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IMPACT OF DEREGULATION ON TECHNICAL EFFICIENCY: THE U.S. MOTOR CARRIER INDUSTRY

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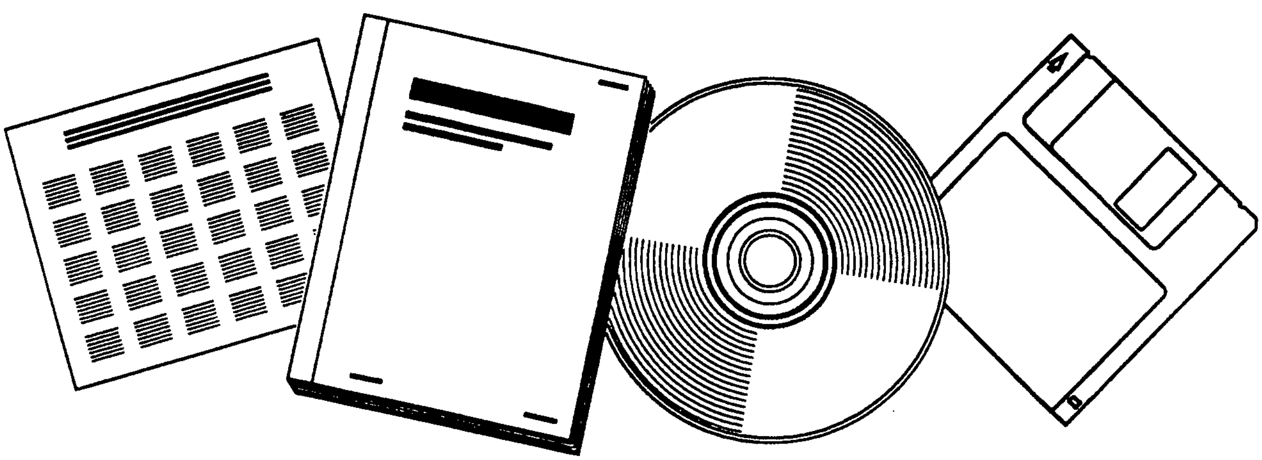

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The Impact of Deregulation on Technical Efficiency: The U.S. Motor Carrier Industry

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The Impact of Deregulation on Technical Efficiency: The U.S. Motor Carrier Industry

by

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<tr><td colspan="4">16. Abstract
This project uses Data Envelope Analysis (DEA) to examine motor carrier efficiency for a fifteen year time series (1976-90) that includes both regulated and deregulated policy regimes. To measure changes in industry productivity over time, a Malmquist Index is calculated from the DEA results. The Malmquist Index allows firm productivity changes to be decomposed into two categories: those related to firms becoming more efficient with a given technology, and those that are due to technological change. Increases in productivity due to technological change can probably not be attributed to the change in regulatory regimes (unless, of course, regulators discouraged technological development) whereas deregulators expected increased competition to result in firm's using existing technologies more effectively.</td></tr>
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A. Introduction

The Motor Carrier Act of 1980 (MCA) was passed due, in part, to economic arguments that the industry would become more efficient if allowed to operate in a free market environment. The ease of entry and the pricing freedom initiated by the Act resulted in a more competitive economic environment at the Federal level. The intent of the Act was to increase industry efficiency, lower costs, and eventually rates.

Given the increasingly competitive market environment following 1980, economic theory suggests the firms that exited the industry would be those unable to adapt by becoming more technically efficient. Although thousands of new firms entered the industry, the number of large, Class I and II general freight commodity carriers fell from over 400 in 1977 to less than 200 in 1991. The reduction in the number of carriers has been of concern. The purpose of this study is to examine how efficiency and productivity were affected by deregulation and whether, as predicted by economic theory, it was the inefficient firms that left the industry.

The purpose of this paper is to examine efficiency in the U.S. trucking industry as well as motor carrier productivity between 1977 and 1990. Efficiency will be measured using Data Envelope Analysis (DEA), a non-parametric technique. Productivity changes are calculated using the Malmquist Index, a non-parametric approach which allows productivity changes to be decomposed into mutually exclusive categories: one measures changes in technical efficiency, while the other indicates changes in technology.

The goal here is to develop a measure of technical efficiency for motor carriers that can be used for a variety of purposes. First, the DEA efficiency scores are calculated and used to test the economic hypothesis that, in an increasingly competitive environment, inefficient firms are the ones driven from the industry. Second, DEA scores will be used in the calculation of Malmquist productivity indices. These indices are used to determine whether carriers located in the western region of the U.S. differed in efficiency from the rest of the country. Tests using the Malmquist indices will also be conducted to determine whether union firms are more efficient than non-union firms in the trucking industry.

Results indicate that while firms have become more efficient in the sense of getting more output for a given amount of inputs, the technology of the trucking industry has developed in such a way as to eliminate any net productivity gains. There do not appear to be any significant regional or union/non-union differences in efficiency, and the efficiency measures do not seem to predict firm survival.

B. Background

Studies of trucking deregulation (McMullen and Stanley, 1987; Corsi, Grimm, and Jarrell, 1988; McMullen and Lee, 1994), have focused on the impact of deregulation on motor carrier industry costs. Evidence suggests that overall costs have decreased due to a drop in factor prices, labor in particular, following deregulation. This is probably due to the entry of many non-union firms which resulted in a decline in the union wage premium (Hirsch, 1987; Rose, 1987; Kerkvliet and McMullen, 1995; McMullen and Lee, 1993).

However, it is difficult to use a cost function methodology to determine how changes in the firm's production process itself have affected costs following deregulation. McMullen and Lee (1993), using a cost function counterfactual methodology, find mixed evidence; changing attributes, including average length of haul and average shipment size, seem to have increased costs for smaller firms while decreasing costs for larger ones.

Kerkvliet and McMullen (1997) find that union firms have higher costs than non-union firms in both pre-and post 1980 periods. The inference is that union firms are more productive than non-union firms, but their methodology did not allow them to explicitly test this hypothesis. A significant contribution made possible by the methodology developed here is that it allows us to explicitly test the hypothesis that union and non-union firms differ in productivity.

The direct evidence on trucking productivity is mixed. Ying (1990) uses a time trend in this cost function to measure changes in trucking productivity after deregulation. He finds a short term deterioration of productivity followed by an improvement. Ozment and Cunningham (1990) use partial productivity measures such as gallons of fuel per tonmiles to measure trucking productivity. They find decreases in productivity in the deregulated environment.

However, a partial productivity measure such as gallons of fuel per tonmile, masks important changes that are happening in the industry. Although total vehicle miles have not changed much in the deregulated environment, trucks have increasingly shifted their operations to less-than-truckload (LTL) shipments. Further, many firms choose to provide more frequent service, also reducing the weight carried in each truck. This change in operations results in more gallons of fuel per tonmile, but it also represents a different type of service.

