DEREGULATION, MERGERS, AND COST SAVINGS IN CLASS I U.S. RAILROADS, 1974-1986

Christopher A. Vellturo
Ernst R. Berndt
Ann F. Friedlaender
Judy Shaw-er Wang Chiang
Mark H. Showalter

WP #3415EFA March 1992

DEREGULATION, MERGERS, AND COST SAVINGS IN CLASS I U.S. RAILROADS, 1974-1986

by

Christopher A. Vellturo
Ernst R. Berndt
Ann F. Friedlaender
Judy Shaw-Er Wang Chiang
Mark H. Showalter*

*Economist, Cambridge Economic Associates; Professor of Applied Economics, MIT Sloan School of Management; Professor of Economics, MIT; Professor, National Cheng Kung University; and Assistant Professor, Brigham Young University
Research support from the National Science Foundation and the MIT Center for Energy Policy Research is gratefully acknowledged.

Revised Version
Manuscript Dated 23 March 1992

DERREGULATION, MERGERS, AND COST SAVINGS IN CLASS I U.S. RAILROADS, 1974-1986

by

Christopher A. Vellturo
Ernst R. Berndt
Ann F. Friedlaender
Judy Shaw-Er Wang Chiang
Mark H. Showalter

ABSTRACT

In this paper we attempt to disentangle the effects of deregulation on rail costs from those directly attributable to mergers and acquisitions. We employ a translog variable cost function, based on an unbalanced panel data set of annual observations for major US Class I railroads from 1974 to 1986.

We find that both deregulation and mergers contributed significantly to cost savings. Using a simulation analysis that employs the fixed effects of the merged firms and their constituents, we estimate that the cost reductions obtained from merger ranged a high of 33 percent for the Burlington Northern to a low of a 3 percent cost increase for the CSX. Further analyses of changes in operating characteristic and labor force rationalizations yielded cost differentials of similar magnitudes. However, firms that were not engaged in significant merger activities experienced similar cost differentials due to changes in operating characteristics and labor force utilization, indicating that consolidation was not a prerequisite for such rationalizations. An analysis of Tobin's marginal q similarly indicated little variation in its behavior merged between merged and non merged firms.

We conclude that although mergers did confer some benefits on the participating firms, they were not a prerequisite for railroads being able to achieve substantial cost savings during the post Staggers period. Deregulation also had an enormous direct impact, which may indeed, be greater.

Manuscript Dated 23 March 1992

Address all Correspondence to:

Professor Ernst R. Berndt
Sloan School of Management
Massachusetts Institute of Technology
Cambridge, Mass., 02139

(617) 253-2665

DEREGULATION, MERGERS, AND COST SAVINGS
IN CLASS I U.S. RAILROADS, 19974-1986

I. INTRODUCTION AND OVERVIEW

Over a decade has elapsed since the passage of the Stagger's Act in 1980, the final and most sweeping legislation in a decade-long series of rail reforms. Few analysts question its success. In 1976, for example, seven major carriers were bankrupt.[1] The other 45 remaining carriers were burdened with unprofitable operations along low-density routes and, due to chronically low rates of return, were unable to attract capital or divert cash to badly deteriorating high-density routes. In contrast, by 1986, the U.S. rail system had consolidated considerably: 25,000 miles of track had been sold or abandoned, and seven carriers handled more than 70 percent of the freight traffic. Rates of return had increased sharply, and the cost of capital had fallen.[2]

Although there is little question that deregulation generally has played a key role in increasing the viability of the U.S. rail system, the role that specific elements of deregulation have played is not well understood. Deregulation occurred in three principle areas: 1) reduced restrictions on the rate-setting ability of the railroads; 2) relaxed common carrier obligations and abandonment policies; and 3) simplified merger applications and approval procedures. Railroads have proceeded along each of these paths.

The effects of eased rate restrictions and capital adjustments in conjunction with network rationalization via abandonments have received considerable attention in recent literature.[3] However, the effects of the large-scale mergers that have occurred since deregulation have received little attention. This study attempts to fill this gap by disentangling, for a particular set of railroad firms, the cost savings directly attributable to mergers from those due to the more general operational adjustments permitted by deregulation. We show that the cost savings attributable to each of these activities was highly variable. Some railroads (e.g., the Burlington Northern) were able to utilize mergers and changes in network utilization to reduce their costs substantially, while others (e.g., Norfolk Southern) appeared to have gained relatively little from mergers or deregulation-induced changes in operating characteristics. In contrast, virtually all railroads have experienced substantial cost savings through labor adjustments, which appear to have been encouraged (or, at least, not discouraged) by deregulation. Thus on balance, deregulation appears to have led to significant changes in railroad operating behavior that overshadows mergers *per se* in the industry's advance towards viability.

This paper takes the following form. Section II provides an overview of railroad mergers and summarizes a number of important changes in rail operations that have occurred in recent years. Section III discusses the nature of economies of mergers and outlines our approach to estimating the cost savings due to mergers. Section IV provides estimates of the cost savings due to merger and their sources. In Section V we present a brief summary and discuss some policy implications.

II. MERGERS AND OPERATING CHARACTERISTICS OF THE RAILROADS

Perhaps the most striking occurrence of the past 15 years has been the dramatic consolidation of the number of firms in the rail industry. In 1974 there were 56 Class I railroads; by 1986, this number had fallen to 21. While some of this reduction in numbers was due to the loss of class I status,[4] the bulk of it was due to consolidation and merger.

Before deregulation, mergers typically involved railroads with substantial parallel trackage.[5] The ICC hearings on these mergers were often lengthy,[6] focusing on the welfare tradeoff between the projected cost efficiencies occasioned by consolidation and economies of scale and the losses to consumers arising from noncompetitive pricing. Because of the potential for noncompetitive behavior, the judgments were generally complex and often involved granting extensive trackage rights to other railroads to ensure competition and/or the inclusion of smaller, satellite firms to guarantee service.

In contrast, mergers in the post-Stagger's period have primarily been end-to-end consolidations that have not involved competing lines.[7] Consequently, the ICC hearings on these consolidations have been relatively brief and have focused on the potential efficiencies occasioned by the implementation of joint marketing agreements and the consolidation of track and maintenance systems. In these cases, reduced competition has not been an issue.

This study concentrates on four major mergers and acquisitions that took place during the period of regulatory relaxation and reform (the Burlington Northern, the CSX, the Norfolk Southern, and the Union Pacific System) and compares their cost savings (and the sources of such savings) and capital utilization to those obtained by railroads not involved in mergers.[8] Table 1 provides a summary of the merger histories of these systems.

Because of the implications of deregulation and mergers for the operation of the railroads, it is useful to examine changes in selected operating characteristics for the period 1974-1986, which includes a time prior to deregulation as well as a period during which substantial deregulation occurred.

Table 1

MAJOR U. S. CLASS I RAIL CONSOLIDATIONS, 1979-84

* *

Baltimore & Ohio Chesapeake & Ohio Western Maryland	=>	Chessie System (CSX1)	=>	CSX Transport Corp. (CSX2)
Seaboard Cost Line Louisville & Nashville	=>	Seaboard System (SBD)		
Burlington Northern St. Louis - San Francisco	=>	BN System (BNSL)	=>	BN System (BNSYS)
		Colorado Southern Fort Worth-Denver		
		Union Pacific Missouri Pacific Western Pacific	=>	Union Pacific System (UPSYS)
		Southern Railway System Norfolk & Western	=>	Norfolk Southern RR (NSC)

These are given in Table 2. Since increased run-through operations are frequently cited as a source of significant savings from end-to-end mergers, onewould expect the average length of haul (ALH) of a merged firm to be significantly greater than that of the constituent firms prior to merger. As is seen in the final two columns of the first page of Table 2, two merged systems exhibited this trend: the Burlington Northern System (BNSYS) and the CSX2, respectively, experienced an increase of 57 percent and 12 percent in ALH. In contrast, the Union Pacific system (UPSYS) and the Norfolk Southern System (NSC) show no such movement. Furthermore, several roads not involved in mergers show large increases in ALH -- Denver and Rio Grande (DRG), 35 percent; the Atchison, Topeka and Santa Fe (ATSF), 18 percent; and the Southern Pacific (SPSYS), 18 percent -- indicating that merger was not a prerequisite to increased ALH.

Each railroad with a marked increase in ALH has, however, experienced a sharp increase in the relative importance of coal in its traffic mix during this period. This is shown in the final two columns of the second page of Table 2. Since coal has a relatively low value-weight ratio, it must be carried long distances to be profitable. Not surprisingly, coal generally has the longest ALH of any commodity type. Therefore, increases in ALH can be attributed primarily to increases in coal traffic over the period. The fact that ALH increases among the merged entities are limited to the heavy coal carriers provides a preliminary indication that efficiency gains from increased run-through operations may not be substantial.

