Southern Economic Journal 2001, 67(4), 938–953

Simulating the Effects of Railroad Mergers

Joon Je Park,* Michael W. Babcock,† Kenneth Lemke,‡ and Dennis L. Weisman§

The purpose of this paper is to add to the empirical literature regarding merger simulation analysis by examining the effect of railroad mergers on railroad market power. This is done by measuring railroad profits and revenue/variable cost ratios corresponding to different degrees of intrarailroad competition for movements of Kansas export wheat to Houston, Texas.

Two models are developed to achieve the objectives of the study. A network model of the wheat logistics system is used to identify the least cost transportation routes from the Kansas study area to the market at Houston. A profit improvement algorithm, which identifies Nash equilibrium prices, is developed to measure the amount by which railroads can profitably raise their prices above variable cost.

The results of the study have implications for U.S. railroad merger policy. The paper indicates that railroad mergers do not necessarily increase railroad market power or make railroad shippers worse off. Instead, the study demonstrates that the impact of railroad mergers on shippers and railroads depends on factors that vary geographically, such as the degree of intrarailroad and intermodal competition in the area.

1. Introduction

The operating performance problems of class I railroads after the mergers of recent years have raised the issue of the impacts of railroad mergers on railroad shippers. Although most of the public's attention has been focused on service problems such as equipment supply and on-time reliability, the effect of recent class I railroad mergers on railroad market power and prices is a matter of policy concern.

Conventional economic theory argues that an increase in intrarailroad competition will result in a decrease in railroad price. There is substantial empirical support for this hypothesis. For example, Levin (1981b) found that hypothetical railroad price increases resulting from railroad deregulation are quite modest in the presence of a moderate degree of intrarailroad competition.[1] Levin (1981a) discovered that for various assumptions regarding railroad demand elasticity and railroad revenue/variable cost ratios, the social benefit (net reduction in deadweight loss) of adding an equal-size railroad competitor to a monopoly railroad market ranges from

* Department of Agribusiness and Applied Economics, North Dakota State University, Fargo, ND 58105-5636, USA; E-mail joonje_park@hanmail.net.

† Economics Department, Kansas State University, Manhattan, KS 66506, USA; E-mail mwb@ksu.edu; corresponding author.

‡ Peru State College, P.O. Box 10, Peru, NE 68421, USA; E-mail klemke@oakmail.peru.edu.

§ Economics Department, Kansas State University, Manhattan, KS 66506, USA; E-mail weisman@ksu.edu.

The authors wish to thank the editor, Jonathan H. Hamilton, and two anonymous referees for their helpful comments on previous drafts of this paper.

Received September 1998; accepted October 2000.

[1] A moderate degree of intrarailroad competition is defined as a scenario in which the price elasticity of demand of an individual railroad is assumed to be three times that of the rail industry price elasticity of demand.

6.8% to 18.9% of revenues in that market. Adding a third railroad in a two-firm railroad market yields social benefits of 2.4%–6.8% of revenues in that market. MacDonald (1987) found that increased intrarailroad competition results in lower railroad grain prices. He found that a movement from a railroad monopoly to a duopoly with equal-size firms leads to an 18% decrease in railroad corn prices. A movement from duopoly to triopoly causes railroad corn prices to fall another 11%. Similar results are reported in MacDonald (1989). The Lemke and Babcock (1987) study of the impact of railroad mergers on western Kansas export wheat rail prices concluded that mergers do not significantly increase market power as long as some intrarailroad competition is maintained. However, mergers that produce regional monopolies result in substantial increases in railroad market power.

The Staggers Rail Act of 1980 contained restrictions on railroad rate bureaus and permitted confidential railroad/shipper contracts. These provisions of the act fostered intrarailroad competition and several studies documented the decline in railroad grain prices resulting from increased railroad rivalry.[2]

The purpose of this study is to add to the empirical literature concerning market power and competition between railroads. This is achieved through a case study of the transportation market for the export of Kansas wheat. However, the models, techniques, and general conclusions of the study can be applied to similarly situated regional transportation markets for homogeneous goods such as coal, ores, field crops, and lumber.

2. The Study Area

The grain origin area of this study includes all of 57 counties and parts of 15 other counties in central and western Kansas that comprise about two-thirds of the Kansas land area. This area is divided into 342 production origins (12 × 12 square mile areas). In 1996, the area produced about 217 million bushels of wheat, which was 85% of the state's production.[3] The area also produced about 77% of total Kansas sorghum production and 81% of the state's corn production.[4]

The area is served by four class I railroads including Burlington Northern (BN) (126 miles), Union Pacific (UP) (852 miles), Santa Fe (SF) (658 miles), and Southern Pacific (SP) (259 miles). In addition, there are five short lines serving the area, including Kyle Railroad (632 miles), Kansas Southwestern (KSW) (302 miles), Central Kansas Railroad (CKR) (882 miles), Cimmaron Valley (CV) (182 miles), and the Garden City Western (45 miles). Thus, the total miles of rail line in the study area is 3938. These railroads serve study area elevators with a total storage capacity of 670 million bushels.

The study focuses on wheat because rail transportation is the dominant transportation mode for Kansas export wheat. This is not the case for corn or sorghum, the other major crops in the study area. For the 1992–1993 crop, small country elevators moved 52% of their wheat ship-

---

[2] These studies include Adam and Anderson (1985), Babcock et al. (1985), Casavant (1985), Fuller, Makus, and Taylor (1983), Klindworth et al. (1985), MacDonald (1987, 1989), U.S. Department of Agriculture (1982, 1984), Fuller et al. (1987), Sorenson (1984), Hauser (1986), and Thompson, Hauser, and Coughlin (1990).

[3] Computed from data in Kansas Department of Agriculture (1997).

[4] Computed from data in Kansas Department of Agriculture (1997).

