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MARKET AREA SENSITIVITY AS A MEASURE OF RAILROAD-BARGE COMPETITION IN THE OKLAHOMA-KANSAS WHEAT TRANSPORTATION MARKET*

Marc A. Johnson and Gary M. Mennem

New directions in national transportation policy have rekindled interest in transportation market structure. The Department of Transportation policy goal to equalize competitive opportunities between modes requires greater understanding of intermodal competitiveness in terms of inherent advantages of each mode in serving particular transportation markets. Flexible railroad ratemaking in the absence of market dominance, provided for in the Railroad Revitalization and Regulatory Reform Act of 1976, requires measures of intermodal competitiveness to define market dominance.

This article serves two purposes. The first is to develop market area sensitivity as a tool for distinguishing competitive from noncompetitive transportation market structures. The second is to describe the competitive nature of the Oklahoma-Kansas wheat transportation market after introduction of inland water navigation to Oklahoma. Fulfillment of the second objective provides an opportunity to demonstrate the market area sensitivity tool in market structure analysis.

The paper begins with development of the market area sensitivity tool in terms immediately applicable to discussion of a what transportation market, with rail and water carrier participants. The technique itself is generally useful in analyzing the competitive structure of transportation markets for numerous commodities, with various modal participants. Discussion proceeds to describe the Oklahoma-Kansas wheat transportation market under transport policies and relative transport prices applicable prior to February, 1976.[1] This is followed by brief speculation on likely impacts upon railroad-barge competition caused by new federal transport policies.

"MARKET AREA SENSITIVITY" AS A STRUCTURAL TOOL

Wheat prices of interest to grain elevator managers are those which represent revenue per bushel net of transfer costs to final markets. These site prices are equal to a base market price offered at a distant location, less transportation costs and marketing service charges. Export price offered at Gulf of Mexico port terminals serves as the base market price, setting a pattern of wheat prices throughout the hard red winter wheat belt, even for domestic usage.

Elevator operators may elect to move wheat by one of several motor, rail and water carriage options. During the peak receiving months of harvest, wheat may be routed by truck or railroad to inland terminal elevators for subsequent shipment to Gulf ports and domestic mills. Rail shipments to inland terminals typically are moved on transit balance, which nearly assures subsequent movements by rail.[2]

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[1] The Railroad Revitalization and Regulatory Reform Act of 1976 (P. L. 94-210) was enacted in February 1976. The Act provides for sweeping changes in railroad ratemaking procedures.

[2] A domestic rail rate is paid on movement from a country elevator to an inland terminal. The transit balance is calculated as the difference between rail rate direct from country point to final market desitnation applicable on the date of the first movement, less amount already paid on the first movement. For domestic final desitnations, movements from inland terminals to final markets are shipped at domestic rail rates application on the date of the first movement, regardless of rate increases approved in the interim. For export final destinations, movements from inland terminals to final markets are shipped at export rail rates applicable on the date of the first movement; export rates tend to be lower than domestic rates leaving the transit balance quite small and, in some cases, negative resulting in a rebate to the shipper.

Consequently, movement of grain via inland terminal elevators is not influenced by the railroad-barge competition discussed here.

Country elevator managers may also elect to ship wheat directly from local storage to Gulf ports or domestic markets without an intermediate stop at inland terminals. Managers hold control of market selection for grain sold at harvest time and that stored locally. Storage income for grain held locally provides incentive for country elevator managers to hold as much good quality grain as possible until farmers decide to sell.

In identifying railroad-barge competition, only two market-transport options are considered: shipment by railroad directly from country elevators to Gulf export markets, and shipment by truck to the Port of Catoosa for barge movement beyond. Due to lack of water transport competition, intrastate movements are excluded. Indirect movements through inland terminals are excluded due to transit balance rail pricing. Truck movements directly from country elevators to Gulf export markets are excluded as an option not competitive with railroads and barges in the area where railroad-barge competition is effective.[3]

Site price received by country elevators for direct shipments by railroad to export points, P_{sr}, equals the base Gulf export wheat price, P_g, less the rail transport rate, t_r, from local storage facilities to the Gulf port, i.e., $P_{sr} = P_g - t_r$. The various pricing arrangements, e.g., F.O.B. origin and F.O.B. destination, will yield relative slight differences in net local price received for grain.

