An Efficiency Assessment of Refrigerated-Food-Products Trucking Carriers in the United States

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Technical efficiency is a very important concept to analyze because it is generally considered a prerequisite to economic efficiency. Therefore, evaluating the technical efficiency of an industry such as refrigerated-food-products trucking carriers is vital to the economic survival, success, and efficiency of the entire agribusiness transportation system that carries the inputs needed for the operation and expansion of agribusiness firms and the agricultural output of food and fiber products demanded by consumers and end users at reasonable prices. The general objective of this study is to estimate the technical efficiency of refrigerated-solids carriers in the United States using secondary data. These carriers haul refrigerated food products on a for-hire basis.

Efficient transportation firms have lower transportation costs and consequently offer lower transportation rates to shippers, enabling managers and owners of agribusiness firms to offer lower consumer prices or expand markets. The money saved by the managers due to the lower transportation rates can be passed directly on to the customers of these agribusiness firms in the form of lower prices or spent on trucking carriers to maintain or enhance their abilities to haul the agribusiness agricultural and food products to more distant markets (Stephenson 1987). Consequently, agribusiness trucking carriers not only play a vital role in agribusiness firms' decision-making processes, but they also satisfy consumers wants and needs by supplying them with a wide variety of consumer goods at reasonable prices.

Efficiency can be estimated as primal or dual-measure through production function, cost minimization or revenue/profit maximization by one of two alternative approaches: the stochastic frontier approach or the nonparametric linear-programming approach. In this paper the parametric efficiency measures are estimated using the stochastic frontier approach on a national and commodity basis.

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Research on the methodology, measurement, source, and cause of efficiency measures has been the subject of analyses since the introduction of stochastic frontier analysis in 1977. The use of efficiency as a measure of progress has caught the attention of individual firms, industry, and policy makers alike. One of the most targeted areas of research seems to address various modes of transportation and segments of the transportation industry. Within transportation, the focus was mainly on railroad cargo transportation, public-passenger transportation, and the airline industry. However, for-hire cargo agribusiness trucking firms that haul food products have seldom been examined. This study estimates the efficiency measures of cargo agribusiness trucking firms and examines the efficiency measures by commodity.

Methods and Data

Following Battese and Coelli (1992), the panel stochastic frontier production function for panel data with firm and time-variant model can be represented as

(1) $Y_{it} = x_{it}\beta + (V_{it} - U_{it})$, i=1,…., N, t=1,…., T,

where Y_{it} is (the logarithm of) the production of the i-th firm in the t-th time period, X_{it} is a kx1 vector of input quantities, V_{it} are random variables which are assumed to be iid N $(0, \sigma^2)$, and U_{it}= are non-negative random variables which are assumed to account for technical inefficiency in production and are assumed to be iid as truncations of zero of the N (μ, σ^2) distribution.

Comprehensive literature reviews (Forsund, Lovell, and Schmidt 1980; Schmidt 1986; Bauer 1990; Greene 1993; and Kumbhakar and Lovell 2000) on the use of stochastic frontier analysis have been evolving since it was first proposed by Aigner, Lovell, and Schmidt; Meeusen and van den Broeck; and Battese and Corra in 1977. The past decade has witnessed a surge in the extension of the parametric techniques to efficiency measurement. Furthermore, within the primal framework, progress has been made on the ability to handle multiple outputs and inputs via the distance functions, adjusting for time-series properties, incorporating autocorrelation and heteroskedasticity, and the use of Bayesian techniques in the parametric-efficiency measures.

The variables used to satisfy the objective of this paper are obtained from *TTS Blue Book of Trucking Companies* for the years 1999–2002. The data for the input variables was divided into labor, capital, operating variable costs, and operating fixed costs. The labor variables include the number of drivers and helpers; the number of cargo handlers; the number of officers, supervisors, clerical and administrative staff; and the total number of other laborers. Capital variables include the number of tractors owned, the number of trucks owned, the number of tractors leased, the number of trucks leased, and other equipment.