One of the problems encountered in measuring productivity is to adopt a generally accepted definition. Theoretically, productivity is measured as output per unit of input. This becomes difficult to measure when there are multiple inputs and outputs.

When increases in productivity are observed over time, they derive from two primary sources. First, there is the "catching up" effect where, given a state of technology, inefficient firms increase the amount of output they are able to produce with a given amount of input. In economic parlance, this involves inefficient firms moving "up" to the production frontier and becoming more efficient. It is this sort of efficiency improvement that deregulators believed would be the primary result of increased competition.

The second kind of productivity gain comes from changes in technology that increase productivity, even for firms which were operating efficiently with the given technology. This change in productivity represents a shift in the production frontier due to changes in technology over time. Unless regulation was thought to hamper technological progress, there is no reason to expect that the more competitive economic environment had an impact on technological advances affecting productivity.

The purpose of this paper is to examine the sources of changes in U.S. motor carrier efficiency and productivity between 1977 and 1990, using DEA and a Malmquist Index. These non-parametric approaches allow productivity changes to be decomposed into mutually exclusive categories: change caused by firms becoming more technically efficient with a given technology, and changes in technology.

C. Data Envelopment Analysis (DEA)

DEA is used to evaluate the relative efficiency of a number of producers, often referred to as decision making units (DMU's) in the literature. Thus, each firm in the sample will have a DEA score. DEA is an extreme point method and compares each producer with the "best practice" producer (s) in the sample. This is in contrast to statistical approaches which typically compare producers to an average producer (Anderson, 1996). For a theoretical discussion of DEA, see Banker, Charnes, and Cooper

(1984), Seiford and Thrall (1990), Lovell (1993), and Grosskopf (1993).

The basic idea behind DEA is that, if one producer is able to produce a certain amount of output with a given set of inputs, other producers should also be able to produce the same output with the same inputs; if they produce less with the same set of inputs, they are not as efficient. To determine efficiency, a "best" or "virtual" producer must be identified for each actual producer in the sample. This is done using linear programming techniques.

There are two types of DEA scores, those that are input oriented and those that are output oriented. The input oriented approach determines how much the input mix would have to change to reach the best practice frontier for a given output level. This approach requires formulating the linear programming dual as a maximization problem in multiplier form. Alternatively, the output oriented approach determines how much output would be obtained if inputs were combined in an optimal fashion. For the output oriented approach, the linear programming dual requires solution of a minimization problem in envelope form (Nolan, 1995).

The approach taken here is output based. The resulting DEA score will be equal to one if the firm is efficient and greater than one if the firm is not efficient. Since DEA is a non-parametric technique, statistical tests cannot be used to determine whether departures from the efficient score of 1, are significant. Indeed, one of the major criticisms of DEA is that statistical tests are difficult. This is a topic of ongoing research.

Another limitation of DEA is that it is an extreme point technique which makes results very sensitive to outliers. For this reason we are very careful to double check the data and eliminate obviously faulty observations (such as when average load shows up as 25 tons and we know this is physically impossible). We also separate the three large national carriers (Roadway, Yellow, and Consolidated) from our sample to see whether their size affects our results.

Finally, DEA allows specification in either variable returns to scale (VRS) (where no constraints are placed on returns to scale) and constant returns to scale (CRS). Preliminary investigation calculating DEA efficiency scores used the VRS version of the model.

On the positive side, there are several advantages DEA has over other methodologies. First, DEA doe not require any assumptions regarding the functional form relating inputs to outputs. This is often a controversial issue in econometric studies.

Second, DEA can easily handle multiple inputs and outputs. Fecher, et. al. (1993) argue that DEA may be appropriate for service industries as it applies well to activities with multiple inputs/outputs. This is particularly applicable to trucking where the typical output variable, tonmiles, is known to be a rather imprecise measure of output.

Finally, there is no need for factor prices in DEA analysis---inputs quantities are sufficient. Indeed, the quantities need not even be reported in the same units (gallons, employees, trucks, etc.) This latter characteristic is particularly important when there are problems with factors prices, the price of capital is often critiqued for being imprecise.

DEA has been successfully applied to the French insurance industry (Fecher,et.al., 1993), the airline industry (Alam and Sickles,1995), public transit (Obeng, 1994; Nolan, 1995), and others. The actual calculation of the frontier is achieved using linear programming, usually DEA techniques introduced by Charnes, Cooper, and Rhodes (1978). DEA techniques produce Farrell (1957) efficiency measures which are identical to the distance functions required for the Malmquist Index introduced in the following section (Forsund,1993).

D.The Malmquist Productivity Index

The original derivation of the Malmquist Index can be found in Caves, Christensen, and Diewert (1982). This definition makes use of the Shephard (1953) concept of distance functions. The discussion here closely follows the presentation found in Fare, Grosskopf, and Lee (1995). Application of these techniques include Forsund (1993); Fare, Grosskopf, Lindgren, and Roos (1992); and Fare, Grosskopf, Norris, and Zhang (1994).

The basic intuition is to define an efficient production frontier, constructed using observed data points. This frontier then represents efficient production given the existing technology. Efficiency in any year is measured as each firm's distance from the production frontier.

To derive the Malmquist Index, it is assumed that there is a production technology, $S^t = \{(x^t, y^t): x^t \text{ can produce } y^t\}$, which describes all possible sets of input-output vectors for each time period, t= 1,...T,. The model used here assumes constant returns to scale because, due to then increased complexity over simple DEA measures, the VRS formulation did not always produce a solution. The imposed assumption of CRS with the results of Bruning and Olson (1982) who used efficiency indexes to test for economies of scale in U.S. trucking. Many other researchers have found evidence of constant returns, both before and after the MCA (McMullen and Stanley, 1987; Grimm, Corsi, and Jarrell, 1989; McMullen and Tanaka, 1995; Adrangi, Chow and Raffiee, 1995).

The output based distance function at time t is defined as:

(1)

$$D_o^t(x^t, y^t) = inf\,[\theta: (x^t, y^t/\theta) \in S^t].$$

This function is homogeneous of degree one in outputs and completely describes the technology in that (x^t, y^t) belongs to S^t only if $D^t_0(x^t, y^t)$ is less than or equal to one.