Capital restructuring is another important aspect of rail operations during this period, since the Stagger's Act substantially relaxed network abandonment restrictions. A number of merged systems have abandoned significant portions of their network. For example, the Burlington Northern and the CSX2 have respectively abandoned or sold 14 percent and 17 percent of their route miles. However, the replacement value of their way and structures (W&S) capital has remained relatively constant over this time period, indicating that significant capital improvements (and maintenance expenditures) over high density roads may have offset the reductions in capital through line abandonment.[9]

As was true with ALH, the other merged firms show no such network consolidation. In fact, the route miles of the Norfolk Southern expanded by 13

TABLE 2

SELECTED COST AND OPERATING STATISTICS, CLASS I RAILROADS, 1974 AND 1986

RAILROAD	VARIABLE COSTS (Million 1971$) 1974	VARIABLE COSTS (Million 1971$) 1986	FREIGHT OUTPUT (Million Ton-Miles) 1974	FREIGHT OUTPUT (Million Ton-Miles) 1986	AVERAGE LENGTH OF HAUL (Miles) 1974	AVERAGE LENGTH OF HAUL (Miles) 1986
BO	307.9		29,699		263	
CO	335.4		29,601		264	
WM	41.0		3,552		125	
CHESSIE	684.3		62,851		256*	
SCL	401.0		35,198		224	
LN	346.3		38,099		295	
SBD	747.4		73,298		261*	
CSX2	1431.7	1,588.3	136,149	130,000	259*	291
BN	704.9		76,302		519	
SLSF	146.7		15,000		376	
CS	21.8		2,504		243	
BNSYS	873.4	1,043.7	93,806	190,000	489*	770
UP	553.9		55,601		625	
MP	284.7		37,702		386	
WP	61.6		5,638		478	
UPSYS	900.2	1,213.7	98,941	140,000	526*	524
SOU	462.8		45,150		295	
NW	541.7		53,000		333	
NSC	1004.5	1,308.9	98,150	91,414	316*	326
ATSF	623.7	752.6	56,900	67,141	626	740
CNWT	249.3	239.9	24,901	26,576	309	320
DRGW	83.5	NA	8,799	11,130	321	432
ICG	338.1	340.2	32,101	19,922	303	277
KCS	68.0	100.6	7,340	11,187	270	346
MKT	65.4	106.1	5,541	8,102	365	324
SOO	83.0	204.1	10,600	19,502	403	392

* Computed as ton-mile weighted average of constituent's ALH.

TABLE 2 (Continued)

RAILROAD	CAPITAL STOCK (Million 1971$) 1974	1986	ROUTE MILES OWNED AND OPERATED (Miles) 1974	1986	PERCENT TONS AGRICULTURE 1974	1986	PERCENT TONS COAL 1974	1986
BO	1,952		3,580		6.7		38.8	
CO	1,124		4,019		4.8		56.8	
WM	229		669		12.3		40.0	
CHESSIE	3,304		8,268		6.5*		46.9*	
SCL	1,442		8,730		10.4		9.6	
LN	1,256		6,002		9.6		41.4	
SBD	2,697		14,732		10.0*		23.9*	
CSX2	5,395	5,784	23,000	19,018	8.7*	9.0	32.3*	38.2
BN	4,293		21,298		28.5		21.5	
SLSF	688		4,539		26.1		7.1	
CS	121		549		41.4		15.8	
BNSYS	5,102	5,252	26,386	22,778	28.5*	19.2	18.0*	51.8
UP	1,861		8,764		28.7		14.1	
MP	1,355		7,938		24.5		10.3	
WP	320		1,332		28.9		0.8	
UPSYS	3,536	4,235	18,034	19,370	27.1*	17.2	11.9*	35.1
SOU	1,718		6,422		10.4		24.1	
NW	1,715		4,419		11.5		49.8	
NSC	3,433	3,884	10,841	16,068	11.0*	11.5	38.0*	45.2
ATSF	2,256	2,538	12,075	11,146	31.1	25.4	4.7	29.8
CNWT	981	1,079	9,839	5,563	27.0	27.7	17.0	24.6
DRGW	367	406	1,800	1,573	13.5	8.6	40.8	52.0
ICG	1,779	1,396	8,929	3,608	17.8	17.5	26.3	33.7
KCS	183	288	1,537	1,534	18.5	8.5	1.7	43.5
MKT	279	276	1,902	1,884	29.9	18.6	4.6	24.2
SOO	545	512	4,353	6,263	23.1	27.7	3.1	20.0

* Computed as ton-miles weighted average of constituent's percent coal and percent agriculture

TABLE 2 (Continued)

Railroad/System	Abbreviation
Atchison, Topeka & Santa Fe	ATSF
Burlington Northern	BN
Chicago, Northwest Transit	CNWT
Colorado Southern	CS
Denver, Rio Grande Western	DRGW
Fort Worth, Denver	FWD
Grand Trunk Western	GTW
Illinois Central Gulf	ICG
Kansas City Southern	KCS
Missouri-Kansas-Texas	MKT
Missouri Pacific	MP
Norfolk & Western	NW
St. Louis, San Francisco	SLSF
Soo Line	SOO
Southern Pacific	SP
Southern Railway System	SOU
Union Pacific Railway	UP
Western Pacific	WP
Consolidated Rail Corp.	CRC
Chessie System	CHESSIE
Seaboard System	SBD
CSX Corporation (1981-82)	CSX1
CSX Corporation (1983-86)	CSX2
Burlington Northern - St. Louis System	BNSL
Burlington Northern System	BNSYS
Union Pacific System	UPSYS
Norfolk-Southern Corporation	NSC

percent during this period.[10] Furthermore, a number of roads not involved in mergers significantly rationalized their network. For example the Chicago Northwest (CNWT) and the Illinois Central Gulf (ICG) respectively abandoned or sold 44 percent and 60 percent of their total route miles during this period. Clearly, opportunities for network consolidation were not limited to systems undertaking mergers, nor was the opportunity seized by every merged firm. Therefore, mergers apparently were not a necessary step in the movement toward efficient route consolidation.

With this information as background, we now turn to the question of the measurement of the cost savings occasioned by mergers and deregulation.

III. THE ANALYSIS OF COST SAVINGS

The potential efficiency gains from mergers fall into three categories: reduced short-run variable costs; reduced long run costs due to adjustments in W&S capital toward efficient levels; and enhanced service quality. Cost functions provide a useful framework to evaluate these efficiencies.

Consider a total cost function for railroad r in year t in which variable costs and fixed costs are related as follows:

$$C^T_{rt} = C^v_{rt}(y_{rt}, w_{rt}, t_{rt}, T_r, F_r, Krt) + \rho_{rt}K_{rt} \tag{1}$$

where $C^T{}_{rt}$ and $C^v{}_{rt}$ are respectively a short run total and a short run variable cost function for firm r at time t;[11] y_{rt} is ton-miles of revenue freight;[12] w_{rt} is a vector of prices for variable inputs (labor, equipment, fuel, materials and supplies); t_{rt} is a vector of technological variables (route miles, ALH, traffic mix); T_r is a vector of time-related variables (an annual time counter to accommodate technical change, as well as time counters for years since deregulation occurred and years since firm r was last involved in a major merger); F_r is a vector of firm-specific indicator variables to reflect network characteristics; K_{rt} is fixed way and structures (ws) capital; and ρ_{rt} is the ex ante cost of capital.

Note that with the exception of route miles, this cost specification does not include specific measures of a given railroad's network configuration, which includes factors that embrace the logistics of a firms's route structure -- end-to-end vs. hub-and-spoke, track grade, density of track utilization, etc. It is of course true that such factors affect variable costs. Unfortunately, however, measures of these variables are not available. As a practical matter, we therefore assume that these unobserved network configurations are invariant for a given railroad over time and attempt to capture the aggregate impact of such network effects on costs by introducing a series of firm-specific indicator variables into the cost function.

The end-to-end merger proposals presented to the ICC in the post-Stagger's era have cited a variety of potential benefits, typically focusing on "increased run-through operations" and "more efficient car utilization".[13] Whether these alleged efficiency gains are in fact realized has not received much attention, perhaps because the prevailing wisdom is that scale economies are prevalent throughout the industry.[14] However, the assumptions underlying the conventional measure of economies of scale may not be useful in assessing the cost efficiencies likely to result from end-to-end mergers.

