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# Alternative Wheat Collection and Transportation Systems for the Southern U.S. Plains

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This study examines means of improving efficiency of the transportation portion of the export wheat handling system in the southern Plains. Analysis focuses on the feasibility of restructuring grain handling facilities to accommodate unit train movements to port locations. To accomplish this, a cost-minimizing network flow model was developed. Results show that the alternative transportation systems would have substantial effects on costs, wheat flow patterns and the economic viability of certain members of the grain handling and storage industry.

The first major grain sale to the U.S.S.R. in 1972-73 revealed weaknesses in the inland grain handling system to accommodate large volumes of export grain. System weaknesses were evidenced by a substantial widening of grain prices at country elevator and port locations. Much of the widening in prices resulted from transportation inefficiencies in the export grain marketing system. Since this time, wheat and feed grain exports have risen rapidly.<sup>1</sup> Furthermore, revenues from grain

exports are constituting an increasing share of producers income. Because transportation is the most costly link in the export grain marketing system, an efficient transportation system is vital to maintaining the competitive position of the U.S. in foreign grain markets.<sup>2</sup> This paper examines means of improving the efficiency of the transportation portion of the export wheat handling system for the hard red winter wheat producing region of the southern U.S. Plains.<sup>3</sup> Analysis focuses on the feasibility of restructuring grain collection facilities to accommodate unit train movements of wheat to port locations.

Previous evaluations of restructuring grain handling systems have sought optimal alternatives to rural railroad line abandonments. Baumel, Miller and Drinka and Ladd and Lifferth investigated the feasibility of restruc-

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<sup>1</sup> Wheat exports in 1972-73 crop year were estimated to be 1 billion bushels. This compares to wheat exports of 1.2 billion bushels in 1978-79 and exports of 1.4 billion bushels in 1979-80.

<sup>2</sup> It is estimated that transportation comprises about three-fourths of the cost of the southern Plains export wheat handling system.

<sup>3</sup> Hard red winter wheat represents 50 percent of U.S.'s wheat production and a larger portion of wheat exports. In recent years, hard red winter wheat production has ranged from 747 to 1,053 million bushels. Principal producing states are Nebraska, Kansas, Oklahoma and Texas.

turing the country elevator industry in Iowa to include subterminal storage facilities located on retained railroad lines. The Iowa study concludes that cost savings associated with unit train movement more than offset losses due to rail service curtailments. Similar studies have been made in Indiana [Hilger, McCarl and Uhrig] and Ohio [Larson and Kane].

Three differences in production and marketing prevent extrapolation of previous research to the southern Plains. First, railroad abandonment is not as serious a threat to the south Plains as to the Midwest. The railroads, in their system diagram maps filed with the Interstate Commerce Commission, have indicated very limited abandonment of branchline segments in the southern Plains. Consequently, both existing country elevators and potential subterminals would have rail service, partially offsetting the cost superiority of subterminals shown in the Midwest studies where some country elevators were left without rail service. Secondly, a substantial inland terminal industry is already located within the wheat producing area. The substantial grain handling and storage capacity of existing inland terminals would make new plant investment unnecessary for accommodation of unit trains. In contrast, substantial investment would be necessary to convert country elevators into subterminals. Finally, wheat production density is only one-fourth that of grain production density in the Midwest. Assembly of large volumes of grain to potential subterminal locations would involve larger market areas and increased assembly cost.

Evaluation of restructuring the export wheat handling system in the southern U.S. Plains is achieved using a cost-minimizing model to determine: 1) the feasibility of converting selected country elevators into subterminals and operating unit trains between these facilities and Gulf of Mexico port locations, 2) the feasibility of operating unit trains between inland terminals and Gulf of Mexico port locations and, 3) the comparative efficiency of alternative organizations. In this

study, system costs are estimated for the current system and contrasted with three alternative organizations. The three alternative systems include:

- 1) a system that involves operation of 80-car unit trains between the study region's inland terminal locations and Texas ports — referred to as the 80-car system.
- 2) a system that involves operation of the 80-car unit trains from the inland terminal locations and operation of 50-car unit trains at potential subterminals that deliver wheat to Texas ports — referred to as the 50, 80-car system; and
- 3) a system that involves operation of 80-car unit trains from inland terminal locations and operation of either 20, 50, or 80-car unit trains at potential subterminals that deliver wheat to Texas ports — referred to as the 20, 50, 80-car system.

