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Grain Transportation Rates and Export Market Development

by

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Preface

This report is a summary of a thesis by Ms. Terry Smaaladen entitled *A Transportation Model of the Spring Wheat Industry*, which was conducted in partial fulfillment of her Master of Science Degree in the Department of Agricultural Economics, North Dakota State University. It was conducted under Hatch Project No. 1368, "Economics of Grain Marketing."

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Highlights

The spatial distribution of commodities is determined by the quantities supplied and demanded in each of the competing regions or markets and by transportation and handling rates. This study analyzes the efficiency of using rail rate reductions for export market development for hard red spring (HRS) wheat from North Dakota via the Pacific Northwest (PNW) ports. A spatial equilibrium model of the HRS wheat distribution system was developed and solved using quadratic programming.

The effects of alternative rail rate configurations to the PNW market were analyzed with particular attention on westbound shipments. In addition, the sensitivity of the spatial distribution of HRS was analyzed with respect to changes in relative ocean rates and expansion in the demand for HRS in the Asian markets.

There were three major conclusions from the study. First, relatively large changes in rail rates were required to stimulate a diversion of traffic from eastern markets to the PNW for export. Second, ocean rates from the PNW to the Asian market would have to increase substantially relative to the U.S. Gulf rates before a significant diversion would occur away from westbound shipments. Third, increased Asian demand for HRS would result in larger quantities of stock supplied from regions closest to the PNW. Producers' prices and net revenue would also increase.

GRAIN TRANSPORTATION RATES AND EXPORT MARKET DEVELOPMENT

by

William W. Wilson, Won W. Koo, and Terry Smaalden

Introduction

Alterations in the absolute and relative levels of transportation rates are frequently advocated by interest groups and to some extent by railroads in an attempt to alter the distribution of particular types of grain for the purpose of market development. The spatial distribution of commodities is determined by the quantities supplied and demanded in each of the competing regions or markets and by transportation and handling rates. In grain marketing, where particular export markets have differing degrees of potential growth, changes in relative railroad rates may be used as a tool in market development. However, the effectiveness of using rail rates in market development depends on quantities supplied and demanded in competing markets and on relative rates of other complementary modes (e.g., ocean rates). This study analyzes the efficacy of using rail rate reductions for export market development of hard red spring (HRS) wheat from North Dakota via the Pacific Northwest (PNW) ports. Railroads have been interested in increased westbound shipments because of the economies of longer hauls and reduced intermodal competition. Producers of HRS wheat, who are predominantly located in North Dakota, view the Asian market as a growth market and consequently have sought changes in relative rail rates (relative to the other markets) to facilitate growth in exports. North Dakota, the second largest wheat-producing state, has a pivotal position in the HRS distribution system with shipments to both the eastern markets and the PNW depending on the many factors affecting spatial distribution.

The domestic distribution of wheat is influenced largely by the location of producers and processors. The rail rate structure has facilitated movement of wheat in the domestic industry through the use of transit privileges and changes in relative rates. In the case of HRS wheat, the traditional domestic movement has been eastward to the major milling centers of Minneapolis and Buffalo.

Exports of HRS wheat have traditionally been shipped through Duluth and/or the U.S. Gulf, both of which reinforced the eastbound shipments from North Dakota. It became apparent in the mid-1960s that the Asian market was a potential growth market for HRS exports. The logical distribution would be for westbound shipments to be exported via the PNW ports in competition with Canadian wheat at Vancouver and with wheat exports via the traditional eastern market. At that time, a blanket rate of 95¢/cwt. for North Dakota origins to the PNW was introduced but failed to stimulate substantial westward movements (Tosterud 1976). In an effort to facilitate westbound shipments from North Dakota, an inverse rail rate structure was introduced in 1965. Rail rates to the PNW were greater for origins in western North Dakota and decreased as distance increased while moving eastward across the state. The inverse rate (i.e., the westbound rate from North Dakota) was comprised of a combination of the eastbound rate from each origin to Minneapolis, plus 31¢/cwt. to represent the barge rate from Minneapolis to New Orleans. The primary reason for using this structure was to equalize Minneapolis with the PNW in the hard red spring wheat export market to the Orient. Rail rates to the PNW ranged from 90¢ to 60¢, gradually declining from extreme eastern Montana to eastern North Dakota. Intermarket rail rate differentials between the PNW and the eastern markets, Duluth and Minneapolis, ranged from 26¢ to 43¢, but numerous rate increases widened the spread to approximately 80¢/cwt. Consequently, the size of origin territory for the Portland export market decreased, and the eastern markets regained their logistical advantage for North Dakota grain. The rationale for the inverse rate structure was that the alteration of freight rate differentials between the PNW market and the Duluth and Minneapolis markets would allow central and eastern North Dakota grain to compete in the PNW market. More recently, rail rates have been realigned to be essentially flat across the state.

The problem in using rail rates to facilitate market development can be analyzed using spatial equilibrium models which have been used extensively in other studies. Linear programming (LP) models assume perfectly inelastic supply and demand functions and have been used in the analysis of grain transportation rates and spatial distribution by Koo and Cramer (1980), Luessen (1968), and Fedeler and Heady (1976), as well as others. Quadratic programming models allow for price dependent functions (e.g., demand) and have been used previously in the analysis of transportation rates by Nagy, Furtan, and Kulshreshtha (1979); by Furtan, Nagy, and Storey (1979); and by Koo (1982).

