The Impacts of Transportation Deregulation on Wheat Shipments in the Pacific Northwest

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A network programming model (NETFLOW) was used to examine the impact of modal transport rate changes resulting from transportation deregulation on modal traffic shares and total wheat transport costs. The analysis reveals that shifts in wheat traffic to rail and away from truck-barge and truck are related to rail deregulation. The model also provides evidence that lower rates under transportation deregulation have significantly decreased the total cost of shipping wheat from country origins to export elevators.

Key words: NETFLOW, modal share, deregulation, transport cost, intermodal competition, wheat transportation, transshipment.

The Pacific Northwest (PNW) serves as a major corridor for the export of U.S. grain. Grain for export arrives at PNW ports from both within the PNW region and from midwest states via a complex transportation system utilizing railroads, trucks, and barges. In recent years there have been regulatory changes affecting these transport modes that have influenced relative transport rates and, in turn, grain shippers' decisions regarding mode choice.

The Inland Waterway Trust Act of 1978 imposed waterway user fees (through a fuel surcharge) on waterway carriers. Regulatory constraints on railroads were significantly reduced by the Staggers Act of 1980, and the Motor Carrier Act of 1980 virtually eliminated regulation of the trucking industry. De facto motor carrier deregulation did not specifically affect agricultural shippers, since agricultural trucking had already been exempted from federal regulation. Truck deregulation did make it possible for agricultural truckers to transport nonagricultural traffic thereby reducing empty

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They gratefully acknowledge helpful comments by three anonymous reviewers. Any remaining errors and omissions are, of course, the responsibility of the authors.

movements and presumably reducing operating costs attributable to agricultural traffic.

Although the imposition of waterway user fees certainly increased costs for barge operators, previous studies indicate that the 1985 level of waterway user fees did not have a significant impact on barge grain traffic (Lubis, Martin, and McMullen; Casavant and Mehringer). It is in the railroad industry that the most pronounced changes have taken place with railroads allowing considerable rate-seeking freedom including the ability to negotiate contract rates.

Prior to deregulation, Friedlaender and Spady predicted that rail rates on bulk commodities would fall by 18% in the Northeast and by 35% in the rest of the country if marginal cost pricing were pursued. Although they expressed some skepticism regarding the feasibility of marginal cost pricing, Friedlaender and Spady predicted lower bulk rail rates following deregulation.

A number of post-Staggers Act studies confirm Friedlaender and Spady's prediction. Klindworth et al. found that published rail rates between Kansas elevators and Gulf ports declined substantially in the four years following the Staggers Act. Fuller et al. found a similar decline in rail rates for wheat in both the South-

Table 1. Modal Shares of Wheat Shipments to Lower Columbia River Export Elevators, 1975-86

Crop Year	Rail	Barge	Truck
1974/75	69.3	25.8	5.8
1975/76	62.4	31.0	6.8
1976/77	45.5	49.0	5.5
1977/78	43.8	48.5	7.8
1978/79	49.7	44.6	5.7
1979/80	50.8	43.1	6.0
1980/81	50.2	44.1	5.7
1981/82	49.5	44.7	5.8
1982/83	50.9	42.6	6.5
1983/84	54.3	41.7	4.0
1984/85	53.4	41.7	5.0
1985/86	57.4	37.5	5.0

Source: Gratran Grain Transportation Consultants of the Pacific Northwest, Portland, Oregon.

Central Plains and the Corn Belt areas. The Fuller study controls for coincident events such as higher rail costs (due to higher fuel prices, wage costs, and excess rail car capacity) and the general economic recession of the early 1980s. They conclude that deregulation was the primary factor in causing rail rates to fall.

The Staggers Act encouraged grain rate reductions by removing several barriers to rail rate innovation. Under the Interstate Commerce Act (1887), rail carriers were bound by the "long haul-short haul" provision in rate making. In effect, the rate on any shipment had to exceed rates on all shipments of shorter distance. This, of course, made it difficult or impossible to introduce multiple-car rates for regional shipments.

