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OPTIMAL GRAIN DISTRIBUTION SYSTEM AND SUBTERMINAL CAPACITY IN NORTH DAKOTA

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Preface

This report represents a continuation of investigating impacts of changes in transportation rates on the hard red spring wheat trade and distribution system. Research was conducted under the North Dakota Agricultural Experiment Station Research Project No. 1360 (North Central Regional Project 137), "Effects of Changes in Transportation on Performance of the U.S. Agricultural Transportation System."

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Highlights

A linear programming model is used to evaluate effects of changes in the rail rate structure in North Dakota and analyze economic incentives for additional multiple-car loading capacity. Shadow prices are used to assess the need for more subterminals.

Results indicate that railroads increased their market share from 1980 to 1983 due to rate changes. Total grain transportation costs in shipping grain and oilseed are substantially lower under the 1983 rate structure than under the 1980 rate structure. The reductions in transportation costs are mostly due to changes in rate structure under the Staggers Act rather than to the introduction of multiple-car rates. The need for more subterminals is dependent on the rate spread between the 3- and 52-car rates. Under the current rate structure there are no economic incentives for either new subterminals or expansion of facilities in North Dakota. Increases in the rate spread, however, show a need for one more subterminal in central and northwestern North Dakota.

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Railroads play an important role for North Dakota grain farmers in shipping grain from producing regions to consuming regions. Approximately 69 percent of North Dakota's grain and oilseed shipments were hauled by rail to consuming regions during the 1981 crop year (Ming and Kuntz 1982). Railroads are the least-cost mode of transportation except for barge for long distance shipping of bulk commodities. Shipping long distance by barges is less expensive than by rail, but barges are only available in areas near inland river systems. Trucks are most competitive with railroads for shorter shipments.

Transportation rates paid to ship grain directly influence farm income. Grain producers in areas with high transportation prices generally receive lower prices for their grain than producers in areas with low transportation rates. Previous research shows that Montana, Wyoming, South Dakota, and North Dakota are the states that have the highest rail transportation rates in the nation (Koo and Thompson 1982). Since transportation costs in North Dakota are above the national average, changes in rail rate policy and structure are important issues facing the North Dakota grain industry.

Railroad rates for grain in North Dakota have undergone two major changes in recent years. The Staggers Act of 1980 allowed railroads to set their own rates within certain limits without being subject to Interstate Commerce Commission (ICC) jurisdiction. This rule gave railroads increased marketing opportunities and allowed more market competition in rail rate determination. In 1980, multiple-car rates were also introduced to North Dakota for westbound shipments of grain. Multiple-car rates are substantially lower than single-car rates. At present, the Burlington Northern and the Soo Line, the only rail carriers in North Dakota, have published lower rail rates for 3-, 26-, and 52-car shipments. However, additional expansion of many existing elevator facilities is required for them to qualify for these rates because the cars must be loaded in 24 hours. Many elevators in North Dakota do not have adequate rail siding or grain storage capacity to load 26- and 52-car trains in 24 hours. Elevators without multiple-car loading facilities must decide if the region's density of production and their grain loading capacity needs justify expansion.

The overall objective of this study is to evaluate the effects of changes in the transportation rate structure on the grain distribution system and on the economic need for more subterminals in North Dakota. The specific objectives are to:

(1) Evaluate an optimal grain distribution system under the 1980 and 1983 rate structure.

(2) Evaluate the need for additional multiple-car handling capacity given the present multiple-car spread and other alternative scenarios.

Changes in the Transportation System: Multiple-Car Shipments and Deregulation

The ICC initially rejected multiple-car rates. They considered such rates discriminatory since they would be used only by large-volume shippers. Locklin (1972) states that loss of traffic to water carriers and pipelines finally resulted in efforts by the railroads to recover such traffic by the establishment of 'cargo' rates; that is, low rates applying only on multiple-car shipments. The first multiple-car rates were used in 1939 to transport blackstrap molasses in tank cars from New Orleans, Louisiana to Peoria, Illinois. Multiple-car rates for grain were first published in the United States by the Soo Line in 1963 (Hauser, Beaulieu, and Baumel 1984). The rates were for wheat shipments from the Twin Cities to Buffalo. Unit train grain shipments to export markets began in 1965 when the ICC approved a rate proposal by the Southern Railway System for trainload shipments of 44 cars from Louisville, Kentucky, to Charleston, South Carolina (Nightengale 1967). This multiple-car export-grain rate set a precedent and was followed by further multiple-car and unit-train rates for corn and soybeans in the Midwestern states where barge competition existed. Multiple-car rates for wheat were not used in the Great Plains until 1979, when most westbound railroads offered multiple-car rates to the Pacific Northwest (PNW).

The first multiple-car rates were implemented in North Dakota by the Burlington Northern on December 1, 1980 (Griffin and Mielke 1982). The rates were for transporting wheat to the PNW, a port that receives significant amounts of wheat from western North Dakota for export. One reason for the introduction of multiple-car rates to the PNW was that truck competition had been increasing steadily during the previous 15 years. By 1980, trucks accounted for 38 percent of the movement of hard red spring wheat from North Dakota to the PNW. There were several reasons for this increased truck competition. In the early 1970s, barge loading facilities were built on the Columbia-Snake river system as far east as Lewiston, Idaho, making trucks' shipping distance shorter. In addition, westbound rail rates had been increasing faster than eastbound rail rates. Grain also served as a backhaul for truckers who were transporting oil drilling supplies and building materials from the West Coast. A second reason for Burlington Northern's introduction of multiple-car rates was the implementation of multiple-car rates by the Union Pacific in the Central Plains. Union Pacific's multiple-car rates widened the rate differential between the Upper and Central Great Plains, causing West Coast grain merchants to buy more grain from the Central Plains for shipment to the PNW. The Burlington Northern had to add multiple-car rates in the Northern Plains or face a loss of volume to the Union Pacific.

The Burlington Northern introduced multiple-car rates for North Dakota's eastbound traffic on July 13, 1981. The main reasons were truck competition and a desire to offer the eastern and PNW markets the same service. In June 1981, the Soo Line introduced a 3-car rate for wheat at $.10/cwt. below their single-car rate in response to Burlington Northern's announcement of their intent to implement multiple-car rates to Minneapolis and Duluth. Burlington Northern then implemented its first multiple-car rates: a 26-car multiple origin rate, and 26-car and 52-car single origin rates. These rates were reduced $.15/cwt., $.20/cwt., and $.25/cwt. from the single-car rate, respectively. Also, in July the Soo Line introduced its own

25- and 50-car rates. A price war between the two rail lines developed but came to a close in February 1982 when Burlington Northern cancelled its 26-car multiple-origin rate and replaced it with a 3-car rate to meet Soo Line competition.

The eastbound rate reduction for Duluth and Minneapolis for wheat in July 1983 was $.03 to $.04/cwt., respectively, from a single to 3-car rate, $.08 to $.13/cwt. from a 3-car rate to 26-car rate, and $.05 to $.06/cwt. from a 26- to 52-car rate. The rate spread was generally higher in the western part of the state than in the east. The westbound grain rate spread was $.15/cwt. between a 52- and 26-car rate.

The rail rate spread is important, because the rate spread assigns an implicit economic value to multiple-car loading facilities. In March 1984, there were fourteen 52-car loading facilities, and forty-eight 26-car loading facilities in North Dakota; nearly all elevators in the state could use the 3-car rate. The 3-car rate, which is the most popular rate for grain shippers, will probably be eliminated once demand for rail transportation increases. There is an oversupply of rail cars at present, and railroads are trying to increase their modal share, but there is no cost savings with the 3-car rate. If demand increases and the 3-car rate is eliminated, the implicit economic value of multiple-car loading facilities will increase.

It is difficult to tell what changes in rail rates are exclusively due to the Staggers Act, because multiple-car rates were implemented in North Dakota at approximately the same time as the Staggers Act and because supply and demand conditions changed from 1980 to 1983. In 1980 shortly before the passage of the Staggers Act, the volume of grain movement was extremely high. The railroad industry had just ended a period of acute car shortages and still was facing a period of high demand. The railroad industry, already under a less strict regulatory environment due to the passage of the Railroad Revitalization and Regulatory Reform Act (4-R Act), basically asked for a series of rate increases to divert traffic away from the railroad so they could more easily meet their increasing demand. Shortly after the passage of the Staggers Act, grain movement began to slow down. Railroads acquired more hopper cars and more grain was moving to the PNW due to increased East Asian purchases. The shift in demand and the surplus of rail cars also caused structural changes in North Dakota's rail rates.

The Staggers Act was the revised version of the 4-R Act which was passed in Congress in 1976. The 4-R Act did make several changes in the regulatory system (Harper 1978). Railroads could change a rate as much as 7 percent from the level effective at the beginning of the year without the rate being suspended. A time limit of 180 days was placed on the Interstate Commerce Commission (ICC) on any proposed rate or fare that involved a capital investment of a million dollars or more by a carrier, shipper, or receiver. Most importantly, the 4-R Act significantly modified standards which the ICC used in determining the reasonableness of rail rates. In the past, the ICC had no economic criteria to determine rail rates. The concept of "market dominance" was introduced to determine if a rate was too high. Market dominance existed when there was a lack of competition with other carriers. Now the ICC must find market dominance before it has the jurisdiction to conclude that rates are unreasonably high.

The Staggers Act allows rail carriers to establish their own rates within certain limits (Thoms 1981) and it tries to promote more competition in the railroad industry. Rate bureaus, which formed cartels to represent railroads in various geographic areas, had their status altered. Rate bureaus no longer had antitrust immunity on single-line rates, i.e., rates that apply between two points on one railroad. This change altered the railroads' rate making procedure. In the past, rate bureaus could collude to decide their rates; now collusion was illegal. Recordings of rate bureau meetings were required and had to be submitted to the ICC--the federal government organization that serves to regulate business transactions of common carriers. There also was no maximum rate unless the carrier had market dominance over that particular class of freight; if the rate was under 190 percent of variable cost, the ICC could not suspend the rate or investigate it on its own. This threshold test for market dominance was later reinterpreted by the ICC. Presently, geographic, product, intermodal, and intramodal competition are also used as standards to determine adequate competition, so the concept of market dominance is still being debated today. Also, the entire burden of proof for an unreasonable rate lay with the protestant. If the shipper asked for the rate to be suspended and the rate was found to be reasonable by the ICC, the shipper would be liable for the interest and back charges.

Development of the Empirical Model

The model used in this study is a spatial equilibrium model based on a linear programming algorithm. Linear programming (LP) was chosen over quadratic programming (QP) because it is extremely difficult to estimate the supply and demand functions for North Dakota's grain at various port locations. A network algorithm, although it is more efficient in terms of computer time than LP, does not show shadow prices which are needed to evaluate the economic need for more subterminals.

