RESPONSE OF AGRICULTURAL SHIPPERS TO RAIL RESTRUCTURING

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Response of Agricultural Shippers to Rail Restructuring

The transportation industry of the United States has experienced varied and substantial changes over the past few years. One major change has been the accelerated restructuring of the rail line network. The present study evaluates changes in grain and fertilizer marketing and transportation activities for a county in Central Illinois in response to a restructuring of the rail line network. Variables describing the marketing and transportation activities before and after rail restructuring include the cost of grain and fertilizer movement, the quantity shipped by specified locations, the origin and destination of shipments, the transport mode, the utilization of specified road types and the utilization of specified marked highway routes, rail track segments, and waterways. 1/

The financial failure of several railroads and the precarious financial state of several others has emphasized the need to eliminate unprofitable lines. The extensive nature of the rail, road, and in some regions, navigable waterway networks in the United States provided many shippers with two or more alternative carrier modes or combinations of modes. This ability of shippers to utilize several transportation modes and, consequently, the decreased reliance on or utilization of any one mode has been especially disadvantageous for railroads since they incur a comparatively large fixed investment and reoccurring expenditures for maintenance of way that other modes, especially the water mode, do not. Although railroads' line haul costs are relatively low, the traffic load for many lines has not been sufficient to justify the large expenditure

necessary for the proper maintenance or replacement of deteriorating lines. As these lines deteriorate to a condition such that service can be maintained only by incurring a large expense, the lines are often the subject of abandonment proposals. Shippers and communities facing the loss of rail service usually are concerned about the expected adverse economic consequences of rail abandonment and usually oppose the application. Understanding the response of agricultural shippers to rail line abandonment will help in establishing policies at the local, State, and national levels that will guide future investment decisions and will mitigate undesirable consequences of rail abandonment.

Theoretical Shipper Response to Rail Line Abandonment

Suppose that an agricultural producer located at an origin O, and with a given quantity of product to ship, faces a farm truck cost function F, an intercity truck cost function T, and a rail cost function R (Figure 1). Then the producer at O would ship by farm truck for destinations up to d_3. For destinations beyond d_3, the producer would ship to a firm located at d_1, which would then ship by intercity truck (incurring transfer charge ab) for destinations up to d_4 or by rail (incurring transfer charge ae) for destinations beyond d_4. The transport cost function facing the producer at location 0 is represented by cjkR. 2/

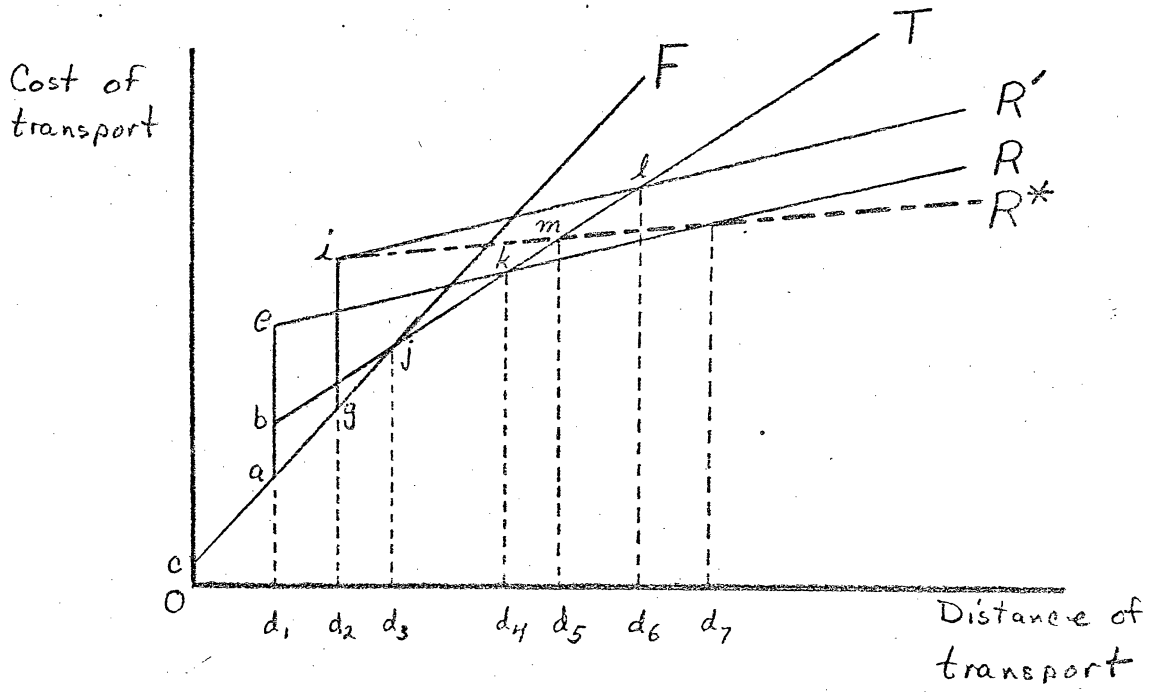
For a general mathematical expression of the functions in Figure 1 let:

(1) $F = F(d, q)$ = farm truck cost function

(2) $T = T(d, q)$ = intercity truck cost function for $d \geq d_1$,

(3) $R = R(d, q)$ = rail cost function for $d \geq d_1$,

Figure 1.--Theoretical response of shippers to rail line abandonment



and

$$(4)\quad \frac{\partial F}{\partial d} > \frac{\partial T}{\partial d} > \frac{\partial R}{\partial d} > 0,$$

$$(5)\quad \frac{\partial^2 F}{\partial d^2} \leq 0, \quad \frac{\partial^2 T}{\partial d^2} \leq 0, \quad \frac{\partial^2 R}{\partial d^2} \leq 0,$$

$$(6)\quad R > T > 0 \quad \text{for } d = d_1$$

Condition (4) requires that the marginal cost of transport be progressively smaller from farm truck to intercity truck to rail, condition (5) requires a constant or decreasing cost with respect to distance for each mode, and condition (6) requires that the terminal costs of rail exceed those of intercity truck at location d_1. The transport cost, C, for the producer at the origin is expressed as:

$$(7)\quad C = \begin{cases} F \text{ for } d \leq d_3 \\ T \text{ for } d_3 < d \leq d_4 \\ R \text{ for } d > d_4 \end{cases}$$

Now suppose that rail service between locations d_1 and d_2 were not available, i.e., R for $d_1 \leq d < d_2$ is not defined. The producer would then ship by farm truck for distances up to d_3 (same as before abandonment), by intercity truck for distances up to d_6 (incurring transfer charge ab at location d_1), and by rail for distances beyond d_6 (incurring transfer charge gi at location d_2). Note that in the particular example in Figure 1 the farmer shipped direct to the new rail loading point at d_2 and bypassed the old rail loading point at d_1. 3/ The total cost of transport after abandonment, C′, is expressed as:

$$(8)\quad C' = \begin{cases} F \text{ for } d \leq d_3 \\ T \text{ for } d_3 < d \leq d_6 \\ R' \text{ for } d > d_6 \end{cases}$$

and is represented by cjlR′ in Figure 1. The increase in transport cost, I′, for distance d after rail abandonment is:

$$(9)\quad I' = C' - C = \begin{cases} T-R \text{ for } d_4 \leq d \leq d_6 \\ R'-R \text{ for } d > d_6 \end{cases}$$

and is represented by the vertical distance between k1R′ and kR. The increase in transport costs after abandonment is a function of the cost functions of F, T, R and R′, the intermodal transfer costs, the distance to the alternative railhead, and the total distance of transport.

Up to now, the quantity to be transported, q, was assumed constant. It is quite unlikely, however, that with rail line abandonment the quantity available for transport at d_2 would be greater than the quantity available for transport at d_1 before abandonment. Suppose this difference in quantity induced a change in the marginal and/or terminal cost of rail transport, i.e.,

$$(10)\quad \frac{\partial R(d,q_2)}{\partial d} < \frac{\partial R(d,q_1)}{\partial d}$$

and/or

$$(11)\quad R(d_o, q_2) < R(d_o, q_1)$$

where

q_1 = total quantity available for transport by rail at d_1 before abandonment,

q_2 = total quantity available for transport by rail at d_2 after abandonment and d_o indicates zero distance from the rail terminal point, i.e., terminal costs. Condition (10) indicates a decreased per unit marginal cost of transport with respect to distance resulting from the larger quantity of product available for shipment at origin d_2 after abandonment. Condition (11) indicates a decreased per unit transfer cost from truck to rail because of the increased quantity of grain loaded at d_2 after abandonment. A rail cost function representing

condition (10) is shown by R* in Figure 1. An example of R* would be the granting of multi-car rates at location d_2 (versus single car rates previous to abandonment) due to increased shipments resulting from the increased gathering area served by the remaining railhead. Assuming that R* existed after abandonment, then the transport cost function, C*, would be:

$$(12) \quad C^* = \begin{cases} F & \text{for } d \leq d_3 \\ T & \text{for } d_3 < d \leq d_5 \\ R^* & \text{for } d > d_5 \end{cases}$$

and is represented as cjmR* in Figure 1. The change in transport costs I*, for distance d after rail abandonment would be:

$$(13) \quad I^* = C^* - C = \begin{cases} T - R & \text{for } d_4 \leq d \leq d_5 \\ R^* - R & \text{for } d > d_5 \end{cases}$$

For $d > d_7$, $R^* - R = I^* < 0$ indicating that transport costs decrease after abandonment. Although not represented in Figure 1, a decrease in the terminal costs after abandonment could also lower total transport costs in some situations.

The achievement of reduced total transport costs after abandonment required the assumption of reduced rates and/or reduced terminal costs from the new railhead. Such assumptions are not normally incorporated into the current rail abandonment decision-making and thus most shippers do not view rail abandonment as decreasing transport costs, at least in the short run.

The Region and Method of Analysis

Logan County, Illinois, was selected as a region for the detailed analysis of the impact of rail abandonment because (1) it was located in a region served by highway, rail, and water transportation facilities, (2) it was typical of many cash-grain production regions in the midwest,

and (3) there was a potential loss of 66 percent of its rail system (USDOT). The County is located in Central Illinois approximately 30 miles northwest of Decatur. It is predominantly rural in character with 95 percent of the land in farms, of which 93 percent is utilized in the production of corn and soybeans, with average yields in 1973 of 122 and 39 bushels per acre, respectively. In 1973, livestock accounted for only 14 percent of all farm receipts. The large grain production and relatively small livestock consumption of grain resulted in approximately 35,000 bushels per square mile requiring transport out of the County. In January 1975, there were 29 grain elevators at 25 locations and 18 fertilizer distributors at 13 locations. Most fertilizer distributors were classified as "full service," although some firms handled only liquid or only dry fertilizer products.