The purpose of this study is to analyze the effectiveness of using transportation rates for export market development. A base model is developed to depict spatial distribution of U.S. HRS wheat. The effects of alternative rail rate configurations to the PNW market are analyzed with particular attention on westbound shipments. In addition, the sensitivity of the spatial distribution of HRS wheat is analyzed with respect to changes in relative ocean rates and expansion in the demand for HRS wheat in the Asian markets.

Empirical Model

Transportation provides space utility and allows goods from one region to compete with those from another. Equilibrium prices, quantities produced and consumed in each market, and quantities traded or transported between markets can be analyzed using spatial equilibrium models. Comparative statics on the transportation demand function can be used to theoretically describe factors affecting trade. The use of transportation rates in market development means reducing the rate to one market, with everything else constant. The result is a diversion of traffic from other markets and an increase in demand because of the lower consumer net price. The effectiveness of transport rates in market development depends on the spatial distribution of supplies and demands.

Factors affecting the spatial distribution of HRS wheat are evaluated using a multimarket spatial equilibrium model (see Appendix A for mathematical specifications). A base model was developed which has transportation activities from 31 supply regions to 12 domestic consumption centers, three export ports, four commercial storage locations, and five importing regions. Perfectly inelastic domestic demand and supply functions are assumed and the import demand functions are price dependent. Simulations under the following three alternative scenarios are evaluated relative to the model: (1) the effect of changes in westbound rail rates from North Dakota, (2) expansion of import demand in the Asian market, and (3) alternative ocean rate spreads from the PNW and the U.S. Gulf to the Asian markets. Thus, the results identify the impacts of these scenarios on the HRS wheat distribution system, as well as on producers' net revenue and relative port prices.

North Dakota, Minnesota, South Dakota, and Montana are the principal producers of spring wheat. Because of the large proportion of production in these states, they were arbitrarily divided into 24 geographic supply regions. Regional boundaries were based on historical marketing patterns, density of production, and data availability. Washington, Oregon, Idaho, Utah-Nevada, Wisconsin, Wyoming, and Colorado were identified as additional supply regions. The criterion for all production centers was based on both central geographic location within the state's spring wheat producing region and location on a primary rail line. Quantity supplied in each region was calculated as the sum of average stocks and average production. A five-year average from 1975/76 to 1979/80 was used. Total average carryover of 225.4 million bushels was allocated among regions based on the regional percentage of total spring wheat storage capacity.

Domestic consuming regions were delineated based upon estimates of spring wheat utilization at major milling centers in the United States. Spring wheat utilization was estimated from 1977 wheat movements in the United States (Leath et al. 1981), telephone surveys of major millers, and results of previous studies. Total estimated domestic consumption equals 167.8 million bushels which is similar to a five-year average of 162.4 million bushels calculated from <u>Wheat Situation</u> (USDA). Twelve milling centers were chosen to represent U.S. spring wheat consumption.

Duluth, Minneapolis, Lewiston (Idaho), and Sioux City were specified as commercial storage points to accommodate the demand for commercial stocks (USDA 1977). Spring wheat commercial storage capacity served as an upper limit in the model and was allocated on the basis of spring wheat handled at each point except Sioux City. It was assumed that Sioux City handled only spring wheat.

Demand functions for the five importing regions were specified to capture their price responsiveness. Rather than estimate the import demand functions, estimates from an existing study were used in the model. Several studies were reviewed to evaluate the appropriateness of estimates of price elasticities of demand for HRS wheat in the importing countries. Studies by Schmitz and Bawden (1973), Shei and Thompson (1977), and Konandreas (1977) all present estimates of import price elasticities for wheat. Konandreas' estimates for short-run price elasticities were deemed most appropriate for the study because they specifically considered U.S.

wheat exports and because the regional definition for the elasticities was more suitable for the model. Demand functions were calculated at a five-year average quantity of U.S. spring wheat imports and derived port prices. Port price for each region was determined by normal trade routes listed in the U.S. Maritime publication (U.S. Department of Commerce 1980). Destination ports were chosen on the basis of ocean freight rate availability.

Domestic transportation consists of rail, truck, barge, and laker. The least-cost transportation charge specified for each marketing route was chosen. Single- and multiple-car rail rates obtained from the Minneapolis Grain Exchange Rate Book No. 16 are given on an X-002 basis effective from July 1, 1981 to October 1, 1981. The Burlington Northern (BN), Union Pacific (UP), Western Pacific (WP), and Chicago, Milwaukee, St. Paul, and Pacific (CMSP) railroad rate bureaus also provided rail rates. Rail rate functions (Koo and Bredvolt 1981) were used to estimate rates for those routes which were not available from other sources.

Truck rates are not published and vary among regions and through time. Therefore, a truck-cost function for a tractor-trailer capable of handling 850 bushels of grain was used to represent trucking charges for each route. These costs were cross-checked with shippers and trucking firms to ensure that they were not substantially below cost. The original average cost formula calculated by Koo and Bredvolt (1981) was adjusted to reflect increased variable costs. Total trucking costs included fixed costs, variable costs, and transfer costs. Transfer costs are costs associated with loading, unloading, and waiting time.

Barge cost functions developed by Koo and Bredvolt (1981) were used to estimate freight charges on the river systems. Barge rates are seasonal and determined in a competitive market established at St. Louis, Missouri. These rates are published as a certain percentage of the tariff rate. Estimated barge costs were cross-checked with grain and barge transport companies. Because laker freight rates are not published, an estimate of the average rate was obtained from private sources.

