The Relationship between Competitive Strategy Choice and the Components of Firm Efficiency in the General Freight Segment of the Motor Carrier Industry

Carl A. Scheraga
Professor of Business Strategy & Technology Management
Dept. of Management
Charles F. Dolan School of Business
Fairfield University
1073 North Benson Road
Fairfield, CT 06824
Phone: 203-254-4000 ext. 2419
Fax: 203-254-4105
E-Mail: cscheraga@mail.fairfield.edu

The Relationship between Competitive Strategy Choice and the Components of Firm Efficiency in the General Freight Segment of the Motor Carrier Industry

Abstract

This study investigates the impact of choosing a particular strategic focus or foci on operational productivity by means of the Malmquist Productivity Index. The Malmquist framework allows the researcher to examine the change in operational productivity over a period of time, which is particularly desirable given that the impact of strategic choices is an inter-temporal phenomenon as opposed to one occurring at a discrete point in time. Furthermore, the Malmquist methodology allows for the decomposition of the change in operational productivity into the two components of operational efficiency change and technological change. Competitive strategy choices are related to changes in operational productivity (as measured by the Malmquist Productivity Index and its components of operating efficiency and technological) by means of a tobit analysis. A consistent sample (for the period 1999-2003) of 83 general freight motor carriers is utilized. The results of the above analysis are then related to operational profitability by means of an analysis of variance.

Keywords: operational efficiency, technological change, Malmquist Productivity Index, strategic focus

1. Introduction and Motivation of the Study

In an article detailing the nature of business strategy, Michael Porter (1996) provides a discussion of the relationship between strategic positioning and operational effectiveness. He notes that operational effectiveness focuses on performing similar activities better than one's rivals. Specifically, it involves, in a relatively "better" manner, the utilization of a firm's inputs to achieve a set of desired outputs. Strategic positioning, on the other hand, involves performing different activities from one's rivals or performing similar activities in different ways. Porter argues that the connection between operational effectiveness and strategic positioning is defined by the concept of *fit*. Fit involves the ability of a firm to link its operational activities in an manner that most effectiviely supports its strategic position. Conversely, a firm, having defined a strategic position, should seek to perform the supporting operational activites as effectively and efficiently as possible.

This last idea has been explored, to some extent, in the transportation literature. Specifically, there is a body of empirical literature, utilizing data envelopment analysis, that has examined the relationship between strategic activity choices and operational efficiency in the airline industry. Banker and Johnston (1994) utilized panel data to examine the relationships between operating strategies, environmental events and efficiency and then related these variables to the competitive position of domestic airlines over the period 1981-1985. In particular, operating efficiency was examined as a function of the percentages of flights through competitive and dominated hubs, the average load factor, aircraft utilization rates, wide-bodied and full-efficient aircraft utilization rates, and a proxy measure for service quality.

Chan and Sueyoshi (1991) investigated the association between operating efficiency and firm structure and strategy for domestic airlines, before and after deregulation, by means of year-by-year comparisons of efficient and inefficient firms. Firm structure was captured by the simple variable of firm size while the strategy variables included capital utilization, promotion and sales expenditures, labor cost, capital intensity and debt. A study by Schefczyk (1993) examined the operational efficiency of 15 large international airlines for the year 1990. He then investigated the relationship between structural and executional drivers and operational efficiency. Specifically, the former set of variables included return on equity, gross margin, passenger load factor, passenger revenues as a percentage of total operating revenues, non-flight assets per available ton-kilometer, revenue growth, and international passenger-kilometers as a percentage of total passenger-kilometers. Two studies by Scheraga (2004a, 2004b) utilized a dataset of thirty-eight large domestic and international airlines for the year 2000 to examine the relationship between airline operational efficiency and financial mobility, as well as, the relationship between operational efficiency and customer service.

While the question of *fit* between firm strategic positioning and operational efficiency is also of interest in the motor carrier industry, except for the work of McMullen (2004) referred to below, there is a dearth of empirical research in this area. Interstate deregulation in 1980 and intrastate deregulation in 1995 certainly provided an incentive for trucking firms to improve their operating efficiency. Furthermore, this is an industry that has also been characterized by a significant amount of logistical and technological innovation. An excellent overview of the nature of this innovation is provided by Belzer (2002). The examples provided below are drawn from this paper.

Just-in-time services have arisen in response to the demands of lean and flexible manufacturing. An example of this is the use of “milk runs.” This operating technique can be implemented by a motor carrier involved in inbound logistics by organizing relatively small shipments into such milk runs, thus allowing for the sequential scheduling of pickups to maximize efficiency and the adherence to tighter schedules (Belzer, 2002, p. 381).

Legal and regulatory changes have also facilitated the growth in standardized truck sizes and weights across the United States. While the standard truck trailer may be as wide as 102 inches and 57 feet in length, there has been an increasing use of 28-foot double trailers, or "pups", on most Interstate routes as well as other trunk highways. Such a configuration is typically used by LTL carriers, and, in fact, the "triple-pup" is now allowed in many jurisdictions. The use of the 28-foot trailer allows the carrier to load freight for a distant destination and then not have to handle it until the final destination is reached. LTL carriers further exploit this size trailer by loading a "head haul" in the front of the trailer at the original point of pickup and then "topping off" the load with additional freight to the same final destination (Belzer, 2002, p. 386).

LTL carriers also realize enhancements in efficiency by palletizing as much freight as possible. An extension of this logistical arrangement is the double stack pallet configuration. Incentives are provided to shippers to configure their pallets so that they can fit in either the top or bottom portions of the double stack platforms. Thus, labor and time savings are realized in the loading and unloading of trailers (Belzer, 2002, p. 388).