The objective function of the model incorporates annual transport costs in shipping grain from producing regions in North Dakota to domestic and export regions. Transportation activities are subject to various constraints associated with regional demands for grain, supplies of grain in each producing region, and rail car capacity at each subterminal. The model contains 132 grain producing regions, 6 demand points, and 12 subterminals.

Figure 1 shows the 132 producing regions in North Dakota. The southeastern counties of North Dakota are omitted from the study because corn, a fairly significant crop in that region, is not included in the study. Figure 2 shows the domestic consuming regions and export locations. Domestic consuming regions are based on locations of grain processing plants and deficit feed grain regions in North Dakota.

This model includes three crops: wheat, feed barley, and sunflower. Two time periods are included in the model to identify seasonal grain movements. The time periods are (1) summer and harvest period and (2) winter and spring. During the summer and harvest periods, it is assumed that the 26-car loading facilities will acquire enough grain to use the multiple-car rate since grain movement is historically higher during this time period. In the winter and spring periods, storage facilities with 26-car loading capacity will use the 3-car rate.

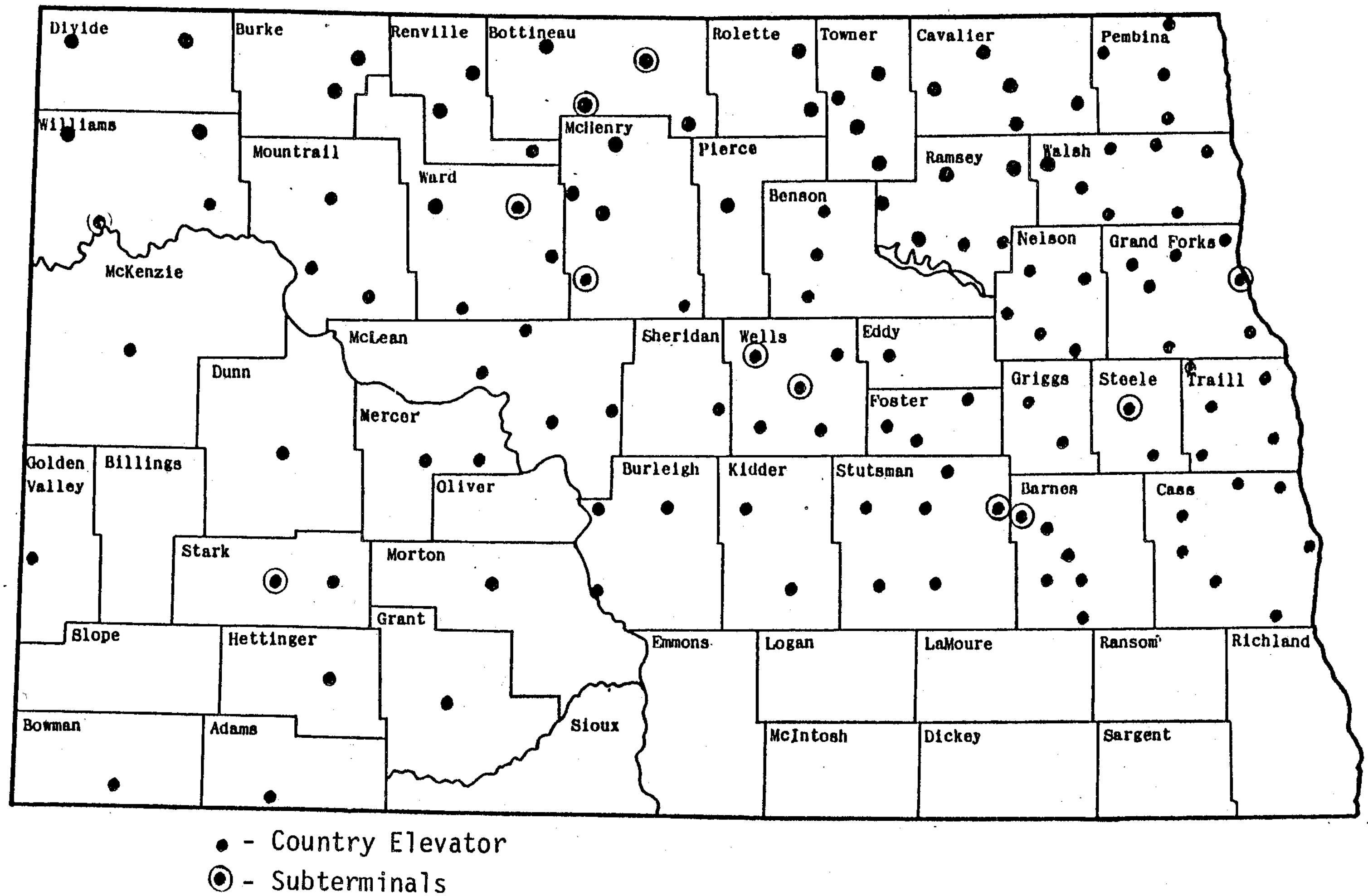

Figure 1. North Dakota Shipping Origins (132) Used in the Linear Programming Model

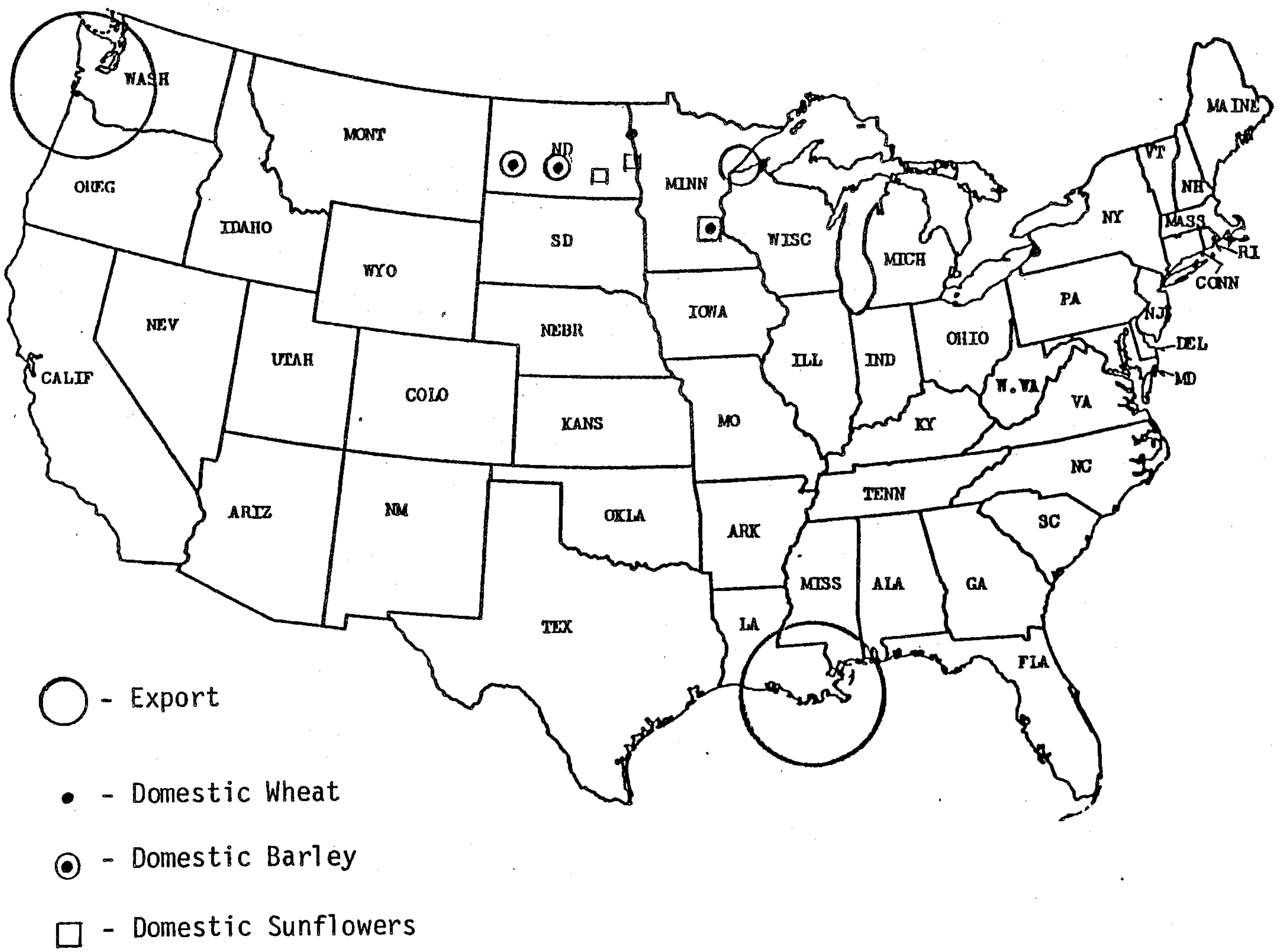

Figure 2. Domestic Consuming Regions and Export Locations for Wheat, Sunflower, and Feed Barley Used in the Linear Programming Model

There are three modes of transportation in the model (rail, truck, and barge) and two transportation activities. The transportation activities are (1) shipments of grain from producing regions to domestic consuming regions and (2) shipments from producing regions to export locations directly and through subterminals. These subterminals receive grain by truck and can ship grain by rail or truck. A balancing equation assures that any grain received by a subterminal outside of its producing region is shipped out within the same time period. A mathematical description of the model is presented in Appendix D1.

A subterminal is any elevator that has a 52-car loading capacity. Each subterminal is subjected to a rail-car loading capacity constraint (RCL). The capacity constraint limits the amount of grain that can be shipped out by 52-car unit trains from six different producing regions in North Dakota (Figure 3). The constraint level differs depending not only on how many subterminals are in each region, but also on the estimated turn-around time in each region to each respective export location.

Rail transportation costs are calculated from actual published rates during July 1983. Trucking rates are based on cost-of-service because trucking rates are variable and the assumption that prices of transportation will be equal to their average cost under a competitive market system. Barge and vessel rates collected from shipping companies represent the average rates plus additional handling charges during July 1983.