Regulatory rules also required that rail carriers proposing a new rate structure go through an expensive and time consuming *ex parte* hearing process. Further, once a rate was in place, rail carriers had to endure an equally complex hearing process to remove it. Often, regulatory constraints prevented removal of these rates. Deregulation has made it possible for rail carriers to experiment with new rates free of bureaucratic costs and risks.

Given the evidence regarding decreasing rail rates in the post-Staggers era, an increase in the use of rail to transport PNW grain relative to the other transport modes would be expected. This study utilizes a network flow model of the PNW wheat transportation system to predict how much wheat would be transported by the alternative modes (truck, truck-barge, and rail) assuming that wheat

shippers are cost minimizers in both the pre- and post-Staggers periods. Cost minimizing modal splits are then compared to the actual observed mode shares. The results indicate that although shippers have switched towards rail in the post-Staggers era, there is still potential for further shifts to rail that could result in yet lower total PNW wheat transportation costs.

The PNW Grain Transport System

The PNW is defined here as the states of Oregon, Washington, Idaho, and Montana. This region produces approximately 18% of total annual U.S. wheat production of which more than 80% is exported. Exports from PNW ports are bound principally for Japan, South Korea, Taiwan, Singapore, Indonesia, and the Philippines.[1]

Exports of wheat and other grains via PNW ports grew on trend throughout the 1970s. The depressed worldwide grain markets of the 1980s resulted in a decline in grain traffic volumes accompanied by an increase in the variability of that traffic. By 1988, export volume had recovered. PNW ports handled nearly 440 million bushels of wheat or more than a third of all U.S. wheat exports. Of this, 97% (427 million bushels) moved through Lower Columbia River ports. The balance was exported through the Puget Sound ports of Seattle and Tacoma. In addition to wheat, PNW ports also ship about 17% of U.S. corn exports.

Grain shippers in the PNW region are connected to export outlets via a complex transportation system. The Burlington Northern and the Union Pacific are the two railroads that link PNW ports to eastern production regions. The PNW is served by two major highways, I-90 and I-84. Finally, commercial navigation is provided on the Snake-Columbia River system where a series of eight locks and dams permit barge shipments originating from as far east as Lewiston, Idaho.

Export elevators on the Lower Columbia River receive grain shipments via rail, truck, or truck-barge combination. Elevators on the Puget Sound receive grain either by truck or rail. Rail historically has been the dominant mode of transporting wheat to Columbia River

