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Introduction :

The relationship between firm size and the unit cost of production in an industry is important in the development of company growth strategies as well as the formulation of public policy. Three general relationships are acknowledged between unit costs and output: increasing returns to scale (also referred to as economies of scale); constant returns to scale; and decreasing returns to scale (also referred to as decreasing returns to scale). If economies of scale exist in an industry, other things being equal, unit costs would decline as the average firm size in the industry increased. Thus, firms within the industry would find a growth-oriented policy would be desirable. From a public policy perspective, if larger firms are more efficient, then policy makers should encourage growth and mergers. Larger more efficient companies would be able to offer lower cost products or services to the public, increasing the total benefit from trade. If this is the case, government should provide a regulatory environment to monitor the behavior or firms to prevent the loss of competition and possible monopolistic exploitation. There must be protection so that the surviving companies would not exploit the consumer and decrease the total benefit to society. If economies of scale do not exist, it should not matter whether a firm is large or small; small companies should be able to effectively compete with larger ones. Firms should focus on the efficiency of their operations, and government policy should be at a minimum, leaving the industry to the natural forces of competition (Boyer 1998). This issue has been studied extensively in the United States domestic trucking industry, and while the general belief is that there are no returns to scale in the industry, there are inconsistencies in the findings of some studies, which suggest that further analysis is necessary. Furthermore, the majority of studies focus on the less than truckload (LTL) sector (Kling 1990; Corsi, Grimm, and Feitler 1992; Harmatuck 1992), and very little research has focused on the truckload (TL) sector. There have also been many changes in the industry since the most recent studies were published. Anecdotal evidence suggests that the industry is changing. In an era of intense competition, larger firms are growing much faster than smaller ones, and smaller firms are failing at a faster rate than the larger ones, leading to an increasing gap between the top ten carriers and the rest of the industry. Thus, it is important to re-examine the issue.

The purpose of this paper is to attempt to assess whether or not economies of scale exist in the domestic truckload industry. First, a review of the literature concerning economies of scale in the truckload industry is presented. Then, recent DOT data is analyzed to discover whether or not there is a relationship between size and unit costs, and, finally the implications of the findings are discussed.

Past Research:

Keaton (1978) reviewed the early literature on scale economies in trucking and found conflicting evidence as to their existence. Corsi, Grimm, and Jarrell (1989) also found conflicting evidence in an excellent review provided as part of their study. In their study, they found that economies of scale do not exist in either the LTL or the TL segments both before and after deregulation. They used three output variables; ton miles, average load, and average size. Corsi, Grim, and Jarrell took into account four price variables; fuel, labor, purchased transportation, and capital. They found that higher average loads decreased costs per unit, but this is inherent in the model.

It is relevant to know the priorities of shippers with regards to carrier selection, because it will impact the service variable. A broad study of shippers was conducted by McGinnis (1990), and service was found to be more important than price when it comes to carrier selection. He found that since deregulation, price has become more significant, but that service remains the number one priority. Since the study by McGinnis, a greater emphasis has been placed on controlling inventory levels. Lower inventories would rely on consistent service and lower transit times. This reinforces the importance of service over price, as the higher *transportation costs* would result in a lower total costs for the company.

Harmatuck (1992) found that the LTL industry had increasing returns to scale since deregulation when controlling for service. In his study, the cost of service as a percentage was higher than the added revenue large carriers receive for providing higher levels of service, thus making service levels negate economies rather than hide them. According to his study, large LTL companies need to provide a higher level of quality, but they need to make sure they charge for it so that scale economies can be exploited. Harmatuck's article contradicts the general belief that economies of scale do not exists in the LTL industry, however he did not find evidence of a direct negative relationship between size and costs. The study also points to a decrease in elasticity in the truckload industry, thus reinforcing the importance of service to shippers.

Allen and Liu (1994) also considered service in their analysis. They said that to accurately evaluate economies of scale in the LTL industry one must account for costs of service. If the service variable is omitted, the research could hide scale economies of large carriers. If economies of scale exist in the truckload industry, carriers have the option of spending the cost advantage on service to gain a competitive advantage or to offer similar service at a lower cost (Allen and Liu 1994). Given the research by McGinnis, one can assume that large motor carriers would opt for spending their returns to scale on service. Allen and Liu (1994) used annual shipper data to control for service levels. They found that, when service was accounted for, economies of scale were present in the LTL industry.