In most cases rail abandonment leaves some shippers in a region without rail service while other shippers retain service. The relative changes in transport costs for shippers losing and retaining service results in changes in the quantity and in the origin and destintion of products shipped into and out of the region. The present study utilized a linear programming model that incorporated the several marketing and transportation alternatives available to individual shipper locations to determine the optimal (least cost) quantity, origin, or destination, and transport mode for grain and fertilizer products. The optimal mix of shipments before abandonment was compared with the optimal mix after abandonment to arrive at an estimate of the impacts of rail abandonment under three marketing/transportation scenarios. The first scenario, called the "basic solution," represented the marketing and transportation

activities that grain elevators and fertilizer distributors in Logan County had or could reasonably be expected to perform. The second scenario called the "high water rate" solution, reflected rather high water-related transport costs and the third scenario called the "domestic grain marketing" solution reflected domestically-oriented demands for grain.

Data needed to construct the model was collected by personal interview of grain elevators and fertilizer distributors in and near Logan County. The survey data established the physical capacity of each location to handle grain and fertilizer (as of January 1975) and the percent of grain and fertilizer shipped to each destination or from each origin for calendar year 1973. The destinations for grain and the origins for fertilizer, the percent of each product from or to an origin or destination, and the available transportation alternatives specified in the model are identified in Table 1. The quantity of grain to be transported was determined by the three-year average of grain production less livestock consumption by township (Ill. Dept. Agri., Census). 4/ The quantity of fertilizer products to be transported to each township was determined by allocating the three-year average Logan County consumption by each township's share of total grain production (Ill. Dept. Agri., Fertilizer). Each solution of the model required the movement of 617,754 tons of grain, 50,067 tons of dry fertilizer, 10,006 tons of anhydrous ammonia and 6,335 tons of other liquid fertilizer.

The costs of operating grain and fertilizer facilities were estimated from secondary sources. The costs of transportation by farm wagon or by truck was estimated using primary and secondary data. For those products

Table 1.--Origin/destination, percent of total shipments and transport alternatives for grain and fertilizer products as used in the mathematical solution

Product	Possible Origin/ Destination	Percent of total shipments	Transport alternatives
Grain 1/	Springfield, Ill.	3.31	Truck
	Decatur, Ill.	28.90	Truck
	Louisiana Gulf	64.23	Truck-barge, rail-barge, single rail, multi-rail, unit train
	Southeast (Atlanta, Ga.)	3.56	Single rail, multi-rail
Phosphate products	Florida	100.00	Single rail to retailer, multi-rail to wholesaler with single rail to retailer, barge to wholesaler with truck to retailer
Potassium products	Canada	NC 2/	Single rail, rail-truck
	New Mexico	NC	Single rail, rail-truck
Dry mixed fertilizer	Ft. Madison, Ia.	44.90	Single rail, truck
	St. Louis, Mo.	35.65	Single rail, truck
	Streator, Ill.	19.45	Single rail, truck
Anhydrous ammonia	Louisiana Gulf		
	Direct	NC	Single rail
	Via Terre Haute, Ind.	NC	Pipeline-truck, pipeline-rail
	Via barge at Pekin, Ill.	NC	Barge-truck, barge-rail
	Via Ft. Madison, Ia.	≤14.60	Pipeline-truck, pipeline-rail
	Texas City, Texas	NC	Single rail
Other liquid fertilizer	Springfield, Ill.	41.94	Truck
	St. Louis, Mo.	23.08	Truck, single rail
	Meridosia, Ill.	34.98	Truck, single rail

1/ In the domestic grain marketing solution the percentage of grain shipped to the four destinations were: To Springfield, Ill., 10 percent; to Decatur, 30 percent; to the Louisiana Gulf, 20 percent; and to the Southeast, 40 percent.

2/ Non-constrained.

moving under Interstate Commerce Commission regulation the published tariffs were used except in cases where adjustments were necessary to reflect actual transportation situations. The cost of barge transport was obtained from published sources and from recent rates paid by several shippers in the area. All cost and tariff coefficients were measured or adjusted to reflect early 1975 levels.

The Basic Solution

As mentioned above, the basic solution represented the marketing and transportation activities that firms in Logan County had or could reasonably be expected to perform. The bill for marketing and transportation of grain and fertilizer for Logan County totaled $9.511 million (Table 2). Most farm areas delivered grain to nearby elevators. Of the 25 elevator locations, only two did not ship or receive any grain in the basic solution. 5/ Most grain was stored at elevators except when storage capacity at nearby elevators was insufficient for local needs. However, the model selected farm storage instead of investment in additional storage facilities at the nearby elevator or instead of shipment of grain to a more distant elevator. Of the 23 elevator locations handling grain, 18 elevators filled their storage capacity in the harvest period. Only one elevator, however, purchased additional storage facilities.