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[1] All data reported in this section were derived from the U.S. Department of Agriculture, Agricultural Marketing Service, *Grain and Feed Market News,* various issues.
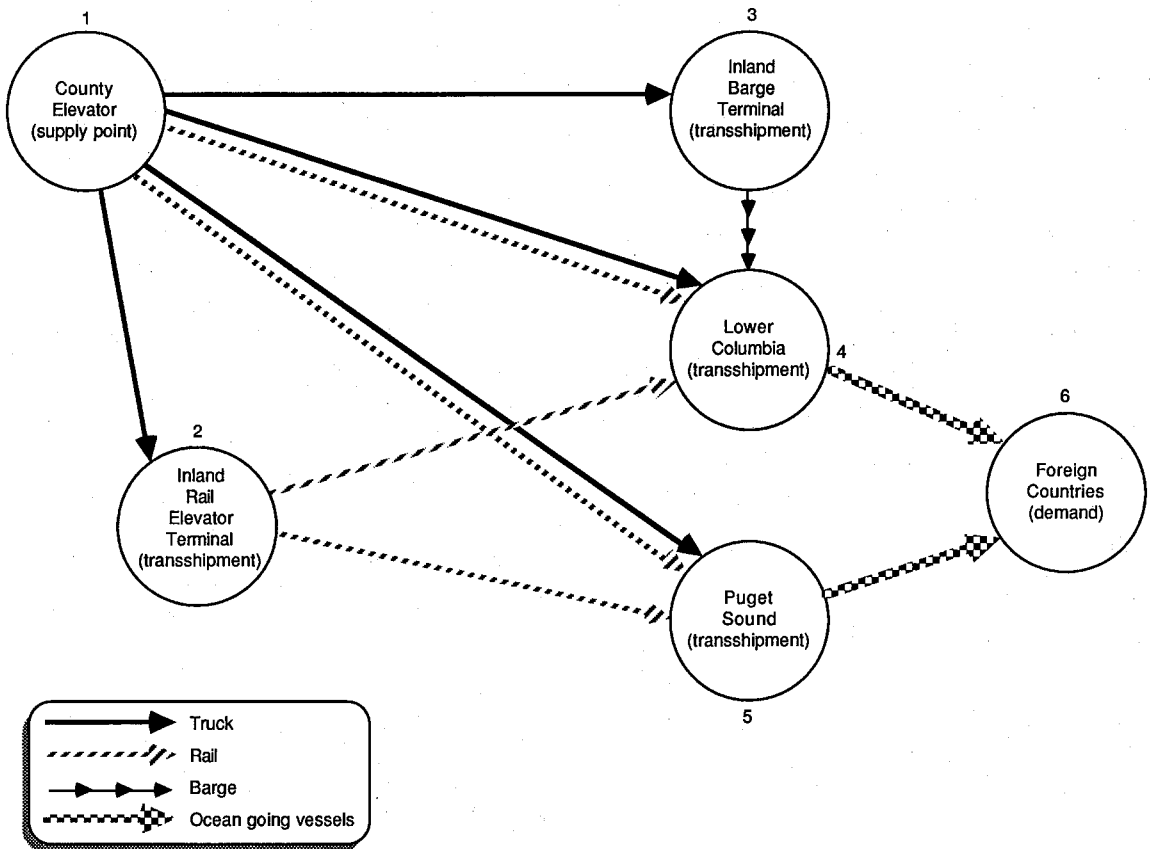
Figure 1. Pacific Northwest wheat transportation system

ports. However, as can be seen in table 1, the rail share fell throughout the 1970s as other modes (barge, in particular) competed for wheat traffic to this destination.

The Network Model

In this analysis a freight network equilibrium model is used to provide an explicit descrip-tion of the PNW wheat transportation system. The network model consists of arcs and nodes. Nodes represent facilities such as grain ele-vators, river terminals, and ports. The arcs depict the available transportation system be-tween nodes: waterways (barge transport), highways (truck transport), and railways. Some nodes in the system are designated as supply points (producing regions) and others are demand points (consuming regions). The arcs link producing points to consuming points either directly or via nodes, referred to as

transshipment points, where commodities are neither produced nor consumed.

In this model of the PNW wheat transpor-tation system, there are three kinds of trans-shipment points: inland barge elevators, in-land rail elevator terminals, and ports, represented by the subscripts k, l, and p, re-spectively. The wheat-producing regions are denoted by the subscript s, and the foreign nations which are the consuming regions are indicated by the subscript f. Wheat may flow from producing regions to ports directly or to river terminals for shipment to port by rail or barge. The wheat is then shipped from port to the final destination (consuming point) by ocean-going vessel. A simple diagram of this network system is shown in figure 1.

The fixed level of wheat export demand is proportionally allocated to supply regions based on regional production in the relevant year, and given the available transport rates for truck, barge, rail, and ocean freighters, the model determines the least-cost transportation

mode and port destination for each supply point.[2]

The transshipment problem for the PNW wheat transportation system is formally stated as:

$$\text{Minimize cost} = \sum_s \sum_p T_{sp} TX_{sp}$$

$$+ \sum_s \sum_p R_{sp} RX_{sp}$$

$$+ \sum_s \sum_k T_{sk} TX_{sk}$$

$$+ \sum_k \sum_p B_{kp} BX_{kp}$$

$$+ \sum_s \sum_l T_{sl} TX_{sl}$$

$$+ \sum_l \sum_p R_{lp} RX_{lp}$$

$$+ \sum_p \sum_f O_{pf} OX_{pf}$$

subject to:

(1) $\sum_p \sum_f OX_{pf} = \sum_s S_s = \sum_f D_f,$

(2) $TX_{sk} = BX_{kp},$ and

(3) $TX_{sl} = RX_{lp}.$

T, R, B, and *O* represent truck, rail, barge, and ocean freight rates, respectively, and the subscript refers to the arc over which the rate applies. Here, *TX, RX, BX,* and *OX* stand for the wheat quantities carried on truck, rail, barge, and ocean-going vessel, respectively, and again subscripts refer to the relevant arc in the network system. $\sum_s S_s$ is the total supply of wheat originating in the *s* supply regions, and $\sum_f D_f$ is the total demand from each of the *f* foreign consuming points.

Constraint (1) requires that the supply of export wheat be exactly equal to the demand for export wheat, measured as total exports to foreign destinations. This quantity was exogenously determined for the purpose of this analysis. Thus, the model cannot be used to determine supply or demand responses to changes in transport rate changes. In that this is a comparative statics analysis, neither supply nor demand are affected by transport costs. It may well be that over time transportation

costs influence wheat prices which in turn influence wheat supply.

Constraints (2) and (3) simply require the quantity of wheat shipped from supply points to rural elevators and inland barge terminals to equal the quantity of wheat shipped from rural elevators and barge terminals to ports, respectively.

The supply of transport services is assumed to be perfectly elastic over each arc in the network system. This is equivalent to stating that additional units of rail service, for example, may be purchased at constant unit cost.[3]

The problem formulated above was solved using the transportation simplex algorithm, a special version of the traditional linear programming simplex method. For a detailed explanation of this algorithm, see Kaplan; Lawler; or Shapiro, among others.

The Data

The PNW wheat transport system was modeled for two years, 1977 and 1985, providing pre- and post-Staggers Act sample periods. The PNW was divided into supply areas, each representing a county or group of counties. It was assumed that wheat production was concentrated at a supply point represented by either a country elevator or an inland subterminal.[4]

For 1977 the model included 80 supply areas; two inland subterminal elevators acting as transshipment points; 15 river terminals; and two port areas, the Puget Sound and the Columbia River. There were six foreign destinations serving as demand areas: the top five destinations for wheat shipments from the PNW during 1973–85 plus a composite destination for the rest of the world. In 1985 there were 78 supply areas, two inland subterminal elevators, 16 river terminals, and the same ports and foreign destinations.

The data required for the model included

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[2] While this model assumes that shippers minimize transport costs in modal selection, other factors, such as capacity constraints, equipment availability, contractual commitments, etc., may also influence this choice.

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[3] This assumption of unlimited capacity on each arc is appropriate for 1985 since this year was characterized by an excess supply of rail cars and underutilization of elevator capacity. In 1977, however, there was a rail car shortage that may have placed some capacity constraints on the system. The model was run for both periods, however, and it provided a very good description of what actually took place in 1977. As indicated in the results section below, since the goal of the network model is simply to provide a good explanation of actual phenomena, the assumption of unlimited arc capacity does not seem to be a problem for 1977.

[4] Inland terminals were designated as supply points whenever possible. It is assumed here that shippers would take advantage of lower multiple car rates available only at inland terminals.

the quantity of wheat supplied at the different supply points and the rates available for the different transport modes. The data for PNW wheat production were obtained from the U.S. Department of Agriculture's Agricultural Marketing Service. In 1977, 83.93% of total PNW wheat was exported, whereas 95.29% of PNW wheat was exported in 1985. To allocate wheat exports among supply areas, it was assumed that in 1977 83.93% of total wheat production from each supply area was exported. Similarly, in 1985 it was assumed that 95.29% of wheat production was exported from each supply area. In this way the total quantity of wheat supplied for export was constrained to equal total export demand as required in the model presented in the previous section.

