A CENTER OF EXCELLENCE FOR
RURAL AND INTERMODAL TRANSPORTATION

MPC REPORT NO. 03–145

Industry Costs and Consolidation: Efficienty Gains and Mergers in theRailroad Industry

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Disclaimer

ABSTRACT

Partial deregulation of the railroad industry substantially eased regulatory impediments to consolidation. Since partial deregulation, there has been a massive consolidation of firms in the railroad industry, which has been premised on efficiency gains, network rationalization, and service quality. In this paper, we focus on efficiency gains. We develop and estimate a model of costs that allows for the estimation of merger specific cost savings as well as industry cost savings. The results suggest that early mergers gave very small effects, but recent "mega" mergers have given very large effects. Our central result is that consolidation in the railroad industry from 1983-1997accounts for about a 17 percent reduction in industry costs.

* Research assistance from Doug Benson and the staff of the Upper Great Plains Transportation Institute are gratefully acknowledged. An earlier version was presented at the University of Florida and at the TPUG Meetings of the American Economic Association, and we gratefully acknowledge comments from the audience and comments and discussions with the Ph.D. econometrics class at the University of Oregon. This research was conducted under funding from the Mountain Plains Consortium for Transportation Research.

ABSTRACT

Partial deregulation of the railroad industry substantially eased regulatory impediments to consolidations. Since partial deregulation, there has been a massive consolidation of firms in the railroad industry, which has been premised on efficiency gains, network rationalization, and service quality. In this paper, we focus on efficiency gains. We develop and estimate a model of costs that allows for the estimation of merger specific cost savings as well as industry cost savings. The results suggest that early mergers gave very small effects, but recent "mega" mergers have given very large effects. Our central result is that consolidation in the railroad industry from 1983-1997 accounts for about a 17 percent reduction in industry costs.

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*Research and writing [illegible] University of Oregon. This research was conducted [illegible]

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1. INTRODUCTION

Railroads were partially deregulated by the Stagger's Rail Act of 1980, following years of decline with multiple bankruptcies, deteriorating productivity and financial positions, and misallocated traffic as a result of artificial constraints imposed by regulation (e.g., Boyer, 1979; 1981). Following partial deregulation, there have been tremendous increases in productivity and decreases in rates and costs.[1,2] For example, as reported by the American Association of Railroads (*Railroad Facts)*, in nominal terms, the average revenue per unit output (ton-miles) has fallen from 2.866 to 1.883 cents, while Berndt et al. (1993), Lee and Baumol (1987), Wilson (1996) and others report tremendous decreases in costs from partial deregulation.

Against these gains is a growing concern over the consolidation of railroad output among fewer and fewer firms. Indeed, since partial deregulation, there has been a massive consolidation of railroad output through railroad mergers. At the time of partial deregulation, there were 40 Class I railroads that provided over 90 percent of all railroad output.[3] By 1997, the number of Class I railroads had fallen to nine, largely as a result of consolidation.[4] Mergers among railroads offer many potential benefits and costs.[5] The espoused benefits include cost savings through network consolidation with greater connectivity, realization of scale effects, less interlined traffic, and removal of duplicate plant (miles of track), and demand-side effects that allow the for better service with more direct routing and single-line service. Operating against these gains is the removal of direct and indirect intramodal competition (among railroads) and, as recent experience suggests, the potential for reduced quality of service. Railroads are required to seek and gain regulatory approval before

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[1]There is a rich literature on the effects of partial deregulation on rates. For example, Barnekov and Kliet (1990), Burton (1993), Friedlaender (1992), Fuller et al. (1987), Grimm and Smith (1987), MacDonald (1989a; 1989b), MacDonald and Cavalluzzo (1996), McFarland (1989), Wilson (1994), Wilson, Wilson, and Koo (1988), and Winston et al. (1990) each consider rates and rent-distribution. While there was at some debate of the effects of partial deregulation, it is now generally accepted that the effect of partial deregulation on rates is large and negative.

[2]Econometric estimation of the structure of railroad costs has a long history. See Winston (1985) for a survey of the early history. More recently, see Barbera et al. (1987), Berndt et al. (1993), Bitzan (1999), Caves et al. (1980; 1981 and 1985), Vellturo (1992), Wilson (1997), and Ivaldi and McCullough (2001). Generally, railroads are found in this literature to have increasing returns and some degree of complementarities in outputs. The effects of partial deregulation are generally found to be large and negative.

[3]Railroad classifications are in terms of gross operating revenues. Class I railroads have revenues in excess of $256 million for three consecutive years. Class II railroads have revenuens of between $20.5 to $256 million for three consecutive years. And, Class III railroads have revenues less than $20.5 million for three consecutive years. The revenue levels have been adjusted a number of times over the last 25 years. For example, in 1978 the Class I level was increased from $1 million to $5 million, and in 1983 it was increased to $10 million. As a result of declassifications, the number of Class I railroads fell by six since 1980.

[4]We note that as documented in Wilner (1997), mergers and a declining number of firms have been observed in the industry for decades. Indeed, the number of Class I carriers in 1920 was over 180 and has fallen every decade since to just 8 in 2000.

[5]Recent research includes Berndt et. al (1993), Bitzan (1999), Harris and Winston (1983), Kwoka and White (1998), and Pittman (1990) and Vellturo et al. (1992). Berndt et al. find that mergers explain only 10 percent of cost changes under partial deregulation. Vellturo et al. (1992) examine four specific mergers that occurred between 1974-86, finding that mergers are idiosyncratic and can increase or decrease costs, and that the source of cost differences emanate from changes in route miles and average length of haul (i.e., mergers with substantial changes in route miles and greater lengths of haul tended to experience the large efficiency gains). Harris and Winston (1983) examine both cost as well as service effects. Kwoka and White (1998) and Pittman (1990) each provide excellent discussions of the issue related to railroad mergers.

a merger can occur. While regulatory policy has changed over time, significant efficiency gains are often part of the application. For example, in the BN-ATSF merger application, operating and support function savings totaled $560 million. In the UP-SP merger application, cost savings of nearly $583.8 million were projected (p.23).

In this paper, we focus entirely on the efficiency gains of mergers. We estimate a model of firm costs, using all Class I firms in the market over the time period. We estimate the effects of each of the twelve mergers taking place from 1983 through 1996. In addition, we estimate industry costs and assess the efficiency gains accruing to the industry from the consolidation of firms. We find that the early mergers in the industry had relatively minor effects - both in terms of firm specific cost savings and in terms of industry cost savings. However, the recent "mega" mergers have had significant cost savings to individual firms and have dramatically reduced industry costs.

In the next section, we provide a description of merger policy since the 1980s. In section 3, we describe our empirical model. Section 4 presents a detailed description of the data sources and data, while Section 5 presents our empirical results.

2. RAILROAD MERGERS[6]

Railroads have been consolidating throughout the industry's history. Policy has varied quite a lot since the inception of the industry. Prior to passage of the Sherman Act in 1890, railroad mergers were not regulated. As noted by Smith (1983), there "were countless mergers and acquisitions..." (p. 558). The Transportation Act of 1920 gave the Interstate Commerce Commission jurisdiction over mergers, exempting such mergers from anti-trust laws. This legislation resulted in a relatively stringent consolidation policy with relatively few railroad mergers.[7]

The Transportation Act of 1940 changed the form of merger policy dramatically. Under this legislation, the ICC could approve consolidation if it was in the public interest. Determination of the public interest considered four specific factors: 1) the effect on the adequacy of transportation to the public, 2) the effect of including or excluding other carriers in the area of the merger, 3) the total fixed charges that would result, and 4) the interests of carrier employees. This legislation was less restrictive than its predecessor, and as Wilner (1997) states, "Beginning during the late 1950s there commenced a rush among railroads to merge and consolidate not seen since before application of the antitrust laws." (P. 89). Over this time period merger applications were growing in complexity, and mergers became larger. This resulted in long merger proceedings, as merger approval took up to eleven years. This legislation remained until passageof the 4-R Act of 1976 (The Railroad Revitalization and Regulatory Reform Act of 1976) and the Staggers Act of 1980, which streamlined the application process.

Under partial deregulation rules, the Interstate Commerce Commission and its successor, the Surface Transportation Board, weighed the potential benefits of more financially stable carriers and the resulting service improvements against potential harms of reduced competition and reductions in essential services.[8] The merger approval process also included provisions for placing conditions on mergers to reduce anticompetitive effects and to preserve essential services where necessary, but noted that such conditions may reduce the benefits of consolidation. Finally, the process included labor protection, and included a provision for requiring the inclusion of other rail carriers in the merger as a last resort. The process only considered a limited amount of "crossover effects," or the effects that such a merger would have in stimulating other mergers. These rules remained intact from 1981 through March 2000 when the STB placed a moratorium on further merger activity in the industry due to concern about growing concentration and service disruptions from recent mergers.

In June 2001 the Surface Transportation Board (STB) issued major revisions to its rail merger guidelines.[9] In its notice of proposed rules, the STB stated[10]:

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[6]For an extensive discussion of railroad merger policy, see Smith (1983) and Wilner (1997).

[7]That is not to say consolidation was not occurring. Mergers had to follow a consolidation plan mandated by the ICC. However, stock controls were not governed and until 1933 stock control was a popular form of firm consolidation. In 1933, the Emergency Railroad Transportation Act, brought such consolidation under jurisdiction of ICC policy. See Smith (1983.

[8]49 CFR §1180.1(c).

[9]STB Ex Parte No. 582 (Sub-No. 1) Major Rail Consolidation Procedures, June 11, 2001.

[10]STB Ex Parte No. 582 (Sub-No. 1) Major Rail Consolidation Procedures, October 3, 2000.

The existing policy statement (49 CRF 1180.1) (established in 1979, and modified in 1981), which has guided the review by us and by the Interstate Commerce Commission (ICC) of all rail merger proposals for more than 20 years, is decidedly pro-merger. It was predicated upon the notion that there was a pressing need for the nation's rail carriers to reorganize their operations on a more economically efficient and sustainable basis. ... railroads have now reduced most or all of their excess capacity, and have greatly improved the efficiency of operations. The last round of consolidations resulted in significant transitional service problems, which could recur with future mergers. Thus, at this point, we believe that it is appropriate to require merger applicants to bear a heavier burden to show that a major merger proposal is in the public interest.