Grain shipped from Logan County elevators to Springfield, Illinois, moved by truck (the only transport option available), to Decatur by rail (except for truck shipments by one elevator), to the Louisiana Gulf by truck-barge and to the Southeast by rail. 6/ Although unit trains did not enter the basic solution, a rate reduction (or barge rate increase) of approximately two cents per bushel would have allowed unit trains to enter the solution.

Table 2.--Total marketing and transportation bill and ton miles of traffic by mode within and outside of Logan County under selected marketing and transportation alternatives

Marketing and transportation situation	Total marketing transportation bill	Ton miles all modes	Ton miles by truck				Ton miles by rail				Ton miles by water	
			Inside County	Outside County	Total	Pct. of all modes	Inside County	Outside County	Total	Pct. of all modes	Total	Percent of all modes
	$1,000	Mil.	---Mil.---			Pct.	---Mil.---			Pct.	Mil.	Pct.
Basic solution	9,511	536.3	9.5	10.5	20.0	4	4.7	40.7	45.4	8	470.9	88
Abandonment of "potentially excess" rail lines	9,681	535.3	10.6	15.2	25.8	5	0.5	36.3	36.8	7	472.7	88
Change from pre-abandonment (Percent)	+2	2/	+6	+44	+29	1/	-89	-11	-19	1/	2/	1/
Abandonment of rail lines "not transferred to ConRail"	9,523	536.0	9.2	10.9	20.1	4	4.5	40.5	45.0	8	470.9	88
Change from pre-abandonment (Percent)	2/	2/	-3	+3	2/	1/	-3	-1	-1	1/	2/	1/
Water charge of $0.002/TM	10,059	367.7	3.4	1.4	4.8	1	12.1	331.7	343.8	91	28.2	8
Abandonment of "potentially excess" rail lines with water charge	10,274	438.2	4.6	6.0	10.6	2	5.8	255.2	261.0	60	166.6	38
Change from pre-abandonment (Percent)	+2	+19	+34	+338	+121	1/	-52	-23	-24	1/	+491	1/
Domestically-oriented grain demands	10,000	368.4	4.2	4.9	9.1	2.5	9.1	193.6	202.7	55.0	156.6	42.5
Abandonment of "potentially excess" lines under domestic grain markets	10,074	370.0	4.6	6.3	10.9	2.9	5.6	195.4	201.0	54.3	158.1	42.7
Change from pre-abandonment (Percent)	+1	2/	+9	+30	+20	1/	-38	+1	-1	1/	+1	1/

1/ Not applicable.
2/ Less than 0.5 percent.

With the exception of one liquid fertilizer distributor, most farm areas received fertilizer products from nearby distributor locations. Of the 16 fertilizer distributor locations, 14 delivered dry fertilizer to farms, 12 delivered anhydrous ammonia to farms, while only 8 delivered liquid fertilizer solutions to farms. One distributor of liquid fertilizer delivered liquid solutions over a rather wide area. Most of those locations not delivering fertilizer to farmers did not have currently operating facilities. No fertilizer distributors purchased additional facilities.

In the basic optimal solution, all phosphorus products were shipped by truck-barge combination. The cost disadvantage for direct rail shipments to distributor locations nearest the barge unloading point were substantial while the cost disadvantage for direct rail shipments to distributor locations in the more distant areas were generally less than $.50 per ton. All other dry fertilizer products were received by rail. Rail shipments from two supply areas were the only transport alternatives for potassium in the basic solution. A separate solution, however, indicated that rail rate reductions for potassium from Canada to an area distributor of approximately 20 percent would result in nearby local fertilizer distributors utilizing a rail-truck option for potassium transport. All shipments of dry mixed fertilizer were by rail but in most cases, the cost advantage of transfer by rail versus truck was between $2 and $4.

In the basic solution, 72 percent of the anhydrous ammonia was shipped from Louisiana by rail direct to local distributors, 15 percent came from Ft. Madison, Iowa, by rail and 13 percent from the Louisiana

Gulf by barge-truck transportation. Those locations nearest the barge unloading point utilized truck-barge shipments most often. With the exception of rail shipments from St. Louis, all liquid fertilizer solutions were transported by truck to local distributors. Truck shipments from St. Louis suffered a cost disadvantage of about $.50 to $2.00 per ton.

Grain and fertilizer movement for Logan County generated 536 million ton miles (TM) of which 4 percent was by truck, 8 percent by rail, and 88 percent by water (Table 2). Of the truck traffic, 9.5 million TM occurred on roads within Logan County and 10.5 million TM occurred on roads outside Logan County. The estimated annual cost of maintenance due to grain and fertilizer traffic was $108,800 for roads within Logan County and $92,400 for roads outside the County. The traffic that was generated on each road type within Logan County is shown in Table 3.

Abandonment of "Potentially Excess" Rail Lines

The Regional Rail Reorganization Act of 1973 directed the Secretary of Transportation to report his recommendations on which locations in the Northeast/Midwest Region should receive rail service (USDOT). This report designated 132 of 201 rail miles in Logan County as "potentially excess." The optimizing model was used to estimate the change in the marketing and transportation of grain and fertilizer as a result of abandonment of "potentially excess" rail lines.

Abandonment of these lines increased the total marketing and transportation bill by only 2 percent over the basic solution.