Five-year average rates were used to represent ocean freight costs from U.S. ports to foreign destinations (Table 1). All freight rates were quoted for a 12,000 to 25,000 long ton vessel and were converted to a metric ton basis in Table 1.

Empirical Results

Several attempts have been made in the past by the railroads, either on their own initiative and/or from pressure from organizations representing spring wheat producers, to alter the westbound export rail rate with the intention of developing the export market. The thrust of this study evaluates the efficacy of alternative domestic transportation rates for export market development.

The relationships between fundamental market conditions and changes in rate differentials are captured in a spatial equilibrium analysis. The U.S. HRS wheat distribution system was modelled with price-dependent import

TABLE 1. OCEAN FREIGHT RATES

Port	Importing Region				
	Europe	Japan	Asia	Africa	South America
	- - - - - - - - - - ($/MT. Ton) - - - - - - - - - -				
Duluth	21.56	40.36	40.36	--[a]	46.00
Gulf	10.26	21.16	22.69	23.00	15.00
PNW	--	18.27	16.77	35.00	--

[a]An arbitrarily high number used for those routes which are inapplicable.

NOTE: Ocean freight rates are calculated as a five-year average based on crop years 1975-79.

SOURCE: International Wheat Council, World Wheat Statistics (1975-79).

demand functions and perfectly inelastic supply and domestic demand functions. A "base model" was simulated following the description of the empirical model above and is used as a measure of comparison for subsequent simulations. These alternative models are compared with the base model to evaluate the impact of alternative fundamental changes in the distribution of U.S. spring wheat.

The first model is a simulation of changes in westbound export grain rates from supply regions in North Dakota to the PNW. The second simulation analyzes the impacts of changes in the ocean rate differential between the PNW and Gulf to the Orient. The third is a simulation of growth in the Asian demand for spring wheat. This simulation is important because the Asian market is considered a growth market and much of this growth is expected to be exported via the PNW. All of these are evaluated relative to the base model in terms of trade flows, producer prices, and net income.

Base Model

A base model was designed to reflect the basic structure of the U.S. spring wheat distribution system. The primary focus was upon the price responsiveness of the export market because domestic demand was fairly stable and price inelastic. Optimal flows of traffic generated in the base model are illustrated in Figures 1 and 2.

Most of North Dakota and the eastern supply regions shipped to eastern domestic consuming regions and to Europe, South America, and Africa via the Duluth and Gulf port markets. Regions west of North Dakota shipped to the western domestic markets and to the PNW to meet export demand.

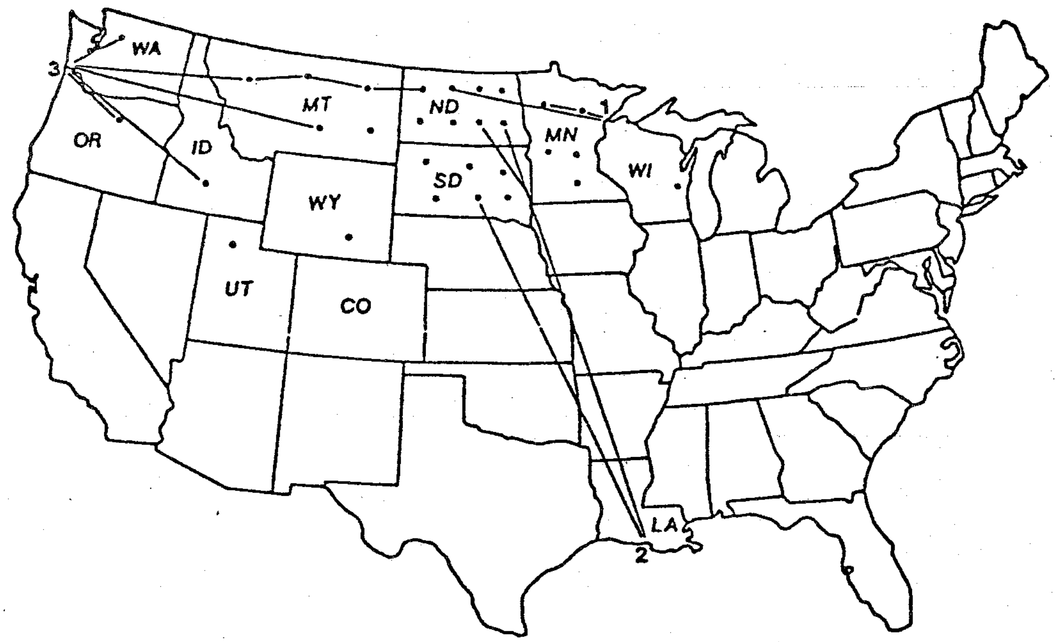

Figure 1. Optimal Flows of Wheat from Producing Regions to U.S. Export Ports in the Base Model

