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A SPATIAL EQUILIBRIUM ANALYSIS OF THE U.S. WHEAT INDUSTRY

by
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FOREWORD

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A SPATIAL EQUILIBRIUM ANALYSIS OF THE U.S. WHEAT INDUSTRY

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I. Summary

The purpose of this study is to evaluate spatial equilibrium conditions for the U.S. wheat industry under alternative trade restrictions and transportation costs.

The method used in this study is a spatial equilibrium model based on a quadratic programming algorithm. The model incorporates transportation and storage activities in shipping wheat from producing regions to domestic consuming and foreign importing regions. The criterion for this study is to maximize the net social payoff. The model incorporates estimated export supply equations in each U.S. port and import demand equations in importing regions. Domestic producing regions are linked to export ports through transportation activities in shipping wheat from producing regions to export ports. Import demand equations in each importing region are incorporated into the model and are linked to U.S. ports through ocean transportation activities in the model.

The model contains 49 domestic wheat producing regions, 23 domestic consuming regions, 12 export ports, and 11 foreign importing regions. Three different classes of wheat are included: winter, spring, and durum. Each wheat has unique production and consumption characteristics which make marketing activities of one wheat different from the others. Transportation activities are based on four modes of transportation — rail, barge, truck, and ocean vessel. Barge transportation activities are coordinated with rail and/or truck transportation through inland water ports on the Mississippi, the Great Lakes, and the Columbia-Snake River System. The model has 40 water access points as inland water ports on the river system.

Equilibrium Prices Vs. Actual Prices

Spatial equilibrium prices for classes of wheat at each U.S. port are determined by export supply of wheat, import demand for wheat, and transportation costs in shipping wheat from producing regions to importing regions under an assumption of free trade. The West Coast ports have the highest price for winter and spring wheat and the Great Lakes ports have the lowest price in the base model. Price differential between the two ports is approximately 70 cents per bushel. Wheat prices at the Gulf ports are about 35 cents per bushel lower than at the West Coast. Durum wheat prices are higher at the Great Lakes and Gulf ports than at the West Coast. The spatial equilibrium price pattern is consistent with actual average export price pattern. However, equilibrium price level is not exactly the same as actual average prices at U.S. export ports. This is mainly because the model does not include all possible institutional constraints in both the U.S. and importing countries, and because the U.S. wheat export market is inefficient in terms of its market share of grain at each export port.

Effects of Trade Restrictions

This study reveals that an import tariff per bushel on wheat imposed by the EEC and/or Japan/Korea is generally absorbed more by consumers in the importing regions than by U.S. wheat producers. This is mainly because changes in the quantities of wheat imported by the EEC and/or Japan/Korea due to the import tariff are not large enough to influence wheat prices at U.S. export ports although price elasticities of export supply in the U.S. are less elastic than price elasticities of import demand in the EEC and Japan/Korea. An import quota gives similar effects to U.S. wheat producers and to consumers in importing regions. This, in general, indicates that trade restrictions are more expensive to importing regions than to U.S. wheat producers. Because of differences in import demand elasticities between the EEC and Japan/Korea, an import tariff in the EEC is more effective than a quota in controlling wheat imports, but an import quota is more effective in Japan/Korea. This could be a major reason why the EEC imposes a tariff on wheat imports and Japan/Korea imposes a quota. When the EEC and Japan/Korea impose tariffs and quotas, respectively, the largest reductions in wheat prices result at U.S. ports and increases result in importing regions. The trade restrictions also result in a substantial reduction in social benefits in both the United States and importing regions. However, the social benefit loss in importing regions is greater than in the United States.

The impacts of trade restrictions on winter wheat are different than those on spring and durum wheat, according to this study. Reductions in spring and durum wheat prices are much smaller than in winter wheat prices when the restrictions are imposed in the EEC and Japan/Korea.

Effects of Ocean Transportation Rates

Changes in ocean freight rates influence wheat prices at U.S. export ports more than in importing regions according to this study. Approximately 80 percent of ocean freight rates increases (85 percent for winter wheat and 70 percent for spring wheat and durum wheat) is borne by U.S. wheat producers, resulting in substantial decreases in wheat prices at U.S. ports. This indicates that volatility in ocean freight rates are a major source of price uncertainty at U.S. export ports.

Effects of Domestic Transportation Rates

Unlike ocean freight rates, changes in domestic freight rates do not influence wheat prices at U.S. export ports. These changes in the freight rates are mainly absorbed by farmers in producing regions. Shipments of wheat for domestic and export market are generally dominated by railroads. In the study, railroads ship approximately 85 percent of wheat marketed for export and trucks play a major role for domestic shipments of wheat.

Export Facilities

The quantities of wheat actually exported in 1980 are similar to the optimal quantities of wheat handled at each port in the base model. The total quantities of wheat handled at the Atlantic, Gulf, West Coast, and Great Lakes are 4, 51, 34, and 11 percent of the total wheat exported, respectively, in the base model. They were 5, 46, 41, and 8 percent of the wheat exported in 1980. This indicates that wheat shipments through the Gulf and Great Lakes ports should be expanded to maximize social benefits in both the U.S. and importing regions.

Wheat Marketing System in 1990

The total quantity of wheat sold in domestic and export markets in 1990 is 2,197 million bushels based on the projected 1990 U.S. export supply and foreign import demand equations, which is approximately 13 percent larger than the quantity traded in 1980. This growth in trade can be attributed to increases in wheat exports rather than domestic consumption. The 1990 exports are about 19 percent higher than the 1980 exports.

In 1990, market shares of domestic shipments of winter, spring, and durum wheat are 73, 21, and 6 percent of total wheat marketed, respectively. They are 79, 16, and 5 percent for export shipments. These 1990 market shares are almost identical to the 1980 market shares.

The 1990 equilibrium prices for winter and spring wheat at each U.S. export port are higher than the 1980 prices. However, the 1990 prices for durum wheat are lower than the 1980 durum wheat prices because of reductions in foreign import demand for durum wheat. These 1990 equilibrium prices are estimated on the basis of the projected U.S. export supply and foreign import demand equations for 1990. Consequently, changes in import demand and export supply conditions could result in different equilibrium prices in 1990.

The quantities of wheat shipped by rail, barge, and trucks are 1,534, 268.3, and 394.4 million bushels, respectively, in 1990. When compared with the 1980 modal share, quantities of wheat shipped by rail are substantially increased while those shipped by other modes remain constant. This is due mainly to an increase in wheat exports whose shipments are dominated by railroads.

II. Introduction

The dependence of the U.S. agricultural economy on foreign trade has been growing over recent decades. U.S. grain exports tripled from 1950 through the early 1970s and then doubled again during the rest of the decade (U.S. Department of Agriculture). Since U.S. exports have been highly volatile due mainly to uncertainty stemming from the supply side in importing regions, U.S. farmers have been facing greater uncertainty in the export market. The uncertainty has been recently fueled by several factors: trade restrictions, unstable transportation rates in shipping grain from exporting countries to importing countries, unstable dollar value in foreign exchange market, and diplomatic uses of agricultural trade (export embargo).

Major grain importing countries such as the European Economic Community (EEC) and Japan insulate their agricultural sector from the unstable world grain market by imposing trade restrictions on their grain imports. Restrictions include tariffs, variable levies, and quotas. The EEC controls imports through variable import levies and Japan through import quotas. The trade restrictions generally provide a high degree of price stability in importing countries but result in greater price uncertainty in exporting countries.

Transportation costs in shipping grain from farms in exporting countries to importing countries are another major source of trade uncertainty (Binkley; Furton et al.). The transportation costs can be composed of two parts: domestic transportation costs in shipping grains from producing regions to domestic consuming regions and export ports, and ocean transportation costs in shipping grains from export ports to foreign importing regions. Domestic transportation costs are relatively more stable than ocean freight rates in shipping grain. Ocean freight rate indexes for grain declined about 160 percentage points from 389.7 in 1980 to 227.5 in 1982 (Maritime

Research, Inc.); however, rail transportation indexes for grain increased about 32 percentage points from 127.9 to 159.5 in the same period (U.S. Department of Agriculture). In addition, differences in ocean freight rates associated with different routes are much greater than those associated with domestic routes. Consequently, grain price volatility is influenced more by ocean freight rates than by domestic transportation costs.

Substitution of fixed exchange rates to a floating exchange system has contributed to instability of grain trade. Depreciation of the U.S. dollar value against foreign currencies makes U.S. grain relatively cheaper in foreign markets and improves the U.S. trade position in the World Grain Market, and vice versa. Consequently, grain trade is dependent upon not only grain price but also the national economy.

Finally, diplomatic uses of grain trade, such as an export embargo have been another source of trade uncertainty. One important development in the U.S. grain trade has been the willingness of communist countries to buy grain for human as well as livestock use during years of poor grain production in those countries. However, grain trade has been politically used against communist countries, causing disorder in international grain trade.

Another important trade issue is price differences between export and import countries and among U.S. export ports. For example, the average export price of wheat (FOB) was $5.92 per bushel in the Pacific Northwest ports and $5.44 per bushel in the Gulf ports in 1981 (International Wheat Council). Price differentials are mainly due to import demand, export supply, trade restrictions, and/or transportation costs.

Price formation under alternative trade restrictions has been studied by Bale and Lutz, Carter and Schmitz, Johnson et al., and Shei and Thompson. Bale and Lutz theoretically discussed impacts of alternative trade interventions on price instability. Carter and Schmitz analyzed the distribution of welfare and price formation in the U.S., the EEC, and Japan under optimal tariff rates. Johnson et al. and Shei and Thompson focused on spatial price determination in import and export countires under alternative trade restrictions and policies. These studies did not discuss the impacts of trade restrictions and changing transportation costs on the spatial equilibrium conditions for U.S. grain exports. Rather, the studies concentrated on the trade equilibrium among trading countries.

Farm income is directly related to trade instability and spatial price differentials. Consequently, those factors affecting trade instability and price differentials could be investigated to improve the U.S. grain marketing structure as well as farm income. These factors will also have a direct impact on North Dakota producers and their ability to market grain, both domestically and internationally.

The general objective is to evaluate spatial equilibrium conditions for the U.S. wheat industry under alternative trade restrictions and transportation rate levels. The specific objectives are as follows:

1. **To analyze the effects of alternative trade restrictions and transportation rate levels on U.S. wheat exports, prices, and social benefits; and**
2. **Evalute the spatial equilibrium condition for the U.S. wheat industry in 1990.**

III. World Wheat Production and Trade

Wheat is a major food grain for a large part of the world. It is widely used in bread, pasta, and bakery goods.

Wheat production increased from 347 million metric tons to 451 million metric tons over the 10-year period from 1971 to 1980 (Table 1). The Soviet Union ranks first, the U.S. second, and China third in wheat production. Wheat production in the Soviet

TABLE 1. WHEAT PRODUCTION BY COUNTRIES OR REGIONS

Major Wheat Producing Countries	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981
	1,000 metric tons											
USA	36,783	44,029	42,046	46,402	48,879	57,886	58,481	55,671	48,322	58,080	64,619	76,025
Canada	9,022	14,412	14,514	16,159	13,295	17,081	23,587	19,862	21,145	17,184	19,158	24,780
Australia	7,890	8,510	6,510	11,987	11,357	11,982	11,800	9,370	18,090	16,188	10,856	16,372
Argentina	4,920	5,680	6,900	6,560	5,970	8,570	11,000	5,300	8,100	8,100	7,780	7,900
Subtotal	58,615	72,631	69,970	81,108	79,501	95,519	104,868	90,203	95,657	99,552	102,413	125,077
EEC	36,608	41,755	43,154	41,429	45,381	40,039	41,466	40,125	50,304	48,826	55,089	10,648
Eastern Europe	22,810	30,239	30,646	31,481	34,048	24,326	28,694	28,683	30,470	23,175	29,368	26,300
Other Europe	7,160	9,060	8,039	9,372	11,259	12,794	15,208	13,103	13,623	11,441	14,679	10,648
U.S.S.R.	82,700	98,760	85,950	109,784	83,849	66,224	96,882	92,161	120,936	90,207	98,182	88,000
Central America	2,230	1,939	1,745	2,039	2,231	2,798	3,363	2,456	2,785	2,273	2,785	3,190
South America	8,733	9,256	8,866	9,866	10,568	11,990	16,272	8,709	12,230	12,640	11,761	11,281
China	24,500	24,000	28,000	30,150	31,200	46,000	50,500	41,000	54,000	62,700	54,155	58,490
Other Asia	44,585	50,075	54,575	50,952	49,293	59,596	68,210	67,048	70,249	76,854	74,191	81,050
Africa	7,431	8,876	9,345	8,736	8.828	10,218	7,743	8,522	8,774	8,774	8,743	9,077
Subtotal	236,757	237,960	270,320	293,462	276,565	272,595	330,813	301,028	363,119	336,890	348,953	342,515
Total World	295,372	346,591	340,290	374,570	356,066	368,114	435,681	391,231	458,776	436,442	451,366	467,592

SOURCE: Review of the World Wheat Situation

Union and China account for approximately 35 percent of the world wheat production. However, the two countries nomally import wheat from other wheat exporting countries. The major wheat exporters — the United States, Canada, Argentina, and Australia — produce only 30 percent of the world wheat production and export over 50 percent of their production (Table 2).

TABLE 2. NET WHEAT EXPORTS AS PERCENTAGE OF DOMESTIC PRODUCTION

Year	USA	Canada	Australia	Argentina
1970	53.8	131.1	116.1	19.7
1971	37.0	95.1	90.5	28.7
1972	72.2	108.3	65.4	39.1
1973	72.3	70.4	58.3	24.1
1974	60.0	80.4	75.4	29.9
1975	55.2	71.3	72.3	36.9
1976	44.2	56.8	81.2	53.6
1977	55.0	80.4	90.3	31.6
1978	66.2	62.1	57.4	46.2
1979	64.4	87.7	91.9	59.3
1980	64.8	88.5	97.2	50.0
1981	64.4	68.0	68.7	54.4

SOURCE: Review of the World Wheat Situation.

A sizable quantity of world wheat production, about 20 percent, is traded internationally. The major wheat exporters (the U.S., Canada, Argentina, and Australia) export 90 percent of all the wheat traded on the international market. The U.S. is the largest exporter, accounting for approximately 45 percent of world trade in wheat (Table 3). Canada is the second largest wheat exporter with a market share of approximately 20 percent. The wheat trade in the international market increased approximately 70 percent over the decade from 59 million metric tons in 1971 to 94 million metric tons in 1980. U.S. wheat exports increased much faster than the world average. The increase was 188 percent from 17 million metric tons in 1971 to 49 million metric tons in 1981 (Table 3).

The leading importers of wheat are China, the EEC, Japan, the Soviet Union, and Brazil. These countries account for about one-half of all imports. Other significant wheat importers include Eastern Europe and Africa.

IV. Methodology

The spatial equilibrium condition of a single commodity with tariffs and transportation costs is shown in Figure 1. The quantity of a commodity traded (OQ) is equal to the quantity exported (ef) or the quantity imported (gh) at the equilibrium price (OP) with the absence of transportation costs and tariffs. With the existence of tariffs and transportation costs measured by the vertical distance between import demand and export supply curves, price differences between import and export regions are equal to the sum of the tariffs and transportation costs. The tariffs and transportation costs are shared by import and export countries depending upon the price elasticities of export supply and import demand. In Figure 1, tariffs and transportation costs, as measured by distance ab, increase price in the importing country from OP to OP_1 and decrease the price in the exporting country from OP to OP_2. The increase in prices in the importing country results in a decrease in the quantity of a commodity traded from OQ to OQ_1. The portion of price change borne by the importer (PP_1) and that borne by producers in the exporting country (PP_2) can be calculated as a function of supply and demand elasticities (Kreinin) as follows:

TABLE 3. WHEAT EXPORTS BY MAJOR EXPORTING COUNTRIES AND THEIR MARKET SHARE

Year	USA	Canada	Australia	Argentina	World Total
	million metric tons				
1970	19.8(33.8)	12.6(21.2)	9.5(16.2)	1.6(2.7)	58.5
1971	16.9(28.8)	15.8(26.9)	8.7(14.8)	1.3(2.2)	58.7
1972	31.8(43.7)	15.6(21.5)	5.6(7.7)	3.4(4.7)	72.7
1973	31.1(49.7)	11.5(18.4)	5.4(8.6)	1.1(1.8)	62.6
1974	28.0(43.9)	11.2(17.6)	8.2(12.9)	2.2(3.4)	63.8
1975	31.5(47.5)	12.1(18.2)	7.9(11.9)	3.2(4.8)	66.3
1976	25.7(40.7)	12.9(20.4)	8.4(13.3)	5.6(8.9)	63.1
1977	29.7(43.0)	16.0(23.2)	9.5(13.8)	2.2(3.2)	69.0
1978	37.2(43.3)	15.0(17.4)	14.9(17.3)	4.8(5.6)	72.0
1979	37.2(43.3)	15.0(17.4)	14.9(17.3)	4.8(5.6)	86.0
1980	41.9(44.6)	17.0(18.1)	10.6(11.3)	3.9(4.2)	93.9
1981	48.9(52.1)	17.0(18.1)	11.0(11.7)	4.3(4.5)	98.7

Numbers in parenthesis indicate export market share of the exporting countries.
SOURCE: Wheat Outlook and Situation (USDA).

(1) $$pp_1 = \left(\frac{e_x}{|e_m| + e_x}\right) \overline{ab}$$

(2) $$pp_s = \left(\frac{e_m}{|e_m| + e_x}\right) \overline{ab}$$

where e_x is price elasticity of export supply and e_m is price elasticity of import demand. Likewise, import quotas influence the price of the commodity in much the same way as does the tariff (Kreinin).