Caves, Christensen, and Diewert (1982) introduced the Malmquist Productivity Index which involves the use of mixed time distance functions using information from both periods, t and t+1:

(2)

$$D_o^{t+1}(x^t, y^t) = inf\ [\theta: (x^t, y^t/\theta) \in S^{t+1}]$$

and

(3)

$$D_o^t(x^{t+1}, y^{t+1}) = inf\ [\theta: (x^{t+1}, y^{t+1}/\theta) \in S^t].$$

The Malmquist Productivity Index can be written as the geometric mean of two mixed period distance functions (Fare, Grosskopf, and Lee, 1995):

(4)

$$M_o(x^{t+1}, y^{t+1}, x^t, y^t) = [\frac{D_o^t(x^{t+1}, y^{t+1})}{D_o^t(x^t, y^t)} \frac{D_o^{t+1}(x^{t+1}, y^{t+1})}{D_o^{t+1}(x^t, y^t)}]^{1/2}$$

Following Fare, Grosskopf, Lindgren, and Roos (1989), equation (4) can be rewritten as:

(5)

$$M_o(x^{t+1}, y^{t+1}, x^t, y^t) = \frac{D_o^{t+1}(x^{t+1}, y^{t+1})}{D_o^t(x^t, y^t)} [\frac{D_o^t(x^{t+1}, y^{t+1})}{D_o^{t+1}(x^{t+1}, y^{t+1})} \frac{D_o^t(x^t, y^t)}{D_o^{t+1}(x^t, y^t)}]^{1/2}$$

Where the first term measures the change in efficiency and the square root of the second bracketed term represents the change in technology between the two periods.

Since output based distance functions are the reciprocal of Farrell's measure of technical efficiency, they can be calculated using the linear programming methodology shown in Fried, Lovell, and Schmidt (1993). The reciprocal of the distance function for firm k in a single period is:

(6)

$$[D_o^t(x^{k',t}, y^{k',t})]^{-1} = \max\theta$$

subject to

$$\theta y_m^{k',t} \le \sum_{K=1}^{k} z^{k,t} y_m^{k,t} \qquad m=1,\ldots,M,$$

$$\sum_{K=1}^{k} z^{k,t} x_n^{k,t} \le x_n^{k',t} \qquad n=1,\ldots,N,$$

$$z^{k,t} \ge 0, \qquad k=,\ldots,K.$$

Yearly distance functions are calculated for each firm. The mixed period distance functions required for calculation of the

Malmquist Index are derived from the following linear programming formulation:

(7)

$$[D^{o^{t}}(x^{k',t+1}, y^{k',t+1})]^{-1} = \max\theta$$

subject to

$$\theta y_m^{k',t+1} \le \sum_{k=1}^{K} z^{k,t} y_m^{k,t}, \qquad m=1,\ldots,M,$$
$$\sum_{k=1}^{K} z^{k,t} x_n^{k,t} \le x_n^{k',t+1} \qquad n=1,\ldots,N,$$
$$z^{k,t} \ge 0, \qquad k=1,\ldots,K.$$

Equations (6) and (7) are then repeated for all firms and time periods to calculate Malmquist Productivity Indices.

One advantage of the Malmquist methodology is that it does not require information on input prices, only quantities. This eliminates possible bias associated with imprecise measurement of factor prices, especially the price of capital. Another benefit is the ease with which multiple outputs can be considered. Given the known heterogeneity of trucking output, tonmiles is not an adequate single measure of output. This methodology allows multiple outputs. Finally, this non-parametric technique does not impose any behavioral assumptions nor does it specify any particular functional form.

A standard criticism of non-parametric techniques is that they do not make any assumptions regarding the stochastic properties of the data, rendering statistical confidence interval testing of the results impossible. Accordingly, this study uses bootstrapping techniques similar to those shown in Atkinson and Wilson (1995) to generate confidence intervals for each of the Malmquist Productivity Indices and component efficiency and technical indices. Note, the bootstrapping technique is only used to produce confidence intervals for the 51 firms and not the entire industry; this was due to computer time constraints.

E. Data

Data for this study are derived from the American Trucking Association's Motor Carrier Annual Reports for the years 1977-1990. Calculation of the Malmquist Index requires data on the same firm from period to period, thus the full sample for each two year period consists of firms that reported the required information for each adjacent year. The frontier for each year is constructed using all firms for which the Malmquist data were available; the number of firms varied from period to period as follows:

1977/78	397 observations
1978/79	416 observations
1979/80	370 observations
1980/81	320 observations
1981/82	297 observations
1982/83	279 observations
1983/84	265 observations
1984/85	234 observations
1985/86	229 observations
1986/87	214 observations
1987/88	185 observations
1988/89	155 observations
1989/90	92 observations

The observed decrease in the number of total observations reflects firms leaving the industry during the time period, or at least more firms leaving the industry than entering. It also is a result of the change in the reporting form in 1988 which reduced the amount of detailed information that most firms had to provide ICC. Since more detailed data were required for this analysis, the number of firms with complete data sets declined. Discussions with industry observers suggests that overall data reliability decreased following 1987, getting worse each year.

Included in this the full sample for each of the above listed years are the 51 "survivor" firms, shown in Table 1. These are the 51 firms for which complete information was available for the entire 1977-1990 period.

The calculation of distance functions requires identification of relevant inputs and outputs. While a single measure, tonmiles, is the standard output definition used in studies of trucking industry costs, there are known differences in production technology between less-than-truckload (LTL) and truckload (TL) operations. Less-than-truckload operations for Instruction 27 general freight commodity carriers (Class I and II carriers with more than 75% of their revenues from intercity freight movements)rose from approximately 68 percent in 1980 to 88 percent in 1987 (Grimm, Corsi, and Jarrell, 1989). As of 1988, 67 percent of those carriers reporting as Instruction 27 derived at least 30 percent of their tonnage from LTL traffic; implying that 33 percent derived less than 30 percent of their tonnage from LTL. Thus, in addition to tonmiles, the number of LTL shipments and the number of TL shipments are included as outputs for calculation of the distance functions.

The inputs include labor, fuel, and capital, defined as: the number of employees (labor), the number of trucks and tractors (capital), and the number of gallons of fuel (fuel). Gallons of fuel is calculated using an average of five miles per gallons and dividing total vehicle miles by five. The five miles per gallon figure was decided upon after discussions with industry representatives who agreed it was appropriate as an average figure. Table 2 contains summary statistics for these variables for each year studied.

F. DEA Results

Average industry scores obtained using DEA analysis are shown in Table 3 for each year. Note that scores equal to one indicate firms that are on the production frontier, firms with scores above one are inefficient and could produce the same amount of output with fewer inputs. The DEA analysis was conducted using both the complete sample and the complete sample minus the three large, transcontinental firms (Roadway, Yellow Freight, and Consolidated Freight). This was done to see if the resulting DEA scores were different when eliminating three of the large firms which were defining the frontier (all three large firms were efficient with DEA scores of approximately 1.0) The results were essential the same in both cases so that Table 3 reports the industry average including the three large firms in the industry sample.

There does not appear to be any noticeable trend in DEA scores either before of after deregulation in 1980. Indeed, the industry average does not improve (go down) substantially after deregulation as expected.

i. Structural Determinants of DEA scores

A regression model is developed here to examine determinants of efficiency scores. Since the DEA efficiency scores are censored, ie., they only take values of one or above, it is appropriate to use a tobit regression technique with the DEA score as the independent variable.