### The Study Region

A contiguous 29,025 square mile area located in portions of Kansas, Oklahoma and Texas was selected for study (Figure 1). The study region is approximately 144 miles at its widest location and is 288 miles in length. This area has annual wheat production of approximately 160 million bushels and, historically, 75 percent of production has been destined for export markets. The study area includes 90 million bushels of on-farm storage and 92 million bushels of country elevator wheat storage capacity. Three hundred forty-seven country elevators operate at 224 locations and, these facilities have typically shipped nearly 90 percent of their wheat receipts to five inland terminal locations.<sup>4</sup> (Figure 1). The inland terminals distribute wheat to domestic processors and Gulf ports as warranted by demand. Approximately 90

<sup>4</sup> The five inland terminal locations are Hutchinson and Wichita, Kansas; Enid, Oklahoma and Amarillo and Fort Worth, Texas. These facilities receive a substantial portion of their annual receipts from outside the study region.

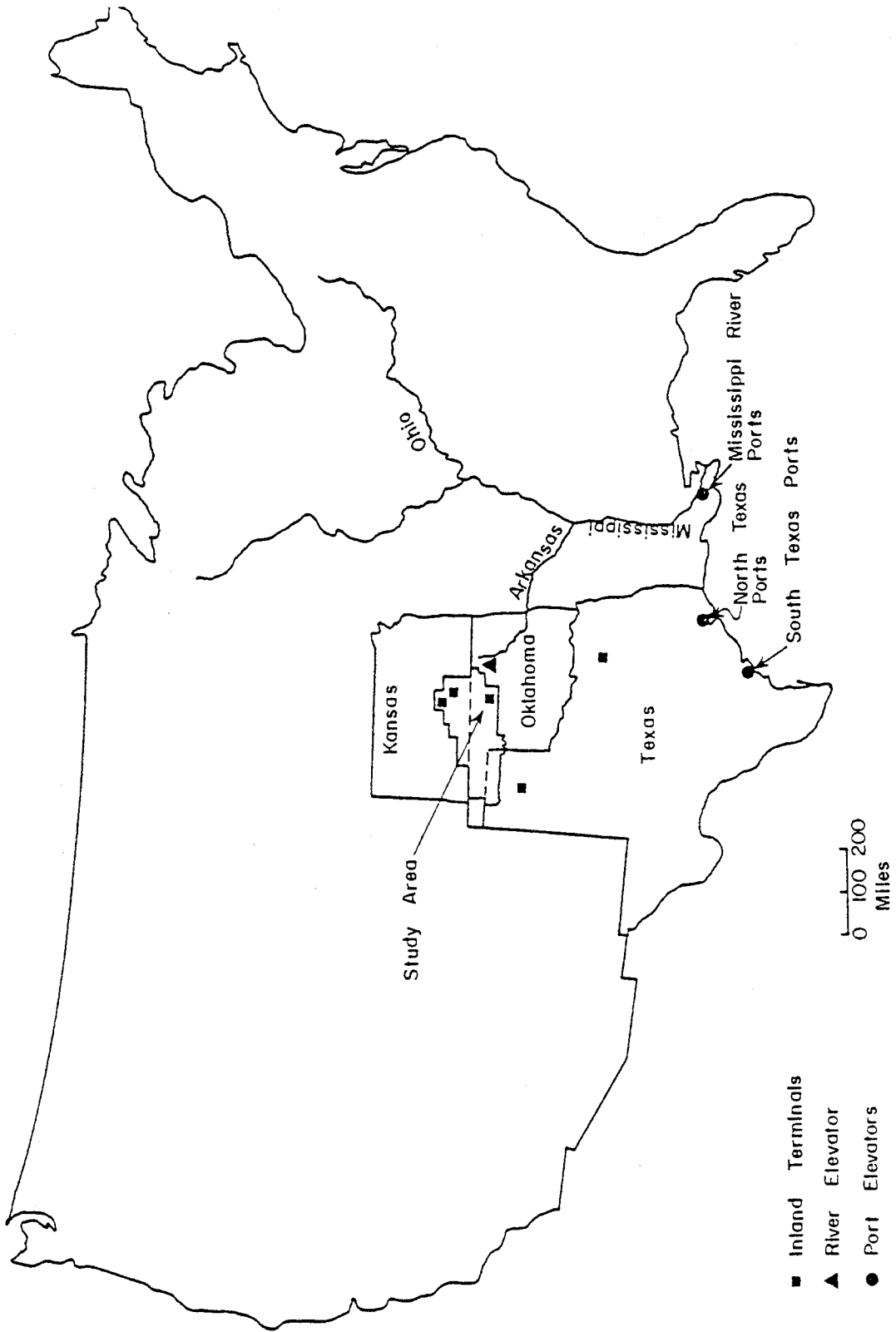


Figure 1. Outline Map of U.S. and Study Area

percent of the region's export-destined wheat flows through North Texas port elevators, while the remainder flows through South Texas (8 percent) and Mississippi River ports (2 percent), (Figure 1).<sup>5</sup>

The study region is located an average of 625 miles from the principal Texas Gulf ports. Railroads which operate 2,200 miles of track within the region are the dominant transporter of the area's wheat production and generate about 95 percent of the wheat traffic ton-miles. The remaining ton-miles are attributable to farm assembly, barge transportation and truck transportation from country elevators to inland terminals, Gulf ports and a river elevator.

The region's single-car rate is an in-transit rate which allows wheat to be shipped from country elevators to Gulf ports on a single through rate that includes a stopover at inland terminals. The rate on a direct shipment from country elevator through the inland terminal to a Gulf port is equal to the sum of the rates from country elevator to inland terminal and from inland terminal to Gulf port. It follows that a grain shipper's transportation charge on export-destined wheat is not unfavorably affected by transshipment at inland terminal locations. Accordingly, a substantial volume of wheat moves through these facilities.