A base model was also developed which used the 1980 rail rate structure under 1983 supply and demand conditions (Model 1). This model is the same as the 1983 model except there are no subterminals, because there were no multiple-car rates at that time. The alternative models are all run under the 1983 rate structure. The different alternative models are as follows:

Model 1: The 1980 base model with the 1980 transportation rate structure

Model 2: The 1983 base model with the 1980 transportation rate structure and the existing multiple-car loading capacity

Model 3: Elimination of the 52-car rate in the 1983 model

Model 4: An increase in the rail-car capacity constraints to the equivalent of one additional subterminal in each rail-car loading capacity constraint (RLC) region

Model 5: An increase in the rail-car loading capacity constraints to the equivalent of two additional subterminals in each RLC region

Model 6: An increase in the rail-car loading capacity constraints to the equivalent of three additional subterminals in each RLC region

Model 7: An increase in the rail-car loading capacity constraints to the equivalent of four additional subterminals in each RLC region

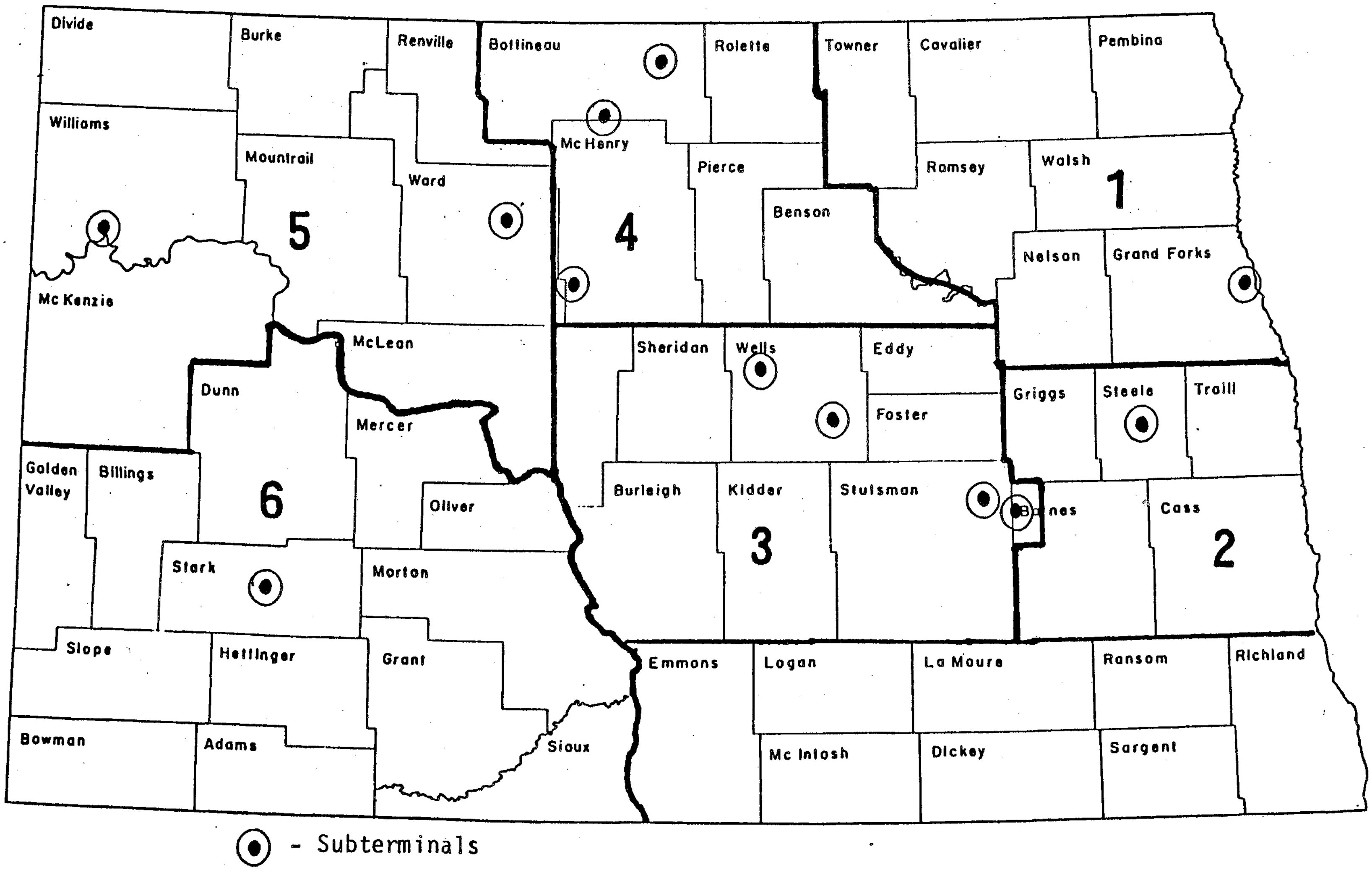

Figure 3. Six Rail Loading Capacity Constraint (RLC) Regions and Subterminals

Model 8: An increase in the rail-car loading capacity constraints to the equivalent of five additional subterminals in each RLC region

Model 9: Elimination of the rail-car loading capacity constraints

Models 10 and 12: A 10 and 20 percent increase in the rail rate spread for the PNW, Duluth, and Minneapolis markets under the original rail-car loading capacity constraints

Models 11 and 13: A 10 and 20 percent increase in the rail rate spread for the PNW, Duluth, and Minneapolis markets under an increase in the rail-car capacity constraints to the equivalent of one additional subterminal in each RLC region

Data Collection

Data needed for this study were the estimated demand for North Dakota wheat, feed barley, and sunflower in each respective consuming region and the supply of these crops in each producing region during the 1982-83 crop year. Rail and barge rates and trucking cost were gathered for July 1983 and July 1980. Rail loading capacity constraints for 52-car loading facilities were also estimated.

Supply

The aggregate supply of wheat, feed barley, and sunflower for the 1980 and 1983 models comes from 132 producing regions. These regions were all within North Dakota. The formula used for calculating supply in each production region is as follows: Total Available Supply equals Production plus Carryover minus Farm Use.

Supplies of sunflower, wheat, and feed barley were estimated for the 1982-83 crop year. Production and stock statistics by county were collected from North Dakota Agricultural Statistics published by the Statistical Reporting Service (SRS). Because the SRS did not estimate sunflower stocks in 1980, the National Sunflower Association estimates were used. Farm use is given as a state-wide figure and is allocated to each county by the livestock census recorded by the SRS. During the 1982-83 crop year no farm use statistics were recorded. It was assumed that 23 percent of the barley crop and 4 percent of the wheat crop were used on the farm. These figures were based on a five-year average from 1976-1980. Farm use was considered to be negligible for sunflower. Once the county surplus was estimated, grain was allocated to each producing region. If there was more than one producing region per county, producing regions were subdivided according to elevator size--the larger the elevator, the more grain the producing region was allocated.

Demand

Demand for grain was divided into two categories: domestic and export. Domestic demand for each crop includes only demand for food; feed demand was excluded because it is subtracted from the supply of grain except when the farm use is greater than the carryover.

The domestic demand for North Dakota's wheat was estimated for its three major domestic consumption points--Grand Forks, North Dakota; Buffalo, New York; and Minneapolis, Minnesota. Grand Forks was assumed to mill only North Dakota wheat. One-half of the wheat milled in Minneapolis was assumed to come from North Dakota. It was assumed that 44 percent of the spring wheat milled at Buffalo comes from North Dakota. This figure was based on the percentage of U.S. spring wheat grown in North Dakota.

Domestic demand points for sunflower are West Fargo, Enderlin (North Dakota), and Minneapolis. West Fargo and Enderlin each have one sunflower crushing facility, while the Minneapolis area has two. The demand figures for West Fargo and Enderlin were obtained from National Sun Industries and Cargill, Inc. These two companies have sunflower processing plants in Enderlin and West Fargo, respectively. The demand for sunflower crushed in Minneapolis was estimated from the North Dakota Public Service Commission grain and oilseed movement report.

Domestic demand for barley was derived from the total available supply equation. Several counties in the southwestern part of the state had negative total available supply. In these counties the farm use statistic was greater than the production and carryover. County deficits were added together, and the total was divided between Dickinson and Bismarck, which served as the two domestic demand points.

Export demand figures were taken from North Dakota Public Service Commission reports showing grain movement from North Dakota during the 1982-83 crop year. Duluth, Pacific Northwest (PNW), and the Gulf were the export demand points for sunflower and wheat. Duluth and the PNW were the export points for barley. Duluth was not used as a demand point during the winter time period. Table 1 shows the domestic and export demand constraints for each crop.

Grain Loading Capacity Constraints

Grain loading capacity constraints were added to the 1983 model for 52-car shipments. The capacity constraint was based on the minimum weight per hopper car in the Burlington Northern tariff for multiple-car shipments times 52 cars divided by the turnaround time in each of the six loading regions. RLC_{omt} parameters were defined as

$$RLC_{omt} = C_n P_t F_{on}$$

where C_n was the number of hopper cars specified by the multiple-car shipment; P_t was the number of days in the period t; F_{on} was the number of facilities in region r.

The turnaround time was based on a survey of each subterminal location in the state. It was assumed that each subterminal had only one multiple-car shipment at a time. Grand Forks and Minot claimed they had more than one during harvest time, hence their turnaround time was lowered during time period one.

TABLE 1. DOMESTIC AND EXPORT DEMAND CONSTRAINTS FOR EACH CROP, 1983

	HRS Wheat	Sunflower	Feed Barley
	cwt.		
Duluth	108,517,981	19,288,463	5,718,357
Gulf Port	52,782,568	208,056	--
PNW	22,088,496	135,216	789,754
Minneapolis	19,366,982	3,630,994	--
Grand Forks	2,919,804	--	--
Buffalo	12,424,040	--	--
West Fargo	--	5,511,000	--
Enderlin	--	2,800,000	--
Dickinson	--	--	604,500
Bismarck	--	--	604,500
TOTAL	206,918,235	31,573,729	7,717,111

Trucking Transportation Cost

Trucking costs were estimated for a semi tractor-trailer hauling 850 bushels of grain. Truck costs were estimated because truck rates were not quoted or published. A truck cost function was estimated for 1980 and 1983. The total trucking cost for a semi tractor-trailer was the summation of fixed, variable, and transfer cost. Cost figures were obtained from truck dealerships and trucking firms in North Dakota.

Fixed costs per year for grain trucks include interest, depreciation, administrative costs, insurance, license, and highway user taxes. Variable trucking costs per mile include wages, tires, fuel, oil, and filters. Transfer costs were determined by the time spent loading and unloading, plus the estimated time a trucker spends waiting to do so. These costs depend upon the number of trips made per year.

The estimated average cost per cwt. by trip distance was

$$AC = .26d + 2.855$$

where AC is average cost per hundredweight, and d is trip distance.

This trucking model was used to estimate 1983 trucking cost. The 1980 formula was derived the same way under the 1980 cost structure. The 1980 formula was

$$AC = .24d + 2.224.$$

Barge Rates

The only barge movement used in this study was that from Minneapolis/St. Paul to the Gulf ports. Cargill, Inc. provided the weekly average barge rates for July 1980 and 1983 (Table 2). The average rates for July 1980 and 1983 were used for the 1980 and 1983 models. Transfer costs for unloading a train or truck at a terminal elevator and loading a barge were assumed to be $.26/cwt. This figure was also based on estimates provided by Cargill, Inc.