Certainly, computer technology has improved the operating efficiency of motor carriers. Internal computer control modules have improved the mechanical efficiency of truck engines. Electronic On-Board Recorders allow the monitoring of a driver's driving activity. A most interesting innovation being developed in Europe is the virtual "tow-bar" technology that removes the need for a second driver in a two-truck convoy. Effectively then, a single driver could lead a whole convoy of automated trucks. Finally, computer technology has provided much enhanced information management. Motor carriers need to track tractors, trailers, and containers that may be geographically distributed over wide areas. Additionally, customers now demand the ability to continuously track their individual shipments in real time (Belzer, 2002, pp. 389-391).

The present study examines the issue of "fit" - the alignment of operational efficiency with strategic positioning - in the general freight segment of the motor carrier industry for the time period 1999-2003. A five-year window is utilized because of the need to allow time for strategic position choices to impact logistical and technological configurations that impact operational efficiency. Precedence for measuring changes in operating efficiency from one end point of a five-year period to the other can be found in Greer (2008).

To capture the change in overall operating efficiency of a motor carrier, as well as the change in the subcomponents of technical efficiency and technological innovation, the Malmquist Productivity Index, as detailed below in section 2, is utilized. The seminal paper, which applied this methodology to the motor carrier industry, is that by McMullen and Okuyama (2000). That study examined productivity changes in the U. S. motor carrier industry following deregulation. The model found in that study is the one utilized in this paper. Such a methodological approach was also utilized by McMullen (2004) in examining the relationship between the productivity of general freight motor carriers, marketing strategies, and the use of information technology. In that study, this relationship was investigated by regressing productivity, as measured by the Malmquist Productivity Index and its sub-components, against measures of marketing strategies and information technology use by means of a tobit regression. This technique is also utilized in this study.

2. Methodology

2.1 Malmquist Productivity Index

The measurement, over time, of changes in overall productivity and its components of operating efficiency change and technological change are achieved by the use of the Malmquist Productivity Index methodology. The underlying basis for this approach is data envelopment analysis which constructs an efficient production frontier using input-output combinations observed in the actual data. Thus efficiency in any time period is measured as each motor carrier's distance from the production frontier. Utilizing the description found in McMullen and Okuyama (2000), this can be briefly described as follows:

Motor Carriers are assumed to have a production technology, which can be described by $S^t = \{(x^t, y^t) : x^t \textit{ can produce } y^t\}$ which represents all of the possible combinations of input-output vectors for each time period t = 1,…,T. A constant returns to scale technology is assumed and as McMullen and Okuyama (2000) note, this is not inconsistent with previous studies that have parametrically estimated trucking costs both before and after deregulation (see McMullen and Stanley, 1995; Grimm, Corsi, and Jarrel, 1989; McMullen and Tanaka, 1995; Adrangi, Chow, and Raffiee, 1995; and Bruning and Olson, 1982). Additionally, they note that the constant returns to scale assumption is necessary in order to avoid biased productivity measurement.

An output based distance function at time *t* is defined as:

$$D_O^t(x^t, y^t) = \inf[\theta : (x^t, y^t / \theta \in S^t] \qquad (1)$$

This distance function is homogeneous of degree one in outputs and (x^t, y^t) belongs to S^t only if $D_o^t(x^t, y^t)$ is less than or equal to one. The Malmquist Productivity Index methodology, as developed by Caves, Christensen, and Diewert (1982), utilizes mixed time distance functions from both time periods *t* and *t+1* which are defined by:

$$D_O^{t+1}(x^t, y^t) = \inf[\theta : (x^t, y^t / \theta \in S^{t+1}] \qquad (2)$$

$$D_O^{t}(x^{t+1}, y^{t+1}) = \inf[\theta : (x^{t+1}, y^{t+1} / \theta \in S^{t}] \qquad (3)$$

The Malmquist Productivity Index, as written by Fare, Grosskopf, Lindgren and Roos (1992) is a geometric mean utilizing (1) - (3) from above:

$$M_O(x^{t+1}, y^{t+1}, x^t, y^t) = [\frac{D_O^t(x^{t+1}, y^{t+1})}{D_O^t(x^t, y^t)} \frac{D_O^{t+1}(x^{t+1}, y^{t+1})}{D_O^{t+1}(x^t, y^t)}]^{1/2} \qquad (4)$$

Fare, Grosskopf, Lindgren and Roos (1992) show that the Malmquist Productivity Index can be rewritten as:

$$M_O(x^{t+1}, y^{t+1}, x^t, y^t) = \frac{D_O^{t+1}(x^{t+1}, y^{t+1})}{D_O^t(x^t, y^t)} [\frac{D_O^t(x^{t+1}, y^{t+1})}{D_O^{t+1}(x^{t+1}, y^{t+1})} \frac{D_O^t(x^t, y^t)}{D_O^{t+1}(x^t, y^t)}]^{1/2} \qquad (5)$$

The first term measures operating efficiency change of a motor carrier while the square root of the term in brackets measures technological change between the two periods. The operating efficiency change term measures the position of a motor carrier's input-output vector relative to the efficient frontier in period *t+1* as compared to the position of its input-output vector relative to the efficient frontier in period *t*. The technological change term measures the shift of the efficient frontier from period *t* to period *t+1*. The linear programming methodology used to derive the distance functions in (1) - (5) can be found in Grosskopf (1993) who notes that the reciprocal of the distance function for a firm *k* in a single period is:

$$[D_O^t(x^{k',t}, y^{k',t})]^{-1} = \max \theta \qquad (6)$$

subject to

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

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

$$z^{k,t} \geq 0 \qquad k=1,\ldots,K$$

The mixed period distance functions are calculated by means of;

$$[D_O^t(x^{k',t+1}, y^{k',t+1})]^{-1} = \max \theta \qquad (7)$$

subject to

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

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

$$z^{k,t} \geq 0 \qquad k=1,\ldots,K$$

The calculations in equations (6) and (7) are repeated for all firms over all time periods. The Malmquist analysis was performed via the Efficiency Measurement System (EMS), version 1.3 which is authored by Dr. Holger Scheel of the University of Dortmund.

