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THE ADVANTAGE OF SIZE IN THE U.S. TRUCKING INDUSTRY: An Application of the Survivor Technique

Carol J. Emerson, Curtis M. Grimm, and Thomas M. Corsi
University of Maryland
College Park, MD 20742

Introduction

The theory of economies of scale, that is, the relationship between the average cost of the firm and its quantity of output gives rise to the notion of the "optimum sized firm." The motor carrier industry provides an excellent study in economies of scale. With the passage of the Motor Carrier Act in 1980, the structure of the motor carrier industry fundamentally changed during the transition from a regulated to a competitive environment. Natural market forces began to take effect and, over time, have begun to change both the optimal size as well as the number of firms operating in the industry.

In the deregulated motor carrier environment, the degree to which firm size confers advantage is an issue that is currently the subject of much debate. The preponderance of econometric evidence, as summarized and extended by Grimm, Corsi and Jarrell (1989), suggests that there are no economies of scale in the TL or LTL sector under either regulation or deregulation.

Yet, the market share of the top three firms has grown from 15.2% in 1977 to 26.4% in 1988. Rakowski (1988) has characterized the advantages to large firms in this new competitive environment as "marketing economies." Large firms, with nationwide services, have distinct advantages in obtaining business from shippers committed in a deregulated enivronoment to limiting their business to a select group of carriers in an effort to enhance their bargaining position. This consolidation process rewards the shippers through lower rates and greater use of electronic data interchange from carriers who are able to make a financial investment once a shipper commits a large share of its business to them (Kling, 1990).

Thus, the purpose of this paper is to try to shed additional light on the extent to which size confers advantage to trucking firms. More specifically, this paper extends the work of Keeler (1989), who used the survivor technique and found a mildly positive relationship between firm size and market share. Keeler's work used data during the transition period after deregulation through 1984. This paper, by employing data through 1988, allows more time for industry adjustments to deregulation. In addition, this paper applies the survivor technique to all motor carriers grouped together as well as to LTL carriers in a separate analysis. The primary result is that larger firm size appears to confer a marketplace advantage in the motor carrier industry. The next section provides details regarding the survivor technique methodology.

Data and Methodology: The Survivor Technique

The survivor technique, as first developed by Stigler (1958), clusters firms by size and then examines which sized clusters increase membership over time. The technique "reveals the optimum size in terms of private costs--that is, in terms of the environment in which the enterprise finds itself." (Stigler, 1958, p.54) The logic of the approach is that over time, competition in an industry will allow only the most efficient sized firms to prosper, or survive.

More specifically, one classifies the firms by size (measured by number of employees, assets, revenue, production, for example) and then calculates the class share of industry output over time. If the percentage of the industry output contributed by a particular class falls over time, this is an indication that this class is a less efficient one and the number of firms in that class will also fall over time. The class size which contributes more industry output over time is the more efficient class, better able to meet the everyday challenges in the industry under study.

To apply the survivor technique effectively, several conditions need to be observed. Because entrepreneurs in these firms may make mistakes in their choice of optimum size, large numbers of firms should be studied in each industry to offset the effects of these errors in management judgement on the industry results. Firms should be studied over several time periods to mitigate any effects of changing factor prices or technology on the optimum firm size. Finally, all competing firms should be selling in the same marketplace. The primary advantage of the survivor technique is that it can capture advantages of size beyond those variables included in a typical econometric cost study. In addition, the technique circumvents difficulties observed in econometric approaches, such as a lack of data availability and the measurement of capital costs with available accounting data. The survivor technique may be used as a preliminary measure in conjunction with other methodologies to verify results. Recently, Keeler (1989) applied the survivor technique to the motor carrier industry.

This paper extends Keeler's work to include data from 1977, 1986, and 1988 on U.S. motor carriers. Following Keeler, we included all Class I and Class II carriers of general commodities, reporting annually to the ICC. Excluded firms included specialty haulers (dump trucks, fuel trucks) and small package delivery (UPS). However, this paper also provides a separate analysis of LTL firms, the segment where potential scale economies are of greatest interest. These selection procedures resulted in a sample of 927 firms for 1977, 664 firms for 1986, and 616 firms for 1988. The size class divisions are based on revenues, the measure of size originally used by Stigler.

