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ASSESSING THE IMPACT OF REGULATORY REFORM ON MOTOR CARRIER COST EFFICIENCY

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ABSTRACT

This paper addresses the question of whether U.S. motor carriers have become more or less cost efficient following the Motor Carrier Act of 1980. The sample consists of Instruction 27 general freight commodity carriers that operated in both regulated (1977) and deregulated (1988) industry settings. Translog cost functions are estimated and a counterfactual methodology is employed to control for changes that have taken place in service quality and network structure. Results indicate that 1988 costs were lower for this group of carriers than they would have been in a regulated setting.

INTRODUCTION

A major objective of the Motor Carrier Act of 1980 (MCA) was to promote efficiency in the trucking industry. It was argued that regulatory reform would result in lower costs that would translate into lower trucking rates. Corsi and Stowers (1991) report a 31.6 percent decrease in real operating expenses per mile, accompanied by a 33 percent decline in revenues between 1977 and 1987 for ICC motor carriers.

Other industry observers, however, question the assertion of increased efficiency in the post-1980 industry. A recent article by Ozment, Cunningham, and Davis (1990) examined five measures of fuel efficiency and equipment utilization and concluded that "...the net effect of deregulation on fuel efficiency and equipment utilization appears to have been negative,"(p.440). This finding is contrary to results expected by industry deregulators.

In particular, the MCA was expected to relax route restrictions, allowing motor carriers to drop circuitous miles and adopt a more efficient network system. It was argued that this would result in higher load factors and lower per mile costs. Are the lower per mile costs reported by Corsi and Stowers (1991) consistent with the decreases in gallons of fuel per tonmile and tons per truck found by Ozment, Cunningham, and Davis (1990)? The answer is yes.

The explanation is that other events occurring concurrent with truck deregulation, resulted in a diversion of heavier tonnage commodities towards railroads and away from trucks. For instance, McMullen, Martin, and Cabeza (1989) report diversion of bulk wheat shipments in the Pacific Northwest away from truck and towards rail when the Stagger's Act of 1980 allowed railroads to negotiate contracts with individual shippers. Further regulatory changes in the Shipping Act of 1984 made intermodal transport competitive with trucks, especially for heavier and full containerload shipments (McMullen, 1991). The result has been a diversion of heavier commodities and full loads to rail and intermodal.

At the same time motor carriers have become more specialized in LTL traffic. LTL shipments are usually lower weight, higher valued commodities. This contributes to lower truck tonnage. Further, higher quality service due to increased service frequency also results in lower load factors.

The decrease in motor carriage tonnage combined with higher quality in the form of increased frequency of service, explains the decreases in tonmiles per gallons of fuel, tonmiles per mile of highway operation, tonmiles per vehicle, and tons per vehicle observed by Ozment, Davis, and Cunningham (1990). (Note that miles per vehicle was the one measure used by Ozment, Cunningham, and Davis (1990) that was not affected by tonnage and this measure increased after 1980.) These problems result from well known deficiencies in tonmiles as an accurate measure of output.

The appropriate question to ask from a social point of view is whether, after controlling for commodity mix and the different output attributes, transportation service costs less in a deregulated environment. This question is approached here using an econometric cost function to get estimates of pre- and post-1980 motor carrier cost functions reflecting the underlying production structure and commodity mixes at two points in time. Statistical tests indicate significant shifts in the production structure between regulated and deregulated periods.

Results also show that the 1988 production structure yields lower average costs than the 1977 production structure, confirming the hypothesis that deregulation led firms to adopt a more efficient production structure. A counterfactual methodology is used to illustrate how changes in factor prices and changes in output attributes contribute to the post-MCA decrease in average costs.

The paper is organized as follows. Section I explains the sample of firms and the data used in this investigation. The econometric specification of the cost function and results are presented in section II. A counterfactual technique is used in section III to determine what 1988 costs would have been if the carriers still faced 1977 factor prices and attribute levels. The final section summarizes the major study results.

DATA AND SAMPLE OBSERVATIONS

This paper examines ICC regulated LTL (section 27) motor carriers that were operating in both 1977 and 1988. Firms that entered after 1980 may have adopted technologies appropriate to the post-regulatory era. Firms that went out of business after 1980 were firms that were not able to adapt to the deregulated environment. What we are interested in here are firms that have successfully survived eight years of deregulation. Of particular interest is whether these firms have altered their cost structures so as to become more efficient in the deregulated environment.