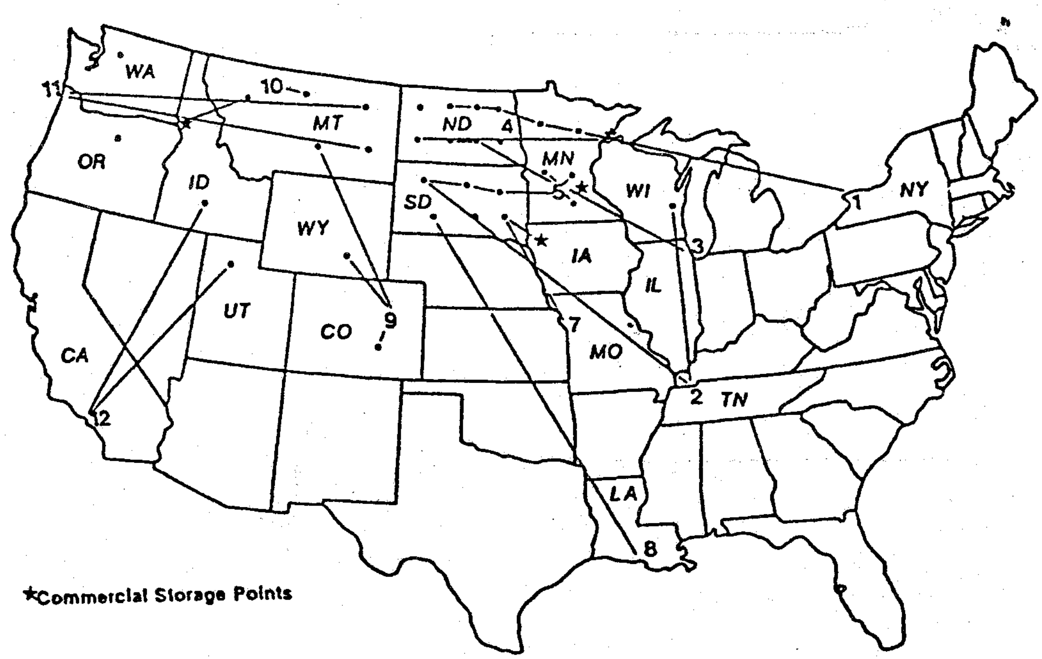

Figure 2. Optimal Flows of Wheat from Producing Regions to Domestic Consuming Regions in the Base Model

Exports to Japan and Asia were shipped via the PNW; Europe via Duluth; Africa and South America via the Gulf port. Appendix Tables B1 and B2 list the optimal shipments of the base model. Duluth, Gulf, and PNW port prices averaged $3.89, $4.20, and $4.49, respectively. The average prices received by farmers shipping to Duluth, the Gulf, and the PNW were $3.36, $3.22, and $3.89 per bushel, respectively. Net farm revenue was $1.252 billion in the base model. The results from this model are similar to actual shipment patterns during the study period and will be used for comparisons in the models simulated below.

Model Simulations

Changes in Westbound Rail Rates for Export

HRS wheat from eastern and central North Dakota is traditionally shipped to eastern markets, and HRS wheat from Montana, Idaho, and Washington is shipped to the PNW. Shipments from western North Dakota are pivotal in the sense that they will be shipped east or west depending on relative market prices (reflecting demand) and domestic freight rates. The purpose of this model was to examine the effectiveness of alternative freight rates as a policy instrument in export market development. Although a small amount of North Dakota's spring wheat was shipped to the PNW in the base model, reductions in the westbound freight rate may permit the PNW to become more competitive for North Dakota's spring wheat. Rail rates from North Dakota shipping points (see Figure 3) to the PNW were reduced from 10 to 70 percent; after the model was simulated for each reduction, trade flows were analyzed. The rate differentials between Duluth and the PNW are shown in Table 2 for each PNW rate reduction. In the base model, the rail rate from Dickinson, North Dakota, to the PNW was 32.9¢/bu. greater than to Duluth. Reductions in the rate to the PNW resulted in a reduction in this differential.

TABLE 2. RAIL RATE DIFFERENTIALS BETWEEN PNW AND DULUTH BY DIFFERENT RATE SCENARIOS (¢/BU.)

North Dakota Supply Region	Rail Rate Reductions from ND to PNW (Percent) 0	10	20	30	40	60	70
Tioga	+21.0	+ 7.9	- 5.1	-18.2	-31.2	-57.4	-70.4
Granville	+46.2	+32.3	-18.6	+ 2.6	- 9.0	-36.5	-50.3
Devils Lake	+64.0	+50.3	+36.5	+22.8	+ 9.0	-18.6	-32.3
Larimore	+79.2	+65.3	+51.5	+37.8	+23.9	- 3.6	-17.4
Dickinson	+32.9	+24.8	+11.4	- 2.0	-15.4	-42.2	-56.2
Steele	+60.0	+46.1	+32.3	+18.6	- 4.8	-22.8	-36.5
Jamestown	+72.0	+58.1	+44.3	+30.5	+16.8	-10.8	-24.5
Casselton	+85.8	+71.8	+58.1	+44.3	+30.5	+ 3.0	-10.8

NOTE: Rail rate differentials are the difference between the rail rate to the PNW and the rail rates to Duluth for each origin. Rail rate differentials to Minneapolis are only slightly different and are not shown here.