The new merger guidelines make several important changes to the way that merger proposals are considered. These include: (1) requiring applications to demonstrate enhanced competition as a result of the merger, (2) explicit consideration of the potential for transitional service disruptions in deciding whether to approve the merger, (3) weighting of the benefits and costs of mergers depending on when such benefits and costs are expected to occur (i.e., benefits that are not expected to occur for some time are given a lower weight), (4) explicit consideration of the effects of mergers on the ability of short-line carriers to maintain essential services, (5) requiring applications to include a plan to keep major gateways open and to provide separate rates for newly created bottleneck situations, (6) broadening of the ability to impose conditions to the merger, (7) adding a formal merger oversight process to the rules, (8) requiring a specific plan for providing improved service as a result of the merger, and (9) requiring applications to include an assessment of the anticipated mergers that will be filed in response to the proposed merger and the effects on the public interest.

3. MODEL

In estimating the effects of mergers, we first estimate a translog cost function given by:

where *C, Q, w,* and T represent costs, output, factor prices and technological and operating characteristics

$$
\begin{aligned}
\ln C_{ft} = {} & \alpha_f + \beta_Q \ln Q_{ft} + \sum_i \delta_i \ln w_{ift} + \sum_j \gamma_j \ln T_{jft} + \frac{1}{2}\beta_{QQ} \ln(Q_{ft})^2 \\
& + \frac{1}{2}\sum_i \sum_k \phi_{ik} \ln(w_{ift}) \ln(w_{kft}) + \frac{1}{2}\sum_j \sum_m \varphi_{jm} \ln(T_{jft}) \ln(T_{mft}) \qquad (1) \\
& + \sum_i \eta_i \ln(Q_{ft}) \ln(w_{ift}) + \sum_j \theta_j \ln(Q_{ft}) \ln(T_{jft}) + \sum_i \sum_j \kappa_{ij} \ln(w_{ift}) \ln(T_{jft}) + \varepsilon_{ft}
\end{aligned}
$$

of the f firm at time t, with ε representing the corresponding error term. We estimate this model jointly with factor share equations (indexed by i) given by:

$$\frac{\partial \ln C_{ft}}{\partial w_{ift}} = s^i_{ft} = \delta_i + \sum_k \phi_k \ln(w_{kft}) + \eta_i \ln(Q_{ft}) + \sum_j \kappa_{ij} \ln(T_{jft}) + \varepsilon^i_{ft} \qquad (2)$$

In estimation, we impose the usual symmetry conditions given by:

$$\phi_{ik} = \phi_{ki}\ (\forall\ k, i), \varphi_{jm} = \varphi_{mj}\ (\forall\ m, j), and\ \kappa_{ij} = \kappa_{ji}\ (\forall\ i, j) \qquad (3)$$

and linear homogeneity conditions given by:

$$\sum_i \delta_i = 1, \sum_i \phi_{ik} = 0 (\forall\ k), \sum_i \eta_i = 0, and \sum_i \kappa_{ij} = 0 (\forall\ j) \qquad (4)$$

We note that in estimating the model, each firm has an individual fixed effect (α_f) to capture unobserved cost effects that are specific to each firm. In defining the fixed effects, we follow the practice used by Caves et. al (1985) by defining a "new firm" in the year following a merger.

3. MODEL

In estimating the effects of mergers, we first estimate a translog cost function given by:

$$\ln C_{it} = \alpha_0 + \alpha_i + \beta_Q \ln Q_{it} + \sum_j \beta_j \ln w_{jit} + \sum_k \gamma_k \ln Z_{kit} + \frac{1}{2}\beta_{QQ}(\ln Q_{it})^2$$

$$+ \frac{1}{2}\sum_j \sum_k \phi_{jk} \ln(w_{jit}) \ln(w_{kit}) + \frac{1}{2}\sum_k \sum_m \psi_{km} \ln Z_{kit} \ln Z_{mit} \quad (1)$$

$$+ \sum_j \rho_{jQ} \ln(Q_{it}) \ln(w_{jit}) + \sum_k \theta_k \ln(Q_{it}) \ln(Z_{kit}) + \sum_j \sum_k \tau_{jk} \ln(w_{jit}) \ln(Z_{kit})$$

where C, Q, w, and Z represent total cost, output, factor prices and output-related characteristics of the i-th firm in time t, with a superscript denoting the corresponding factor share. We estimate the model jointly with factor share equations (derived from (1)) given by:

$$\frac{\partial \ln C_{it}}{\partial \ln w_{jit}} = S_{jit} = \beta_j + \rho_{jQ} \ln Q_{it} + \sum_k \phi_{jk} \ln w_{kit} + \sum_k \tau_{jk} \ln Z_{kit} \quad (2)$$

In estimation, we impose the usual symmetry conditions given by:

$$\phi_{jk} = \phi_{kj}\ (\forall\, k, j),\ \psi_{km} = \psi_{mk}\ (\forall\, m, k),\ \text{and}\ \tau_{jk} = \tau_{kj}\ (\forall\, k, j) \quad (5)$$

and linear homogeneity conditions given by:

$$\sum_j \beta_j = 1,\ \sum_j \phi_{jk} = 0\ (\forall k),\ \sum_j \rho_{jQ} = 0,\ \text{and}\ \sum_j \tau_{jk} = 0\ (\forall k) \quad (6)$$

We note that in estimating the model, each firm has an individual fixed effect that captures the production effects that are specific to each firm. In defining the fixed effects, we follow the practice used by Caves et al (1985) by defining a "new firm" in the year following a merger.

4. DATA

Our data come primarily from Class I railroad annual reports to the Interstate Commerce Commission (i.e., R-1 reports).[11] These data consist of detailed information pertaining to financial and operating characteristics of the nation's largest railroads and are the most comprehensive data available at the firm level. The data are firm specific, running from 1983 through 1997 and comprising an unbalanced panel. In total, there are a possible 240 firm years in the data. We use 237 of these in our estimation, omitting three due to missing values. Finally, we provide a list of railroad names and abbreviations used to identify firms in Table A-1 of the Appendix. These abbreviations are used through the remainder of the paper.

In Table 1, we summarize the number of firms over time along with average firm size measured by revenue ton-miles and miles of road.[12] The number of firms has fallen dramatically. In 1983, there were 28 firms in the data; by 1997 the number of firms in the data fell to only nine firms.[13]

Corresponding with the decrease in the number of firms is a tremendous increase in firm size, measured by either revenue ton-miles (RTM) or miles of road (MOR). In 1983, the average firm produced about 29.5 billion ton-miles over a network size of about 6,030 miles. In 1997, the average firm produced about 150 billion ton-miles over a network size of about 13,519 miles. The increase in average firm output is over 400 percent, while the increase in average firm network size is over 120 percent. As an industry, Class I railroads produced about 825 billion ton-miles over a network of about 168,000 miles in 1983. By 1997, Class I railroads produced about 1,349 billion ton-miles (an increase of 64 percent) over a network of about 121,670 (a decrease of about 28 percent). Thus, at an industry level, railroads are producing more output over a smaller network. At the firm level, firms are growing much faster than the industry in terms of output and, while increasing network sizes, the network itself is used much more intensively. For example, in 1983, firms produced about 4.89 million ton-miles per mile of road. In 1997, firms produced about 11.09 million ton-miles per mile of road, an increase of about 127 percent.

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[11] The R-1 data were first established in 1978. In 1983, there was a change from betterment accounting to depreciation based accounting in 1983. Under betterment accounting long-term investments were often included as expenses. Under depreciation based accounting standards, such items are depreciated and only a portion of the investment is included as expenses.

[12] Revenue ton-miles (RTM) is the classic measure of firm output. It is the number of ton-miles that are engaged in the production of revenue. A ton-mile is one ton moved one mile. We also note that since the production characteristics of one ton moved 1000 miles are distinctly different than 1000 tons moved one mile, analysts often include empirical measures such as length of haul to capture differences. Miles of road (MOR) is a measure of network size. This measure reflects the number of miles of track exclusive of parallel lines. Essentially it is the same as route miles.

[13] These data correspond quite closely with the American Association of Roads *Railroad Facts* (various years). However, there are some differences. In the early years of our data, EJE and Long Island are Class I carriers in *Railroad Facts*. However, as the EJE is a switching line and Long Island is a commuter rail line, they were omitted from our data. Other differences between our data reflect differences in the timing of mergers. For example, in 1986 WP and MP were part of the UP merger. It is common as in this case that separate and consolidated reports were filed with the ICC. In our data, we use the UP consolidated reports. Similarly, in 1986, the Southern and NW are reflected in the consolidated report of the NS. In 1987, we have 18 firms in the data. The difference is the BM and DH railroads, each of which were declassified as Class I carriers in 1988 and 1987, respectively. Data are available for each firm in the year declassified, but they are not reflected as Class I railroads in the *Railroad Facts*. For 1992, 1993, and 1994, hours of work data are not available for KCS. As a result, this firm was dropped from the data.

TABLE 1. NUMBER OF FIRMS, AVERAGE FIRM SIZE, AND TOTAL INDUSTRY OUTPUT

Year	Number of Railroads	Average Revenue Ton-miles (In billions)	Average Miles of Road (Miles)	Total Revenue Ton-miles (In billions)	Total Miles of Road (Miles)
1983	28	29.46	6030	824.79	168838
1984	27	34.01	6118	918.17	165188
1985	22	39.84	7298	876.50	160562
1986	18	48.21	8638	867.72	155488
1987	18	52.43	8190	943.75	147414
1988	16	61.91	8873	990.54	141963
1989	15	67.59	9167	1013.82	137504
1990	14	73.86	9514	1033.97	133189
1991	14	74.21	9274	1038.88	129839
1992	13	82.06	9708	1066.78	126201
1993	13	85.33	9516	1109.31	123703
1994	12	100.06	10260	1200.70	123123
1995	11	118.70	11352	1305.69	124871
1996	10	134.65	12668	1346.46	126682
1997	9	149.89	13519	1349.04	121670

There are two reasons for the reduction of firms in Table 1. First, some firms were declassified as Class I railroads. These are the smallest of the railroads, which after reaching a minimum size threshold no longer need to satisfy the same level of financial and operating disclosure. Six of the original 28 firms were declassified as Class I railroads, and in each case, the share of industry output produced by these Class I carriers is less than one-half of one percent in the last year for which data are available. The disappearance of the remaining firms is the result of consolidation activities summarized in Table 2. During the time period, there were 12 mergers identified in Table 2. Of the original 28 firms, 17 disappeared as the result of being consolidated into an existing firm identity or, in four cases, were reorganized under a new firm identify (NS, CSX, BNSF, and UPSP). There are only three firms in the data which were not part of a merger over the entire time period (CR, ICG, and KCS), and two of these have since been party to a merger.