This resulted in a sample of 117 motor carriers for which full data sets were available in both 1988 and 1977.

Data from 1977 were from Trincs Blue Book of the Trucking Industry, 1988 data were from the American Trucking Association's 1988 Motor Carrier Annual Report. Data in both years were derived from the same primary source: financial reports of the motor carriers to the Interstate Commerce Commission.

In the following section, a specific cost function will be defined and estimated for these firms in both 1977 and 1988 and comparisons will be made between cost effectiveness in the two periods. Details of the econometric specification will be discussed below but for now the cost function is specified in general terms as:

$$(1)\ C = C(p, y, a)$$

where p is a vector of input prices, y measures truck output, and a is a vector of output attributes. Output attributes are included here because the standard measure of output, tonmiles, does not captures all of the heterogeneity in motor carrier output.

For instance, two carriers may carry the same amount of tonmiles (TONMI), but one carrier may transport heavy weight commodities short distances and the other light commodities for long distances. The costs involved in the two sorts of activities may be quite different. It is for this reason that average length of haul (ALH), defined as tonmiles divided by tons, is included as an attribute. A larger ALH is usually associated with lower per unit costs as fixed (usually terminal) costs are distributed over more units of output. Similarly, average load (ALOAD), defined as tonmiles divided by miles, is used as a control for weight differences. Higher ALOAD is usually considered an indication of load factor and a higher load factor would be associated with lower per unit costs.

Other attributes included in the cost function are average shipment size (ASIZE) and insurance per tonmile (INS). ASIZE is defined as tons per shipment; smaller shipment size is associated with higher cost because a large number of small shipments requires greater transactions and handling costs. INS is included to control for differences in the value of the commodity mix carrier by a firm. Higher valued commodities may require more handling and thus cause greater costs.

Four factors of production are considered here: labor, owned capital, rented capital, and fuel. Accordingly, factor prices are the price of labor (PL), price of owned capital (PK), price of rented capital (PR), and the price of fuel (PF). See Appendix I for a definition of these variables.

Table 1 provides a comparison of mean values for output, attributes, and factor prices in both 1977 and 1988.

Note that all dollar amounts are expressed in terms of 1988 dollars to allow for

Table 1

Variable Means and Definitions
for 1977 and 1988

Variable	Definition*	1977	1988
TONMI	Tonmiles	206,286	306,806
ALOAD	Average load (tons)	10.07	8.99
ALH	Average length of haul (miles)	221.21	302.58
INS	Insurance per tonmile ($/tonmile)	.0149	.0163
ASIZE	Average shipment size (tons/shipment)	2.01	2.85
PK	Price of owned capital ($/capital)	2.25	1.72
PR	Price of rented capital ($/rented tonmile)	2.32	1.18
PF	Price of fuel ($/gallon)	.30	.69
PL	Price of labor (annual $/employee)	41,210	35,790
Number of firms		117	

*For more detailed discussion of variable definitions, see Appendix I.

accurate comparison of prices between the two periods.

The prices of all factors of production fell between 1977 and 1988 with the lone exception of fuel. Fuel prices rose over this time period due to the tightening in world oil markets and the market power exerted by OPEC, factors exogenous to regulatory reform.

The decrease in price of labor was expected since unionized labor was a major beneficiary of regulation (Moore, 1978). This is consistent with research conducted by Rose (1987) and Hirsch (1988) showing that union/non-union wage differentials and overall union power has declined following trucking deregulation.

A decrease was also observed in the price of rented capital between 1977 and 1988. This may be the result of relaxed entry that resulted in a huge influx of new, small carriers into the industry (from 17,000 ICC regulated Class I and II carrier in 1978 to over 30,000 in 1988.) The increased supply of small firms that often rent out their services, may have caused the observed price reduction for purchased transportation service. Overall, average tonmiles (TONMI) produced by this group of firms increased by 49 percent to over 306,000 tonmiles in 1988, and average length of haul (ALH) rose from 221 miles to 303 miles between 1977 and 1988. This reflects the expansion of network systems encouraged by easing of entry restriction into geographic regions.

Average load (ALOAD) fell from 10 to 9 tons per tonmile between 1977 and 1988. The hypothesis of inter-modal commodity switch away from heavy weight and towards lighter, higher valued commodities, is consistent with both the decline in ALOAD and the increase in average commodity value (INS) from 1.49 cents per tonmile in 1977 to 1.63 cents per tonmile in 1988.