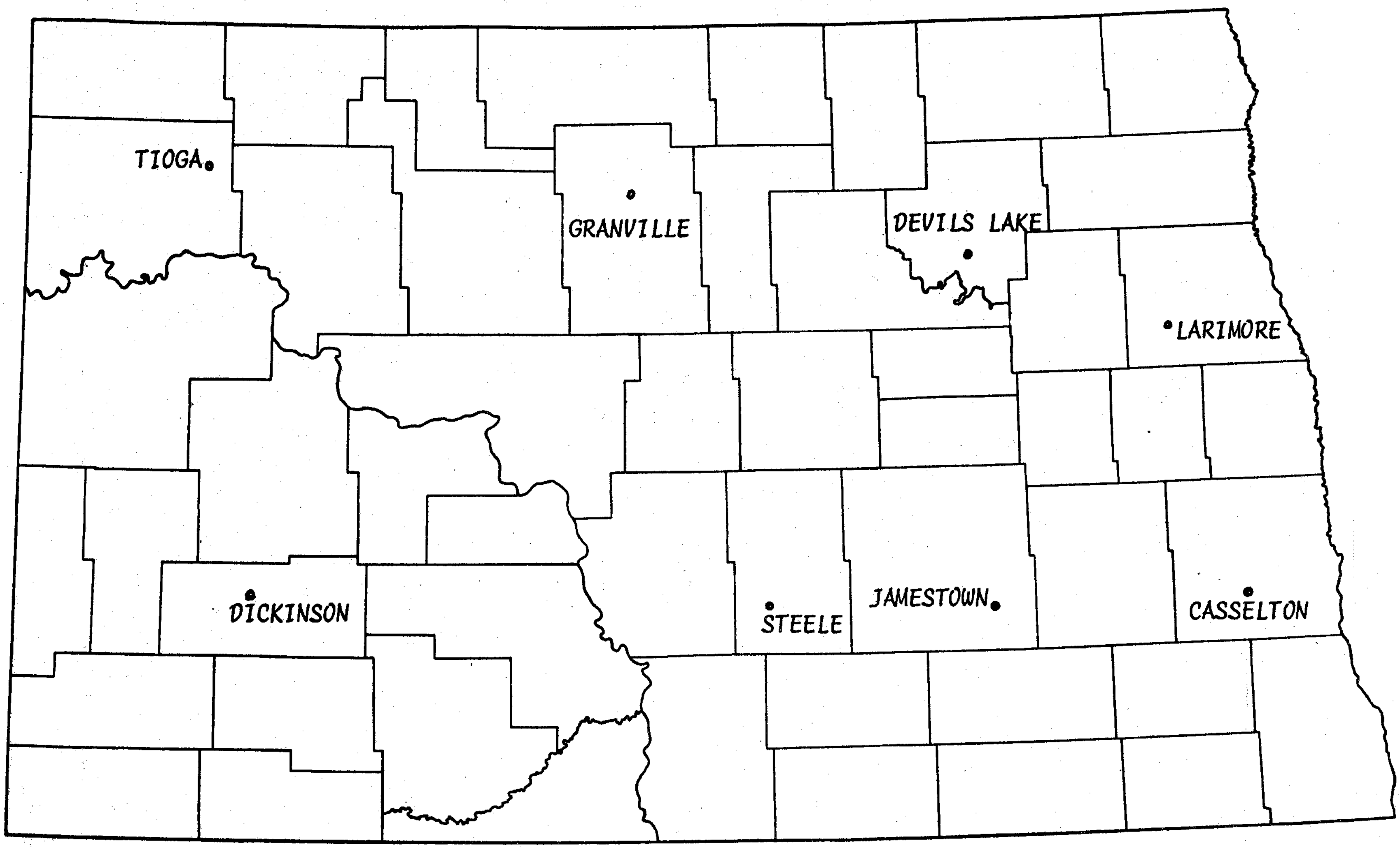

Figure 3. North Dakota Supply Regions

The effect of the alternative westbound rail rates on westbound shipments from North Dakota supply regions are shown in Table 3. The 0 percent decrease represents the westbound shipment patterns in the base model. In that case, only Tioga, North Dakota, had westbound shipments. As westbound rail rates were decreased, Dickinson diverted shipments to the PNW with a 20 percent decrease, and the amount increased for each incremental decrease in the westbound rail rate (with the exception of a 70 percent decrease). Granville and Steele, North Dakota, diverted shipments from the eastern markets to the western markets when the westbound rail rates were decreased by 60 percent (when freight rate was 61¢/bu.) or the differential was decreased by 82¢/bushel.

TABLE 3. NORTH DAKOTA WHEAT SHIPMENTS TO PNW UNDER ALTERNATIVE FREIGHT RATE DECREASES

North Dakota Supply Region	Percent of Decrease						
	0	10	20	30	40	60	70
	(metric tons)						
Tioga	29,538	29,538	29,538	29,538	29,538	29,538	29,538
Granville	0	0	0	0	0	337,926	337,926
Devils Lake	0	0	0	0	0	0	0
Larimore	0	0	0	0	0	0	0
Dickinson	0	0	210,854	489,721	586,845	591,414	591,414
Steele	0	0	0	0	0	15,890	55,503
Jamestown	0	0	0	0	0	0	0
Casselton	0	0	0	0	0	0	0
Total	29,538	29,538	240,392	519,259	616,383	974,768	1,014,381

NOTE: Beginning with a 30 percent reduction, wheat is shipped from PNW rather than the Gulf to Africa.

The influence of intermarket competition exerted on freight rates from North Dakota to the PNW, Duluth, and Minneapolis markets are reflected in these results. There are two basic reasons for the relatively small diversion of traffic coinciding with changes in rail rates: (1) the large spring wheat supply in states west of North Dakota, and (2) the inelastic demand for HRS wheat in the domestic market. Optimal results indicate that HRS wheat supplies in the western states are too great for North Dakota to compete substantially in the PNW export market. The average HRS wheat supply of 3.5 million metric tons in Montana and Idaho can supply the largest PNW export demand (1980/81) of 2.6 million metric tons. Since these two states alone can meet peak export demand at the PNW, North Dakota shippers bear a significant disadvantage in shipping west. North Dakota is essentially a residual supplier in the PNW market. Only western North Dakota regions responded to changes in the intermarket freight rate differential. Since these regions lie on the periphery of two market areas, it is logical that they would be sensitive to freight rate changes. However, central and eastern North Dakota regions continued to ship eastward despite favorable westbound freight rates. Thus, the eastern markets hold an advantage in securing wheat from North Dakota. The other factor which limits intermarket competition is the inelastic demand for spring wheat in the domestic market. Shipments of HRS wheat from North Dakota to the PNW must compete with these demands from the domestic milling centers.

