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ALTERNATIVE EXPORT WHEAT DISTRIBUTION SYSTEMS FOR THE SOUTHERN U. S. PLAINS

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Abstract

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Paper reports on alternative logistical systems for marketing export-destined wheat from southern U.S. Plains. Study concludes 1) regions export system is not economical when compared to alternatives which include multicar shipments 2) efficiency gains are derived from unit train concept and 3) feasibility of subterminals and associated unit trains isn't contingent upon rail abandonment.

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This paper examines means of improving the logistical efficiency of the export wheat handling system for the hard red winter wheat production region of the southern U.S. Plains. Analysis focuses on the feasibility of restructuring grain collection facilities and train operations to incorporate unit train movements of wheat to port locations.

Previous evaluation of restructuring grain handling systems have sought optimal alternatives to rural railroad line abandonments. Baumel, et.al., and Ladd and Lifferth investigated the feasibility of restructuring the country elevator industry in Iowa to include subterminal storage facilities located on retained railroad lines. Subterminals would receive grain from producers and country elevators and grain destined for port locations would be moved on unit trains. The study concludes that cost savings associated with unit train movement more than offset losses due to rail service curtailments. Similar conclusions have been reached in similar situations in other Corn Belt states, Indiana (Hilger, et.al.) and Ohio (Larson, et.al).

Although previous studies contain some aspects which parallel those of the wheat producing region of the southern U.S. Plains, three important differences in production and marketing prevent extrapolation of results of previous research to this region. First, railroad abandonment is not as serious a threat to the U.S. Plains as to the Midwest. Consequently, both existing country elevators and potential subterminals would have rail service, partially obscuring the cost superiority of subterminals shown in the Midwest 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 upgrade country elevators into subterminals, creating a relative cost disadvantage for a potential subterminal organization. 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, unfavorably affecting the feasibility of a subterminal organization.

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 renovating selected country elevators into subterminals and operating unit trains between these facilities and Texas port locations, 2) the feasibility of operating unit trains between inland terminals and Texas port locations and 3) the effect of these organizations on the cost of handling export wheat. The alternative organizations involve 80-car shipments from existing inland terminal facilities and various combinations of 20, 50 and 80-car shipments from potential subterminal locations.

The Study Region

To determine the potential of multicar shipments and a subterminal organization in this wheat producing region, a contiguous 29,025 square mile area located in portions of Kansas, Oklahoma and Texas was selected (Figure 1). This area has annual wheat production of approximately 160 million bushels and, historically, 75 percent of production has been destined for export markets. Three hundred forty-seven country elevators operate at 244 locations and, these facilities typically have shipped nearly 90 percent of their wheat receipts to five inland terminal industry locations. This industry includes thirty-four facilities ranging in storage capacity of three to twenty-five million bushels and, in aggregate, represents 215 million bushels of capacity. Approximately 90 percent of the region's export-destined wheat flows through