When several importing countries trade with one exporting country, prices in the exporting country are influenced differently by tariffs and by transportation costs. An import tariff imposed by a country is applied to only the portion of total grain that country imports. Impacts on prices in the exporting country of the tariff imposed by an importing country are, therefore, dependent upon the import country's market share of the total quantity traded, in addition to price elasticities of export supply and import demand. In applying Equations 1 and 2 to calculate changes in prices due to a tariff imposed by an importing country in a multiregional trade case, the price elasticity of export supply associated with that country's imports should be used instead of the total supply elasticity.[1] On the other hand, when transportation costs are changed in an exporting country, the costs should be applied to the total quantity of commodity traded. Impacts of changes in transportation costs on prices in importing and exporting countries are, therefore, dependent upon price elasticities of export supply and import demand, regardless of the quantities of commodity imported by each importing country.

The Model

A spatial equilibrium model for the U.S. wheat industry is developed on the basis of a quadratic programming algorithm. The model incorporates transportation and storage activities in shipping wheat from producing areas to domestic regions and foreign importing countries. The criterion for this study is to maximize social benefits, defined as the

[1]The price elasticity of supply associated with a country's import for a given product is inversely related to its share in the world market. Assume that Q_s is the total exports of a given product and Q_d is the quantity of the commodity imported by the other countries and Q_s-Q_d is the quantity of the commodity imported by the country, A, in question. Then, price elasticity of supply of country A's import (e_A) can be calculated as follows:

$$e_A = \frac{\Delta(Q_s-Q_d)}{\Delta_p} \quad \frac{P}{(Q_s-Q_d)}$$

$$= \frac{\Delta Q_s}{\Delta P} \quad \frac{P}{Q_s} \quad \frac{Q_s}{Q_s-Q_d} \quad \frac{\Delta Q_d}{\Delta\Delta P} \quad \frac{P}{Q_d} \quad \frac{Q_d}{(Q_s-Q_d)}$$

$$= e_s \quad \frac{Q_s}{Q_s-Q_d} \quad -e_d \quad \frac{Q_d}{Q_s-Q_d}$$

where e_s is the total supply elasticity of the product and e_d is the demand elasticity from the other import countries. This indicates that e_A can be very elastic even if e_s is inelastic.

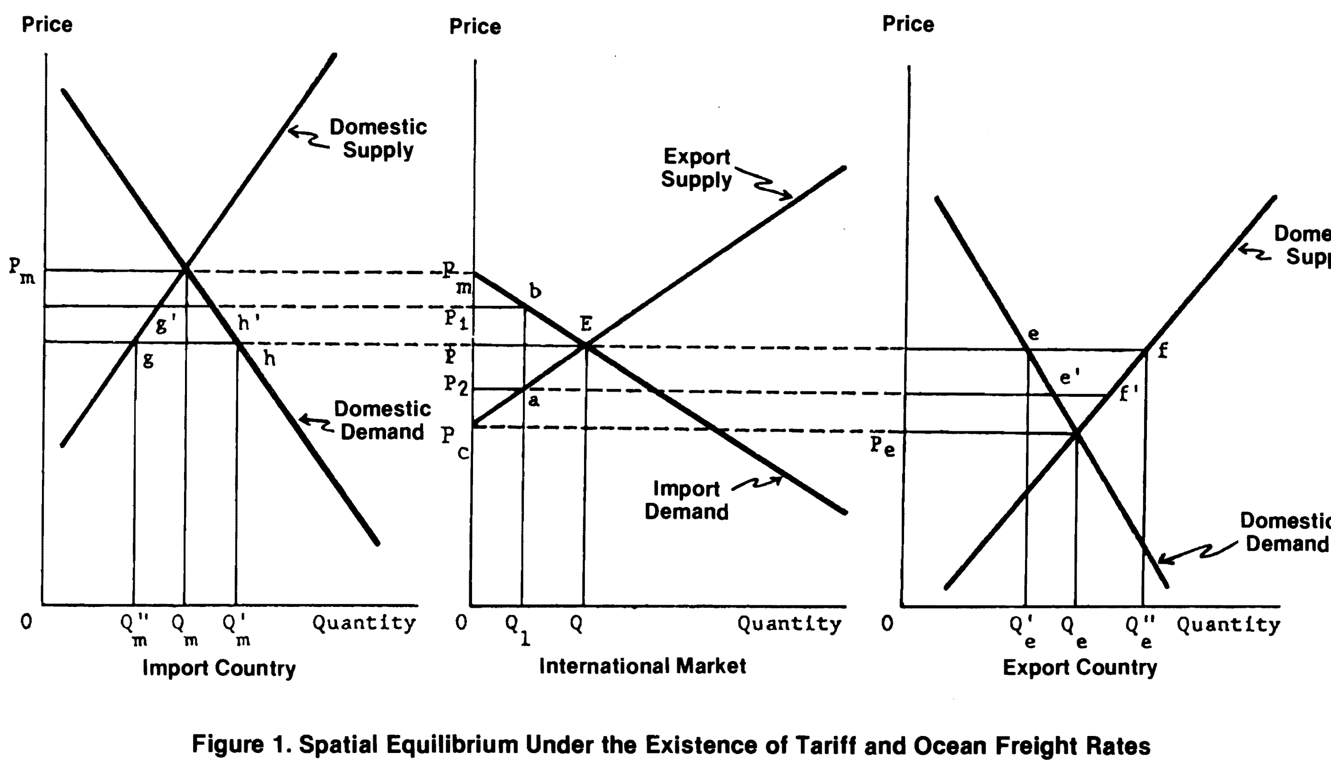

Figure 1. Spatial Equilibrium Under the Existence of Tariff and Ocean Freight Rates

net social payoff by Samuelson. The social payoff is measured by the sum of consumer and producer surplus obtained from the international wheat market. In Figure 1, the value of social payoff is equal to the sum of the area P_mEP (importers surplus) and the area PEP_c (exporters surplus). The basic structure of the model is similar to those developed by Furton et al., Takayama and Judge, and Shei and Thompson. The only difference is that the model used in this study includes domestic transportation activities associated with wheat shipments from producing regions to domestic consuming regions and export ports and excludes trade activities associated with other wheat export countries. The domestic transportation activities are included because prices at U.S. ports are influenced by changes in domestic transportation, ocean transportation, and trade restrictions. The trade activities associated with other exporting countries are excluded because the model becomes too large to manage when those trade activities are included. In addition, it is assumed that export prices at U.S. ports are not largely influenced by trade activities associated with other wheat exporting countries because the U.S. is a price leader in the oligopolistic world wheat export market.

The model incorporates estimated export supply equations in each U.S. port. Fixed quantities of domestic demand and supply of wheat are incorporated as a constraint in consuming and producing regions, respectively. Domestic producing regions are linked to export ports through alternative transportation activities in shipping wheat from producing regions to export ports. Similarly, producing regions are connected to domestic consuming regions through alternative domestic transportation activities in shipping grain from producing regions to consuming regions. Import demand equations in each importing region are incorporated and linked to U.S. ports through ocean transportation activities in the model.

The model contains 49 domestic wheat producing regions and 23 domestic consuming regions (Figures 2 and 3). Producing regions are delineated on the basis of wheat production location and domestic consuming regions on the basis of wheat processing capacities. The model includes 12 ports: two from the Atlantic Coast, four from the Gulf, three from the West Coast, and three from the Great Lakes (Figure 4). Foreign importing regions used in this study are the EEC (Western Europe), Eastern Europe,

Figure 2. Domestic Consuming Regions

Figure 3. Domestic Producing Regions

Figure 4. Commercial Storage Locations and Export Ports

Africa, the Middle East, South Asia, West Asia, Japan and Korea, Central America, Brazil and Venezuela, South America, and the U.S.S.R. Nine commercial storage locations are selected mainly from the Great Plains states to capture commercial storage activities (Figure 4).

The model includes three different classes of wheat; winter, spring, and durum. Each wheat has unique production and consumption characteristics which make marketing activities of one wheat different from the others.

Four modes of transportation (rail, truck, barge, and ocean vessel) are included in the study. Transportation activities associated with the modes of transportation are: 1) shipments of grain from producing regions to domestic consuming regions, 2) shipments from producing regions to ports, and 3) shipments from U.S. ports to foreign importing regions. Barge transportation activities are coordinated with rail and truck transportation through inland water ports on the Mississippi River, the Great Lakes, and the Columbia-Snake River system. The model includes 40 water access points as inland water ports on the river system.

The Objective Function

The objective function (net social payoff) is calculated on the basis of wheat export supply equations for winter, spring, and durum wheat at each U.S. export port and import demand functions for winter, spring, and durum wheat in each importing region. The net social payoff (W) is the social payoff less transportation costs in shipping wheat from-producing regions to domestic consuming and importing regions (Samuelson).

The objective function is expressed as follows:

$$(3)\quad W = \sum_{g=1}^{3}\sum_{h=1}^{12}\int_{0}^{p} ES_{gh}dP_{gh} + \sum_{g=1}^{3}\sum_{n=1}^{11}\int_{p}^{p^*} ED_{gn}\,dP_{gn}$$
$$-\sum_{g=1}^{3}\sum_{i=1}^{47}\sum_{j=1}^{23} C_{gij}DX_{gij} - \sum_{g=1}^{3}\sum_{i=1}^{47}\sum_{s=1}^{9} C_{gis}SX_{gis}$$
$$-\sum_{g=1}^{3}\sum_{i=1}^{47}\sum_{h=1}^{12} C_{gin}EX^{2}{}_{gih} - \sum_{g=1}^{3}\sum_{h=1}^{12}\sum_{n=1}^{11} C_{ghn}EX^{2}{}_{ghn}$$

where $ES_{gh}(=\alpha_{ogh}+\alpha_{gh}+P_{gh})$ is the export supply function for wheat g in port h

$ED_{gn}(=\beta_{0gn}-\beta_{1gn}P_{gn})$ is the import demand function for wheat g in importing region n

DX_{gij} is the quantity of wheat g shipped from producing region i to domestic consuming region j

p^* is the price-axis intercept of the import demand curve $(=\beta_0/\beta_1)$

SX_{gis} is the quantity of wheat g shipped from producing region i to commercial storage location s

$EX^1{}_{gih}$ is the quantity of wheat g shipped from producing region i to export port h

$EX^2{}_{ghn}$ is the quantity of wheat g shipped from export port h to foreign importing region n

C represents total transportation costs for the corresponding transportation activities.

Constraints for the Base Model

The objective function is subject to the following constraints:

$$(4)\ S^{u}_{gi} > \sum_{j=1}^{23} DX_{gij} + \sum_{s=1}^{9} SX_{gis} + \sum_{h=1}^{12} EX^{1}_{gih} \quad i=1, 2, ...47;\ g=1, 2, 3$$

$$(5)\ S^{m}_{gi} < \sum_{j=1}^{23} DX_{gih} + \sum_{s=1}^{9} SX_{gis} + \sum_{h=1}^{12} EX^{1}_{gih} \quad i=1, ...47;\ g=1, 2, 3$$

$$(6)\ DD_{gj} < \sum_{i=1}^{47} DX_{gij} \quad j=1, 1, ...23;\ g=1, 2, 3$$

$$(7)\ SC_{s} > \sum_{g=1}^{3} \sum_{i=1}^{47} SX_{gis} \quad s=1, 1, ...9$$

$$(8)\ \beta_{ogn} - \beta_{1gn} \quad P_{gn} = \sum_{h=1}^{12} EX^{2}_{ghn} \quad g=1, 2, 3;\ n=1, 2, ...11$$

$$(9)\ \alpha_{ogh} + \alpha_{1gh} \quad P_{GH} = \sum_{i=1}^{47} EX^{1}_{gih} \quad g=1, 2, 3;\ h=1, 2, ...12$$

$$(10)\ \sum_{i=1}^{47} EX^{1}_{gih} = \sum_{n=1}^{11} EX^{2}_{ghn}$$

$$(11)\ P_{gn} - P_{gn} < t_{n} + C_{ghn} \quad g=1, 2, 3;\ n=1, 2, ...11;\ h=1, 2, ...12$$

where S^{u}_{gi} is the quantity of wheat g available in producing region i

S^{m}_{gi} is the minimum quantity of wheat g which must be sold in producing region i

DD_{gj} is the quantity of wheat g required in domestic consuming region j

$\sum_{h=1}^{12} EX^{2}_{ghn}$ is import demand for wheat g in importing region n (ED_{gn})

$\sum_{i=1}^{47} EX^{1}_{gih}$ is export supply of wheat g in export port h (ES_{gh})

SC_{s} is the wheat storage capacity at commercial storage location s

t is import tariff imposed by importing region n

and other variables are previously defined.

Equations 4, 6, and 7 represent domestic supply, domestic demand, and storage capacity constraints, respectively. Equation 5 represents farm storage capacities in producing regions. Equations 8 and 9 are introduced to meet import demand and export supply conditions in importing and exporting regions, respectively. Equation 10 represents an inventory-clearing condition at U.S. ports, indicating that the quantity of wheat received by each port from domestic producing regions must be equal to the quantity of wheat shipped to importing regions. Equation 11 indicates that there will be no trade between two countries if price differences between these regions are equal to or less than the sum of import tariffs (t_{n}) and ocean freight rates (C_{ghn}). This equation meets the Kuhn-Tucker condition for the optimal solution of the model. Spatial equilibrium prices are determined subject to Equations 8, 9, and 11.

This study contains base models for 1980 and 1990 which are identical in terms of model structure. The only difference is that while the 1980 model is based on 1980 data for demand for wheat, supply of wheat, and transportation costs, the 1990 model is based on projected demand and supply data for 1990. In addition, the study contains 16 alternative models that are based on alternative trade restrictions and transportation cost structures. The models are described in Table 4.

The alternative models are compared with the 1980 base model to evaluate impacts of alternative trade restrictions and changes in ocean freight rates and domestic transportation costs on the U.S. wheat industry. Models 2 through 7 evaluate the effects of alternative trade restrictions on the U.S. wheat export market. Models 8 through 13 evaluate the impacts of changes in ocean freight rates on the U.S. wheat export market and distribution system. Finally, Models 14 through 17 analyze the U.S. wheat distribution system under alternative rail and barge transportation cost structures.

TABLE 4. DESCRIPTION OF THE BASE AND ALTERNATIVE MODELS

Model	Description
Model 1	1980 base model (equation 3 through 11)
Model 1(A)	1990 model
Model 2	$1.00 tariff is imposed in the EEC
Model 3	A 20 percent reduction in imports (Quota) is imposed in the EEC
Model 4	$1.00 tariff is imposed in Japan/Korea
Model 5	A 20 percent reduction in imports (Quota) is imposed in Japan/Korea
Model 6	$1.00 tariff is imposed in both the EEC and Japan/Korea
Model 7	$1.00 tariff is imposed in the EEC and quota is imposed in Japan/Korea
Model 8	20 percent increase in ocean freight rates
Model 9	40 percent increase in ocean freight rates
MOdel 10	25 percent increase in ocean freight rates between the Atlantic ports and import regions
Model 11	25 percent increase in ocean freight rates between the Gulf ports and import regions
Model 12	25 percent increase in ocean freight rates between the West Coast ports and import regions
Model 13	25 percent increase in ocean freight rates between the Great Lakes ports and import regions
Model 14	10 percent increase in rail transportation costs
Model 15	20 percent increase in rail transportation costs
Model 16	10 percent increase in barge transportation costs
Model 17	20 percent increase in barge transportation costs

Abbreviated Tableau for the Base Model

The base model used for this study has an objective function in quadratic form and a set of linear equations as constraints of the model. The software package used to solve the quadratic programming model is **Minos** developed at Stanford University (Murtagh and Saunders).

A prototype model is developed to show relationship between activities associated with objective function and constraints. The prototype model contains one class of wheat, one mode of transportation, two import regions, three U.S. ports, three domestic producing regions, three domestic consuming regions, and two storage locations. The import demand equations are assumed to be as follows:

$$ED_1 = \alpha_{11} - \alpha_{11} P_{m1}$$
$$ED_2 = \alpha_{12} - \alpha_{22} P_{m2}$$

Export supply equations are assumed to be as follows:

$$ES_1 = \beta_{11} + \beta_{21} P_{sl}$$
$$ES_2 = \beta_{12} + \beta_{ss} P_{s2}$$
$$ES_3 = \beta_{13} + \beta_{23} P_{s3}$$

The objective function which is the net social payoff calculated form the export supply and import demand equations is expressed as follows:

$$W = \sum_{h=1}^{3} \beta_{1h}P_{sh} + \sum_{h=1}^{3} \beta_{2h}P^2_{sh} - \sum_{n=1}^{2} \alpha_{in}P_{mn}$$

$$+ \sum_{n=1}^{2} \alpha_{2n}p^2_{mn} + \tfrac{1}{2} \sum_{n=1}^{2} \alpha^2_{1n}/\alpha_{2n} - \sum_{i=1}^{3} \sum_{j=1}^{3} C_{ij}DX_{ij}$$

$$- \sum_{i=1}^{3} \sum_{s=1}^{2} C_{is}SX_{is} - \sum_{i=1}^{3} \sum_{h=1}^{3} C_{ih}EX^1_{ih} - \sum_{h=1}^{3} \sum_{n=1}^{3} C_{hn}EX^2_{hn}$$

The objective function is maximized subject to the same constraints as those associated with the base model (Equations 4 through 11). The linear portions of the objective functions and the constraints are delineated in the context of the linear programming tableau shown in Figure 5. The nonlinear variables are separately treated in a special subroutine in **Minos** (Murtagh and Saunders).