Site price received for wheat movements by water transport through the Port of Catoosa, P_{sw}, equals the river port terminal price offered, P_p, less the rate for trucking grain, t_t, from local storage to river port facilities, i.e., $P_{sw} = P_p - t_t$. The spread, S, between river port wheat price and the higher export wheat price is allocated to water transport rates and port service charges. The river port price is typically quoted at a level equal to the Gulf export price less an identifiable price spread, i.e., $P_p = P_g - S$. Substituting this river port price definition into the definition of site price received with water movement, the site price becomes Gulf export price less the price spread and less the truck rate from local storage to river port facilities, i.e., $P_{sw} = P_g - S - t_t$.

Elevator managers oriented toward maximum profits or maximum revenues will choose to ship wheat by the means which yields the highest site price. (Of course, this disregards the differential values between modes due to nonprice differences in modal services.) Since transportation rates for wheat depend chiefly upon distance of movement, locations where site prices with water transport equal or exceed those with rail transport represent the geographical market area for water transportation, i.e., locations for which $P_{sw} \geq P_{sr}$ [2, pp. 124-129].

Substituting definitions for the two site prices, locations for which $P_g - S - t_t \geq P_g - t_r$ lie in the water transport market area. Subtracting P_g from both sides, adding t_t to both sides and multiplying the inequality by -1 yields $S \leq t_r - t_t$. When the Gulf-Catoosa wheat price spread equals the difference between rail rate to the Gulf and truck rate to the river port, country elevator managers will be indifferent between shipping wheat by railroad or barge, on a price basis; locations satisfying the equality represent the boundary between water and rail carrier market areas. When the inequality holds for a particular elevator, it lies in the interior of the water carrier market area and, except for nonprice considerations, the decision to ship by water is clear.

Elevators located on the boundary of the water transport market area will have perfectly elastic demands for railroad service and for truck-barge service. A slight decline in the rate of one transport mode, unaccompanied by a rate change of the other, will cause traffic to shift to the lower-priced mode. Over time, equilibrium rates will be established at a level equal to long-run average cost of the least costly mode, in the presence of intramodal competition. Transport companies would perceive no control over "going" market rates. Where the expanse of a modal market area is extremely sensitive to slight fluctuations in relative transport prices, the different modes face highly elastic demand functions over a broad geographical range.

A more realistic description of the way market area sensitivity represents transport demand conditions must consider indivisibility of transport options and the regulatory environment. Suppose DD′ represents the demand function for wheat transport of an individual country elevator at a particular location (Figure 1). Consider only railroad and truck-barge shipment alternatives. Let OC_b represent the level of minimum long-run average cost for operating a barge line and assembling wheat from this elevator's location by

[3] Some truck shipments will be made as exempt backhauls by regulated carriers. During the period July 1, 1971, to June 30, 1972, only six percent of wheat shipments made directly from Kansas country elevators to Gulf ports moved by truck [6, p. 7]. During the 1972-73 crop year only two percent of these shipments were made by truck [6, p. 23]. Observation suggests that wheat shipments by truck directly from northern Oklahoma country elevators to Gulf ports occurs very infrequently.

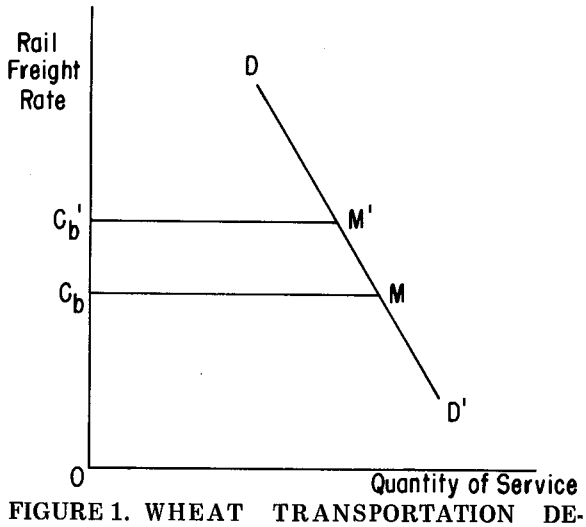


FIGURE 1. WHEAT TRANSPORTATION DEMAND

truck; let the long-run average cost of railroad service lie below OC_b.

Under Interstate Commerce Commission regulations applicable prior to February 1976, railroad firms jointly petition for fixed and equal rate levels. Therefore, when railroads provide the least costly transport service, they operate as a regulated, multiplant monopoly over a range of low transport prices. At rail rates below OC_b, railroads will face the entire wheat transportation demand function of the elevator, i.e., segment MD'. Wheat transportation demand of elevators, at low transport rates, will likely be inelastic.[4] A monopoly seeking to maximize profits will desire to increase transport prices in the inelastic portion of the demand function it faces.[5] Thus, railroad firms have incentive to press the regulatory agency for permission to raise rail rates.