Changes in Ocean Rate Differentials

The growth of the Asian market has increased the prominence of the PNW port as a primary export terminal for spring wheat exports. Factors that make the PNW ports more advantageous than the Gulf ports in shipping grain to the Orient are deeper port channels to accommodate larger ships, less traffic congestion, no canal locks to limit vessel size, and the availability of all wheat classes. The ocean freight rate differential through the years has favored wheat shipment from the PNW to Asia. Since the 1962/63 marketing year, the rate to Asia from the PNW was less than that from the U.S. Gulf except in 1970/71 and 1971/72 when the U.S. Gulf's advantage was only slight. In recent years the PNW rate advantage has ranged from 40¢/MT in 1976/77 to $8.65/MT in 1980/81. Early efforts to equalize domestic transportation costs between the U.S. Gulf and the PNW by using the inverse rail rate structure failed to account for the ocean rate differentials favoring the PNW.

Wheat was shipped to the Orient from the PNW in the base model. The ocean freight rate from the PNW to the Orient was increased in this simulation to evaluate the competitive relationship between the PNW and the Gulf in shipping to the Orient. The five-year average rate advantage of the PNW over the U.S. Gulf for shipments to the Orient was $4.41/MT and was the value used in the base model. The results of the various simulations are in Table 4. Changes in the shipping pattern did not occur until the ocean rate from the PNW to the Orient was increased by $10.52/MT--a $6.11/MT premium over the U.S. Gulf. Japan imported less wheat, but 57,501 metric tons (8 percent of its total spring wheat imports) were shipped from the Gulf. Likewise, Asian imports decreased with each rate increase, but the PNW remained the most economical shipping port. The PNW has this advantage due to the close proximity of large supplies of HRS wheat in

TABLE 4. OPTIMAL WHEAT SHIPMENTS FROM PORTS TO THE ORIENT IN MODEL 3 (METRIC TONS)

Percentage Change in Ocean Rates	PNW Rate Relative to Gulf ($MT/Ton)	Ports: PNW Japan	PNW Asia	Gulf Japan	Gulf Asia
		- - - - - - (metric tons) - - - -			
Base Model	-4.41	725,462	1,308,684	0	0
20	-0.91	715,841	1,293,991	0	0
40	+2.61	706,194	1,279,254	0	0
60	+6.11	693,073	1,264,561	57,501	0
80	+9.62	531,665	1,255,920	158,935	0

Montana and Idaho and the lower procurement costs relative to the U.S. Gulf. Domestic transportation dominates the shipping pattern because it is more expensive relative to ocean transportation. This model illustrates the premise that relatively high domestic transportation rates tend to isolate market areas. In this case, a relatively large change in the ocean rate differential was required to divert traffic away from the PNW.

Growth in Asian Demand

Spring wheat exports to Europe have essentially stabilized, whereas the Asian export market is perceived to have greater growth potential. Japan and the Philippines became major cash customers of U.S. wheats in the mid-1960s. Japan imported 884,466 metric tons of spring wheat in the 1980/81 crop year compared to 343,847 metric tons in 1967. The Philippines' spring wheat imports have been as high as 609,390 metric tons in crop year 1979/80. Wheat consumption increased in these countries after World War II, mainly as a result of U.S. promotional efforts in the reconstruction period. Recent attention has been focused on the People's Republic of China (PRC) as a potential growth market for spring wheat. Their spring wheat imports totalled 123,343 metric tons for crop year 1980/81. Chinese agricultural policy is directed toward a diversion of crop acreage from grains to cash crops, such as cotton, oilseeds, and sugar. A key factor of the policy has been to provide grain imports to those areas shifting acreage (PRC Outlook 1981, 5, 16). Although there is no long-run commitment by the PRC government to supply its domestic needs via imports, continued trade negotiations are an encouraging factor. Population, income, normalized trade relations, a shift in consumer taste and preferences, and a restructuring of the agricultural base have contributed to the development of the Asian market for spring wheat. Wheat exporters anticipate that these factors, as well as rising domestic production costs, will continue to stimulate a growth in demand.

The ramifications of growth in the Asian demand for U.S. spring wheat, particularly in westbound shipments from North Dakota, were simulated in this model. The Asian and Japanese demand curves were shifted to the right by raising the value of the intercept term to capture a growth in demand.

A minimal increase occurred in imports to the Orient. Larger quantities of stocks were shipped from Idaho and Montana to the PNW export market, but the shipping pattern did not change. Larger quantities of stocks were shipped from regions closest to the port rather than altering the shipping pattern to accommodate greater exports. This reflects the higher procurement costs from interior regions, such as eastern Montana and North Dakota.