Data Collection

Data used for the model are demand for wheat in domestic consuming regions, supply of wheat in producing regions, and transportation costs in shipping wheat from producing regions to domestic consuming and foreign importing regions. In addition, the model incorporates export supply equations in U.S. export ports and import demand equations in importing regions.

Estimated Export Supply and Impact Demand Equations

Export supply equations are derived from export supply elasticities of U.S. wheat at average export quantity and price levels.[2] Export supply elasticity of each class of wheat (e_x) is obtained from price elasticities of domestic demand (e_d) and domestic supply (e_s) as follows:

$$(11)\quad e_s = \frac{Q_s}{Q_e}\, e_s + \frac{Q_d}{Q_e}\, |e_d|$$

where Q_x is the total quantity of wheat supplied, Q_e is the total quantity of wheat exported, and Q_c is the total quantity of wheat domestically consumed. Quantities of each wheat supplied, exported, and demanded are three-year averages (1978-1980) of the data obtained from the **Grain Market News** (U.S. Department of Agriculture). Price elasticities of domestic supply and demand for each class of wheat are obtained from supply and demand functions for wheat which were empirically estimated from time series data from 1961 to 1980 (Koo, 1982). The estimated price elasticities of domestic supply are 0.099 for winter wheat, 0.218 for spring wheat, and 0.132 for durum wheat. The estimated price elasticities of domestic demand are -0.259 for winter wheat, -0.595 for spring wheat, and -0.455 for durum wheat. Finally, export supply elasticities estimated from Equation 11 are 0.219, 0.508, and 0.466 for winter, spring, and durum wheat, respectively. It is assumed the price elasticities are the same at all U.S. export ports. The 1980 estimated equations for winter, spring, and durum wheat for 1980 in each U.S. port are shown in Table 5.

The 1990 export supply equations for winter, spring, and durum wheat at each U.S. export port are determined on the basis of the estimated elasticities of export supply and the projected quantities of wheat exported at each port in 1990. The projected quantities are calculated by allocating the projected total quantity of U.S. wheat exports in 1990 on the basis of a three-year average of grain inspected at each U.S. port for export. The export projection is obtained from the U.S. Department of Agriculture (NIRAP projection). The estimated export supply equations for classes of wheat are shown in Table 6.

Import demand equations for each class of wheat are derived from import demand elasticities at average import quantity and price levels in each importing region.[3] Import demand elasticity (e_m) for each class of wheat is obtained from price elasticities of domestic demand (e_d) and domestic supply (e_s) in importing regions as follows:

$$(12)\quad e_m = \frac{Q_d}{Q_m}\,|e_d| + \frac{Q_s}{Q_m}\, e_s$$

---

[2]Suppose a linear supply equation is specified as $Q_s = \alpha_0 + \alpha_1 P_s$. The intercept ($\alpha_0$) and slope ($\alpha_1$) of the equation can be derived as follows:

$$\alpha_1 = e_s \frac{Q_s}{Ps} \quad \text{and} \quad \alpha_0 = \overline{Q_s} - \alpha_1 \overline{P_s};$$

where e_s is price elasticity of supply equation, Q_s is a mean quantity of supply and P_s is a mean price in supply region.

[3]Suppose that a linear demand equation is specified as $Q_d = \beta_0 - \beta_1 P_d$. The intercept ($\beta_0$) and slope ($\beta_1$) of the equation can be derived as follows:

$$\beta_1 = e_d \frac{Q_d}{P_d} \quad \text{and} \quad \beta_0 = Q_d + \beta_1 P_d.$$

Where e_d is price elasticity of demand equation, Q_d is a mean quantity of demand and P_d is a price in demand region.

Activities	P_{m1}	P_{m2}	P_{s1}	P_{s2}	P_{s3}	DX_{11}	DX_{12}	DX_{13}	DX_{21}	DX_{22}	DX_{23}	DX_{31}	DX_{32}	DX_{33}	SX_{11}	SX_{12}	SX_{21}	SX_{22}	SX_{31}	SX_{32}	EX^{1}_{11}	EX^{1}_{12}	EX^{1}_{13}	EX^{1}_{21}	EX^{1}_{22}	EX^{1}_{23}	EX^{1}_{31}	EX^{1}_{32}	EX^{1}_{33}	EX^{2}_{11}	EX^{2}_{12}	EX^{2}_{21}	EX^{2}_{22}	EX^{2}_{31}	EX^{2}_{32}		RHS
Objective Value	$-\alpha_{11}$	$-\alpha_{12}$	β_{11}	β_{12}	β_{13}	$-C_{11}$	$-C_{12}$	$-C_{13}$	$-C_{21}$	$-C_{22}$	$-C_{23}$	$-C_{31}$	$-C_{32}$	$-C_{33}$	$-C_{11}$	$-C_{12}$	$-C_{21}$	$-C_{22}$	$-C_{31}$	$-C_{32}$	$-C_{11}$	$-C_{12}$	$-C_{13}$	$-C_{21}$	$-C_{22}$	$-C_{23}$	$-C_{31}$	$-C_{32}$	$-C_{33}$	$-C_{11}$	$-C_{12}$	$-C_{12}$	$-C_{22}$	$-C_{31}$	$-C_{32}$		
Domestic Supply (maximum)						1	1	1							1	1					1	1	1													≤	S_1^u
									1	1	1						1	1						1	1	1										≤	S_2^u
												1	1	1					1	1							1	1	1							≤	S_3^u
Domestic Supply (minimum)						1	1	1							1	1					1	1	1							-1	-1					≥	S_1^m
									1	1	1						1	1						1	1	1						-1	-1			≥	S_m^2
												1	1	1					1	1							1	1	1					-1	-1	≥	S_m^3
Domestic Demand						1			1			1																								≥	DD_1
							1			1			1																							≥	DD_2
								1			1			1																						≥	DD_3
Storage Capacity															1		1		1																	≤	SC_1
																1		1		1																≤	SC_2
Import Equilibrium	α_{21}																													1		1		1		=	α_{11}
		α_{22}																													1		1		1	=	α_{12}
Export Equilibrium			β_{21}																											-1	-1					=	β_{11}
				β_{22}																												-1	-1			=	β_{12}
					β_{23}																													-1	-1	=	β_{13}
Inventory Clearing																					1			1			1			-1	-1					=	0
																						1			1			1				-1	-1			=	0
																							1			1			1					-1	-1	=	0
Statial Equilibrium Condition	1			-1																																	C_{11}
		1		-1																																	C_{12}
	1				-1																																C_{21}
		1			-1																																C_{22}
	1					-1																															C_{31}
		1				-1																															C_{32}

Figure 5. Interrelation Between Objective Activities and Their Constraints, Base Model

TABLE 5. ESTIMATED EXPORT SUPPLY EQUATIONS FOR WINTER, SPRING, AND DURUM WHEAT, 1980

U.S. Ports	Winter		Spring		Durum	
	Intercept	Slope	Intercept	Slope	Intercept	Slope
1. Philadelphia	10,094.10	0.602	—	—	—	—
2. Norfolk	23,552.90	1.405	—	—	—	—
3. Mobile, AL	4,677.20	0.273	—	—	—	—
4. New Orleans, LA	102,898.71	5.999	21,639.70	4.309	4,589.20	0.587
5. Houston, TX	332,082.19	19.359	1,115.50	0.222	567.20	0.072
6. Corpus Christi	28,063.28	1.636	—	—	—	—
7. San Francisco, CA	26,624.29	1.613	—	—	4,449.80	0.596
8. Portland	234,293.75	14.190	31,841.30	6.126	1,112.46	0.149
9. Seattle	13,312.15	0.810	5,619.10	1.081	—	—
10. Duluth	—	—	39,958.30	9.363	24,046.30	3.471
11. Chicago	—	—	—	—	—	—
12. Toledo	13,913.60	0.968	—	—	—	—

Dependent variable equals quantities of export supplied in 1,000 bushels of not applicable.

TABLE 6. ESTIMATED EXPORT SUPPLY EQUATIONS FOR WINTER, SPRING, AND DURUM WHEAT, 1990

U.S. Ports	Winter		Spring		Durum	
	Intercept	Slope	Intercept	Slope	Intercept	Slope
1. Philadelphia	12,090.77	0.747	—	—	—	—
2. Norfolk, VA	27,901.56	1.723	—	—	—	—
3. Mobile, AL	4,650.00	0.281	—	—	—	—
4. New Orleans, LA	122,766.94	7.410	26,617.77	4,734	6,231.04	0.636
5. Houston, TX	392,482.56	23.689	687.44	0.122	778.66	0.079
6. Corpus Christi	34,412.33	2,077	—	—	—	—
7. San Francisco, CA	33,481.56	2,099	—	—	6,231.04	0.666
8. Portland, OR	280,876.44	17.612	40,738.89	7.003	1,528.46	0.163
9. Seattle	4,650.00	0.290	6,623.25	1.139	—	—
10. Duluth	41,075.00	0.003	50,298,.57	10.528	33,597.75	3.689
11. Chicago	4,358.60	0.314	—	—	—	—
12. Toledo	12,314.10	0.889	—	—	—	—

where Q_m is the quantity of wheat imported, and other variables are previously defined. It is assumed that price elasticities of domestic supply (e_s) are completely inelastic in importing regions (Shei and Thompson). Price elasticity of import demand is, therefore, calculated with the first term on the right hand side of Equation 12. Domestic consumption and imports were averaged over a three-year period (1978-1980) for each of the 11 importing regions. Information for domestic consumption and imports in importing regions was obtained in the **World Wheat Statistics** (International Wheat Council). Price elasticities of domestic demand for wheat in importing regions were taken from a study by Rojko et al. The estimated import demand elasticities for U.S. wheat are -1.97 in Western Europe, -1.23 in Eastern Europe, -0.41 in Africa, -0.36 in the Middle East, -0.6775 in South Asia, -2.16 in East Asia, -0.38 in Japan, -1.28 in Central America, -0.31 in Brazil and Venezuela, -0.33 in South Asia, and -2.85 in the U.S.S.R. It is assumed, since adequate data are not available, that the price elasticities are the same for winter, spring, and durum wheat in these importing regions. The estimated import demand equations for winter, spring, and durum wheat for 1980 are shown in Table 7.

The 1990 import demand equations for winter, spring, and durum wheat in each importing region are estimated on the basis of the estimated import demand elasticities and projected total quantities of wheat imported in each importing region in 1990. The projected quantities are calculated by allocating the projected U.S. exports on the basis of average imports in importing regions. The projected quantities of U.S. wheat exports are obtained from the U.S. Department of Agriculture (NIRAP projection). The estimated import demand equations are presented in Table 8.

Domestic Demand and Supply

Supply and demand for each class of wheat used in the model is a three-year average of the data from

TABLE 7. ESTIMATED IMPORT DEMAND EQUATIONS FOR WINTER, SPRING, AND DURUM WHEAT, 1980

Import Regions	Winter		Spring		Durum	
	Intercept	Slope	Intercept	Slope	Intercept	Slope
1. EEC	146,806.38	-17.472	178,247.04	-21.743	88,143.00	-8.961
2. Eastern Europe	105,668.74	-10.439	5,882.56	- 0.596	8.753.68	-0.739
3. Africa	106,953.71	- 5.623	9,703.38	- 0.523	33,449.65	-1.502
4. Middle East	158,798.83	- 7.625	14,721.74	- 0.523	—	—
5. South Asia	326,477.26	-22.856	82,146.26	- 5.549	—	—
6. West Asia	139,913.95	-15.642	18,457.68	- 1.984	—	—
7. Japan/Korea	213,237.62	-10.296	48,603.60	- 2.262	2,172.02	-0.089
8. Central America	97,757.91	- 9.489	33,271.07	- 3.098	2,910.33	-0.229
9. Brazil/Venezuela	101,275.30	- 4.167	25,661.24	- 1.013	6,913.99	-0.230
10. South American	111,033.77	- 4.836	1,895.22	- 0.079	3,560.50	-0.125
11. U.S.S.R.	449,101.41	-59.579	—	—	—	—

Dependent variable equals quantities of wheat demanded in 1,000 bushels.
[a]Not applicable.

TABLE 8. ESTIMATED IMPORT DEMAND EQUATION FOR WINTER, SPRING, AND DURUM WHEAT, 1990

Import Regions	Winter		Spring		Durum	
	Intercept	Slope	Intercept	Slope	Intercept	Slope
1. EEC	176,845.75	-21.047	214,720.00	-26.19	106,180.63	-10.80
2. Eastern Europe	128,259.500	-12.67	2,398.48	- 0.24	8,219.85	- 0.69
3. Africa	128,429.63	- 6.75	11,624.22	- 0.63	40,732.18	- 0.12
4. Middle East	190,162.19	- 9.13	17,535.37	- 0.86	71.03	- 0.00
5. South Asia	391,435.38	-27.43	98,595.88	- 6.66	0.00	0.00
6. West Asia	166,232.94	-18.59	7,288.70	- 0.79	0.00	0.00
7. Japan/Korea	255,502.06	-12.34	58,184.27	- 2.71	2,529.45	- 0.10
8. Central America	116,757.31	-11.33	39,666.65	- 3.69	3,518.15	- 0.28
9. Brazil/Venezuela	120,883.94	- 4.97	30,628.34	- 1.21	8,254.83	- 0.28
10. South America	133,726.88	- 5.80	2,253.83	- 0.09	4,231.11	- 0.15
11. U.S.S.R.	538,178.31	-71.40	0.00	0.00	0.00	0.00

1978 to 1980. Supply of wheat in each producing region is a sum of actual production and carryover stocks minus quantities of wheat used on-farm. On-farm stocks in each state were obtained from **Grain Stocks** (USDA). These data are the actual amount of wheat held as on-farm stocks in each state. The on-farm stocks are reallocated to each producing region by using the ratio of regional wheat production to the total state production from 1979 to 1980. The quantities of wheat used on-farm were obtained from the 1980 **Farm Use** (USDA). Both on-farm stocks and farm use were broken down into winter, spring, and durum according to the production proportion in each producing region. The total projected supply for 1980 is 2,639 million bushels; 1,946 million bushels for winter wheat, 526 million bushels for spring wheat, and 166 million bushels for durum wheat (Table 9).

The total projected supply for 1990 in each producing region is calculated on the basis of the 1990 state surplus projection by North Central Regional Committee (NC-137) and South Regional Committee (S-115) members. The surplus projection is calculated by subtracting quantities of wheat consumed by livestock in each state from the state production projection. For the states which do not have representatives to the NC-137 or S-115 regional committee or which did not participate in the 1990 state surplus grain projections, the state surplus projection is estimated on the basis of the 1990 state production projection by the U.S. Department of Agricultural (NIRAP projection). The quantities of wheat consumed are subtracted from the USDA projection for wheat production to estimate the surplus wheat in each state. The aggregate livestock consumption projection is obtained from the USDA (NIRAP projection) and is allocated to each state on the basis of wheat fed to livestock. The final adjustments for the state surplus projection are made by adding carryover stocks to the estimated state surplus projection. The carryover stocks used are the last five years' average U.S. carryover stock (1975-1980). The national carryover stocks are allocated to each state on the basis of the state storage capacity (Inventory Mangement Division, ASCS).

TABLE 9. ESTIMATED TOTAL WHEAT SUPPLY BY CLASSES OF WHEAT, 1980

Producing Region	Total	Winter	Spring	Durum
	1,000 bushels			
1. Wenatchee, Washington	165,436	147,667	17,769	
2. Bend, Oregon	80,050	74,464	5,586	
3. Chico, California	34,094	34,094		
4. Bakersfield, California	46,414	39,065		7,349
5. Grangeville, Idaho	34,766	27,231	7,533	
6. Pocatello, Idaho	66,250	27,334	38,916	
7. Nepha, Utah	10,689	8,338	2,351	
8. Flagstaff, Arizona	16,479	4,603		11,876
9. Great Falls, Montana	114,510	57,910	53,533	3,062
10. Bozeman, Montana	16,479	103,634	2,735	14
12. Casper, Wyoming	9,516	9,234	282	
13. Limon, Colorado	123,500	120,440	3,060	
14. Albuquerque, New Mexico	10,973	10,973		
15. Dickinson, North Dakota	87,093	1,182	39,922	45,989
16. Carrington, North Dakota	220,486	608	140,500	79,378
17. Rapid City, South Dakota	27,639	23,509	3,650	489
18. Huron, South Dakota	70,619	9,393	55,291	5,925
19. Alliance, Nebraska	38,456	38,456		
20. Lexington, Nebraska	83,510	83,510		
21. Scott City, Kansas	175,109	175,109		
22. Great Bend, Kansas	205,312	205,312		
23. Emporia, Kansas	60,231	60,231		
24. Woodward, Oklahoma	96,797	96,797		
25. Clinton, Oklahoma	60,076	60,076		
26. Henreyetta, Oklahoma	64,854	64,854		
27. Lubbock, Texas	83,103	83,103		
28. Corsicana, Texas	39,820	38,820		
29. Fort Stockton, Texas	2,636	2,636		
30. Cuero, Texas	2,636	2,636		
31. Alexandria, Minnesota	81,860	1,660	77,827	2,374
32. St. James, Minnesota	53,671	1,439	50,188	2,043
33. Boone, Iowa	3,371	3,371		
34. Sedalia, Missouri	84,640	84,640		
35. Malvern, Arkansas	32,065	32,065		
36. Richland Center, Wisconsin	4,515	3,777	738	
37. Springfield, Illinois	73,227	73,227		
38. Richmond, Kentucky	12,636	12,636		
39. Cookeville, Tennessee	11,007	11,007		
40. Flint, Michigan	33,859	33,859		
41. Anderson, Indiana	51,817	51,817		
42. Marion, Ohio	64,475	64,475		
43. Montgomery, Alabama	30,743	30,743		
44. Ithaca, New York	5,722	5,722		
45. State College, Pennsylvania	14,524	14,524		
46. Charlottesville, Virginia	9,957	9,957		
47. Winston-Salem, North Carolina	15,574	15,574		
Total	2,639,403	1,946,795	526,195	166,409

The state surplus projections are subdivided into each producing region on the basis of the ratio of grain projection in each producing region to the total state production. The 1990 projected supply of each class of wheat is presented in Table 10.