To clarify this point, recall that the conventional measure of returns to scale takes the following form, which in the case of railroads is often referred to as *returns to density*: [15]

$$RTS = [\partial \ln C^T / \partial \ln y]^{-1} \tag{2}$$

where $C^T(\cdot)$ is defined in (1). Short run returns to scale or density (i.e. the inverse of the elasticity of total cost with respect to output, holding all other factors -- including capital -- fixed) are said to be increasing, constant, or decreasing as RTS is greater than, equal, or less than one. In almost all rail studies to date, it is this version of scale economies that has been estimated, and without exception the finding is one of substantial returns to scale. However, the assumptions underlying this scale concept may not be useful in assessing the cost efficiencies likely to result from end-to-end mergers for two principal reasons.

First, this short run RTS measure implicitly treats all other arguments in the total cost function as fixed. Consider, however, a merger between railroads A and B, assuming for the moment that they are of equal size. While the new entity, railroad C, has more output than A or B, it also supports a bigger route structure and a larger W&S capital stock. In addition railroad B may carry traffic with significantly different characteristics (longer ALH, greater proportion of coal traffic, etc.) than, say, railroad A. It is also possible that the input prices may differ, since fuel prices differ geographically and railroads now negotiate a significant proportion of their labor contracts separately. Therefore, to observe an estimated RTS of, say, 1.5 and conclude that a merger would provide significant cost savings would be premature.

Second, RTS is a measure of expansion at the margin. While marginal measures may be appropriate in cases when a large system engulfs a small one (e.g., the Burlington Northern's merger with the St.Louis and San Francisco), they are less meaningful in cases involving firms of nearly equal size (e.g., the merger of the Southern and Norfolk-Western roads to create the Norfolk Southern System or the merger of the Chessie and Family lines to form the CSX). Scale economies could well be exhausted at output levels moderately beyond the output of each individual firm, and in such cases, a simple marginal approach would not capture the effects caused by quantum changes in the scale of operations.

The first issue noted above can be addressed by constructing a more comprehensive measure of firm expansion, in which not only output but also route-miles and W&S capital change in response to an end-to-end rail merger.[16] Specifically, consider a measure hereafter referred to a "returns to expansion" (RTE), which we define as:

$$RTE = [\partial \ln C^T/\partial \ln y + \partial \ln C^T /\partial \ln N + \partial \ln C^T/\partial \ln K]^{-1} \quad (3)$$

where K represents W&S capital and N represents the number of miles of track owned and operated by the railroad. Moreover. the second issue noted above can be addressed simply by estimating RTE for the merged entities, *ex post*.

Although this alternative definition of scale economies generalizes conventional measure of RTS by incorporating changes in size related variables, it does not capture efficiencies related to fundamental changes in a railroad's operational structure or characteristics. These potential efficiencies can be dealt with by considering the changes in the fixed effects (network configuration) and the technological variables of each constituent railroad and their merged counterpart. To this end, we perform the counterfactual experiment of comparing the estimated costs of the merged firm with the sum of the estimated costs of the constituent firms had they had not merged. We can further decompose the cost differences into network effects, capital effects, and operating effects by permitting specific elements to change in the merged and constituent firms.

Specifically, we undertake the following analysis for each of the merged firms: 1) retain the firm-specific network effects for each constituent firm, and estimate new firm-specific effects for the newly consolidated firms; (2) for the post-merger period, project variable costs for the constituent firms under the assumption that they did not merge; (3) compare these projected costs to those estimated for the merged entity, thereby producing an estimate of the total cost savings attributable to the merger. (4) decompose the estimated cost savings into its component parts by assuming separate adjustments in each component, while holding the other component(s) constant. By analyzing differences in projected costs due to changes in fixed effects (i.e. network structure) alone and fixed effects in conjunction with changes in operating characteristics, we can appoximate the magnitudes of the cost savings due to mergers alone and the cost savings due to deregulation-induced changes in operating characteristics.

In terms of long-run capital adjustments, note that mergers potentially provide railroads with an opportunity to adjust their capital levels easily through the consolidation of maintenance yards and the elimination of nodal switching facilities. If merged firms exploited these potentials for cost savings, one would expect to observe their capital to adjust to long-run efficient levels more readily than their unmerged counterparts. In particular, minimization of the total cost function given in eq (1) yields the following equilibrium condition:

$$- \frac{\partial C^V}{\partial K} = \rho \tag{4}$$

where ρ represents the rental cost of capital. Thus in equilibrium the savings in variable costs from a marginal unit increase in capital (the shadow value of capital) should just equal the <u>ex ante</u> rental cost of acquiring the marginal unit (the opportunity cost). Since capital should be subject to diminishing returns, shadow values in excess of the opportunity cost indicate undercapitalization, while shadow values below the opportunity cost indicate overcapitalizatation.

If mergers enhanced a railroad's ability to adjust its capital, we would expect to observe a greater movement toward capital equilibrium on the part of firms that participated in merger activity than those that did not. Consequently by observing the relative capital adjustments of merged and unmerged firms, we can assess whether mergers affected long-run as well as short-run costs.

IV. THE COST EFFICIENCIES OF MERGERS

The estimated cost efficiencies in this paper are based on Berndt et al. (1991), in which estimates of a cost function are computed using a time-series, cross section of the major class I railroads for the period 1974-1986.[17] Thus this data set provides a picture of the technological structure of the railroads during the latter period of regulation and the period of substantial deregulation.

Because of our interest in mergers in this analysis, we will focus on the behavior of the four major railroads that engaged in end-to-end mergers during the sample period (Burlington Northern, CSX System, Norfolk Southern System, and the Union Pacific System). In addition, we include other railroads that engaged in other merger activity (Conrail, which was formed by the government out of the bankrupt eastern roads, the Grand Trunk Western, and the Soo). Finally, for purpose of comparison, we will consider the behavior of a number of representative non-merged systems: the Atchison, Topeka and the Santa Fe (a large western road); the Illinois, Central Gulf (a large southern road); the Denver Rio Grande (a small western road); and the Missouri Kansas Texas (a small western road).[18]

Berndt et al. (1991) estimate a translog approximation of a short-run variable cost function and its associated input share equations of the following general form:

$$C^V = C^V(y, w, x_F, t, T, F) \tag{5}$$

where C^V represents variable costs,[19] y represents total freight ton-miles, w represents a vector of prices for variable inputs (labor, equipment, fuel, and "other"), x_F represents W&S capital, t represents a vector of technological variables (miles of track, average length of haul, agricultural tonnage as a proportion of total tonnage, coal tonnage as a proportion of total tonnage), T represents a vector of time counters (a time trend to capture technical change and dummy variables to represent time since last merger and time since deregulation), and F encompasses a vector of firm-specific indicator variables to capture the effects of the network. Although this specification uses an aggregate output variable of ton-miles, costs are permitted to vary with the composition of tonnage carried among agricultural goods, coal, and "other" commodities--primarily manufactured goods.

The firm-specific indicator variables were added to the intercept and the linear terms of the input price variables of the cost function, as well as to the intercept terms of the input share equations. This procedure assumes, in effect, that firm-specific differences in technology consist of a "neutral" component and an input-specific component, but are independent of the firms' output, W&S capital, and technological characteristics. Moreover, the cross-equation constraints on the fixed effect coefficients permit network effects, unobserved by the econometrician, to affect the firms' cost minimizing variable input decisions.[20]

Since the sample period included a substantial number of years in which rate regulation was significantly reduced, it is likely that output and its related technological variables (ALH, % coal, % agriculture) are endogenous to the firm, rather than exogenous. Consequently, the cost function and its associated input share equations were estimated by a 3SLS procedure that assumed that the following variables and their transformations were endogenous: output, average length of haul, the proportion of coal traffic, and the proportion of agricultural traffic.[21]

We now turn to the impact of mergers upon rail costs and operations. We begin with a discussion of a number of measures of cost elasticities and scale economies and then consider the differential impact of mergers upon costs and the capital adjustments of merged and unmerged firms.

A. Estimated Cost Elasticities and Returns to Scale

Table 3 presents a number of selected cost elasticities and returns to scale and their standard errors,[22] based on the translog cost function estimated in Berndt _et al_. (1991). A comparison of the parameter estimates with their standard errors indicate that the estimates of returns to scale and cost elasticities are generally statistically significant. The estimates of traditional short run returns to scale, computed using equation (2), are all greater than unity. In many cases, they are substantially so, even in 1986.