### Structure of Model and Analytical Procedure

Improving marketing system efficiency is a goal that cannot be pursued in isolation. Because of a high degree of interdependence among the elements constituting this area's export wheat marketing system, a cost-minimizing model was developed to repre-

sent the entire system.<sup>6</sup> The model's principal cost elements are: 1) farm storage costs, 2) farm assembly costs, 3) truck, rail, and barge transportation costs that link country elevators, potential subterminals, inland terminals, the river elevator and port terminals, and 4) all elevator facilities' grain handling and storage costs.

The analytical model represents a wheat crop year (June 1-May 30). The crop year is subdivided into three time periods to facilitate a temporal analysis. Based on historical data it was determined that the first time period, the harvest period, includes about twenty-one days. It is during this time period that the annual wheat supply is generated. The following forty-five day period represents post-harvest repositioning activity, and the final period is the remaining 299 days of the crop year.

The 29,025 square mile region is subdivided into  $3 \times 3$  mile areas (9 square miles) resulting in 3,225 production origins. The harvest-time supply of export wheat and available wheat storage at each production origin is predetermined. Producers may store the export wheat production at farms (production origins) or ship directly by farm truck to country elevators or subterminals. Any country elevator or subterminal within thirty miles of a farm represents a potential delivery point. If wheat is farm-stored, producers deliver to country elevators in later time periods. Wheat must be assembled to country elevators or potential subterminals prior to further movement through the system.

Country elevators and potential subterminals have predetermined amounts of storage capacity available for area wheat production. All potential subterminals in the 50, 80-car or the 20, 50, 80-car organization are converted country elevators. Country elevators may

<sup>5</sup> North Texas ports include eight export elevators at Houston, Galveston, Beaumont and Port Arthur, Texas. South Texas ports include two export elevators at Corpus Christi, Texas, while Mississippi River ports include ten houses adjacent to the Mississippi River and located between Baton Rouge and the New Orleans, Louisiana area.