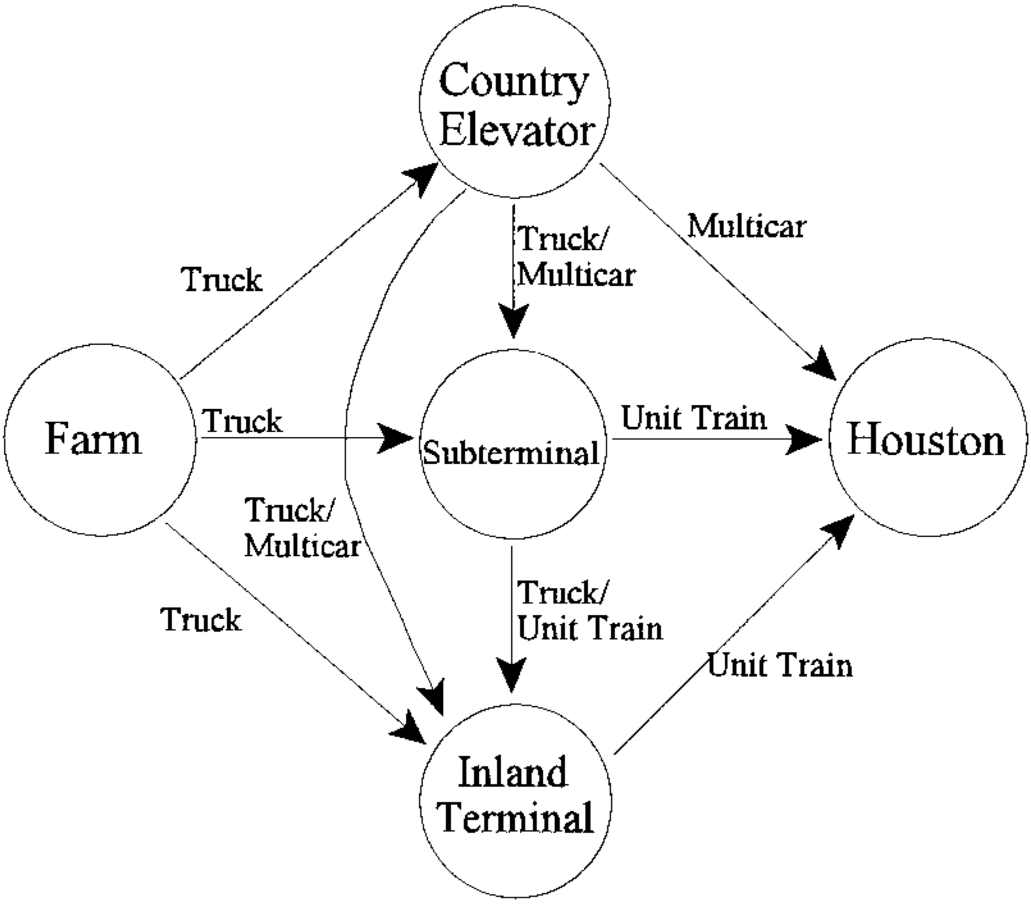

Figure 1. Types of Shipment Patterns of the Study from Production Origins to Houston, Texas

ments by rail. The corresponding percentages for large country elevators and terminal elevators were 69% and 99%, respectively.[5]

Most of the wheat grown on Kansas farms travels through a system of country elevators and inland terminal elevators to domestic flour mills or export terminals at coastal ports. Port terminals on the Gulf of Mexico have been the major destination for Kansas export wheat. During the 1992–1993 crop year, 62% of all Kansas wheat shipments were to the Gulf of Mexico ports.

The wheat logistics system in Kansas is displayed in Figure 1. Trucks are used to ship wheat from farms to country elevators, inland terminal elevators, or subterminal elevators. Country elevators ship wheat to subterminals, inland terminals, domestic flour mills, or export ports (e.g., Houston) by truck or rail. Inland terminal elevators and subterminal elevators ship wheat by rail and by truck to other inland terminals or by rail to final markets. Inland terminal elevators have functioned as intermediate collection, storage, and routing points. Subterminals are designed for rapid loading of unit trains of wheat.

In the study area, inland terminal elevators are located at Salina, Wichita, and Hutchinson,

[5] Kansas Department of Agriculture (1993).

Kansas. Subterminals are located at Colby, Dodge City, Wakeeney, Liberal, and Ogallah, Kansas, and Enid, Oklahoma.

Houston was selected as the only market in order to make the study more tractable. This assumption is not overly restrictive because in the 1992–1993 crop year, more than 60% of Kansas wheat shipments moved to Houston for export.[6]

3. Models and Procedures

Two models are required to achieve the objectives of the study. A network model is required to identify the least cost transportation routes from the study area to Houston. The network model is a variation of the linear programming methodology. A model is also required to compute prices. We assume that oligopoly interaction is described by price-setting behavior in a homogeneous goods industry. Service differences (e.g., delivery times) between transportation modes are not important to shippers of products with a low value-to-weight ratio (e.g., wheat) who select transport modes on the basis of cost (Harper 1982, p. 16). Hence, we treat transportation in this model as a homogeneous service.

A profit improvement algorithm is needed to measure the amount by which railroads can mark up their prices above variable cost in the face of changing market conditions. This approach is very much in the spirit of the merger simulation literature (Werden and Froeb 1994, 1996), albeit with homogeneous products, because the primary objective of the study is to simulate changes in market power postmerger. As Werden and Froeb point out, this approach can represent a marked improvement over the traditional structural methods for evaluating mergers.

The Network Model

With regard to the first of these models, the network includes 342 production origins (12 miles × 12 miles in area), 280 country elevators, 6 subterminals, 3 inland terminals, and one destination (Houston).

In the network model, the initial movement of wheat is from a production origin to a country elevator, terminal elevator or a subterminal. A production origin may ship wheat to any country elevator that is within a 50-mile radius; it may ship to a subterminal if it is within a 70-mile radius. A production origin can ship to any terminal. Because one of the objectives of this study is to examine the ability of railroads to increase their market power and profits as intrarailroad competition is reduced, production origins must be allowed to deliver Kansas wheat farther than historical average mileages in order to identify transportation costs of alternative routes.[7]

In the network model, wheat moves through the logistics system to the final demand point. After the wheat is assembled at country elevators or subterminals, the following types of shipment patterns may occur (Figure 1):

---

[6] Exclusion of non–Gulf of Mexico port areas will not prevent achieving the objectives of the study. This is because those ports are served by other wheat supply areas that have a locational advantage. Thus, the Pacific Northwest ports are served by Washington, Montana, and the Dakotas. California ports are served by Utah, California, and Arizona. The western Great Lakes ports are served by Montana, the Dakotas, and Minnesota.

[7] In 1992, the average distance traveled to deliver wheat from study area farms to country elevators was 11 miles.

(i) Multicar (15-car) rail shipments from country elevators to Houston.

(ii) Multicar (15-car) rail shipments from country elevators to inland terminals or subterminals. This is followed by a 100-car-unit train movement from inland terminals or subterminals to Houston.

(iii) Commercial truck movement from country elevators to inland terminals or subterminals. The subsequent movement is a unit train shipment of 100 cars from inland terminals or subterminals to Houston.

(iv) Commercial truck movement from country elevators served by a given railroad to another country elevator served by a competing railroad(s). This is followed by multicar (15-car) shipments to inland terminals or subterminals. The next movement is 100 car unit train movement from inland terminals or subterminals to Houston.