As we noted previously, however, in end-to-end mergers it is not likely that expansion would occur with W&S capital and route-mileage fixed. Thus more appropriate measure of scale effects would involve incorporating changes in W&S capital (K) and route miles (N), and estimating returns to expansion (RTE) as

TABLE 3

RETURNS TO SCALE AND COST ELASTICITIES

		COST ELASTICITIES WITH RESPECT TO:										RETURNS TO EXPANSION			
		SRRTS		WS CAP		RT MILE		ALH		% COAL		SHORT RUN		LONG RUN	
name	year	Parm	Std.Err	Parm	Std.Err	Parm	Std.Err	Parm	Std.Err	Parm	Std.Err	Parm	Std.Err	Parm	Std.Err
BN	74	2.154	0.472	-0.073	0.136	0.266	0.145	-0.631	0.189	-0.049	0.040	1.521	0.399	1.493	0.483
BN	79	2.203	0.623	-0.215	0.157	0.453	0.194	-0.424	0.206	-0.061	0.036	1.446	0.419	1.412	0.417
BNSYS	84	2.440	0.839	-0.090	0.166	0.345	0.195	-0.334	0.203	-0.075	0.037	1.504	0.467	1.475	0.556
BNSYS	86	2.350	0.715	-0.109	0.159	0.293	0.190	-0.341	0.186	-0.083	0.035	1.639	0.523	1.547	0.582
FAMILY	74	3.238	1.410	-0.166	0.165	0.583	0.109	-0.700	0.245	0.080	0.059	1.378	0.308	1.342	0.308
FAMILY	79	3.049	1.406	-0.186	0.182	0.637	0.120	-0.752	0.273	0.089	0.064	1.283	0.288	1.275	0.288
CHES1	74	1.781	0.386	-0.295	0.168	0.439	0.141	-0.774	0.284	-0.010	0.049	1.417	0.307	1.408	0.304
CHES1	79	1.637	0.337	-0.323	0.174	0.463	0.148	-0.852	0.301	-0.016	0.053	1.332	0.285	1.379	0.297
CSX2	84	2.329	0.711	-0.213	0.186	0.609	0.123	-0.678	0.288	0.025	0.056	1.213	0.288	1.174	0.281
CSX2	86	2.095	0.549	-0.171	0.179	0.508	0.117	-0.814	0.294	0.014	0.057	1.229	0.289	1.171	0.279
NW	74	1.461	0.339	-0.064	0.180	0.048	0.174	-0.800	0.278	-0.086	0.049	1.498	0.330	1.708	0.452
NW	79	1.402	0.282	-0.123	0.177	0.103	0.164	-0.798	0.269	-0.094	0.049	1.443	0.316	1.474	0.329
SOU	74	2.025	0.407	-0.176	0.144	0.318	0.101	-0.618	0.190	-0.007	0.036	1.574	0.337	1.562	0.337
SOU	79	1.766	0.345	-0.167	0.158	0.252	0.117	-0.570	0.195	-0.040	0.037	1.535	0.353	1.538	0.357
NS	84	1.732	0.343	-0.093	0.168	0.285	0.117	-0.770	0.266	-0.044	0.047	1.301	0.286	1.298	0.302
NS	86	2.135	0.493	-0.209	0.162	0.550	0.103	-0.812	0.263	0.009	0.055	1.236	0.280	1.226	0.278
MP	79	3.166	1.167	-0.096	0.135	0.400	0.104	-0.384	0.168	0.014	0.034	1.613	0.407	1.736	0.514
UPSYS	84	2.203	0.554	-0.032	0.163	0.321	0.142	-0.510	0.196	-0.046	0.038	1.347	0.370	1.726	0.748
UPSYS	86	2.378	0.617	-0.123	0.160	0.403	0.139	-0.435	0.182	-0.027	0.034	1.427	0.405	1.418	0.436
CRC	79	1.415	0.227	-0.159	0.138	0.214	0.143	-0.858	0.259	-0.071	0.046	1.313	0.313	1.190	0.281
CRC	84	1.812	0.312	-0.165	0.092	0.171	0.115	-0.574	0.182	-0.078	0.032	1.793	0.425	1.382	0.320
CRC	86	1.553	0.249	-0.192	0.101	0.166	0.129	-0.669	0.197	-0.094	0.035	1.617	0.382	1.351	0.312
GTW	79	1.715	0.489	-0.348	0.136	0.133	0.226	-0.550	0.201	-0.022	0.030	2.715	1.438	2.654	1.226
GTW	84	1.867	0.406	-0.339	0.135	0.233	0.187	-0.501	0.160	-0.036	0.028	2.327	0.961	2.271	0.806
GTW	86	1.971	0.522	-0.520	0.156	0.460	0.204	-0.616	0.185	-0.006	0.033	2.233	0.962	2.387	0.855
SOO	74	3.835	1.598	-0.199	0.073	0.261	0.121	-0.108	0.183	0.010	0.022	3.098	0.994	3.100	1.186
SOO	79	3.738	1.497	-0.158	0.078	0.238	0.132	-0.068	0.218	0.020	0.022	2.878	0.999	3.119	1.353
SOO	84	3.611	1.467	-0.129	0.081	0.204	0.133	-0.088	0.215	0.000	0.023	2.843	0.910	3.229	1.479
SOO	86	7.528	6.913	-0.214	0.107	0.563	0.153	-0.327	0.230	0.046	0.042	2.072	0.462	2.077	0.474
ATSF	79	1.839	0.375	-0.020	0.158	0.121	0.181	-0.370	0.172	-0.088	0.030	1.550	0.474	2.873	2.076
ATSF	84	1.905	0.421	-0.072	0.153	0.176	0.192	-0.334	0.170	-0.111	0.033	1.588	0.463	1.792	0.662
ATSF	86	1.836	0.422	-0.171	0.151	0.214	0.209	-0.351	0.174	-0.122	0.034	1.700	0.510	1.681	0.528
DRGW	74	2.414	0.454	-0.475	0.088	0.412	0.123	-0.344	0.079	-0.048	0.026	2.843	0.975	3.014	0.973
DRGW	79	2.424	0.561	-0.607	0.119	0.566	0.151	-0.240	0.078	-0.040	0.039	2.691	0.984	3.044	0.991
DRGW	84	2.412	0.941	-0.713	0.143	0.601	0.222	0.118	0.114	-0.093	0.067	3.301	1.438	3.869	1.485
ICG	74	2.388	0.415	-0.194	0.101	0.387	0.080	-0.709	0.173	-0.001	0.042	1.635	0.315	1.541	0.298
ICG	79	2.246	0.305	-0.186	0.103	0.351	0.079	-0.633	0.150	-0.019	0.035	1.640	0.335	1.596	0.330
ICG	84	2.204	0.293	-0.203	0.094	0.347	0.074	-0.644	0.154	-0.031	0.034	1.674	0.309	1.600	0.294
ICG	86	1.593	0.233	-0.125	0.101	0.047	0.129	-0.830	0.195	-0.085	0.035	1.819	0.362	1.750	0.361
MKT	74	2.865	0.710	-0.148	0.065	0.061	0.111	-0.219	0.163	-0.035	0.018	3.814	1.726	4.656	3.269
MKT	79	2.455	0.364	-0.248	0.077	0.163	0.118	-0.304	0.128	-0.047	0.020	3.099	1.289	3.094	1.280
MKT	84	2.740	0.474	-0.175	0.097	0.210	0.110	-0.458	0.128	-0.040	0.028	2.504	0.742	2.594	0.869
MKT	86	3.301	0.633	-0.352	0.081	0.382	0.111	-0.300	0.104	-0.019	0.021	3.006	1.097	2.998	1.002

given in Eq (3). The next section of Table 3 provides estimates of the elasticity of short run total costs with respect to the other components of RTE: W&S capital (K); and route miles (N). For all railroads, the W&S elasticity is negative and substantial,[23] while that for route mileage is positive, but less than unity. These estimates imply that, cet. par., if a railroad abandons or sells 10 percent of its low density trackage, it may expect reductions in total variable costs between 0.6 percent and 6.4 percent. Eased line abandonment restrictions therefore may represent significant steps toward improving the economic viability of railroads.

To highlight the importance of ALH and the proportion of coal traffic on costs, Table 3 also presents estimates of elasticities of total costs with respect to ALH and the percentage of coal traffic. As expected, the partial ALH elasticities are negative, and many are substantial. These indicate that railroads face considerable incentives to increase their average length of haul, either by greater use of run-through operations (whether attained through joint marketing agreements or merger) or by changes in their traffic mix. The cost elasticities with respect to % Coal are mostly negative, and are smaller in absolute value than those with respect to ALH, indicating that coal usually involves longer hauls and larger shipments, both of which are the source of substantial economies.

Returns to expansion, which incorporate simultaneous changes in output, W&S capital and route miles, are given in the last section of Table 3. The short-run returns provide estimates of RTE conditional on the actual capital stock; the long run estimates of RTE are conditional on the optimal capital stock.[24] Both the short run and long run estimates of RTE are substantially below those of the estimates of conventional returns to scale or of density, although they are still above unity, indicating that railroads could exploit economies of scale by expanding through end-to-end mergers. Although the long run estimates of RTE are somewhat below the short run estimates, they are quite similar, indicating that optimal capital adjustments would not substantially change the incentives to expand through merger.