Domestic demand for wheat consists of the demand for food and industrial uses, the demand for feed use and the demand for seed. However, feed and seed uses are not included in the demand estimation since it is determined by the farm sector. Consequently, only the food demand for wheat is considered as domestic demand in each consuming reigon. Total domestic demand for food and industrial use was obtained from the Wheat Situation (USDA). The demand was decreased by the amount used on-farm for feed and seed (Agricultural Statistics, 1981) to arrive at the domestic consumption of wheat for food and industrial use.

The total domestic consumption of wheat for food and industrial use is allocated to each consuming region by using the ration of the milling capacity for each wheat at each consuming region to the total capacity. Total milling capacity was obtained for each state from Milling and Baking News (Sosland

TABLE 10. ESTIMATED TOTAL WHEAT SUPPLY BY CLASSES OF WHEAT, 1990

Producing Region	Total	Winter	Spring	Durum
	1,000 bushels			
1. Wenatchee, Washington	199,780	178,667	21,376	
2. Bend, Oregon	91,712	85,252	6,420	
3. Chico, California	35,544	35,544		
4. Bakersfield, California	48,531	40,863		7,668
5. Grangeville, Idaho	48,818	32,743	9,075	
6. Pocatello, Idaho	79,630	32,887	46,743	
7. Nepha, Utah	13,670	10,540	3,130	
8. Flagstaff, Arizona	16,824	4,694		12,130
9. Great Falls, Montana	132,637	67,114	61,941	3,582
10. Bozeman, Montana	18,976	15,788	3,169	19
12. Casper, Wyoming	11,247	10,910	337	
13. Limon, Colorado	125,611	122,471	3,140	
14. Albuquerque, New Mexico	12,080	12,080		
15. Dickinson, North Dakota	115,539	1,618	52,917	61,004
16. Carrington, North Dakota	293,041	870	186,667	105,495
17. Rapid City, South Dakota	25,697	21,842	3,392	463
18. Huron, South Dakota	65,690	8,737	51,435	5,518
19. Alliance, Nebraska	42,944	42,944		
20. Lexington, Nebraska	93,206	93,206		
21. Scott City, Kansas	176,445	176,445		
22. Great Bend, Kansas	207,154	207,154		
23. Emporia, Kansas	60,959	60,959		
24. Woodward, Oklahoma	90,994	90,994		
25. Clinton, Oklahoma	56,334	56,344		
26. Henreyetta, Oklahoma	32,766	32,766		
27. Lubbock, Texas	57,555	57,555		
28. Corsicana, Texas	27,593	27,593		
29. Fort Stockton, Texas	2,080	2,080		
30. Cuero, Texas	1,894	1,894		
31. Alexandria, Minnesota	67,783	1,356	64,462	1,965
32. St. James, Minnesota	44,415	1,199	41,528	1,688
33. Boone, Iowa	3,283	3,283		
34. Sedalia, Missouri	50,935	50,935		
35. Malvern, Arkansas	31,356	31,356		
36. Richland Center, Wisconsin	4,039	3,381	658	
37. Springfield, Illinois	44,885	44,885		
38. Richmond, Kentucky	11,941	11,941		
39. Cookeville, Tennessee	12,160	12,160		
40. Flint, Michigan	31,106	31,106		
41. Anderson, Indiana	54,352	54,352		
42. Marion, Ohio	49,976	49,976		
43. Montgomery, Alabama	8,879	8,879		
44. Ithaca, New York	7,191	7,191		
45. State College, Pennsylvania	18,103	18,103		
46. Charlottesville, Virginia	9,813	9,813		
47. Winston-Salem, North Carolina	15,454	15,454		
Total	2,691,735	1,896,272	586,791	208,672

Publishing Company). The total projected demand for 1980 is 672 million bushels; 488 million bushels for winter wheat, 138 million bushels for spring wheat, and 45 million bushels for durum wheat (Table 11).

The 1990 domestic demand for each class of wheat is estimated on the basis of the 1990 national demand for industrial and food uses projected by the U.S. Department of Agriculture (NIRAP projection). The national demand is allocated to each consuming region by using the ratio of the milling capacity for each wheat at each consuming region to the total capacity. The projected demand for 1990 by each class of wheat in consuming regions is presented in Table 12.

Minimum Quantities of Wheat Sold

Minimum quantities of wheat that must be sold from each producing region were used as a constraint of the model. The quantities were computed by dividing the minimum income derived from the sales of wheat for each state over three years from

TABLE 11. DOMESTIC USE OF WHEAT BY CLASS, 1980

Consuming Region	Total	Winter	Spring	Durum
	1,000 bushels			
1. Portland, Oregon	32,248	26,058	2,330	3,860
2. Los Angeles, California	28,889	24,075	4,814	
3. Great Falls, Montana	8,062	4,031	4,031	
4. Salt Lake City, Utah	19,483	18,683	800	
5. Denver, Colorado	10,749	9,838	911	
6. Fargo, North Dakota	7,390		4,293	3,097
7. Omaha, Nebraska	19,483	19,175	308	
8. Wichita, Kansas	73,229	71,291	1,938	
9. Dallas, Texas	42,325	42,325		
10. St. Paul, Minnesota	80,619		54,989	25,630
11. Ames, Iowa	6,719	5,900	819	
12. Kansas City, Missouri	42,997	42,321	676	
13. Greenville, Mississippi	7,390	5,899	863	628
14. Springfield, Illinois	40,310	38,340	1,970	
15. Kalamazoo, Michigan	16,124	15,853	271	
16. Evansville, Indiana	18,811	17,208	1,603	
17. Knoxville, Tennessee	26,201	25,075	1,126	
18. Atlanta, Georgia	22,842	21,141	1,701	
19. Columbus, Ohio	41,653	40,808	845	
20. Buffalo, New York	69,198	6,883	50,645	11,670
21. Philadelphia, Pennsylvania	27,545	26,058	1,487	
22. Roanoke, Virginia	12,765	12,291	470	
23. Winston-Salem, North Carolina	16,796	15,241	1,555	
Total	671,828	488,494	138,445	44,885

TABLE 12. DOMESTIC USE OF WHEAT BY CLASS, 1990

Consuming Region	Total	Winter	Spring	Durum
	1,000 bushels			
1. Portland, Oregon	33,312	26,924	2,389	3,999
2. Los Angeles, California	29,842	24,489	5,353	
3. Great Falls, Montana	8,328	4,164	4,164	
4. Salt Lake City, Utah	20,126	19,304	822	
5. Denver, Colorado	11,104	10,160	944	
6. Fargo, North Dakota	7,634		4,426	3,208
7. Omaha, Nebraska	20,126	19,812	314	
8. Wichita, Kansas	75,646	73,661	1,985	
9. Dallas, Texas	43,722	43,722		
10. St. Paul, Minnesota	83,280	$ 56,730	26,550	
11. Ames, Iowa	6,940	6,096	844	
12. Kansas City, Missouri	44,416	43,719	697	
13. Greenville, Mississippi	7,634	6,096	887	651
14. Springfield, Illinois	41,640	39,624	2,016	
15. Kalamazoo, Michigan	16,656	16,377	279	
16. Evansville, Indiana	19,432	17,780	1,652	
17. Knoxville, Tennessee	27,066	25,908	1,158	
18. Atlanta, Georgia	23,596	21,844	1,752	
19. Columbus, Ohio	43,028	42,165	863	
20. Buffalo, New York	71,482	7,112	52,281	12,089
21. Philadelphia, Pennsylvania	28,454	26,924	1,530	
22. Roanoke,Virginia	13,186	12,700	486	
23. Winston-Salem, North Carolina	17,350	15,748	1,602	
Total	694,000	504,329	143,174	46,497

1978 to 1980 by the price received by farmers in each state to arrive at the minimum amount of wheat sold for each state. The minimum sales were compared with the average production for those three years. The minimum sale percentage was calculated by dividing the sales by average production. The percentage was then multiplied by the production to determine the minimum sales.

Income derived from sales of wheat was obtained from State Farm Income Statistics (USDA). Prices received by farmers was obtained from **Agricultural Prices, Annual Summary, 1980** (USDA). The estimated minimum quantity of wheat that must be sold was 2,153 million bushels: 1,703 million bushels of winter wheat, 347 million bushels of spring wheat, and 103 million bushels of durum wheat (Table 13). This minimum sale projection is used in both the 1980 and 1990 models.

Transportation Costs

Transportation costs for rail, truck, and barge are estimated on the basis of information obtained from industrial sources. The estimation procedure of the costs is detailed in a study by Koo and Thompson.

TABLE 13. ESTIMATED MINIMUM WHEAT SALES, 1980

Producing Region	Total	Winter	Spring	Durum
	--------	1,000 bushels	--------	
1. Wenatchee, Washington	143,878	128,414		15,464
2. Bend, Oregon	65,171	60,624		4,547
3. Chico, California	33,165	33,165		
4. Bakersfield, California	45,153	38,009	7,149	
5. Grangeville, Idaho	29,746	23,300		6,446
6. Pocatello, Idaho	56,681	23,383		33,298
7. Nepha, Utah	8,906	7,033		1,873
8. Flagstaff, Arizona	16,479	4,603	11,876	
9. Great Falls, Montana	75,206	38,030	1,996	35,180
10. Bozeman, Montana	10,763	8,959	7	1,796
11. Miles City, Montana	27,362	4,876	5,186	17,300
12. Casper, Wyoming	7,235	7,021		214
13. Limon, Colorado	94,954	92,621		2,333
14. Albuquerque, New Mexico	8,967	8,967		
15. Dickinson, North Dakota	48,853	676	25,771	22,406
16. Carrington, North Dakota	123,611	332	44,453	78,826
17. Rapid City, South Dakota	16,709	14,208	293	2,208
18. Huron, South Dakota	42,658	5,668	3,592	33,397
19. Alliance, Nebraska	33,156	33,156		
20. Lexington, Nebraska	71,993	71,993		
21. Scott City, Kansas	156,228	156,228		
22. Great Bend, Kansas	183,164	183,264		
23. Emporia, Kansas	53,728	53,728		
24. Woodward, Oklahoma	90,574	90,574		
25. Clinton, Oklahoma	56,212	56,212		
26. Henreyetta, Oklahoma	32,614	32,614		
27. Lubbock, Texas	78,661	78,661		
28. Corsicana, Texas	37,693	37,693		
29. Fort Stockton, Texas	2,831	2,831		
30. Cuero, Texas	2,494	2,494		
31. Alexandria, Minnesota	58,103	1,179	1,697	55,227
32. St. James, Minnesota	38,095	1,015	1,461	35,619
33. Boone, Iowa	2,832	2,832		
34. Sedalia, Missouri	79,931	79,931		
35. Malvern, Arkansas	30,788	30,788		
36. Richland Center, Wisconsin	3,763	3,148		615
37. Springfield, Illinois	64,734	64,734		
38. Richmond, Kentucky	10,438	10,438		
39. Cookeville, Tennessee	8,898	8,898		
40. Flint, Michigan	30,061	30,061		
41. Anderson, Indiana	49,049	49,049		
42. Marion, Ohio	61,357	61,357		
43. Montgomery, Alabama	26,585	26,585		
44. Ithaca, New York	5,022	5,022		
45. State College, Pennsylvania	10,777	10,777		
46. Charlottesville, Virginia	7,223	7,223		
47. Winston-Salem, North Carolina	14,001	14,001		
Total	2,153,908	1,703,681	103,481	346,749

Ocean freight-rates between U.S. ports and foreign importing regions were obtained from **Chartering Annual, 1980** (Maritime Research, Inc.). Ocean freight-rates vary over time, depending upon travel distance, volume shipped, size of ship, and characteristics associated with origin and destination. The ocean freight rates used in this study are average rates of all shipment rates in 1980 for wheat from U.S. ports to foreign importing regions. Table 10 shows calculated ocean freight rates for wheat between U.S. ports and foreign importing regions. All U.S. ports are categorized into four areas: Atlantic, Gulf, West Coast, and Great Lakes. All export ports in the same area have the same rates. The estimated ocean freight rates used for this study are shown in Table 14.

V. Spatial Equilibrium Under Alternative Trade Restriction and Ocean Freight Rates

The impacts of alternative trade restrictions and ocean freight rates on the U.S. wheat export market are analyzed on the basis of Models 1 through 13. Alternative trade restrictions are applied to only the EEC and Japan/Korea which are major wheat importers in the world.

Spatial Equilibrium Wheat Prices

The models determine the equilibrium wheat prices at U.S. ports and importing regions and the equilibrium quantities traded between the U.S. and importing regions. The price determination is dependent on the supply equations of U.S. wheat, import demand equations, and changes in tariffs and transportation costs.

Table 15 presents average winter, spring, and durum wheat prices, respectively, under alternative import tariffs and ocean freight rates. The durum wheat price is the highest among the three classes of wheat. Winter and spring wheat prices are comparable among U.S. ports. This price pattern is consistent with the actual average wheat prices from 1978 to 1980.

Winter wheat price in the base model is highest at the West Coast (Portland/Seattle), second highest at the Gulf ports and lowest at the Great Lakes. The spatial price difference is due mainly to the demand and supply situation at each export port, domestic transportation costs in shipping wheat from producing regions to export ports and ocean transportation costs from export ports to importing regions. The West Coast has a cost advantage in shipping wheat to Japan and other Asian countries, but the Gulf ports have a cost advantage in receiving winter wheat from producing regions. Consequently, Japan and other Asian countries' import demands for winter wheat at the West Coast are greater than at other U.S. export ports. This leads to higher prices at the West Coast. Wheat prices at the West Coast increase until the price difference is large enough to cover additional domestic transportation costs required in shipping wheat to the West Coast. The Great Lakes has a cost disadvantage over the Atlantic and Gulf ports in shipping wheat to most importing regions. This lowers import demand for winter wheat at the Great Lakes and results in a lower price. On the supply side, because of relatively low domestic transportation costs from producing regions to the Great Lakes, winter wheat is supplied to the Great Lakes despite the lower wheat price.

The Gulf ports have higher import demand for winter wheat from most importing regions except Southeast Asia, but winter wheat prices at the Gulf ports are lower than at the West Coast because domestic transportation costs to the Gulf ports are lower. Most winter wheat produced in the Southern Plains is moved to the Gulf ports for export. The spatial equilibrium price pattern obtained from the

TABLE 14. OCEAN FREIGHT RATES, 1980

Import Region	Atlantic	Gulf	California	West	Lakes
	$/Ton				
1. EEC	23.54	26.64	34.25	34.25	32.75
2. Eastern Europe	—	31.37	—	—	31.79
3. Africa	33.02	49.62	59.49	40.29	63.63
4. Middle East	42.00	51.55	56.23	47.71	68.71
5. SouthAsia	45.95	43.06	32.03	31.60	55.70
6. East Asia	—	46.23	36.73	49.33	—
7. Japan/Korea	—	38.69	27.21	25.53	—
8. Central America	—	34.48	16.97	23.17	31.53
9. Brazil/Venezuela	34.16	35.13	—	—	44.75
10. South America	—	40.28	33.67	33.67	—
11. U.S.S.R.	25.64	—	—	—	25.99

SOURCE: Maritime Research, Inc.

TABLE 15. AVERAGE WHEAT PRICES AT U.S. PORTS UNDER ALTERNATIVE TRADE RESTRICTIONS, 1980

Model	Atlantic	Gulf	West	Lakes
	$/bu.			
Winter Wheat				
Average Export Price*	4.44	4.51	4.45	—
1. Base	4.38	4.47	4.76	4.09
2. $1.00 Tariff in the EEc	4.32	4.41	4.71	3.99
3. 20 Percent Quota in the EEC	4.36	4.44	4.73	4.06
4. $1.00 Tariff in Japan/Korea	4.34	4.42	4.72	4.04
5. 20 Percent Quota in Japan/Korea	4.27	4.35	4.51	3.93
6. $1.00 Tariffs in the EEC and Japan/Korea	4.26	4.34	4.63	3.96
7. $1.00 Tariff in the EEC and Quota in Japan/Korea	4.16	4.25	4.47	3.83
Spring Wheat				
Average Export Price*	—	4.81	4.96	4.13
1. Base	—	4.46	4.80	4.17
2. $1.00 Tariffs in the EEC	—	4.07	4.46	3.78
3. 20 Percent Quota in the EEC	—	4.39	4.79	4.09
4. $1.00 Tariff in Japan/Korea	—	4.45	4.79	4.16
5. 20 Percent Quota in Japan/Korea	—	4.34	4.68	4.06
6. $1.00 Tariff in the EEC	—	4.03	4.42	3.74
7. $1.00 Tariff in the EEC and Quota in Japan/Korea	—	3.94	4.28	3.65
Durum Wheat				
Average Export Price*	—	6.09	—	5.36
1. Base	—	5.86	5.80	5.85
2. $1.00 Tariffs in the EEC	—	5.33	5.27	5.31
3. 20 Percent Quota in the EEC	—	5.43	5.56	5.42
4. $1.00 Tariff in Japan/Korea	—	5.86	5.80	5.84
5. 20 Percent Quota in Japan/Korez	—	6.00	5.77	5.81
6. $1.00 Tariff in the EEC and Japan/Korea	—	5.33	5.26	5.30
7. $1.00 Tariff in the EEC and Quota in Japan/Korea	—	5.31	5.25	5.29

*Actual average wheat prices from 1978 to 1980

base model is consistent with the actual average price pattern at U.S. ports, but equilibrium price level is different from the actual price. This is mainly because the model does not include all possible institutional constraints which actually affects U.S. wheat exports, and because the U.S. wheat export market is inefficient in terms of its market share of grain at each port.