(v) Commercial truck movements from country elevators served by a given railroad to an inland terminal or a subterminal served by a competing railroad(s). The subsequent shipment is unit train shipment of 100 cars from inland terminals or subterminals to Houston.

Competition between railroads is simulated by not allowing railroads with routes to Houston to transfer wheat traffic to other railroads. Class III railroads that do not have direct routes to the Gulf of Mexico ports are allowed to transfer shipments to railroads that are not competitors for the same production origins. For example, the Kyle transfers wheat traffic to the SF before the BN–SF merger and to the BNSF after the merger but not to the UP. This is because the Kyle and the UP both serve the northern portion of the study area while the SF does not.

The objective function of the network model is to minimize total logistics system costs, which include grain transportation and handling costs, subject to the following constraints:[8]

(i) The flow of wheat into each transshipment point exactly equals the flow out of the transshipment point.

(ii) The total amount of wheat supplied exactly equals the total amount of wheat demanded.

(iii) All grain transportation and handling cost coefficients are greater than or equal to zero; all endogenous variables are greater than or equal to zero.

A transport cost–minimizing algorithm is used to solve the network model for the least cost movements of wheat. This algorithm requires that the following capacity constraints be added to the model:

(iv) Storage at each facility must be equal to the storage capacity (total storage capacity of all the elevators at the location is used).

(v) The quantity of wheat shipped by each mode between each location must be less than or equal to the total storage capacity at the original location.

(vi) No wheat stocks will remain at the production origins or at transshipment points at the end of the crop year.

The cost-minimizing algorithm is used to solve the network model.[9]

The Profit Improvement Algorithm

The profit improvement algorithm is used to evaluate each railroad's ability to raise prices above variable costs. The algorithm can simulate a range of prices from variable cost to a level that diverts all traffic to rival railroads or other modes of transport.

---

[8] The network model is a variation of the linear programming methodology. For a detailed discussion of the mathematics of the network model, see Park (1998, pp. 80–3).

[9] For a more detailed discussion of the cost-minimizing algorithm, see Chow (1984).

The profit improvement algorithm starts with all railroad prices set equal to variable cost and systematically generates changes in prices for a given railroad that will increase its excess of revenues over variable costs. The algorithm uses the solution of the network model to calculate shadow prices for alternative routes from production origins to final destination. Shadow prices represent the increase in total transportation costs if one unit of grain is shipped over a route that is not part of the least cost solution. Shadow prices indicate a railroad's cost advantage over its competitors on a specific route. In the profit improvement algorithm, shadow prices are used to determine the amount a railroad's prices may be increased without loss of traffic on each of its routes. The algorithm can also evaluate the impact of raising prices to levels at which some traffic is diverted to other carriers. Thus, the profit improvement algorithm can simulate the entire range of prices and profits, wherein the merging railroads serve the entirety of the market to where they serve none of the market.

Procedures

The rail market power and profit (revenue-variable cost) effects of two intrarailroad competition scenarios are simulated. These are "No Mergers" and "Mergers."

No Mergers. The four class I railroads (UP, SP, BN, SF) and the five short lines compete with each other for shipment of study area wheat.

Mergers. The number of class I railroads is reduced as a result of the BN–SF and UP–SP mergers. These two class I railroads and the five short lines compete with each other for shares of the study area wheat transportation market.

For the Mergers simulation, mergers are allowed to occur by removing the restriction that railroads cannot interchange traffic and by eliminating interchange charges between merging carriers.

For the No Mergers and Mergers simulations, the network model and the profit-improvement algorithm are used to calculate Nash equilibrium profits (revenue-variable cost) and Lerner ratios. To illustrate the procedure for calculating the Nash equilibrium, suppose there are three competing railroads (A, B, and C) in a particular region. In the first step of the calculation, the profit-improvement algorithm is employed to compute the maximum revenue/variable cost ratio for each of the three railroads assuming the other two railroads set their respective prices at variable cost.

The second step in the calculation of the Nash equilibrium is to reestimate the network model to identify the new least cost carrier for each production origin, given that the least cost carrier identified in the first step is charging its maximum revenue/variable cost ratio. For example, suppose that for a given set of production origins, railroad A is the least cost carrier. Assume railroad A is able to achieve an average revenue/variable cost ratio of 1.10 assuming railroads B and C set their respective prices at variable cost. In the second step, the network model is rerun to identify the new least cost carrier for each of these production origins assuming that railroad A is charging 110% of variable cost.

After the new least cost railroad is identified for each production origin, the profit-improvement algorithm is used to determine the maximum revenue/variable cost ratio for the new least cost railroad, given the revenue/variable cost ratio of the previous least cost carrier (i.e., railroad A). To simplify, suppose railroad B is the new least cost railroad for the given set of production origins referred to above. The profit-improvement algorithm will determine the maximum revenue/variable cost ratio for railroad B, given that railroad A is charging average prices that are 110% of variable cost.

The procedure described above is repeated for the third least cost railroad for each production origin. The Nash equilibrium is approached with each successive iteration of the procedure.

The Nash equilibrium is achieved when the algorithm reports that the last iteration does not improve the least cost carrier's (i.e., railroad A in the example) profit by more than 10 cents per 1000 bushels (i.e., virtually no change). When this is achieved, the procedure has converged to a Nash equilibrium, resulting in a simultaneously rational choice pricing strategy for each competing railroad.

Net revenue and market power estimates are calculated for each railroad that is included in each of the two simulations. Net revenue is railroad revenue minus variable costs measured in dollars per 1000 bushels. In this study, we adopt a Lerner-type index for measuring market power, which is defined as the ratio of rail revenue to rail variable costs. Market power is reported for each railroad affected by mergers. The market power value reported for a railroad is calculated by dividing the estimated total revenue of all the railroad's shipments by the total rail variable cost of these shipments. This Lerner index measure of market power was selected because it was the ratio used by the former Interstate Commerce Commission to test for rail market dominance.[10] It should be noted, however, that because variable costs may decrease after a merger, an increase in market power is not necessarily inconsistent with a decrease in price.

4. The Data

The network model requires the specification of several predetermined structural dimensions, including the following:

(i) the number of storage periods within the crop year;

(ii) the size and number of production origins in the study area;

(iii) sites and storage capacities of country elevators in the study area;

(iv) sites of inland terminals; and

(v) sites of export terminals.

The model assumes a single storage period.[11]

Each production origin is represented by a 12 × 12 mile square area, resulting in 342 farm production origins in the study area.