TABLE 2. BARGE RATES FROM MINNEAPOLIS/ST. PAUL TO GULF PORTS, JULY 1980 AND 1983

	July 1980		July 1983	
	ton	cwt.	ton	cwt.
1st Week	$14.23	.71	$7.86	.40
2nd Week	14.86	.75	8.05	.41
3rd Week	15.16	.76	8.05	.41
4th Week	19.80	.99	8.67	.44
5th Week	20.12	1.01	9.41	.47
		.84		.44

Rail Transportation Rates

Actual rail rate data were collected from industry souces including the Minneapolis Grain Exchange, the Soo Line, and the Burlington Northern Railroad. The 1980 wheat and barley rates were obtained from the Minneapolis Grain Exchange Rate Book ex-parte 368-A level No. 15 and increased by 12.36 percent to bring them to the July 1980 level. Sunflower rates for 1980 were obtained from the Minneapolis Grain Exchange Book No. 16. The 1980 barley and sunflower rates to the PNW and sunflower rates to the Gulf were obtained from the North Dakota Public Service Commission and the Burlington Northern Railroad. The 1983 rates were from Soo tariff 4087-C and Burlington Northern tariff 4022-D Section 1 and 3. Sunflower rates from North Dakota country origins to the Gulf were obtained from the Minneapolis Grain Exchange traffic department. Gulf rates from Minneapolis, and rates for Minneapolis to Buffalo by rail were obtained from the Burlington Northern.

Results

All models are based on the 1983 supply of grain and oilseed in each producing region, on demand conditions in each consuming region, and on the 1983 rate structure, except Model 1, which has the 1980 rate structure. Model 1 serves as the 1980 base model. Model 2 includes the existing multiple-car loading capacity constraints and serves as the 1983 base model. Model 3 includes the 1983 rate structure with no 52-car rates. Models 4, 5, 6, 7, and 8 increase the multiple-car loading capacity constraints to the equivalent of one, two, three, four, and five subterminals in each of the six subterminal regions. Model 9 has no loading capacity constraints for the subterminals. Models 10 and 11 increase the rate spread between the 3 and 52 car rate by 10 percent for the PNW and Duluth. Model 10 uses the present subterminal constraints; Model 11 increases the multiple-car loading capacity by one subterminal. Models 12 and 13 increase the 3- and 52-car rate spread by 20 percent for the PNW and Duluth. Model 12 uses the original grain loading capacity constraint; Model 13 increases the capacity by one subterminal for each region.

Effects of Changes in Transportation Rate Structure on the North Dakota Grain Industry

Total Transportation Costs for Grain and Oilseed Shipments to Both Domestic and Export Markets

Estimated total transportation costs for shipments of wheat, feed barley, and sunflower are shown in Table 3. In Model 1, which includes the 1980 rate structure, the total costs for wheat, sunflower, and feed barley are $285.6 million, $36.4 million, and $17.8 million, respectively, leading to a total transportation cost of $338.9 million. Total transportation costs for Model 2 are $231.0 million for wheat, $36.0 million for sunflower, $9.4 million for feed barley, and a total transportation cost of $276.7 million. The largest saving in transportation costs is in wheat and feed barley under the 1983 rate structure. Total transportation costs are reduced $62.2 million in Model 2 compared to Model 1 as a result of decreases in rail and barge rates, and the introduction of multiple-car rates.

TABLE 3. ESTIMATED TOTAL TRANSPORTATION COSTS IN SHIPPING GRAIN FROM PRODUCING REGIONS TO CONSUMING REGIONS UNDER THE 1980 AND 1983 RATE STRUCTURES

Model	Wheat	Sunflower	Barley	Total
		($1,000)		
Model 1	285,615	36,484	17,821	338,924
Model 2	231,004	36,071	9,408	276,708
Model 3	237,525	26,759	9,612	282,769

Model 3, which has the 1983 rate structure with no 52-car rates, shows an increase of $6.1 million in total transportation cost from the 1983 base model (Model 2). This indicates that the reductions in transportation costs ($62.2 million) are mostly due to changes in transportation rate structure under the Staggers Act rather than the introduction of multiple-car rates.

Transportation Costs for Domestic and Export Shipments

Estimated transportation costs in shipping wheat, sunflower, and feed barley to export regions are shown in Table 4 for Models 1 and 2. Under the 1980 rate structure total transportation costs to export markets are $274.6 million. Wheat has the largest cost of the three crops because of its volume. Transportation costs for wheat are $137.0 million in time period one and $88.9 million in time period two. Sunflower costs to export markets are $30.2

TABLE 4. ESTIMATED TRANSPORTATION COSTS IN SHIPPING GRAIN FROM PRODUCING REGIONS TO EXPORT REGIONS UNDER THE 1980 AND 1983 RATE STRUCTURES

Time Period	Wheat	Sunflower	Feed Barley	Total
		($1,000)		
Under the 1980 rate structure (Model 1)				
Time Period 1	137,023	30,174	14,971	182,168
Time Period 2	88,989	879	2,529	92,397
TOTAL	226,012	31,053	17,000	274,565
Under the 1983 rate structure (Model 2)				
Time Period 1	119,853	23,040	8,987	151,880
Time Period 2	59,031	3,751	278	63,060
TOTAL	178,884	26,791	9,265	214,940

million during time period one and $0.88 million during time period two. Feed barley costs to export are $14.9 million in time one and $2.5 million in time two. The reason that total export cost is greater in time period one is because the Duluth port is open in the time period. This causes the greatest volume of movement to occur during the nonwinter months, thus outweighing the relatively lower transportation rates to Duluth. The lower costs to Duluth are reflected in the average costs in dollars per cwt. to export markets for wheat, sunflower, and feed barley in time periods one and two. The average costs in dollars per cwt. are $1.09, $1.07, and $1.69 for time period one and $2.76, $3.53, and $4.42 for time period two for wheat, sunflower, and feed barley, respectively.[1]

Due to the majority of export demand being shipped under multiple-car rates, 1983 transportation costs to the export markets are where the greatest cost savings occur. Total export costs are $214.9 million in 1983. Wheat to export markets had a total transportation cost of $119.9 million in time one and $59.0 million in time two. Sunflower export costs are $23.0 million in time one and $3.8 million in time two. Barley export costs are $9.0 million and $0.28 million for time periods one and two. The cost ratios between the two time periods are similar to the 1980 model. However, there is a greater reduction in rates in time period two because multiple-car rates to the PNW

[1]The average costs in dollar per cwt. for grain are calculated by dividing the total transportation costs of the grain by the quantities of the grain shipped. Consequently, the average costs depend upon the average hauling distance and modal share in the given time period.

were greatly reduced from the former "paper" rates for sunflower and barley to the West Coast. This reduction is also reflected in the average cost per cwt. The average costs are $.98, $.90, and $.88 in time period one, and $1.96, $2.95, and $2.16 for time period two, for wheat, sunflower and barley, respectively. Like transportation cost, the greatest reduction in average cost from the 1980 model is in time period two.

Estimated costs in shipping grain to domestic consuming regions are listed in Table 5 for Models 1 and 2. Transportation costs to domestic markets are lower than export markets because of the closeness of processing centers. Total transportation costs to domestic markets are $64.4 million in 1980. Costs in the different time periods are basically the same, since demand in the processing centers is not seasonal. Transportation costs for wheat are greater in time period two because shipments to Buffalo have to move entirely by rail instead of by truck-vessel or rail-vessel combination via the Duluth market. The costs are also reflected in the average cost per cwt. for moving wheat, sunflower, and feed barley to domestic markets. The average rates are $1.00, $0.41, and $0.18 in time period one and $1.34, $0.41, and $0.19 in time period two.

TABLE 5. ESTIMATED TRANSPORTATION COSTS IN SHIPPING GRAIN FROM PRODUCING REGIONS TO DOMESTIC CONSUMING REGIONS UNDER THE 1980 AND 1983 RATE STRUCTURES

Time Period	Wheat	Sunflower	Feed Barley	Total
		($1,000)		
Under the 1980 rate structure (Model 1)				
Time Period 1	32,232	2,824	166	35,222
Time Period 2	26,371	2,607	154	29,132
TOTAL	58,603	5,431	321	64,355
Under the 1983 rate structure (Model 2)				
Time Period 1	28,145	4,826	190	33,161
Time Period 2	23,975	4,454	176	28,605
TOTAL	52,120	9,280	367	61,767

The total domestic transportation costs for Model 2 are $61.8 million. Domestic transportation costs do not decrease as much as export transportation costs because multiple-car rates are used for shipments to export markets but not to domestic processing centers. Furthermore, domestic consuming centers receive a higher percentage of grain by truck. The average costs per cwt. in 1983 are $0.89, $0.55, and $0.21 for wheat, sunflower, and feed barley in time period one; $1.13, $0.51, and $0.19 in time period two.

Modal Competition

Approximately 90 percent of North Dakota's grain and oilseeds was moved by rail in Model 2 compared to 39 percent in Model 1. The rest of North Dakota's grains and oilseeds was moved by truck or a truck-laker or truck-barge combination to its final destination (Table 6). The drastic decrease of truck's modal share under the 1983 rate structure is due to two reasons: (1) multiple-car rates were implemented after July 1980, (2) railroads had surplus capacity in early 1980 and reduced their rates to increase their market share.

TABLE 6. ESTIMATED GRAINS AND OILSEED SHIPPED BY TRUCKS AND RAIL UNDER THE 1980 AND 1983 RATE STRUCTURES

Mode	Wheat	Sunflower	Feed Barley	Total
		(1,000 cwt.)		
Under the 1980 rate structure (Model 1)				
Rail	43,701	24,584	772	69,058
Truck	164,399	5,934	6,953	117,286
Under the 1983 rate structure (Model 2)				
Rail	195,957	23,122	6,518	225,559
Truck	13,134	8,396	1,209	22,739

For sunflower and feed barley shipments, modal shares for rail under the 1983 rate structure are slightly lower than under the 1980 rate structure. This is contrary to wheat shipments which have greater advantages than sunflower and barley shipments under the multiple-car rail transportation system.

Optimal Flows of Grain and Oilseed

There are substantial increases in grain and oilseed shipments to the PNW under the 1983 rate structure compared to the shipments under the 1980 rate structure. All the grain shipped to the PNW is shipped by subterminal under multiple-car rates due to the greater rail rate spread to West Coast markets.

Table 7 shows the quantities of grain and oilseed shipped from subterminals in North Dakota to three major export locations. The northeastern and central portions of the state ship grain to Duluth during time period one and the Gulf during time period two. Wimbledon and Finley ship exclusively to the Gulf. PNW shipments come from as far east as Russel. Subterminals in the central part of the state (i.e., Minot and Russel) compete with the eastern and western markets due to multiple-car rates.