It has long since been held that economies of density and, perhaps, size exist in the industry.

TABLE 2. SUMMARY OF FIRMS AND YEARS IN DATA

Railroad	#	Years in Data	Reason for Disappearance
Change of Status			
BLE	2	1983-1984	Lost Class I status
BM	6	1983-1988	Lost Class I status
DH	5	1983-1987	Lost Class I status
DMIR	2	1983-1984	Lost Class I status
FEC	9	1983-1991	Lost ClasS I status
PLE	2	1983-1984	Lost Class I status
Merger Activity (1983-1997)-Summary of the 12 mergers			
DTI	1	1983	Merged with GTW
MILW	2	1983-1984	Merged with SOO
NW	2	1983-1984	Merged with SOU to form NS
SOU	2	1983-1984	Merged with NW to form NS
MP	3	1983-1985	Merged with UP
WP	3	1983-1985	Merged with UP
BO	3	1983-1985	Merged with CO and SCL to form CSX
CO	3	1983-1985	Merged with BO and SCL to form CSX
SCL	3	1983-1985	Merged with BO and CO to form CSX
MKT	5	1983-1987	Merged with UP
SSW	7	1983-1989	Merged with SP
DRGW	11	1983-1993	Merged with SP
CNW	12	1983-1994	Merged with UP
ATSF	13	1983-1995	Merged with BN
BN	13	1983-1995	Merged with ATSF
SP	14	1983-1996	Merged with UP
UP	14	1983-1996	Merged with SP
1997 Firms			
CSX	12	1986-1997	Formed from BO, CO, and SCL (1986)
NS	13	1985-1997	Formed from SOU and NW (1985)
UPSP	1	1997	Formed from UP and SP (1997)
BNSF	1	1996-1997	Formed from BN and SF (1996)
GTW	15	1983-1997	Merged with DTI (1984)

TABLE 2. SUMMARY OF FIRMS AND YEARS IN DATA

Railroad	#	Years in Data	Reason for Disappearance
SOO	15	1983-1997	Merged with MILW (1985)
CR	15	1983-1997	No Consolidation activity
ICG	15	1983-1997	No Consolidation Activity
KCS	12	1983-1991,1995-	No Consolidation Activity

[a] From 1992-94 KCS did not report data for hours of work, which did not allow for calculation of labor factor prices. We excluded KCS for 1992, 1993, and 1994 for the purposes of estimation. However, for the simulation exercises later, we used RTM and MOR figures as reported in the Moody's *Transportation Manual* (1997).

Economies of density reflect falling long-run average cost with output, given a fixed network size. Economies of size reflect falling long-run average cost when output and network size are increased. Given these economies may exist, a chief impetus underlying mergers has been, among other incentives, the realization of greater economies.[14] In Table 3, we document the scale effects from the 12 mergers over the time period. In this table, we identify the firms, output of firms, and network size, along with the share of the total output and network size in the industry in the year of the merger and the immediate year following the merger. As is evident in Table 3, the size of mergers has increased substantially over the 15 year period. The GTW-DTI merger in 1983 brought together two firms with combined output and network shares of less than 1 percent. In fact, the first six mergers in the time period, including the formation of CSX and NS, involved firms with output and network shares of less than 10 percent each. However, in the mid-1990s, the consolidation movement involved the industry leaders. The ATSF-BN merger in 1995 formed BNSF, which had an output and network share of over 25 percent, and the UP-SP merger in 1996 formed UPSP which had an output share of 33.5 percent and a network share of 28.72 percent in 1997.

Our primary interest is in evaluating the effects of changing industry costs as a result of consolidation activities. Our approach is to estimate a cost function and then to simulate industry costs to evaluate the changing industry structure. In specifying our cost function, we use variables to reflect output, network size, factor prices, and a set of firm characteristics. We use revenue ton-miles (RTM) as the measure of output and miles of road (MOR) as the measure of network size. In both cases, we expect that increases in the variables increase cost. We use five factor prices, including labor (WL), fuel (WF), equipment (WE), materials and supplies (WM), and way and structure (WS). Again, increases in each of these variables are expected to increase costs.

We include four variables to capture differences in firm operating characteristics and in the mix of traffic handled. These include average length of haul (the average number of miles a ton travels), average speed (train miles per hour in service), percent of traffic in through trains, and percent of traffic in way trains. There are tremendous quasi-fixed costs in railroad production,[15] and as average length of haul increases these

[14]Railroads may merge for a variety of reasons. These include the absorption of competition, greater network connectivity, the realization of economies and the expansion of product lines, i.e., the realization of scope economies.

[15]A movement from an origin to a destination requires yard switching of cars, bookkeeping and clerical costs, terminal switching costs, etc. Many of these costs are fixed for a given the movement, regardless of distance of the movement.

costs fall with distance traveled. Thus, given all else, as average length of haul increases, total costs are expected to decline. Average speed is the number of train miles per train hour (the running speed of a train). It is a measure of service quality, and is expected to increase costs. The remaining two variables reflect differences in the composition of output. Railroads produce ton-miles through three distinct production activities delineated by way, through, and unit train operations. Way train services are essentially a gathering activity. Operations occur over short distances, small shipment sizes, and slow speeds. These are generally considered the high cost mode of operations. Through train services are provided between major terminals with longer hauls, larger shipment sizes, and faster speeds than way train services. These operations generally reflect the bulk of railroad operations. Unit train services generally are extremely large shipments over very long lengths of haul, occurring at fast speeds, and in a dedicated fashion. These services generally occur between a single origin and destination, and are considered the least costly of activities. In the estimation, we include the percentage of ton-miles that are in way trains and through trains. We expect the first-order effects to be positive, reflecting the notion that unit train traffic is the least costly operation of railroads.

TABLE 3. SUMMARY OF MERGER EFFECTS

Merger	Year	Firm	RTM	Share (%)	MOR	Share (%)
1	1983	DTI	1.365	0.17	527	0.31
	1983	GTW	3.633	0.44	950	0.56
	1984	**GTW**	**5.581**	**0.61**	**1325**	**0.80**
2	1984	MILW	12.510	1.36	3023	1.83
	1984	SOO	9.961	1.09	4628	2.80
	1985	**SOO**	**18.342**	**2.09**	**7975**	**4.97**
3	1984	NW	43.766	4.77	7746	4.69
	1984	SOU	46.010	5.01	8595	5.20
	1985	**NS**	**91.755**	**10.47**	**17620**	**10.97**
4	1985	BO	25.276	2.89	5268	3.28
	1985	CO	32.213	3.68	4500	2.80
	1985	SCL	76.573	8.74	14177	8.83
	1986	**CSX**	**127.502**	**14.69**	**22887**	**14.72**
5 & 6	1985	MP	51.371	5.86	10920	6.80
	1985	UP	74.612	8.51	8783	5.47
	1985	WP	5.786	0.66	1409	0.88
	1986	**UP**	**136.097**	**14.44**	**21416**	**13.77**
7	1987	MKT	9.714	1.03	3130	2.12
	1987	UP	157.219	16.66	20944	14.21
	1988	**UP**	**176.648**	**17.83**	**22653**	**15.96**
8	1989	SP	69.382	6.84	9879	7.19
	1989	SSW	17.026	1.68	2898	2.11
	1990	**SP**	**86.096**	**8.33**	**12600**	**9.46**
9	1993	DRGW	17.399	1.57	2179	1.76
	1993	SP	101.119	9.12	11920	9.64
	1994	**SP**	**132.972**	**11.07**	**13715**	**11.14**
10	1994	CNW	37.199	3.10	5211	4.23
	1994	UP	235.771	19.31	17499	14.21
	1995	**UP**	**307.426**	**23.55**	**22785**	**18.25**

TABLE 3. SUMMARY OF MERGER EFFECTS

Merger	Year	Firm	RTM	Share (%)	MOR	Share (%)
11	1995	ATSF	104.487	8.00	9126	7.31
	1995	BN	293.415	22.47	22200	17.78
	1996	**BN**	**411.060**	**30.53**	**35208**	**27.79**
12	1996	SP	155.592	11.56	14404	11.37
	1996	UP	323.350	24.02	22266	17.58
	1997	**UP**	**451.855**	**33.50**	**34946**	**28.72**

Merged firm in bold.

The final set of variables included in the estimation include fixed effects for firms and a set of variables to reflect the effects of productivity. The fixed effects are firm dummy variables. In defining the firm dummies, we introduce a "new" dummy whenever a firm is part of a merger. The effects of productivity are captured in a time trend. Table 4 contains detailed descriptions of the construction of the variables we use in the analysis, while Table 5 contains summary statistics of the raw data over time.

The primary feature of Table 5 is the reduction in average cost per ton-mile. In 1983, it was 6.4 cents, falling to 3.01 cents in 1997. This is a reduction in real costs per ton-mile of over 50 percent over the time period. There are a number of variables driving costs (including mergers discussed above). The realization of economies is potentially an important driving force. And, as noted earlier, both network size and firm outputs have grown substantially over the time period. In addition, there are a number of changes in the traffic characteristics of firms, each pointing toward greater efficiency and reduced costs in producing output. First, average length of haul has increased from 366 miles in 1983 to 489 miles in 1997, an increase of 33 percent. Second, the mix of traffic has become less concentrated in terms of way and through operations and more toward unit train operations. Specifically, in 1983, 80 percent of the average firm's gross ton-miles were in through train activities with about 8.6 percent in way train activities and about 11.4 percent in unit train activities. By 1997, only about 69 percent of activities were through train, 4.6 percent were way train, and unit train activities were about 26.2 percent. Again, unit train activities are expected to be the lowest cost activity in producing ton-miles, and this change in traffic mix is about a 15 percentage point change.

The remaining variables explaining cost indicate change as well. Labor and materials factor prices fluctuated over the time period with no discernable trends. However, both equipment and way and structure factor prices have increased substantially, while fuel price has fallen. In terms of factor shares, labor and way and structure are the largest cost expenditures. In 1983, labor costs were about 35 percent of total costs, decreasing to 27 percent in 1997. Way and structure costs in 1983 were about 23 percent of total costs, increasing to about 33 percent in 1997. Equipment shares fell from 14 to 11 percent, fuel fell from 7 to 5 percent, while materials and supplies increased slightly from 19 to 22 percent.