Producers' Revenue and Market Prices Under the Base and Alternative Models

A summary of producers' revenue and spatial prices for the base model and three scenarios is shown in Table 5. A 20 percent decrease in the rail rate from North Dakota to the PNW resulted in a slight increase in producers' revenue and average net price. This scenario resulted in a slight decrease in the equilibrium PNW port price and an increase in prices at the U.S. Gulf and Duluth. Relative to the base model, the spread between the PNW port price and that at Duluth decreased by 4¢/bushel. Lower rail rates to the PNW imply that merchants for the traditional eastern movements must bid higher port prices to receive quantities sufficient for the domestic demands and export markets via Duluth and the U.S. Gulf. However, as indicated in Table 3, some movement is diverted. The results shown in Table 5 under Model 2 assume the PNW has an ocean rate disadvantage of $6.11/MT relative to the U.S. Gulf in shipments to the Orient (see Table 4). In this case, producers' revenue decreases by $132 million, and the average producer's price decreases by 3¢/bushel relative to the base model. Increasing the ocean rate from the PNW to the Orient (in this case by about 29¢/bushel) results both in a decrease in the PNW port price by 22¢/bushel relative to the base model and in a decrease in the spreads relative to the other markets. This indicates that most of the increase in ocean rates in a particular market segment is absorbed by producers selling to that port in terms of lower port prices. Price spreads in the other markets are reduced because the competitive advantage of the PNW is offset in this case by the inflated ocean rate.

TABLE 5. SUMMARY OF CHANGES IN FARM REVENUE AND PORT PRICES

Revenue and Prices[a]	Model			
	Base	(1)	(2)	(3)
Producers' Revenue	1.252	1.253	1.231	1.391
Producers' Average Net Price	3.33	3.34	3.30	3.67
PNW Port Price	4.49	4.48	4.27	5.83
Gulf Port Price	4.20	4.24	4.22	4.20
Duluth Port Price	3.89	3.92	3.92	3.92

NOTES: (1) A 20 percent decrease in North Dakota freight rate to the PNW.

(2) A 60 percent increase in ocean freight rate from the PNW to the Orient.

(3) A 20 percent increase in intercept term of Japanese and Asian demand.

[a]Prices are in $/bushel and revenue in billion dollars.

Producers' revenue and average producers' prices increased as a result of a 20 percent increase in the Japanese and Asian demand functions. The greatest price increase was at the PNW port from which all of the increased shipments were exported. The price spreads relative to the other markets increased relative to the base model, reflecting the increased competition for HRS wheat exports via the PNW.

Summary and Conclusion

Attempts to use freight rates in market development have frequently been made. Adjustments in the absolute and relative values of freight rates are made in an attempt to alter the distribution pattern of a particular commodity. The effectiveness of altering routes of a particular mode to stimulate market development depends on the spatial distribution of supply and demand, as well as on their elasticities and rates of complementary modes. In the case of grain transportation, demands for the commodity are typically price inelastic and the price of transportation is small relative to the value of the commodity. The purpose of this paper was to analyze factors which influence the distribution of hard red spring wheat in movements from North Dakota to the Pacific Northwest. North Dakota has a pivotal position in the HRS wheat distribution system; part of the state ships to eastern markets and part ships to western markets, depending on market conditions. In light of anticipated growth in Asian demand for HRS wheat, shipped primarily through the PNW, rail rate adjustments have been made in the past to stimulate increased movement from North Dakota to the PNW.

A spatial equilibrium model of the HRS wheat distribution system was developed and solved using quadratic programming. The base model provides a good depiction of actual grain movements and prices. The results of three simulations were compared to the base model to analyze factors potentially influencing traffic patterns from North Dakota. In the optimal solution, Duluth and Minneapolis were the primary markets for North Dakota wheat. Most of North Dakota and eastern supply regions shipped wheat to eastern domestic markets and to the Duluth and U.S. Gulf export terminals. Regions west of North Dakota supplied western domestic markets and the PNW export market. Europe imported HRS wheat via Duluth, Africa and South America via the U.S. Gulf, the Orient via the PNW.

Relatively large changes in rail rates were required to stimulate a diversion of traffic from eastern markets to the PNW for export. There are two important reasons for this. First, the supply of HRS wheat in the states west of North Dakota is too large relative to PNW and Asian demands for North Dakota wheat to be competitive at the PNW on a regular basis. Second, there is a very large inelastic demand for HRS wheat in the eastern markets which compete with the PNW for HRS wheat from North Dakota. The PNW's advantage in shipping HRS wheat to the Asian market is predicated on relatively low domestic transportation costs and an ocean rate advantage relative to the U.S. Gulf. Simulations were conducted to determine the ocean rate differential necessary to divert Asian shipments from the PNW to the U.S. Gulf. The ocean rate from the PNW to the Asian market would have to increase substantially relative to the U.S. Gulf before a significant diversion would occur. The Asian market has been perceived to have a greater growth potential relative to traditional markets for HRS. Results of simulations of increased Asian demand were that larger quantities of stocks were supplied from regions closest to the PNW. However, producers' prices and net revenues would increase as a result of the increased demand.

Rail rates are frequently thought of as being a magical tool for market development. However, their efficacy must be analyzed in the context of spatial equilibrium, which includes the spatial distribution of competing supplies and demands, as well as the price responsiveness and rates for complementary modes. General conclusions regarding the efficacy of using rate adjustments to stimulate movements cannot be made but depend on the market conditions unique to each commodity. Transport rates would be effective in stimulating traffic movements for those commodities with relatively price elastic demands and/or in cases where the price of transportation is a large proportion of the delivered price. In the case of HRS wheat transportation, commodity demands and supplies are relatively inelastic and the price of transportation is a relatively small proportion of the commodity price; consequently, rail rate decreases are not very effective in altering the traditional distributional patterns.

A major conclusion of this paper is that the logistical advantage and productive capacity of competing supply regions dominate the shipping pattern in the spring wheat industry. Freight rate decreases would benefit shippers by reducing the marketing bill and raising prices, but would not be very effective in altering the distribution of spring wheat from North Dakota.