Grain collection patterns were altered only slightly by the abandonment. The average length of haul by farmers appeared to increase by only

Table 3.--Ton miles of traffic generated on designated road types within Logan County under selected marketing and transportation alternatives

	Road classification [1]					
	Divided highway or interstate system	Other primary: Federal and State marked routes	Secondary roads, bituminous surfaced	Gravel or stone: surfaced, graded and drained	Soil surface, graded and drained	Unimproved road
	Thousand ton miles					
Basic solution	366	6,404	1,131	1,356	224	9
Abandonment of "potentially excess" rail lines	467	7,337	1,175	1,364	226	8
Change from pre-abandonment (Percent)	+28	+15	+4	+1	+1	-4
Abandonment of rail lines "not transferred to ConRail"	368	6,060	1,183	1,356	221	8
Change from pre-abandonment (Percent)	+1	-5	+5	2/	-1	-4
Water charge of $0.002/TM	161	541	1,031	1,456	223	9
Abandonment of "potentially excess" rail lines	372	1,544	963	1,464	222	8
Change from pre-abandonment (Percent)	+131	+185	-7	+1	2/	-4
Domestic grain market pattern	340	1,427	819	1,380	234	9
Abandonment of "potentially exess" rail lines	491	1,636	833	1,379	231	9
Change from pre-abandonment (Percent)	+44	+15	+2	2/	-1	-6

1/ Miles of each type of road in Logan County in order of left to right are: 26, 94, 298, 574, 192, 3.
2/ Less than 0.5 percent.

a small amount. Some slight changes in farmer marketing patterns were observed. Of the 12 elevator locations losing rail service, only three shipped grain by rail prior to abandonment. The share of grain handled by these three elevators declined slightly from 7.1 to 6.7 percent as a result of the abandonment. The share of grain handled by all 12 of the elevators which lost rail service increased from 43 to 45 percent (Table 4). This increase in shipments despite the loss of rail service resulted from minor changes in farmer marketing patterns, rerouting of some rail shipments over nonabandoned track segments, and the ability to substitute truck or truck-barge shipments for rail shipments. Fifteen of 25 elevator locations experienced changes in the quantity, destination, or mode of grain shipments. Many of these changes resulted from the switch from rail to truck shipments to Decatur.

Most distributors of dry fertilizer experienced some change in operations as a result of rail abandonment. The most common change in operations for those locations losing rail service was to reduce or discontinue receipts of potassium and phosphate products for blending (usually transported by rail) and replace them with already blended fertilizer available from local suppliers and usually transported by truck. Although most distributor locations altered either their mix of product purchases, their source of supply, or mode of transport, only three distributors changed the total quantity of product handled. The average receipt of dry fertilizer and the market share of distributors losing or retaining rail service was not altered.

Of the 12 distributor locations for anhydrous ammonia that were active in the basic solution, 10 experienced changes in procurement patterns. Six of these 10 locations experienced changes in the

Table 4.--Average tons shipped and market share of firms losing and retaining rail service under selected marketing and transportation alternatives

Marketing and transportation scenario	Grain shipments				Dry fertilizer shipments				Anhydrous ammonia shipments			
	Firms losing rail service		Firms retaining rail service		Firms losing rail service		Firms retaining rail service		Firms losing rail service		Firms retaining rail service	
	Avg. per firm	Mkt. share	Avg. per firm	Mkt. share	Avg. per firm	Mkt. share	Avg. per firm	Mkt. share	Avg. per firm	Mkt. share	Avg. per firm	Mkt. share
	Tons	Pct.	Tons	Pct.	Tons	Pct.	Tons	Pct.	Tons	Pct.	Tons	Pct.
Basic solution	22,282	43	26,951	57	1,952	39	5,092	61	376	38	1,040	62
Abandonment of "potentially excess" rail lines	23,003	45	26,286	55	1,952	39	5,092	61	431	43	950	57
Change from pre-abandonment (Percent)	+3	1/	-2	1/	0	1/	0	1/	+15	1/	-9	1/
Basic solution	13,400	4	25,694	96	1,591	6	3,349	94	91	2	702	98
Abandonment of rail lines not transferred to ConRail"	4,200	1	26,494	99	1,591	6	3,349	94	91	2	702	98
Change from pre-abandonment (Percent)	-69	1/	+3	1/	0	1/	0	1/	0	1/	0	1/
Water increase $0.002/TM	22,232	43	26,998	57	1,952	39	5,092	61	358	36	1,071	64
Abandonment of "potentially excess" rail lines	15,578	30	33,140	70	1,952	39	5,092	61	340	34	1,101	66
Change from pre-abandonment (Percent)	-30	1/	+23	1/	0	1/	0	1/	-5	1/	+3	1/
Domestically-oriented grain demands	16,876	33	31,942	67	1,952	39	5,092	61	376	38	1,040	62
Abandonment of "potentially excess" rail lines	14,447	28	34,184	72	1,952	39	5,092	61	431	43	950	57
Change from pre-abandonment (Percent)	-14	1/	+7	1/	0	1/	0	1/	+15	1/	-9	1/

1/ Not applicable.

quantity of anhydrous ammonia received while the other four locations experienced changes in origin and/or transport mode. There was a small increase in the sales volume for those distributors which lost rail service.

Since there were no rail shipments of mixed liquid fertilizer by locations losing rail service, there were no changes in the procurement patterns as a result of abandonment of "potentially excess" rail lines.