TABLE 4. DATA DEFINITIONS AND SOURCES USED TO ESTIMATE THE RAILROAD COST FUNCTION*

Variable	Source
Variable Construction	
Real Total Cost	(OPERCOST-CAPEXP +ROIRD +ROILCM+ROICRS)/GDPPD
OPERCOST	Railroad Operating Cost (R1, Sched. 410, ln. 620, Col F)
CAPEXP	Captial Expenditures Classified as Operating in R1 (R1, Sched 410, lines 12-30, 101-109, Col F)
ROIRD	Return on Investment in Road (ROADINV-ACCDEPR)*COSTKAP
ROADINV	Road Investment (R1, Sched 352B, line 31) + CAPEXP from all previous years
ACCDEPR	Accumulated Depreciation in Road (R1, Sched 335, line 30, Col. G)
COSTKAP	Cost of Capital (AAR *Railroad Facts*)
ROILCM	Return on Investment in Locomotives [(IBOLOCO+LOCINVL)-(ACDOLOCO+LOCACDL)]*COSTKAP
IBOLOCO	Investment Base in Owned Loc. (R1, Sched 415, line 5, Col. G)
LOCINVL	Investment Base in Leased Loc. (R1, Sched 415, line 5, Col. H)
ACDOLOCO	Accum. Depr. Owned Loc. (R1, Sched 415, line 5, Col. I)
LOCACDL	Accum. Depr. Leased Loc. (R1, Sched 415, line 5, Col. J)
ROICRS	Return on Investment in Cars [(IBOCARS+CARINVL)-(ACDOCARS+CARACDL)]*COSTKAP
IBOCARS	Investment Base in Owned Cars (R1, Sched 415, line 24, Col. G)
CARINVL	Investment Base in Leased Cars (R1, Sched 415, line 24, Col. H)
ACDOCARS	Accum. Depr. Owned Cars (R1, Sched 415, line 24, Col. I)
CARACDL	Accum. Depr. Leased Loc. (R1, Sched 415, line 24, Col. J)
Output Variable	
RTM	Revenue Ton-Miles (R1, Sched 755, line 110, Col. B)

TABLE 4. DATA DEFINITIONS AND SOURCES USED TO ESTIMATE THE RAILROAD COST FUNCTION*

Variable	Source
Road Miles	
Miles of Road	(R1, Sched 700, line 57, Col. C)
Factor Prices (all divided by GDPPD)	
Labor Price	Labor Price per Hour (SWGE+FRINGE-CAPLAB) / LBHRS - all W&S labor costs are excluded from the labor share for the quasi-cost function
SWGE	Total Salary and Wages (R1, Sched 410, line 620, Col B)
FRINGE	Fringe Benefits (R1, Sched 410, lns. 112-114, 205, 224, 309, 414, 430, 505, 512, 522, 611, Col E)
CAPLAB	Labor Portion of Cap. Exp. Class. as Operating in R1 (R1, Sched 410, lines 12-30, 101-109, Col B)
LBHRS	Labor Hours (Wage Form A, Line 700, Col 4+6)
Equipment Price	Weighted Average Equipment Price (ROI and Ann. Depr. per Car and Locomotive - weighted by that type of equipment's share in total equipment cost)
Fuel Price	Price per Gallon (R1, Sched 750)
Materials and Supply Price	AAR Materials and Supply Index
Way and Structures Price	(ROIRD+ANNDEPRD)/ MOT
ANNDEPRD	Annual Depreciation of Road (R1, Sched 335, line 30, Col C)
MOT	Miles of Track (R1, Sched 720, line 6, Col B)
Technological Conditions	
Speed	Train Miles per Train Hour in Road Service = TRNMLS/(TRNHR-TRNHS)
TRNMLS	Total Train Miles (R1, Sched 755, line 5, Col. B)
TRNHR	Train Hours in Road Service - includes train switching hours (R1, Sched 755, line 115, Col. B)
TRNHS	Train Hours in Train Switching (R1, Sched 755, line 116, Col. B)
Average Length of Haul	RTM / REVTONS

TABLE 4.	DATA DEFINITIONS AND SOURCES USED TO ESTIMATE THE RAILROAD COST FUNCTION*
Variable	**Source**
REVTONS	Revenue Tons (R1, Sched 755, line 105, Col. B)
Unit Train Gross Ton-Miles	(R1, Sched 755, line 99, Col. B)
Way Train Gross Ton-Miles	(R1, Sched 755, line 100, Col. B)
Through Train Gross Ton-Miles	(R1, Sched 755, line 101, Col. B)
Through Train	Through Train Gross Ton-Miles / (Unit Train Gross Ton-Miles + Way Train Gross Ton Miles + Through Train Gross Ton-Miles)
Way Train	Way Train Gross Ton-Miles / (Unit Train Gross Ton-Miles + Way Train Gross Ton Miles + Through Train Gross Ton-Miles)

italics indicate that the variable is used directly in the translog estimation

TABLE 5. SUMMARY STATISTICS BY YEAR

Year	# Firms	AC cents	RTM Bil	MOR Miles	ALH Miles	Through %	Way %	Speed MPHr	Labor $/hr	Equip. $/Unit	Fuel $/gal	M and S $/mile	WS $/mile
1983	28	6.40	29.46	6030	366	80.0	8.6	24.8	25.50	22690	1.17	189	45021
1984	27	5.89	34.01	6118	372	79.8	7.6	24.8	26.11	23506	1.13	182	51215
1985	22	5.36	39.84	7298	407	79.0	7.0	26.0	24.45	28074	1.00	182	46470
1986	18	5.08	48.21	8638	403	78.2	5.7	28.0	24.71	24127	0.62	176	41022
1987	17	4.33	52.43	8190	419	76.7	6.9	28.1	25.75	24918	0.65	162	40273
1988	16	4.37	61.91	8873	429	77.6	5.7	26.5	27.06	24339	0.58	163	40182
1989	15	3.93	67.59	9167	456	76.3	5.6	28.5	26.83	28176	0.63	165	42220
1990	14	3.80	73.86	9514	448	75.0	5.4	27.9	27.07	27809	0.73	164	45271
1991	14	3.68	74.21	9274	453	72.7	5.3	28.2	26.31	31726	0.70	180	46652
1992	13	3.43	82.06	9708	481	73.4	5.6	28.5	25.94	31826	0.63	185	46784
1993	13	3.29	85.33	9516	493	72.3	5.4	27.0	25.19	32750	0.62	187	50005
1994	12	3.31	100.06	10260	498	70.1	5.4	26.5	25.88	37708	0.58	186	56074
1995	11	3.17	118.70	11352	494	68.6	4.8	26.0	25.79	38622	0.56	187	66947
1996	10	3.00	134.65	12668	494	68.5	4.8	24.4	26.01	38602	0.63	183	60333
1997	9	3.01	149.89	13519	489	69.1	4.6	22.1	26.54	37501	0.60	178	65398

Note: All monetary variables are measured in real terms using the Gross Domestic Product Price Deflator with 1992 as the base year. AC is measured in cents per ton-mile, materials and supplies is an index, and way and structure (WS) is measured in terms of cost per mile of track. Through and way percent are the percent of gross ton-miles in through and way train operations. Except for the number of firms, RTM and MOR, the 1992, 1993, and 1994 figures do not reflect KCS data.

5. EMPIRICAL RESULTS

We estimated the cost function and associated factor shares with homogeneity and symmetry restrictions imposed on the data. In estimation, we used three-stage-least squares due to the potential bias introduced by output and associated network/traffic characteristics (ALH, percent through train, percent way train, speed). For instruments, we separated the railroads into east and west regions and used corresponding commodity specific gross state products taken from the Bureau of Economic Analysis. The BEA provides gross state products across industies by state. We aggregated gross state product information across states in the east and west for the primary products hauled by railroads (coal, chemicals, agricultural, food and kindred products, nonmetallic and a residual defined as total gsp minus all included).

The results of the estimation are provided in Table 6. We also, for comparison purposes, provide seemingly unrelated regression results in table A3 of the Appendix. We also conducted a Hausman (1978) test for differences between SUR and 3SLS, finding that 3SLS results should be used. Generally, the results correspond extremely well with previous research of this type where comparisons can be made. First, there are economies of density. At mean values, a 1 percent change in output (RTM) leads to a .8274 increase in costs. Second, a 1 percent increase in miles of road (MOR) leads to a .6272 percent increase in costs. Third, average length of haul has a negative coefficient. However, in the 3SLS results, this coefficient is not statistically different from zero, while in the SUR results it has a modest negative effect on costs (relative to previous research).[16] The network activity variables (Through % and Way %) suggest that costs are lower for railroads with considerable unit train traffic. Fourth, speed does not have a statistically significant effect on mean values but, based on F-tests, has an important effect through the second order terms. Finally, the trend variable has a negative and statistically significant effect of -.0234, suggesting that costs fall approximately -0.0213 percent per year during the time period. Most of these results are fully consistent with recent research in this area, using models that are comparable (see, for example, Bitzan, 1999) who reported similar results with a similar specification. In the ensuing subsections, we use these results to simulate the effects of specific mergers through the time period and to simulate industry costs over the time period of analysis.

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[16]Our examinations suggest that the effects of traffic composition (e.g., the percentage of unit, way, and through train traffic, average length of haul, etc.) are significantly correlated and are significantly affected by the inclusion or exclusion of firm effects.