METHODOLOGY

As noted above, the commodity mix has changed, factor prices have changed, and firm's network systems have evolved differently as regulatory restraints were eliminated. To compare costs between the two periods, cost functions are estimated separately for 1977 and for 1988 using factor prices, output, and attributes for the relevant year.

The econometric techniques used here are standard in the trucking literature. To estimate equation (1) we use the translog function which provides a widely used second order approximation to any arbitrary, twice differentiable cost function (Diewert, 1974). The translog cost function used here takes the form:

$$\ln C = \alpha_0 + \sum_{i=1}^{N} \alpha_{iln} p_i + \alpha_q$$

$$\frac{1}{2}\sum_{i=1}^{N}\sum_{j=1}^{N} \gamma_{ij} \ln$$

$$\frac{1}{2}\sum_{i=1}^{N}\sum_{k=1}^{K} \gamma_{ik} \ln$$

$$i,j=1,\ldots,N k,h=$$

where each variable is measured as a deviation from its sample mean. Linear homogeneity implies the following constraints on parameters:

$$\sum_{i=1}^{N} \alpha_i = 1 \qquad \sum_{i=1}^{N} \gamma_{iq} = \sum_{i=1}^{N} \gamma_{ik} = 0$$

$$\sum_{i=1}^{N} \gamma_{ij} = \sum_{j=1}^{N} \gamma_{ij} = \sum_{i=1}^{N}\sum_{j=1}^{N} \gamma$$

Factor share equations are estimated simultaneously to increase the efficiency of the cost function estimation. Since the factor shares must sum to unity, one of the factor share equations is dropped from the system. The final results are invariant to the share equation dropped (Barten, 1969). The resulting system of equations is estimated using Zellner's Iterated Seemingly Unrelated Regressions.

Equation (2) is estimated separately for 1977 and 1988. First order results are reported in Table 2, full results are in Appendix II. To see whether the regulated and deregulated cost structure differed significantly, a likelihood ratio test is used. A X^2 statistic is calculated where X^2 is equal to $-2(L_1 - L_2)$ and L_1 is the logarithm of the likelihood function of the translog cost function (2) using a pooled data set obtained by combining 1977 and 1988 samples. L_2 is the sum of the logarithms of the likelihood functions obtained by estimating (2) separately for 1977 and 1988 samples. Degrees of freedom are equal to the number of restrictions.

The computed X^2 test statistic was 271.46, well in excess of the critical value of 72.12. Thus, results indicate that the 1977 and 1988 cost functions are statistically different using a 5% level of significance. This confirms expectations that the overall industry cost (and thus production) structure changed after the MCA of 1980. Deregulators argued that the increased flexibility after 1980 would allow firms to select a more efficient, lower cost production structure. Firms that survived in the less regulated industry would have to become more cost effective or go out of business.

Figure 1 shows average cost functions generated from the estimated 1988 and 1977 estimated cost functions. Overall average costs were higher in the regulated setting. To see how much of the higher costs were due to factor prices and how much to changing output characteristics, a counterfactual methodology is used.

COUNTERFACTUAL ILLUSTRATION

It is not possible to directly compare regulated and deregulated costs at any one point in time because the alternative regulatory environments did not co-exist. What is done here is to take the 1977 cost function and see what average costs would have been if the deregulated industry factor prices and attribute levels had prevailed in the regulated environment.

In Figure 1, the curve labelled ACa shows what average costs would have been in 1977 for a firm that had 1977 average factor prices and attribute levels. The 1977 cost function estimated in the previous section is used to forecast what average costs would be over a wide range of possible output (tonmiles) as indicated by curve Aca.