Spring wheat prices are slightly higher than winter wheat prices in the base model (Table 15). No spring wheat price is determined at the Atlantic ports because of its locational disadvantage in receiving spring wheat. Spring wheat production is concentrated in the Dakotas, Montana, and Minnesota. Spring wheat price is highest at the West Coast (Portland/Seattle) and lowest at the Great Lakes in the base model. This is due to import demand and export supply conditions related to both domestic and ocean transportation costs. The spatial equilibrium prices obtained from the base model are lower than the actual average prices at the Gulf and West Coast ports and higher at the Great Lakes ports because of the same reasons as winter wheat.

As with spring wheat, durum wheat price is not determined at the Atlantic ports. Durum wheat price is highest at the Great Lakes and lowest at the West Coast. It is imported mainly by the EEC and Africa through the Gulf and Great Lakes ports. Most durum wheat produced in Arizona is shipped for export to the Gulf ports. Durum wheat produced in the Dakotas and Minnesota is shipped for export to the Great Lakes. Because of the same reasons as spring and winter wheat, the equilibrium prices are slightly lower than the actual price at the Gulf ports and higher at the Great Lakes ports.

Effects of Import Tariff and Quota

A specific import tariff of $1.00 per bushel of wheat imposed in either the EEC or Japan/Korea has minimal effects on winter wheat prices at U.S. export ports, although both regions' price elasticities of import demand for U.S. winter wheat are more elastic than the elasticities of U.S. export supply.[4] The main reason for this is that changes in quantities of winter wheat imported by either the EEC or Japan/Korea due to the import tariff are not large enough to influence U.S. export prices.

[4]This discussion is based on Equations 1 and 2.

U.S. wheat export prices are less influenced by the specific tariff imposed by Japan/Korea than that imposed by the EEC. This is mainly because import demand elasticities in Japan/Korea are much less elastic than those in the EEC. When both regions impose a specific import tariff of $1.00 per bushel of wheat, U.S. winter wheat prices are reduced by approximately 13 cents per bushel. This indicates that approximately 87 percent of the import tariffs are absorbed by consumers in importing regions.

Economic effects of an import quota are different from a tariff. Instead of imposing a tax on an imported commodity, as under the tariff, the government may directly restrict the volume of imports to a certain maximum level. The absolute limit is known as the import quota. In this study, 80 percent of optimal imports obtained from the base model is used as an import quota in the EEC or Japan/Korea. The import quota results in much greater impacts on U.S. export prices than tariffs when it is imposed in Japan/Korea, because the region's import demand for U.S. wheat is inelastic. Howdever, the import quota imposed by the EEC results in smaller effects on U.S. export prices than the tariffs.

U.S. winter wheat prices at ports are most significantly influenced when a tariff is imposed in the EEC and a quota is imposed in Japan/Korea. In this case, winter wheat prices at the U.S. ports are reduced more than 20 cents per bushel.

The impacts of trade restrictions on spring wheat are different from those on winter wheat. When a specific tariff of $1.00 per bushel is imposed in the EEC, the tariff results in a substantial reduction in spring wheat prices at the U.S. ports. This is because the EEC's import market share for spring wheat is larger than for winter wheat. Spring wheat prices are reduced by approximately 34 cents at the West Coast and 39 cents at the Gulf and Great Lakes ports. However, the impacts of import tariffs on spring wheat prices at U.S. export ports are minimal when the tariff is imposed in Japan/Korea. The reason is less elastic import demand for spring wheat in Japan/Korea compared to that in the EEC. When the tariff is imposed in both the EEC and Japan/Korea, reductions in spring wheat prices are 38 cents at the West Coast and 43 cents at the Gulf and Great Lakes ports. This indicates that more than 50 percent of the tariff is absorbed by consumers in importing countries and the other 50 percent by producers in the U.S. The reductions in spring wheat prices at U.S. ports are much greater than winter wheat price reductions when a tariff is imposed in the importing regions.

Effects of an import quota on spring wheat prices at U.S. ports are similar to those on winter wheat prices. A quota imposed in the EEC results in much smaller effects on wheat prices at U.S. ports than a quota imposed in Japan/Korea. This is because price elasticities of import demand for spring wheat in Japan/Korea are less elastic than in the EEC. The price effects are largest when tariffs and quotas are imposed in the EEC and Japan/Korea, respectively, because tariffs are more effective in controlling imports than quotas in the EEC and vice versa in Japan/Korea.

Impacts of the import tariffs imposed in the EEC and/or Japan/Korea on durum wheat prices are similar to those imposed on spring wheat prices. The only difference is that reductions in durum wheat prices are greater than in spring wheat prices with import tariffs in the EEC. Durum wheat prices at U.S. ports are not influenced by an import tariff imposed by Japan/Korea. This is because imports of durum wheat in that region are not large enough to influence the durum wheat price at U.S. export ports and because the import demand elasticity of durum wheat is less elastic in Japan/Korea compared to elasticity in the EEC. Effects of an import quota on durum wheat prices are similar to those on spring and winter wheat. Although the import quota imposed in the EEC results in much smaller effects on the U.S. wheat price than the import tariff, the import quota in Japan/Korea results in much greater effects on the U.S. wheat prices.

Effects of Ocean Freight Rates

Increases in ocean freight rates result in a much larger reduction in wheat prices in all U.S. export ports than in importing regions. The effects on wheat prices are contrary to the effects of import tariffs which are much larger in importing regions than in the U.S. The reason is an import tariff imposed by a country is applied to only the quantity of wheat that country imports, while transportation rates are applied to the total quantity of wheat traded with all nations.

Table 16 presents changes in U.S. export prices under alternative ocean freight rates. A 20 percent increase in ocean freight rates results in about a 19 cent per bushel reduction in winter wheat prices in all U.S. export ports (Model 8). A further 20 percent increase in ocean freight rates reduces prices an additional 18 cents per bushel (Model 9). The average ocean freight rate for shipping wheat from U.S. export ports to import regions is about $1.05 per bushel. Therefore, 20 and 40 percent increases in ocean freight rates cause average freight rate increases of 22 and 44 cents per bushel. This indicates that the increases in ocean freight rates are largely absorbed by wheat producers in the U.S. by depressing the export price of winter wheat at U.S. export ports. The proportion of ocean freight rates borne by U.S. exporters is approximately 85 percent of the freight rates.

A 25 percent increase in ocean freight rates at the Atlantic ports results in reduction in the winter wheat price at the ports and increases in wheat prices in other ports except at the West Coast (Model 10). The reason for this is that an increase in ocean freight rates at the Atlantic ports shifts import

TABLE 16. AVERAGE WHEAT PRICES AT U.S. PORTS UNDER ALTERNATIVE OCEAN FREIGHT RATES

Model	Atlantic	Gulf	West	Lakes
	$/bu.			
Winter Wheat				
1. Base	4.38	4.47	4.76	4.09
8. 20 Percent Increase	4.17	4.28	4.62	3.82
9. 40 Percent Increase	3.96	4.09	4.49	3.56
10. 25 Percent in Atlantic	4.11	4.47	4.76	4.09
11. 25 Percent in Gulf	4.45	4.28	4.80	4.16
12. 25 Percent in West	4.38	4.47	4.56	4.09
13. 25 Percent in Lakes	4.39	4.47	4.76	3.73
Spring Wheat				
1. Base	—	4.46	4.80	4.17
8. 20 Percent Increase	—	4.29	4.71	3.95
9. 40 Percent Increase	—	4.11	4.67	3.71
10. 25 Percent in Atlantic	—	4.46	4.80	4.17
11. 25 Percent in Gulf	—	4.29	4.85	4.22
12. 25 Percent in West	—	4.11	4.61	4.27
13. 25 Percent in Lakes	—	4.49	4.89	3.94
Durum Wheat				
1. Base	—	5.86	5.80	5.85
8. 20 Percent Increase	—	5.71	5.64	5.69
9. 40 Percent Increase	—	5.55	5.47	5.54
10. 25 Percent in Atlantic	—	5.86	5.80	5.85
11. 25 Percent in Gulf	—	5.68	5.81	5.86
12. 25 Percent in West	—	5.87	5.61	5.86
13. 25 Percent in Lakes	—	5.88	5.83	5.68

demand from the Atlantic ports to the Gulf and West Coast ports. The winter wheat price at the West Coast ports remains unchanged. Similarly, an increase in ocean freight rates at the Gulf ports decreases the winter wheat price at the Gulf ports and increases the winter wheat price at other U.S. export ports. It is also the case when ocean freight rates are increased at the Great Lakes. However, changes in ocean freight rates at the West Coast do not change winter wheat prices at other export ports. This indicates that the West Coast does not influence other export ports although the West Coast is influenced by changes in ocean freight rates at other ports.

Increases in ocean freight rates result in reductions in spring wheat prices in all export ports (Models 8 and 9). However, the proportion of ocean freight rates borne by U.S. wheat producers for spring wheat export is smaller than for winter wheat export. U.S. spring wheat producers absorb about 70 percent of the ocean freight rate increases and the remainder is absorbed by the foreign importers. The portion of ocean freight rates borne by U.S. spring wheat producers is about 15 percent lower than for winter wheat producers because export supply elasticities of spring wheat are greater than winter wheat. The reduction in spring wheat price is largest at the Great Lakes ports and lowest at the West Coast ports. This indicates that the proportion of ocean freight rates borne by U.S. wheat producers is different at U.S. export ports due to different import demand elasticities in importing regions.

An increase in ocean freight rates at the Atlantic ports does not change spring wheat prices in other ports because no spring wheat is exported through the Atlantic ports. An increase in ocean freight rates at the Gulf ports reduces spring wheat prices at the Gulf ports and results in increases in wheat prices in other ports. Similarly, increases in ocean freight rates at the West Coast and the Great Lakes reduce spring wheat prices at the export ports and increase spring wheat prices at other ports due to the shifts in import demand.

Interrelationships between durum wheat prices and ocean freight rates are similar to those for spring wheat. U.S. durum wheat producers absorb approximatley 70 percent of ocean freight rate increases for durum wheat exports and the remainder is absorbed by foreign importers. Variations in durum wheat price are different in each U.S. export port because of different price elasticities of import demand for durum wheat at each U.S. export port.

Equilibrium Quantities of Wheat Traded

The total quantity of wheat sold in the domestic consuming and export market is 1,932 million bushels in the base model, which is similar to the three-year average of wheat sold, 1,939 million bushels (1978-1980). Approximately 65 percent of the wheat goes to export markets and the remainder to domestic consuming regions. Of the quantity of wheat shipped to domestic consuming regions, market shares for winter, spring, and durum wheat are 73, 21, and 6 percent of the total wheat market, respectively. The market share of winter, spring, and durum wheat in export markets is 79, 15, and 6 percent, respectively (Table 17). The average market share from 1978 to 1980 is similar to the optimal market share obtained from the base model, indicating that U.S. wheat markets are optimally shared by winter, spring, and durum wheat industries.

Import tariffs imposed by the EEC and/or Japan/Korea result in substantial increases in wheat prices which lead to a decrease in the quantities of wheat imported by these regions. However, the impact on the total quantity of U.S. wheat exports is minimal. The reduction in U.S. wheat exports is 17 million-bushels with a $1.00 tariff per bushel of wheat in the EEC and Japan/Korea (Table 17). The reduction in U.S. wheat exports is much larger with a $1.00 tariff in the EEC than in Japan/Korea, approximately 14 million bushels in the EEC and only 3 million bushels in Japan/Korea (Table 17). This is due to inelastic import demand elasticities in Japan/Korea compared to those in the EEC.

Wheat import quotas result in much greater impacts in Japan/Korea and smaller effects in the EEC in terms of their wheat imports compared to import tariffs. These impacts are due mainly to price elasticities of import demand in those countries. In Japan, import demand elasticities are inelastic. Consequently, the effects of quotas are much larger than that of tariffs in Japan/Korea. On the other hand, import demand elasticities are elastic in the EEC. Hence, reductions in wheat imports under a tariff system are much greater than under a quota system.

Increases in ocean freight rates result in reductions in the total quantities of wheat exported from the U.S. The reductions are 12 and 24 million bushesl with 20 and 40 percent increases, respectively, in ocean freight rates (Table 17). Unlike import tariffs, changes in ocean freight rates are absorbed more by U.S. wheat producers than by consumers in importing regions and, consequently, result in moderate reductions in the total quantity of wheat exported.

A 25 percent increase in ocean freight rates in each export port results in minimal changes in the quantities of wheat exported. Increases in ocean freight rates at the Atlantic ports or Great Lakes do not affect the total quantity of wheat exported. However, increases in the Gulf ports and West Coast ports result in slight reductions in the total quantities of wheat exported. The quantities of wheat imported by the EEC and Japan are shown in Tables 18 and 19. As expected, the EEC is more sensitive to changes in import tariffs and ocean freight rates than Japan, because the EEC has a more elastic import demand equation than Japan. The total quantities of wheat imported are reduced with the presence of import tariffs and with increases in ocean freight rates in both the EEC and Japan. Because of more elastic import demand in the EEC compared to Japan, the reduction in the quantity of wheat imported is much greater in the EEC than in Japan. This indicates that import tariffs are more ef-

TABLE 17. QUANTITIES OF WINTER, SPRING, AND DURUM WHEAT EXPORTED UNDER ALTERNATIVE TRADE RESTRICTIONS AND OCEAN FREIGHT RATES

Model	Winter	Spring	Durum	Total
	million bushels			
Average Exports*	994	201	65	1,260
1. Base	1,001	199	68	1,268
2. $1.00 Tariff in the EEC	1,003	194	63	1,260
3. 20 Percent Quota in the EEC	999	186	61	1,246
4. $1.00 Tariff in Japan/Korea	1,001	193	62	1,246
5. 20 Percent Quota in Japan/Korea	996	192	63	1,250
6. $1.00 Tariff in the EEC and Japan/Korea	997	185	61	1,243
7. $1.00 Tariff in the EEC and Quota in Japan/Korea	992	183	60	1,235
8. 20 Percent Increase	995	191	62	1,248
9. 40 Percent Increase	968	187	62	1,236
10. 25 Percent in Atlantic	1,003	194	63	1,261
11. 25 Percent in Gulf	999	193	63	1,255
12. 25 Percent in West	1,000	193	63	1,256
13. 25 Percent in Lakes	1,003	193	63	1,258

*Actual average exports from 1978 to 1980.

TABLE 18. QUANTITIES OF WINTER, SPRING, AND DURUM WHEAT IMPORTED BY THE EEC UNDER ALTERNATIVE TRADE RESTRICTIONS AND OCEAN FREIGHT RATES

Model	Winter	Spring	Durum	Total
	million bushels			
Average Imports*	49.3	56.9	28.6	134.8
1. Base	45.8	51.5	27.9	125.2
2. $1.00 Tariff in the EEC	29.6	37.1	22.7	89.4
3. 30 Percent Quota in the EEC	39.5	47.9	23.7	—
4. $1.00 Tariff in Japan/Korea	45.6	51.1	26.9	123.6
5. 20 Percent Quota in Japan/Korea	49.1	54.1	27.2	—
6. $1.00 Taqriff in the EEC and Japan/Korea	29.6	37.0	22.0	88.6
7. $1.00 Tariff in the EEC and Quota in Japan/Korea	32.3	41.1	22.9	—
8. 20 Percent Increase	43.4	49.0	26.6	119.0
9. 40 Percent Increase	41.9	45.5	26.2	113.6
10. 25 Percent in Atlantic	44.7	50.9	26.9	122.5
11. 25 Percent in Gulf	44.0	50.5	26.8	121.3
12. 25 Percent in West	44.4	51.2	26.8	122.4
13. 25 Percent in Lakes	44.7	49.6	26.7	121.0

*Actual average imports from 1978 to 1980.

TABLE 19. QUANTITIES OF WINTER, SPRING, AND DURUM WHEAT IMPORTED BY JAPAN/KOREA UNDER ALTERNATIVE TRADE RESTRICTIONS AND OCEAN FREIGHT RATES

Model	Winter	Spring	Durum	Total
	million bushels			
Average Imports*	153.8	35.1	1.6	190.5
1. Base	155.2	36.8	1.5	193.5
2. $1.00 Tariff in the EEC	155.2	36.7	1.5	193.4
3. 20 Percent Quota in the EEC	155.5	36.0	1.6	—
4. $1.00 Tariff in Japan/Korea	145.4	33.6	1.4	180.4
5. 20 Percent Quota in Japan/Korea	123.1	28.1	1.3	—
6. $1.00 Tariff in the EEC and Japan/Korea	145.0	33.0	1.4	179.4
7. $1.00 Tariff in the EEC and Quota in Japan/Korea	123.1	28.1	1.3	—
8. 20 Percent Increase	154.8	35.7	1.5	192.0
9. 40 Percent Increase	154.4	35.6	1.5	191.5
10. 25 Percent in Atlantic	155.2	35.8	1.5	192.0
11. 25 Percent in Gulf	154.8	35.7	1.5	192.0
12. 25 Percent in West	155.2	36.0	1.5	192.7
13. 25 Percent in Lakes	155.2	35.8	1.5	192.5

*Actual average imports from 1978 to 1980

fective than import quotas in controlling wheat imports in the EEC and vice versa in Japan/Korea. This could be the reason the EEC currently imposes tariffs on wheat and Japan/Korea imposes quotas.