---

[10] Some analysts have suggested that in industries with high fixed costs, the ratio of price to variable costs may not be an accurate measure of market power, presumably because some prices must diverge from variable costs in order for the entity to remain financially viable (Clark 1923, chapter XX). See Fisher and McGowan (1983) and the debate that ensued in the *American Economic Review* (June 1984) for further discussion of this point in the context of measuring market power and distinguishing between accounting and economic profit. In this study, we are primarily concerned with changes in the price to average variable cost ratios that result from changes in underlying market conditions. Given this is a comparative statics exercise, changes in the price to average variable cost ratio in a given market, *ceteris paribus*, are indicative of changes in market power.

[11] Multiple crop year time periods are not appropriate for this study. The objectives of the paper require identification of geographic areas where individual railroads have a cost advantage. Effective storage capacity constraints at production origins and multiple time periods would force the network model to select other than least cost routes for some wheat shipments. Therefore, a model with multiple time periods would not provide accurate information about the potential market areas of individual railroads or the ability of one railroad to constrain a rival railroad's prices.

A total of 280 locations (including 13 country elevators in Nebraska) were selected for country elevator sites based on the elevator size and the presence of rail service. A total of 46 locations were not included in the network model because they have no rail service. The storage capacities for country elevators are obtained from Kansas Grain and Feed Association (1994).

Five elevator locations (Colby, Dodge City, Liberal, Ogallah, and Wakeeney, Kansas) in the study area and one elevator location (Enid, Oklahoma) out-of-state were selected from country elevator locations in the study area to be subterminal sites. A country elevator is considered a subterminal site if an elevator facility at that location has railroad service and has sufficient storage and loading capacity for 100 car shipments.

Three inland terminals (Hutchinson, Salina, and Wichita, Kansas) are selected as intermediate transshipment terminals. It is assumed that the storage capacity at inland terminals is sufficient and no restriction for inadequate storage facilities is necessary.

Houston, Texas, is chosen as the export terminal and is used to measure the shipping distances from the study area.

The network model requires an estimate of the quantity of wheat supplied for export from each of the 342 production origins.[12] The average Kansas wheat production of 1994, 1995, and 1996 is assumed to be the total wheat supply. A three-year average is used due to the interyear variability of wheat production. During the assumed time frame, the study area produced an average 283.93 million bushels of wheat, which was 87.4% of the total Kansas wheat production. The three-year average production of each study area county is divided by the area of the county to obtain the average production for each square mile. The wheat supply for export of each production origin is then estimated by multiplying the three-year average production of each square mile by the number of square miles in the production origin.[13] By assumption, the quantity of wheat demanded at Houston is equal to the total three-year average production (284 million bushels) of the study area.[14]

The network model requires transportation cost estimates for farm trucks, commercial trucks, and railroads. Costs are used rather than prices because the objectives of the study require estimates of the least cost carrier's cost advantage relative to its competitors. Also, cost estimates are needed to calculate revenue/variable cost ratios, our measure of market power.

In this study, it is assumed that movements from production origins are by wheat harvester trucks.[15]

Commercial truck costs are assumed to have a cost advantage relative to railroads for short hauls. This is because truck costs increase in direct proportion to distance, whereas rail costs do not, given the high percentage of fixed costs in the railroad cost structure (Coyle, Bardi, and Novak 2000, p. 108 and p. 135). Thus, after the short-line railroad cost function is estimated, the commercial truck cost function is assumed to have a cost advantage relative to the short

[12] We assume that all of the study area wheat production is exported. In reality, only a part of the wheat output is exported with the remainder being shipped to various domestic markets. However, it is unlikely that the amount of wheat shipped would significantly affect intermodal and intramodal competition in the study area. Also, we have no sufficiently detailed recent data to estimate the proportion of study area wheat that is exported.

[13] The wheat production data are from *Kansas Farm Facts* (Kansas Department of Agriculture 1995, 1996).

[14] The demand for Kansas winter wheat at Houston is assumed to be perfectly price inelastic. This assumption is consistent with the empirical evidence. Koo (1985) found U.S. wheat producers bear 85% of the burden of an increase in transportation cost in the form of a lower price received for their wheat, implying that demand is inelastic. He also discovered that a 40% increase in ocean freight rates would produce only a 1.5% decline in the quantity of U.S. winter wheat exports.

[15] The prices charged for these wheat shipments are from Kansas Department of Agriculture (1994).

line for 0 to 50 miles, but higher costs than the short line for distances that are greater than 50 miles. The estimated commercial trucking cost function used in the model is dollars/1000 bushels = 9.8 + 0.7376 (one-way mileage).

The mileage between country elevators, subterminals, and terminals in the study area is estimated by aggregating the highway map distances between origins and destinations.[16]

Estimates of class I railroad variable costs are from the Interstate Commerce Commission Railroad Costing Program (Interstate Commerce Commission 1991). The 1994 costs of BN, SF, UP, and SP are used for wheat shipments from the study area to Houston. When these railroads merge in the Mergers simulation, the combined railroad is assumed to operate at the costs of the lowest cost partner. This assumption has a parallel in the merger simulation literature (Werden and Froeb 1996, p. 72, and Werden and Froeb 1994, p. 415). For example, because BN has lower costs than SF, the BNSF is assumed to operate with the BN cost structure.

Short lines have lower costs than class I railroads. The three major sources of cost savings are labor, equipment, and maintenance of way. Labor costs are lower due to more flexible work rules, smaller crews, and lower wages and benefits. Short lines formed since 1970 operate with an average of 0.54 employees per mile of track compared with 1.8 employees for class I railroads.[17] Therefore, short-line railroads are able to operate rail lines at a lower cost than that of class I railroads.

Because the Interstate Commerce Commission costing program only measures class I rail costs, and there is no other cost function for short lines, some assumption must be made regarding the measurement of short-line railroad costs. Among class I railroads, Illinois Central (IC) has the lowest cost structure. Thus, the cost function of IC is regarded as the short-line railroad cost function.

Grain-handling costs were supplied by Mack N. Leath of the Economic Research Service, U.S. Department of Agriculture.

5. Empirical Results

Before discussing the impact of intrarailroad competition on railroad prices, it is useful to discuss the nature of the results generated by the network model and the profit-improvement algorithm. Although the estimates of rail variable costs derived in this study are estimates of actual costs, the values derived for rail revenues and prices are not estimates of actual revenues or prices. In the No Mergers and Mergers cases, these values underestimate actual rail prices and revenues because they are derived under stylized assumptions concerning the prices set by competitor railroads. Although these estimated prices do not provide estimates of actual railroad prices, they do provide an indication of expected trends in price/variable cost ratios (measures of market power) due to changes in the intensity of competition between railroads.