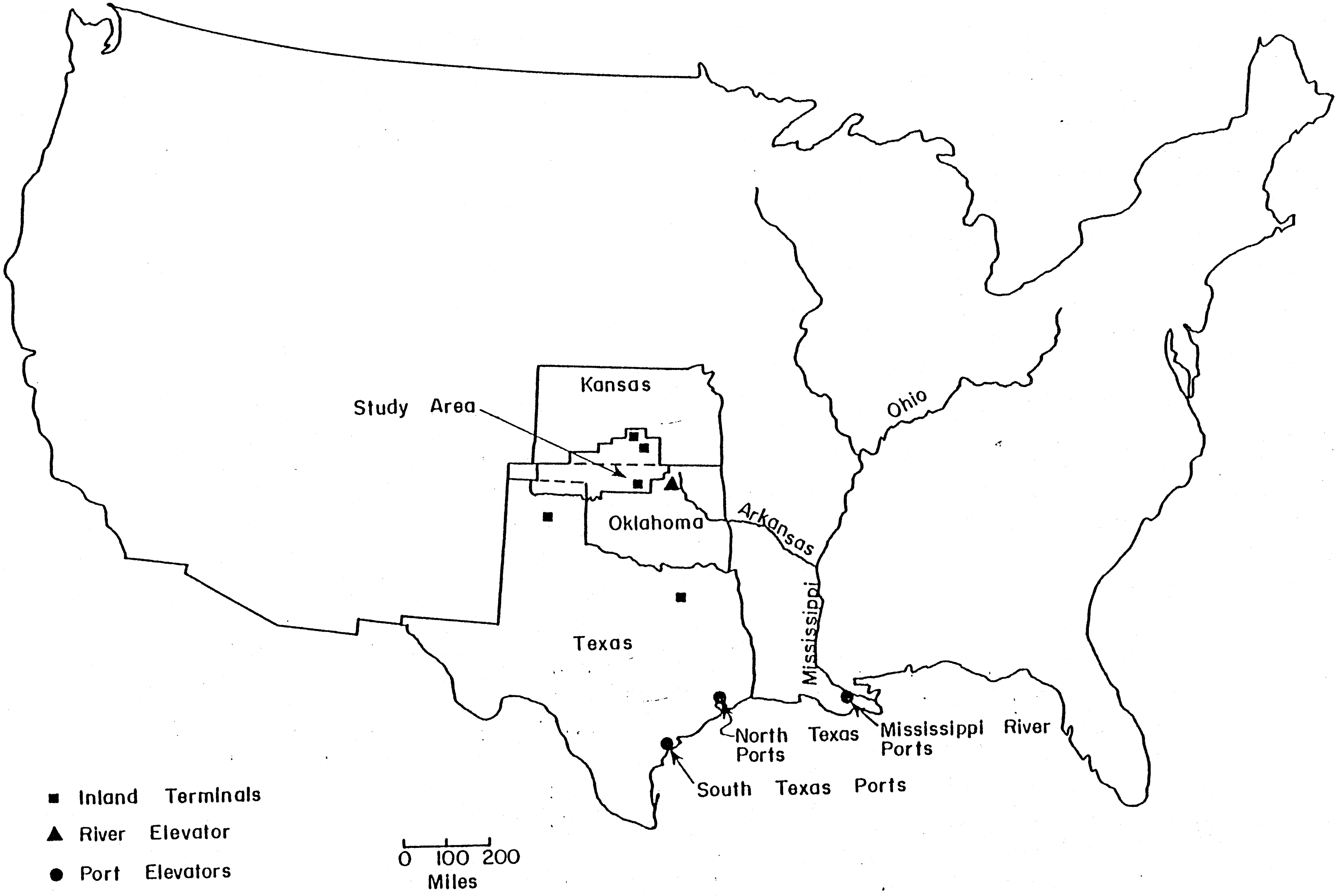

Figure 1. Outline Map of U.S. and Study Area

North Texas port elevators, while the remainder exits through South Texas (8 percent) and Mississippi River ports (2 percent), (Figure 1).

The region's single-car rate structure allows for storage-in-transit at the inland terminal locations. Wheat may 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 to inland terminal and from inland terminal to 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 transhipment at inland terminal locations.

Model and Research Procedure

Interest was in estimating costs of alternative distribution schemes that would likely evolve given the inclination of existing railroad and elevator management. Accordingly, the desired model orientation was on answering "what if" types of questions. The study's emphasis was not on determining the costs of the optimum subterminal organization (number, size and location) with their associated least-cost unit sizes.

Because of a high degree of interdependence among the elements constituting this area's export wheat marketing system, a cost-minimizing model is developed to represent the entire system. 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 hauling and storage costs.

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).

A prototype network model is presented here to provide additional insight into the structure of the model. A network model is constructed with nodes and interconnecting arcs. Nodes represent elements comprising the system; these include production origins (3 X 3 mile areas), country elevators, subterminals, inland terminals, the river elevator and port terminals. Arcs connect nodes and include information regarding lower and upper bounds associated with arc flow and include the unit cost of this flow.

The prototype model includes two production origins (P=2), one country elevator (C=1), one subterminal (S=1), one inland terminal (I=1), one river elevator (R=1) and one port terminal (E=1). The prototype model includes two time periods (T=2), (Figure 2). To represent two time periods, it is necessary to establish three points in time. Grain stored from point 1 in time to point 2 in time will have been stored through the first time period. Similarly, grain stored from point 2 in time to point 3 in time will have been carried through the second period. The nodes of the network are defined as follows:

P_{ik}: represents production location i at point k in time

$i = 1, 2$
$k = 1, 2, 3$

C_{ik}: represents country elevator i at point k in time

$i = 1$
$k = 1, 2, 3$

S_{ik}: represents subterminal i at point k in time

$i = 1$
$k = 1, 2, 3$

I_{ik}: represents inland terminal i at point k in time

$i = 1$
$k = 1,2,3$

R_{ik}: represents river elevator i at point k in time

$i = 1$
$k = 1, 2, 3$

E_{ik}: represents port elevator i at point k in time

$i = 1$
$k = 1, 2, 3$

The quantity of grain which may be shipped from a country elevator in the first time period is constrained to available transportation. Accordingly, a set of artifical nodes are created. They are represented in Figure 2 as A_i^t and A_i^r, where:

A_i^t: represents the truck node associated with country elevator i during harvest, and

A_i^r: represents the rail node associated with country elevator i during harvest, and

$i = 1$.