The dependent variables in this regression are ALH (average length of haul), ALOAD (average load), Tonmiles (TONMI) and Region where firms are divided into one of the nine ICC designated geographic regions. States included in each region are as follows:

Region 1: Connecticut, Massachusetts, Maine, New Hampshire, Rhode Island and Vermont

Region 2: Delaware, Maryland, New Jersey, New York, Pennsylvania, West Virginia

Region 3: Indiana, Illinois, Michigan, Ohio

Region 4: Alabama, Florida, Georgia, Kentucky, Mississippi, North Carolina, South Carolina, Tennessee, Virginia

Region 5: Minnesota, North Dakota, South Dakota, Wisconsin

Region 6: Iowa, Kansas, Missouri, Nebraska

Region 7: Arkansas, Louisiana, Oklahoma, Texas

Region 8: Idaho, Colorado, Montana, Wyoming, New Mexico, Utah

Region 9: Arizona, California, Nevada, Oregon, Washington

The tobit regression is thus of the general form:

DEA = f(TONMI, ALH, ALOAD,UNI, R2-R9)

where R2-R9 refers to regions 2-9, region 1 is implicitly included in the constant term of the regression. ALH and AL are both indicators of the network structure of the carrier. UNI is a dummy variable equal to one if the firm is union, equal to zero is non-union. The estimated equations for 1977 and 1988 are reported in Table 4.

In 1977, ALOAD, TONMI, and UNI all are significant determinants of the DEA score. A higher average load was associated with a lower DEA score, indicating higher efficiency. Similarly firms with greater tonmiles and unionized firms resulted in greater efficiency. The insignificance of most of the rest of the explanatory variables makes it difficult to predict e DEA efficiency scores, especially in the post-1980 period..

It appears that whatever efficiency gains were made possible by unions in the 1977 period, were not present in 1988. This is compatible with observations of decreased union power in the post-MCA period.

To test explicitly whether union and non-union firms have significantly different efficiency scores in the post-1980 period, we simply calculate each firm's DEA scores. To test whether the mean efficiency scores for union and non-union firms were identical, we use the following formula for the test statistic (assuming that the inefficiencies follow the exponential distribution [Banker,1996]):

$$T = \frac{[\ \Sigma_{j \in G1} (\hat{\theta}_j - 1) / N_1\ ]}{[\ \Sigma_{j \in G2} (\hat{\theta}_j - 1) / N_2\ ]}$$

Distributed as a Chi-squared statistic, this was equal to .82, indicating that the mean efficiency scores for union and non-union firms were not significantly different at the 5% level of significance. Thus, results here do not indicate differences in efficiency between the 129 union and 109 non-union firms in our 1987 sample.

ii. Survivor firms and DEA scores

A hypothesis put forth earlier was that less efficient firms would be the ones which do not survive over time. Indeed, in a competitive industry, inefficient firms will not be able to compete in the long run and will be forced out of business. Here a survivor firm is defined as one whose last appearance in our data set was in 1990. Thus, if a firm entered into our data set in 1985, it counts as a survivor as long as it appears in the 1990 data set. If, however, it was in the industry at any time in our data set but does not appear in the last year (1990), it is not a survivor.

The survivor firm is represented with a zero/one dummy where SUR(survivor) = 1 if the firm appears in 1990, =0 if not. Thus the dependent variable in this regression is binary (ie. it can only take the values 0 or 1) and thus it is appropriate to use a probit regression model. DEA scores are then used as one of a set of independent variables expected to influence the survival of the firm. In particular, the probit model is specified in general terms as:

$$SUR = f(DEA, ALH, ALH^2 ALOAD, LTL, TONMI, ORATIO)$$

The DEA score is expected to be negatively related to survival: the lower the DEA score (the closer it is to one, the lower bound, indicating efficiency), the higher the chance of survival. ALH and ALOAD reflect characteristics of the trucking firm's operations. TONMI is a proxy for firm size. LTL refers to the percentage of tons that are carried in LTL versus truckload(TL) operations. LTL operations are usually more capital intensive and thus increases in the percentage of LTL operations is expected to result in apparent inefficiencies. Finally, ORATIO is defined as operating expenses divided by operating revenue; a higher ORATIO would be expected to be negatively related to survival.

After running a preliminary OLS regression to get starting values, the resulting estimation using 1988 data was:

$$\begin{aligned} SUR = \; & \underset{(2.35)}{3.84} - \underset{(-1.84)}{.002ALH} - \underset{(-2.22)}{.17E\text{-}05\, ALH^2} - \underset{(-.36)}{.008ALOAD} + \underset{(2.53)}{.67LTL} \\ & + \underset{(1.32)}{.38E\text{-}09\, TONMI} - \underset{(-.35)}{.03DEA} - \underset{(-2.82)}{4.66\, ORATIO} \end{aligned}$$

(t-statistics are in parentheses)

These results show that LTL, ALH^2, TONMI, and the ORATIO have a significant impact on survival. In particular, the greater the percentage of a firm's operations are in LTL, the higher the chance of survival. This is consistent with the experience of the 1980's, as firms have increased their percentage of LTL operations in order to provide higher service quality. It appears that firms which have expanded LTL operations are the ones that have survived in the deregulated environment. Similarly, larger firms (those with greater tonmiles, TONMI) also have a higher chance of survival---this is consistent with the observed growth of concentration amongst Class I and II carriers.

The negative and significant coefficient on ORATIO is consistent with expectations: firms that have higher expenses relative to revenues are in poorer financial shape and thus have a greater chance of going out of business, whether through bankruptcy or merger. The DEA coefficient is negative as expected, but it is not statistically significant.

G. Malmquist Results

We could not get results for the interperiod Malmquist Indices with the VRS model used in the DEA analysis. Since most econometric evidence suggests that the industry exhibits CRS and that formulation worked all the time, we use a CRS specification. DEA scores calculated using the CRS specification tend to be biased in the downward direction, VRS tends to increase DEA scores (Forsund and Finn, 1993).

The Malmquist Productivity Index for the entire industry in each year is shown in Table 5. A value of 1.0 indicates no change in productivity, less than one indicates a decrease in productivity, and a number greater than one indicates an increase in productivity.

In the 1977-1981 period, the overall Malmquist Index measure of productivity was below one, increasing slightly in the 1980's. The fact that the index hovered around one indicates that there was no real increase in productivity.

These Malmquist Productivity results do not support the argument that deregulation forced firms to become more efficient, thus increasing productivity. However, the Malmquist Index has two components: the productivity gain/loss due to changes in firm efficiency (firms moving closer to the production frontier) and those due to changes in technology (shifts in the production frontier itself). As mentioned earlier, it is changes in the efficiency component of the Malmquist Productivity Index which shows whether deregulation caused firms to eliminate inefficient behavior and move closer to the efficient production frontier.