<sup>6</sup> A global minimum is not obtained with the cost-minimizing model because it is not allowed to select optimal locations, rather the model determines the feasibility of unit train operation for predetermined subterminal locations.

ship to subterminals, inland terminals, Gulf port terminals and a river elevator on the Arkansas River. The river elevator is linked to all Gulf ports via barge transportation. Any movement from country elevator to subterminal must be less than seventy-five miles. Truck and rail modes are available for all country elevator shipments to subterminals and the river elevator, in which case, only truck carriage is available. All country elevator rail shipments are single-car movements.

Twenty-six potential subterminal sites were selected. Potential sites were restricted to those locations where railroads were willing to consider the offering of unit train service and country elevators had the financial ability to make the necessary investment to convert to a subterminal.

The twenty-six predetermined subterminal locations require upgrading or investment costs in order to accommodate the 20, 50, or 80-car unit trains. The level of investment is related to the size of unit train to be accommodated. Inland terminals, port terminals and the river elevator have predetermined wheat storage capacities available for study area wheat marketings. Inland terminals may ship by either truck or by single-car movement to other inland terminals, by truck to the river elevator, and by 80-car unit train to port elevators. Currently, railroad shipments from inland terminals to ports move on single-car rates; this situation is reflected in estimation of current system cost. No investment is required at inland terminals in order to load the 80-car unit trains. Port terminals may receive truck, rail or barge delivered grain which may be stored for short periods of time prior to loading aboard ship. The quantity of wheat demanded at each of the three port areas in each time period is predetermined and based on historical flows to these ports.

The need to include substantial microscopic detail of the transportation and marketing system as well as to include spatial and temporal dimensions results in a very large analytical model. For this reason, the model was developed as a network flow model.

Fuller and Shanmugham showed that network flow models are capable of accommodating characteristics of the wheat marketing system and are computationally more efficient than linear programming codes. Linear programming and network flow models yield identical least-cost solutions. See authors for a mathematical representation of the developed model.

To include the annual fixed cost associated with converting a country elevator into a subterminal (for the 50, 80-car and 20, 50, 80-car organizations) a procedure involving a series of iterative computer solutions of the model is required. The initial solution of the model includes no subterminal conversion costs. The initial solution provides necessary input to the subsequent computer solution, in particular, the subterminal's annual fixed cost associated with converting a country elevator to a subterminal is divided by the subterminal's annual volume as determined by the initial solution. The resulting unit cost parameter is entered into the model and a solution again obtained. Again, the annualized costs is divided by the resulting subterminal volume, yielding a new and larger cost parameter. This procedure is repeated until the volume of the potential subterminal stabilizes or remains unchanged from solution to solution. The iterative procedure is internalized and typically five of six solutions are required prior to stabilization of volumes at subterminals. A subterminal with its associated unit train service is feasible if it provides a lower cost means of moving wheat to port areas than competing alternatives and, accordingly, attracts wheat for this movement. A subterminal's feasibility is indicated in the solution when its stabilized volume multiplied by the unit fixed cost associated with conversion from country elevator to subterminal equals the total annual fixed cost of conversion. A subterminal is unfeasible if its stabilized volume is zero. This occurs when the wheat moves to export via a less costly alternative than the subterminal with its associated unit train service.

To estimate the grain handling and trans-

portation costs associated with marketing the region's export-destined wheat supply under the current system, it is assumed that shippers faced with the current single-car, transit rate structure would continue to route wheat as they have in the past. Accordingly, the network model is constrained to force wheat flows to follow the historic flow pattern allowing the costs of the current system to be calculated. When calculating costs of the alternative systems, grain is not forced to follow the historic flow pattern except as dictated by historical quantities of export demands at the various port areas. Wheat was allowed to flow through least-cost channels in order to meet the predetermined export demand at each port area.

This study focuses on estimating costs of alternative distribution schemes that would likely evolve given the inclination of existing railroad and elevator management. Accordingly, the desired model orientation is on answering "what if" types of questions.<sup>7</sup> The study's emphasis is not to determine the costs of the optimum subterminal organization (number, size, and location) with their associated least-cost unit sizes.

### Data

Because the analysis includes all major costs associated with the export wheat marketing system, an extensive data gathering effort was involved. Considerable emphasis was placed on estimating accurate transportation cost parameter. All estimated costs were representative of 1977-78.