An additional set of dummy nodes are required to include renovation costs at subterminals. They are represented in Figure 2 as S_r nodes.

Each arc connecting the various nodes include three parameters. These parameters include a lower bound or a required flow, an upper bound or maximum flow and a cost of unit flow through the arc. The lower bound on all arcs is set equal to zero except for those linking the source node with the production origin nodes and the port terminal nodes with the sink node (Figure 2). The lower and upper bounds on the arcs terminating at the production origin node (P_{11} and P_{12}) are set equal to the quantity of harvested wheat at each production origin which is export-destined. The arcs connecting the port elevator with the sink node have their lower and upper bounds set equal to the exogenously estimated quantity of foreign wheat demanded at the port elevator. Arcs connecting the C_{ik} nodes with the A_i^t and A_i^r nodes have their upper bounds set equal to the respective quantity of truck and rail service available at harvest. All remaining arcs have upper bounds set equal to infinity, except those representing wheat storage activities.

Many arcs include costs of either grain receiving, storage, loading and/or transportation. The multiperiod or storage characteristics of the model are introduced through the use of storage arcs which link a storage facility through points in time. For example, the vertical arc connecting P_{11} (production origin 1, time point 1) and P_{12} (production origin 1, time point 2) represents the first time period and includes the farm storage cost associated with production origin 1. The upper bound on this vertical arc reflects the wheat storage available at this production origin. The vertical storage arcs linking the subterminal, inland terminal, river elevator and port terminal through alternative time frames include similar types of cost and upper bound information.

Arcs linking production origin nodes with the country elevator or subterminal include farm assembly cost and unloading costs at these repective facilities. Arcs linking the country elevator with the subterminal, inland terminal and river elevator include the unit cost of loading the appropriate mode, transportation cost and the unloading cost at the respective facilities. Similar types of costs are included on those arcs which connect the inland terminal, river elevator and port terminal. To estimate the costs of the current system, rail arcs included only single-car movement. When the feasibility of multi-car shipments is examined, the rail arcs connecting the inland terminal with the port terminal include 80-car unit train costs, whereas the arcs linking the subterminal with the port elevator includes either 20, 50, or 80-car unit train costs. Arcs connecting the S_{ik} node (subterminal) and the S_r nodes include estimated subterminal unit fixed renovation cost.

Four export-wheat distribution systems are represented with the network flow model. These included the current system and three alternative distribution systems. Estimated current system costs represent a benchmark against which alternative distribution system costs are compared. The three alternative distribution systems are limited to: 1) a system that involves operation of 80-car unit trains between the study area's five inland terminal locations and Texas ports--referred to as the 80-car system; 2) a system that involves operation of 80-car unit trains from the five inland terminal locations and, operation of 50-car unit trains at twenty-six 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 the five inland terminal locations and operation of the twenty-six potential subterminals serviced by either 20, 50 or 80-car unit trains that deliver wheat to Texas ports--referred to as the 20, 50, 80-car 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 distribution system, grain was not forced to follow the historic flow pattern except as dictated by historic quantities of export demands at the various port areas.

Results

The analyses show that the alternative distribution 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.

With the 80-car system, 96 percent of the wheat destined for Texas ports would flow through inland terminals for purposes of capturing the lower cost 80-car unit train. Because of the relative cost advantage of trucks over short distances, the truck mode would be the principal assembler of wheat from country elevator to inland terminal. The subterminal organization (20, 50-car and 20, 50, 80-car systems) with its associated multi-car shipments would be feasible in spite of the keen cost competition provided by the inland terminals and their associated 80-car trains. Analysis indicates that fourteen of the twenty-six potential subterminal locations would be capable of supporting a 50-car loading facility (50, 80-car system), while all potential locations would be able to support a subterminal served by either a 20, 50 or 80-car train. If implemented, subterminals in the 50, 80-car system would capture 46 percent of the wheat destined for Texas ports and 62 percent of the similarly destined wheat in the 20, 50, 80-car system. Results indicate that almost no export wheat would flow from country elevators to subterminals. Rather, all subterminal receipts would come directly from producers' either at harvest or later from on-farm storage. Since subterminals would ship directly to port elevators, large volumes would by-pass existing country elevator and inland terminal facilities.