The study area is divided into four subregions to facilitate handling of the large computational requirements of the network model (Figure 2). Results of these four subregions are aggregated to evaluate results for the whole study area logistics system.

---

[16] The Kansas transportation map published by the Kansas Department of Transportation is used for in-state mileage calculations. A road atlas published by Rand McNally and Company was used for calculating out-of-state highway mileages.

[17] See Dooley (1991).

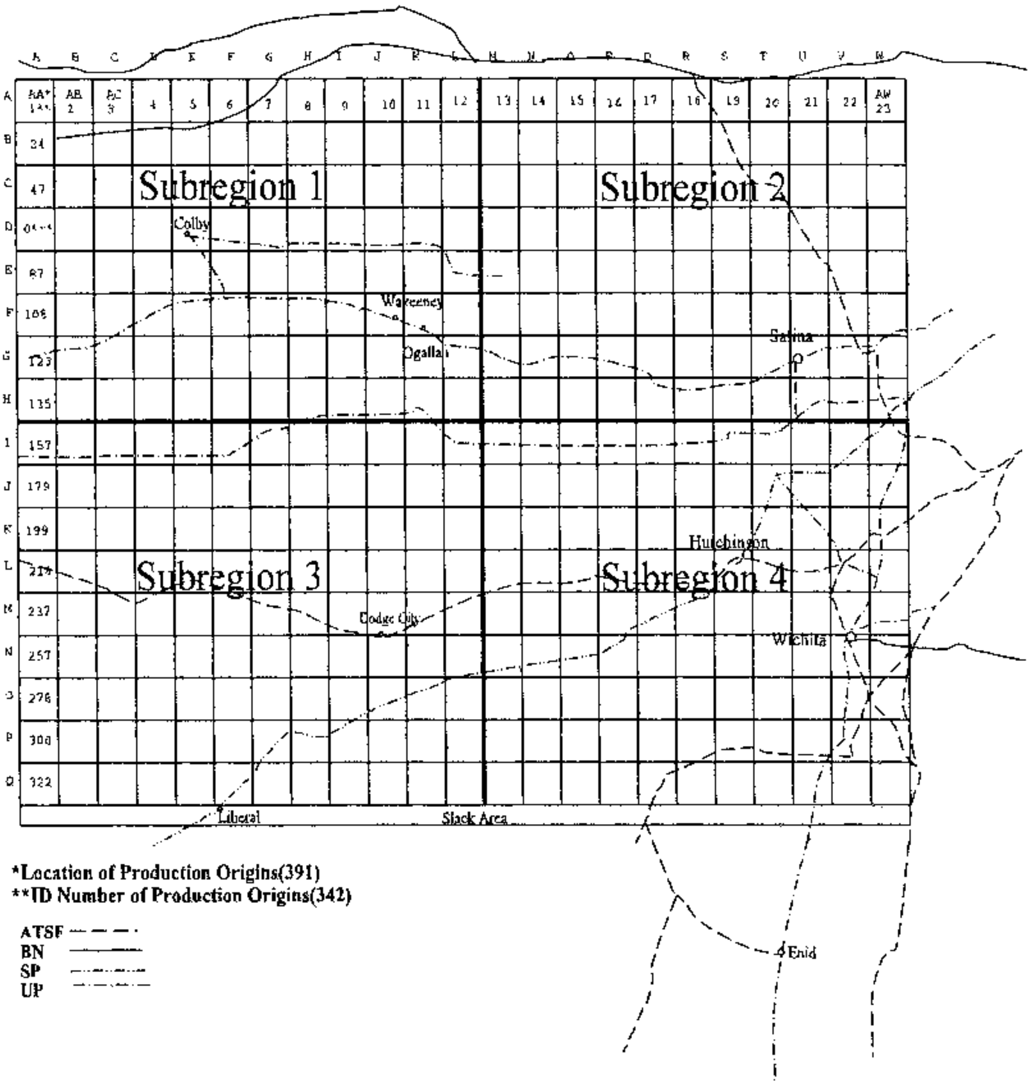

Figure 2. Production Origins and Subregions in the Study Area

Empirical Results: Subregion 1

Table 1 displays estimated net revenue (revenue-variable cost) and revenue/variable cost ratios for the railroads serving subregion 1 for the two railroad versus railroad competition scenarios. The No Mergers and Mergers cases solutions are Nash equilibrium outcomes. In the Mergers scenario the BN–SF and UP–SP mergers occur. In subregion 1, the BN–SF merger greatly benefits the combined railroad by permitting more direct routing of BN shipments to Houston (using SF routes). Also, as discussed earlier, the analysis assumes that after the merger the combined railroad operates with the cost structure of the lowest cost partner, postmerger. Thus, because BN costs are lower than SF costs, BNSF is assumed to operate at BN cost. The UP obtains no benefit from the merger with SP in subregion 1. This is because UP has more direct routes to Houston than SP and UP has lower costs than SP.

Table 1. Estimated Revenues–Variable Cost and Revenue/Variable Cost Ratios for Affected Railroads: Subregion 1

Railroad	No Mergers	Mergers	Percentage Change from No Mergers
	Revenues–Variable Cost (Dollars Per 1000 Bushels)		
Kyle	$33.90	$16.40	−51.6
Burlington Northern	$38.80	$42.90	10.6
Union Pacific	$27.10	$13.00	−52.0
	Revenue/Variable Cost Ratio		
Kyle	1.070	1.041	−2.7
Burlington Northern	1.082	1.109	2.5
Union Pacific	1.069	1.037	−3.0

As indicated in Table 1, BN net revenue increases from $38.80 per 1000 bushels in the No Mergers simulation to $42.90 in the Mergers case. In contrast, Kyle net revenue plunged from $33.90 per 1000 bushels in the No Mergers case to only $16.40 in the Mergers scenario. The corresponding figures for UP are $27.10 (No Mergers) and $13.00 (Mergers). In terms of percentage changes from the premerger case, the mergers result in a 10.6% gain in net revenue for BN while Kyle and UP suffer 51.6% and 52.0% declines, respectively.