An examination of the merged rail systems indicates that the RTE generally fell post merger, particularly in the case of the Norfolk Southern and the CSX. Since the merged entity is considerably larger than its constituent firms, this is to be expected. Nevertheless, the RTE of the merged entities is sufficiently large to indicate that returns to scale are pervasive in the industry, even if route mileage and capital expand with output. Clearly, these economies are not primarily dependent on the more intensive utilization of a given network and its associated capital. Thus it is likely that mergers were able to yield economies of expansion to the merged entities.

B. Counterfactual Costs Simulations

Estimates of the magnitude of these economies can be obtained by a simulation analysis in which we perform a counterfactual experiment where we estimate the aggregate costs of the constituent firms had they had not merged and compare those costs with those estimated for their merged counterpart. In undertaking this exercise, however, it is important to note that cost differentials arise from several sources: (1) organizational and unobserved network changes that are reflected in the fixed effects; (2) increases in the scale of output; and (3) changes in operating characteristics such as ALH, W&S capital route miles, and percentage coal traffic. Because these latter variables were also doubtless affected by the regulatory freedom afforded by the Staggers

Act, changes in them cannot be attributed solely to merger. To disentangle these effects we performed a number of conceptual experiments.

B.1. "Pure" Merger Simulations

The first experiment represents the "pure" merger effect and attributes cost differentials to organizational changes and scale effects. To this end we use our estimates of fixed effects for each of the constituent firms; we project into the post-merger years constituent railroad costs as if they had not merged and compare the sum of their costs with fitted costs incurred by merged firms which utilize their own fixed effects. Specifically, we assume that: factor prices for constituent firms equal those of the merged entity; the deregulation time counters change over time; output and technical factors shift so that the sum of constituent output in each period matches merged output (with the output assigned to each constituent firm being proportional to its pre-merged output); and the output-weighted averages of the constituent firm technical factors equal the technical factors of the merged entity[25]. Since the output of the merged firm is greater than that of each of its individual constituents, the estimated cost differentials reflect returns to expansion as well as those arising from organizational changes and unobserved network effects. Nevertheless, because the technical variables or operating characteristics are assumed to be the same for the merged firm and its constituents, these estimated cost differentials can be thought of as capturing the pure merger effect.

The results of these simulations are contained in Table 4. The column marked "Fixed Effects of Const. Firms" presents the "pure" merger effect, and measures the cost differentials arising from differences in the scale of output and the fixed effects of the merged firm and its constituents (which represent

Table 4

Cost Savings Due to Merger and Operating Characteristics, Merged Railroads

		Cost Savings in 1986 if Railroad Had:					
Firm	Years	Fixed Effects of Const. Firms	All Oper. Charact, Const. Firms	WS Capital of Const. Firms	Rt Miles of Const. Firms	ALH of Const. Firms	% Coal of Const. Firms
		(Billions of 1974 $)					
CSX	81-86						
Savings		-.073	.612	.013	.211	.342	.003
Percent		3.7	31.3	0.7	10.8	17.5	0.1
BN	80-86						
Savings		.404	.475	.014	.144	.281	.060
Percent		32.7	37.0	1.1	11.7	22.7	4.9
UPS	83-86						
Savings		.283	.034	.041	.025	-.013	-.003
Percent		14.9	2.2	2.6	1.6	-0.8	-0.3
NSC	82-86						
Savings		.225	-.458	-.003	-.306	-.107	-.001
Percent		12.9	26.2	-0.2	-17.5	-6.1	0.1

unobserved organizational and network changes). In 1986, these cost savings ranged from a high of $400 million (32.7 percent) for the Burlington Northern System to a low of an actual incremental cost of mergers of $73 million (3.7 percent) for the CSX, with the Union Pacific System and the Norfolk Southern System each achieving savings of approximately $230 million as a result of merger, respectively representing 14.9 percent and 12.9 percent of their total costs.

B.2. Simulations With Partial Changes in Operating Characteristics

The other simulations assume that in the counterfactual experiments only a subset of the constituent firms' operating characteristics would have changed "but for" the merger. We continue to assume that the deregulation time counters change over time and that the factor prices and total output are the same for the merged firms and the aggregate of the constituent firms. The first of these simulations assumes that each constituent firms maintains all its pre-merger operating characteristic levels and compares the aggregate costs of the constituent firms (each of which has its pre-merger operating characteristics) with the costs of the merged entity (which has its own operating characteristic); subsequent simulations assume that each of the constituent firms continues to maintain one of its pre-merger operating characteristics at the pre-merger level (e.g., W&S capital), but has the other operating characteristics change to the levels of the merged firm. In this way, we can estimate the cost savings associated with the pre and post merger operating characteristics. Of course, since these operating characteristics were doubtless affected by the regulatory freedom associated with the Staggers Act, their changes cannot be attributed to merger alone. Nevertheless, a comparison of the cost differentials attributed to fixed effects alone and the cost savings attributed to fixed effects cum operating characteristics should set an upper bound for the cost savings due to merger.

B.2.1 Constituent Firms Retain All Pre-Merger Operating Characteristic Levels

The first of these simulations assesses the combined effects of all of the operating characteristics and assumes that each constituent firm continues to utilize its pre-merger operating characteristics, while the merged entity utilizes its own operating characteristics. The cost differentials due to the combined changes in operating characteristics are given in the column marked "All Oper. Charact. Const. Firms" in Table 4. In this case, we see that the change in operating characteristics actually imposed substantial costs upon the Norfolk Southern System, totalling approximately $460 million in 1986. In contrast, the other merged systems gained from the changes in operating characteristics, with the greatest gains accruing to the CSX System, which realized an additional $613 million (31 percent) cost saving. The Burlington Northern also gained substantially ($460 million or 31 percent), while the Union Pacific System gained relatively little ($34 million or 2 percent).

B.2.2 Constituent Firms Retain Pre-Merger Operating Characteristic Levels For One Characteristic

The next four simulations attempt to assess the impact of changes in specific operating characteristics and assesses the cost differential arising from changes in W&S capital, route miles, ALH, and the percentage of coal traffic. In each simulation, the level of one characteristic remains at the pre-merger level for the constituent firms while the other characterisitics are allowed to vary. The estimated costs for this "modified" constituent firm are then compared to the constituent costs had all characteristics changed. The gains from changes in W&S capital and the percentage of coal traffic are uniformly small. In contrast the gains from changes in route miles and average length of haul are variable and relatively large in the case of the Burlington Northern and the CSX. However, they are negligible for the Union Pacific, and actually negative for the Norfolk Southern. Since the Norfolk Southern was attempting to position itself strategically to acquire Conrail during this period, it is difficult to determine whether the changes in route miles and ALH can be attributed to merger per se or its unsuccessful attempt to acquire Conrail.

B.3. Counterfactual Simulations Summary

With the exception of the Union Pacific, the merged firms appear to have experienced greater cost differentials from changes in operating characteristics than from the "pure" merger effects arising from differences in the scale of operations and fixed effects that reflect unobserved changes in network utilization and managerial organization. The Burlington Northern appears to have realized the greatest gains from merger, achieving economies from both the "pure" merger effects and changes in operating characteristics. In contrast, while the Norfolk Southern gained from the pure merger effect, it experienced greater losses due to changes in operating characteristics. Because of its strategic interactions with Conrail, however, it is likely that this was not primarily due to merger or deregulation.

B.4. Counterfactual Simulations For Firms Not Involved in Mergers

As we have discussed previously, all railroads were able to adjust their operating characteristics in response to the regulatory freedom afforded by the

Staggers Act. Thus it is unclear whether the cost savings obtained by the merged firms due to changes in operating characteristics were due to merger or regulatory freedom, or a combination of both. To shed some light on this question, we perform a similar counterfactual experiment with railroads that did not participate in end-to-end mergers and simulate their projected costs if they had maintained their 1981 operating characteristics. Again, we first assume that all of the operating characteristics were maintained at their 1981 levels, and then assume that each of the relevant characteristics was maintained at its 1981 level.

The results of this simulation are presented in Table 5 for the railroads considered in this analysis and show a high degree of variability. In particular, the large railroads (Conrail, the ATSF, and the ICG) appear to have experienced substantial cost savings from changes in operating characteristics, while the small railroads generally experienced losses. As was true in the case of the merged firms, changes in W&S capital had little effect upon costs as did changes in the percentage of coal traffic (with the exception of the SOO). In contrast, the large firms appeared to be able to exploit economies from reduced route miles or increased ALH, while the small firms were not. In this connection, the economies that the ICG obtained from adjustment in route miles were striking, as were the economies that the ATSF obtained from ALH.