Xu et al. (1994) also analyzed costs in the LTL industry. They found constant returns to scale if output characteristics were held constant. They say that the advantage that large LTL carriers have is the ability to attract longer hauls and heavier trucks. Therefore, it is not fair to hold output characteristics, average length of haul and average load size, constant as they are the reason for increasing returns to scale (Xu et al. 1994).

Adrangi et al. (1995) tested the issue of economies of scale from a profit function approach. They used data from 1979 and 1984 to conduct a pre and post deregulation study. They found that the industry can be characterized by constant returns to scale, and that no major costs benefit could be obtained through mergers.

Past research on the topic of economies of scale in the motor carrier industry is somewhat inconsistent and remains incomplete, especially with respect to the truckload segment. Many studies have not accounted for safety or administrative overhead. Past research is also dated; more recent data should be analyzed to reassess the issue of scale economies because the industry is changing. Large carriers are growing disproportionately to the industry average. Capacity constraints are indicative of emerging barriers to entry. Entrants into the market are being dissuaded by higher fuel prices, lack of driver availability, higher insurance costs, and more expensive equipment due to recent emission standards (Abt 2004; Long 2004). Growth in the top carriers and the industry since the time of the last analysis is displayed in Table 1.

Table 1: Carrier Growth

Company	**Percentage Increase 1989-2002**
J. B. Hunt Transport, Inc.	341%
Werner Enterprises, Inc.	433%
Ryder Integrated Logistics, Inc.	452%
Industry Average	**46%**

Source: Technical Transportation Services, Inc. 1989-2002.

Methodology:

The Methodology will be discussed in three parts. First, the model will be explained. Second, variables and hypotheses will be discussed. Third, the data used in the analysis will be described. The statistical technique used was the Linear Regression module in the Statistical Package for the Social Sciences (SPSS).

The Model:

The cost per ton-mile is given by the function:

Costs/TMI **Exp/TM** = f (**Ton-Miles**, RSP, ALH, ALS, ADE, DRE, INE)

Where:

Exp/TM = Total Expense per Ton-Mile

Rev/Ship = Revenue per Shipment

Ave LH = Average Length of Haul

Ave Load = Average Load Size

Admin/Exp = Administrative compensation as a percentage of total expenses

Driver/Exp= Driver Compensation as a percentage of total expenses

Ins/Exp = Insurance Expense as a percentage of total expenses

Many of the variables used in this model are repeated in past research; however most models from previous research were under specified. To gain an accurate picture of economies of scale in the truckload industry one must account for safety and administrative overhead. This model will use insurance as a percentage of total expense as a surrogate for safety. The administrative compensation per expense will be a measure of managerial efficiency.

The relationships between the dependent and independent variables are expected to be non-linear. This suggests that the model should be multiplicative and in the form:

(1) $Y = a\, X1^{b} X2^{c} X3^{d} \ldots Xn^{p}$

The multiplicative form reflects curvilinear relationships, but the parameters are linear when in natural logarithmic form. Therefore, converting the data in natural logarithms will permit ordinary least squares estimation of equation (1) by:

(2) $\ln Y = \ln a + b \ln X1 + c \ln X2 + d \ln X3 + Ö p \ln Xn$

The estimated parameters of equation (2) are the exponents of the respective variables. This permits direct interpretation of the relationships between the variables even though the data are in logs (Ozment and Chard 1986).

Variables and Hypotheses:

The relationship between ton-miles and cost per ton-mile will answer the question as to whether there are economies of scale in the truckload segment of the motor carrier industry. A company with more ton-miles should have a lower cost per ton-mile if everything else is held constant (Corsi, Grimm, and Jarrell 1989; Harmatuck 1992; Allen and Liu 1994; Allen and Liu 1995; Boyer 1998). Other output characteristics include average load size and average length of haul. A higher average load size will decrease the cost per ton-mile as will a higher average length of haul. A high average load size will decrease cost per unit, but will not give us insight into the profitability of a truckload firm. The rate structure is given by shipment instead of by pound. A higher average length of haul could yield a cost advantage due to fuel and time efficiencies. Drivers spend more time on the road rather then at shipper's docks.