Three input variables and five output variables are utilized in this analysis, as suggested by McMullen and Tanaka (1995) and McMullen and Okuyama (2000). The input variables are labor, fuel, and capital. Labor is defined as the number of employees, capital is the number of trucks and tractors, and fuel is the number of gallons of fuel. Gallons of fuel are calculated based on an average of five miles per gallon and dividing total vehicle miles by this number (see McMullen and Okuyama [2000]).

The primary output variable is revenue ton-miles with a set of attribute output variables defined by average length of haul (ton-miles divided by tons), average load (ton-miles divided by miles), average shipment size (tons divided by the number of shipments), and insurance per ton-mile. McMullen and Tanaka (1995) assert that there is a need to include these output attribute variables because of the heterogeneity of motor carrier output. A similar set of attribute variables is utilized by McMullen (2004). Insurance per ton-mile is used to capture differences in the value of commodities being transported. The notion is that higher valued commodities require more insurance against loss and damage as well as possibly more handling costs.

2.2 Strategy Variables

In his seminal work, Porter (1980) developed the paradigm of three generic strategies for creating a competitive advantage. A firm pursuing a position of cost leadership will emphasize efficiency in order to lower costs thus being able to under-price competitors. The focus of such a strategy is one of low margins and high volume. A firm with a strategic orientation towards differentiation seeks to produce a product or service that embodies distinctive qualities for which customers are willing to pay a premium price. The third strategy is a niche-seeking one. This strategy seeks to identify a small part of the market not served by direct competitors of the firm. The firm is able to charge a premium price for a high quality product desired by this small market segment, that is, volume of sales will be low, but margins high.

Feitler et al., (1997) suggest seven dimensions to capture the strategic orientation of motor carriers that are adopted in this study for the general freight segment. These dimensions reflect a comprehensive consideration of the manifestations of strategic positioning that have been considered in the motor carrier literature. Four of these dimensions directly draw their inspiration from the Porter framework. Smith et al. (1992) captured a carrier’s focus on cost by measuring total operating expenses per mile. Corsi and Grimm (1989) investigated the related dimension of efficiency by examining annual miles per truck. More specifically, this reflects a motor carrier’s intensity of usage of its capital input, or in a general sense, capacity utilization. This variable is akin to a variable utilized by McMullen and Lee (1999) in their investigation of sources of cost efficiency in the U. S. motor carrier industry before and after deregulation. In that study they construct a variable, which is the ratio of standby equipment to operating equipment. They argue that this variable represents how fully a firm is using its equipment. The larger the value of this ratio, the more inputs lie idle and thus the greater the cost inefficiency. A carrier's ability to charge a premium price for trucking services is reflected in the dimension Corsi et al. (1991) measured by total (TL plus LTL) revenues per ton. Scheraga et al. (1994) measure a carrier's LTL niche focus by the percentage of LTL revenue as a percentage of total revenue.

Three additional dimensions have also been discussed in the literature. Scheraga et al. (1994) investigated the impact of a motor carrier's financial mobility on its performance. This dimension captures the amount of risk assumed by a motor carrier in its management of its capital resources. The measure utilized to capture this dimension is the total debt to equity ratio. Smith et al. (1990) and Corsi et al. (1991) measure the service dimension by average employee compensation. They argue that higher paid employees should provide customers with better service. The final dimension of size, reflecting synergies due to economies of scope, as discussed by Child (1974) and Scheraga et al. (1994) is represented by total operating revenues.

An observation must be made with regard to the variable measuring the service dimension, that is, average employee compensation. It might be argued that rather than higher paid employees being motivated to provide customers with better quality service, that such wages are the result of employees working in union firms. The assumption that higher wages are associated with a better level of service follows from previous research (Smith et al. 1990) that demonstrates through factor analysis that this variable was included with other measures in an overall service dimension factor.

As noted above, following the approach utilized by McMullen (2004), the Malmquist Productivity Index and its two sub-components of operating efficiency change and technological change were inserted into a tobit regression and regressed on the seven strategy variables. Values for the strategy variables were the five-year averages over the time period 1999-2003 inclusive. Data for all of the stages of analysis in this study was drawn from the American Trucking Association's (ATA) comprehensive financial and operating statistics for the relevant years. A consistent sample of eighty-three general freight motor carriers was obtained for the time period 1999-2003. Each of these firms had complete data for all of the necessary variables for each year of the time period of this study.

However, there are other behavioral and structural factors that need to be considered. As McMullen and Okuyama (2000) note, there are known differences in the production technology utilized by LTL motor carriers as compared to their TL counterparts. A study by Corsi and Infanger (2004) provides additional characteristics that differentiate the general freight LTL motor carrier sector. Of twelve motor carrier segments profiled, the general freight LTL segment demonstrated the highest average firm size as measured by annual revenues. Additionally, this segment displayed a moderate level for its industry concentration ratio as measured by revenue concentration. Related to this latter observation is that by Feitler et al. (1997) who note that the market structure of the general freight LTL segment has vastly changed during the period of deregulation, that is, the number of general freight LTL motor carriers in the market has significantly declined. Thus, as a motor carrier becomes more focused in the LTL niche, it may find its behavior increasingly influenced by the idiosyncratic firm structure and market conduct that characterizes this segment. These differences, in a broad sense, should be captured by the niche focus variable. However, increases in the value of this niche focus, with concomitant increasing exposure to a different market structure and set of conduct activities, may also influence choices a motor carrier makes with regard to other strategic activities. For example, McMullen and Okuyama (2000) suggest that general freight carriers who expanded into LTL service in the post-deregulation environment may have also pursued a differentiation strategy.