In addition to using Stigler's original survivor technique to study firm size, this paper will also extend Keeler's more recent variant by including data from the period 1984-1988. Keeler (1989, p.237) states Stigler's hypothesis in mathematical terms as follows:

$$\text{prob}\,[MS(1) > MS(0)] = F\,[size(0)] \qquad (1)$$

where MS(1) is the market share in a later period, MS(0) is the market share of the same size class in an earlier period, and size(0) is the average size of firms in the given size class in the first size period. In this framework, increasing returns to scale would mean that the probability of a size class increasing market share over time will be higher for larger firms. The dependent variable is then a discrete function and is estimated using a discrete choice model.

More specifically, in the probit equation used for this study, the dependent variable is discrete and valued at zero if the size class lost market share, and one if it stayed the same or gained market share. The independent variable, ton-miles (TONMILES) is a physical output measure for size. Additionally, following Keeler, three other independent variables are included to control for items other than size that may affect the dependent variable. These include 1) the percent of vehicle-miles performed with company-owned vehicles (PCOWN); (firms that contracted with owner-operators may experience lower costs than firms using their own drivers.) 2) the average compensation per employee (WAGES); (firms paying higher wages will have more difficulty competing than those with lower wages) and 3) average length of haul (ALH); (smaller length of haul implies more traffic over the route structure, thus making it more attractive for shippers to use that firm and more likely that the firm will run more profitably with fuller trucks; thus a negative coefficient to ALH would indicate the presence of economies of integration.) A generalized, second-degree polynomial form is used.

The sample consists of all Class I and Class II motor carriers reporting the needed data. There were 663 firms in 1984 and 532 firms in 1988. Using Keeler's methodology, the firms were stratified into 217 nonoverlapping size classes for 1984-1988 and a probit equation is estimated.

Results Using Stigler's Survivor Technique

Eight firm size classes were used with total operating revenue as a measure for market share. Tables 1 and 2 present the results for the total industry, integrating our findings with Keeler's (1989) work. Table 1 shows a downward trend in the number of firms in the lower five size classes, while the largest size class shows an increase from 1975 to 1988. Table 2 shows similar results for the percentage of revenues for each size class. More specifically, in 1977, only one firm had revenues representing greater than five percent of the industry revenues. This increases steadily so that by 1986, there were three firms with 23.6% of the total revenue, showing both an increase in firm numbers and, more importantly, an increase in the average revenue contributed by each firm. By 1988, the top three firms had increased their share to 26.4% of the market. Firms with greater than one percent of the market had increased their total share from 31.7% of revenues in 1977 to 51.4% in 1988. The firms with revenues of less than or equal to one percent of the industry revenue, as a group, dropped from 68.6% of total revenues in 1977 to 48.4% in 1988. A clear pattern is shown for the years 1977 to 1988 for each size class less than or equal to one percent of the industry revenue,

TABLE 1
Number of Firms by Size Class of Firm for the Years 1975, 1977, 1980, 1984, 1986, 1988

Firm Class:	1975	1977	1980	1984	1986	1988
% of Industry Revenues	Number of Firms in Each Class, Each Year Truckload and Less Than Truckload Sectors					
Over 5%	0	1	2	3	3	3
2.5 to 5%	4	3	3	2	3	3
1 to 2.5%	7	11	12	11	10	10
.75 to 1%	12	13	11	6	5	5
.5 to.75%	18	16	9	11	13	7
.25 to.5%	41	40	31	31	32	37
.1 to.25%	110	94	93	87	81	74
Under .1%	989	927	721	628	517	477
All Firms	1181	1105	882	779	664	616

Source.---Data for 1975, 1980, 1984 from Keeler (1989), p. 235. Data for 1977, 1986, 1988 drawn from Motor Carrier Annual Reports.