If rail rates rise to a level equivalent to the long-run average cost of providing barge service, OC_b, the elevator manager finds himself on the boundary of the railroad and water transport market areas, indifferent between the two transport options. Existence of competition among barge lines and among truck lines will insure that, over time, entry and exit of barge and truck units will maintain the truck-barge transport rate near OC_b. Neither the railroad nor the truck-barge mode will perceive ability to raise price above OC_b without losing traffic from the elevator.

Consequently, railroads face demand functions C_bMD'. The truck-barge option serves as a competitive ceiling on railroad rates. Where rates reach the competitive ceiling OC_b, shipping firms lie on the boundary between modal market areas.

Modal market areas may have "thick" boundaries, or boundaries may be very sensitive, when intramodal competition is absent in the least cost mode. At locations more distant from the river port, the truck-barge alternative is more costly, say, OC_b', due to greater assembly costs. Railroads would face demand functions similar to $C_b'M'D'$ at these locations. As long as the gradient of rail rates is similar to that of truck-barge costs, elevator managers at many locations will be indifferent between transport modes, and market area boundaries will be "thick".

TRANSPORT COMPETITION IN THE WHEAT MARKET

Introduction of inland water navigation to Oklahoma has reshaped the structure of the wheat transportation market in Oklahoma and Kansas. Under fixed railroad rate regulation, the market area from which wheat is drawn for water transport is extremely sensitive to relative transport prices of railroads and truck-barge combinations. The sensitivity of the water transport market area suggests a high degree of competition, across a broad geographical region, at current rate levels.

The McClellan-Kerr Arkansas River Navigation System reached the Port of Catoosa, near Tulsa, Oklahoma, in December 1970. In September 1974, a river port grain terminal was opened to facilitate barge shipment of wheat and soybeans to New Orleans export markets and southeastern flour and feed mills. The Port of Catoosa grain terminal is the only major origin for barge shipment of wheat from Oklahoma.

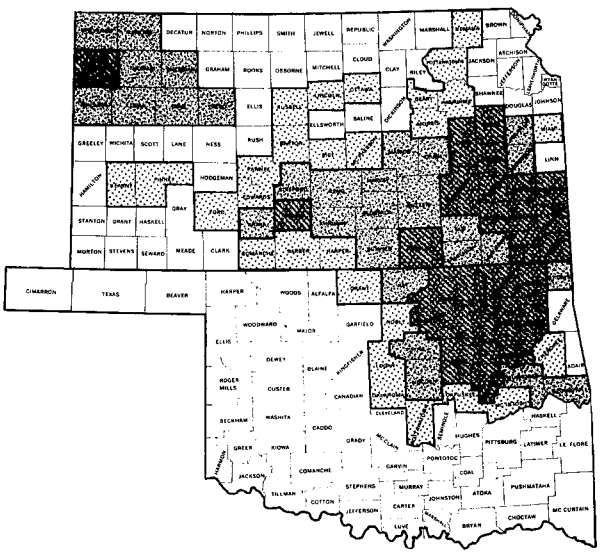
Recall from the above discussion that for direct shipments from local grain elevators to final markets, the water transport mode will be selected if the railroad rate to the Gulf less truck rate to the river port is greater than the spread between Gulf wheat

[4] At least two of Hicks' four conditions for inelastic demand for inputs are satisfied for the wheat transportation market. First, transportation is an essential input because wheat production and consumption centers are separated by great distances. Secondly, the product being shipped has an inelastic demand. Short term elasticity of wheat food demand with respect to wheat price is near -0.10 [1, p.17; 4, p. 47; 5, pp. 15, 16]. Short-run elasticity of wheat export demand with respect to wheat price is near -0.50 [5, p. 45].

[5] A monopolist will seek an equilibrium where marginal revenue equals marginal cost. Since marginal cost is a nonnegative quantity, marginal revenue at equilibrium must be nonnegative. Marginal revenue is defined as $p(1+1/e)$ where p = price and e = elasticity of demand. Where the demand facing the railroad firm is inelastic, i.e., $-1 < e < 0$, marginal revenue is negative. By reducing service quantity and increasing price, total revenue is increased and marginal revenue is made more positive.

price and the river port price. Railroad rates to the Gulf and trucking rates to the Port of Catoosa, applicable during October 1975, were used to compose market areas within which grain facilities at the Port of Catoosa potentially affect direct shipments of wheat.[6] Transportation rates for each county are those applicable to the county seat town. Market areas for the Port of Catoosa are shown for three different Gulf-Catoosa price spreads in Figure 2.