To discover whether or not returns to scale exist in the TL industry, we must control for the cost of service. All things held constant, the higher the revenue per shipment the higher the expected level of service. Given McGinnis's study on shipper priorities, larger carriers would spend possible scale economies on service rather then offer a lower price. However, Harmatuck's (1992) study suggests that larger carriers should charge a premium for their increased service rather than keeping the same price as competitors. Using this theory, one would expect that an increase in the revenue per shipment would raisethecost/tonmile.

Insurance should be a significant factor in returns to scale. Larger carriers can pool their risks and are more predictable than smaller carriers when it comes to accidents and damage. Larger companies can afford better safety programs that would help their insurance rates as well. All of these factors could lead insurance companies to lower their insurance rate per ton-mile for larger carries. This would give larger carriers a costs advantage. Another advantage larger carriers should have with regards to insurance is the administrative cost of the insurer. If insurance rates are held constant, large carriers still have an advantage because it costs less for the insurer to manage one account rather then several hundred. Given these possible advantages, insurance costs should fall per unit as the ton-miles of the carrier increase. Insurance rates will be calculated as a cost per expense.

Driver compensation as a percentage of total expense should provide insight into the effects of driver pay on turnover. Driver turnover has become an increasing problem within the industry. Driver turnover for the industry is currently over 130% (Guido 2005). The costs to hire a driver averages around $5,000. With average operating ratios hovering around .98, carriers cannot afford the extra expense. In theory, if a carrier raises driver pay more drivers would be attracted to work and stay with that carrier, given they receive a sufficient amount of miles. Using a total cost approach, raising driver pay could lower the costs per ton-mile due to a decrease in driver turnover.

Administrative overhead costs could also be an advantage for larger carriers. Administrative expenses can be minimized by larger carriers because of their ability to allocate the maximum number of people a manager can manage effectively. Smaller carriers will need a manager regardless if they have the optimum number of trucks or not. Larger carriers are also able to streamline their processes by hiring specialized managers in different aspects of the business, where a small carrier manager would have to take on many managerial functions regardless if he is trained or not. This should lead to greater inefficiency.

Refrigerated carriers carry higher costs of maintenance, insurance, and capital equipment. This has the potential the skew the data, therefore a dummy variable for refrigerated carriers must be included in the initial linear regression to test the significance of the variable.

Data:

The data used in the study was obtained from the Department of Transportation (USDOT) from data submitted by individual carriers. It covers the years 1999-2002 and includes 1,808 observations. The entire data set originally consisted of over 26,000 entries; however, all LTL and House Hold Goods carriers were eliminated, as they are not included in this study. Carriers which only had one or two data entries over the four year period were also eliminated. The next procedure was to remove data that was obviously inaccurate due to faulty reporting or no reporting at all.

The costs per ton-mile were calculated by dividing total expenses by ton-miles. The average load size was calculated by dividing the total number of shipments by total tons. The total number of shipments was obtained by dividing total highway miles by the average length of haul. Average length of haul was calculated by dividing ton-miles by total tons shipped. An alternate average length of haul was obtained by dividing total highway miles by the total number of shipments. Revenue per shipment was calculated using both the reported total number of shipments and the alternate calculation for total number of shipments, with the latter taking precedence. Descriptive statistics of the data sample are shown in Table 2.

Table 2: Descriptive Statistics of the Data

	Gross Rev	Op Ratio	Exp/TM	Ton Miles	Rev/Ship
Min	2,554,708	0.6481	0.0216	3,361,482	100
Max	2,247,885,805	1.2949	1.9677	32,556,083,120	8836
Mean	36,297,852	0.9844	0.1331	396,801,249	869
Median	10,629,118	0.9846	0.0831	119,520,000	688
Std dev	145,146,860	0.0539	0.1710	1,611,667,219	656

	Ave LH	Ave Load	Admin/Exp	Driver/Exp	Ins/Exp
Min	50	1.0	0.0000	0.0000	0.0000
Max	2575	30.0	0.2808	0.5784	0.1371
Mean	588	17.3	0.0589	0.1777	0.0388
Median	455	18.0	0.0550	0.1967	0.0367
Std dev	457	5.6	0.0327	0.1077	0.0174

Empirical Results and Review of Hypotheses:

A linear regression was run with the data in natural logarithmic form using SPSS (Statistical Package for the Social Sciences); the model explained over 99% of the data set with a .00000 level of significance. Thus, the model is very accurate in explaining the variation in unit costs from the sample. Given the large sample size and the statistical significance, this model can be seen as a solid picture of the TL segment of the industry. Table 3 displays the significance of the model. The dummy variable for refrigerated carriers was found to be insignificant and was omitted in the final regression.