APPENDIX A

Mathematical Specification of the Spatial Equilibrium Model

The spatial equilibrium model is developed and solved on the basis of a quadratic programming algorithm. The objective function is specified as the maximization of farm net revenue (FNR) to capture the effects of quantity responsiveness to price in importing regions. Total revenue is designated as the sum of domestic revenue (P_jD_j) plus export revenue (P_mD_m) where P_j is the cash price for domestic sales, D_j is the quantity of HRS wheat demanded in the jth consuming region, D_m is the quantity of HRS wheat demanded in the mth foreign importing region, and P_m (also defined as $\alpha_m - \beta_mD_m$) is the import price of wheat in the mth importing region. Transportation charges from the supply regions to domestic milling centers ($t_i\ Q_{ij}$), export terminals ($t_{ip}\ Q_{ip}$), commercial storage points ($t_{is}\ Q_{is}$), and importing regions ($t_{pm}\ Q_{pm}$) equal total transportation costs to producers. Thus, farm net revenue is as follows:

$$FNR = \sum_{j=1} P_j\ D_j + \sum_{m=1} P_m\ D_m \tag{1}$$

$$- \sum_{i=1} \sum_{j=1} t_{ij}\ Q_{ij} - \sum_{i=1} \sum_{p=1} t_{ip}\ Q_{ip} - \sum_{i=1} \sum_{s=1} t_{is}\ Q_{is}$$

$$- \sum_{p=1} \sum_{m=1} t_{pm}\ Q_{pm}$$

where $P_m = \alpha_m - \beta_m\ D_m$

The objective function is subject to the following constraints:

$$S_i > \sum_{j=1} Q_{ij} + \sum_{p=1} Q_{ip} + \sum_{j=1} Q_{is} \tag{2}$$

$$DQ_j < \sum_{i=1} Q_{ij} \tag{3}$$

$$C_s > \sum_{i=1} Q_{is} \tag{4}$$

$$D_j - \sum_{i=1} Q_{ij} = 0 \tag{5}$$

$$D_m - \sum_{p} Q_{pm} = 0 \tag{6}$$

$$\sum_{n=1} Q_{pm} = \sum_{i=1} Q_{ip} \tag{7}$$

where S_i is supply of HRS wheat in the ith producing region, DQ_j is total quantity of HRS wheat required in the jth consuming region, and C_s is storage capacity in the sth storage location.

Equations 2 and 3 are the supply constraint in each supply origin and domestic demand constraint in each consuming region, respectively. Equation 4 is the storage capacity constraint in each commercial storage location. Equations 5 and 6 represent equilibrium conditions in domestic and importing regions, respectively. Equation 7 is the inventory clearing condition at each U.S. port and indicates that total quantity of HRS wheat received must equal the quantity shipped.

APPENDIX B
(Tables)

TABLE B1. DOMESTIC SHIPMENTS OF WHEAT IN THE BASE MODEL (METRIC TONS)

	Domestic Milling Centers												Storage Points		
Supply Regions	BUF	CHAT	CHIC	GFKS	MPLS[a]	DHM	KC	ND	DEN	GFLS	PORT	LA	LEWISTON	SX CITY	DULUTH
Gooding, ID (3)												83,689			
Salt Lake City, UT (4)												69,020			
Limon, CO (5)									69,020						
Douglas, WY (6)									18,425						
Missoula, MT (7)													19,873		
Havre, MT (8)										119,998					
Wolf Point, MT (9)											56,359				
Billings, MT (10)									72,072						
Miles City, MT (11)											22,706				
Granville, ND (13)															92,783
Devils Lake, ND (14)	96,218			124,442											
Larimore, ND (15)	553,043														
Dickinson, ND (16)															591,414
Steele, ND (17)					381,713										
Jamestown, ND (18)			176,246		139,365			4,016							
Lemmon, SD (20)		92,335													
Roscoe, SD (21)		42,839			233,420										
Watertown, SD (22)					175,646									88	
Kadoka, SD (22)								25,317							
Sioux Falls, SD (25)						37,599	75,272							27,128	
Crookston, MN (26)	430,767														
Alexandria, MN (28)	614,504				599,194										
St. Cloud, MN (29)					316,767										
Mankota, MN (30)					397,571										
Milwaukee, WS (31)		24,930													
	1,694,532	160,104	176,246	124,442	2,243,666	37,599	75,272	29,333	159,517	119,998	79,065	152,709	19,873	27,216	684,197

[a]Includes 486,421 tons of stocks.

TABLE B2. REGIONAL SHIPMENTS OF WHEAT TO PORTS IN THE BASE MODEL

Supply Regions	Port: Duluth	Gulf	PNW
	- - - - - (Metric Tons)	- - - - - -	
Connel, WA	0	0	505,129
Redmond, OR	0	0	182,656
Gooding, ID	0	0	764,650
Missoula, MT	0	0	25,659
Havre, MT	0	0	201,982
Wolf Point, MT	0	0	292,070
Billings, MT	0	0	32,462
Miles City, MT	1,745	0	0
Tioga, ND	0	0	29,538
Granville, ND	245,143	0	0
Jamestown, ND	0	525,716	0
Casselton, ND	0	477,287	0
Highmore, SD	0	119,141	0
Crookston, MN	1,003,516	0	0
Grand Rapids, MN	30,536	0	0
	1,280,940	1,122,144	2,034,146

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