While the evidence concerning the cost savings that the nonmerged firms obtained from changed operating characteristics is mixed, it is similar to that of the firms that experienced major mergers post Staggers. This suggests that mergers did not have a differential impact upon the operating characteristics employed by the railroads during the onset of regulatory freedom. Indeed, the observed changes can probably be attributed to deregulation rather than to

Table 5

Cost Savings Due to Operating Characteristics
By Railroad, 1981-1986

Firm	Cost Savings in 1986 if Railroad Had Maintained 1981 Operating Characteristics				
	All Operat. Charact.	WS Capital	Route Miles	ALH	% Coal
	(Billions of 1974 $)				
CRC					
Savings	.428	-.056	.150	.274	.009
Percent	30.3	-3.9	10.6	19.4	0.64
GTW					
Savings	-.016	.001	-.009	.004	.001
Percent	-9.1	0.6	-5.1	-2.3	0.6
SOO					
Savings	-.089	.004	-.046	-.004	-.043
Percent	-36.9	1.7	19.1	1.7	17.8
ATSF					
Savings	.311	.011	.016	.135	.158
Percent	34.3	1.2	1.8	21.5	6.4
ICG					
Savings	.187	-.011	.148	-.062	.010
Percent	50.1	-3.0	39.7	-16.2	2.6
MKT					
Savings	-.006	.004	-.004	0.0	-.001
Percent	-4.1	-2.7	6.2	0.0	-0.7

mergers.

C. Labor Utilization For Merging and Non-Merging Firms

Additional support for the conclusion that observed cost savings are more likely the result of non-merger related changes in operational characteristics post-deregulation is provided by an analysis of changes in labor utilization during the post-Staggers period. That labor savings played a major role in cost reductions achieved by merging firms is indicated in Table 6, where we summarize ICC data on actual labor costs of merged firms with the projected labor costs of their constituent firms. Employment, measured through number of employees or hours worked, has fallen dramatically for merged firms over this time period. From 1979-1982 to 1986, employment fell 28 percent, 41 percent, 31 percent and 17 percent for the CSX, BNSYS, UPSYS and NSC roads, respectively. Over this same time period (roughly 1980 to 1986), output increased for two roads (BNSYS and UPSYS), and remained relatively constant for CSX and NSC. Using average compensation rates for each of the four firms in 1986 (measured in $1974), we compute that reduced employment accounts for savings ranging from $420 million for the Union Pacific System to $110 million for the Norfolk Southern, figures that are comparable to the cost adjustments associated with changes in operating characteristics and unobserved managerial and network effects.

The remaining issue involves whether the mergers were necessary for these firms to consolidate labor so dramatically. Table 7 explores employment trends of the other railroads used in this analysis. With the exception of two small roads (the Soo and the GTW), these railroads experienced reductions in their work force and labor costs comparable to those achieved by the firms that undetook no major merger activity. For these firms, reductions in employment from 1981 to 1986 ranged from 27 percent to 55 percent, without any of these firms having

Table 6

COST SAVINGS REALIZED FROM EMPLOYMENT SHIFTS FOR LARGE RAIL MERGERS
(Savings in Thousands of 1974 $)

FIRM/SYSTEM (Year)	Average Number of Employees	Total Hours Paid (000)	Average Firm-Wide Wage Rate	Implied 1986 Labor Costs
CSX Corporation:				
Member Firms (1981)	69,508	161,532		1,112,956
CSX (1986)	47,803	116,388	$6.89	801,913
Total Change	-21,705	-45,144		- 310,835
Percent Change	-31.2%	-27.9%		-27.9%
* *				
Burlington Northern System:				
Member Firms (1979)		144,695		1,027,335
BN System (1986)	35,110	85,490	$7.10	606,979
Total Change		-59,205		-420,356
Percent Change		-40.9%		-40.9%
* *				
Union Pacific System:				
Member Firms (1981)	49,713	124,675		873,972
UP System (1986)	33,271	86,105	$7.01	603,596
Total Change	-16,442	-38,570		-399,166
Percent Change	-33.1%	-30.9%		-30.9%
* *				
Norfolk-Southern Corporation:				
Member Firms (1981)	41,704	93,563		660,555
NSC Corp. (1986)	34,857	77,906	$7.06	550,016
Total Change	-6,847	-15,657		-110,538
Percent Change	-16.4%	-16.7%		-16.7%

Source: Interstate Commerce Commission Wage Form A-200, 1979, 1981, 1986

Table 7

COST SAVINGS REALIZED FROM EMPLOYMENT SHIFTS
FOR MAJOR U.S. RAILROADS NOT INVOLVED IN MERGERS
(Savings in Thousands of 1974 $)

FIRM/SYSTEM (Year)	Average Number of Employees	Total Hours Paid (000)	Average Firm-Wide Wage Rate	Implied 1986 Labor Costs
Chicago Northwest Railroad:				
CNW (1981)	14,345	37,319		259,501
CNW (1986)	9,450	25,494	$6.95	177,273
Total Change	-4,895	-11,825		- 82,226
Percent Change	-34.1%	-31.7%		-31.7%
* *				
Atchison, Topeka & Santa Fe:				
ATSF (1981)	33,605	83,130		591,924
ATSF (1986)	23,965	57,113	$7.12	406,671
Total Change	-9,640	-26,017		-185,263
Percent Change	-28.7%	-31.3%		-31.3%
* *				
Southern Pacific System:				
SPSYS (1981)	38,561	93,090		632,433
SPSYS (1986)	29,425	70,860	$6.79	481,408
Total Change	-9,136	-22,230		-185,263
Percent Change	-23.7%	-23.9%		-23.9%
* *				
Consolidated Rail Corporation:				
CRC (1981)	70,264	165,585		1,166,848
CRC (1986)	33,768	80,229	$7.05	481,408
Total Change	-36,496	-85,356		-601,489
Percent Change	-51.9%	-51.5%		-51.5%

Source: Interstate Commerce Commission Wage Form A-200, 1981 and 1986.

suffered major losses in output. These figures are comparable to those obtained for the firms experiencing major mergers.

Since employment reductions were not limited to merged entities, it appears that labor cost savings were possible to a large extent without merger, and therefore that such savings should not be attributed to efficiency gains brought about by consolidations. Indeed, Vellturo (1989) has argued that deregulation may have played a more important role in reducing labor costs than did direct labor savings associated with mergers.

D. Captial Utilization Issues: Tobin's q Estimates

Finally, if mergers have presented railroads with a unique opportunity to consolidate their capital, estimates of their Tobin's-q values based on the short-run cost function (i.e. the marginal Tobin's q) should reveal two trends. First, merged systems should show significantly greater movement towards q values of one than those of constituent firms prior to merger, and second, the movements of marginal q toward unity should not be as rapid for firms not involved in consolidations.

To construct these estimates of marginal Tobin's q, we have used our estimated translog cost function to compute the shadow value of capital ($= - \partial C_V/\partial K$), and have also taken the ratio of this shadow value to the ex ante rental price of capital. Results of these calculations for 1974, 1979 and 1986 are given in Table 8.

As is seen in Table 8, there appears to be little evidence to support the claim that mergers were a necessary route to improve Tobin's q values through capital consolidation and investment. Although shadow values tend to rise in absolute value over time indicating that Class I railroads have made some progress toward capital consolidation, most railroads exhibit this trend, implying that firms not involved in mergers were equally able to consolidate.

The four merged entities fall into two categories. From 1974 to 1979, prior to merger, the constituent firms in the eastern mergers (CHES and FAMILY for CSX2 and the NW and SOU for the NSC) all had q-ratios increasing to levels not far from unity (CHES was above unity in 1979); since these improvements came prior to merger, merger was not a prerequisite. However, such roads with streamlined systems may have been attractive merger targets. In contrast, roads with excessive capital as reflected in their low Tobin's q ratios (e.g., ATSF) were not actively pursued for end-to-end consolidation. The western mergers, on the other hand, have shown improvements in their shadow values and q-ratios over the 1974-86 time period. The BNSYS shadow value was about two percentage points higher in 1986 than the BN value in 1974, and the q-ratio increased by about 45 percent. Similarly, the UPSYS shadow value in 1986 was about seven percentage points higher than the UP value in 1974, and its q-ratio increased by about 250 percent. However, the capital rationalizations inherent in these figures occurred between 1974 and 1979, and not after the consolidations. Indeed, the output of both the BN and UP expanded significantly during this same period, allowing both firms to improve their capital situation by simply not expanding their capital structure in the face of rising demand, rather than taking steps to cut back on their capital. Other non-merged firms with significant output expansion in the period show similar improvements in shadow values and Tobin's q ratios (e.g., the GTW and the MKT roads).