A similar pattern is reflected in the market power (revenue/variable cost) measures. According to Table 1, the revenue/variable cost ratio of BN increases from 1.082 (No Mergers) to 1.109 (Mergers) while the corresponding figures for Kyle are 1.070 and 1.041. In terms of percentage changes from the premerger case, the mergers result in a 2.5% increase in the revenue/variable cost ratio of BN while that of the Kyle decreases 2.7%. The market power of UP declines from 1.069 (No Mergers) versus 1.037 (Mergers), a 3% decline. The Nash equilibrium prices result in revenue/variable cost ratios that are well below that which is generally accepted as the minimum price needed to cover total rail costs.[18]

Empirical Results: Subregion 2

Table 2 displays estimated net revenue and revenue/variable cost ratios for the railroads serving subregion 2 for the two competition between railroads scenarios.

After the BN–SF and UP–SP mergers occur, the two short lines serving the area, CKR and Kyle, suffer substantial declines in net revenue. For the CKR, net revenue declines from $21.60 per 1000 bushels (No Mergers) to $17.60 (Mergers), a decline of 18.5%. The corresponding figures for the Kyle are $32.30 (No Mergers) and $18.80 (Mergers), a 41.8% plunge. The net revenue of UP is virtually unaffected by the mergers because as in subregion 1, the UP gains no benefits from its merger with SP. However, net revenue of BN rises from $20.60 per 1000 bushels (No Mergers) to $28.10 (Mergers), a 36.4% increase.

The mergers have no effect on the revenue/variable cost ratios of the CKR and the UP. Relative to the No Mergers case, the mergers result in a 2.3% decrease in the market power ratios of the Kyle (from 1.070 to 1.045) and a 2.9% increase in that of the BN (from 1.051 to

[18] According to Coyle, Bardi, and Novak (2000, p.135), railroads have a high proportion of fixed costs and must therefore set prices substantially in excess of variable costs to cover total costs. Prices exceed variable costs by the largest amounts for those commodities with price inelastic demand for railroad transport.

Table 2. Estimated Net Revenue and Revenue/Variable Cost Ratios for Affected Railroads: Subregion 2

Railroad	No Mergers	Mergers	Percentage Change from No Mergers
Revenues–Variable Costs (Dollars Per 1000 Bushels)			
Central Kansas Railway	$21.60	$17.60	−18.5
Kyle	$32.30	$18.80	−41.8
Burlington Northern	$20.60	$28.10	36.4
Union Pacific	$15.90	$15.60	−1.9
Revenue/Variable Cost Ratio			
Central Kansas Railway	1.065	1.065	0
Kyle	1.070	1.045	−2.3
Burlington Northern	1.051	1.081	2.9
Union Pacific	1.053	1.051	−0.2

1.081). Thus, the mergers have relatively little impact on Nash equilibrium market power in subregion 2.

Empirical Results: Subregion 3

Competition between railroads changes as the geographic focus shifts to subregion 3. As a result of the UP–SP merger, the SP is able to significantly reduce its costs. This is because the merger allows the SP to use the more direct UP routes to Houston for the wheat the SP can obtain on its line from Liberal to Hutchinson, Kansas. As before, the analysis assumes that the combined railroad operates at the lower costs of the UP. Because there are no former BN lines in either subregion 3 or subregion 4, the only effect of the BN–SF merger is that SF assumes the lower cost structure of the BN.

Table 3 displays subregion 3 estimated net revenue and revenue/variable cost ratios for affected railroads for the two railroad competition scenarios. The mergers of BN–SF and UP–SP cause a plunge in the net revenue of CV from $61.20 per 1000 bushels to only $20.80, a decline of nearly 66%. The net revenue of BNSF is virtually unaffected by the mergers, increasing from $24 per 1000 bushels (No Mergers) to $24.40 (Mergers), a 1.7% gain. In contrast, the net revenue of UPSP soars from $5.30 per 1000 bushels (No Mergers) to $32.50 (Mergers),

Table 3. Estimated Net Revenue and Revenue/Variable Cost Ratios for Affected Railroads: Subregion 3

Railroad	No Mergers	Mergers	Percentage Change from No Mergers
Revenues–Variable Costs (Dollars Per 1000 Bushels)			
Cimarron Valley Railroad	$61.20	$20.80	−66.0
Burlington Northern Santa Fe	$24.00	$24.40	1.7
Union Pacific Southern Pacific	$5.30	$32.50	513.2
Revenue/Variable Cost Ratio			
Cimarron Valley Railroad	1.154	1.061	−8.1
Burlington Northern Santa Fe	1.056	1.073	1.6
Union Pacific Southern Pacific	1.009	1.094	8.4

Table 4. Estimated Net Revenue and Revenue/Variable Cost Ratios for Affected Railroads: Subregion 4

Railroad	No Mergers	Mergers	Percentage Change from No Mergers
Revenues–Variable Costs (Dollars Per 1000 Bushels)			
Central Kansas Railway	$9.20	$8.30	−9.8
Kansas Southwestern Railway	$7.80	$5.80	−25.6
Burlington Northern Santa Fe	$14.70	$18.30	24.5
Union Pacific Southern Pacific	$10.70	$16.40	53.3
Revenue/Variable Cost Ratio			
Central Kansas Railway	1.025	1.027	0.2
Kansas Southwestern Railway	1.021	1.019	−0.2
Burlington Northern Santa Fe	1.041	1.061	1.9
Union Pacific Southern Pacific	1.037	1.057	1.9

an increase of 513%. The SP routes from southwest Kansas to Houston are very circuitous, so the merger with UP greatly reduced SP costs, producing a commensurate gain in net revenue. The gain is augmented by the SP operating at the lower costs of the UP after the merger.

The effect of the BN–SF and UP–SP mergers on the revenue/variable cost ratios of subregion 3 railroads are generally the same as those for net revenue. The CV ratio falls from 1.154 (No Mergers) to 1.061 (Mergers), a decrease of 8.1%. The Nash equilibrium market power ratios of BNSF and UPSP increase after the mergers; however, the percentage increases are only 1.6% for the BNSF and 8.4% for UPSP.

Empirical Results: Subregion 4

Table 4 contains estimated net revenue and revenue/variable cost ratios for the railroads serving subregion 4 for the two railroad competition scenarios. The BN–SF and UP–SP mergers have a negative impact on the net revenue of subregion 4 short lines with net revenue of CKR declining about 10% (from $9.20 per 1000 bushels to $8.30). The corresponding figures for KSW are $7.80 per 1000 bushels (No Mergers) and $5.80 (Mergers), a decline of 25.6%. The net revenue of BNSF increases 24.5% from $14.70 per 1000 bushels (No Mergers) to $18.30 (Mergers) while the net revenue of UPSP expands from $10.70 per 1000 bushels (No Mergers) to $16.40 (Mergers), a 53.3% increase. This large gain in UPSP net revenue is a result of the SP obtaining the direct routes of the UP to Houston and by operating at the lower costs of the UP.