To investigate possible interactions between increases in the niche focus variable and the other strategy variables Pearson correlation coefficients were calculated amongst the seven strategy variables. Correlations that were greater than or equal to 0.5 and also statistically significant were found between the niche strategic variable and the cost, price, and size strategic variables. All of these correlations were positive. The latter correlation is certainly not surprising given the tendency to larger size motor carriers in the general freight LTL segment noted above. In turn, a statistically significant correlation was found between the size strategic variable and price strategic variable. This correlation was incorporated into the tobit regression analysis to capture the impact of firm size, regardless of whether that firm is predominantly a TL or LTL motor carrier, on its pricing strategy. Such a correlation may be capturing differences in the ability of motor carriers to set prices due to differences in firm structure and market power. Thus, the following interaction variables were constructed: Niche *x* Cost, Niche *x* Price, Niche *x* Size, and Size *x* Price. The tobit analysis was performed using the LIFEREG procedure in the SAS (2002) statistical package.

2.3 Measurement of Performance Impact

In the final part of the analysis in this paper, the impact of changes, in operating efficiency, technological innovation, and the overall Malmquist Productivity Index, on motor carriers' operating ratios is investigated. As Feitler et al. (1997) note, the operating ratio (operating expenses divided by operating revenues times 100) is the traditional measure of financial fitness. This impact was empirically examined using the Tukey-Kramer method (Tukey 1953, Kramer 1956). In this case, testing differences in the means was complicated by the fact that each of the sub-samples was of unequal size. The original Tukey test (1952) was designed specifically for pair wise comparisons based on the studentized range ratio (see formula below) and controls the maximum experiment-wise error rate (MEER) when the sample sizes are equal. The sample sizes in this study were not equal and, therefore, the unequal cell sizes required that an extension of the test proposed by Tukey (1952, 1953) be used. Tukey (1953) and Kramer (1956) independently proposed a modification for unequal cell sizes and it is the Tukey-Kramer method that was used in this study. Hayter (1984) provided proof that the Tukey-Kramer procedure controls the MEER and it has also fared well in Monte Carlo studies (Dunnett 1980).

Specifically, for two groups y_i and y_j, with n_i *and* n_j observations in each group respectively and s being the root mean square error based on v degrees of freedom, their means $\overline{y_i}$ and $\overline{y_j}$ are considered significantly different by the Tukey-Kramer criterion if:

$$|\overline{y}_i - \overline{y}_j| / s\sqrt{(1/n_i + 1/n_j)/2} \geq q(\alpha;\kappa,\nu) \qquad (8)$$

where $q(\alpha;\kappa,\nu)$ is the α-level critical value of a studentized range distribution of κ independent normal random variables with ν degrees of freedom. The software utilized is the GLM (General Linear Model) procedure in the SAS (2002) statistical package, which calculates significance for the Tukey-Kramer statistic at the 5% level.

3. Results

Table 1 presents the Malmquist analysis for the eighty-three general freight motor carriers. Forty-nine firms demonstrated an improvement (OEFFCH > 1) in operating efficiency; twenty-seven demonstrated a decline (OEFFCH < 1) in operating efficiency; and seven remained stationary (OEFFCH = 1) with regard to their relative operating efficiency. Twenty-five firms demonstrated an improvement (TECHCH > 1) in relative efficiency due to technological innovation; fifty-three demonstrated a decline (TECHCH < 1) in relative efficiency due to technological regression; and five firms remained stationary (TECHCH = 1) with neither technological innovation or regression. Finally, forty-two firms demonstrated an improvement in the Malmquist Productivity Index (> 1); thirty-six demonstrated a decline (< 1); with five firms displaying no change over the time period.

Table 2 presents the mean values (with minimum and maximum value) for the seven strategic activity variables utilized in the set of tobit regressions. The results of these regressions are presented in tables 3 - 5. Table 3 shows that five statistically significant relationships were found with regard to changes in operating efficiency. In the sample utilized in the study here, as a general freight motor carrier increased its focus on the LTL market niche, it increased its improvement in operating efficiency. An inverse relationship was observed between the strategic focus on firm size growth and changes in operating efficiency. Three interaction variables (in conjunction with the correlation calculations noted above) reveal additional relationships. As general freight motor carriers increased their focus on the LTL market niche, they tended to increase their focus on a premium pricing strategy as well as a focus on firm size growth. Both of these had a negative change impact on operating efficiency. Finally, general freight motor carriers, both TL and LTL, who had a strategic focus on firm size growth also tended to pursue a premium pricing strategy. This had a positive impact on operating efficiency.

Table 4 shows that seven statistically significant relationships were found with regard to technological change. General freight motor carriers pursuing a strategic focus of efficiency or firm size growth demonstrated positive technological change. At the same time, those firms that pursued a premium pricing or a LTL market niche strategic focus displayed technological regression. Again, three interaction variables revealed additional relationships. As above, as general freight motor carriers increased their strategic focus on the LTL market niche, they tended to increase their strategic focus on a premium pricing strategy as well as a strategic focus on firm size growth. However, in the case of technological change, both of these had a positive impact. Finally, also as above, general freight motor carriers, both TL and LTL, who had a strategic focus on firm size growth also tended to pursue a premium pricing strategy. Unlike the case of operating efficiency, this strategic posture had a negative impact on technological change.

Table 5 indicates that four statistically significant relationships were found with regard to the overall Malmquist Productivity Index. General freight motor carriers that pursued a focus on the LTL market niche demonstrated an improvement in the index while those pursuing a focus on firm size growth exhibited degradation in the index. Finally, there were two statistically significant interaction variables. Firms, both TL and LTL, who had a strategic focus on firm size growth and tended to pursue a premium pricing strategy showed an improvement in the index. Conversely, those firms who pursued a strategic focus on the LTL market niche and a focus on firm size growth displayed a negative impact on the index.

Table 6 presents the results of the Tukey-Kramer analysis that examines the impact of changes in the Malmquist Productivity Index and its sub-components on the operating ratio. While changes in the overall index had no statistically significant impact on the operating ratio, general freight carriers, that were characterized by an operating efficiency change and technological change that was greater than or equal to one, exhibited a statistically significant better operating ratio.