Table 8 also provides data on the average rate of return to capital, which we define as $(R-VC)/X_F$, where R represents total revenues, VC represents actual variable costs and X_F represents W&S capital. With the exception of the

TABLE 8

CAPITAL DISEQUILIBRIUM BY RAILROAD
SELECTED YEARS

	Year	SHADOW PRICE	OPPTNTY COST	MARG Q	ROR CAPITAL
BN	74	0.0266	0.1323	0.2013	0.0706
BN	79	0.1067	0.1383	0.7712	0.0595
BNSYS	84	0.0437	0.1640	0.2666	0.1315
BNSYS	86	0.0405	0.1366	0.2966	0.1086
FAMILY	74	0.0828	0.1341	0.6179	0.0930
FAMILY	79	0.1201	0.1398	0.8587	0.0126
CHES	74	0.1265	0.1311	0.9653	0.1031
CHES	79	0.1788	0.1400	1.2767	0.0046
CXS2	84	0.1260	0.1655	0.7613	0.0188
CSX2	86	0.0815	0.1366	0.5962	-0.1215
NW	74	0.0348	0.1256	0.2773	0.1257
NW	79	0.0792	0.1302	0.6079	0.0436
SOU	74	0.0935	0.1323	0.7064	0.1423
SOU	79	0.1022	0.1302	0.7850	0.0338
NS	84	0.0556	0.1640	0.3388	-0.0322
NS	86	0.1230	0.1366	0.9002	-0.0198
MP	75	0.0271	0.1419	0.1910	0.1541
MP	79	0.0621	0.1383	0.4492	0.1150
UP	75	0.0473	0.1257	0.3764	0.0683
UP	78	0.0589	0.1302	0.4522	0.1616
UPSYS	84	0.0208	0.1640	0.1268	0.0160
UPSYS	86	0.0629	0.1366	0.4606	0.0868
CRC	79	0.0585	0.1293	0.4526	0.0355
CRC	84	0.0512	0.1574	0.3252	0.0661
CRC	86	0.0512	0.1201	0.4264	0.0647
GTW	75	0.1705	0.1358	1.2554	0.0105
GTW	79	0.2766	0.1517	1.8233	-0.1091
GTW	84	0.3282	0.1546	2.1228	-0.0772
GTW	86	0.4443	0.1361	3.2643	-0.0815
SOO	74	0.0699	0.1362	0.5133	0.1229
SOO	79	0.0738	0.1415	0.5215	0.0635
SOO	84	0.0639	0.1640	0.3895	0.0397
SOO	86	0.1318	0.1442	0.9140	0.1000
ATSF	79	0.0124	0.1302	0.0955	0.0312
ATSF	84	0.0475	0.1640	0.2895	0.0081
ATSF	86	0.0845	0.1366	0.6183	-0.0036
DRG	74	0.2061	0.1362	1.5141	0.0788
DRG	79	0.3532	0.1415	2.4955	0.0471
DRG	84	0.4326	0.1693	2.5545	0.0098
ICG	74	0.0759	0.1323	0.5738	0.0575
ICG	79	0.0897	0.1415	0.6342	-0.0176
ICG	84	0.1077	0.1724	0.6249	-0.0357
ICG	86	0.0520	0.1504	0.3455	-0.0879
MKT	74	0.0708	0.1647	0.4298	0.0064
MKT	79	0.1598	0.1573	1.0160	-0.0483
MKT	84	0.1322	0.1846	0.7162	-0.0444
MKT	86	0.2481	0.1752	1.4162	-0.0797

Burlington Northern System, which was able to extract sizable economic rents from the coal traffic emanating from the Powder River Basin, there is no evidence that merged systems earned a higher rate of return than their unmerged counterparts. Indeed, the rate of return to capital was generally lower for the merged entity than its constituents. Moreover, there does not appear to be any systematic difference between the rates of return of the merged firms and the other railroads that were not involved in merger. This is consistent with the analysis of the Tobin q ratio's which indicated that the capital disequilibrium of the constituent firms was not improved by merger; nor was it appreciably less for the merged firms than for the nonmerged firms.

V. CONCLUDING REMARKS

In this paper we have attempted to assess the cost savings that can be attributed to the end-to-end mergers that occurred in the late 1970's and early 1980's and compare them with the savings generated by changes in operating characteristics and labor and capital utilization. Using a simulation approach based on a translog variable cost function of the major US railroads for the period 1974-1986, we find that the pure merger effect (a combination of scale effects and unobserved changes in managerial organizations and network utilization) accounted for cost savings ranging from a high of 33 percent for the Burlington Northern to an actual cost increase of 4 percent for the CSX, with the savings of the Norfolk Southern and the Union Pacific being roughly comparable (respectively 15 percent and 14 percent).

It is interesting to note that the cost adjustments due to operating characteristics were of a comparable magnitude and often of a different direction. For example, the combined changes in operating characteristics caused the CSX to enjoy cost savings of 31 percent, while actually imposing cost penalties on the Norfolk Southern of 26 percent. In addition, the Burlington Northern gained an additional 36 percent in savings due to aggregate changes in operating characteristics, while those of the Union Pacific were quite modest (2 percent). The source of these cost differentials arose primarily from changes in route miles and ALH. Railroads that were able to increase their ALH and reduce their route miles enjoyed substantial efficiency gains.

It is also important to note that the changes in operating characteristics experienced by the merged firms are comparable to the other railroads considered in this analysis, indicating that deregulation, rather than mergers, enabled railroads to change their operating characteristics. Support for this hypothesis is provided by the substantial rationalization of rail labor, which occurred in both merged and unmerged firms. Reductions in the work force led to substantial savings in labor costs that were comparable in magnitude to those occasioned by changes in operating characteristics and the "pure" merger effects. Finally, there appears to be little difference in movements of Tobin's q ratios for merged vs. non-merged firms since 1979.

Since deregulation provided a climate that enabled the railroads to rationalize their labor force and their operating characteristics, mergers were neither a necessary nor a sufficient condition for these economies. Indeed, the CSX actually appears to have experienced a small merger penalty, while the direct gains from merger afforded to the Norfolk Southern and the UPS appeared to have been relatively modest.

We conclude, therefore, that mergers were certainly not a prerequisite for railroads to achieve substantial cost and productivity improvements in our 1974-1986 sample period. Deregulation also had an enormous impact; indeed, its impact may have been much larger.

Endnotes

1. At that time the following railroads were insolvent: Penn-Central, Lehigh Valley, Erie-Lackawanna, New Jersey Central, Reading, Boston and Maine, and the Chicago, Milwaukee, St. Paul and Pacific

2. For example, in 1975, three railroads had A+ or AA bond ratings from Moody's. By 1986, eleven firms had achieved these rating.

3. The studies on rate adjustments generally conclude that the rate-setting freedom afforded by deregulation has enhanced the railroads' ability to achieve revenue adequacy in two principle ways: i) through the exploitation of market dominance in a number of areas and for a number of products; and ii) by permitting the railroads to develop innovative pricing/contract mechanisms such as long-term contracts and multi-firm/intermodal joint marketing agreements that have significantly enhanced their competitiveness. Studies on capital adjustments conclude that in spite of the apparent freedom afforded by the Staggers Act, railroads have still failed to rationalize their capital stock sufficiently to earn a competitive return on their capital. Rail rate adjustments are analyzed in Friedlaender (1991), Rose (1988) and Moore (1983). Capital adjustemnts are anlayzed in Friedlaender et.al, (1991a, 1991b).

4. In 1978 the ICC raised the minimum freight revenue required for Class I status from $1 million to $5 million; in 1983 it further raised the minimum to $10 million.

5. For example, the following major mergers all involved consolidation of railroads with substantial parallel trackage: the Penn-Central (from the New York Central and the Pennsylvania railroads); the initial Burlington Northern (from the Great Northern, the Northern Pacific, and the Burlington railroads); the Chessie System (from the C&O, B&O, and Western Maryland railroads); and the Family Lines (from the Seaboard, Louisville and Nashville, and Clinchfield and Ohio railroads).

6. For example the initial Burlington Northern merger required eleven years and three submissions before final approval, while the Penn Central application spanned seven years. See Saunders (1978) for details.

7. One notable exception involved the proposed merger of the Southern Pacific and the Atchison, Topeka and Santa Fe railroads, in which each had extensive parallel trackage. The original proposal came before the ICC in 1984 and was finally rejected in 1987 on the basis of the potential monopoly power of the consolidated railroad.