The coefficients of the model reveal the relationships between the independent variables and unit costs. The measure of size, ton-miles, has a negative relationship with expense per ton-mile. This is indicative of increasing returns to scale, thus supporting the hypothesis. Revenue per shipment is almost a one for one positive relationship with expense per ton-mile, meaning that an increase in revenue from service is almost completely negated by the costs of service. The administrative expense as a percentage of total expense has a weak positive relationship with expense per ton-mile; this signifies that large carriers have

Table 3: Regression Analysis

R	R Square	Adjusted R Square	Std. Error of the Estimate	F	Sig.
0.996	0.991	0.991	0.060	15206	0.0000

Table 4: Coefficients

	Un-standardized Coefficients		Standardized Coefficients		
Independent Variable	B	Std. Error	Beta	T	Sig.
(Constant)	0.1716	0.0295		5.82	0.0000
Ton Miles	-0.0127	0.0015	-0.0232	-8.33	0.0000
Rev/Ship	0.9886	0.0039	0.9509	251.88	0.0000
Ave Haul	-0.9834	0.0033	-1.1882	-294.67	0.0000
Ave Load	-0.9817	0.0037	-0.6867	-267.17	0.0000
Admin/Exp	0.0060	0.0030	0.0048	1.98	0.0474
Driver/Exp	-0.0041	0.0018	-0.0054	-2.24	0.0253
Ins/Exp	0.0054	0.0030	0.0045	1.82	0.0690

no advantage with regards to managerial efficiency, thus rejecting the hypothesis. The driver compensation per expense has a negative relationship with expense per ton-mile. This may contradict the traditional belief that driver pay will not affect the turnover rates for a truckload firm. This finding would only be relevant holding all things constant. If a firm raises pay but does not provide sufficient miles to the drivers, then their turnover rates will not be positively impacted. Table 4 displays the coefficients and significance levels for the independent variables.

Implications:

This analysis has serious implications on the truckload industry. Recent sweeping changes have given larger carriers a cost advantage. While the relationship between size and unit cost is statistically significant, the size of the coefficient is relatively small, suggesting that the industry is still going through change. Barriers to entry into the industry are emerging due to the driver shortage, rising insurance costs, fuel prices, and emission standards. If the current trends continue, larger carriers will seize greater shares of the market and perhaps realize even greater increasing returns to scale. The overall affect will be a more efficient market, as long as sufficient competition remains.

The present state of the industry requires no economic regulation from the government. At this point, government should encourage mergers and acquisitions, which should lower the overall costs of truckload transportation. As the larger carriers become dominant, government should focus on facilitating competition so that their power is not abused. As larger companies begin to realize greater returns to scale it will be increasingly hard to maintain a competitive advantage as a smaller carrier. Therefore, corporate strategies should focus on growth and strong mergers.

The study also suggests that the diver turnover problem that currently plagues the industry can be remedied in part by increasing driver wages. The costs of hiring drivers outweigh the savings due to lower wages, holding all else constant. It is important to note that if companies increase driver wages, then they must maintain driver miles. If they fail to give the driver adequate miles, then drivers will not earn more money, and the firm may suffer from the same turnover rates with higher labor expenses, leaving it at a competitive disadvantage.

The relationship between revenue per shipment and expense per ton-mile suggest that minimal gains can be realized if a carrier provides higher service. However, this variable does not take into account the marketing advantage a carrier gains due to service. Superior service makes a carrier very attractive to shippers because of their ability to lower inventory. With the marketing advantage, carriers with high service levels should be able to pick and choose favorable routes that can get their drivers home and provide backhauls.

It was found that larger carriers may not have insurance cost advantage. One explanation may be the potential for harsh punishments resulting from lawsuits. If large carriers suffer from harsher penalties than smaller carriers, insurance companies will charge them higher rates due to an increase in risk.

The data also suggests that larger carriers do not have an advantage with regards to administrative costs. This can be rationalized by the fact that some large carriers invest in management positions that are geared toward providing more favorable routes. Administrative overhead could be a tradeoff for an advantage gained through less driver turnover and more backhauls.