Economic-engineering cost estimating techniques were used to estimate all truck carriage costs. A survey of wheat producers and commercial truckers provided insight into truck characteristics, age, annual miles, and operating characteristics and costs. The

commercial trucker survey revealed that per bushel cost parameters were influenced by distance of haul. For this reason, two cost functions were estimated; one function for trip distances less than or equal to 350 miles, the other for distances in excess of 350 miles. Hauls of 350 miles or less generally had no backhauls, while the longer trips (specifically from study area to Gulf ports) had backhauls on 20 percent of the trips. Costs were estimated for commercial trucks with gross vehicle weight (GVW) of 80,000 pounds.

To estimate rail cost parameters, a computerized rail cost program was developed to calculate the variable cost associated with all single and multi-car point-to-point movements. To make rail costs comparable to total truck cost, variable rail cost was multiplied by a ratio of 1.35.<sup>8</sup> Because of the difficulty in estimating fixed cost, the rail costs reported in this paper for each alternative distribution scheme include only variable cost. Cost estimates were based on the Interstate Commerce Commission (ICC) cost scales according to instructions for adjusting cost estimates in the *Rail Carload Cost Scale 1974*, published by the ICC in 1976. A railroad freight rate index, published in the *Marketing and Transportation Situation*, was used to update cost estimates to the 1977-78 period (U.S. Department of Agriculture).

Cost of barging grain from the river elevator to Gulf ports was estimated by use of the economic-engineering techniques. The estimates reflect the smaller barges and tows associated with the Arkansas River's nine-foot draft limitation.

The model includes the variable cost of operating existing on-farm, country elevator,

<sup>7</sup> It is acknowledged that this heuristic orientation results in conservative cost-saving estimates of the various distribution schemes, but this procedure was thought to give rise to more realistic estimates of savings than a comparison with optimal cost estimates.

<sup>8</sup> The 1.35 ratio is an average fully allocated to variable cost ratio for railroads operating in the study region. This ratio was calculated by estimating a railroad's fully allocated to variable cost ratio for each served elevator location in the study region and then averaging this ratio with other estimated ratios. The fully allocated cost approximates fixed costs. The fully allocated and variable costs were estimated from the Interstate Commerce Commission's cost scales.

river elevator, inland terminal and port elevator facilities. On-farm storage costs were estimated for circular steel bins by the economic-engineering technique. Elevator cost parameters were updated U.S. Department of Agriculture estimates and include the unit costs of receiving, loading-out and storing wheat for each type of facility. Receiving and loading-out costs reflect the effect of the transportation mode being accommodated.

When new capital is invested for purposes of converting a country elevator to a subterminal, total cost is included in the model. Analysis revealed that the level of necessary investment to convert a country elevator to a subterminal was related to the size of unit train shipment to be handled by the converted country elevator and the storage capacity of the country elevator to be converted. Generally, the small elevators incurred greater conversion cost than the larger elevators. The larger country elevators generally had more of the equipment required of a subterminal than did the smaller elevators, accordingly, the smaller investment and cost of converting a larger elevator. Also, for any particular elevator size category, the necessary conversion cost increased as size of accommodated unit train increased. Since all trains are to be loaded within a 24-hour period, greater elevator conversion cost is required for larger unit train shipments.

Unit trains operating from subterminal locations moved directly to Gulf ports, in which case wheat grades were determined at the subterminal. This results in an additional cost to the subterminal organization; the increased cost is attributable to courier service that operates between subterminals and official graders at inland terminal locations. The additional cost varied from \$.001 to \$.002 per bushel.

## Results

This section relates and contrasts the current; 80-car; 50, 80-car and the 20, 50, 80-car organizations. The analyses show that the alternative systems would have substantial

effects on system costs, wheat flow patterns and the economic viability of certain members of the grain handling and storage industry.