4. Discussion and Conclusions

As noted above, general freight motor carriers who pursued a strategic focus on the LTL market niche showed an improvement in operating efficiency. This may be a reflection of a phenomenon described by McMullen and Lee (1999) whereby motor carriers with more extensive network systems are able to increase route density and thus reduce costs. The networks of LTL firms tend to be larger and more complex in order to accommodate, for example, integrated systems of load consolidation facilities. However, Bruning (1992) notes that overinvestment in network components such as terminal facilities may lead to cost inefficiencies. This may be what is being captured by the interaction term Niche *x* Size which had a negative relationship with changes in operating efficiency. McMullen and Lee (1999) also suggest that larger motor carriers (TL and LTL) may achieve scale economies in managing labor. However, too much growth in size may result in managerial diseconomies of scale. This latter possibility is suggested by the negative relationship between the strategic focus of firm size growth and changes in operating efficiency. At the same time, the interaction term Price *x* Size, which reflects the tendency of motor carriers to pursue a strategic focus on premium pricing as well as that of firm size growth, exhibited a positive relationship with changes in operating efficiency. If premium pricing is a reflection of a differentiation strategy then what may be occurring here is consistent with what Corsi et al. (1991) observed in that firms that pursued a differentiation strategy were more successful in the post-deregulation period. At the same time, this relationship does not hold (as evidenced by the negative relationship between the interaction term Niche *x* Price) for firms pursuing a strategic focus on the LTL market niche and one focused on premium pricing. As McMullen and Lee (1999) suggest, LTL motor carriers providing higher quality and more frequent service may experience higher unit costs. A premium pricing focus may be a reflection, to some extent, of such an orientation with the concomitant negative impact on operating efficiency.

Unlike the case of operating efficiency, general freight motor carriers that increased their strategic focus on the LTL market niche and tended to increase their strategic focus on either a premium pricing strategy or one of firm size growth, displayed positive technological change. This is consistent with the observations of Crum et al. (1996, 1998). From the results of surveys that they conducted, they report that LTL and large carriers in particular, perceive larger favorable impacts of electronic data interchange (EDI) than their TL and small carrier counterparts. LTL firms also reported a higher level of satisfaction with EDI on the part of customers, the firm itself, top management and employees than TL firms. The fact that there was a positive relationship between the interaction variable Niche *x* Size and technological change while motor carriers simply pursuing a strategic focus of a LTL market niche demonstrated technological regression suggests that there may be a size threshold in the realization of the benefits from EDI as noted above. This is reinforced somewhat by the fact that general freight motor carriers (TL and LTL) that pursued a strategic focus of growth in firm size exhibited positive technological change. Crum et al. also note that EDI adoption seems to be very much customer driven. Customer service reflecting a diiferentiation strategy may be what is being captured by the positive impact of the interaction variable Niche *x* Price. Again, the existence of a size threshold is suggested by the fact that firms simply pursuing a strategic focus of premium pricing exhibited technological regression. Finally, firms pursuing a strategic focus of efficiency (capacity utilization) demonstrated positive technological change. This is consistent with work done by Hubbard that demonstrates that loaded miles per period are higher among trucks with advanced on-board computers. Additionally, he notes that on-board computers have increased capacity utilization by improving dispatchers' ability to make and implement better resource allocation decisions.

This study has demonstrated that there seems to be a significant relationship between a general freight motor carrier's choice of strategic focus or foci and its ability to pursue both operating efficiency and technological change. The Malmquist Productivity Index methodology enables the researcher to investigate both of these two elements of firm efficiency. This is an enhancement to previous studies in the transportation literature that utilized data envelopment analysis to investigate the impact of strategic positioning choices on firm efficiency in that the latter traditional methodology does not differentiate between a motor carrier's movement to the efficient production frontier and its change in technology.

The fact that the relationship between a firm's choice of strategic orientation and its ability to pursue operating efficiency and technological change is not always a positive one suggests that Porter's (1996) concept of *fit* is an aspiration not easily achieved. The ability to achieve such fit not only has efficiency implications but financial performance ones as well. Firms, in this study, that achieved improvement in operating efficiency or technological change experienced statistically significant better values for their operating ratio - a traditional measure of financial fitness in the motor carrier industry. Equally important, as Porter (1996) notes, strategic *fit* is fundamental to the sustainability of competitive advantage. While competitors may benchmark and imitate individual activities, it is far more difficult for them to replicate whole systems of activities.