Changes in the two Malmquist component indices, efficiency and technology, are also shown in Table 5. The efficiency index shows a large increase in 1979-80, a slight decrease in 1981-82, and then measures well above one throughout most of the remainder of the 1980's. The 1981/82 decrease in efficiency is consistent with Ying's (1990) finding of slight decreases in productivity immediately after the MCA, followed by productivity increases through 1984.

Another big surge in efficiency is seen in 1986-87 as demonstrated by an index of 1.951. Efficiency seems to hold constant for the remainder of the 1980's, with the exception of a large and unexplained decrease in the efficiency index in 1988-89. Part of the reason that the post-1987 results appear so different from those of earlier years, is that the ICC reporting requirements changed after 1987 and the data became generally less reliable.

Table 6 shows the comparable Malmquist Productivity Index and its components for the panel of 51 surviving firms. Bootstrapped confidence intervals are used to indicate which indices were significantly different from one, given the chosen 95% confidence interval. Results indicate that the increase in post-MCA year's efficiency is significant whereas technological regression is also significant as indicated by the values generally below one. The falling technological efficiency score may reflect the fact that, following the MCA, firms began to engage in more LTL traffic which required changes in the ways firms operate. LTL firms use terminal facilities and have a different network structure, known to produce higher costs. In addition, post-MCA competition in the motor carrier industry has focused on increases in frequency of service, another measure of service quality. These service quality increases are not shown in our results except that they may be an explanation for what is showing up here as technological regression.

Tables 7-9 show the Malmquist Index and its efficiency and technological change components for the panel of 51 firms in 1977/78, 1980/81, and 1987/88, respectively. Although the Malmquist indices do not exhibit any consistent pattern in any of the years, the component indices differ quite a bit between the pre- (1977/78) and post- (1980/81 and 1987/88) periods. In particular, in 1977/78, 27 of the 51 firms had efficiency indices less than one which indicates a decrease in efficiency between those years; in 1980/81 only 10 firms had an efficiency score less than one, and by 1987/88, only 4 firms showed a decrease in efficiency. This finding is consistent with the pre-deregulation expectations: firms that survived had to increase efficiency in order to compete successfully and remain in the industry.

Another fact that emerges from Tables 7-9 is that technological regression (a technical index less that one) was observed for every one of the 51 firms in both of the post-deregulated time periods (1980/81 and 1987/88). The same calculation from the 1977/78 period shows 28 of the 51 panel firm exhibiting what we have called technological progress. The finding that all survivor firms experienced this decline provides strength to the argument that this "technological change" index includes both changes in actual technology as hypothesized in previous studies, but also changes in the production process that may not involve just new technology, but different ways of doing business. In particular, survivor firms may have expanded into LTL service, providing faster, more frequent, and higher quality service that is showing up here as technological regression. Indeed, this is consistent with Corsi,Grimm, Smith, and Smith (1991) who find that firms pursuing a "differentiation "strategy (different levels of service quality) were more successful in 1987, whereas such behavior did not appear to influence firms profitability in the regulated (1977) period.

i. Regional Differences in Malmquist Scores

It has been suggested that productivity growth has been greater in some parts of the country than others. Accordingly, regional Malmquist scores are presented for each year in Table 10. These results show no substantial difference in the pattern of productivity gain/loss between the nine regions.

VII. Summary and Conclusions

This study uses non-parametric techniques to examine the question of efficiency and productivity in the U.S. trucking industry both before and after the MCA of 1980. Contrary to expectations, the DEA efficiency scores do not show an increase in efficiency following deregulation.

A more detailed investigation of productivity using Malmquist indices also shows little overall change in productivity following the MCA of 1980. The Malmquist index does allow decomposition into efficiency and technical change. It is here that important changes become evident. In particular, Malmquist results show that, as expected, firms did become more efficient in the sense of moving closer to their relevant production frontier. The reason that the overall Malmquist productivity index shows little change is that the efficiency gains were offset by technical regression in the post-MCA period.

In the pre-1980 period, many firms experienced what is classified in the Malmquist methodology as technological progress. One explanation is that firms in the regulated industry were protected from competition and they were able to increase loads without fear of losing traffic to other carriers.

Increasing load for an existing system with show up as an increase in efficiency (ie. more output per unit of input).

When the industry deregulated, carriers chose to compete not only on the basis of price, but service quality as well. In fact, the changes that took place in the motor carrier industry, were changes in the way firms do business, especially changes in service quality. Trucking firms have moved towards provision of more LTL service which uses more resources and is more costly. Further, many carriers have made an effort to provide more frequent service. Both of these factors are viewed by shippers as improvements in service quality, but they show up in this analysis as technological regression.

Thus, the Malmquist indicates that carriers did increase efficiency as expected by using their resources more fully and moving closer to their production frontiers. What was unexpected is the downward shift in the frontier brought about by the change in the way business is conducted. The big problem is the lack of a good measure of service quality to include in the analysis as an output. Without this further information, current techniques can do nothing but show overall decreases in productivity following deregulation.

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Table 1

1. McCracken Motor Freight
2. Ideal Truck Lines, Inc.
3. Alvan Motor Freight, Inc.
4. Gross Common Carrier, Inc.
5. Preston Trucking Co., Inc.
6. Midwest Motor Express, Inc.
7. Roadway Express Inc.
8. The O K Trucking Company
9. Carolina Freight Carriers Corp.
10. Landgrebe Motor Transport, Inc.
11. Churchill Truck Lines, Inc.
12. Be-Mac Transport Co.
13. Carstensen Freight Lines, Inc.
14. Advance Transportation Company
15. A-P-A Transport Corp.
16. Frederickson Motor Express
17. Arkansas-Best Freight (ABF) Freight System, Inc.
18. Central Freight Lines, Inc.
19. Nashua Motor Express, Inc.
20. Consolidated Freightways, Inc.
21. Crescent Truck Lines, Inc.
22. Willig freight Lines
23. Putnam Transfer and Storage Co.
24. Transus Inc.. (Georgia Highway Exp Inc)
25. Red Star Express, Inc.
26. TNT Holland Motor
27. Wilson Trucking Corp.
28. Ward Trucking Corp.
29. Shipper's Express, Inc.
30. Houff Transfer Inc.
31. H & W Motor Express Co.
32. New Penn Motor Express, Inc.
33. Merchant's Truck Line, Inc.
34. Beaufort Transfer Co.
35. Howard's Express
36. Estes Express Lines
37. Greenwood Motor Lines, Inc.
38. Fore Way Express, Inc.
39. Con-Way Eastern Express, Inc. (Penn Yan Express Inc.)
40. Clark Bros Transfer, Inc.
41. Brown Transfer Company