International ocean freight rates published by the International Wheat Council were utilized in the international transport analysis. Barge transportation rates were obtained from information provided by Tidewater Barge Lines, Inc., and included a river transfer charge in 1977 and both a river transfer charge and the user fee (fuel surcharge) in 1985.

Grain moving by truck was not subject to regulation in 1977 so 1977 rates were not readily available. Accordingly, 1977 truck transport rates were calculated using a worksheet developed and used in a previous study of the PNW transportation system (see Martin et al.). The 1985 truck rates were obtained from a telephone survey of trucking firms.[5]

Rail rates were published and readily available in tariff form for both 1977 and 1985. It is important to note, however, that the Staggers Act gave railroads the ability to enter freely into contracts with shippers. As of mid-1985, 57.3% of railroad grain tonnage was being shipped under such contracts (Wolfe). Since contract rates are not represented in the published tariff rates, the rail rates used here in the 1985 model may overstate the cost of rail transport actually available to grain shippers.

There is one other issue that must be dealt with in determining rail transportation flows in 1985 and that is the problem presented by use of multicar unit trains. Although multicar trains and rates apparently were available in 1977, widespread use did not occur until after passage of the Staggers Act (Casavant and Mehringer). Accordingly, for 1977 transpor-

tation flows, only the single rail car option was considered.

In 1985, however, wheat shipments by rail from inland terminals had to be classified by the number of carloads filled because multicar load shipments had different transportation rates. Multiple-car rates are considerably lower than single-car rates. Rail shipments were made from Montana in 52, 26, and single rail carloads, whereas shipments from Oregon, Idaho, and Washington were made in 26, 3, and single carloads. Whether a given rail shipment was assigned to a 52, 26, 3, or single carload in the network model depended on both the location of the supply point and the average monthly shipment made by each supply point elevator. For example, if an inland terminal made an average monthly shipment of 2,236 metric tons, it was assumed that a 26 carload unit train was used. This practice may overstate the use of multicar shipments, because it assumes that every terminal that could physically fill multicar unit trains in fact used them. In the absence of actual data on multicar shipments from each terminal, this method of assigning unit trains was considered to be a reasonable alternative.

The Results

A comparison of the wheat transportation flows predicted by the network model with the actual transport flows for both 1977 and 1985 is presented in table 2. In 1977 the model provides a good approximation of the transport modal splits that actually took place. The model predicts that 47.53% of wheat traffic would go by truck-barge, compared to the actual 45.10% of traffic that did use the truck-barge combination. The predicted and actual rail share of traffic are both very close to 46%. The model appears to slightly underpredict the use of the truck option in 1977, a 6.04% share being predicted whereas a 9.31% share was observed.

The relatively good fit of the network model is particularly pleasing because infinite transport capacity of each arc is assumed in applying the model, an assumption that some industry observers may argue was not valid in the late 1970s due to rail car shortages. The fact that the model comes very close to predicting the actual rail traffic flows despite the assumption of infinite arc capacity suggests that

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[5] The worksheet approach used for 1977 truck rates was utilized to estimate 1985 rates as well. The estimates corresponded very closely to actual rates found through the survey.

Table 2.   Comparison of NETFLOW Model and Real Wheat Movements to PNW Ports by Mode

	Modeled		Actual	
	Wheat Shipment	%	Wheat Shipment	%
1977				
Truck-barge	3,355.70	47.53	3,184.14	45.10
Rail	3,278.10	46.43	3,218.73	45.59
Truck	426.70	6.04	657.30	9.31
Total	7,060.50	100.00	7,060.17	100.00
1985				
Truck-barge	2,039.56	25.66	3,246.00	40.83
Rail	5,295.03	66.60	4,324.50	54.40
Truck	615.46	7.74	379.45	4.77
Total	7,950.05	100.00	7,949.95	100.00

Source: U.S. Department of Agriculture, *Grain and Feed Market News,* various issues.

the rail car shortage did not have a large impact on wheat transport flows in the PNW in 1977.