To examine the impact of the deregulated change in firm attributes (ALH,

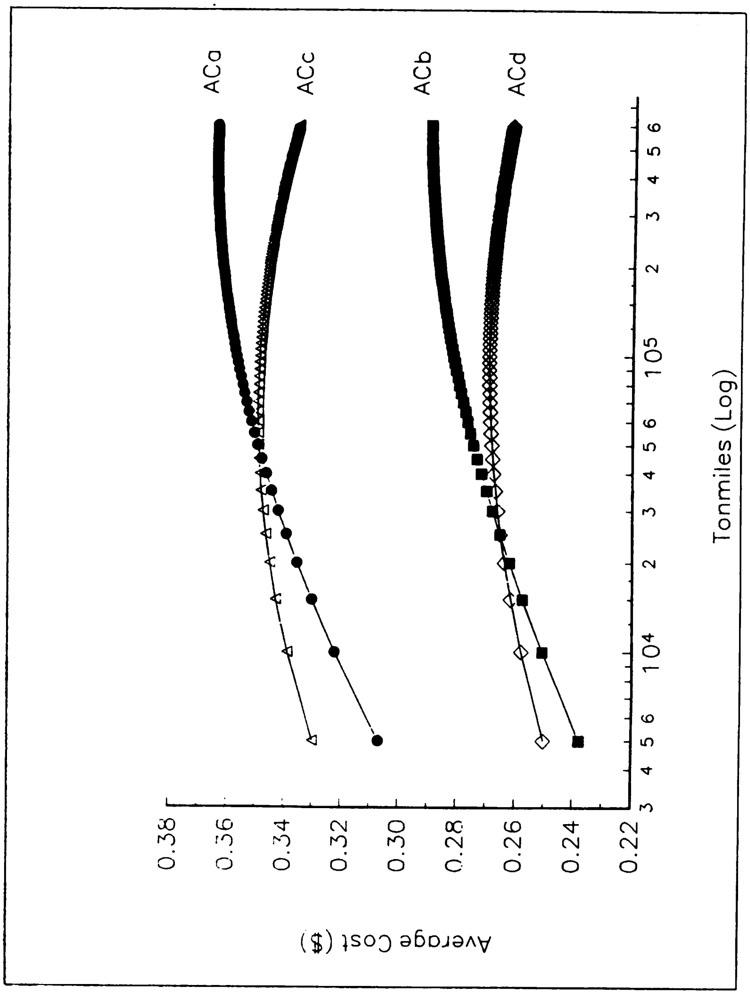
ACa
ACc
ACb
ACd
Average Cost ($)
0.38
0.36
0.34
0.32
0.30
0.28
0.26
0.24
0.22
Tonmiles (Log)
3 4 5 6 10⁴ 2 3 4 5 6 10⁵ 2 3 4 5 6

Figure 1

ALOAD, INS and ASIZE), the average 1988 values of these attributes are inserted into the 1977 function and average costs are again computed. The result is the curve labeled ACc. Curve Acc indicates that the deregulated attributes would have increased average costs for firms producing less than approximately 60,000 tonmiles per year, and reduced costs for larger firms. Since the average output level in 1977 was just over 200,000 tonmiles, this result indicates that the attribute level changes tended to decrease average cost for the mean firm in 1977.

To separate the effect of factor price changes, 1988 factor prices were placed in the 1977 cost function (with 1977 attributes), and average costs were generated. Comparison of Curve ACb with Aca shows that the deregulated factor prices lower 1977 average costs for all levels of output.

Finally, Curve ACd illustrates the combined effect of deregulated attributes and factor prices on average costs for the 1977 industry. If the 1977 industry had been able to experience deregulated factor prices and attributes, it would have been able to produce output at a lower average cost.

It is important to note that the major changes in factor prices, the decrease in the price of labor and of rented capital, can be directly attributed to deregulation. Similarly, changes in attribute levels, especially ALH and ALOAD, are generally acknowledged to be the result of regulatory changes included in the MCA of 1980.

CONCLUDING REMARKS

This study examines a sample of 117 LTL motor carrier firms that operated in both the regulated (1977) and deregulated (1988) industry. Restricting the sample to carriers operating in both regulatory environments allows direct observation of how firms adapted to the deregulated environment. Deregulators predicted that firms would be forced to become more cost efficient, largely through achieving network efficiencies and offering different types of service.

Past studies of the industry have found decreases in partial efficiency measures such as gallons of fuel per tonmile, a result in apparent contradiction to deregulatory predictions. This study explains how such partial measures do not control for changes in output characteristics that have made direct pre- and post deregulation comparisons difficult. The cost function approach adopted here controls for changes in the attribute mix and allows direct comparison of costs in regulated and deregulated settings.

The results here show a decrease in average costs following deregulation. Further, much of the decrease in unit cost can be credited to the changes in factor prices and output attributes initiated by deregulation itself. The finding of decreased costs following deregulation is particularly impressive because the higher quality, post-MCA service (as indicated by increases in service frequency and LTL service) is more costly to produce.

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APPENDIX I

Data for the computation of cost and factor prices are from the American Trucking Association's (ATA's) 1988 Motor Carrier Annual Report and Trincs Blue Book of the Trucking Industry, Yearbook of Motor Carriers, 1978 edition.