42. Old Dominion Freight Line, Inc.
43. Century Motor Freight, Inc.
44. Overnight Transportation Co.
45. Middlewest Freightways, Inc.
46. Southeastern Freight Lines, Inc.
47. Yellow Freight Systems, Inc.
48. Nussbaum Trucking, Inc.
49. Crouse Cartage Co.
50. Holmes Freight Lines, Inc.
51. Birmingham-Nashville Express

Table 2

Summary Data Statistics, 1977-1990

Variable: Tonmile (TONMI)

Year	Mean	Std Dev	Minimum	Maximum
1977	185493182	573316243	175048	5946167668
1978	208923462	666225941	160794	6814926850
1979	212309567	703202612	397770	7062209102
1980	203528344	658568042	722095	6427503550
1981	216806823	673128106	490003	6098256596
1982	192966236	685050898	232544	6346924354
1983	203078745	710990896	436595	6102703080
1984	210342036	775823949	266976	7066182843
1985	208478352	741408325	240000	6991138384
1986	259046132	869038093	369723	7716506958
1987	269840413	987665503	722240	8628462938
1988	298086998	1068088895	954816	9429040705
1989	401363037	1347745847	537197	9637139204
1990	449398696	1315782305	1050564	10631614618

Variable: Less-Than-Truckload Shipments (LTL)

1977	385239	791070	0	10643221
1978	403374	877241	0	11515998
1979	401324	920172	0	11655494
1980	417167	941143	0	11238390
1981	425767	947100	0	9794221
1982	404607	998846	0	9758666
1983	399439	1035295	0	9810565
1984	472975	1263561	0	11070492
1985	441596	1231556	0	11156978
1986	518390	1487788	0	12741921
1987	568556	1648564	0	14063902
1988	573557	1705915	0	14955460
1989	732015	2037726	0	15835735
1990	609636	1890170	0	15244666

Variable: Truckload Shipments (TL)

1977	18569	30802	0	251167
1978	19739	35348	0	316074
1979	19930	36945	0	346696
1980	17294	31481	0	274031
1981	17204	31369	0	291404
1982	14630	31456	0	387793
1983	15386	30393	0	311977
1984	15409	27704	0	172173
1985	14901	24743	0	158449
1986	17772	28852	0	201748
1987	18657	31727	0	238973
1988	20181	31197	0	189945
1989	25861	54992	0	547829
1990	38488	65359	0	598370

Variable: Power Units (POWER)

Year	Mean	Std Dev	Minimum	Maximum
1977	761	1851	1	20192
1978	845	2111	2	22060
1979	887	2308	1	23409
1980	970	2446	3	23115
1981	1017	2529	5	23234
1982	996	2679	8	18798
1983	971	2775	5	23752
1984	1060	3236	1	28584
1985	1082	3411	1	30276
1986	1288	3956	1	34990
1987	1369	4392	1	37340
1988	1515	4750	21	41964
1989	1965	5688	7	44385
1990	1800	5200	3	44734

Variable: Number of Employees (LABOR)

1977	628	1492	4	19341
1978	699	185	1	21687
1979	727	1955	4	23602
1980	779	2110	9	21197
1981	773	2001	8	19139
1982	721	2067	8	18798
1983	686	2024	8	18620
1984	764	2292	2	19942
1985	758	2354	4	20645
1986	861	2603	7	23230
1987	921	2887	8	25190
1988	993	3108	8	27037
1989	1278	3758	7	28987
1990	1158	3475	11	28806

Variable: Gallons of Fuel (FUEL)

1977	2508885	7389974	146	78413979
1978	2752792	8489447	266	90217368
1979	2814701	9043708	878	99839639
1980	2799743	8583824	39	88063656
1981	2962453	8670256	1351	77987822
1982	2679738	8779903	630	78070239
1983	2707185	9139940	95	74357710
1984	2934573	10047762	885	89201112
1985	2848450	9520457	532	83476838
1986	3426906	11075209	2846	97868004
1987	3578603	12261066	5639	107602984
1988	3976702	13172303	226	121982276
1989	5471241	17528127	3291	130944219
1990	5769932	16798887	613	126588207

Table 3

Average Industry DEA Scores 1977-90

Year	Mean	Std Dev	Minimum	Maximum	Number of Firms
1977	3.08	2.39	1.0	24.49	483
1978	2.84	1.60	1.0	9.10	479
1979	3.30	2.08	1.0	21.68	461
1980	2.86	1.68	1.0	10.45	395
1981	2.61	1.49	1.0	8.16	352
1982	3.07	1.72	1.0	11.43	301
1983	3.36	1.92	1.0	10.90	336
1984	3.27	1.77	1.0	14.46	296
1985	3.00	1.53	1.0	8.92	287
1986	5.16	3.44	1.0	28.00	263
1987	2.91	1.90	1.0	21.61	230
1988	2.33	2.91	1.0	43.08	227
1989	2.82	1.38	1.0	11.15	168
1990	3.27	2.36	1.0	17.18	209

Table 4

Tobit Regression Results

Determinants of DEA Scores, 1977 and 1988

Dependent variable: DEA score*

	1977	1988
Constant	6.027	4.56
	(16.32)	(5.31)
ALH	.0003	-.001
	(1.18)	(-1.35)
ALOAD	-.16	-.04
	(-6.53)	(-.85)
TONMI	-.14 E-08	-.76 E-09
	(-3.40)	(-1.50)
UNI	-1.03	-.17
	(-4.40)	(-.34)
R2	-.14	-1.71
	(-.40)	(-1.88)
R3	-.86	-1.89
	(2.28)	(-2.02)
R4	-.78	-1.45
	(-1.89)	(-1.61)
R5	-1.13	-1.59
	(-2.15)	(-1.23)
R6	-.51	-1.59
	(-1.07)	(-1.61)
R7	-1.84	-1.80
	(-3.07)	(-1.46)
R8	-1.16	-1.10
	(-1.77)	(-.84)
R9	-.76	-.99
	(-1.54)	(-.96)

* Note: numbers in parenthese are t-statistics

Table 5

Malmquist Indices, Indices of Efficiency Change, and Technical Efficiency Indices: Industry, 1977/78 - 1989/90 (Geometric Means)

Year	Malmquist	Efficiency	Technical	# Firms
1977/78	.999	.986	1.013	399
1978/79	.961	.594	1.617	423
1979/80	.883	1.390	.635	376
1980/81	.954	1.151	.829	327
1981/82	.921	.830	1.11	300
1982/83	1.025	1.079	.949	282
1983/84	.998	1.201	.831	268
1984/85	.938	1.015	.925	239
1985/86	.996	.698	1.426	236
1986/87	.978	1.951	.501	221
1987/88	.922	1.174	.785	192
1988/89	1.012	.426	2.375	163
1989/90	.991	1.000	.991	94

<u>Table 6</u>

Malmquist Indices, Indices of Efficiency Change, and Technical Efficiency Indices: Panel of 51 Firms, 1977/78 - 1989/90 (Geometric Mean)

Year	Malmquist	Efficiency	Technical	# Firms
1977/78	.972	.995	.977	51
1978/79	.952	.774*	1.23*	51
1979/80	.887*	.982	.902*	51
1980/81	.938*	1.091*	.860*	51
1981/82	.942*	.845*	1.114*	51
1982/83	.998	1.000	.998	51
1983/84	1.001	1.234*	.811*	51
1984/85	.941*	1.060*	.888*	51
1985/86	1.003	.652*	1.538*	51
1986/87	.997	2.515*	.396*	51
1987/88	1.002	1.190*	.842*	51
1988/89	.994	1.068*	.930*	51
1989/90	.990	.903*	1.097*	51

* Indicates that bootstrap results show these to be significantly different from one.