The model predictions for 1985 do not conform nearly as well to actual flows as did the 1977 model. The network model predicts that only 25.66% of wheat flows would go by truck-barge, leaving 66.60% of the traffic to be transported by rail. The actual truck-barge traffic constituted 40.83% of total wheat transport flows, whereas only 54.40% moved by rail.

As expected, there was an increase in the observed rail share of traffic from 45.59% in 1977 to 54.40% in 1985, but this is a much smaller increase than was predicted by the model. The rail rates used in the model were tariff rates and may overstate the true rail rates available (due to the widespread use of contracting). Thus, an underprediction of rail share would be expected. The low actual rail share in 1985 is also unexpected because there was excess rail car capacity in the 1980s, a factor that should have further depressed rail rates and encouraged use of rail transport *vis-à-vis* other modes.

A possible explanation for the apparent suboptimal utilization of rail services in 1985 is that wheat shippers had not fully adjusted to the changes in the competitive transportation market environment. In particular, shippers who are assumed to take advantage of the lower multicar unit train rates may not yet be fully exploiting these opportunities as assumed in the cost-minimizing solution to the network equilibrium model.

Informal discussions with several country elevator managers in the region reveal at least three reasons why traffic did not more com-

pletely shift towards rail. First, although many elevators have the minimum physical capacity to handle multicarload shipments, they are not taking advantage of these rates due to logistics management constraints. In particular, little effort appears to be made towards consolidating small shipments into larger shipments eligible for multicarload discounts. A major drawback to using multicarload rates is that multicar loadup facilities usually are needed. These facilities require a substantial investment. Smaller elevators may be unable or unwilling to make such investments.

Second, some country elevator firms or cooperatives also own river barge loading facilities. These organizations may tend to route as much grain as possible through their own facilities despite the new lower rates now available on rail service.

The final factor mentioned by elevator managers is that some shippers simply lack sufficient information to negotiate and utilize contract rates. Terms of contract rates are kept confidential, so it is hard for shippers to know whether or not they are getting a good deal. Further, shippers express concern over the lack of shipping decision flexibility under contract rates. However, since the model estimated here does not explicitly include contract rate discounts, this cannot explain the divergence between the model predictions and the actual outcome. If contract rates had been used extensively, the actual shift in traffic towards rail should have been even greater than predicted by the model.

Another possible reason for the apparent underutilization of rail is that rail companies may

Table 3. Estimated PNW Average Cost of Transporting a Metric Ton of Wheat from Country Origin Point to an Export Elevator in Real and Nominal Terms: 1977 and 1985

	Average Cost Nominal	Average Cost Real
	----------------- $ -----------------	
1977	15.03	15.03
1985	14.23	7.83
% Change:	−5.32	−47.90

Note: Real costs were calculated by adjusting the nominal transport cost by the 1977 transportation cost price index.

Table 4. Estimated Total Cost of Moving Wheat from Country Origin Point to Export Elevator

	Nominal	Real (in 1977 dollars)
1977 Volumes		
1977 rates	$106.114 million	$106.114 million
1985 rates	$100.466 million	$55.281 million
Savings:	$5.648 million	$50.833 million
1985 Volumes		
1977 rates	$119.488 million	$119.488 million
1985 rates	$113.128 million	$62.248 million
Savings:	$6.360 million	$57.240 million

make rail service available in a selective manner, resulting in certain elevators continuing to use the truck or truck-barge option. Managers of several smaller elevators suggested that they do not use rail even though rail rates are lower than truck rates because railroads do not provide them with timely and dependable service. These small elevators are not on abandonable branch lines, but the railroads appear to prefer to allocate available cars to larger shippers rather than deal with these small volume elevators. As a result, these small elevators turn to alternative modes which are more readily available.