Effects on Social Welafre

The social benefit losses presented in Table 20 are measured by consumers' and producres' surpluses. A specific tariff of $1.00 per bushel of wheat in the EEC and Japan results in substantial reductions in social benefits in the U.S. and these importing regions. The reductions are primarily due not only to increase in wheat prices in importing regions and to decreases in wheat prices in the U.S., but also to decreases in the quantity of wheat traded. Social benefit losses in the U.S. are much larger when a tariff is imposed by the EEC than when imposed by Japan/Korea. The social benefit losses in the U.S. are $127 million when a tariff is imposed in the EEC and $40 million when it is imposed in Japan/Korea. The social benefit losses are $28 million and $134 million in the EEC and Japan/Korea under the tariff system. This is because price elasticities of import demand for wheat in the EEC are much more elastic than those in Japan/Korea. Unlike tariffs, social

TABLE 20. ESTIMATED SOCIAL WELFARE LOSSES UNDER ALTERNATIVE TRADE RESTRICTIONS AND OCEAN FREIGHT RATES

Model	Import Regions	U.S.	Total
	-----million dollars-----		
1. Base	0	0	0
2. $1.00 Tariff in the ECC	28	127	155
3. 20 Percent Quota in the EEC	12	43	55
4. $1.00 Tariff in Japan/Korea	134	40	174
5. 20 Percent Quota in Japan/Korea	388	144	529
6. $1.00 Tariff in the EEC and Japan/Korea	180	168	348
7. $1.00 Tariff in the EEC and Quota in Japan/Korea	398	272	670
8. 20 Percent Increase	89	162	251
9. 40 Percent Increase	177	322	499
10. 25 Percent in Atlantic	7	5	13
11. 25 Percent in Gulf	45	79	124
12. 25 Percent in West	29	62	91
13. 25 Percent in Lakes	21	9	30

benefit losses in the U.S. are much larger with a quota imposed inJapan/Korea than that imposed in the EEC. The social benefit losses in the U.S. are $43 million when a quota is imposed in the EEC and $144 million when it is imposed in Japan/Korea. The social benefit losses are $12 million in the EEC and $388 million in Japan/Korea under the quota system. The social benefit losses are largest when the EEC imposes a tariff on wheat and Japan/Korea imposes a quota; these are the trade restrictions currently imposed by both countries.

Increases in ocean freight rates result in reductions in social benefits in both the U.S. and foreign import regions. The decrease in social benefits in the U.S. due to increases in ocean freight rates is much larger than that in foreign import regions. This is because U.S. wheat producers absorb a larger portion of ocean freight rate increases than do foreign importers.

Increases in ocean freight rates at the Atlantic and Great Lakes ports result in the smallest change in social benefits in the U.S. However, social benefits are substantially decreased with increases in ocean freight rates at the Gulf and West Coast ports. Social benefits losses in the U.S. are largest with an increase in ocean freight rates at the Gulf ports and lowest with an increase in ocean freight rates at the Atlantic ports. From the importers' point of view, benefit loss is largest with an increase in ocean freight rates at the West Coast and lowest with an increase at the Atlantic ports.

VI. Impacts of Changes in Domestic Transportation Costs on the U.S. Wheat Industry

Spatial equilibrium conditions for the U.S. wheat export markets are not influenced by domestic transportation costs. The reasons are: 1) domestic transportation rate differentials among routes originating from producing regions to potential export ports are much smaller than ocean freight-rate differentials, and 2) the magnitude of average domestic transportation costs in shipping wheat from producing regions to export ports is smaller than average ocean freight rates between export ports and importing regions. Therefore, this section is concentrated on impacts of changes in domestic transportation costs on modal share and transportation costs.

Modal Share and Intermodal Competition

The total quantities of wheat transported are 1,286.3, 254.9, and 390.9 million bushels by rail, truck, and barge, respectively, in Model 1 (Table 21). This indicates that railroads play a very important role in shipping grain from producing regions to final destinations. Characteristics of the modal share are different for domestic and export shipments. For domestic shipments of wheat, approximately 55 percent of wheat transported is shipped by truck, 29 percent by rail, and 16 percent by barge. On the other hand, over 85 percent of wheat transported is shipped by rail for export shipments. Reasons are as follows: 1) average travel distance for export shipments is much greater than for domestic shipments and 2) rail has a comparative cost advantage over truck for long distance shipments.

TABLE 21. QUANTITIES OF WHEAT SHIPPED BY MODES OF TRANSPORTATION UNDER THE BASE AND ALTERNATIVE MODELS

Model	Rail	Barge	Truck
	----million bushels----		
Domestic			
1. Base	197.4	101.3	373.1
14. 10 Percent in Rail	172.2	102.9	396.7
15. 20 Percent in Rail	145.5	106.6	419.7
16. 10 Percent in Barge	197.4	101.3	373.1
17. 20 Percent in Barge	197.4	101.3	373.1
Exports			
1. Base	1,088.99	153.7	17.8
14. 10 Percent in Rail	1,074.9	168.3	17.8
15. 20 Percent in Rail	883.3	304.4	123.3
16. 10 Percent in Barge	1,088.9	153.7	17.8
17. 20 Percent in Barge	1,160.6	81.9	17.8
Aggregate			
1. Base	1,286.3	254.9	390.9
14. 10 Percent in Rail	1,247.1	271.2	414.6
15. 20 Percent in Rail	978.8	411.0	543.0
16. 10 Percent in Barge	1,286.3	254.9	390.9
17. 20 Percent in Barge	1,358.1	183.2	390.9

Models 14 and 15 show changes in quantities of wheat shipped with 10 and 20 percent increases in rail rates, respectively. The total quantities of wheat shipped by railroads are not sensitive to a 10 percent increase in rail rates, but the quantities are sensitive to a 20 percent increase in rail rates. This is mainly due to competition between rail and barge for export shipments of wheat. The quantities of wheat shipped by rail are reduced approximately 2 percent with a 10 percent increase in rail rates in shipping wheat from producing regions to export markets and are reduced approximately 23 percent with a 20 percent increase in rail rates. When wheat is shipped from producing regions to domestic consuming regions, the quantities of wheat shipped by rail are reduced more than 10 and 20 percent with 10 and 20 percent increases in rail rates, respectively.

Changes in rail rates are sensitive to the quantities of wheat shipped by truck for domestic shipments and are not sensitive to those by barge. On the contrary, changes in rail rates are sensitive to the quantities of wheat shipped by barge for export shipments and are not sensitive to those by truck because travel distance is greater for export shipments than for domestic shipments. This indicates that railroads compete with barges rather than with trucks for export shipments.

The quantities of wheat shipped by barge are more sensitive to changes in rail rates than to changes in barge rates in both domestic and export shipments of wheat. The degree of sensitivity is much larger for export shipments than for domestic shipments. This indicates that barges have a comparative advantage over railroads for long-distance hauls and compete with railroads in shipping wheat to export markets. Changes in barge rates do not affect the quantities of wheat shipped by truck in both domestic and export shipments. This indicates that barges do not compete with trucks in shipping wheat from producing regions to final destinations.

Transportation Costs Under Alternative Transportation Rates

Estimated total transportation costs for wheat shipments are shown in Tables 22 and 23. Table 22 presents the total transportation costs in shipping wheat from producing regions to final destinations by three classes of wheat. Table 19 presents the total transportation costs by modes of transportation. In the base model, the total transportation costs are $675 million — $508 million for winter wheat shipments, $103 million for spring wheat shipments, and $37 million for durum wheat shipments.

Total transportation costs are influenced more by changes in rail rates than by changes in other modes of transportation in both domestic and export shipments of wheat. Changes in rail rates influence transportation costs for export shipments more than

TABLE 22. ESTIMATED TOTAL TRANSPORTATION COSTS IN SHIPPING WHEAT BY CLASSES OF WHEAT UNDER THE BASE AND ALTERNATIVE MODELS

Model	Winter	Spring	Durum
	million dollars		
Domestic			
1. Base	89,559	43,155	13,603
14. 10 Percent in Rail	92,776	44,191	14,333
15. 20 Percent in Rail	99,806	45,264	15,071
16. 10 Percent in Barge	89,640	45,027	14,016
17. 20 Percent in Barge	90,003	46,899	14,429
Exports			
1. Base	415,310	87,077	23,237
14. 10 Percent in Rail	448,827	94,468	25,293
15. 20 Percent in Rail	449,215	101,386	27,349
16. 10 Percent in Barge	423,003	87,661	23,476
17. 20 Percent in Barge	432,207	88,245	23,714
Aggregate			
1. Base	507,870	130,232	36,840
14. 10 Percent in Rail	540,905	138,660	39,626
15. 20 Percent in Rail	549,021	146,650	42,420
16. 10 Percent in Barge	551,643	132,688	37,492
17. 20 Percent in Barge	522,211	135,145	38,144

domestic shipments, because more wheat is shipped by rail than by other modes of transportation for export shipments. Impacts of changes in barge rates on total transportation costs are not clear. Total transportation costs for domestic shipments of spring wheat are most influenced with changes in barge rates. However, transportation costs for export shipments of winter wheat are influenced more by changes in barge rates than other wheat classes are.

Total transportation costs are $517 million for railroads, $87 million for barges, and $71 million for trucks in the base model. Truck transportation costs are largest for domestic shpments of wheat — about 45 percent of the domestic transportation cost. For export shipments of wheat, rail transportation costs are largest — about 90 percent of export transportation costs.

Increases in rail rates reduce total rail transportation costs for domestic shipments of wheat, because percentage changes in the quantities of wheat shipped by rail are larger than those in rail rates. However, total transportation costs for export shipments are increased with a 10 percent increase in rail rates and then decreased with a 20 percent increase in rail rates. The changes in transportation costs are mainly due to different degrees of sensitivity between the quantities shipped by rail and changes in rail rates. Increases in rail rates (Models 14 and 15) also increase barge and truck transportation costs because more wheat is shipped by barge and trucks than by rail with increases in rail rates in the base model. On the other hand, increases in barge rates (Models 16 and 17) increase rail and truck

TABLE 23. ESTIMATED TOTAL TRANSPORTATION COSTS IN SHIPPING WHEAT BY RAIL, BARGE, AND TRUCK UNDER THE BASE AND ALTERNATIVE MODELS

Models	Rail	Barge	Truck	Total
	thousand dollars			
Domestic				
1. Base	49,591	128,554	68,172	146,318
14. 10 Percent in Rail	47,059	28,997	74,546	150,602
15. 20 Percent in Rail	43,664	29,328	87,149	160,141
16. 10 Percent in Barge	49,591	31,024	67,068	147,683
17. 20 Percent in Barge	49,591	33,494	68,248	151,333
Exports				
1. Base	467,263	58,677	2,684	526,624
14. 10 Percent in Rail	505,589	60,316	2,684	568,589
15. 20 Percent in Rail	466,942	72,686	28,323	577,950
16. 10 Percent in Barge	471,293	60,163	2,683	534,139
17. 20 Percent in Barge	509,490	31,993	2,684	544,166
Aggregate				
1. Base	516,855	87,231	70,856	672,941
14. 10 Percent in Rail	552,648	89,313	77,230	719,192
15. 20 Percent in Rail	510,606	102,014	115,471	738,091
16. 10 Percent inBarge	520,884	91,188	69,752	681,823
17. 20 Percent in Barge	559,081	65,487	70,931	695,499

transportation costs. Increases in barge rates increase barge transportation costs for domestic shipments of wheat. However, impacts of changes in barge rates on barge transportation for export shipments are not the same as for domestic shipments. Barge transportation costs for export shipments are increased with a 10 percent increase in barge rates and then are decreased with a 20 percent increase in barge rates. This indicates that the barge industry can increase its revenue by increasing rates by 10 percent.

Average transportation costs per bushel-mile in shipping wheat from producing regions to final destinations are shown in Table 24. The average transportation costs per bushel-mile are interpreted as actual transportation and handling costs in shipping one bushel of wheat for a distance of one mile.

Average transportation cost per bushel-mile for all wheat is 0.044 cents in the base model. The average costs are 0.067 cents for domestic shipments and 0.040 cents for export shipments in the base model. Average costs per bushel-mile for rail, barge, and truck are 0.069, 0.028, and 0.155 cents for domestic shipments, respectively. They are 0.043, 0.025, and 0.158 cents for export shipments. In both domestic and export shipments, trucking is the most expensive mode of transportation and barge is the least expensive mode.

Increases in rail rates increase average rail transportation costs per bushel-mile in both domestic and export shipments of wheat. Increases in rail rates also reduce average barge and truck transportation costs per bushel-mile. Railroads compete with barges for long-distance shipments of wheat and also compete with trucks for short distance shipments of wheat. Consequently, increases in rail rates result in a shift of wheat shipments from rail to truck and barge. These increases cause reductions in average transportation costs by barge and truck. Unlike increases in rail rates, increases in barge rates result in increases in barge rates and do not affect transportation costs of other transportation modes.

Average Travel Distance

Average distances traveled for domestic wheat shipments are 276 miles for winter wheat, 1,188 miles for spring wheat, and 660 miles for durum wheat in the base model. Spring wheat travels the greatest distance because spring wheat production is concentrated in Minnesota, the Dakotas, and Montana, but its demand is national in scope. Unlike domestic shipments, average distances traveled are over 1,000 miles for winter, spring, and durum wheat for export shipments. Spring and durum wheat travels greater distances than winter wheat.

Average distances traveled by transportation mode are presented in Table 25. Average distances traveled for domestic shipments are 938 miles for rail, 1,052 miles for barge, and 125 miles for truck. Rail and barge travel greater distances for export shipments than for domestic shipments. However, a truck travels shorter distances for export shipments, because export rail rates are lower than domestic rates.

TABLE 24. ESTIMATED TRANSPORTATION COSTS PER BUSHEL-MILES BY MODES OF TRANSPORTATION UNDER THE BASE AND ALTERNATIVE MODELS

Model	Rail	Barge	Truck	Total
	cents/bushels			
Domestic				
1. Base	0.069	0.028	0.155	0.067
14. 10 Percent in Rail	0.077	0.028	0.155	0.070
15. 20 Percent in Rail	0.083	0.027	0.154	0.073
16. 10 Percent in Barge	0.069	0.030	0.155	0.068
17. 20 Percent in Barge	0.069	0.032	0.155	0.070
Exports				
1. Base	0.043	0.025	0.158	0.040
14. 10 Percent in Rail	0.048	0.025	0.153	0.043
15. 20 Percent in Rail	0.050	0.023	0.153	0.046
16. 10 Percent in Barge	0.043	0.028	0.158	0.041
17. 20 Percent in Barge	0.043	0.032	0.158	0.042
Aggregate				
1. Base	0.045	0.026	0.156	0.044
14. 10 Percent in Rail	0.049	0.025	0.155	0.047
15. 20 Percent in Rail	0.053	0.024	0.154	0.070
16. 10 Percent in Barge	0.045	0.029	0.156	0.045
17. 20 Percent in Barge	0.045	0.032	0.156	0.046

TABLE 25. ESTIMATED AVERAGE TRAVEL DISTANCE BY MODESL OF TRANSPORTATION UNDER THE BASE AND ALTERNATIVE MODELS

Model	Rail	Barge	Truck	Total
	miles			
Domestic				
1. Base	938	1,052	125	684
14. 10 Percent in Rail	929	1,066	128	686
15. 20 Percent in Rail	918	1,076	148	686
16. 10 Percent in Barge	938	1,050	126	696
17. 20 Percent in Barge	938	1,043	125	686
Exports				
1. Base	1,082	1,304	94	1,097
14. 10 Percent in Rail	1,066	1,327	94	1,091
15. 20 Percent in Rail	1,046	1,390	144	1,024
16. 10 Percent in Barge	1,086	1,275	95	1,099
17. 20 Percent in Barge	1,089	1,187	95	1,083
Aggregate				
1. Base	1,016	1,144	124	852
14. 10 Percent in Rail	1,012	1,120	126	850
15. 20 Percent in Rail	1,005	1,081	147	823
16. 10 Percent in Barge	1,081	1,173	124	864
17. 20 Percent in Barge	1,021	1,104	124	848

In general, average distances are 1,016 miles for rail, 1,144 miles for barge, and 124 miles for truck in both domestic and export shipments of wheat. The average distances could be interpreted as market boundaries in terms of mileages.

Changes in rail and barge rates vary the average mileages; however, the changes are not great. Increases in rail rates decrease average distances traveled by barge, and increase those by truck. This indicates that barge and truck have larger market boundaries due to increases in rail rates. Likewise, increases in barge rates decrease average distance traveled by barge and increase the distance traveled by rail. This indicates that railroads have larger market boundaries due to increases in barge rates.

TABLE 26. QUANTITIES OF WINTER, SPRING, AND DURUM WHEAT HANDLED BY U.S. PORTS FOR EXPORTS IN THE BASE MODEL

U.S. Port	Winter	Spring	Durum	Total	1980 Exports[a]
	million bushels				
Philadelphia, PA	12.7	0.0	0.0	12.7	18.0
Norfolk, VA	29.7	0.0	0.0	29.7	58.4
Mobile, AL	5.9	0.0	0.0	5.9	10.5
New Orleans, LA	129.7	40.9	8.0	178.6	216.4
Houston, TX	418.6	2.1	1.0	421.7	418.0
Corpus Christi, TX	35.4	0.0	0.0	35.4	24.2
San Francisco, CA	33.4	0.0	7.9	41.3	71.0
Portland, OR	302.3	61.2	2.0	365.5	429.2
Seattle, WA	17.2	10.8	0.0	28.0	1.9
Duluth, MN	0.0	79.0	44.3	123.3	90.4
Chicago, IL	0.0	0.0	0.0	0.0	0.0
Toledo, OH	17.8	0.0	0.0	17.8	14.3

[a]Quantities of wheat inspected for exports in 1980 Grain Market News.