Table 7

51 Panel Firm Scores for 1977/78

Firm Name	Malmquist	Efficiency	Technical
McCracken Bros	1.037	.742	1.397
Ideal Truck	1.117	1.073	1.041
Alvan Motor	.707	.917	.771
Gross Common	1.055	1.177	.897
Preston Truck	1.043	.987	1.057
Midwest Motor	.999	.934	1.070
Roadway Expres	1.029	.892	1.152
The OK Truckin	.984	1.089	.903
Carolina Frt	1.032	.918	1.123
Landgrebe Mtr	1.067	1.224	.823
Churchill Trk	1.037	1.008	1.028
Be-Mac Trnspt	1.043	.965	1.080
Carstensen Frt	.923	1.206	.765
Advance Trnspt	.925	1.230	.752
A-P-A Trnspt	.903	.755	1.195
Fredrickson	.869	.812	1.069
ABF Frt Syst	.722	.635	1.137
Central Frt	1.064	1.180	.901
Nashua Mtr	1.035	1.186	.873
Consolidated	.850	.736	1.155
Crescent Trk	.833	.724	1.151
Willig Frt	.921	.865	1.065
Putnam Trnsfr	.961	1.281	.750
Transus Inc.	1.084	.978	1.108
Red Star Exp	.795	.701	1.134
TNT Holland	.967	1.074	.903

Wilson Trkng	1.094	.915	1.200
Ward Trkng	1.009	.999	1.009
Shippers Exp	.957	1.035	.925
Houff Trnsfr	.988	1.054	.938
H&W Mtr Exp	.758	.733	1.034
New Penn Mtr	.997	1.121	.890
Merchant's Trk	1.064	1.053	1.010
Beaufort Trns	1.086	1.421	.764
Howard's Exp	.951	1.438	.661
Estes Exp	.987	1.071	.922
Greenwood Mtr	1.066	1.533	.695
Fore Way Exp	.963	.942	1.023
Conway Eastrn	.948	.973	.974
Clark Bros	.958	1.030	.931
Brown Trnsfr	.982	.992	.990
Old Dominion	.877	.849	1.033
Century Mtr	.949	.911	1.041
Overnite Trnsf	1.110	1.052	1.055
Middlewest Frt	1.035	1.032	1.003
Southeastern	.966	1.033	.935
Yellow Frt	.941	.806	1.167
Nussbaum Trkng	1.039	1.207	.861
Crouse Crtg	1.015	1.086	.934
Holmes Frt	1.150	1.060	1.084
Birmingham-Nashville Exp	.945	1.006	.940

Table 8

51 Panel Firm Scores for 1980/81

Firm Name	Malmquist	Efficiency	Technical
McCracken Bros	.821	.950	.864
Ideal Truck	.843	.960	.878
Alvan Motor	.893	1.046	.853
Gross Common	.959	1.184	.810
Preston Truck	.995	1.185	.839
Midwest Motor	1.013	1.170	.866
Roadway Expres	.941	1.048	.898
The OK Truckin	1.087	1.280	.849
Carolina Frt	.934	1.039	.899
Landgrebe Mtr	.897	1.016	.883
Churchill Trk	.991	1.163	.853
Be-Mac Trnspt	.957	1.079	.887
Carstensen Frt	.823	1.025	.803
Advance Trnspt	1.026	1.264	.812
A-P-A Trnspt	.927	1.019	.910
Fredrickson	.908	1.110	.818
ABF Frt Syst	.986	1.068	.923
Central Frt	.942	1.127	.836
Nashua Mtr	1.011	1.110	.911
Consolidated	.957	1.044	.917
Crescent Trk	1.077	1.240	.867
Willig Frt	1.005	1.151	.873
Putnam Trnsfr	.940	1.071	.878
Transus Inc.	1.110	1.281	.867
Red Star Exp	.898	1.034	.868

TNT Holland	.977	1.187	.823
Wilson Trkng	.877	1.082	.811
Ward Trkng	.990	1.147	.863
Shippers Exp	.912	1.051	.868
Houff Trnsfr	.911	1.125	.810
H&W Mtr Exp	.836	.958	.873
New Penn Mtr	.968	1.197	.809
Merchant's Trk	.826	.963	.857
Beaufort Trns	.958	1.191	.805
Howard's Exp	.572	.696	.821
Estes Exp	.920	1.107	.832
Greenwood Mtr	.947	1.110	.853
Fore Way Exp	.887	1.129	.785
Conway Eastrn	.922	1.104	.836
Clark Bros	.939	.995	.944
Brown Trnsfr	.755	.812	.930
Old Dominion	1.388	1.677	.828
Century Mtr	1.134	1.342	.845
Overnite Trnsf	.982	1.123	.874
Middlewest Frt	.932	1.077	.865
Southeastern	.988	1.193	.827
Yellow Frt	1.012	1.122	.902
Nussbaum Trkng	1.024	1.121	.914
Crouse Crtg	.870	1.038	.838
Holmes Frt	.925	1.043	.887
Birmingham-Nashville Exp	.799	.826	.967

Table 9

51 Panel Firm Scores for 1987/88

Firm Name	Malmquist	Efficiency	Technical
McCracken Bros	.563	.754	.747
Ideal Truck	1.008	1.120	.900
Alvan Motor	.916	1.105	.830
Gross Common	1.005	1.075	.935
Preston Truck	1.009	1.322	.763
Midwest Motor	1.398	1.538	.909
Roadway Expres	.942	1.202	.784
The OK Truckin	1.214	1.542	.787
Carolina Frt	1.031	1.216	.850
Landgrebe Mtr	1.112	1.211	.918
Churchill Trk	1.055	1.258	.839
Be-Mac Trnspt	.564	.753	.749
Carstensen Frt	1.242	1.493	.832
Advance Trnspt	1.015	1.162	.874
A-P-A Trnspt	1.451	1.799	.807
Fredrickson	.951	1.154	.824
ABF Frt Syst	1.052	1.281	.821
Central Frt	1.019	1.144	.891
Nashua Mtr	1.059	1.133	.934
Consolidated	1.000	1.191	.840
Crescent Trk	1.100	1.480	.743
Willig Frt	.996	1.126	.885
Putnam Trnsfr	1.110	1.156	.958
Transus Inc.	1.056	1.512	.698
Red Star Exp	.961	1.212	.793
TNT Holland	1.088	1.250	.870