TABLE 6. THREE STAGE ESTIMATION RESULTS

Variable	Estimat	Std. Error	Variable	Estimate	Std. Error	Variable	Estimate	Std. Error
q1 (RTM)	0.8274*	(0.1576)	w2w3	-0.0010	(0.0015)	t1w1	-0.0105	(0.0106)
w1 (Labor)	0.3602*	(0.0069)	w2w4	0.0087	(0.0073)	t1w2	-0.0458*	(0.0081)
w2 (Equip.)	0.1525*	(0.0055)	w2w5	-0.0254*	(0.0056)	t1w3	-0.0100*	(0.0027)
w3 (Fuel)	0.0595*	(0.0018)	w3w3	0.0458*	(0.0034)	t1w4	0.0465*	(0.0121)
w4 (Materials)	0.1862*	(0.0086)	w3w4	-0.0118*	(0.0047)	t1w5	0.0198**	(0.0101)
w5 (Way & Struc.)	0.2414*	(0.0063)	w3w5	-0.0152*	(0.0023)	t2w1	-0.0701*	(0.0102)
t1 (MOR)	0.6272*	(0.1355)	w4w4	0.0345*	(0.0169)	t2w2	-0.0138	(0.0083)
t2 (ALH)	-0.0427	(0.2052)	w4w5	-0.0209*	(0.0043)	t2w3	0.0315*	(0.0025)
t3 (Through %)	0.7486*	(0.2226)	w5w5	0.1470*	(0.0088)	t2w4	0.0313*	(0.0127)
t4 (Way %)	0.0625	(0.0538)	t1t1	-0.1055	(0.1518)	t2w5	0.0210*	(0.0094)
t5 (Speed)	0.0825	(0.1660)	t1t2	0.1923	(0.2582)	t3w1	0.0059	(0.0102)
t6 (Trend)	-0.0234*	(0.0116)	t1t3	-0.5235**	(0.2852)	t3w2	0.0117	(0.0081)
q1q1	0.0721	(0.1624)	t1t4	0.1180*	(0.0571)	t3w3	-0.0087*	(0.0025)
q1w1	0.0231*	(0.0101)	t1t5	0.0878	(0.2131)	t3w4	0.0314*	(0.0127)
q1w2	0.0399*	(0.0077)	t1t6	0.0112	(0.0119)	t3w5	-0.0404*	(0.0094)
q1w3	0.0039	(0.0027)	t2t2	-0.2475	(0.4116)	t4w1	-0.0031	(0.0042)
q1w4	-0.0521*	(0.0115)	t2t3	-0.2978	(0.5125)	t4w2	0.0151*	(0.0034)
q1w5	-0.0149	(0.0097)	t2t4	0.1685*	(0.0814)	t4w3	-0.0045*	(0.0010)

TABLE 6. THREE STAGE ESTIMATION RESULTS

Variable	Estimat	Std. Error	Variable	Estimate	Std. Error	Variable	Estimate	Std. Error
q1t1	0.1944	(0.1377)	t2t5	0.2251	(0.1832)	t4w4	-0.0198*	(0.0054)
q1t2	0.0194	(0.2339)	t2t6	0.0372*	(0.0179)	t4w5	0.0123*	(0.0039)
q1t3	0.6643*	(0.2649)	t3t3	0.2312	(0.6184)	t5w1	-0.0181	(0.0113)
q1t4	-0.0642	(0.0563)	t3t4	0.1906**	(0.1086)	t5w2	-0.0170**	(0.0090)
q1t5	0.0330	(0.1354)	t3t5	0.3617	(0.2241)	t5w3	0.0012	(0.0028)
q1t6	-0.0145	(0.0116)	t3t6	-0.0185	(0.0136)	t5w4	0.0475*	(0.0142)
w1w1	0.1177*	(0.0140)	t4t4	0.0541	(0.0421)	t5w5	-0.0135	(0.0102)
w1w2	-0.0040	(0.0057)	t4t5	-0.2624*	(0.0812)	t6w1	-0.0050*	(0.0007)
w1w3	-0.0176*	(0.0033)	t4t6	0.0049	(0.0045)	t6w2	-0.0040*	(0.0005)
w1w4	-0.0105	(0.0136)	t5t5	-1.0851*	(0.2721)	t6w3	0.0004*	(0.0002)
w1w5	-0.0854*	(0.0079)	t5t6	-0.0465*	(0.0169)	t6w4	0.0044*	(0.0009)
w2w2	0.0216*	(0.0050)	t6t6	-0.0013	(0.0011)	t6w5	0.0042*	(0.0006)

Note: Acronyms are used in presenting the results. In () following the acronyms for output (q), factor prices (w), and operating, network, and technological variables (t) are key words to identify the relevant variable. A*and**indicate significance at the 5 and10 percent levels.

5.1 Individual Mergers

In the data, there were 12 mergers as documented in Table 2 and 3. We do note that two mergers involving the Union Pacific (UP) occurred in the same year (MP-UP and WP-UP), and we treat those as a single merger. We do two sets of simulations. The simulations are a comparison of costs between separate firms (hereinafter, constituent firms) with the combined firms. That is, for the case of two firms combining to form a new firm, we calculate the cost savings as:

$$CostEffect = C(Q_1 + Q_2 : X_{1+2}) - \left(C(C(Q_1 : X_1) + C(Q_2 : X_2)\right) \quad (5)$$

In both simulations, we set the scale variables (RTM and MOR) at pre-merger values (i.e. the merged firm's RTM and MOR are the combined pre-merger values of RTM and MOR). The simulations differ by treatment of the remaining variables. In simulation 1 we use the merged firm's remaining variables. This allows the reference values other than output and miles of road to change as the firm's combine. In the second set of simulations we use a weighted average (by revenue ton-miles) of constituent firm non-scale reference variables. The results based on the 3SLS estimates are in Table 7, and results based on SUR are in table A4 of the appendix.

A general view of our results suggests that the effects of mergers are idiosyncratic, with both increases and decreases in costs. A comparison of costs before and after a merger, controlling for scale effects and using observed reference points, suggests that in three of the 11 mergers, there are cost increases, while in the remaining nine mergers there are cost savings (D-1 in Table 7). The largest estimated cost savings accrue in the UP-SP-WP, CSX, and BNSF mergers. In this formulation, observed changes in reference values are embedded in the calculation. To control, albeit crudely, for changes in reference values, we construct reference values for the merged firm that are weighted averages of the constituent firms the year before the merger. The cost savings using this approach are less frequently observed. Indeed, only six of the 11 calculations indicate cost savings, with cost increases in the other five mergers (D-2 in Table 7). The results suggest that changes in the reference points play an important role in assessing the effects of mergers.

To examine the results in greater detail, we present changes before and after each merger by operating statistic (MOR, RTM, ALH, SPEED, WAY, THOUGH, and UNIT) on an absolute basis and on a percentage basis. Table 8 shows the changes in operating statistics resulting from mergers. In calculating the before and after changes, except for miles of road and revenue ton-miles, we constructed a weighted average (by rtm) of each of the constituent firm characteristics to serve as a "before" merger reference point. For miles of road and revenue ton-miles, the scale variables, we simply added up the constituent firm variables to form the before-merger reference point. We do note, however, that we simply report the before and after merger changes. In calculating the cost changes before and after the merger (CD-1, CD-2) we held the scale variables fixed. That is, while the cost changes included scale effects, they did not include changes in the combined outputs or miles of road that may have resulted from the merger.

TABLE 7. SIMULATED MERGER EFFECTS - THREE STAGE LEAST SQUARES

Merger	RR	Year	RTM	MOR	C-B	AC-B	C-M1	AC-M1	D-1	%	C-M2	AC-M2	D-2	%
1	DTI	1983	1.365	527	121.83	08.92		.	.	.	.	.	.	.
1	GTW	1983	3.633	950	418.29	11.51		.	.	.	.	.	.	.
1	GTW	1984	4.998	1477	540.12	.	578.69	11.57	38.58	7.14	563.40	11.27	23.28	4.31
2	MILW	1984	12.509	3023	736.14	05.88	.	.	.	.	.	.	.	.
2	SOO	1984	9.961	4628	497.18	04.99	.	.	.	.	.	.	.	.
2	SOO	1985	22.47	7651	1233.32	.	1143.63	05.08	-89.69	-7.27	1188.29	05.28	-45.02	-3.65
3	NW	1984	43.766	7746	2602.49	05.94	.	.	.	.	.	.	.	.
3	SOU	1984	46.010	8595	2842.19	06.17	.	.	.	.	.	.	.	.
3	NS	1985	89.776	16341	5444.68	.	5998.62	06.68	553.94	10.17	4763.92	05.30	-680.76	-12.50
4	BO	1985	25.27	5268	1708.22	06.75	.	.	.	.	.	.	.	.
4	CO	1985	32.213	4500	1465.18	04.54	.	.	.	.	.	.	.	.
4	SCL	1985	76.573	14177	4383.69	05.72	.	.	.	.	.	.	.	.
4	CSX	1986	134.062	23945	7557.08	.	6750.39	05.03	-806.69	-10.67	8496.01	06.33	938.93	12.42
5&5	MP	1985	51.37	10920	2951.33	5.74	.	.	.	.	.	.	.	.
5&6	UP	1985	74.612	8783	2536.36	03.39	.	.	.	.	.	.	.	.
5&6	WP	1985	5.785	1409	318.14	05.49	.	.	.	.	.	.	.	.
5&6	UP	1986	131.768	21112	5805.83	.	4376.13	03.32	-1429.69	-24.62	4840.86	03.67	-964.97	-16.6
7	MKT	1987	9.713	3130	333.73	03.43	.	.	.	.	.	.	.	.
7	UP	1987	157.219	20944	5198.47	03.30	.	.	.	.	.	.	.	.
7	UP	1988	166.933	24074	5532.20	.	4977.81	02.98	-554.39	-10.02	5552.41	03.32	20.21	0.36

TABLE 7. SIMULATED MERGER EFFECTS - THREE STAGE LEAST SQUARES

Merger	RR	Year	RTM	MOR	C-B	AC-B	C-M1	AC-M1	D-1	%	C-M2	AC-M2	D-2	%
8	SP	1989	69.382	9879	2384.55	03.43	.	.	.	.	.	.	.	.
8	SSW	1989	17.025	2898	652.49	03.83	.	.	.	.	.	.	.	.
8	SP	1990	86.408	12777	3037.04	.	3018.73	03.49	-18.31	-0.60	2833.11	03.27	-203.93	-6.71
9	DRGW	1993	17.398	2179	375.84	02.16	.	.	.	.	.	.	.	.
9	SP	1993	101.118	11920	3266.70	03.23	.	.	.	.	.	.	.	.
9	SP	1994	118.51	14099	3642.54	.	2998.14	02.53	-644.40	-17.69	2954.63	02.49	-687.91	-18.9
10	CNW	1994	37.198	5211	888.62	02.38	.	.	.	.	.	.	.	.
10	UP	1994	235.770	17499	4486.55	01.90	.	.	.	.	.	.	.	.
10	UP	1995	272.969	22710	5375.17	.	5347.43	01.95	-27.73	-0.51	5549.13	02.03	173.96	3.23
11	ATSF	1995	104.	9126	3187.06	03.05	.	.	.	.	.	.	.	.
11	BN	1995	293.4	22200	3688.30	01.25	.	.	.	.	.	.	.	.
11	BN	1996	397.9	31326	6875.36	.	6058.11	01.52	-817.25	-11.88	4881.71	01.22	-1993.65	-29
12	SP	1996	155.592	14404	3323.70	02.13	.	.	.	.	.	.	.	.
12	UP	1996	323.34	22266	5611.89	01.73	.	.	.	.	.	.	.	.
12	UP	1997	478.942	36670	8935.59	.	9283.19	01.93	347.60	3.89	9584.05	02.00	648.46	7.25

Note: C-B, C-M1, C-M2 are the predicted costs for the firms before the merger (B) and after the merger (M1 and M2). The results denoted by M1 and M2 are calculated using the before merger scale variables (i.e., RTM and MOR). The M1 results are based on the combined firm factor prices and operating and network characteristics. The M2 results are based on a weighted (by RTM) average the constituent firm's factor prices and operating and network characteristics. AC-B, AC-M1, and AC-M2 are the related average cost in cents per ton-mile. D-1 and D-2 are the difference in costs i.e., D-1 is C-M1 minus C-B and D-2 is C-M2 minus C-B. The % columns are the cost differences relative to C-B.