The entire shaded area of Figure 2 (including all tones) denotes the region from which the Port of Catoosa might draw wheat if the port terminal wheat price were 25 cents per bushel under the Gulf price.[7]



Market Area at 29¢ Gulf-Catoosa Bid Spread

Additional Market Area at 27¢ Gulf-Catoosa Bid Spread

Additional Market Area at 25¢ Gulf-Catoosa Bid Spread

FIGURE 2. WATER TRANSPORT MARKET AREAS FOR VARIOUS GULF-CATOOSA PRICE SPREADS, OKLAHOMA AND KANSAS, 1975

Elevators in the unshaded counties would ship wheat by railroad in preference to barge shipment. Medium and darkly-shaded areas demarcate counties from which country elevators would ship wheat through the Port of Catoosa with a Gulf-Catoosa price spread of 27 cents per bushel.[8] At a 29-cent Gulf-Catoosa price spread wheat from only the most darkly shaded counties will move through the river port.

With a 29-cent-per-bushel wheat price spread, the water transport alternative loses attraction to nearly all major wheat growing counties of Oklahoma and Kansas. As the port terminal reduces its price spread by two cents per bushel, from 29 to 27 cents, the water transport market area expends broadly into the wheat growing region. Another two-cent reduction in the river port price spread, from 27 to 25 cents, expands the water transport market area by one county on the southern and western boundaries and by several counties on the northern boundary.

Total 1975 wheat production in counties lying within the Catoosa market area is shown for 25-, 27- and 29-cent Gulf-Catoosa wheat price spreads in Table 1. Table 1 does *not* represent quantities of grain actually moved on the river. Some is consumed in the local counties as feed and seed. Some is shipped directly to wheat processors within the region. Some is shipped to inland terminal elevators for temporary storage. However, the table does reflect total volume of grain produced in the region where water transportation has a *competitive influence* along with railroad transportation.

Table 1 reveals that a rise in the Gulf-Catoosa wheat price spread from 25 to 27 cents per bushel decreases total wheat volume, for which the Port of Catoosa competes by more than 100 million bushels, or by 42 percent. Raising the price spread to 29 cents per bushel nearly withdraws water transportation from competition for wheat movement.

The extreme sensitivity of the water transport market area for wheat shipments suggests that with current rate levels, rail and water carriage options are

[6] Trucking rates, t_t^o (in cents per bushel) to the Port of Catoosa from Oklahoma elevators are obtained from the relationship

$$t_t^o = \underset{(0.109)}{1.894} + \underset{(0.001)}{0.091}\ (\text{MILES})$$

where MILES is the distance to the port. Truck rates from Kansas points, t_t^k, are obtained from

$$t_t^k = \underset{(0.381)}{3.540} + \underset{(0.004)}{0.094}\ (\text{MILES}) - \underset{(0.000007)}{0.000045}\ (\text{MILES})^2$$

Numbers in parentheses are standard errors of coefficients. Standard deviations of the estimates are 0.81 and 0.73 cents per bushel, respectively.

[7] The advantages of moving northwestern Kansas wheat through Kansas City and West Coast markets were tested. Wheat for export moves through Kansas City by railroad on a transit balance. Thus, except for quality premiums paid by processors, northwestern Kansas elevator managers will perceive no wheat price difference by shipping through Kansas City than by shipping directly to the Gulf. On the basis of site price comparisons, during the period July 1, 1974, to June 30, 1975, rail shipment to the West Coast competed with movement through the river port during only one week at the 27-cent Gulf-Catoosa wheat price spread and at no time at the 25-cent spread.

[8] During October 1975, the river port discount was 27 cents per bushel; the barge rate to Chattanooga, Tennessee, was 20-1/2 cents per bushel.

TABLE 1. TOTAL WHEAT PRODUCTION IN THE PORT OF CATOOSA MARKET AREAS ESTABLISHED BY 25, 27 AND 29 CENT-PER-BUSHEL RIVER PORT DISCOUNTS, 1975

Area	River Port Discount (¢/bu.)		
	25¢	27¢	29¢
	(Million-Bushels)		
Oklahoma	32	14	3
Kansas	208	125	26
Total	240	139	29

SOURCE: The Oklahoma Crop and Livestock Reporting Service.

highly competitive across a broad region of Kansas and a narrow region of Oklahoma. A unilateral increase in the transport price of either mode will cause that mode to lose great volumes of wheat traffic. Each mode, then, faces highly elastic demands for service to elevators in many of the wheat-growing counties of the two states. Thus, at current transport rate levels, a large portion of the Oklahoma-Kansas wheat transportation market is highly competitive.