## Current Export Systems

Table 1 shows the estimated per bushel cost of marketing the study region's export wheat, via the current system, is 52.08 cents per bushel. This cost reflects the study region's historic flow pattern associated with railroads single-car, transit rate structure. The analyses shows variable rail cost and grain handling and storage cost to comprise about 58 and 22 percent of the system's aggregated costs, respectively. Approximately 104 million of the 118.2 million bushels of wheat moving to export transits at inland terminals while 1.75 million bushels moves via the river elevator (Table 2).

## 80-Car System

This organization involves the use of 80-car trains between the five inland terminal locations and Texas ports. Analysis indicates this organization would incur an average cost of 45.39 cents per bushel, a cost savings of 6.69 cents per bushel relative to the current system or a total annual cost savings of \$7.9 million (Table 1). Principal saving is due to the introduction of unit trains. The 80-car system reduces railroad's variable cost from \$35.7 to \$23.3 million, a cost saving of \$12.4 million. Truck costs increase with this organization because of the greater use of this mode in assembling export wheat to inland terminals. Because of the relative cost advantage of trucks over short distances, the truck mode would transport 57 percent of the wheat moving from country elevators to inland terminals.

With the 80-car system, farmers and country elevators would not be forced to act differently than with the current system. Farmers would continue to deliver to nearby country elevators, which would direct wheat to inland terminals for subsequent movement on the 80-car trains. Currently, 88 percent

TABLE 1. A Cost Comparison of the Current; 80-Car; 50, 80-Car; and 20, 50, 80-Car Systems

System	Farm Assembly Cost (\$)	Total Variable Grain Handling and Storage Cost <sup>a</sup> (\$)	Total Cost of Commercial Trucking (\$)	Total Variable Cost to Railroads <sup>b</sup> (\$)	Total Cost of Barging (\$)	Subterminal Grain Grading Cost (\$)	Fixed Cost of Subterminal Renovating (\$)	Aggregated Cost (\$)	Per Bushel Cost ¢/Bu.
Current	8,943,192	13,360,719	3,223,883	35,734,264	296,100	0	0	61,558,158	52.08
80-Car	8,984,853	13,524,274	7,499,219	23,293,435	345,168	0	0	53,646,949	45.39
50, 80-Car	9,527,088	12,995,030	4,817,290	22,824,922	345,168	53,300	768,716	51,331,514	43.43
20, 50, 80-Car	9,703,019	12,878,349	3,570,169	21,140,705	375,624	89,681	1,446,192	50,203,739	42.47

<sup>a</sup>Includes variable cost of handling and storing grain at farms, country elevators, inland terminals, subterminals, river elevator and port elevators.

<sup>b</sup>Includes only railroads variable cost. Rail cost parameters entered in network model represented total cost, which were obtained by multiplying the variable cost parameter by 1.35.

(104 million bushels) of the study region's export-destined wheat moves on rail-transit billing through inland terminals, while an estimated 95 percent (112.7 million bushels) would move to these locations with the 80-car system (Table 2). Increased volumes flow through inland terminals for purposes of moving on the lower cost 80-car unit trains.

### 50, 80-car System

This organization includes 80-car unit trains operating from inland terminal locations and 50-car unit trains operating from selected country elevators which are converted to subterminals. The 50, 80-car organization would decrease system costs relative to the current and 80-car organization. This organization would reduce annual marketing costs 1.96 cents and 8.65 cents per bushel relative to the 80-car and current systems, respectively (Table 1). The 50, 80-car results exhibit cost savings of \$10.2 million relative to the current system. Again, the unit train is the principal source of system savings.

Fourteen of the twenty-six potential subterminal locations would be feasible, that is, they provide a lower cost means of moving their area's export-destined wheat to port locations than available alternatives. In general, the feasible subterminal locations would have large country elevators and would not be in close proximity to inland terminals from which 80-car unit trains operate. Because of the keen cost competition between potential subterminals and inland terminals, a subterminal in the proximity of an inland terminal would most likely be unfeasible.