TABLE 7. OPTIMAL GRAINS AND OILSEEDS MOVED BY SUBTERMINALS TO MAJOR EXPORT MARKETS IN MODEL 2

Subterminal	Duluth	Gulf	PNW
		(1,000 cwt.)	
Grand Forks	3,057	1,831	
Courtenay	292	3,895	
Fessenden	428	3,190	
Harvey	1,169		
Russel	741		3,373
Voltaire	330		
Wimbledon		1,595	
Minot		104	
Bottineau	1,070		
Dickinson			4,580
Williston			2,963
Finley		5,602	
TOTAL	7,091	16,219	10,916

Most wheat moves by truck to Duluth in the eastern third of the state (Appendix 2). The railroads gain their biggest competitive advantage during time period two when the Duluth port is closed and the northern half of the inland waterway system is closed, making the average trip distance longer to export markets. The northwestern corner of North Dakota ships grain primarily to the PNW.

The 1983 model shows Duluth, Grand Forks, and Minneapolis receiving grain by truck (Appendix 2), but only 6 percent of the wheat is moved by truck. Almost all the grain shipped to the PNW is moved by subterminals under multiple-car rates (Table 8). Modal share of rail is the biggest change from the 1980 to 1983 model. However, multiple-car rates allowed the optimal flow of westward wheat to move eastward from Minot.

Most truck movement from the Red River Valley is to Fargo and Duluth. Outside the Red River Valley, optimal flow is by rail to Duluth. Demand for sunflower at Duluth is so high that sunflower is moved to Duluth from as far west as McLean and Morton counties (Appendix 2). The West Fargo sunflower processing plant receives sunflower entirely by truck in 1980.

Sunflower is the only crop for which trucks increased their modal share under the 1980 rate structure compared to the 1983 one (Appendix 2). The reasons for this are that (1) the Enderlin plant, built after 1980, provided producers with a nearer domestic processing plant, and (2) there were fewer multiple-car shipments of sunflower than wheat (Table 9) because sunflower's density of production was less than wheat and was closer to processing centers.

TABLE 8. WHEAT MOVED BY SUBTERMINALS TO MAJOR EXPORT MARKETS IN MODEL 2

Subterminal	Duluth	Gulf	PNW
		(cwt.)	
Grand Forks	3,057,600	1,834,560	
Courtenay		3,895,863	
Fessenden		3,190,217	
Harvey			
Russel			3,372,667
Voltaire		1,792,970	
Wimbledon		1,595,276	
Minot			6,946,202
Bottineau			
Dickinson			4,534,063
Williston			2,614,930
Finley		5,601,844	

TABLE 9. SUNFLOWER SHIPPED BY SUBTERMINAL TO MAJOR EXPORT MARKETS IN MODEL 2

Subterminal	Duluth	Gulf	PNW
		(cwt.)	
Grand Forks			
Courtenay	292,570		
Fessenden	428,080		
Harvey	1,169,830		
Russel	741,760		
Voltaire	330,870		
Wimbledon			
Minot		104,028	24,928
Bottineau	1,070,670		
Dickinson			
Williston	42,680		
Finley			

In the 1983 model, barley is shipped mainly by rail to Duluth (Appendix 2). Utilization of multiple-car rates is limited to shipments from Dickinson and Williston to PNW (Table 10).

Evaluation of Multiple-Car Grain Loading Facilities

Models 4 through 13 are used to evaluate the need for multiple-car loading facilities for each crop reporting region in North Dakota. Because the need for multiple-car facilities depends mainly upon the rate spread between

TABLE 10. BARLEY SHIPMENT BY SUBTERMINALS IN MODEL 2

	Duluth	Gulf	PNW
		(cwt.)	
Dickinson			46,838
Williston			348,039

single- and multiple-car shipments, the present multiple-car and other alternative rate spreads are introduced. Models 4 through 9 are based on the present rate spread, while Models 10 through 13 are based on alternative rate spreads.

The rail car loading capacity (RLC) constraints limit the amount of grain that can be shipped by 52-car loading facilities. The reductions in total transportation costs caused by one unit reduction in the respective RLC value is equal to the shadow price of the RLC constraint times the amount of grain that is shipped by 52-car loading facilities. This reduction is called the reduced cost. This also can be interpreted as savings in transportation costs obtained by adding one more subterminal. To justify additional subterminals in a region the annual savings in transportation and handling costs from additional subterminals (reduced costs) should be larger than the annual investment and operating costs of the facilities.

The investment cost of a 20-year annuity is calculated to put the reduced cost figures in perspective. Additional investment costs for expansion of a 26-car loading facility to a 52-car facility or of a 3-car loading facility to a 52-car facility are highly dependent on the type of facilities an elevator builds. Expansion costs in North Dakota range from $100 thousand to $500 thousand, and total building costs of a new subterminal with a 500,000-bushel capacity is about $3.4 million (Chase and Helgeson). Given the wide price range for expansion, it is hard to pinpoint the annual cost for a "typical" subterminal expansion. Volatile interest rates also make it difficult to derive the annual cost of investment. Assuming a discount rate of 15 percent and a 20-year loan period on an initialized payment at the beginning of the time period, a $500 thousand loan translates into an annual cost of $80 thousand. The annual cost for the same loan at an annual interest rate of 12 percent is $67 thousand. Annual costs for a new facility loan of $3.4 million are $544 thousand and $456 thousand at annual interest rates of 15 percent and 12 percent, respectively. According to a study by Chase and Helgeson, annual variable costs of a subterminal with a 500,000-bushel capacity are approximately $126 thousand. Total annual investment and operating costs, therefore, range between $206 thousand and $193 thousand for expansion of the existing facilities and between $682 thousand and $670 thousand for a new facility.

Optimal Subterminal Capacity Under the Current Rail Rates

Reduced costs and shadow prices in each region under alternative RLCs are presented in Table 11. Under the current rail rates, shadow prices are

TABLE 11. REDUCED COSTS AND SHADOW PRICES UNDER ALTERNATIVE LOADING CAPACITY CONSTRAINTS

RCD Region	Model 2	Model 4	Model 5	Model 6	Model 7	Model 8
	----------	----------	---------- dollars	----------	----------	----------
Reduced Costs						
1	97,016	74,729	62,812	19,164	0	0
2	53,202	91,728	66,041	14,676	11,403	11,403
3	116,504	95,118	38,290	27,516	15,971	15,791
4	43,311	0	0	0	0	0
5	94,393	0	0	0	0	0
6	17,763	0	0	0	0	0
Shadow Prices						
1	0.01865	0.00734	0.00400	0.00084	0	0
2	0.01450	0.01250	0.00600	0.00100	0.00075	0.00050
3	0.00960	0.00625	0.00209	0.00125	0.00063	0.00063
4	0.00562	0	0	0	0	0
5	0.00844	0	0	0	0	0
6	0.00562	0	0	0	0	0

the largest in Region 1, second largest in Region 2, and third in Region 3. The shadow price in Region 3 is 0.96 cents per bushel which is one-half of that in Region 1. However, the reduced cost in Region 3 is the largest because the quantities of grain and oilseed shipped by 52-car unit trains are twice as much as those in Region 1. This results in the largest savings in transportation and handling costs in Region 3. Because region 1 is close to Minneapolis and Duluth and has strong rail and truck competition in shipping grain and oilseed to the eastern market, most of the grain and oilseed produced in this region is shipped by truck.

As grain handling capacity increases, shadow prices of the RLC constraint decrease. This indicates that increases in RLC decrease the implicit economic value of multiple-car shipments. The reduced costs also decrease with one exception. Reduced costs in Region 2 become higher when the

RLC constraints are increased to the equivalent of one additional subterminal. The reason is that percentage increases in quantities of grain and oilseed shipped by the additional subterminal are greater than the percentage decreases in the implicit economic value of the subterminal.

Additional subterminals are economically feasible if reduced costs in a region are larger than annual investment and operating costs of the additional facilities. Based on the cost analysis for a subterminal with a 500,000-bushel capacity, none of these reduced costs are larger than annual investment and operating costs for either a new facility or expansion of the existing facilities. This indicates that additional subterminals are not economically justified in any North Dakota region under the current rail rate structure.

Reduced Costs Under Alternative Rate Spreads

The remaining alternative models increase the spread between the 3- and 52-car rates. The rate spread is increased because the 3-car rate is believed to be ephemeral; because there are no cost savings with the 3-car rate, a larger premium is placed on multiple-car loading facilities.

Models 10 through 14 increase the rate spread 10 and 20 percent for all three export markets. All regions have a greater shadow price under the 10 and 20 percent increases in the rate spread than under the current rate structure (Table 12). The reduced costs in all regions are not large enough to economically justify building one additional new subterminal. However, Regions 3 and 5 have reduced costs larger than annual investment and operating costs of an upgraded subterminal, indicating that transportation and handling costs can be saved by adding one more subterminal under 10 and 20 percent increases in the rate spread. There are also economic incentives to add two upgraded subterminals in Regions 3 and 5 at 20 percent increases in the rate spread. Region 3 already has four subterminals and Region 4 has two, yet these regions have higher reduced costs than other regions for the following major reasons: (1) the increases in the rate spread give a comparative advantage to railroads over trucks in shipping grain and oilseed to the east and (2) grain and oilseed shipments to the west become economically feasible at the rate spread.

Regions 1 and 2 do not have strong economic incentives for adding one additional subterminal because trucks and rail are competitive in shipping grains and oilseed from these regions to Minneapolis and Duluth. Region 4 also does not have economic incentives for adding one additional facility when the rate spread is increased 10 percent. Moderate incentives, however, occur when the rate spread is increased 20 percent. Region 6 has no economic incentives to build more subterminals or to expand existing facilities at increased rate spreads because of low concentration of grain in this region.

Summary and Conclusion

An efficient grain distribution system is essential if North Dakota farmers are to increase their income. Farmers in areas with high transportation rates generally receive lower commodity prices than farmers in

TABLE 12. REDUCED COSTS AND SHADOW PRICES UNDER ALTERNATIVE RATE SPREAD

RCD Region	Model 10	Model 11	Model 12	Model 13
	dollars			
Reduced Costs				
1	153,093	136,949	173,274	127,336
2	132,008	73,382	172,786	97,231
3	217,882	188,239	254,837	211,356
4	150,898	105,569	196,179	129,285
5	390,796	201,538	394,148	258,299
6	68,959	14,480	98,513	62,206
Shadow Prices				
1	0.02783	0.01650	0.03330	0.02200
2	0.02000	0.01800	0.02650	0.02450
3	0.17750	0.01250	0.02375	0.01916
4	0.20155	0.00750	0.02672	0.01096
5	0.03328	0.01140	0.04031	0.01771
6	0.01765	0.00203	0.02422	0.00833

areas with low transportation rates. Because North Dakota has some of the highest rail rates in the nation, farmers in this area are more sensitive to the grain rate structure than are farmers in other states.