Wheat Export Facilities

Table 26 presents the total quantities of wheat received by each U.S. port in the base model and the quantities of wheat actually inspected for exports in 1980. The 1980 exports at each U.S. port are similar to the optimal quantities of wheat handled at each port in the base model. In the base model, the total wheat handled at the Atlantic, Gulf, West Coast, and Great Lakes are 4, 51, 34, and 11 percent of the total wheat exported, respectively.They are 5, 46, 41, and 7 percent of the wheat exported in 1980, respectively. This indicates that wheat shipments through the Gulf and Great Lakes ports should be expanded to maximize social benefits in both the U.S. and import countries. The Gulf ports should handle more winter wheat and the Great Lakes ports should handle more spring and durum wheat to maximize social welfare in both the U.S. and importing regions. Most winter wheat is currently exported through Houston and Portland because of the location of winter wheat production and import demand. Winter wheat production is concentrated in the Great Plains states. The Northern Plains are close to the West Coast and wheat production in this area satisfies import demand in the West Coast ports. The Southern Plains ship wheat to the Gulf ports. On the demand side, Japan, one of the major wheat importers, has a cost advantage in importing wheat through the West Coast ports over other U.S. ports and the EEC imports mainly through the Gulf ports. Spring and durum wheat are exported mainly through Portland and Duluth since spring and durum wheat production is concentrated in Minnesota, the Dakotas, and Montana. The EEC imports through Duluth and Japan imports through Portland. Table 27 presents quantities of wheat handled at each U.S. export port under the base and selected alternative models. The quantities of wheat handled at each port are held constant with chances in ocean freight and domestic transportation rates. The only changes are modal share as described earlier.

VII. Wheat Marketing and Distribution in 1990

The basic structure of the model used to evaluate the 1990 wheat marketing and distribution is the same as the 1980 base model. The only difference is data used in the study. The 1990 model is based on 1990 export supply and import demand equations for each class of wheat. The transportation rates associated with each transportation activity are the 1980 data. This assumes that the relative transportation rate structure among transportation modes remains constant while transportation rates vary over time.

Spatial Equilibrium Prices

The 1990 equilibrium prices for winter and spring wheat at each U.S. port are higher than the 1980 prices. However, the price for durum wheat is lower than the 1980 durum wheat price. Higher spring and winter wheat prices in 1990 are due to substantial increases in the projected import demand for winter and spring wheat in 1990 compared to the projected export supply. However, 1990 durum wheat prices are lower because increases in the projected import demand for durum wheat are relatively smaller than export supply. Since the equilibrium prices are determined on the basis of the projected import demand and export supply of each class of wheat, changes in the demand and supply schedules could result in different prices for each class of wheat in 1990.

Winter wheat prices at the Atlantic, Gulf, West Coast, and Great Lakes are $4.43, $4.52, $4.80, and $4.14 per bushel, respectively. Spring wheat prices are $4.51, $4.85, and $5.22 at the Gulf, West Coast, and Great Lakes ports, respectively, and durum wheat prices are $5.78, $5.55, and $5.60 at the same respective ports. These price patterns are the same for both the 1980 and 1990 base models. Winter

TABLE 27. QUANTITIES OF ALL WHEAT HANDLED BY U.S. PORTS UNDER THE BASE AND SELECTED ALTERNATIVE MODELS

U.S. Ports	Model 1	Model 9	Model 10	Model 11	Model 12	Model 13	Model 15	Model 17
	(million bushels)							
Philadelphia, PA	12.7	12.5	12.5	12.8	12.7	12.7	12.7	12.7
Norfolk, VA	29.7	29.1	29.3	29.8	29.7	29.7	29.7	29.7
Mobile, AL	5.9	5.8	5.8	5.8	5.9	5.9	5.9	5.9
New Orleans, LA	178.6	174.6	178.7	176.6	178.6	178.6	178.7	178.7
Houston, TX	421.7	414.2	421.8	420.8	424.7	421.7	421.7	421.7
Corpus Christi, TX	35.4	34.7	35.4	35.0	35.4	35.3	35.4	35.4
San Francisco, CA	41.3	40.3	41.3	41.5	40.7	41.3	41.3	41.3
Portland, OR	365.5	361.3	366.0	372.4	360.8	355.4	366.0	365.8
Seattle, WA	28.0	28.7	28.0	30.1	27.6	28.1	28.0	28.0
Duluth, MN	123.3	118.0	123.6	123.8	123.3	120.1	121.3	123.3
Chicago, Il	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Toledo, OH	17.8	17.3	17.9	17.9	17.8	17.5	17.5	17.5

wheat prices are highest at the West Coast ports and lowest at the Great Lakes. However, spring wheat prices are highest at the Great Lakes ports. Durum wheat prices are highest at the Gulf ports and lowest at the West Coast ports.

Quantities of Wheat Traded

The total quantity of wheat sold in domestic and export markets will be 2,197 million bushels, approximately 13 percent larger than the quantity traded in 1980. Approximately 68 percent of the wheat (1,503 million bushels) goes to export markets and the remainder (694 million bushels) to domestic consuming regions. The 1990 wheat exports are about 19 percent higher than the 1980 exports (1,268 million bushels). Of the quantity of wheat shipped to domestic consuming regions, market shares for winter, spring, and durum wheat are 73, 21, and 6 percent of total wheat marketed, respectively. The market share is identical to the 1980 market share. The 1990 market share of winter, spring, and durum wheat in export markets is 79, 16,and 5 percent of wheat exported. The 1990 market share is increased 1 percent for spring wheat and decreased 1 percent for durum wheat.

Distribution and Marketing System

The quantities of wheat shipped by rail, barge, and trucks are 193.8, 121.8, and 378.4 million bushels, respectively, for domestic shipments. They are 1,340.2, 146.5, and 16.0 million bushels for export shipments. Domestic shipments are dominated by truck and export shipments by rail. The 1990 modal share is similar to the 1980 modeal share.

The total transportation cost is $835.8 million in shipping 2,197 million bushels of wheat to domestic and export markets. Average cost is approximately 35 cents per bushel. The total transportation costs are $166.5 million for domestic shipments of 694 million bushels and $669.3 million for export shipments of 1,503 million bushels. Average costs for domestic and export shipments are 24.0 and 44.5 cents per bushel, respectively. Average costs for export shipments are higher than for domestic shipments because travel distance for export shipments are much greater than domestic shipments. The average distances are 850 miles for domestic shipments and 1,142 miles for export shipments.

Average costs per bushel-mile are 0.61 cents for domestic shipments and 0.41 cents for export shipments. This indicates that transportation costs for export shipments are less expensive than for domestic shipments. This is mainly because unit and multiple-car trains are used for export shipments while single-car trains are generally used for domestic shipments. Average costs per bushel-mile for rail, barge, and trucks are 0.60, 0.28, and 1.55 cents for domestic shipments and 0.43, 0.24, and 1.51 cents for export shipments, respectively.

Wheat Export Facilities

Table 28 presents the total quantities of wheat received by each U.S. port in the base model. Approximately 90 percent of wheat exported is handled by four major export ports — New Orleans, Houston, Portland, and Duluth. When the quantities of wheat handled at each port are aggregated for export regions, the quantities are 50.9 million bushels in the Atlantic ports, 765.7 million bushels in the Gulf, 514.1 million bushels in the West Coast, and 171.9 million bushels in the Great Lakes. Market share by export regions is 4, 51, 34, and 11 percent of the total wheat exported in the Atlantic, Gulf, West Coast, and Great Lakes regions, respectively. The market share is identical to the 1980 market share.

Winter wheat is mainly exported through the Gulf and West Coast ports because winter wheat production is concentrated in the Great Plains states.

TABLE 28. QUANTITIES OF WINTER, SPRING, AND DURUM WHEAT HANDLED BY U.S. PORTS FOR EXPORTS IN THE BASE MODEL

U.S. Port	Winter	Spring	Durum	TYotal
	(million bushels)			
Philadelphia, PA	15.4	0.0	0.0	15.4
Norfolk, VA	35.5	0.0	0.0	35.5
Mobile, AL	5.9	0.0	0.0	5.9
New Orleans, LA	156.3	47.9	9.9	214.1
Houston, TX	499.5	1.2	1.2	501.9
Corpus Christi, TX	43.8	0.0	0.0	43.8
San Francisco, CA	42.5	0.0	9.9	52.4
Portland, OR	366.4	74.7	2.4	443.5
Seattle, WA	6.1	12.2	0.0	18.3
Duluth, MN	0.1	94.8	55.3	150.2
Chicago, IL	5.7	0.0	0.0	5.7
Toledo, OH	16.0	0.0	0.0	16.0

Spring and durum wheat are exported through Dulluth because spring and durum wheats are mainly produced in the Dakotas, Minnesota, and Montana.

VIII. Optimal Shipment Pattern

Optimal wheat flows are presented in two ways — domestic flows from producing regions to domestic consuming and export regions and export flows from U.S. ports to import regions. Since optimal flow patterns are similar among models, this section presents optimal flows for the base models in 1980 and 1990.

The 1980 Optimal Wheat Flows

Domestic Flows

Since production of wheat is concentrated in the Northern Plains, wheat generally flows from this territory to the eastern states where wheat consumption is high. Wheat produced in western North Dakota, Montana, Idaho, and Wyoming is moved to Portland and Seattle for export (Figure 6). Gulf ports receive wheat from the Southern Plains, Missouri, Illinois, and Indiana. Wheat produced in North Dakota and Minnesota is moved to Duluth for export.

Spring wheat production is concentrated in Montana, Minnesota, and the Dakotas. Spring wheat produced in western Montana is moved to Seattle and Portland for export (Figure 7). Wheat produced in the Dakotas and Minnesota is moved to the northeastern states and to eastern Europe and the EEC through the Great Lakes. Wheat is also moved from the Dakotas and Minnesota to the Gulf ports for export and to domestic consuming regions through the Mississippi River system.

Durum wheat is produced in Montana, the Dakotas, and Arizona. Wheat produced in Montana is moved to Portland and Seattle for export (Figure 8). Durum wheat produced in the Dakotas is shipped to Duluth for export and to Buffalo, New York for domestic consumption. Foreign import demand for durum wheat to the Gulf ports is met by wheat produced in Arizona.

Export Flows

Optimal export flows of wheat from U.S. ports to import regions are presented in Table 29. Winter wheat is shipped from the Gulf ports to Europe, Africa, South Asia, West Asia, South America, and the U.S.S.R. Japan/Korea and South Asia import wheat through Portland and Seattle. No winter wheat is shipped through Duluth for export.

The basic flows of spring wheat are similar to the flows of winter wheat. Japan/Korea and South Asia import spring wheat through Portland and Seattle. Africa, the Middle East, South Asia, and South America import through the Gulf ports, and the EEC and Eastern Euorpe import through Duluth.

Most durum wheat is imported by the EEC, Eastern Europe, and Africa. The EEC and Eastern Europe import durum wheat through Duluth; Africa imports through the Gulf, West Coast, and Great Lakes ports.

The 1990 Optimal Wheat Flows

Since there are no dramatic changes in production patterns and import demand, flow patterns in 1990 are similar to the 1980 flows of wheat. Wheat production is concentrated in the Great Plains states. Consequently, the wheat is moved from the Great Plains to the eastern states where wheat consumption is high.

Spring and durum wheat produced in the Dakotas, Minnesota, and Montana are moved to Buffalo through the Great Lakes and are also exported to the

Figure 6. Optimal Flows of Winter Wheat From Producing Regions to Dometic Consuming and Export Regions in the 1980 Base Model

Figure 7. Optimal Flows of Spring Wheat From Producing Regions to Domestic Consuming and Export Regions in the 1980 Base Model

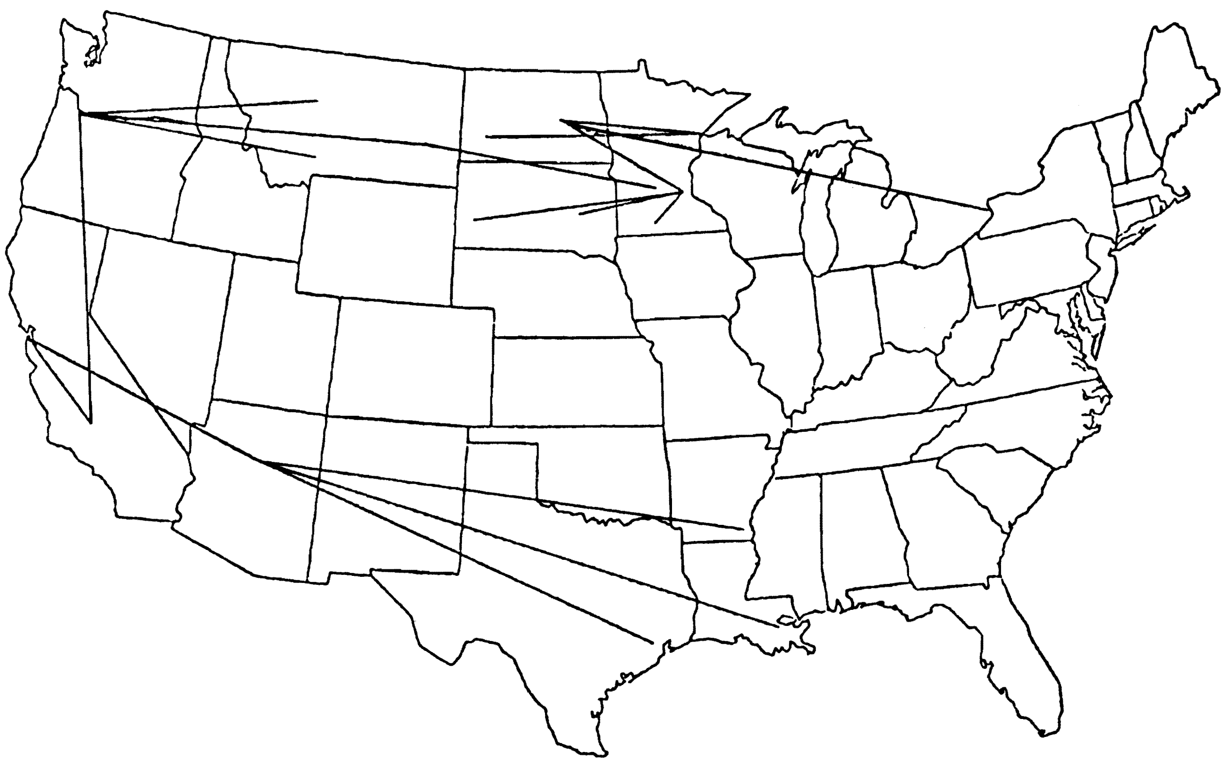

Figure 8. Optimal Flows of Durum Wheat From Producing Regions to Domestic Consuming and Export Regions in the 1980 Base Model

TABLE 29. OPTIMAL FLOWS OF WHEAT FROM U.S. PORTS TO IMPORT REGIONS IN THE 1980 BASE MODEL

U.S. Port	EEC	Eastern Europe	Africa	Middle East	S. Asia	W. Asia	Japan/Korea	C. America	Brazil/ Venezuela	S. America	USSR	Total
Winter												
Philadelphia, PA	0	0	12,733	0	0	0	0	0	0	0	0	12,733
Norfolk, VA	0	0	29,713	0	0	0	0	0	0	0	0	29,713
Mobile, AL	0	0	0	0	0	0	0	0	0	5,898	0	5,898
New Orleans, LA	0	0	0	75,829	0	0	0	0	0	53,891	0	128,720
Houston, TX	44,809	43,361	30,663	0	30,276	41,523	0	0	78,253	23,097	126,655	418,636
Corpus Christi, TX	0	0	0	35,378	0	0	0	0	0	0	0	35,378
San Francisco, CA	0	0	0	0	0	0	0	33,454	0	0	0	33,454
Portland, OR	0	0	0	0	14,298	0	155,254	0	0	0	0	302,552
Seattle, Wa	0	0	0	0	17,189	0	0	0	0	0	0	17,189
Duluth, MN	0	0	0	0	0	0	0	0	0	0	0	0
Chicago, IL	0	0	0	0	0	0	0	0	0	0	0	0
Toledo, OH	0	5,811	0	0	0	0	0	12,063	0	0	0	17,874
Spring												
Philadelphia, PA	0	0	0	0	0	0	0	0	0	0	0	0
Norfolk, VA	0	0	0	0	0	0	0	0	0	0	0	0
Mobile, AL	0	0	0	0	0	0	0	0	0	0	0	0
New Orleans, LA	0	0	6,523	8,122	13,551	1,165	0	0	10,061	1,436	0	40,858
Houston, TX	0	0	0	2,106	0	0	0	0	0	0	0	2,106
Corpus, Christi, TX	0	0	0	0	0	0	0	0	0	0	0	0
San Francisco, CA	0	0	0	0	0	0	0	0	0	0	0	0
Portland, OR	0	0	0	0	25,366	0	35,889	0	0	0	0	61,255
Seattle, WA	0	0	0	0	10,810	0	0	0	0	0	0	10,810
Duluth, MN	51,507	1,252	0	0	0	0	0	16,243	10,015	0	0	79,016
Chicago, IL	0	0	0	0	0	0	0	0	0	0	0	0
Toledo, OH	0	0	0	0	0	0	0	0	0	0	0	0
Durum												
Philadelphia, PA	0	0	0	0	0	0	0	0	0	0	0	0
Norfolk, VA	0	0	0	0	0	0	0	0	0	0	0	0
Mobile, AL	0	0	0	0	0	0	0	0	0	0	0	0
New Orleans, LA	0	0	8,030	0	0	0	0	0	0	0	0	8,030
Houston, TX	0	0	989	0	0	0	0	0	0	0	0	989
Corpus Christi, TX	0	0	0	0	0	0	0	0	0	0	0	0
San Francisco, CA	0	0	2,355	0	0	0	1,547	1,331	0	2,677	0	7,909
Portland, OR	0	0	1,977	0	0	0	0	0	0	0	0	1,977
Seattle, WA	0	0	0	0	0	0	0	0	0	0	0	0
Duluth, MN	26,920	3,726	8,445	0	0	0	0	0	5,260	0	0	44,350
Chicago, IL	0	0	0	0	0	0	0	0	0	0	0	0
Toledo, OH	0	0	0	0	0	0	0	0	0	0	0	0

EEC through Duluth. Spring wheat produced in Montana is shipped to Japan/Korea through Seattle and Portland. Optimal flows of winter, spring, and durum wheat from producing regions to domestic consuming and exporting regions are shown in Figures 9, 10, and 11, respectively.