The total ton miles of traffic and the modal share of traffic remained almost steady (Table 2). Even so, truck traffic, a small part of total traffic, increased by 29 percent. Traffic within Logan County, which included the local collection/distribution use, increased by 6 percent while the truck traffic outside Logan County increased by 44 percent. Most of the increased truck traffic resulted from grain to Decatur that was previously transported by rail. Most of the increase in road use within Logan County occurred on the marked routes (Table 3). Estimates of maintenance expenditures increased 9 percent for roads within Logan County and 44 percent for roads outside Logan County.

The Final System Plan

The Final System Plan designated 9 percent of the track miles in Logan County as "not designated for transfer to Consolidated Rail Corporation" (ConRail) and hence would be abandoned if not subsidized (USRA). 7/ Changes in the marketing and transportation of grain and fertilizer with these lines deleted were measured with the optimizing model.

The total marketing and transportation bill increased by only 0.1 percent as a result of discontinuance of rail service.

The two elevator locations losing rail service both shipped by rail prior to abandonment. After abandonment these rail shipments were replaced with truck shipments but instead were shipped through other nearby elevators. The two elevator locations losing rail service reduced their shipments of grain by an average of 9,200 tons each resulting in a decline of their market share from 4 to 1 percent.

The increased distance of grain shipments from two farm areas resulted in increased utilization of secondary bituminous roads by 5 percent. This increased distance of farmer haul was generally in the direction of the final market destination and hence contributed to a decline in the use of primary marked routes.

One location losing rail service switched dry fertilizer receipts from rail to truck without a change in the quantity received. Since neither fertilizer location which lost rail service received liquid mixed or anhydrous ammonia fertilizer by rail there were no other changes in fertilizer shipments as a result of rail abandonment.

The total ton miles of traffic by all modes decreased slightly, ton miles by truck increased slightly, ton miles by rail declined by 1 percent and ton miles by water did not change. The traffic share of each mode also did not change from the basic solution. The estimated highway maintenance costs decreased 2 percent for roads within Logan County and increased 3 percent for roads outside the County. The total maintenance costs for all roads increased by less than 0.5 percent.

Higher Water Related Transport Costs

The impact of rail abandonment in Logan County was mitigated greatly by the presence of low-cost barge transportation on the Illinois-

Mississippi Waterway. If Logan County were located further from the river or if water transport costs were sufficiently high so that railroads handled a majority of traffic then the abandonment impact would likely be much greater. In this solution the cost for water transport was increased by $0.002 per ton mile, a rate level at which railroads rather than barges were the predominant carrier of freight to the Gulf. The $0.002 per ton mile is equivalent to a rate of $2.30 per ton for the 1,150 mile journey from the river loading point near Logan County to New Orleans, Louisiana. This increase was added onto the transport rate of $3.69 per ton for grain, $7.15 per ton for phosphates from Florida and $11.50 per ton for anhydrous ammonia from the Gulf.

The marketing and transportation alternatives selected by firms in Logan County in response to higher water transport costs are represented in Tables 2, 3 and 4. Note especially the decreased total ton miles of traffic generated by all modes (367.7 million ton miles versus 536.3 million ton miles in the basic solution). This reduction in ton miles is a result of the more direct movements to the Gulf by rail (approximately 750 miles) than by barge (approximately 1,200 miles). 8/ As expected, railroads accounted for most of the ton miles of freight. Also, the percent of traffic by trucks, especially trucks outside Logan County, was considerably less than in the basic solution because of decreased truck movement between local firms and barge loading and unloading facilities. This decreased intercity truck movement can also be observed by the sharply reduced utilization of primary Federal and State marked route highways (Table 3).

The abandonment of potentially excess rail lines with higher water-related transport costs increased the total marketing and transportation

bill by 2 percent. 9/

Although 14 of 19 farm areas altered the farm to elevator marketing patterns, the average length of farmer haul appeared to decrease slightly. This slight decrease resulted from the change of shipment made from primarily unit trains before abandonment (94 percent of shipments to the Gulf) to extensive use of truck-barge shipments after abandonment. Five elevator locations did not participate in grain movement compared with six elevator locations not participating in the optimal solution prior to abandonment. Three elevator locations did not participate in the movement of grain in either solution. Elevator locations losing rail service decreased the quantity of grain moving through their facilities from an average of 22,232 tons to 15,578 tons each and decreased their market share of total grains shipments from 43 to 30 percent. Shipments of grain from these locations after abandonment were usually by truck direct to Decatur or barge loading points rather than to nearby elevators capable of loading unit trains. There were no intra-elevator transfers within Logan County and most such shipments suffered a cost disadvantage of between $1 and $3 per ton. Elevators experiencing the greatest decline in shipments were those located nearest the barge loading points and which had shipped to the Gulf by unit trains prior to abandonment. After abandonment these elevators shipped to the Gulf via truck-barge but other elevators in the area participated in these shipments, thus reducing the quantity shipped through specific locations.

Of 16 dry fertilizer distributor locations, only two locations changed the quantity of fertilizer received as a result of rail abandonment. Seven other locations changed shipment mode and/or product mix received. Two

locations did not enter in either solution. There was no change in the market share of firms losing rail service as a result of the abandonment. Rail shipments of phosphates, potassium, and dry mixed fertilizer, however, accounted for 55 percent of total fertilizer shipments, down from 98 percent of shipments prior to abandonment.