From Table 8, there are a number of immediate results. First, the last two mergers (ATSF-BN and UP-SP) have the largest changes in network size. The BN-SF merger resulted in a 3,880 mile increase in route miles, while the UP-SP fell 1,724 miles. Second, in six of the eleven cases, average length of haul increased, and fell in the other five cases. The largest increases are for the BNSF and UPSP mergers, where average lengths of haul increased by about 65 and 125 miles, respectively. Third, it does appear from the data that speed is adversely affected by merger activity. In 9 of 11 cases, speed falls the year that firms first report as a consolidated firm. In the well documented UPSP merger, the decrease in speed is about 2.93 miles per hour, representing about a 10 percent decrease in speed of service. Finally, the change in traffic characteristics from mergers appears to favor greater percentages of unit train traffic, primarily associated with lower percentages of through train traffic. In 9 of the 11 mergers, there was an increase in the percentage of unit train traffic. In all 11 cases, a change in unit train traffic was reflected by an opposite change in through train traffic. On average, unit train traffic increased 2.6 percent before and after a merger, while through train traffic decreased 2.2 percent.

Each of the changes presented in Table 8 can increase or decrease costs. In translating these into cost effects, we present simulations in Table 9. In these simulations, we attempt to break down the total changes in costs into each of the effects. These include: 1) the change in predicted values (Cost); 2) pure scale and intercept effects (Scale); 3) the change from output beyond that from combining two smaller railroads (RTM); 4) changes in factor prices (Wage, Equip, Fuel, Matl, W&S); and changes in network characteristics (MOR, ALH, TTP, WTP, Speed). For the scale and intercept effects, we fix total revenue ton-miles and miles of road at the pre-merger levels. We then calculate costs using post-merger reference variables (i.e., factor prices, network characteristics, and time) so that the constituent firms and the merged firm have the same values for all variables, except for the intercept and scale variables (RTM and MOR).

TABLE8. CHANGES IN OPERATING STATISTICS FROM MERGERS

Absolute Changes

Merger	MOR	RTM	ALH	SPEED	WT%	UT%	TT%
DTI-GTW	-152.0	583.27	7.48	1.13	-5.3	-0.7	6.0
MILW-SOO	324 .0	-4128.99	-9.69	-1.60	0.1	0.0	-0.1
NS	1279.0	1978.02	53.25	-0.02	0.6	0.5	-1.1
CSX	-1058.0	-6560.77	-17.36	0.89	-1.8	11.3	-9.5
UP-MP-WP	304.0	4328.15	-29.38	-3.81	0.7	3.7	-4.4
MKT-UP	-1421.0	9715.20	34.07	-0.89	-0.3	2.5	-2.2
SP-SSW	-177.0	-311.59	-18.66	-7.78	0.3	2.6	-2.9
DRGW-SP	-384.0	14454.28	4.13	-1.03	0.6	3.0	-3.6
CNW-UP	75.0	34456.04	-65.80	-5.02	1.2	5.3	-6.5
ATSF-BN	3882 .0	13158.48	64.79	-0.09	0.2	-2.7	2.6
UP-SP	-1724.0	-27087.14	125.56	-2.93	-0.5	3.0	-2.4

Percentage Changes

	MOR	RTM	ALH	SPEED	WT%	UT%	TT%
DTI-GTW	-10.29	11.67	3.41	4.44	-44.96	-10.51	7.29
MILW-SOO	4.23	-18.37	-2.47	-5.46	0.76	0.15	-0.09
NS	7.83	2.20	19.57	-0.09	10.96	7.61	-1.28
CSX	-4.42	-4.89	-5.64	3.85	-15.74	5387.53	-10.77
UP-MP-WP	1.44	3.28	-5.19	-9.97	14.26	13.74	-6.48

TABLE8. CHANGES IN OPERATING STATISTICS FROM MERGERS

MKT-UP	-5.90	5.82	5.33	-2.60	-6.43	8.22	-3.40
SP-SSW	-1.39	-0.36	-2.72	-17.95	8.35	39.46	-3.21
DRGW-SP	-2.72	12.20	0.65	-3.45	23.77	29.32	-4.14
CNW-UP	0.33	12.62	-9.70	-15.79	34.75	14.96	-10.71
ATSF-BN	12.39	3.31	8.00	-0.29	4.96	-5.00	6.11
UP-SP	-4.70	-5.66	16.68	-9.99	-14.75	8.41	-4.02

Changes in costs again are significant and generally negative (Cost). The scale and intercept effects are the largest in magnitude and negative in eight of the 11 cases. The scale effects are largest for the ATSF-BN and UP-MP-WP mergers. In addition to scale effects were changes in output and miles of road of the combined system. Of course, changes in output influence costs. In seven of the 11 cases, output increased in the year after merging. In some cases, the changes are quite substantial, with increases in excess of 10 percent (table 8) for DRGW-SP and CNW-UP with associated increases in costs of 11.35 and 9.35 percent, respectively (Table 9). In other cases there are reductions in output. For example, in the MILW-SOO merger, output fell by 18.37 percent (Table 8) with an associated reduction in cost of 13.12 percent. Associated with the mergers were changes in network size. In six of the 11 cases, network size fell. In five of the 11 cases, network size increased. In the ATSF-BN merger, the increase in network size was substantial, 3,882 miles (a 12.39 percent increase) with an associated increase in costs of 17 percent.

There are also important changes in the reference variables. In most mergers wages increase, with associated effects on costs reaching 6.95 percent in the DTI-GTW merger. Equipment prices also tend to increase with associated effects on costs of less than 1 percent. Fuel and material prices are more mixed but with only nominal effects on costs. Way and structure prices do vary and vary substantially. In the formation of NS, changes in way and structure increased costs by about 17 percent, while in the MILW-SOO merger costs decreased by about 7 percent.

Changes in network/operational variables are of some note. In this regard, average lengths of haul have changed, in some cases, by a sizable degree in absolute terms (e.g., ALH increased by 519 miles (16.68 percent) before and after the merger. However, the cost function does not suggest that these changes have a particularly strong influence on costs. One plausible explanation is the linkage of ALH to MOR and the percentage of through, way and unit train traffic. As suggested by Table 8, comparisons of before and after traffic characteristics do suggest that the percent of through train traffic falls, in some cases, in excess of 10 percent. The corresponding effects on costs are present. In the CNW-UP merger, for example, through train percent fell by nearly 11 percent with an associated increase in unit train traffic of nearly 15 percent. The effect on costs is substantial with a reduction in excess of 10 percent. In the CSX merger, unit train traffic was very small in the constituent firms and increased by over 11 percent the year after the merger with a corresponding reduction in through train traffic of about 10 percent. The effect on costs is an almost 10 percent reduction in costs from the reduction in through train traffic.

TABLE 9. COST CHANGE DECOMPOSITION

Merger	Total Change in Cost	Changes in Cost by Source (Millions of Dollars)											
		Scale	RTM	Wage	Equip	Fuel	Matl	W&S	MOR	ALH	TTP	WTP	Speed
DTI-GTW	58.37	64.26	21.61	38.32	-14.01	-4.78	-5.90	4.56	-11.39	-5.41	7.61	19.24	-8.23
MILW-SOO	-241.31	-85.97	-147.30	22.64	5.31	-8.01	0.80	-79.45	20.58	-0.29	-0.19	0.84	11.75
NS	687.19	-830.84	126.13	23.01	152.98	-54.14	-0.95	823.98	236.10	193.14	-48.93	89.04	-0.60
CSX	-1137.74	504.75	-343.72	360.94	25.71	-155.45	-31.67	-381.36	-198.81	-144.36	-738.47	-181.31	-13.57
UP-MP-WP	-1295.97	-1887.36	131.76	46.60	40.10	-154.32	-55.65	-86.62	51.12	-51.22	-224.23	43.38	154.64
MKT-UP	-286.53	114.15	286.96	8.25	30.86	-22.40	1.23	-2.51	-285.89	59.36	-129.93	-44.61	35.60
SP-SSW	-28.87	-219.53	-10.69	141.15	-15.09	23.47	-0.71	30.89	-29.00	0.74	-65.18	32.08	240.69
DRGW-SP	-306.83	-579.18	346.83	170.31	44.37	-47.45	6.09	30.23	-63.51	0.68	-92.95	108.81	25
CNW-UP	472.47	-194.45	497.88	-43.86	-15.31	15.95	10.50	287.77	20.06	-199.83	-618.08	206.23	416.56
ATSF-BN	-671.63	-2272.85	120.41	8.91	10.27	26.94	-15.27	46.60	886.06	171.50	262.04	31.33	7.01
UP-SP	-137.77	314.86	-519.44	-3.74	-32.05	18.42	24.36	634.69	-554.52	519.45	-370.85	-371.02	248.41