The results in table 3 show what the average cost of transporting a metric ton of wheat from country origin point to an export elevator would have been in both 1977 and 1985 if the least-cost transport method predicted by the network model had been used. The numerator in this calculation is the cost predicted by the network model, and the denominator is total tons shipped.[6] Both real and nominal costs are presented. Real average transport cost per ton would have fallen by almost 48% had cost-minimizing strategies been pursued. These figures present a fairly accurate measure of average costs for 1977 since the actual transport modes are well predicted by the network model. The 1985 figures only show the full potential reduction in average costs that would be possible if cost-minimizing transport modes had been chosen.

To get a dollar figure of the potential cost savings, table 4 shows the estimated total shipping cost of moving wheat from country origin

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[6] Ton-miles would have been a superior measure; however, tons were the only data available.

point to export elevators in 1977 and 1985. To net out the impact on total transport cost arising from different volumes of wheat, the calculations are made for both years using 1977 volumes (and 1977 and 1985 average costs) and 1985 volumes. If 1985 volumes had been shipped at 1977 real rates, the total cost would have been $119.488 million; however, shipping the same volume of wheat at 1985 rate levels would have only cost $62.25 million—a saving of $57.24 million. This exercise shows that considerable cost savings are available in the post-Staggers regulatory environment, and, to the extent the actual network system deviates from the minimum cost network system, there are still savings to be realized by shippers of PNW wheat.

Finally, the model was used to estimate the sensitivity of rail market share to changes in the rail rate, assuming that both barge and truck rates remained constant. The results of this exercise are presented in table 5. Note that increases in rail rates in 1977 reduced rail market share considerably more than similar rate increases in 1985. Fuller et al. argue that regulation allowed rate bureaus to act as a cartel, and the Interstate Commerce Commission let railroads charge rates where the upper bound was set by competition. If rail regulation allowed railroads to act monopolistically, they would be expected to set rates on the elastic portion of the demand curve. The modal share should be more sensitive to rate increases than to a rate decrease since higher rates are on the relatively more elastic segment of the demand curve. Thus, the sensitivity of 1977 rail market share to rate increases is not inconsistent with the hypothesis that regulation allowed carriers to act in a noncompetitive manner.

Table 5. Estimated Modal Share Sensitivity of PNW Grain Shipments to Changes in Rail Rates: 1977 and 1985

Change in Rail Rates	1977		1985	
	Market Share	Change in Market Share	Market Share	Change in Market Share
		%		
+10	20.72	−25.71	59.70	−6.90
+5	41.40	−5.03	63.00	−3.50
+1	41.69	−4.74	63.43	−3.17
0	46.43	0.00	66.60	0.00
−1	47.55	1.12	71.80	5.29
−5	54.00	7.57	76.89	10.29
−10	56.58	10.15	78.30	11.71

Summary and Conclusion

This study used a network freight equilibrium model to examine the PNW export wheat transportation system both before and after the 1980 enactment of the Staggers Act. As expected, the rail share of PNW wheat transport flows increased in the post-Staggers period but not nearly as much as predicted by the cost-minimizing network model. This finding raises the question of why wheat shippers did not minimize costs in the post-Staggers period, especially since the network cost minimization model appeared to realistically describe shippers' pre-Staggers Act behavior.

A couple of possible explanations have been discussed. First, it simply may be that shippers have not yet fully adjusted to the change in regulatory environment. In this case, additional information provided to shippers on transport options may be necessary before it becomes possible to realize potential cost savings in the post-Staggers PNW wheat transport system.

Alternatively, rail companies, enjoying their new-found freedom from regulation, may be selectively providing the lower cost services to shippers. Indeed, the charge of discriminatory actions on the part of railroads towards isolated grain shippers was one of the reasons railroads became regulated in the first place. If this is the problem, then governmental action may be necessary if grain shippers are to achieve the cost savings that a minimum cost transportation system can provide.

Obviously, further research in this area is essential to determine why 1985 wheat shippers are not fully realizing potential transport cost savings. This issue is particularly important to farmers since the farm level price for wheat is the price at the export port less transport costs (Townsend; Tomek and Robinson). Thus, any further reduction in wheat transport costs could benefit PNW wheat producers by increasing the average farm level price.

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