Of the 16 distributor locations, 7 changed the quantity of anhydrous ammonia received, 3 experienced changes in the origin of product or mode of transport, 1 experienced no changes, and 5 did not enter either solution. Rail shipments of anhydrous ammonia decreased from 100 percent of all shipments before abandonment to 76 percent of all shipments after abandonment. Two locations which were nearest the barge loading points increased their receipts of anhydrous ammonia even though they lost rail service. The market share of distributors losing rail service declined from 36 to 34 percent.

Since the only location that received liquid mixed fertilizer by rail before abandonment did not lose rail service, there were no changes in the procurement patterns for these distributors.

Some minor changes occurred in the distribution of fertilizer to farmers. Three distributors that retained rail service increased the area over which they distributed anhydrous ammonia to farmers.

The abandonment increased the total ton miles of traffic by 19 percent. Most of this increase is accounted for by the increased barge shipments and because of the greater circuity of truck-barge shipments than rail shipments to the Gulf. The market share of transport increased slightly for trucks, decreased from 91 to 60 percent for railroads, and increased from 8 to 38 percent for barges. Truck traffic within Logan

County increased by 34 percent resulting in increased road maintenance costs of 18 percent. Most of the traffic increase occurred on the marked routes. In fact, traffic on most secondary and other roads decreased slightly as a result of the reduced farm to elevator trucking since many local elevators participated in the truck-barge shipments to the Gulf. Prior to abandonment, however, unit trains carried most grain to the Gulf and fewer elevators participated in the large volume movements. Hence, delivery distance from farm to elevator was greater. Truck traffic outside Logan County increased by 338 percent with a corresponding increase in estimated highway maintenance costs. Rail traffic decreased by 24 percent while barge traffic increased by 491 percent.

Domestically-Oriented Demands For Grain

Grain marketing patterns in Logan County clearly reflect the strong export demand. Lower export demand in relation to inland domestic demand would require different transportation services and, hence, the impact of rail abandonment would likely be different. The demand for grain at each destination as represented in the basic solution was altered to reflect a situation in which most grain from Logan County moved to domestic market locations (see footnote 1 in Table 1). The resulting grain and fertilizer shipments, the marketing and transportation bill, the ton miles of traffic generated by each mode, and the utilization of each road type in the pre-abandonment solution are given in Tables 2, 3 and 4.

The marketing and transportation bill for grain and fertilizer under domestically-oriented grain demands was $10 million. Nineteen of 25 elevator locations participated in grain shipments, which averaged 31,942 tons per firm. The transportation of grain and fertilizer

generated 368.4 million ton miles of which trucks carried 2.5 percent, railroads 55.0 percent and barges 42.5 percent.

The abandonment of potentially excess rail lines under domestically-oriented demands for grain caused an increase of only 1 percent in the total marketing and transportation bill. 10/ The movement of grain from farms to elevators changed only slightly. With the exception of a slight increase in the distance of deliveries to two elevator locations (which retained rail service), the average length of haul by farmers did not increase. Sixteen of the 25 elevator locations experienced changes in the quantity, destination, or mode of shipment of grain. Elevators active in the pre-abandonment solution and which lost rail service decreased grain shipments an average of 2,429 tons each, which reduced their share of total grain shipments from 33 to 28 percent. However, those locations shipping grain to Decatur (all by rail prior to abandonment) decreased their shipments by an average of 8,053 tons and reduced their market share of grain to Decatur from 38 to 10 percent. Shipments to the Southeast prior to abandonment were all by rail and from locations not losing rail service. Hence, there was little change in shipments as a result of abandonment. Shipments to Springfield and to the Gulf were exclusively by truck and truck-barge prior to abandonment and, hence, changes in shipment patterns were infrequent and occurred mostly in response to adjustments brought about by changes in shipments to Decatur.

The fertilizer portion of the model with domestically-oriented demands for grain was not changed from the basic solution. Hence, changes in fertilizer marketing and transportation as a result of rail abandonment in the current solution parallel the changes as described in the basic solution and are not repeated here.

The total ton miles of traffic by all modes after abandonment increased by less than 1 percent from the pre-abandonment solution. The market share of both truck and water transportation increased very slightly while the share of rail decreased from 55.0 to 54.3 percent. The slight increase in truck and truck-barge shipments resulted in a slight increase in utilization of local collector road and substantial increases in the utilization of the divided highway (interstate) roads (44 percent) and other primary marked routes (15 percent). Estimated highway maintenance costs increased by 5 percent for roads inside Logan County and by 30 percent for roads outside the County for an overall increase of 15 percent.

Conclusions

Despite the abandonment of almost two-thirds of the rail lines in Logan County, the percentage increase in the marketing and transportation bill was not great for any of the hypothetical abandonment scenarios evaluated. The analysis of abandonment of rail lines in Logan County designated not to be included in ConRail resulted in only an increase in total costs of approximately $12,000. No estimates on the potential savings to the railroads were estimated for the various abandonment options. In the Final System Plan, the net loss from the entire line from East Peoria to Decatur was estimated at $436,000, a loss of $7,440 per mile (USRA, pp. 71-73). The loss attributable to the 22.1-mile portion of the line included in the mathematical model (from north of Mt. Joy to Midland City) was not available, but it surely would be much greater than the $12,000 of increased costs of marketing grain and fertilizer. Hence, the movement of grain and fertilizer for Logan County could not of

itself economically justify the existence of the rail line.