Subterminals ship directly to port elevators, therefore, if the fourteen feasible subterminals were constructed they would direct export wheat away from the existing inland terminal locations. It's estimated that subterminals would capture 45 percent of the study region's export wheat. Thus, the portion of export wheat moving to inland terminals would be reduced from the current 88 percent (104 million bushels) to 52 percent (62 million bushels) (Table 2). In addition,

**TABLE 2. Volumes of Export Wheat Handled by Country Elevators, Subterminals, Inland Terminals and River Elevator With The Current: 80-car; 50, 80-car; and 20, 50, 80-car Systems**

System	Country Elevators	Inland Terminals <sup>a</sup>	Sub-terminals	River Elevator
	------(000 bushels)-----			
Current <sup>b</sup>	118200	104066	0	1750
80-car <sup>b</sup>	118200	112686	0	2040
50,80-car <sup>c</sup>	64907	62020	53300	2040
20,50,80-car <sup>c</sup>	45221	42341	72979	2220

<sup>a</sup>All volumes handled by inland terminals must have previously been handled by country elevators.

<sup>b</sup>With this organization producers deliver to country elevators.

<sup>c</sup>With this organization producers may deliver to either country elevators or subterminals.

export wheat would be directed away from country elevators and to subterminal locations. With the current and 80-car system, all export wheat moves via the country elevator. With the 50, 80-car organization, farmers would bypass country elevators to deliver to nearby subterminals. The volume handled by country elevators would decrease from 118.2 to 64.9 million bushels, while subterminals's farmer-delivered receipts would become 53.3 million bushels (Table 2). Subterminal receipts would come directly from producers either at harvest or later from on-farm storage. Twenty-three country elevators located in the proximity of the fourteen feasible subterminals would no longer receive export-destined wheat. Accordingly, the economic viability of these firms would be seriously endangered with the 50, 80-car organization.

In contrast to findings of the Midwest studies, subterminals in the south Plains study region would receive nearly all (99.9 percent) of their export destined wheat from farmers rather than from other country elevators: this is due to keen cost competition between the subterminal and inland terminal organizations. That is, when all costs are considered, it is generally more efficient for a country elevator to ship wheat to an inland terminal for subsequent movement on an 80-car unit train than to ship to a nearby subterminal for subsequent movement on a 50-car unit train.

Variable grain handling and storage costs tend to decrease slightly with the increased

use of the subterminal organizations. The analysis indicates that subterminal storage would fill with the harvest-time supply of wheat and then receive their remaining receipts in later time periods from producer-stored supplies. It follows that the harvest-time supplies are handled only once prior to arriving at port locations. With the current and 80-car system nearly all grain flows from country elevators to inland terminals, in which case, the wheat is handled twice. Only a portion of wheat moving via subterminals is handled twice prior to arriving at port areas, accordingly, a slight reduction in variable costs. Although system variable costs are reduced with increased use of subterminals, the additional fixed cost of conversion more than offsets these cost reductions. The annual fixed cost of converting country elevators into subterminals in the 50, 80-car organization is \$.77 million.

Farm assembly cost increases from \$8.9 million with the current organization, to \$9.5 million with the 50, 80-car organization (Table 1). Producers would tend to bypass local country elevators to take advantage of the higher bid price at subterminals, thus increasing their assembly distance.

#### *20, 50, 80-Car System*

This organization includes 80-car unit trains operating from inland terminal locations and either 20, 50, or 80-car unit trains operating from selected country elevators which are converted to subterminals. The 20,

50, 80-car organization would be the most efficient of the three alternative systems; the estimated cost of this system would be 42.47 cents per bushel, a savings of 9.61 cents per bushel relative to the current system (Table 1). The annual cost saving of this organization would be \$11.4 million. The additional efficiency of this system is primarily due to the increased use of unit trains.

The twelve unfeasible subterminal locations in the 50, 80-car organization would be feasible as 20-car subterminals in the 20, 50, 80-car system. Their feasibility is due to the lower cost associated with converting a country elevator to a 20-car unit train subterminal rather than a 50-car unit train facility. Likewise, it was found that any feasible subterminal in the 50, 80-car system that handled volume in excess of 2.67 million bushels would be a feasible location for an 80-car unit train subterminal. Accordingly, all twenty-six potential subterminal locations would be feasible in the 20, 50, 80-car system.

