
- United States Department of Agriculture. Foreign Agricultural Service. 1978. Foreign Agricultural Circular FG 3-78:4.
- United States Department of Agriculture. Foreign Demand and Competition Division. 1967. Brazil's position in world agricultural trade. ERS-Foreign 190.
- United States Department of Agriculture. Foreign Demand and Competition Division. 1972. The agricultural economy of Thailand. ERS-Foreign 321.

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APPENDIX

Table A-1. Estimates of ρ and coefficients for seasonal dummies in the import demand equation.
 Dependent variable is I_{Ft}

	Full model				Final reduced model			
	D_1	D_2	D_3	$\hat{\rho}$	D_1	D_2	D_3	ρ
Greece				0.34 (0.22) ^a				-0.13 (0.23)
Israel				0.32 (0.22)				0.32 (0.22)
Japan ^b	76.6 (47.2)	32.4 (45.4)	-31.4 (46.6)	0.25* (0.12)	168** (54)	1 (48)	-112* (52)	0.34** (0.11)
Portugal				0.37 (0.22)				-0.39 (0.22)
Spain	-17.9 (41.1)	62.9 (38.2)	-28.1 (49.7)	0.29* (0.11)	-5 (40)	66 (40)	-51 (43)	0.88** (0.21)
U.K.	-135 (94)	27 (71)	141* (66)	0.18 (0.12)	-17 (43)	85** (41)	-53 (45)	0.03 (0.13)
Japan	7 (42)	47 (45)	-7 (52)	0.87** (0.25)				

^aStandard deviations are in parentheses.

^bThe Japanese model using the import price as P_{Dt} .

*Significantly different from zero at the 5% level.

**Significantly different from zero at the 1% level.

Table A-2. Estimates of and coefficients for seasonal dummies in the equation for the domestic price of feed grains. The dependent variable is P_{Dt}

	Full model				Final reduced model			
	D ₁	D ₂	D ₃	ρ	D ₁	D ₂	D ₃	ρ
Greece				-0.22 (0.19) ^a				0.58** (0.19)
Israel				0.35 (0.22)				0.36 (0.22)
Japan	-1.0 (0.9)	-1.5 (0.8)	2.4** (0.8)	0.48** (0.11)				
Portugal				0.19 (0.23)				0.02 (0.24)
Spain	-55 (37)	-21 (45)	96** (37)	0.29** (0.11)	-54 (33)	-17 (33)	93** (33)	0.26* (0.11)
U.K.	0.7 (0.4)	-0.8 (0.4)	0.1 (0.3)	0.32** (0.12)	1.0** (0.3)	-0.4 (0.3)	0.1 (0.3)	0.32* (0.12)

^aStandard deviations are in parentheses.

*Significantly different from zero at the 5% level.

**Significantly different from zero at the 1% level.

Table A-3. Estimates of ρ and coefficients for seasonal dummies in the equation for the production of livestock products. The dependent variables is Q_{PLt}

	Full model				Final reduced model			
	D ₁	D ₂	D ₃	ρ	D ₁	D ₂	D ₃	ρ
Greece				0.13 (0.22) ^a				0.11 (0.23)
Israel				0.06 (0.24)				0.18 (0.23)
Japan ^b	-11 (11)	40** (11)	12 (11)	0.43* (0.21)	-12 (11)	38** (11)	14 (11)	0.18 (0.12)
Portugal				0.21 (0.23)				0.21 (0.23)
Spain	21 (12)	-12 (12)	-58** (10)	0.94** (0.25)	21 (12)	-12 (12)	-58** (10)	0.60** (0.09)
U.K.	9.3 (3.7)	-13.6** (3.8)	-24.1** (3.8)	0.17 (0.12)	9.0* (3.6)	-14.8** (3.5)	25.3** (3.6)	0.18 (0.12)
Japan	-5.5 (9.7)	59.3** (9.9)	-3.8 (10.1)	0.09 (0.12)				

^aStandard deviations are in parentheses.