The BN–SF and UP–SP mergers produce virtually no change in Nash equilibrium revenue/variable cost ratios for CKR and KSW railroads and only a 1.9% increase for BNSF and UPSP. This outcome may be due to the fact that this region is relatively close to the terminals in Salina, Wichita, and Hutchinson, Kansas, and therefore railroad market power is constrained not only by intrarailroad competition but also by strong intermodal competition from trucks, which have a cost advantage relative to railroads for short hauls.

Graphical Presentation of Empirical Results

Figure 3 displays the changes in railroad revenue to variable cost ratios for each location on each railroad segment in the study area resulting from mergers. The changes in Lerner ratios

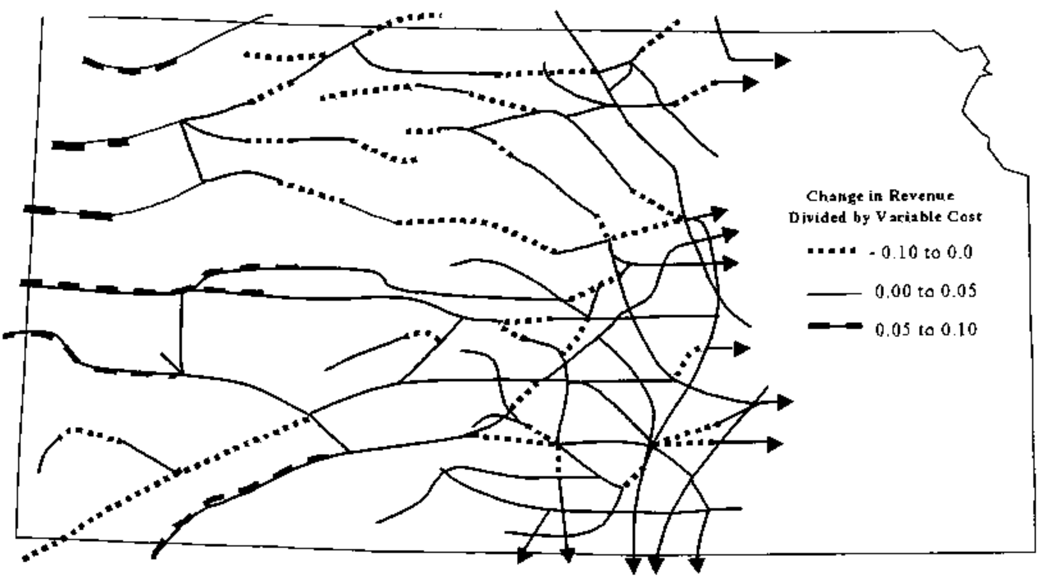

Figure 3. Changes in Railroad Revenue to Variable Cost Ratios Resulting from Mergers

are computed by subtracting the premerger Nash equilibrium ratio from the postmerger Nash equilibrium ratio. In some locations, the ratio decreased after the mergers while it increased at other locations. The changes ranged from −0.10 to 0.10. Because most of the Lerner ratios are only marginally above 1.0, in percentage terms, the changes range from −10% to +10%. Examination of Figure 3 indicates that the largest increases in Lerner ratios after the mergers occurred in the far western part of the study area. However, there are relatively few locations that experienced the largest category of increase in the Lerner ratio. The majority of locations experienced either a very small increase or a decrease in revenue/variable cost after the mergers.

6. Summary and Conclusion

The mergers of UP–SP and BN–SF reduced the number of class I railroads in the study area from four to two. The impact of the mergers on net revenue and market power of the combined railroads does not result in readily observable rules of thumb. For example, relative to the No Mergers scenario, the mergers increased the net revenue of the BNSF by greatly different percentages in the various subregions, ranging from a high of 36.4% (subregion 2) to a low of 1.7% (subregion 3). The mergers resulted in a 52% decline in net revenue of UPSP in subregion 1, a 1.9% decrease in subregion 2, a 53.3% increase in subregion 4, and a sixfold increase in subregion 3.

The impact of the mergers on the net revenue of study area short lines also varied greatly. Relative to the No Mergers case, net revenue of Kyle plunged 51.6% in subregion 1 and decreased nearly 42% in subregion 2. In subregion 3, net revenue of the CV plummeted 66%. The impact of the mergers on CKR and KSW net revenue is less but nevertheless negative. The CKR sustains decreases in net revenue of 18.5% (subregion 2) and nearly 10% (subregion 4). The KSW experienced nearly a 26% decline in net revenue in subregion 4 as a result of the mergers. Thus, the mergers appear to threaten the long-run viability of study area short lines.

Relative to the No Mergers scenario, the BN–SF and UP–SP mergers resulted in marginal changes in market power for the combined railroads. For the BNSF, the mergers resulted in a maximum percentage change in the revenue/variable cost ratio of 2.9% (subregion 2) and a minimum increase of 1.6% (subregion 3). The corresponding figures for UPSP were 8.4% (subregion 3) and −3.0% (subregion 1).

There is no reason to expect that the economic impacts in Kansas caused by a reduction in the number of class I railroads from four to two can be extended to other geographic areas. Indeed a different class I merger grouping would have altered the merger impacts in the study area. As noted already, UP accounted for 45% of the premerger study area class I railroad mileage and SF had nearly 35%. Thus, a merger of UP–SF would have produced a railroad controlling 80% of the study area class I rail mileage. In contrast, the actual class I premerger mileage shares were BNSF with 41.4% and UPSP with 58.6%. Thus, the main conclusion of the study (negligible changes in market power) may be partly due to the particular rail mergers that actually occurred.

The results of the study indicate that the ability of railroads to raise prices is restricted if the shippers in the area have access to at least two railroads—a result consistent with the predictions of the Bertrand model for homogenous products (Tirole 1988, pp. 209–11). The results are also consistent with those of Lemke and Babcock (1987), Levin (1981b), and MacDonald (1987, 1989).[19]

The results of the study have implications for U.S. railroad merger policy. The study indicates that railroad mergers do not necessarily increase railroad market power or make railroad shippers worse off. Instead, the study demonstrates that the impact of railroad mergers on shippers and railroads depends on factors that vary geographically, such as the degree of competition between railroads and intermodal competition.

References

Adam, B. D., and Dale G. Anderson. 1985. Implications of the staggers rail act of 1980 for level and variability of country elevator price bids. *Proceedings of the Transportation Research Forum—1985* 26:357–63.

Babcock, Michael W., L. Orlo Sorenson, Ming H. Chow, and Keith A. Klindworth. 1985. Impact of the staggers rail act on agriculture: A Kansas case study. *Proceedings of the Transportation Research Forum—1985* 26:364–72.