The total ton miles of traffic also changed only slightly except in the scenario of higher water-related transport rates. In this case, the substantial increase in the total ton miles of traffic was principally a result of the increased circuity of truck-barge (approximately 1,200 miles) over rail (approximately 750 miles) shipments to the Gulf.

The traffic share of railroads declined in all abandonment scenarios, but in only the higher water charge scenario was the decline in traffic large. With the imposition of substantially higher water rates, rails were by far the greatest carrier of grain and fertilizer. The water rate increase of $0.002 per ton mile was, however, only large enough that railroads enjoyed a slight cost advantage. The abandonment of rail lines resulted in a switch to truck-barge shipments rather than switching shipments to alternate locations which still had rail service.

In all scenarios, the total ton miles of truck traffic increased. In almost all cases the change in truck traffic on roads was less the closer to the farm unit. Changes in traffic within Logan County were less than changes in traffic outside Logan County and changes in traffic on local roads was usually less than changes in traffic on the marked routes. Although many firms altered their marketing and transportation practices as a result of rail abandonment, the movement of grain from farms to local elevators and of fertilizer from local distributors to farms experienced only a few significant changes. With the relatively large number of elevators in the County, farmers were usually able to ship to several alternative locations without significantly increasing

the distance of transport or the utilization of local roads. In the case of fertilizer, only a few locations changed the total quantity of fertilizer handled and, hence, the movement of fertilizer to farms was also not changed significantly by rail abandonment.

Although changes in highway utilization in the aggregate was not usually great, the change in the utilization of specifically marked routes or specific track segments was sometimes rather large. These changes in utilization, however, reflect only the local grain and fertilizer traffic and do not take into account traffic of other products or traffic associated with other areas.

Even though the impact of rail abandonment on total costs or total ton miles of traffic transported by each mode was usually small, the impact on individual firms was sometimes substantial. The solutions indicated a number of firms that discontinued a large portion or even all of their shipments after rail service was discontinued. Statements by firm managers of drastic adverse impacts as a result of rail abandonment along with statements of minimal impact for the overall system are not necessarily inconsistent.

Changes in grain shipments as a result of rail abandonments usually involved a large portion of the elevator locations. In most cases, the model indicated that an elevator utilizing and then losing rail service was more likely to lose grain to other locations than switch to shipments by an alternate mode. Likewise, switching the final destination of grain shipments was also a more common occurrence for grain elevators losing rail service than the switching of the mode of shipment to that destination.

In the case of fertilizer distributors, however, the loss of rail service seldom changed the total quantity of fertilizer received. The most common response of fertilizer distributors using and then losing rail service was to alter the origin and/or transportation mode of the products received. The greater ability of fertilizer distributors to maintain the total quantity of product handled than the grain elevators can be explained in part by the fewer number of fertilizer distributors, and, hence, greater distributor to farm transport distance.

FOOTNOTES

1/ Livestock feed distributors were not included in the analysis since (1) livestock production was a relatively small enterprise in Logan County when compared to cash grain production, and (2) previous studies had indicated that feed distributors in the corn belt region were not extensive users of rail transportation (Bunker, p. 175). Hence, feed distributors were not expected to suffer large impacts due to rail restructuring.

2/ The example in Figure 1 and the theoretical analysis assumes the shipper does not have direct access to rail service or to large intercity truck service. An assumption of direct access requires only minor modifications but is not discussed in this paper.

3/ If $F(d_2, q) > T(d_2, q)$ then shipments beyond d_6 (rail) would be by farm truck to location d_1, by intercity truck (incurring transfer charge ab) to d_2, and by rail (incurring some transfer charge equal to gi), the remaining distance.

4/ Consumption of grain by livestock in Logan County was estimated by B. L. Brooks, et al., at the University of Illinois.

5/ The cost coefficients in the objective function represent the full cost of transportation services, the average cost of highway maintenance, the variable cost for use of existing grain and fertilizer marketing facilities, and the full cost for the use of required new facilities, if any. Two locations did not have currently operating grain facilities. These elevator locations may enter the solution by incurring variable costs plus average fixed costs for the appropriate size and type of facility. One elevator location without operating facilities did enter the basic solution.

6/ Truck rates to Decatur are lower than published rail rates. However, differential bids for truck or rail receipts of grain by processors influences greatly the choice of transport mode.

7/ ConRail was established for the purpose of operating and maintaining railroad properties transferred from the Penn Central and several other bankrupt railroads.

8/ While the average fuel consumption per ton mile is less for barges (0.0030 gal./ton mile) than for railroads (0.0056 gal./ton mile), the greater distance of the truck-barge movement results in a greater total fuel consumption by barge than by rail for grain from Logan County to the Louisiana Gulf.

9/ The changes discussed in this section were derived by comparison of the post-abandonment solution with increased water transport rates to the pre-abandonment solution with increased water transport rates.

10/ The changes discussed in this section were derived by comparison of the post-abandonment solution with domestically-oriented demands for grain to the pre-abandonment solution with domestically-oriented demands for grain.

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