Total cost (TC) is defined here to include a 12 percent return to capital:

$TC = TOE + .12(NOPE + WC)$ where: TOE is total operating expense, NOPE is net operating property and equipment, and WC is net current assets, or working capital. A real value for net operating property and equipment is obtained by deflating the 1988 dollar values using a ten year average of the producer's durable equipment implicit price deflator for trucks.

The price of labor (PL) was calculated by dividing total employee compensation by the total number of employees.

The price of rented capital (PRK) was defined as the amount spent on purchased transportation divided by the total number of rented vehicle miles.

The price of capital (PK) was computed by dividing residual expenses (those obtained by subtracting total fuel, labor, and purchased capital expenditures from total cost) by net operating property and equipment plus working capital.

Finally, the price of fuel (PF) was calculated by dividing total fuel and oil expense by the average number of gallons of fuel. For this computation it was assumed that trucks get an average of 5 miles per gallon. The average number of gallons of fuel was obtained by dividing total vehicle miles by 5.

For those firms which did not report purchased transportation or fuel expenses, regional averages were used as proxies for the market price of fuel and purchased transportation faced by those firms. Firms were assigned to a region according to the state in which the firm was located.

APPENDIX II
Results From Estimation of Equation (2)

	1977		1988	
Variable	Estimate	t-Statistic	Estimate	t-Statistic
CONSTANT	11.220	28.236	11.875	43.660
TONMI	1.013	6.552	1.261	10.652
TONMI^2	-.017	-.338	.048	1.155
ALH	-.419	-1.054	-.599	-2.501
ALOAD	-.107	-.209	-.750	-2.510
ASIZE	-.127	-.368	.0079	.044
PF	.017	3.502	.039	4.790
PR	.134	2.277	.147	2.193
PK	.313	10.261	.341	5.583
PL	.536	10.373	.472	6.920
INS	.500	.802	.470	1.674
INS^2	.511	.981	.066	.250
ALH^2	.315	.700	-.192	-.660
ALOAD^2	.994	1.364	.066	.192
ASIZE^2	.152	.826	.176	2.073
PF^2	.0085	2.285	.020	8.920
PR^2	-.0075	-.202	.024	.466
PK^2	-.015	-.866	.032	1.623
PL^2	.027	.743	.053	1.670
ALH*INS	-.0036	-.011	-.123	-.585
ALH*ASIZE	.135	.598	.087	.919
ALH*ALOAD	-.555	-1.444	-.456	-2.241
ALH*PF	.004	.873	.012	1.804
ALH*PR	.044	.918	.043	1.132
ALH*PK	.042	1.389	.026	.517
ALH*PL	-.089	-2.396	-.082	-1.674
INS*ALOAD	.264	.531	-.333	-1.199
INS*ASIZE	.190	.582	.048	.348
INS*PF	-.0006	-.143	-.005	-.748
INS*PL	-.014	-.261	.009	.184
INS*PR	-.0084	-.139	-.043	-.846
INS*PK	.023	.879	.039	.871
ASIZE*TONMI	-.029	-.414	.046	.945
ASIZE*ALOAD	-.116	-.392	-.381	-3.419
ASIZE*PF	.0025	1.483	.0078	2.246
ASIZE*PR	.062	1.993	.037	1.326
ASIZE*PK	.017	1.306	.027	1.051
ASIZE*PL	-.081	-3.011	-.072	-3.013
TONMI*ALOAD	.129	.972	.074	.653
TONMI*INS	.037	.291	.111	1.599
TONMI*ALH	-.032	-.300	.0002	.002
TONMI*PR	-.0084	-.637	-.0068	-.516
TONMI*PF	-.0002	-.120	-.0032	-1.904
TONMI*PK	-.012	-1.271	-.001	-.052
TONMI*PL	.021	1.580	.011	.611
ALOAD*PF	-.0025	-.472	-.016	-1.898
ALOAD*PR	-.050	-.613	-.044	-.684
ALOAD*PK	.006	.189	-.0017	-.036

Appendix II (Cont.)

ALOAD*PL	.046	.635	.062	1.031
PF*PR	-.0002	-.074	.0005	.112
PF*PK	.0004	.144	-.004	-1.211
PF*PL	-.0087	-2.217	-.017	-3.926
PR*PK	.020	1.754	-.0079	-.351
PR*PL	-.012	-.397	-.016	-.454
PK*PL	-.0056	-.305	-.020	-.972

Number of observations 117

R^2 .977 .970