^bThe Japanese model using the import price as P_{Dt} .

*Significantly different from zero at the 5% level.

**Significantly different from zero at the 1% level.

Table A-4. Estimates of ρ and coefficients for seasonal dummies in the demand for livestock products.
The dependent variable is D_{Lt}

	Full model				Final reduced model			
	D_1	D_2	D_3	ρ	D_1	D_2	D_3	ρ
Greece				0.42 (0.21) ^a				0.42 (0.12)
Israel				0.04 (0.24)				0.04 (0.24)
Japan ^b	-12 (12)	39** (13)	10 (13)	0.20 (0.12)	-12 (13)	40** (13)	10 (13)	0.20 (0.12)
Portugal				0.18 (0.23)				0.18 (0.23)
Spain	-17 (15)	49** (13)	-26 (13)	0.78** (0.07)	-17 (15)	48** (13)	-26 (13)	0.78** (0.07)
U.K.	195** (28)	-12 (18)	-43* (20)	0.61** (0.10)	201** (28)	-13 (18)	-45* (20)	0.61** (0.10)
Japan	-16 (13)	41** (13)	11 (13)	0.52* (0.24)				

^aStandard deviations are in parentheses.

^bThe Japanese model using the import price as P_{Dt} .

*Significantly different from zero at the 5% level.

**Significantly different from zero at the 1% level.

Table A-5. Estimate of ρ and coefficients for seasonal dummies in the livestock inventory equation.
The dependent variable is L_t

	Full model				Final reduced model			
	D ₁	D ₂	D ₃	ρ	D ₁	D ₂	D ₃	ρ
Greece				0.90** (0.22) ^a				0.90** (0.43)
Israel				0.24 (0.23)				0.62** (0.19)
Japan ^b	2996 (6400)	-10697 (6181)	15894 (8043)	0.41 (0.22)	3365 (6438)	-10705 (6211)	-16225 (8156)	0.17 (0.12)
Portugal				-0.05 (0.24)				0.04 (0.24)
Spain	-1805* (781)	5244** (1387)	-650 (741)	0.56* (0.16)	-1821* (780)	5290** (1377)	-651 (739)	0.56** (0.16)
U.K.	-260 (666)	1186* (497)	991 (605)	0.91** (0.26)	85 (722)	1325* (527)	889 (613)	0.49** (0.11)
Japan	20519* (9512)	37466* (10680)	-81823 (16188)	0.17 (0.12)				

^aStandard deviations are in parentheses.

^bThe Japanese model using the import price as P_{Dt} .

*Significantly different from zero at the 5% level.

**Significantly different from zero at the 1% level.

Table A-6. Estimates of ρ and coefficients for seasonal dummies in the demand-supply relationship for livestock products. The dependent variable is D_{Lt}

	Full model				Final reduced model			
	D_1	D_2	D_3	ρ	D_1	D_2	D_3	ρ
Greece				0.47* (0.21) ^a				0.47* (0.21)
Israel				0.22 (0.23)				0.22 (0.23)
Japan ^b	-6.7 (3.5)	-12.1** (4.0)	5.1 (4.0)	0.81** (0.07)	-7.0 (3.5)	-12.0** (4.0)	5.2 (4.0)	0.90** (0.07)
Portugal				0.47* (0.21)				0.48* (0.21)
Spain	-60** (16)	150** (17)	131** (18)	0.80** (0.07)	-61** (16)	150** (17)	131** (18)	0.80** (0.07)
U.K.	-6.5 (16.5)	-28.2 (15.0)	35.5** (16.4)	0.49** (0.11)	-7.3 (16.5)	-28.1 (15.0)	36.6* (16.4)	0.49** (0.11)
Japan	-6.7 (3.5)	-12.1** (4.0)	5.1 (4.0)	0.81** (0.07)				

^aStandard deviations are in parentheses.

^bThe Japanese model using the import price as P_{Dt} .

*Significantly different from zero at the 5% level.

**Significantly different from zero at the 1% level.