Table 1
Malmquist Analysis

	GENERAL FREIGHT MOTOR CARRIER	OEFFCH	TECHCH	MALMQUIST
1	7 HILLS TRANSPORT INC	1.7099	0.5812	0.9939
2	A & B FREIGHT LINE INC	5.3477	0.5808	3.1061
3	AAA COOPER TRANSPORTATION	0.9110	0.9422	0.8584
4	ABF FREIGHT SYSTEM INC	0.8833	1.0334	0.9128
5	ADAMS MOTOR EXPRESS INC	1.1466	0.7037	0.8069
6	ALTON BEAN TRUCKING INC	1.0312	0.6814	0.7027
7	APACHE TRUCK LINES INC	1.4400	0.7504	1.0807
8	ARMELLINI EXPRESS LINES INC	1.1813	0.6423	0.7588
9	BIGBEE TRANSPORTATION INC	1.9649	0.7712	1.5154
10	BOBS TRANSPORT & STORAGE CO INC	0.6496	0.9862	0.6407
11	BOWLUS TRUCKING CO INC	1.0973	0.7638	0.8381
12	BUSKE LINES INC	1.1163	1.0995	1.2273
13	CARGO TRANSPORTERS INC	0.8989	1.2880	1.1578
14	CARLISE CARRIER CORP	1.0439	1.0290	1.0741
15	CENTRAL VIRGINIA TRUCKING COMPANY INC	1.0210	0.9072	0.9263
16	CONCEPT FREIGHT SERVICE INC	0.9666	0.8273	0.7996
17	CONTRACT TRANSPORTATION SYSTEMS CO	0.7060	1.2887	0.9098
18	COX TRANSPORTATION SERVICES INC	1.9452	0.6706	1.3045
19	CRESSLER TRUCKING INC	1.1181	1.0801	1.2076
20	CRETE CARRIER CORP	0.6629	1.2341	0.8180
21	D O N INVESTMENTS INC	0.2790	0.9073	0.2531
22	DAKOTA CARTAGE CO INC	2.0536	0.6230	1.2795
23	DAVIS CARTAGE CO	3.2740	0.6734	2.2047
24	ERDNER BROS INC	1.5647	0.8681	1.3584
25	ESTES EXPRESS LINES	0.7493	1.1575	0.8673
26	FUCHS INC	1.2240	0.8791	1.0759
27	G & H MOTOR FREIGHT LINES INC	1.2063	0.8439	1.0180
28	GAINES MOTOR LINES INC	0.4222	0.6302	0.2660
29	GARNER TRUCKING INC	1.5367	0.7963	1.2236
30	GENCOM INC	1.6844	0.6807	1.1466
31	GOEMAN'S TRUCKING LTD	1.0000	1.0000	1.0000
32	HESS TRUCKING CO	2.8959	0.6732	1.9494
33	HO HO HO EXPRESS INC	1.0335	0.7847	0.8110
34	HOLIDAY EXPRESS CORP	1.0059	0.7849	0.7895
35	HOUFF TRANSFER INC	1.1599	0.9495	1.1014
36	HYWAY TRUCKING COMPANY	1.3311	1.0829	1.4415
37	ITA INC	1.0000	1.0000	1.0000
38	J B HUNT TRANSPORT INC	0.7720	1.3052	1.0076
39	J D S REFRIGERATED TRANSPORTATION INC	2.3201	0.5332	1.2372
40	JAT OF FORT WAYNE INC	0.6994	0.8384	0.5864
41	JEVIC TRANSPORTATION INC	0.8558	1.1192	0.9577
42	K & K TRUCKING INC	1.0907	0.7011	0.7647
43	K C TRANSPORTATION INC	0.7817	1.1677	0.9128

Table 1 Continued
Malmquist Analysis

	GENERAL FREIGHT MOTOR CARRIER	OEFFCH	TECHCH	MALMQUIST
44	KANE FREIGHT LINES INC	1.0793	1.1216	1.2105
45	KEE TRANS INC	1.1264	1.1008	1.2399
46	KINARD TRUCKING INC	4.9247	1.0750	5.2939
47	L & H TRUCKING INC	1.2106	0.8447	1.0226
48	LAND SPAN INC	1.1611	1.1340	1.3167
49	LIEDTKA TRUCKING INC	1.3287	0.8065	1.0716
50	M & C TRUCKING CO	1.8568	0.8716	1.6185
51	MAGNUM LTD	0.9787	1.1523	1.1278
52	MERCER TRANSPORTATION CO INC	1.0000	1.0785	1.0785
53	MID-SOUTH EXPRESS DELIVERY INC	1.0000	1.0000	1.0000
54	MILLER BROTHERS EXPRESS LC	1.1033	0.8792	0.9700
55	MOTOR WEST INC	1.4243	0.7052	1.0045
56	NEALON TRANSPORTATION INC	1.3435	0.7446	1.0003
57	NEW PENN MOTOR EXPRESS INC	0.8409	0.7467	0.6279
58	NUSSBAUM TRUCKING INC	2.2713	0.8418	1.9119
59	OLD DOMINION FREIGHT LINE INC	1.0073	0.9806	0.9878
60	OPIES TRANSPORT INC	2.7887	0.9571	2.6689
61	ORMSBY TRUCKING INC	0.7446	0.8361	0.6226
62	OSBORN TRANSPORTATION INC	0.9839	0.8853	0.8711
63	POHL TRANSPORTATION INC	1.3923	0.9877	1.3752
64	RAWHIDE TRUCKING INC	1.0000	1.0000	1.0000
65	READY TRUCKING INC	0.2405	0.9762	0.2348
66	RICHARD BELLERUD TRUCKING INC	1.0000	1.0000	1.0000
67	RISINGER BROS TRANSFER	0.2896	1.1217	0.3248
68	ROADWAY EXPRESS INC	1.0469	0.8855	0.9271
69	ROLLOUT EXPRESS INC	1.0000	1.0155	1.0155
70	SAIA MOTOR FREIGHT LINE INC	0.6725	0.8332	0.5603
71	SERVICE TRUCKING INC	1.1837	0.9222	1.0916
72	SMF INC	0.9834	0.7997	0.7864
73	SOUTHWESTERN MOTOR TRANSPORT INC	0.9377	1.1200	1.0502
74	STAHLY CARTAGE CO	1.8219	0.9065	1.6516
75	SUPERVAN SERVICE CO INC	4.2721	0.7058	3.0151
76	TERESI TRUCKING INC	1.1720	0.7212	0.8453
77	TRANSUS INTERMODAL LLC	1.0022	1.1283	1.1307
78	TRIANGLE TRUCKING INC	1.7231	0.6259	1.0786
79	TRUCK SERVICE INC	1.3050	0.7552	0.9855
80	VAN EERDEN TRUCKING COMPANY INC	0.8915	0.9190	0.8193
81	WALLER TRUCK CO INC	0.9173	1.1365	1.0425
82	WILSON TRUCKING CORPORATION	0.1158	1.0188	0.1180
83	YELLOW TRANSPORTATION, INC.	0.9525	1.0114	0.9633