Optimal export flows of wheat from U.S. ports to importing regions are presented in Table 30. Export flows of wheat in the 1990 model are basically similar to the 1980 export flows; the only difference is increases in quantities of wheat traded.

IX. Conclusions and Policy Complications

This study reveals that the 1980 wheat export market is not efficient in terms of its market share at each port. Import demand and/or export supply conditions should be adjusted at each U.S. export port to maximize social benefits. This can be accomplished by adjusting only supply conditions based on optimal wheat flow from producing regions to export ports rather than by adjusting import demand conditions which are generally uncontrollable by the U.S. The supply adjustment includes more spring and durum wheat shipments to the Great Lakes and more winter wheat shipments to the Gulf ports.

It has been known that trade restrictions such as import tariffs and quotas are major sources of price uncertainty at U.S. export ports. However, this study reveals that the burden of trade restrictions imposed by importing countries is much greater to consumers in importing countries than to wheat producers in the U.S. The burden is dependent upon the type of trade restriction and characteristics of import demand associated with a particular importing country. An import tariff is more effective in the EEC in controlling wheat imports and an import quota is more effective in Japan/Korea. The total social benefit loss is $670 million when the EEC and Japan/Korea impose import tariffs and quotas, respectively. This study also reveals that the social benefit loss is larger for winter wheat producers than for spring and durum wheat producers. It is important for policy makers in both the U.S. and importing countries to be aware of the impacts of trade restrictions on social benefits and on the agricultural economy.

Changes in ocean freight rates influence wheat prices at U.S. export ports more than in importing regions. Approximately 80 percent of ocean freight rate increases is borne by U.S. wheat producers, resulting in substantial decreases in wheat prices at U.S. export ports. This indicates that volatility in ocean freight rates is a major source of price uncer-

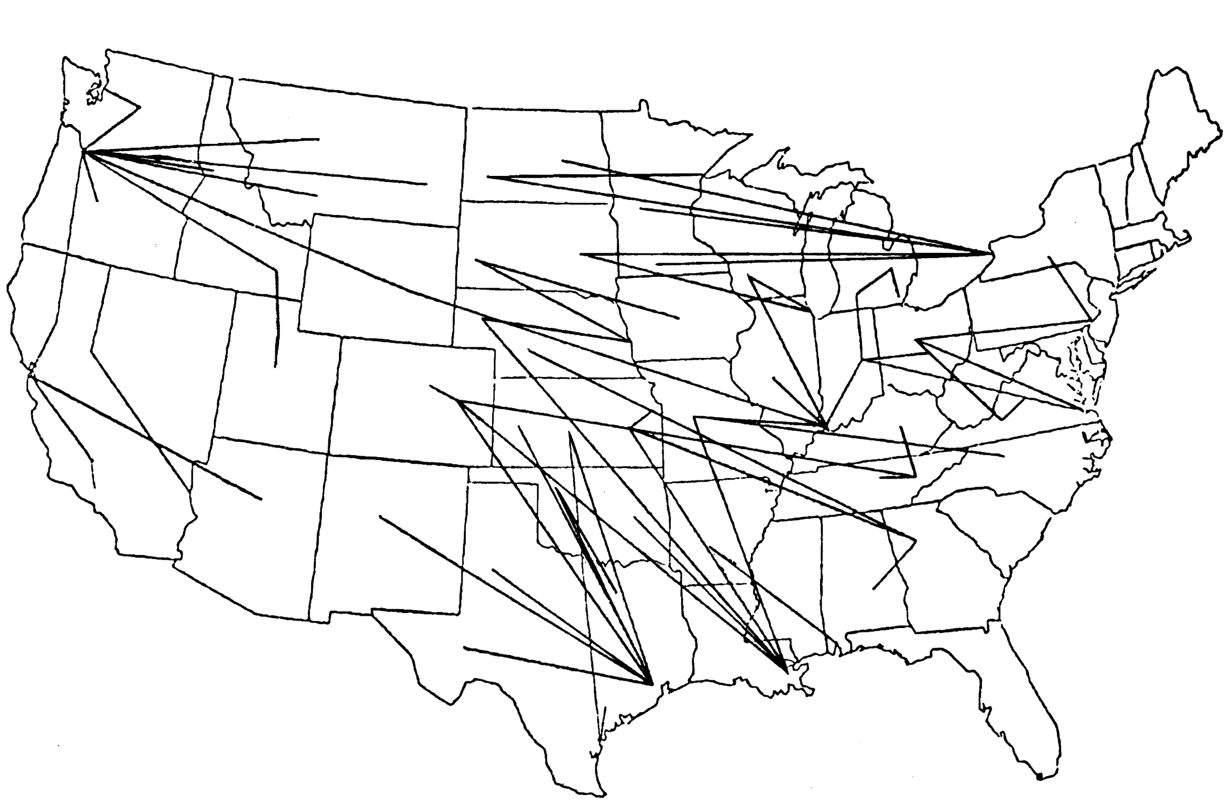

Figure 9. Optimal Flows of Winter Wheat From Producing Regions to Domestic Consuming and Export REgions in the 1990 Base Model

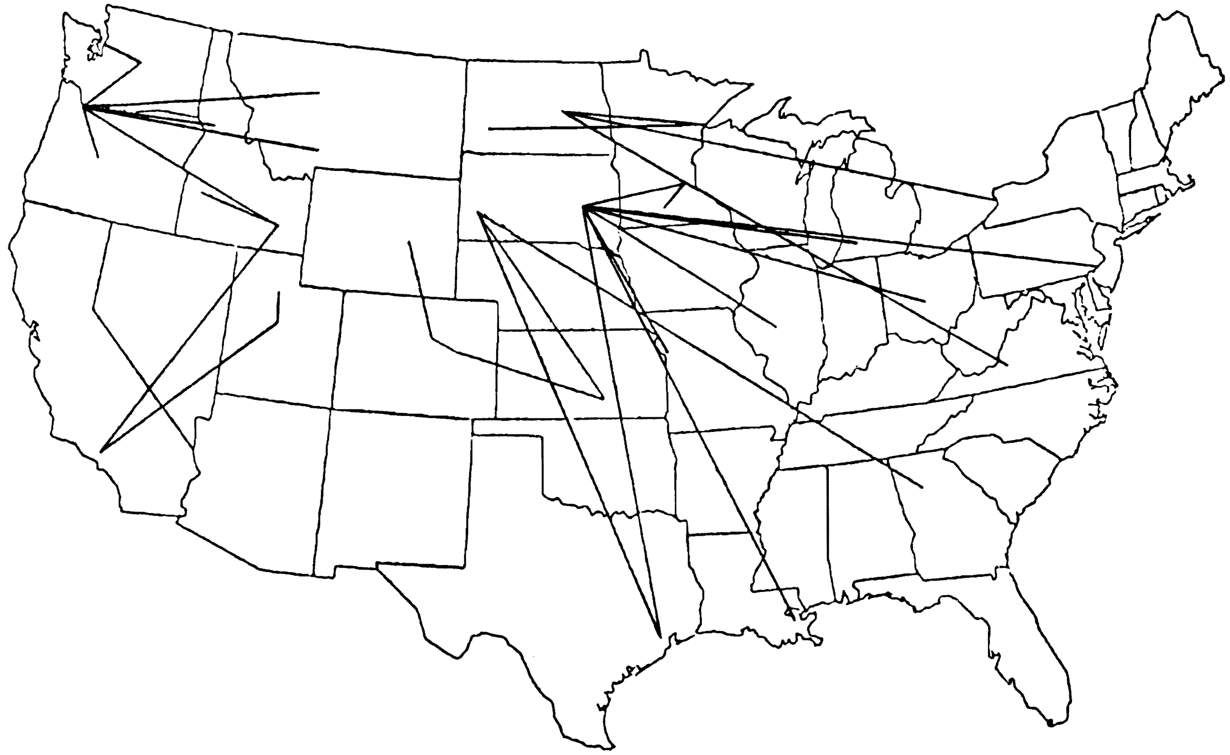

Figure 10. Optimal Flows of Spring Wheat From Producing Regions to Domestic Consuming and Export Regions in the 1990 Base Model

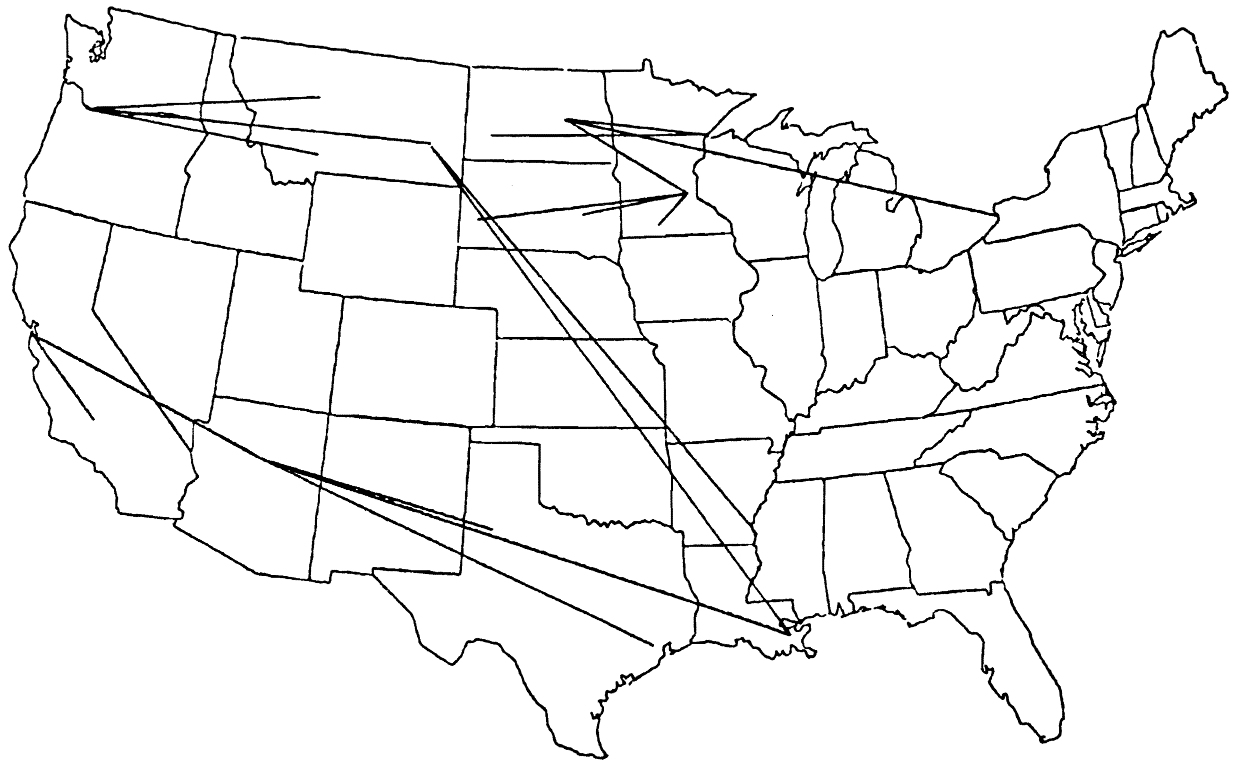

Figure 11. Optimal Flows of Durum Wheat From Producing REgions to Domestic Consuming and Export Regions in the 1990 Base Model

TABLE 30. OPTIMAL FLOWS OF WHEAT FROM U.S. PORTS TO IMPORT REGIONS IN THE 1990 BASE MODEL

U.S. Port	EEC	Eastern Europe	Africa	Middle East	S. Asia	W. Asia	Japan/Korea	C. America	Brazil/ Venezuela	S. America	USSR	Totai
Winter												
Philadelphia, PA	0	0	15,402	0	0	0	0	0	0	0	0	15,402
Norfolk, VA	0	0	35,539	0	0	0	0	0	0	0	0	35,539
Mobile, AL	0	0	5,920	0	0	0	0	0	0	0	0	5,920
New Orleans, LA	31,969	48,706	30,598	0	44,980	0	0	0	0	0	0	156,253
Houston, TX	20,996	0	0	132,598	0	48,436	0	0	49,377	99,672	148,343	499,535
Corpus Christi, TX	0	0	0	0	0	0	0	0	43,798	0	0	43,798
San Francisco, CA	0	0	0	0	0	0	0	42,470	0	0	0	42,470
Portland, OR	0	0	0	0	181,023	0	185,419	0	0	0	0	366,442
Seattle, Wa	0	0	0	0	6,609	0	0	0	0	0	0	6,069
Duluth, MN	0	53	0	0	0	0	0	0	0	0	0	53
Chicago, IL	0	5,659	0	0	0	0	0	0	0	0	0	5,659
Toledo, OH	0	4,667	0	0	0	0	0	11,355	0	0	0	16,021
Spring												
Philadelphia, PA	0	0	0	0	0	0	0	0	0	0	0	0
Norfolk, VA	0	0	0	0	0	0	0	0	0	0	0	0
Mobile, AL	0	0	0	0	0	0	0	0	0	0	0	0
New Orleans, LA	0	0	7,785	10,873	15,253	2,323	0	0	10,042	1,703	0	47,979
Houston, TX	0	0	0	1,238	0	0	0	0	0	0	0	1,238
Corpus, Christi, TX	0	0	0	0	0	0	0	0	0	0	0	0
San Francisco, CA	0	0	0	0	0	0	0	0	0	0	0	0
Portland, OR	0	0	0	0	31,902	0	42,827	0	0	0	0	74,730
Seattle, WA	0	0	0	0	12,152	0	0	0	0	0	0	12,152
Duluth, MN	60,667	1,073	0	0	0	0	0	19,169	13,857	0	0	94,766
Chicago, IL	0	0	0	0	0	0	0	0	0	0	0	0
Toledo, OH	0	0	0	0	0	0	0	0	0	0	0	0
Durum												
Philadelphia, PA	0	0	0	0	0	0	0	0	0	0	0	0
Norfolk, VA	0	0	0	0	0	0	0	0	0	0	0	0
Mobile, AL	0	0	0	0	0	0	0	0	0	0	0	0
New Orleans, LA	0	0	9,907	0	0	0	0	0	0	0	0	9,907
Houston, TX	0	0	1,235	0	0	0	0	0	0	0	0	1,235
Corpus Christi, TX	0	0	0	0	0	0	0	0	0	0	0	0
San Francisco, CA	0	0	3,245	48	0	0	1,815	1,631	0	3,190	0	9,928
Portland, OR	0	0	2,433	0	0	0	0	0	0	0	0	2,433
Seattle, WA	0	0	0	0	0	0	0	0	0	0	0	0
Duluth, MN	35,163	3,556	10,185	0	0	0	0	0	6,347	0	0	55,250
Chicago, IL	0	0	0	0	0	0	0	0	0	0	0	0
Toledo, OH	0	0	0	0	0	0	0	0	0	0	0	0

tainty at U.S. export ports. This implies that stabilizing ocean freight rate is important to reduce uncertainty in marketing wheat and increase farm income. Unlike ocean freight rates, changes in domestic freight rates do not influence wheat prices at U.S. export ports. These changes in the freight rates are mainly absorbed by farmers in producing regions, resulting in decreases in wheat prices received by farmers. Domestic transportation in shipping grain to export market is dominated by railroads while wheat shipments to domestic consuming regions are shared by railroads and trucks. Consequently, it is clear that unstable rail and truck freight rates is a major source of price uncertainty at farm level. Recent two legislations, **Railroads Revitalization and Regulatory Reform Act** (4R Act) and **The Staggers Act,** have encouraged more temporal flexibility in rail pricing. Two major changes may occur in the post deregulation era: 1) geographical rate variations may be widened; and 2) seasonal and demand-sensitive rate variations may also occur. These changes may aggravate volatility in domestic freight rates. Economic consequences of the rail rate deregulation, therefore, should be carefully examined in light of uncertainty in wheat price received by farmers and farm income.

Wheat exports in 1990 are projected to be about 19 percent higher than the 1980 exports. Winter and spring wheat prices at each U.S. ports are expected to be higher than the 1980 prices. However, the 1990 prices of durum wheat are projected to be lower than the 1980 prices. This is due mainly to projected reductions in foreign import demand for durum wheat. Consequently, changes in foreign import demand and export supply schedules could result in different equilibrium prices in 1990.

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