TABLE 2
Percentage of Industry Revenue by Size Class of Firm for the Years 1975, 1977, 1980, 1984, 1986, 1988

Firm Class:	1975	1977	1980	1984	1986	1988
% of Industry Revenues	Percentage Revenue for Each Class, Each Year Truckload and Less Than Truckload Sectors					
Over 5%	.00	5.3	11.59	20.80	23.6	26.4
2.5 to 5%	14.35	11.0	10.50	7.12	8.7	8.7
1 to 2.5%	10.15	15.4	17.50	17.09	16.0	16.3
.75 to 1%	10.54	10.9	9.55	5.36	4.6	4.5
.5 to.75%	11.21	9.7	5.04	6.18	7.9	4.2
.25 to.5%	15.38	14.3	11.51	11.58	10.9	13.2
.1 to.25%	16.75	14.5	15.40	13.99	12.8	11.9
Under .1	21.62	18.9	18.91	17.88	15.5	14.8

Source.---Data for 1975, 1980, 1984 from Keeler (1989), p. 235. Data for 1977, 1986, 1988 drawn from Motor Carrier Annual Reports.

when taken by themselves, with the exception of those with .25 to .5% of industry revenue. In all cases except the latter, the percentage of revenue has declined from 1977 to 1988. The group with .25 to .5% of revenue overall has experienced fluctuating results with revenue as well as the number of firms in the class.

The top firm class has grown over the years from 1977 to 1988 both in numbers and percentage of revenue of the industry. The second largest firm class has actually declined in percentage of industry revenues over the same period, perhaps a result of bankruptcies of some fairly large firms during the period studies and the shift of their business to firms in the largest-size category. The percentage of revenue for the third largest class has grown during the period studied.

The LTL results shown in Table 3 exhibit similar patterns.

TABLE 3
Less Than Truckload
Firms and Revenues by Size Class of Firm for the Years 1977, 1986, 1988

Firm Class:	1977		1986		1988	
% of Industry Revenues	No. of Firms	Revenues (% of Total)	No. of Firms	Revenues (% of Total)	No. of Firms	Revenues (% of Total)
Over 5%	1	5.9	3	28.7	3	32.4
2.5 to 5%	4	15.1	4	13.5	5	16.4
1 to 2.5%	12	16.6	14	22.0	13	19.7
.75 to 1%	15	13.3	5	4.1	3	2.4
.5 to.75%	18	10.6	11	6.9	11	6.5
.25 to.5%	36	13.0	27	9.3	23	8.0
.1 to.25%	86	13.9	55	8.4	49	8.4
Under .1%	380	11.6	193	7.0	167	6.3
All Firms	552	100.00	312	100.00	274	100.00

Source.---Data tape from the American Trucking Association corresponding to the Motor Carrier Annual Report for each respective year. Data listed here are calculated from this source.

The top three size classes grew even more dramatically in the LTL sector, from 37.6% of the revenue in 1977 to 68.5% in 1988. The top two classes increased both in numbers of firms in the class and in the percentage revenue represented by that class. The third largest class has results which are less clear because the number of firms

fluctuated along with the percentage revenue of the class. The remaining five size classes have consistently shrunk both in numbers of firms and percentage of industry revenue for the class.

Both the total industry and LTL results support anecdotal evidence that there are marketplace advantages to greater size. In particular, the increasing percentage of revenues in the largest size class found by Keeler through 1984 does not appear to be an artifact of the early deregulation transition period, as this class continues to grow in size through 1986 and 1988.

Results of Keeler's Probit Variant

Keeler used the probit model to gain further insight into factors that determine whether market share is gained or lost in a given size class. For the years 1980-1984 he found at least marginally significant results for the output terms. Our probit equation for the years 1984-1988 suggests even stronger evidence of scale economies. The results are shown in Table 4. Both the TONMILES and TONMILES^2 terms are positive and significant. The results indicate that there is a strong relationship between firm size, as measured by ton-miles and a growth in market share from the first period to the next.