TABLE 9. COST CHANGE DECOMPOSITION

		Changes in Cost by Source (Percentage Change in Cost)											
	Total Change in Cost	**Scale**	**RTM**	**Wage**	**Equip**	**Fuel**	**Matl**	**W&S**	**MOR**	**ALH**	**TTP**	**WTP**	**Speed**
DTI-GTW	10.81	10.89	3.66	6.95	-2.32	-0.80	-0.99	0.78	-1.93	-0.91	1.31	3.37	-1.38
MILW-SOO	-19.57	-7.65	-13.12	2.06	0.47	-0.71	0.07	-6.61	1.83	-0.03	-0.02	0.08	1.06
NS	12.62	-14.42	2.19	0.40	2.73	-0.93	-0.02	16.68	4.10	3.47	-0.84	1.57	-0.01
CSX	-15.06	7.26	-4.95	5.48	0.37	-2.19	-0.45	-5.20	-2.86	-2.04	-9.61	-2.54	-0.19
UP-MP-WP	-22.32	-43.64	3.05	1.09	0.94	-3.45	-1.27	-1.96	1.18	-1.17	-4.93	1.01	3.71
MKT-UP	-5.18	2.17	5.45	0.16	0.59	-0.42	0.02	-0.05	-5.43	1.14	-2.41	-0.84	0.68
SP-SSW	-0.95	-7.20	-0.35	4.86	-0.49	0.78	-0.02	1.02	-0.95	0.02	-2.09	1.06	8.57
DRGW-SP	-8.42	-18.92	11.33	5.89	1.47	-1.53	0.20	1.00	-2.07	0.02	-2.95	3.69	0.82
CNW-UP	8.79	-3.65	9.35	-0.82	-0.29	0.30	0.20	5.71	0.38	-3.62	-10.40	4.03	8.48
ATSF-BN	-9.77	-43.94	2.33	0.17	0.20	0.52	-0.29	0.91	17.13	3.43	5.34	0.61	0.14
UP-SP	-1.54	3.20	-5.28	-0.04	-0.32	0.19	0.25	6.90	-5.64	5.57	-3.63	-3.63	2.59

5.2 Industry Consolidations

This final section concerns the effects on industry costs. To this end, we concern ourselves with the changing distributions of firms and output. Our counterfactual is: if the 19XX distribution of firms were to produce the 1983 level of output using the 1983 network size, what would be industry costs? In proceeding, we give each firm in the sample the same reference point (1983 mean values of non-scale variables). We then predict costs for each firm in the sample for 1983. Total industry costs using this approach are about $50.5 billion. We then allocate the 1983 output and miles of road to firms operating in 1984, 1985, ..., 1997 in accordance to their share of the 1984, ..., 1997 output and miles of road. The resulting numbers are reported in Table 10.

As shown in Table 10, industry costs are falling throughout the time period of analysis. We do note that there are changes in costs from mergers but also from changes in market shares over time. Thus, in any given year, there may be changes in costs even when there are no mergers. For years without mergers (1983, 1987, 1989,and 1991-3), these changes in market share reduce costs, but by relatively small amounts.

The relatively small mergers of the 1980s and early 1990s have only modest effects on industry costs. For example, if the 1990 distribution of firms produced the 1983 level of industry output using the 1983 industry network size, costs savings would only be about 3 percent. However, with the recent mega mergers of the 1990s, the effects are considerably larger. Indeed, the ATSF-BN merger occurred in 1996, and the change in the firm distribution from 1995 was quite large. All told, reductions in industry costs using the 1996 and 1997 distribution of firms are very large, running about $9 billion and representing an 18 percent reduction in industry costs of producing the 1983 level of output using the 1983 network.

TABLE 10. SIMULATED INDUSTRY COSTS - 3SLS

Firm Distribution	Industry Cost	Cost-Change	% Change from 1983	% Change from prev. yr.
1983	50429740000			
1984	50529732871	99992870	0.2	0.2
1985	49765278842	-664461159	-1.32	-1.52
1986	49148536453	-1281203548	-2.54	-1.22
1987	49378585325	-1051154675	-2.08	0.46
1988	49,349,171,305	-1,080,568,696	-2.14	-0.06
1989	49,251,201,575	-1,178,538,425	-2.34	-0.2
1990	48,851,331,025	-1,578,408,976	-3.13	-0.79
1991	48,719,215,207	-1,710,524,793	-3.39	-0.26
1992	48,517,196,428	-1,912,543,572	-3.79	-0.4
1993	48,186,095,413	-2,243,644,587	-4.45	-0.66
1994	47,174,555,210	-3,255,184,791	-6.46	-2.01
1995	46,430,428,722	-3,999,311,278	-7.93	-1.47
1996	41,500,214,405	-8,929,525,595	-17.71	-9.78
1997	41,153,381,945	-9,276,358,055	-18.4	-0.69

Note: Firm-distribution denotes year of the firm distribution used. For example, the figures for 1994 reflect the estimated industry costs of producing the 1983 level of output using the 1983 network size. The outputs and network size of the individual firms are allocated according to 1994 market shares applied to the 1983 industry totals. The column cost change is the corresponding costs of a given year minus the 1983 cost, and the percent change is the change in cost relative to 1983.

6. CONCLUSIONS

Over the past few decades there has been a massive consolidation of output in the railroad industry. While industry average revenues and costs have been falling, there are growing concerns over the welfare consequences of railroad mergers. Indeed, this concern along with recent experiences on service disruptions resulted in a moratorium on further railroad mergers by the Surface Transportation Board, which was removed in June 2001. Yet, the issues on railroad mergers remain.

Previous research has suggested that there are cost savings associated with railroad mergers, but these cost savings explain only a small component of cost savings of deregulation (about 10 percent). Our research suggests that mergers are becoming more and more between firms with large market shares, and that corresponding efficiency gains are larger. To our knowledge, we are the first to present industry cost savings from a changing firm distribution. To this end, our results point to very large effects of industry consolidation on costs. These estimates have grown over time and are largest at the end of the sample, reflecting two of the largest-ever mergers (BN-SF and UP-SP).

The results from a cost savings perspective point strongly to the merits of further consolidation in the industry. However, further research addressing the demand and pricing effects is necessary to fully address the desirability of further industry consolidation.

6. CONCLUSIONS

Over the past few decades there has been a massive consolidation of carriers in the railroad industry. While industry average revenues and costs have been falling, there are growing concerns over the adverse consequences of railroad mergers. Indeed, this concern along with recent experiences on service disruptions resulted in a moratorium on further railroad mergers by the Surface Transportation Board, which was removed in June 2001. Yet, the issues on railroad mergers remain.

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The results from a cost savings perspective point strongly to the merits of further consolidation in the industry. However, further research addressing the demand and pricing effects is necessary to fully address the desirability of further industry consolidation.

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8. APPENDIX

Table A1. Railroad Name and Abbreviation

Abbreviation	Name
ATSF	Atchison, Topeka & Santa Fe
BLE	Bessemer and Lake Erie
BM	Boston and Maine
BN	Burlington Northern
BO	Baltimore and Ohio
CNW	Chicago and Northwestern
CO	Chesapeake and Ohio
CR	Consolidated Rail Corporation
CSX	CSX Transportation
DH	Delaware and Hudson
DMIR	Duluth, Missabe, and Iron Range
DRGW	Denver, Rio Grande and Western
DTI	Detroit, Toledo and Ironton
FEC	Florida East Coast
GTW	Grand Trunk and Western
ICG	Illinois Central Gulf
KCS	Kansas City Southern
MILW	Milwaukee Road
MKT	Missouri-Kansas-Texas
MP	Missouri Pacific
NS	Norfolk Southern
NW	Norfolk and Western
PLE	Pittsburgh, Lake Erie
SCL	Seaboard Coast Line
SOO	SOO Line
SOU	Southern Railway
SP	Southern Pacific
SSW	Saint Louis and Southwestern
UP	Union Pacific
WP	Western Pacific

Table A2. SUR and 3SLS Fixed Effects

	SUR		3SLS	
Parameter	**Estimate**	**Std. Error**	**Estimate**	**Std. Error**
Intercept	-0.5240*	(0.1515)	-0.4329	(0.2725)
ATSF	0.6164*	(0.1469)	0.4986**	-0.2702
BLE	-0.5177*	(0.2585)	-0.8730*	(0.4366)
BO	1.1067*	(0.1804)	1.0669*	(0.3296)
CNW	0.8461*	(0.1741)	0.8855*	(0.3268)
CO	1.0510*	(0.1782)	0.9766*	(0.3246)
CR	0.8803*	(0.1382)	0.7440*	(0.2672)
CSX	0.5089*	(0.1378)	0.3913	(0.2855)
DMIR	-0.9822*	(0.3052)	-1.0782**	(0.5457)
DRGW	0.7107*	(0.1879)	0.7680*	(0.3388)
FEC	0.5645*	(0.2006)	0.3465	(0.3916)
GTW	1.0857*	(0.1960)	0.9799*	(0.3685)
BM	0.7129*	(0.2022)	0.6535*	(0.3670)
DH	0.3293	(0.2069)	0.5488	(0.3724)
DTI	0.1131	(0.2267)	-0.1610	(0.4174)
SCL	0.6693*	(0.1430)	0.5316**	(0.2761)
ICG	0.9791*	(0.1819)	1.0183*	(0.3329)
KCS	0.7552*	(0.1858)	0.7463*	(0.3403)
MILW	0.9667*	(0.1901)	1.0028*	(0.3432)
MKT	0.4061*	(0.1966)	0.4399	(0.3548)
MP	0.7710*	(0.1526)	0.9271*	(0.2773)
NS	0.6002*	(0.1365)	0.4346	(0.2719)
NW	0.9925*	(0.1623)	0.9333*	(0.2985)
PLE	0.2406	(0.3897)	-0.2933	(0.7282)
SOO	0.6261*	(0.1996)	0.8045*	(0.3440)
SOU	0.6754*	(0.1640)	0.7687*	(0.3048)
SP	0.7724*	(0.1531)	0.6076*	(0.2826)
SSW	0.7989*	(0.1891)	0.8824*	(0.3403)
UP	0.6804*	(0.1406)	0.6810*	(0.2494)
WP	0.6142*	(0.2041)	0.7920*	(0.3672)
gtw1	1.2057*	(0.1871)	1.1745*	(0.3494)
soo1	0.7250*	(0.1803)	0.8028*	(0.3233)
up1	0.1827	(0.1145)	0.0598	(0.2111)

Table A2. SUR and 3SLS Fixed Effects

	SUR		3SLS	
Parameter	Estimate	Std. Error	Estimate	Std. Error
sp1	0.4990*	(0.1386)	0.3606	(0.2550)
sp2	0.2250**	(0.1258)	0.0603	(0.2325)
bn1	-0.5352*	(0.1320)	-0.7554*	(0.2204)

Note: A * and a ** indicate significance at the 5 and 10 percent levels, respectively.