In recent years, changes in the rail rate structure due to multiple-car rates and deregulation have had significant impacts on North Dakota's grain marketing system. The purpose of this study was to analyze these impacts on North Dakota's distribution system for wheat, feed barley, and sunflower and to evaluate multiple-car loading facilities.

The method used in this study was a spatial equilibrium model based on a linear programming algorithm. The model incorporated transportation activities in marketing grain from North Dakota's producing regions to its major consuming areas. The optimal flows of grain between producing and consuming regions were determined by transportation and handling costs, the availability of multiple-car unit trains, and the quantities of grain in each producing and consuming region. The model has 132 producing regions, 12 subterminal locations, 3 domestic consuming regions, and 3 export regions. Two time periods are used to identify seasonal grain flows.

Transportation rates for railroads are based on published tariffs effective in July 1980 and July 1983. Barge rates are based on the average monthly rates during July 1980 and July 1983. Truck rates are based on trucking costs in 1980 and 1983. Trucking costs are used under the assumption that truck rates are equal to average total cost. Crop production statistics were collected from the Statistical Reporting Service. Demand figures at consuming regions are derived from North Dakota Public Service Commission reports and industry estimates.

Results indicate that railroads dramatically increase their market share under the 1983 transportation rate structure. Trucks move 74 percent of grains and oilseeds under the 1980 rate structure and only 8 percent under the 1983 rate structure. Total transportation costs are $61 million lower under the 1983 rate structure than under the 1980 structure. Total transportation cost savings are approximately $12.0 million when 52-car loading facilities are introduced in North Dakota. This indicates that the reductions in transportation costs are mostly due to changes in the transportation rate structure under the Staggers Act rather than to the introduction of multiple-car rates.

Additional subterminals can be economically justified if savings in transportation and handling costs (reduced costs) by adding one subterminal are larger than annual investment and operating costs of the subterminal. Based on the cost analysis of a subterminal with a 500,000-bushel capacity, this indicates that subterminals are either overbuilt or at their proper level in North Dakota under the current rate structure. However, there are economic incentives for expansion of the existing facilities in Regions 3 and 5 when the rate spread is increased 10 and 20 percent by discontinuation of 3-car rates or reductions in 52-car rates.

Multiple-car rates help shippers reduce the total freight marketing bill. However, the multiple-car rates also threaten to change the grain marketing infrastructure in North Dakota. First, overexpansion of multiple-car loading facilities could lead to bankruptcy. Second, although expansion is at the proper level, elevators near subterminals will be at a competitive disadvantage. Ultimately, many smaller country elevators will either go out of business or will become satellite elevators by merging with subterminals. Several elevator mergers have already taken place around Williston and Minot. Banks and regional cooperatives that finance expansions should probably examine not only the elevator's financial situation but also the area's regional needs.

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Appendix 1

Mathematical Model

Mathematical Model

The objective function is to minimize transportation and handling cost. The equation can be written as:

$$(12)\quad Z = \sum_{t=1}^{2}\sum_{c=1}^{3}\sum_{k=1}^{3}\sum_{i=1}^{I}\sum_{j=1}^{J} DC_{tckij}\, DX_{tckij} + \sum_{t=1}^{2}\sum_{c=1}^{3}\sum_{k=1}^{3}\sum_{i=1}^{I}\sum_{h=1}^{H} EC_{tckih}\, EX_{tckih} + \sum_{t=1}^{2}\sum_{c=1}^{3}\sum_{i=1}^{I}\sum_{s=1}^{S} TC_{tcis}\, TX_{tcis} + \sum_{t=1}^{2}\sum_{c=1}^{3}\sum_{s=1}^{S}\sum_{h=1}^{H} SC_{tcsh}\, SX_{tcsh}$$

where:

Z = value of the objective function

t = index for time period

c = index for grain type

k = index for mode of transportation

i = index for production region

h = index for export region

j = index for domestic consumption

s = index for subterminal

DC_{tckij} = transportation and private storage cost in shipping crop c from producing region i by transportation mode k to domestic consumption point j

DX_{tckij} = quantity of crop c shipped from production region i by transportation mode k in time period t to domestic consumption point j

EC_{tckih} = transportation and private storage cost in shipping crop c in time period t from production region i by transportation mode k to export region h

EX_{tckih} = quantity of crop c shipped from production region i by transportation mode k in time period t to export region h

TC_{tcis} = transportation and private storage cost in shipping crop c in time period t from production region i by truck to subterminal s

TX_{tcis} = quantity of crop c shipped from production region i by truck in time period t to subterminal s

SC_{tcsh} = transportation and private storage cost of crop c from subterminal s in time period t to export region h

SX_{tcsh} = quantity of crop c shipped from subterminal s in time period t to export region h

The objective function is subject to the following constraints:

Total available grain in each producing region must be greater than or equal to the quantity of grain shipped to each consuming region.

$$(13)\quad S_i \geq \sum_{t=1}^{2} \sum_{k=1}^{3} \sum_{i=1}^{I} DX_{tckij} + \sum_{t=1}^{2} \sum_{k=1}^{3} \sum_{h=1}^{H} EX_{tckih} + \sum_{t=1}^{2} \sum_{h=1}^{H} \sum_{k=1}^{3} TX_{tckis}$$

where:

S_i = quantity of grain available in producing region i. EX EX, TX are previously defined.

Total quantity of grain received by each domestic consuming region must be greater or equal to the quantity of grain required in each consuming region.

$$(14)\quad DD_{tcj} \leq \sum_{k=1}^{3} \sum_{i=1}^{I} DX_{tkcij}$$

where:

DD_{tcj} = quantity of grain c required in consuming region j

Total quantity of grain received at each export port must be greater or equal to the quantity of grain required in each port. Each port can receive grain from producing regions or subterminals.

$$(15)\quad ED_{cih} \leq \sum_{n=1}^{H} \sum_{i=1}^{M} EX_{cih} + \sum_{h=1}^{H} \sum_{i=1}^{I} SX_{csh}$$

where:

$ED_{c}ih$ = quantity of grain c required in export port h

The total amount of grain received in each subterminal location s must be equal to the total grain shipped from each subterminal to export location.

$$(16)\quad \sum_{c=1}^{3}\sum_{n=1}^{3}\sum_{i=1}^{I} TX_{ckis} = \sum_{c=1}^{3}\sum_{h=1}^{H}\sum_{i=1}^{I} SX_{cksh}$$

where TX_{ckis} and SX_{cksh} are previously defined

The total quantity of grain shipped by rail by each subterminal must be less than or equal to total rail capacity for each subterminal in time length t.

$$(17)\quad RLC_{t*sr} \geq \sum_{s=1}^{S}\sum_{h=1}^{H}\sum_{a=1}^{4}\sum_{r=1}^{R} SX_{csh}A_{rchm}$$

where:

RC_{t*s} = rail car capacity constraint for region r for time length t times the number of subterminals s in region r

Aschr = the estimated turn-around time from region r to destination h for multiple car shipment m

SX_{csh} has already been defined.

The 1980 base model will not have the TX_{tcis} or SX_{tcsh} portion of the objective function since subterminals are not being considered in this model. The 1980 model will also not have constraints 5 and 6 and the TX portion of the supply constraint.