Wilson Trkng	.965	1.261	.765
Ward Trkng	1.024	1.338	.765
Shippers Exp	.985	1.066	.924
Houff Trnsfr	.961	1.453	.661
H&W Mtr Exp	1.025	1.116	.919
New Penn Mtr	1.038	1.176	.883
Merchant's Trk	1.020	1.171	.872
Beaufort Trns	.544	.718	.758
Howard's Exp	1.030	1.233	.835
Estes Exp	.931	1.050	.887
Greenwood Mtr	1.161	1.319	.880
Fore Way Exp	1.136	1.290	.881
Conway Eastrn	.943	1.165	.809
Clark Bros	1.033	1.138	.908
Brown Trnsfr	.929	.992	.937
Old Dominion	1.013	1.192	.850
Century Mtr	.939	1.057	.889
Overnite Trnsf	.993	1.176	.844
Middlewest Frt	1.003	1.142	.879
Southeastern	.987	1.102	.896
Yellow Frt	1.008	1.290	.781
Nussbaum Trkng	.982	1.159	.848
Crouse Crtg	1.010	1.153	.876
Holmes Frt	1.145	1.291	.887
Birmingham-Nashville Exp	1.051	1.250	.841

Table 10

Regional Malmquist Indices, 1977-1990

Region 1

Year	Malmquist	Efficiency	Technical
1977/78	.94	1.05	.89
1978/79	1.01	.86	1.17
1979/80	.93	1.05	.88
1980/81	.98	1.16	.85
1981/82	.92	.85	1.08
1982/83	1.01	1.12	.89
1983/84	.94	1.16	.81
1984/85	.90	1.01	.89
1985/86	.95	.59	1.61
1986/87	.96	2.60	.37
1987/88	.94	1.10	.85
1988/89	.94	.93	1.01
1989/90	1.00	.89	1.12

Region 2

Year	Malmquist	Efficiency	Technical
1977/78	.94	1.05	.89
1978/79	.96	.80	1.21
1979/80	.92	1.04	.88
1980/81	.91	1.08	.84
1981/82	.94	.81	1.16
1982/83	.96	1.04	.92
1983/84	1.02	1.23	.83
1984/85	.92	.99	.93
1985/86	.98	.70	1.41
1986/87	.98	1.95	.51
1987/88	.93	1.18	.79
1988/89	1.00	1.09	.92
1989/90	.95	.85	1.12

Region 3

Year	Malmquist	Efficiency	Technical
1977/78	1.01	1.16	.87
1978/79	.96	.78	1.22
1979/80	.87	.98	.89
1980/81	.98	1.19	.82
1981/82	.93	.86	1.07
1982/83	1.04	1.16	.89

1983/84	.98	1.19	.82
1984/85	1.01	1.05	.96
1985/86	1.11	.90	1.24
1986/87	.89	1.55	.58
1987/88	.91	1.14	.80
1988/89	.93	1.03	.89
1989/90	1.05	.90	1.16

Region 4

Year	Malmquist	Efficiency	Technical
1977/78	1.04	1.05	.99
1978/79	.99	.79	1.24
1979/80	.91	1.04	.87
1980/81	.95	1.13	.84
1981/82	.89	.78	1.15
1982/83	1.05	1.08	.98
1983/84	.99	1.20	.83
1984/85	.93	1.02	.91
1985/86	1.00	.74	1.35
1986/87	.97	1.89	.52
1987/88	.93	1.14	.82
1988/89	.92	1.06	.87
1989/90	.98	.91	1.08

Region 5

Year	Malmquist	Efficiency	Technical
1977/78	.99	.94	1.05
1978/79	.92	.76	1.21
1979/80	.87	.96	.91
1980/81	1.03	1.18	.87
1981/82	.88	.82	1.07
1982/83	.98	1.00	.98
1983/84	1.02	1.24	.82
1984/85	.95	1.04	.91
1985/86	.99	.65	1.52
1986/87	.98	2.54	.39
1987/88	1.08	1.22	.89
1988/89	.99	.96	1.03
1989/90	1.03	.93	1.11

Region 6

Year	Malmquist	Efficiency	Technical
1977/78	1.02	1.08	.94

1978/79	.91	.77	1.19
1979/80	.86	.95	.90
1980/81	.91	1.06	.86
1981/82	.97	.90	1.07
1982/83	1.00	.99	1.01
1983/84	1.07	1.29	.83
1984/85	1.04	1.12	.93
1985/86	.98	.70	1.39
1986/87	1.01	2.19	.46
1987/88	.80	1.02	.79
1988/89	.92	.99	.93
1989/90	1.02	.93	1.09

Region 7

Year	Malmquist	Efficiency	Technical
1977/78	.94	.88	1.07
1978/79	.95	.78	1.21
1979/80	.87	.93	.93
1980/81	1.03	1.19	.86
1981/82	.87	.74	1.17
1982/83	1.05	1.11	.95
1983/84	.95	1.19	.79
1984/85	.85	.94	.91
1985/86	.94	.70	1.35
1986/87	1.00	2.06	.48
1987/88	1.14	1.38	.82
1988/89	1.05	1.12	.93
1989/90	1.01	.93	1.09

Region 8

Year	Malmquist	Efficiency	Technical
1977/78	1.04	.97	1.07
1978/79	.95	.78	1.22
1979/80	.99	1.03	.95
1980/81	.99	1.12	.89
1981/82	1.02	.93	1.09
1982/83	.91	.95	.96
1983/84	.91	1.04	.88
1984/85	1.04	1.10	.94
1985/86	.89	.58	1.55
1986/87	.99	2.09	.47
1987/88	1.01	1.17	.86
1988/89	.96	1.01	.95

1989/90	1.00	.92	1.09

Region 9

Year	Malmquist	Efficiency	Technical
1977/78	1.00	.89	1.12
1978/79	1.00	.81	1.22
1979/80	.90	1.07	.84
1980/81	.98	1.12	.88
1981/82	.93	.89	1.05
1982/83	1.08	1.06	1.02
1983/84	1.01	1.23	.82
1984/85	.89	.97	.91
1985/86	1.08	.70	1.54
1986/87	.97	2.14	.45
1987/88	.88	1.08	.81
1988/89	1.09	1.20	.91
1989/90	1.06	.96	1.10

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