8. We do not analyze Conrail, which was formed from the bankrupt Eastern railroads, because it was a governmental entity until 1986. In addition, there were a few mergers of small lines (the Guilford System, the Grand Trunk Western, and the Soo) that we do not consider.

9. It should be noted that this measure of W&S capital includes maintenance expenditures.

10. This expansion primarily occurred in the mid 1980's as the Norfolk Southern purchased numerous feeder lines to position itself to acquire Conrail when that system was released from federal control. The Norfolk Southern bid was ultimately rejected by Congress, which sold Conrail to the public as an independent entity in 1987.

11. In this study, fixed capital refers to way and structures capital that includes track, grading, bridges, buildings, etc. Equipment capital or rolling stock is treated as a variable input in the short run since an active rental market exists for such equipment.

12. Since the formation of Amtrak in the early 1970's railroads have only carried freight. Because ton-mile data are only available for total traffic, we use this as a measure of output, but include the composition of traffic as technological variables.

13. Another important measurement issue involves service quality. Measures of service quality are typically market specific; for example, Levin and Weinberg (1979) employ market shares in point-to-point markets, while Harris and Winston (1983) use the mean and variance of transit time for specific point-to-point shipments. Since this study relies upon data at the firm level rather than point-to-point shipment data, an analysis of service quality is not possible. Thus, we will not be able to account for service quality improvements.

14. See, for example, Harris (1977), Keeler (1974), Friedlaender and Spady (1981), Caves et al (1981, 1985).

15. The analysis proceeds analogously for the multi-product case. See Bailey and Friedlaender (1982) for a discussion of multi-product measures of returns to scale.

16. Caves et al. (1985) and Friedlaender et al. (1991) have utilized measures of returns to scale that incorporate network effects.

17. See Caves, Christensen, and Swanson (1981), Brown, Caves and Christensen (1979), Friedlaender and Spady (1981), and Caves et al. (1985) for related work on rail costs.

18. The other railroads included in the sample that were not affected by merger were: the Chicago Northwest Transit; the Kansas City Southern; the Missouri Kansas Texas; and the Southern Pacific. The results for these railroads were not reported because they failed to satisfy a sufficient number of regularity conditions to give an adequate picture of their behavior over the sample period.

19. Costs and related variables were all measured in 1974 dollars to abstract from the effects of inflation

20. See Mundlak (1978), Vellturo (1989) and Berndt et al. (1991) for a full discussion of this point. Most analyses of fixed effects assume that they affect total costs alone (e.g., Mundlak (1978) and Caves et al. (1985). Because we assume that these effects may be related to factor utilization and that firms are able to minimize costs with respect to variable factors, we introduce them into the linear terms of the factor price expressions within the cost function. We do not, however, introduce them into the capital stock terms because we assume that

in the short run firms are not able to minimize costs with respect to W&S capital. To ensure consistency we impose the appropriate cross-equation restrictions on the coefficients of the indicator variables in the cost equation and the input share equations.

21. The instruments used were related to firm-specific demand variables and included mine-mouth coal prices, coal production, oil prices, farm income, and the value of manufacturing shipments. To test the hypothesis of endogeneity, the system of equations was estimated in two ways: first by a 3SLS procedure that assumed that output and its related variables were endogenous; and second, by a maximum likelihood (ML) procedure that assumed that all of the regressors were uncorrelated with the error terms. Under the null hypothesis of exogeneity ML estimation is efficient, while 3SLS is consistent. If the alternative hypothesis of endogeneity is true, only 3SLS is consistent. The χ^2 statistic corresponding to the null hypothesis that $B_{3SLS} = B_{ML}$ was 1252.99, which is much larger than the critical value with 38 degrees of freedom at any reasonable level of significance. This indicates that output and its related variables should be treated as endogenous. Hence the cost function and its associated input share equations were estimated by 3SLS, with demand-related instruments used for output and its related variables.

22. The estimates of the standard errors are robust to heteroskedasticity, based on the White (1980) procedures.

23. This is to be expected, since an increase in W&S capital should permit a firm to economize on its variable factors. Indeed, a positive elasticity would imply a negative marginal product of capital and thus violate a regularity condition.

24. Long run total costs are obtained by solving Eq (5) for the equilibrating amount of W&S capital that equates the firm's opportunity cost with its shadow value of capital, and then substituting this optimal amount of capital into the estimated cost function. The estimates of long run returns to expansion are simply obtained by utilizing Eq (4) with the optimal amount of capital.

25. This approach is applied to each of the four mergers of interest with the exception of the Norfolk Southern (NSC). Shortly after merger the NSC acquired significant trackage in an effort to better position itself for its offer to purchase Conrail (an offer ultimately rejected by Congress). Had the Norfolk and Western and the Southern Systems not merged, these acquisitions would have made little sense, since neither system could separately position itself adequately. We therefore assume that these additional acquisitions were a product of the merger and would not have been pursued by the constituent firms. As such, output and technical factors were fixed for the constituent firms at their pre merger levels.

REFERENCES

Bailey, Elizabeth E. and Ann F. Friedlaender [1982], "Market Structure and Multiproduct Industries," Journal of Economic Literature, 20:3, September, 1024-1048.

Berndt, Ernst, Ann F. Friedlaender, Judy Shaw-Er WangChaing and Christopher A. Vellturo (1991), "Mergers, Deregulation, and Cost Savings in the U.S. Rail Industry," National Bureau of Economic Research, Working Paper No. 3749, June, 1991. Forthcoming, Journal of Productivity Analysis.

Caves, Douglas W., Laurits R. Christensen, and Joseph A. Swanson [1981], "Productivity Growth, Scale Economies, and Capacity Utilization in U.S. Railroads, 1955-1974," American Economic Review, 71:5, December, 994-1002.

-----,Laurits R. Christensen, and Joseph A. Swanson [1980] "Productivity in U.S. Railroads, 1951-1974," Bell Journal of Economics, Spring, pp. 166-181.

-----, Michael W. Tretheway, and Robert J. Windle [1985], "Network Effects and the Measurement of Returns to Scale and Density for U.S. Railroads," in Andrew F. Daughety, ed., Analytical Studies in Transport Economics, Cambridge: Cambridge University Press, 97-120.

Friedlaender, Ann F. [1991], "Fair Rates and Rates of Return in a Deregulated Rail Industry," MIT Department of Economics Working Paper No. 576, March.

-----, Ernst R. Berndt, Judy Shaw-Er Wang Chiang, and Christopher A. Vellturo [1991], "Rail Costs and Capital Adjustments in a Quasi-Regulated Environment," National Bureau of Economic Research, Working Paper No.3841, September.

-----, and Richard H. Spady [1981], Freight Transport Regulation: Equity, Efficiency, and Competition in the Rail and Trucking Industry, Cambridge, MA: The MIT Press.

Harris, Robert G. [1977], "Economies of Traffic Density in the Rail Freight Industry," Bell Journal of Economics, 8:2, Autumn, 556-564.

-----, and Clifford Winston [1982], "Potential Benefits of Rail Mergers: An Econometric Analysis of Network Effects on Service Quality," Review of Economics and Statistics, Vol 64, No.1 (February), 32-39.

Keeler, Theodore E. [1983], Railroads, Freight and Public Policy, Washington, DC: The Brookings Institution.

-----, [1974], "Railroad Costs, Returns to Scale and Excess Capacity," Review of Economics and Statistics, 56:2, May, 201-208.

Levin, Richard C. and D. Weinberg [1979], "Alternatives for Restructuring the Railroads: End-to-End or Parallel Mergers?", Economic Inquiry, 27:3, 371-388.

Meyer, John R. and William B. Tye [1985], "The Regulatory Transition," American Economic Review, 75:2, May, 46-51.

Moore, Thomas G. [1983], "Rail and Truck Reform: The Record So Far," Regulation, November/December, 33-41.

Mundlak, Yair [1978], "On the Pooling of Time Series and Cross Section Data," Econometrica, 46:1, January, 69-85.

Rose, Nancy L. [1988], "An Economic Assessment of Surface Freight Transportation Deregulation," in Economic Deregulation: Promise and Performance, Proceedings of the 1987 Donald S. MacNaughton Symposium, Syracuse: Syracuse University Press, 149-173.

Saunders, Richard [1978], The Railroad Mergers and the Coming of Conrail, Connecticut: Greenwood Press.

Vellturo, Christopher A. [1989], "The Deregulation of the U.S. Rail Industry: Efficiency and Equity in Attaining Rail Viability," Cambridge, MA: MIT Department of Economics, unpublished Ph. D. dissertation, September.

White, Halbert J. [1980], "A Heteroskedasticity-Consistent Covariance Matrix Estimator and a Direct Test for Heteroskedasticity," Econometrica, 48:4, May, 817-838.