NEW FEDERAL TRANSPORT POLICIES

Though the wheat transportation market of Oklahoma and Kansas appears highly competitive, any exogenous policy or endogenous market adjustments in transport rates or the Gulf-Catoosa wheat price spread have the potential of disrupting the competitive balance. Two recent changes in federal transport policy can possibly affect the role water carriage plays in this market.

One policy of concern is railroad rate flexibility authorized in the Railroad Revitalization and Regulatory Reform Act of 1976. During the years 1976 and 1977, railroads can vary specific rates as much as seven percent above or below rates existing on the first day of each year. The purpose of this provision is to correct rate maladjustments in transport markets caused by a series of general rate increases. According to Interstate Commerce Commission (ICC) statistics of 1972, railroad revenues from wheat shipments within the western region (composing 89 percent of total U.S. wheat tonnage shipped by railroad) cover fully allocated railroad cost by a substantial margin.[9] Variable costs are covered by an even larger margin. This suggests that railroads potentially can lower rail rates on wheat when faced with competition from another model.

A second policy of concern is proposed water carrier user charges. The recently announced policy of the U.S. Department of Transportation (DOT) is that implicit subsidization of freight carriers by government construction of operating ways must not favor particular modes. Waterways are currently constructed by the Army Corps of Engineers without charge to barge lines. Consistent with DOT policy, a waterway user charge levied on a ton-mile basis and a fee for the use of each lock have been proposed to collect a portion of future waterway development costs from navigational users.[10]

The effect of a per-unit tax is to raise marginal water carrier operating costs, results in one of two consequences. Where water carriers are the low-cost mode, water transport rates could be raised to a level equal with that of an alternative mode. Where transport rates are competitive between modes, the quantity of water carrier service supplied for wheat movement would be curtailed.

In combination, downwardly flexible rail rates and upward pressures on barge rates could collapse the wheat transport market area served by the Port of Catoosa. While some water transport rate increases may be absorbed with lower Gulf-Catoosa wheat price spreads to maintain volume flows through the port terminals, this is a limited alternative. With railroad rates allowed to fluctuate with the market, railroads and water carriers may not be as competitive over such a broad region as they were under fixed rate regulations. Any cost advantage passed on to elevators and wheat producers in reduced rail rates would expand the market area for rail services, making the rail mode dominant in the wheat production region.

Existence of the grain terminal at the Port of Catoosa will continue to serve as a built-in rail rate ceiling at a rate level competitive with barge movement. Barge loadings of soybeans and some wheat will keep the port facility operational. However, this rail rate ceiling established by the existence of the barge freight alternative will be set higher if a per-unit tax is placed on barge movements. If railroads continue to set rates in concert and water rates climb in response to user charges, railroads will enjoy transportation market dominance in the wheat production region without reducing rail rates. The result

[9] The ratio of railroad revenue to fully allocated railroad cost is 120.4 for wheat shipments; the ratio of revenue to variable cost is 173.4 [3].

[10] The Waterway User Tax Act of 1975 (H.R. 8590).

is a transfer of traffic to the railroad and a higher railroad rate ceiling (a transfer from rail shippers to the railroad).

CONCLUSIONS

When location of a boundary between two modal transport market areas is highly sensitive to slight changes in relative transport prices, the two modes are highly competitive in that region, at existing rate levels. Use of this principle suggests that, with fixed rail rates and variable truck and barge rates applicable prior to February 1976, railroad and water transport of wheat are competitive in the northeastern quarter of Oklahoma and over a great portion of Kansas. Adding the fact that railroads, acting in concert, have established wheat shipment rates considerably above total cost, one can conclude that water transport serves to place only a competitive ceiling on railroad rates.

New laws permitting flexible railroad rate making gives railroads the power to adjust rates downward slightly, resulting in collapse of the influence water transport has had upon wheat shipments from the area. Lower rail rates would mean higher wheat prices paid to elevators, and potentially, to farmers. However, if fuel taxes are imposed upon water carriers, the competitive railroad rate ceiling imposed by the water transport alternative will ultimately rise. Railroads would have to decrease rates less to capture traffic formerly carried by barge, and less of the cost advantage of using rail service would be passed back to country elevators.

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