Table 2
Mean Values - Motor Carrier Strategies

Strategy	Mean	Minimum	Maximum
Cost **(Total operating expenses per mile)**	1.9033	0.5174	8.7095
Efficiency **(Annual miles per truck)**	114,934.80	11,845.92	692,469.64
Price **(Total revenues per ton)**	78.1019	8.3271	372.83
Niche **(Percentage of LTL revenue as a percentage of total revenue)**	0.1847	0.00	1.00
Risk **(Total debt to equity ratio)**	2.2759	0.1066	17.9817
Service **(Average employee compensation)**	48,904.68	21,260.61	105,787.84
Size **(Total operating revenues)**	162,061,601	3,844,913.60	2,756,107,248

Table 3
Impact of Strategic Choices on Operating Efficiency Change
Tobit Regression

Variable	Estimate	Std. Error	Chi-Square	Pr > Chi Sq.
Intercept	1.5544	0.4265	**13.2805**	**0.0003**
Cost	-0.1063	0.0884	1.4478	0.2289
Efficiency	-1.1248×10^{-6}	9.8391×10^{-7}	1.3068	0.2530
Price	-0.0006	0.0020	0.1091	0.7412
Risk	-0.0284	0.0284	1.0004	0.3172
Niche	3.5681	1.1403	**9.7908**	**0.0018**
Service	8.2863×10^{-7}	6.6786×10^{-6}	0.0154	0.9013
Size	-1.3716×10^{-9}	4.2885×10^{-10}	**10.2147**	**0.0014**
Cost x Niche	-0.0034	0.3158	0.0001	0.9913
Price x Niche	-0.0136	0.0048	**7.9965**	**0.0047**
Price x Size	1.7342×10^{-11}	4.5892×10^{-12}	**14.2809**	**0.0002**
Niche x Size	-4.6449×10^{-9}	1.5852×10^{-9}	**8.5852**	**0.0034**

Table 4
Impact of Strategic Choices on Technological Change
Tobit Regression

Variable	Estimate	Std. Error	Chi-Square	Pr > Chi Sq.
Intercept	0.7866	0.0886	**78.8759**	**<0.0001**
Cost	0.0196	0.0183	1.1414	0.2854
Efficiency	3.6869×10^{-7}	2.0429×10^{-7}	**3.2569**	**0.0711**
Price	-0.0010	0.0004	**5.5722**	**0.0182**
Risk	-0.0005	0.0059	0.0067	0.9350
Niche	-0.4590	0.2368	**3.7582**	**0.0526**
Service	2.1638×10^{-6}	1.3867×10^{-6}	2.4349	0.1187
Size	4.1076×10^{-10}	8.9045×10^{-11}	**21.2791**	**<0.0001**
Cost x Niche	-0.0269	0.0656	0.1679	0.6820
Price x Niche	0.0027	0.0010	**7.2032**	**0.0073**
Price x Size	-2.9420×10^{-12}	9.5287×10^{-13}	**9.5334**	**0.0020**
Niche x Size	6.5245×10^{-10}	3.2916×10^{-10}	**3.9290**	**0.0475**

Table 5
Impact of Strategic Choices on Malmquist Index
Tobit Regression

Variable	Estimate	Std. Error	Chi-Square	Pr > Chi Sq.
Intercept	1.2591	0.3709	**11.5245**	**0.0007**
Cost	-0.0712	0.0768	0.8592	0.3540
Efficiency	-4.5090×10^{-7}	8.5553×10^{-7}	0.2778	0.5982
Price	-0.0019	0.0017	1.2260	0.2682
Risk	-0.0249	0.0247	1.0180	0.3130
Niche	1.8331	0.9915	**3.4178**	**0.0645**
Service	3.0915×10^{-6}	5.8072×10^{-6}	0.2834	0.5945
Size	-6.2500×10^{-10}	3.7289×10^{-10}	**2.8092**	**0.0937**
Cost x Niche	-0.0840	0.2746	0.0936	0.7596
Price x Niche	-0.0050	0.0042	1.4139	0.2344
Price x Size	8.8151×10^{-12}	3.9903×10^{-12}	**4.8801**	**0.0272**
Niche x Size	-2.4188×10^{-9}	1.3784×10^{-9}	**3.0791**	**0.0793**

Table 6
Tukey-Kramer Test of Differences - Operating Ratio

	Operating Ratio
Efficiency Change < 1 (N=27)	98.57 **
Efficiency Change ≥ 1 (N=56)	96.58 **
Technological Change < 1 (N=53)	98.48 **
Technological Change ≥ 1 (N=30)	96.08 **
Malmquist Index < 1 (N=36)	98.32
Malmquist ≥ 1 (N=47)	97.02

** : Statistically significant at 5% level

Bibliography

Adrangi, B., Chow, G., Raffiee, K., 1995. Analysis of the Deregulation of the U. S. Trucking Industry: A Profit Function Approach. Journal of Transport Economics and Policy 29 (3), 233-245.

American Trucking Associations Inc., 1999-2003. Motor Carrier Annual Reports, Alexandria, VA.

Banker, R., Johnston, H., 1994. Evaluating the Impacts of Operating Strategies on Efficiency in the U. S. Airline Industry. In: Charnes, A., Cooper, W., Lewin, A., Seiford, L., (Eds), Data Envelopment Analysis: Theory, Methodology, and Application, Kluwer Academic Publishers, Boston, Dordrecht, and London, pp. 97-128.

Belzer, M., 2002. Technological Innovation and the Trucking Industry: Information Revolution and the Effect on the Work Process. Journal of Labor Research 23 (3), 375-395.

Bruning, E., Olson, R., 1982. The Use of Efficiency Indexes in testing for Scale Economies in the Motor Carrier Industry. Journal of Transport Economics and Policy 16 (3), 277-293.

Bruning, E., 1992. Cost Efficiency Measurement in the Trucking Industry: An Application of the Stochastic Frontier Approach. International Journal of Transport Economics 19 (2), 165-186.