Appendix 2

Optimal Flows of Grain

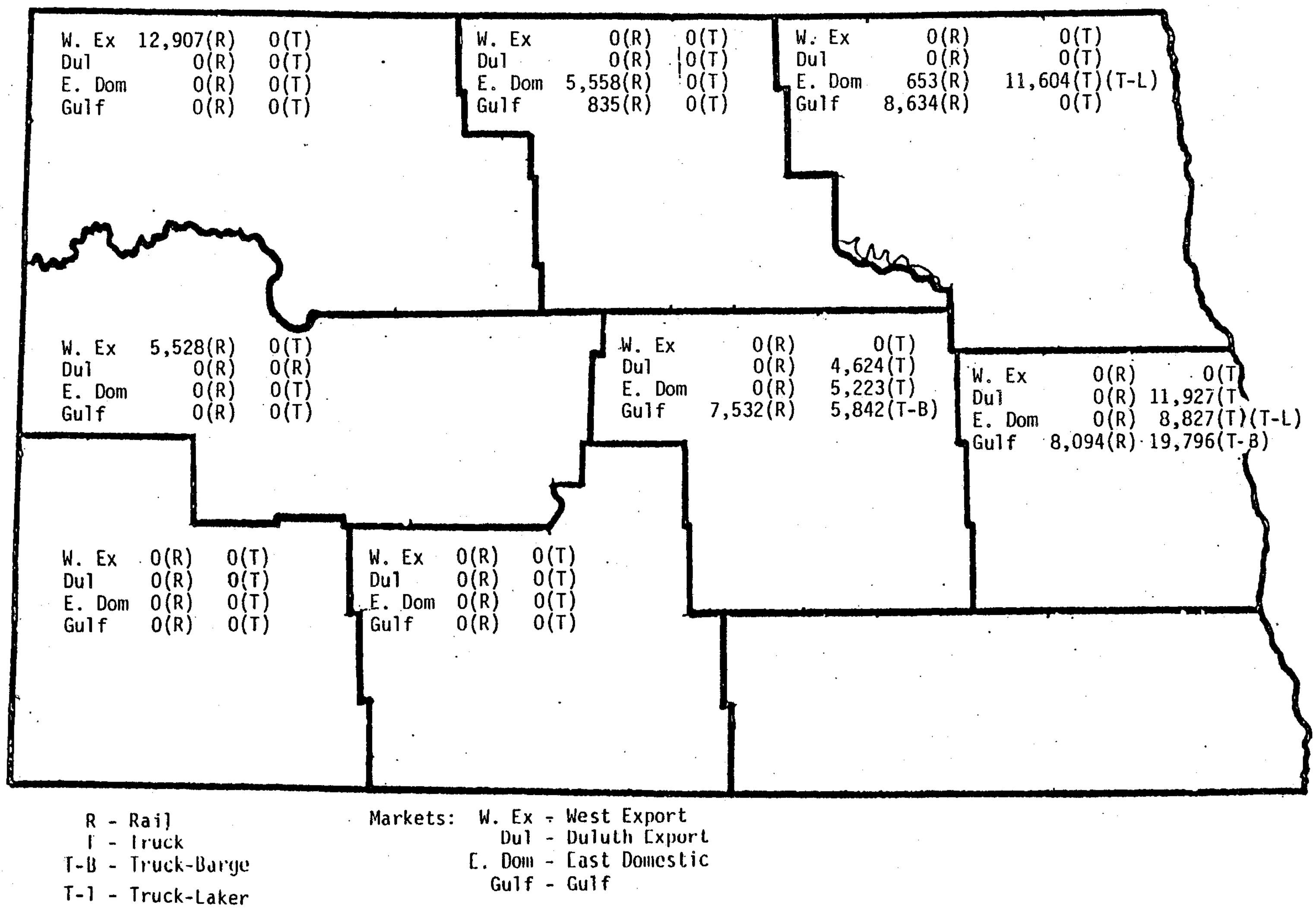
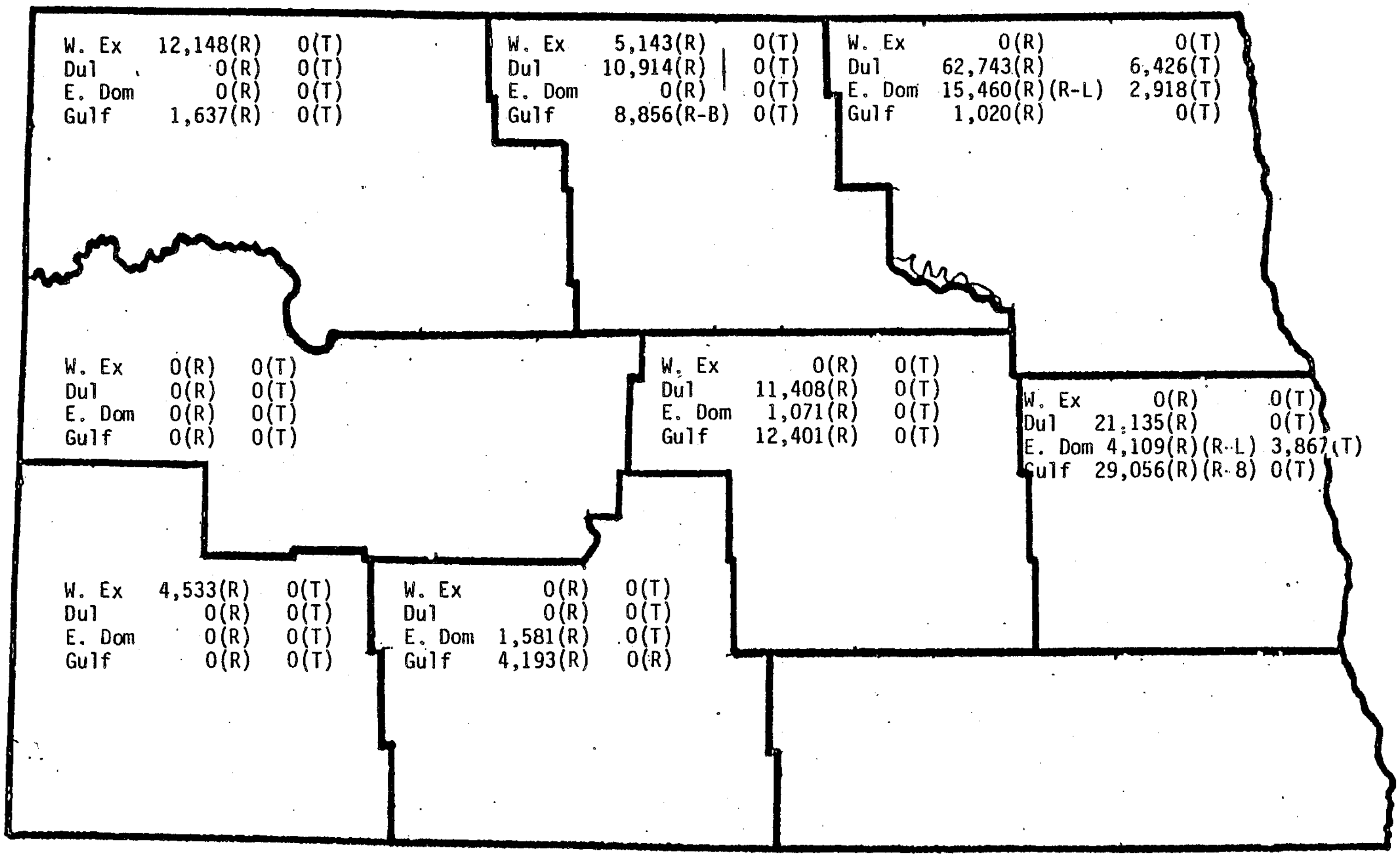


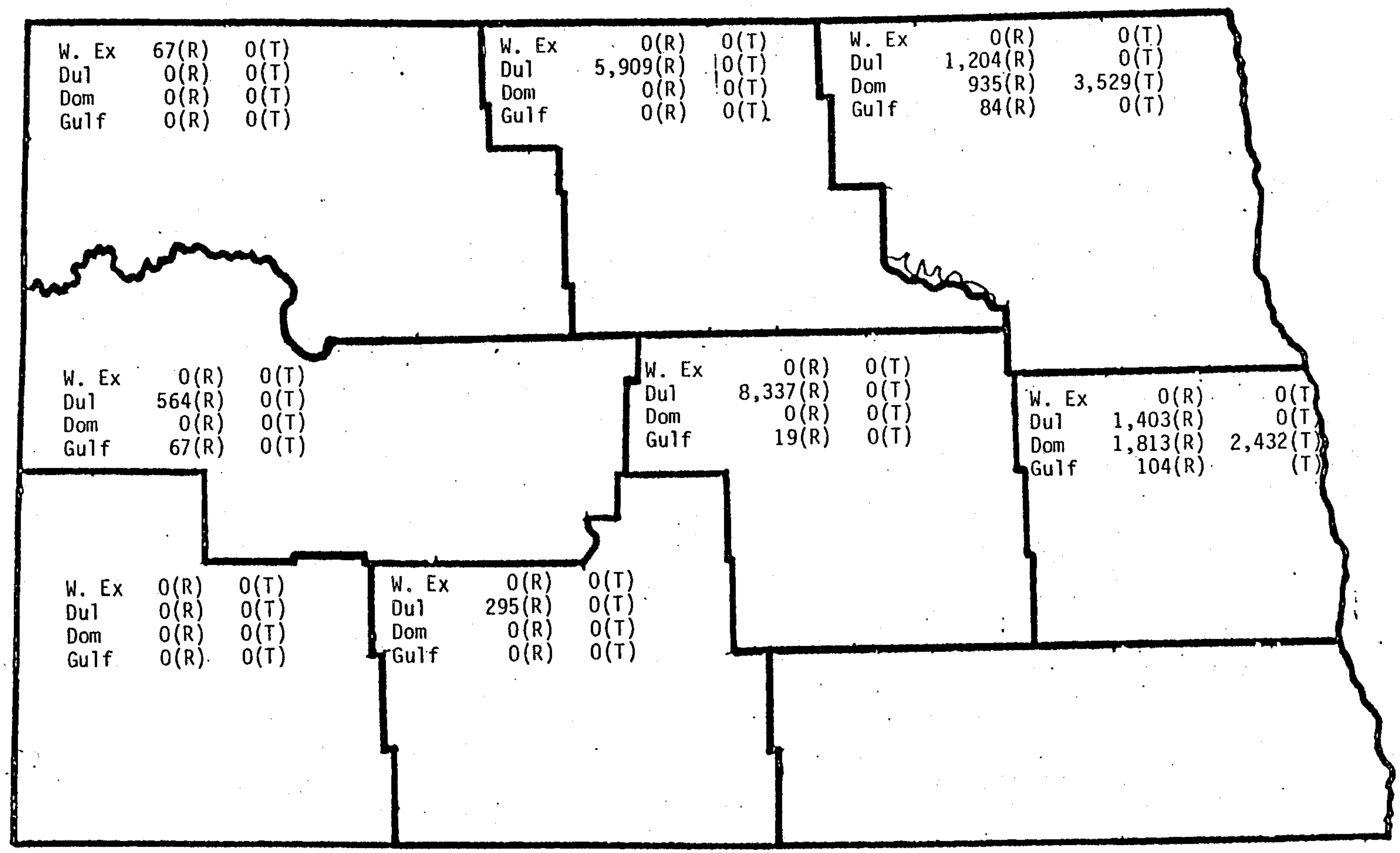
Figure A1. Flows of Wheat from Elevators by Crop Reporting District Under the 1980 Rate Structure (1,000 cwt.)



R - Rail
T - Truck
T-B - Truck-Barge
T-l - Truck-Laker

Markets: W. Ex - West Export
Dul - Duluth Export
E. Dom - East Domestic
Gulf - Gulf

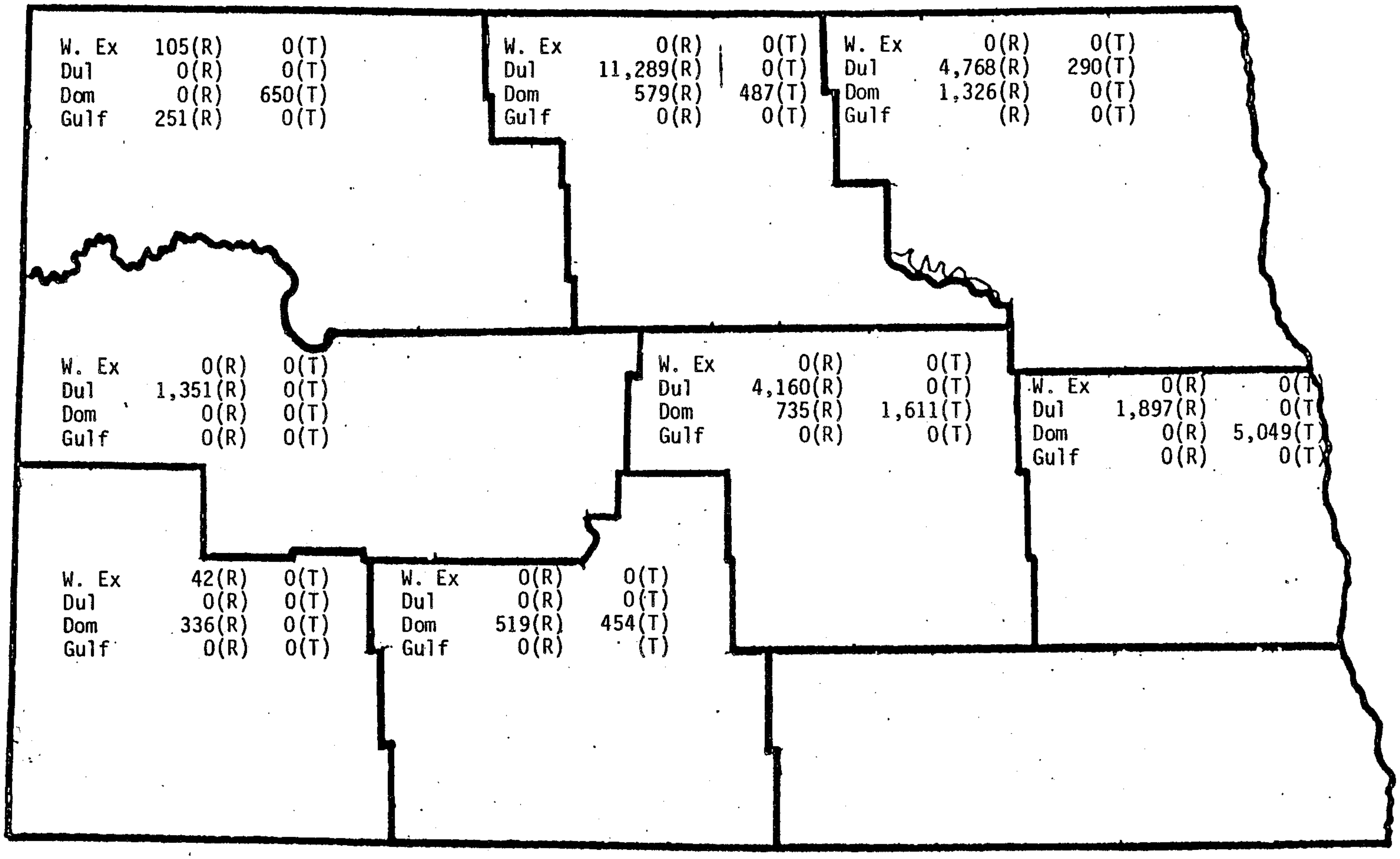
Figure A2. Flows of Wheat from Elevators by Crop Reporting District Under the 1983 Rate Structure (1,000 cwt.)