Casavant, Kenneth L. 1985. An examination of the relationship between the staggers rail act and agriculture in the United States. *Proceedings of the Transportation Research Forum—1985* 26:373–6.

Chow, Ming H. 1984. Economic impacts of structural changes in the wheat logistics system: Exporting winter wheat from twelve counties in northeast Kansas. Ph.D. thesis, Kansas State University, Manhattan, KS.

Clark, Maurice J. 1923. *Studies in the economics of overhead costs*. Chicago: University of Chicago Press.

Coyle, John J., Edward J. Bardi, and Robert A. Novak. 2000. *Transportation*. Cincinnati: South Western College Publishing.

[19] In seeking to measure the effect of railroad deregulation, Levin (1981b) concluded that the intensity of interrailroad competition is a critical determinant of the level of railroad prices and profits. He computed percentage changes in the railroad prices for field crops relative to the 1972 regulated base case. He estimated that with no interrailroad competition, these prices would increase by 40–80%. However, he discovered that in the presence of a moderate degree of interrailroad competition, these prices would only increase by 5–6%. Thus, as long as there is some interrailroad competition, increases in railroad postmerger market power are likely to be modest.

MacDonald (1989) estimated the effect of the Staggers Rail Act on railroad grain transportation. He found that before deregulation rail prices for Kansas wheat were relatively high due to a lack of water carrier competition. However, after deregulation, he found that interrailroad competition produced 8–15% reductions in rail prices for Kansas wheat shipped to Texas Gulf of Mexico ports. The implication is that if interrailroad competition remains after railroad mergers, then increases in railroad market power are likely to be moderate.

Dooley, Frank J. 1991. Economies of size and density for short line railroads. Fargo, ND: Upper Great Plains Transportation Institute MPC Report No. 91-2, North Dakota State University.

Fisher, F. M., and J. J. McGowan. 1983. On the misuse of accounting rates of return to infer monopoly profits. *American Economic Review* 73:82–97.

Fuller, Stephen W., Larry Makus, and Merritt Taylor. 1983. Effect of railroad deregulation on export grain rates. *North Central Journal of Agricultural Economics* 5:151–63.

Fuller, Stephen W., David Bessler, James MacDonald, and Michael Wolgenant. 1987. Effect of deregulation on export-grain rail rates in the plains and the corn belt. *Journal of the Transportation Research Forum* 28:160–7.

Harper, Donald V. 1982. *Transportation in America*. Englewood Cliffs, NJ: Prentice-Hall, Inc.

Hauser, Robert J. 1986. Competitive forces in the U.S. inland grain transportation industry: A regional perspective. *The Logistics and Transportation Review* 22:158–73.

Interstate Commerce Commission, Bureau of Accounts. 1991. *Uniform railroad costing system: Phase III movement costing program users manual*. Washington, DC: Interstate Commerce Commission, Bureau of Accounts.

Kansas Department of Agriculture. 1993. *Kansas grain marketing and transportation: Data for 1992 crop and historical data 1983–91*. Topeka, KS: Kansas Department of Agriculture.

Kansas Department of Agriculture. 1994. *Custom wheat cutter rates—1994*. Topeka, KS: Kansas Department of Agriculture.

Kansas Department of Agriculture. 1995. *Farm facts—1995*. Topeka, KS: Kansas Department of Agriculture.

Kansas Department of Agriculture. 1996. *Farm facts—1996*. Topeka, KS: Kansas Department of Agriculture.

Kansas Department of Agriculture. 1997. *Farm facts—1997*. Topeka, KS: Kansas Department of Agriculture.

Kansas Grain and Feed Association. 1994. *1994 Kansas official guide, a reference for buyers and sellers*. Topeka, KS: Kansas Grain and Feed Association.

Klindworth, Keith A., L. Orlo Sorenson, Michael W. Babcock, and Ming H. Chow. 1985. *Impacts of rail deregulation on marketing of Kansas wheat*. Washington, DC: U.S. Department of Agriculture, Office of Transportation.

Koo, Won W. 1985. Tariffs and transportation costs on U.S. wheat exports: A quadratic programming approach. In *Transportation models for agricultural products*, edited by Won W. Koo and Donald W. Larson. Boulder, CO: Westview Press, pp. 105–23.

Lemke, Kenneth, and Michael W. Babcock. 1987. Impact of rail mergers on Kansas export wheat rail rates and costs. *Journal of the Transportation Research Forum* 28:151–9.

Levin, Richard C. 1981a. Verified Statement of Richard C. Levin. Washington, DC: Interstate Commerce Commission, Finance Docket No. 30,000 (Sub. No. 34).

Levin, Richard C. 1981b. Railroad rates, profitability, and welfare under deregulation. *Bell Journal of Economics* 12:1–20.

MacDonald, James M. 1987. Competition and rail rates for the shipment of corn, soybeans, and wheat. *Rand Journal of Economics* 18:151–63.

MacDonald, James M. 1989. Railroad deregulation, innovation, and competition: Effects of the staggers act on grain transportation. *Journal of Law and Economics* 32:63–95.

Park, Joon Je. 1998. The economic impact of rail mergers on Kansas export wheat rail rates. Ph.D. thesis, Kansas State University, Manhattan, KS.

Sorenson, Orlo L. 1984. Some impacts of rail regulatory changes on grain industries. *American Journal of Agriculture Economics* 66:645–50.

Thompson, S. R., Robert Hauser, and B. Coughlin. 1990. The competitiveness of rail rates on export-bound grain. *The Logistics and Transportation Review* 26:35–52.

Tirole, Jean. 1988. *The theory of industrial organization*. Cambridge, MA: MIT Press.

U.S. Department of Agriculture, Office of Transportation. 1982. *An assessment of impacts on agriculture of the staggers rail act and motor carrier act of 1980*. Washington, DC: U.S. Department of Agriculture, Office of Transportation.

U.S. Department of Agriculture, Office of Transportation. 1984. *Effects of the staggers act on grain marketing*. Washington, DC: U.S. Department of Agriculture, Office of Transportation.

Werden, Gregory J., and Luke M. Froeb. 1996. Simulation as an alternative to structural merger policy in differentiated products industries. In *The economics of antitrust*, edited by M. B. Coate and A. N. Kleit. Boston, MA: Kluwer Academic Publishers, pp. 65–88.

Werden, Gregory J., and Luke M. Froeb. 1994. The effects of mergers in differentiated products industries: Logit demand and merger policy. *Journal of Law, Economics, and Organization* 10:407–26.