Caves, D. Christensen, L., Diewert, W., 1982. The Economic Theory of Index Numbers and the Measurement of Input, Output, and Productivity. Econometrica 50 (6), 1393-1414.

Chan, P., Sueyoshi, T., 1991, Environmental Change, Competition, Strategy, Structure and Firm Performance: An Application of Data Envelopment Analysis in the Airline Industry. International Journal of Systems Science 22 (9), 1625-1636.

Child, J., 1974. Managerial and Organizational Factors Associated with Company Performance. Part 1. Journal of Management Studies 11 (3), 175-218.

Corsi, T. Grimm, C., 1989. Strategies and Performance in the Truckload General Freight Segment Before and After Deregulation. Journal of the Transportation Research Forum 30 (1), 84-91.

Corsi, T., Grimm, C., Smith, K., Smith, R., 1991. Deregulation, Strategic Change, and Firm Performance among LTL Motor Carriers. Transportation Journal 31 (1), 4-13.

Corsi, T., Infanger, G., 2004. Motor Carrier Industry Profile Study: Financial and Operating Performance Profiles by Industry Segment, 2001-2002. FMCSA-RI-04-026, Analysis Division, Office of Information Management, Federal Motor Carrier Safety Administration, September.

Crum, M., Premkumar, G., Ramamurthy, K., 1996. An Assessment of Motor Carrier Adoption, Use, and Satisfaction. Transportation Journal 35 (4), 44-57.

Crum, M., Johnson, D., Allen, B., 1998. A Longitudinal Assessment of EDI Use in the U. S. Motor Carrier Industry. Transportation Journal 38 (1), 15-28.

Dunnett, C., 1980. Pairwise Multiple Comparisons in the Homogeneous Variance, Unequal Sample Size Case. Journal of the American Statistical Association 75 (372), 789-795.

Fare, R., Grosskopf, S., Lindgren, B., Roos, P., 1992. Productivity Developments in Swedish Pharmacies 1980-1989: A Non-Parametric Malmquist Approach. Journal of Productivity Analysis 3 (1-2), 81-97.

Feitler, J., T. Corsi, Grimm, C., 1997. Measuring Firm Strategic Change in the Regulated and Deregulated Motor Carrier Industry: An 18-Year Evaluation. Transportation Research Series E 33 (3), 159-169.

Greer, M., 2008. Nothing Focuses the Mind on Productivity Quite Like the Fear of Liquidation: Changes in Airline Productivity in the United States, 2000-2004. Transportation Research Part A 42 (2), 414-426.

Grimm, C., Corsi, T., Jarrell, J., 1989. U. S. Motor Carrier Cost Structure under Deregulation. Logistics and Transportation Review 25 (3), 231-249.

Grosskopf, S., 1993. Efficiency and Productivity. In: Fried, H., Lovell, C., Schmidt, S. (Eds), The Measurement of Productive Efficiency: Techniques and Applications, Oxford University Press, New York and Oxford, pp.160-194.

Hayter, A., 1984. A Proof of the Conjecture that the Tukey-Kramer Method is Conservative. The Annals of Statistics 12 (1), 61-75.

Hubbard, T., 2003. Information, Decisions, and Productivity: On-Board Computers and Capacity Utilization in Trucking. American Economic Review 93 (4), 1328-1353.

Kramer, C., 1956. Extension of Multiple Range Tests to Group Means with Unequal Numbers of Replications. Biometrics 12 (3), 307-310.

McMullen, B., Stanley, L., 1988. The Impact of Deregulation on the Production Structure of the Motor Carrier Industry. Economic Inquiry 26 (2), 299-316.

McMullen, B., Tanaka, H., An Econometric Analysis of Differences between Motor Carriers: Implications for Market Structure. Quarterly Journal of Business and Economics 34 (4), 16-28.

McMullen, B., Lee, M., 1999. Cost Efficiency in the U.S. Motor Carrier Industry Before and After Deregulation. Journal of Transport Economics and Policy 33 (part 3), 303-318.

McMullen, B., Okuyama, K., 2000. Productivity Changes in the U.S. Motor Carrier Industry Following Deregulation: A Malmquist Index Approach. International Journal of Transport Economics 27 (3), 335-354.

McMullen, B., 2004. The Impact of Information Technology on Motor Carrier Productivity. Journal of the Transportation research Forum 43 (2), 7-23.

Porter, M., 1996. What is Strategy? Harvard Business Review November-December, 61-78.

SAS Institute, Inc., 2002. SAS/STAT User's Guide, Version 8, Cary, North Carolina.

Schefczyk, M., 1993. Operational Performance of Airlines: An Extension of Traditional Performance Paradigms. Strategic Management Journal 14 (4), 301-317.

Scheraga, C., Haslem, J., Corsi, T., 1994. The Financial Mobility of Motor Carriers: Pre- and Post-Deregulation. Transportation Research Series A 28 (5), 410-414.

Scheraga, C. 2004a. Operating Efficiency versus Financial Mobility in the Global Airline Industry: A Data Envelopment and Tobit Analysis. Transportation Research Part A 38 (5), 383-404.

Scheraga, C., 2004b. The Relationship between Operational Efficiency and Customer Service: A Global Study of Thirty-Eight Large International Airlines. Transportation Journal 43 (3), 48-58.

Smith, K., T. Corsi, Grimm, C., 1990. Motor Carrier Strategies and Performance. Transportation Research Series A 24 (3), 201-210.

Smith, R., T. Corsi, C. Grimm, Smith, K., 1992. The Effects of LTL Motor Carrier Size on Strategy and Performance. Logistics and Transportation Review 28 (2), 129-146.

Tukey, J., 1952. Allowances for Various Types of error Rates. Unpublished IMS Address, Chicago, Illinois.

Tukey, J., 1953. The Problem of Multiple Comparisons. Unpublished Manuscript.