R - Rail
T - Truck

Markets: W. Ex - West Export
Dul - Duluth Export
Dom - Domestic (Crush: West Fargo and Minneapolis)
Gulf - Gulf

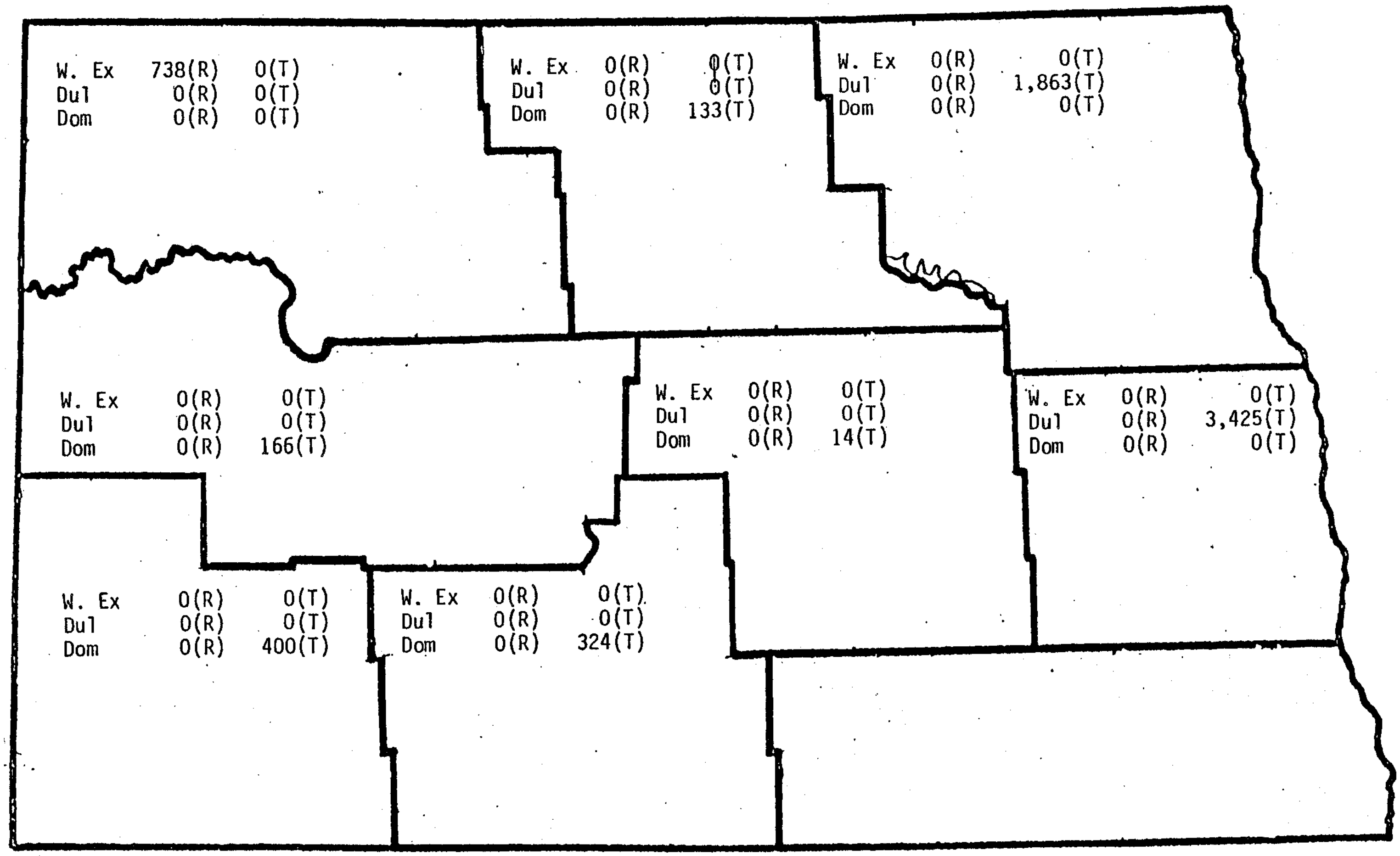
Figure A3. Flows of Sunflower from Elevators by Crop Reporting Districts Under the 1980 Rate Structure (1,000 cwt.)



R - Rail
T - Truck

Markets: W. Ex - West Export
Dul - Duluth Export
Dom - Domestic (Crush: West Fargo, Enderlin, and Minneapolis)
Gulf - Gulf

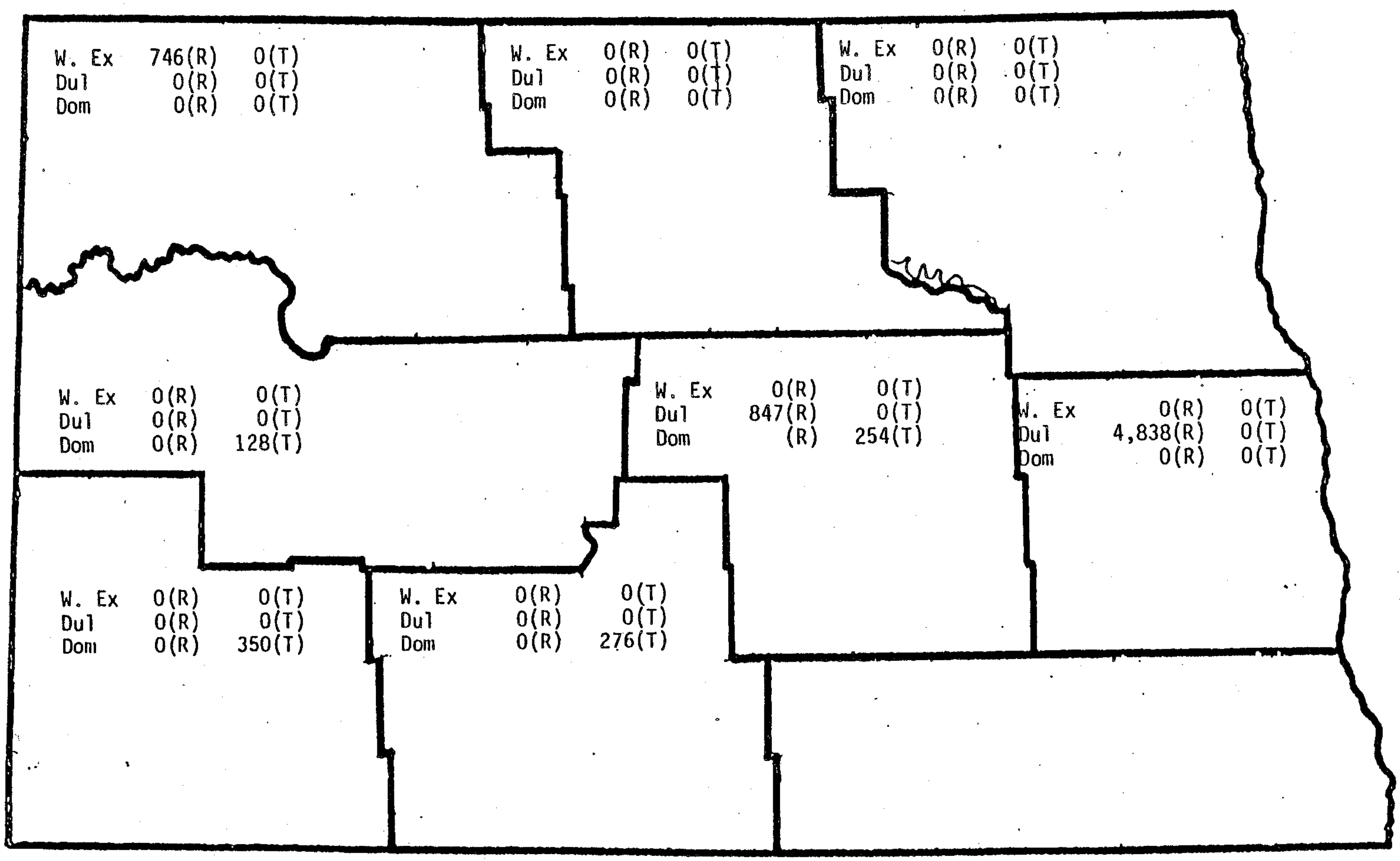
Figure A4. Flows of Sunflower from Elevators by Crop Reporting Districts Under the 1983 Rate Structure (1,000 cwt.)



R - Rail
T - Truck

Markets: W. Ex - West Export
Dul - Duluth Export
Dom - Domestic (Bismarck and Dickinson)

Figure A5. Flows of Feed Barley from Elevators by Crop Reporting Districts Under the 1980 Rate Structure (1,000 cwt.)



R - Rail
T - Truck

Markets: W. Ex - WEst Export
Dul - Duluth Export
Dom - Domestic (Bismarck and Dickinson)

Figure A6. Flows of Feed Barley from Elevators by Crop Reporting Districts Under the 1983 Rate Structure (1,000 cwt.)