Potential for Further Research:

Many questions arise after this analysis of economies of scale in the truckload segment of the motor carrier industry. Further research is needed on higher average load size and profitability. The cost structure of the truckload industry is a flat rate per shipment. Therefore, a lower average load size should increase the profitability of the carrier. Empirical evidence is needed to determine if this is an accurate statement. Further research is also needed into the affect of average length of haul on driver turnover. This could yield a hidden advantage to firms with shorter hauls; because it could increase the time drivers get to spend with their families given they are provided backhauls to their home base. A study into the affect of driver pay on turnover is warranted given the results in this analysis. Administrative overhead is an advantage that large carriers are not taking. A study should be conducted on how large carriers can streamline management and what is keeping them from it.

References:

Abt, Neil (2004), "Economists Say Trucking Future Bright; Challenges Include Driver Crunch, Fuel," Transport Topics, October 11, pp. 7, 32.

Adrangi, Bahram, Garland Chow, and Kambiz Raffiee (1995), "Analysis of the Deregulation of the US Trucking Industry: A Profit Function Approach," *Journal of Transport Economics and Policy*, Vol. 29, No. 3 (September), pp. 233-246.

Allen, Bruce W. and Dong Liu (1994), "Service Quality and Motor Carrier Costs," *Transportation Executive Update*, (January/February), pp. 14-16.

Allen, Bruce W. and Dong Liu (1995), "Service Quality and Motor Carrier Costs: An Empirical Analysis," *The Review of Economics and Statistics*, Vol. 77, No. 3 (August), pp. 499-410.

Boyer, Kenneth D. (1998), *Principles of Transportation Economics*, (Addison-Wesley Longman, Inc.).

Grimm, Curtis M., Thomas M. Corsi, and Judith L. Jarrell (1989), "US Motor Carrier Cost Structure Under Deregulation" *Logistics and Transportation Review*, (September) Vol. 25, No. 3, pp. 231-249.

Guido, Daniel W. (2005), "Driver Chrun Sets Record: Turnover for Large TL Carriers Swells to 136%," *Transport Topics*, April 4, p. 1, 26.

Harmatuck, Donald J. (1992), "Motor Carrier Cost Function Comparisons," *Transportation Journal*, Vol. 31, No. 4 (Summer), pp. 31-46.

Keaton, Mark (1978), "The Structure of Costs in the US Motor Carrier Industry" *Proceedings of the Transportation Research Forum*, Vol. 19, No.1, pp. 356-364.

Long, Mindy (2004), "Industry Seeks Consensus Over Engine Incentives," *Transport Topics*, August 9, pp. 1, 34.

McGinnis, Michael A. (1990), "The Relative Importance of Cost and Service in Freight Transportation Choice Before and After Deregulation," *Transportation Journal*, Vol. 30, No. 1 (Fall), pp. 30-38.

Ozment, John and Douglas N. Chard (1986), "Effects of Customer Service Variables on Sales: An Analysis of Historical Data," *International Journal of Physical Distribution and Materials Management*, Vol. 16, no. 3, pp. 14-28.†

Rakowski, James P., "Marketing Economies and the Results of Trucking Deregulation in the Less-Than-Truckload Sector (1988)," *Transportation Journal*, Vol. 27, No. 3 (Spring), pp. 11-22.

Xu, Kefeng, Robert Windle, Curtis M. Grimm, and Thomas M. Corsi (1994), "Re-evaluating Returns to Scale in Transport," *Journal of Transport Economics and Policy*, Vol. 28, No. 3 (September), pp. 275-287.

Faculty comment:

Dr. John Ozment, Mr. Bradford's mentor, said of his student's work:

> Adam Bradford's paper potentially provides a very important contribution to the transportation literature. The issue of whether there are economies of scale in the truckload segment of the trucking industry is very timely and has implication for managers of trucking firms as well as government policy makers. While previous studies did not find evidence of economies of scale, it has been several years since those works were published, and there was reason to believe that results may now be different. His study found that the extremely large truckload carriers apparently have a cost advantage over smaller carriers.
>
> Adam put an unbelievable amount of time and effort into the study. In addition to the amount of reading, which was more than sufficient for an honor's thesis, he had to pour through thousands of the U.S. Department of Transportation's records of trucking companies to develop the data base he used. He also had to reach a level of competence in the use and interpretation of statistical techniques for the analysis that is far beyond the grasp of most undergraduate students.