Regarding control variables, the first order terms are generally of the expected sign but not statistically significant. The ALH term is negative and insignificant, while the ALH^2 term is positive and significant. The PCOWN term is also negative and insignificant, while the PCOWN^2 term is positive and significant. Finally, the WAGES and WAGES^2 terms are both positive, but insignificant, contrary to the findings of Keeler (1989) which indicate lower wage firms tend to increase market share over time.

Implications and Conclusions

In both of our analyses, size appears to provide an advantage to firms in the motor carrier industry. To reiterate, results from use of the survivor technique should be interpreted with caution; the reader should be cognizant of results using other methods to determine the effects of size in an industry. Nonetheless, the results appear to provide support for authors such as Ying (1990), Rakowski (1988), Keeler (1989), and Kling (1990) who have found advantages of size in the post-deregulation motor carrier industry.

Indeed, the advantages of size appear to be clearer when more recent evidence is examined. Evidence obtained using the survivor technique shows that the top three size classes, representing firms holding from 1 to 2.5%, 2.5% to 5%, and over 5% have grown dramatically from 31.7% of revenue in 1977 to 51.4% in 1988. The less-than-truckload (LTL) results for the same size classes also show tremendous growth from 37.6% in 1977 to 68.5% in 1988. Evidence obtained using a probit equation suggests that there is a positive and significant relationship between ton-miles as a measure of size and the probability that a given size class grew from 1984 to 1988. Average length of haul (ALH) and the percentage of company owned vehicles used (PCOWN) (as opposed to owner operators) were held

TABLE 4
Probit Results, 1984-1988: Dependent Variable Is Probability That Market Share Did Not Fall for Each Size Class

Variable	Coefficient (Standard Error)	T-Statistic
CONSTANT	0.13918	0.79885E-01
	(1.7422)	
AVERAGE LENGTH OF HAUL (ALH)	0.21085E-02	-0.87419
	(0.24120E-02)	
PERCENT OF VEHICLE MILES DRIVEN IN CO. OWNED VEHICLES	-0.41627E-01	-1.4749
	(0.28223E-01)	
TON MILES	0.10049E-07	2.3279
	(0.43168E-08)	
ANNUAL WAGES	0.28687E-04	0.51774
	(0.55407E-04)	
½ALH^2	0.86084E-05	3.4239
	(0.25142E-05)	
½PCOWN^2	0.10038E-02	3.1302
	(0.32067E-03)	
½TONMILES^2	0.28039E-17	2.9525
	(0.94969E-18)	
½WAGES^2	0.13244E-08	1.1249
	(0.11773E-08)	
ALH*PCOWN	0.13100E-04	0.61798
	(0.21198E-04)	
ALH*TONMILES	-0.13802E-10	-3.4635
	(0.39850E-11)	
ALH*WAGES	-0.47780E-07	-1.0037
	(0.47602E-07)	
PCOWN*TONMILES	0.35428E-10	0.99556
	(0.35586E-10)	
PCOWN*WAGES	-0.89993E-06	-1.4571
	(0.61763E-06)	
WAGES*TONMILES	-0.13258E-12	-1.1306
	(0.11726E-12)	

Number of Observations: 226
R^2 = 0.166549
Variables are defined in text.

constant and both squared terms were highly significant and positive indicating the importance of including those variables. Perhaps because the time span considered in this study is longer and takes place more in the deregulated era of motor carriage, the size change trend within the industry is much more apparent. It could be that the intermediate sized firms which yielded clearer results than in Keeler's study have taken longer to adapt to the deregulated environment. That is, the smaller firms, who could not compete without the protection of regulation, were either forced to withdraw

from the industry more quickly because they may not have had the financial or managerial expertise to carry them through such a dramatic environmental change or were purchased by a much larger firm. The largest firms, on the other hand, may have had the human as well as the financial assets to adapt to the new environment fairly quickly. The intermediate firms may have had enough financial backing to carry them while the management either adapted or not over a longer period of time; this study, using a longer time period, may better show the consequences of such actions. Further study is needed to explore these suggestions in more detail.