Most of the changes in flow patterns observed with the 50, 80-car system are also the case with the 20, 50, 80-car organization. Export wheat is increasingly redirected to subterminals and away from inland terminals. Inland terminal's share of the export-destined wheat would be reduced to 36 percent (42.3 million bushels), while subterminals share would be increased to 62 percent (72.9 million bushels) (Table 2). In addition, subterminals would attract additional wheat away from country elevators. Country elevator receipts would decrease from the 118.2 million bushels associated with the current and 80-car systems to 45.2 million bushels with the 20, 50, 80-car organization (Table 2). Subterminals would receive nearly 73 million bushels of farmer-delivered receipts. Forty-seven country elevators would no longer receive export-destined wheat from producers. As with the 50, 80-car system, export wheat would be increasingly stored on-farms for later delivery to subterminals. It follows that on-farm storage would be an essential part of a subterminal organization on the south Plains.

Nearly all of the observations regarding costs in the 50, 80-car system are also valid for the 20, 50, 80-car organization. Variable grain handling and storage costs tend to decrease with the 20, 50, 80-car organization but the \$1.45 million in annual fixed cost associated with conversion to subterminals more than offsets the annual reduction in variable cost (Table 1). In addition, producers' assembly cost would further increase with the 20, 50, 80-car system. This is a result of the increased volume handled by the subterminal organization and the additional distance which producers would travel in order to obtain the higher price associated with subterminal locations.

As in the 50, 80-car organization, almost no export wheat would move from country elevators to subterminals. This was partially unexpected since eleven subterminals would be offering the same 80-car unit train service as the inland terminals. A closer examination revealed the 80-car unit trains operating from subterminal locations to be at a cost disadvantage relative to those operating at inland terminals. Because unit train movement from subterminal locations to port elevators is more circuitous, these locations would be at a 2 to 4 cent per bushel disadvantage. A second factor that would place subterminals at a cost disadvantage is the conversion cost necessary to accommodate the 80-car train. No conversion cost would be necessary at inland terminals. A third factor unfavorably effecting 80-car unit trains operating from subterminals is the slightly higher grain handling and storage costs relative to inland terminals.

In general, the 50, 80-car and the 20, 50, 80-car distribution systems would affect farmers, country elevators and inland terminals more dramatically than the 80-car organization. Producers would tend to bypass local country elevators to take advantage of lower transportation costs and resulting higher bid prices at subterminals, thus increasing their assembly distance. Results indicate that 45 and 62 percent of the export-destined wheat would move directly to subterminals

in the 50, 80-car and 20, 50, 80-car solutions, respectively. This export destined wheat would bypass country elevators and inland terminals, thus substantially reducing volume handled by these facilities.

### Summary and Implications

The purpose of this study is to compare the efficiency of alternative distribution systems for marketing hard red winter wheat from the southern U.S. Plains to Gulf port locations. Railroads operating in the southern Plains are generally profitable and have indicated limited abandonment of branchline segments. This study's efficiency analysis focuses on the unit train concept and associated efficiencies for moving wheat from south Plains origins to Gulf ports.

Two principal conclusions arise from this research. First, the unit train concept is a feasible means of improving the export wheat marketing system efficiency in the Plains study area, and cost savings are large enough that similar results may be concluded for other Plains areas. Second, a subterminal organization served by unit trains is feasible and cost reducing as compared to an organization of unit trains operating from only inland terminal locations. Although the greatest opportunity for cost reduction and increased efficiency includes a subterminal organization, this organization requires simultaneous development of several system components. Consequently, this would be the most difficult alternative to implement.

Unit trains are the principal source of potential system efficiency and, accordingly, railroads are the most critical marketing agents for purposes of providing incentives to remodel the current system. Railroads potential actions can significantly affect other system participants, in particular, the grain handling industry. Reduction in railroad operating cost must, in part, be passed on to grain handlers and, in turn, to farmers in order to obtain the desired outcome.

Although system efficiency is improved with an organization involving subterminals, reorganization impacts would not be uniform

and, in fact, would be unfavorable for some firms. Those country elevators no longer involved in handling export-destined wheat and inland terminals whose volume is drastically reduced would be likely losers in such a reorganization scheme. Reduced volumes unfavorably affect profits and the value of invested capital.

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