Table A3. Seeming Unrelated Regression Results

Variable	Estimat	Std. Error	Variable	Estimate	Std. Error	Variable	Estimate	Std. Error
q1 (RTM)	0.6599*	(0.0873)	w2w3	-0.0008	(0.0015)	t1w1	-0.0101	-0.0103
w1 (Labor)	0.3606*	(0.0068)	w2w4	0.0109	(0.0072)	t1w2	-0.0434*	-0.0079
w2 (Equip.)	0.1522*	(0.0054)	w2w5	-0.0255*	(0.0055)	t1w3	-0.0109*	(0.0027)
w3 (Fuel)	0.0596*	(0.0018)	w3w3	0.0460*	(0.0034)	t1w4	0.0451*	-0.0119
w4 (Materials)	0.1872*	(0.0085)	w3w4	-0.0115*	(0.0047)	t1w5	0.0193**	-0.0098
w5 (Way and Struc)	0.2401*	(0.0062)	w3w5	-0.0157*	(0.0023)	t2w1	-0.0710*	(0.0100)
t1 (MOR)	0.6867*	(0.0841)	w4w4	0.0273	(0.0167)	t2w2	-0.0197*	(0.0080)
t2 (ALH	-0.1751**	(0.1044)	w4w5	-0.0196*	(0.0042)	t2w3	0.0317*	(0.0025)
t3 (Through Train)	0.1850	(0.1137)	w5w5	0.1459*	(0.0087)	t2w4	0.0371*	(0.0123)
t4 (Way Train)	0.0008	(0.0262)	t1t1	-0.0812	(0.0941)	t2w5	0.0218*	(0.0092)
t5 (Speed)	0.1031	(0.0889)	t1t2	0.2899**	(0.1464)	t3w1	0.0051	(0.0101)
t6 (Trend)	-0.0226*	(0.0068)	t1t3	-0.2647**	(0.1549)	t3w2	0.0093	(0.0079)
q1q1	0.1161	(0.0956)	t1t4	0.1011*	(0.0312)	t3w3	-0.0085*	(0.0025)
q1w1	0.0237*	(0.0099)	t1t5	-0.0101	(0.0986)	t3w4	0.0324*	(0.0125)
q1w2	0.0399*	(0.0075)	t1t6	0.0022	(0.0072)	t3w5	-0.0384*	(0.0092)
q1w3	0.0046**	(0.0026)	t2t2	0.3616**	(0.2030)	t4w1	-0.0029	(0.0040)
q1w4	-0.0538*	(0.0113)	t2t3	-0.3652	(0.2522)	t4w2	0.0141*	(0.0032)
q1w5	-0.0145	(0.0095)	t2t4	0.0736**	(0.0421)	t4w3	-0.0041*	(0.0010)
q1t1	0.1219	(0.0859)	t2t5	0.1098	(0.0948)	t4w4	-0.0178*	(0.0051)

Table A3. Seeming Unrelated Regression Results

Variable	Estimat	Std. Error	Variable	Estimate	Std. Error	Variable	Estimate	Std. Error
q1t2	-0.2391**	(0.1344)	t2t6	0.0291*	(0.0100)	t4w5	0.0108*	(0.0037)
q1t3	0.2860*	(0.1389)	t3t3	-0.2400	(0.3364)	t5w1	-0.0146	(0.0107)
q1t4	-0.0730*	(0.0301)	t3t4	-0.0102	(0.0560)	t5w2	-0.0127	(0.0085)
q1t5	0.0782	(0.0701)	t3t5	0.1375	(0.1280)	t5w3	0.0007	(0.0026)
q1t6	-0.0059	(0.0069)	t3t6	-0.0025	(0.0076)	t5w4	0.0416*	(0.0134)
w1w1	0.1157*	(0.0139)	t4t4	-0.0163	(0.0211)	t5w5	-0.0149	(0.0097)
w1w2	-0.0059	(0.0056)	t4t5	-0.1195*	(0.0414)	t6w1	-0.0051*	(0.0007)
w1w3	-0.0178*	(0.0033)	t4t6	0.0024	(0.0024)	t6w2	-0.0042*	(0.0005)
w1w4	-0.0070	(0.0135)	t5t5	-0.4758*	(0.1342)	t6w3	0.0004*	(0.0002)
w1w5	-0.0849*	(0.0078)	t5t6	-0.0285*	(0.0088)	t6w4	0.0045*	(0.0009)
w2w2	0.0213*	(0.0049)	t6t6	-0.0009	(0.0006)	t6w5	0.0043*	(0.0006)

Note: Acronyms are used in presenting the results. In () following the acronyms for output (q), factor prices (w), and operating, network, and technological variables (t) are key words to identify the relevant variable. A * and ** indicate significance at the 5 and 10 percent levels.

Table A4. Simulated Merger Effects - Seemingly Unrelated Regressions

Merger	RR	Year	RTM (Bil)	MOR Miles	C-B (Mil)	AC-B (Cents)	C-M1 (Mil)	AC-M1 (Cents)	D-1 (Mil)	%	C-M2 (Mil)	AC-M2 (Cents)	D-2 (Mil)	%
1	DTI	1983	1.365	527	128.57	09.419	.	.	.	.	.	.		
1	GTW	1983	3.633	950	444.14	12.225	.	.	.	.	.	.	.	
1	GTW	1984	4.998	1477	572.72	.	601.11	12.026	28.39	4.95	603.97	12.084	31.25	5.45
2	MILW	1984	12.509	3023	774.45	06.191	.	.	.	.	.	.	.	.
2	SOO	1984	9.961	4628	545.84	05.480	.	.	.	.	.	.	.	.
2	SOO	1985	22.471	7651	1320.29	.	1187.19	05.283	-133.09	-10.08	1243.03	05.532	-77.25	-5.85
3	NW	1984	43.766	7746	2730.15	06.238	.	.	.	.	.	.	.	.
3	SOU	1984	46.010	8595	2962.46	06.439	.	.	.	.	.	.	.	.
3	NS	1985	89.776	16341	5692.60	.	6661.69	07.420	969.09	17.02	5661.90	06.307	-30.70	-0.53
4	BO	1985	25.276	5268	1748.70	06.918	.	.	.	.	.	.	.	.
4	CO	1985	32.213	4500	1502.92	04.666	.	.	.	.	.	.	.	.
4	SCL	1985	76.573	14177	4464.14	05.830	.	.	.	.	.	.	.	.
4	CSX	1986	134.062	23945	7715.75	.	7141.79	05.327	-573.97	-7.43	7966.06	05.942	250.31	3.24
5&6	MP	1985	51.370	10920	3098.09	06.031	.	.	.	.	.	.	.	.
5&6	UP	1985	74.612	8783	2757.60	03.696	.	.	.	.	.	.	.	.
5&6	WP	1985	5.785	1409	349.46	06.040	.	.	.	.	.	.	.	.
5&6	UP	1986	131.768	21112	6205.15	.	4916.43	03.731	-1288.71	-20.76	5307.63	04.028	-897.52	-14.46
7	MKT	1987	9.713	3130	351.01	03.614	.	.	.	.	.	.	.	.
7	UP	1987	157.219	20944	5684.35	03.616	.	.	.	.	.	.	.	.
7	UP	1988	166.933	24074	6035.37	.	5498.13	03.294	-537.24	-8.90	5924.01	03.549	-111.35	-1.84

Table A4. Simulated Merger Effects - Seemingly Unrelated Regressions

Merger	RR	Year	RTM (Bil)	MOR Miles	C-B (Mil)	AC-B (Cents)	C-M1 (Mil)	AC-M1 (Cents)	D-1 (Mil)	%	C-M2 (Mil)	AC-M2 (Cents)	D-2 (Mil)	%
8	SP	1989	69.382	9879	3005.84	04.332	.	.	.	.	.	.	.	.
8	SSW	1989	17.025	2898	697.70	04.098	.	.	.	.	.	.	.	.
8	SP	1990	86.408	12777	3703.54	.	3378.04	03.909	-325.49	-8.78	3225.02	03.732	-478.52	-12.92
9	DRGW	1993	17.398	2179	408.73	02.349	.	.	.	.	.	.	.	.
9	SP	1993	101.118	11920	3556.56	03.517	.	.	.	.	.	.	.	.
9	SP	1994	118.517	14099	3965.29	.	3388.85	02.859	-576.44	-14.53	3287.86	02.774	-677.43	-17.08
10	CNW	1994	37.198	5211	986.62	02.652	.	.	.	.	.	.	.	.
10	UP	1994	235.770	17499	5623.50	02.385	.	.	.	.	.	.	.	.
10	UP	1995	272.969	22710	6610.12	.	6533.98	02.394	-76.14	-1.15	6543.57	02.397	-66.55	-1
11	ATSF	1995	104.487	9126	3832.31	03.668	.	.	.	.	.	.	.	.
11	BN	1995	293.414	22200	5527.02	01.884	.	.	.	.	.	.	.	.
11	BN	1996	397.901	31326	9359.33	.	8873.58	02.230	-485.74	-5.18	7432.87	01.868	-1926.46	-20.58
12	SP	1996	155.592	14404	3903.71	02.509	.	.	.	.	.	.	.	.
12	UP	1996	323.349	22266	7486.89	2.315	.	.	.	.	.	.	.	.
12	UP	1997	478.942	36670	11390.60	.	12394.70	02.588	1004.10	8.81	11980.36	2.501	589.76	5.17

Note: C-B, C-M1, C-M2 are the predicted costs for the firms before the merger (B) and after the merger (M1 and M2). The results denoted by M1 and M2 are calculated using the before merger scale variables (i.e., RTM and MOR). The M1 results are based on the combined firm factor prices and operating and network characteristics. The M2 results are based on a weighted (by RTM) average the constituent firm's factor prices and operating and network characteristics. AC-B, AC-M1, and AC-M2 are the related average cost in cents per tonmile. D-1 and D-2 are the difference in costs i.e., D-1 is C-M1 minus C-B and D-2 is C-M2 minus C-B. The % columns are the cost differences relative to C-B.