Keeler advanced several more specific reasons in explanation of his results that seem to apply as well to the results of this study. Prior to deregulation, entry and rate restrictions were in effect, thus allowing firms with high union wages to prosper despite their high costs of operation. Once the restrictions were lifted with the passage of the Motor Carrier Act, those firms with high wages were at an immediate disadvantage and many of them left the industry, as shown indirectly by Keeler's significant and negative coefficient on the wage variables. (As the wages decrease the probability of an increase in market share increases.) This correction of high wage firms leaving the industry, may have taken place rather quickly, thus explaining the current insignificant coefficients on wages resulting from the probit analysis on the period 1984 to 1988.

Large firms operating in the industry have the advantage of using a hub and spoke structure and keeping their costs at a minimum by efficient use of equipment, thus adding to their profitability. It may well be easier to offer high levels of service quality at a reasonable price with a larger system. That is, a larger route structure with more equipment operating more frequently translates into greater service quality for the shipper and thus will add to revenue. The result with fully utilized equipment is increased profitability. LTL companies such as Consolidated, Yellow and Roadway seem to fit this category.

Finally, without the constraints of regulation, firms have the flexibility to respond to the marketplace, to add routes and equipment, to reduce rates, to take whatever measures will translate into greater profitability without the constraints of regulation. It is the larger firms that have the flexibility to do this successfully because of their larger number of routes and shipper customers. Thus advantages of size accrue to this group. Further research on size advantages could include a more detailed, disaggregated analysis of the LTL haulers, that is, those firms which haul shipments of less than 10,000 pounds. TL and LTL operations have very different cost structures (Grimm, Corsi and Jarrell, 1989). TL carriers do not require the hub and spoke operations that are expensive to maintain and are essential for the LTL segment. For that reason alone, one would expect the LTL segment to exhibit advantages to larger size firms.

The survivor technique has been applied to industries many times since the seminal work of Stigler in 1958. It has been able to offer insight not only into what structure has worked in various industries over time, but also into why the structure exists or has changed.

Keeler extended Stigler's technique by employing discrete choice analysis with control variables to account for reasons other than size that economies of scale exist. This study built on Keeler's work with more recent data and a disaggregation of the TL and LTL sectors. Our results would indicate that advantages of size become more apparent in the motor carrier industry with the passage of time. The industry underwent a significant structural change in 1980. As a result, the number of large firms and the percentage that those firms contribute to industry revenue has increased. The results of this study indicate that the top three size classes as a group have consistently grown since 1977, while the other five classes have gotten smaller during that time. Thus it would appear that larger firms have had greater success over time and that there are size advantages in the whole motor carrier industry as well as in the LTL sector.

It is important to compare these findings of size advantages to the earlier cited work indicating that econometric analysis suggests no economies of scale in the motor carrier industry (TL or LTL) in the deregulated environment. As Keeler suggest, it is quite plausible that the size advantages to motor carriers, characterized above as "marketing economies," are simply not measured in the traditional econometric economies of scale studies. The firm size advantages revealed through the survivor technique involve such considerations as the benefits that large firms have as a result of national coverage and its associated potential for improved service quality. Large firms are also better positioned to develop close partnerships with shippers anxious to consolidate their business with only a limited number of carriers. Finally, strategic management studies of the motor carrier industry (in particular the LTL sector) reveal that large and medium size firms outperform small firms, especially when firm size is coupled with the firm's strategic focus (Corsi, Grimm, K. Smith, and R. Smith, 1991 and R. Smith, Corsi, and Grimm, 1991). In short, the survivor technique points to size advantages that are not accounted for in the econometric economies of scale studies. This, indeed, is one of its best attributes. Further investigation should explore the differences between the econometric economies of scale approach and the survivor technique with respect to the implications for firm size in an attempt to reconcile further the two sets of results.

A final note is in order. That there may be moderate advantages accruing to larger motor carriers does not suggest that the industry should be re-regulated. A degree of size advantage is the norm in many industries where market forces function to allocate resources, and we would not recommend a return to economic regulation in the motor carrier industry.

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