In contrast to the findings of other studies, subterminals would receive nearly all grain 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 grain to an inland terminal for subsequent movement on an 80-car train than to ship to a nearby subterminal for subsequent movement on a 20, 50 or 80-car train. Analysis of individual costs revealed several reasons for this outcome. First, the greater efficiency of the 80-car trains operating from inland terminals places the subterminal organization with its 20-car or 50-car trains at a cost disadvantage. Further, when 80-car trains operate from both inland terminals and subterminals, trains operating from subterminals are at a 2¢ to 4¢ per bushel cost disadvantage relative to trains operating from inland terminals locations. This is due to less direct rail routes from subterminals to ports than from inland terminals to ports. A second factor that places subterminals at a cost disadvantage is their renovation cost which is necessary to accommodate unit trains. No renovation costs are associated with inland terminals. A third factor unfavorably impacting subterminals is their slightly higher grain handling and storage costs relative to inland terminals.

All three distribution systems show sizeable annual cost savings relative to the current system. Annual system cost savings range from $7.9 million (6.29¢/bushel) for the 80-car organization to $11.4 million (9.61¢/bushel) for the most efficient distribution system, the 20, 50, 80-car organization. The 50, 80-car results exhibit system cost savings of $10.2 million or 8.65¢ per bushel (Table 1).

The principle source of system savings is reduced variable rail cost, which is primarily attributable to multi-car shipments. The 80-car system reduces railroad variable cost from $35.7 million to $23.3 million--a savings of $12.4 million. The greatest rail cost savings is associated with subterminals and the additional use of unit trains at country locations. Estimated variable rail cost savings associated with the respective 50, 80-car and the 20, 50, 80-car organizations are $12.9 million and $13.6 million, relative to the current system.

Although total system costs decrease with the increased use of multi-car shipments, farm assembly costs increase. Farm assembly costs increase from $8.9 million with the current organization, to $9.7 million with the 20, 50, 80-car organization. The increased cost is attributable to greater assembly distances for delivery to subterminals.

With the 80-car organization, 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. In general, the 50, 80-car and the 20, 50, 80-car distribution systems would affect farmers country elevators and inland terminals most dramatically. Producers would tend to bypass local country elevators to take advantage of lower

Table 2. A Cost Comparison of the Current; 80-Car; 50, 80-Car; and 20, 50, 80-Car Systems

System	Farm Assembly Cost ($)	Total Variable Grain Handling and Storage Cost[1] ($)	Total Cost of Commercial Trucking ($)	Total Variable Cost to Railroads[2] ($)	Total Cost of Barging ($)	Subterminal Grain Grading Cost ($)	Annual 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

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

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

transportation costs and resulting higher bid prices at subterminals and all export-destined wheat shipped from subterminals would bypass inland terminals. Results show that twenty-three and forty-seven elevators would no longer receive this grain under the 50, 80-car and the 20, 50, 80-car organization, respectively. Accordingly, the economic viability of these firms could be seriously endangered.

Conclusions

Several conclusions are derived from this study. They are: 1) the South Plains wheat export system is not economical when compared to the alternative distribution systems which include multi-car shipments, 2) system efficiency gains are derived from the multi-car or unit train shipments and 3) the feasibility of subterminals and associated unit trains is not contingent upon rail abandonment.

Although system efficiency is improved with an organization involving subterminals, reorganization impacts are not uniform and, in fact, are unfavorable for some firms. Those country elevators no longer involved in handling export-destined wheat and inland terminals whose volume is drastically reduced are likely losers in such a reorganization scheme. Reduced volumes unfavorably affect profits and the value of this invested capital.

References

Baumel, C.P., John J. Miller and Thomas P. Drinka. A Summary of an Economic Analysis of Upgrading Branch Rail Lines: A Study of 71 Lines in Iowa, FRA-OPPD-76-3, DOT-FR-44034, Iowa State University, March 1976.

Fuller, S.W. and C.V. Shanmugham, "Network Flow Models: Use in Rural Freight Transportation Analysis and a Comparison with Linear Programming," So. J. Agri. Econ., 10(1978) 183-188.

Hilger, D.A., B.A. McCarl and J.W. Uhrig, "Facilities Location: The Case of Grain Subterminals," Amer. J. Agr. Econ., 59(1977) 674-682.

Larson, Donald W. and Michael D. Kane. "Effects of Rail Abandonment on Grain Marketing and Transportation Costs in Central and Southwestern Ohio," No. Cent. J. Agr. Econ., 1(1979) 105-113.

Ladd, G.W. and D.R. Lifferth. "An Analysis of Alternative Grain Distribution Systems," Amer. J. Agr. Econ., 57(1975): 420-438.