Operating variable costs include fuel, oil, and lubricants, and total maintenance. The operating fixed-cost category is composed of total operating taxes and licenses, total insurance, and depreciation and amortization. The output variable consists of total ton-miles, which is the measurement most commonly used according to Cantos, Pastor, and Serrano (1999), because this demand-related measure of output allows an assessment of the level of user consumption and the value they place on the service. This ton-mile output measurement assumes little or no government control on the provision of the service; otherwise, measures that isolate the government regulatory measures like truck-miles, which represent the degree of capacity or service level supplied by the trucking company, are more suitable for this type of analysis (Cantos, Pastor, and Serrano 2000).

Summary statistics for the U. S. trucking companies by commodity groups are shown in Table 1. Due to space limitations only the mean statistics are presented in the table. Mean statistics indicate that agribusiness trucking carriers had a mean output value of 15.31. The mean value of the agricultural-commodity sector indicates these carriers ranked thirteen in terms of ton-miles; armored-truck-service carriers had the lowest mean value. The carriers that had the highest mean value for the output component were the bulk chemical carriers, with a mean value of 16.565. The mean value of labor, 3.9, indicates that the agricultural-commodity group had the third-lowest mean value among the U.S. trucking carriers. This value implies that the carriers in this category had the smallest number of employees during the study period.

Mean values of capital indicate that agricultural-commodity carriers ranked 22nd for ownership or lease of vehicular equipment among the carrier groups shown in Table 1. These carriers as a group had a mean value of 3.86. This value implies that the carriers in this group did not invest heavily in the ownership or leasing of vehicular equipment to service its customers, while most of the other carriers did.

The agricultural commodity carriers had the14th-lowest operating variable costs in the United States in 2001. This value implies that this group did a fair job of keeping its operating variable costs as low as possible to serve their customers more efficiently than many of the carrier groups in the United States during the study period. The agricultural commodity carriers also had the 20th-lowest operating fixed cost among the carrier groups in the United States in 2001, 10.75, implying that the carrier group was able to keep items such as insurance expenses as low as possible to provide competitive services to their customers.

Results

To examine the efficiency of the agribusiness trucking firms by commodity, two sets of results representing cross-section and panel models are estimated using Equation (1). The first set of results presented in Table 2 refers to cross-sectional efficiency measures of the firms by each individual year, while the second set of results in Table 3 are restricted to only those firms with four consecutive years of data. Furthermore, the efficiency measures are estimated using a panel framework. Results of the time-series and panel-model efficiency measures are presented in Table 2 and Table 3, respectively. Table 2 shows the technical-efficiency measures for 1283, 1949, 1935, and 1654 trucking companies for the years 1999, 2000, 2001, and 2002, respectively. Table 2 also shows the means and standard deviations of efficiency measures by type of commodity carrier for 1999–2002. Overall, mean values of the efficiency measures show that the carrier groups were highly technically inefficient in the study period. For example, mean values ranged from a high of 0.455 for 2000 to a low of 0.402 for 2002.

Table 1. Means of Variables Used in the Analysis, 1999–2002.

Name	Freq	Output	Labor	Capital	Operating variable cost	Operating fixed cost
Gen. freight, LTL	643	14.59	5.4	4.87	11.25	11.27
Gen. freight, TL	2825	15.57	4.39	4.29	11.28	11.08
Heavy machinery	191	15.32	4.28	4.26	11.19	11.32
Petroleum products (tank truck)	530	15.4	4.52	4.41	11.1	11.04
Refrigerated liquids (tank truck)	77	15.46	4.32	4.07	11.13	10.92
Refrigerated solids	588	15.64	4.3	4.21	11.25	10.97
Dump trucking	227	15.24	3.86	4	10.97	10.86
Agricultural commodities	224	15.31	3.9	3.86	11.01	10.75
Motor vehicles	84	15.16	4.86	4.64	11.28	11.5
Armored truck service	10	11.67	6.12	5.13	11.3	11.69
Building materials	451	15.58	4.06	4.1	11.1	10.97
Film & associated commodities	4	13.9	3.65	3.29	10.16	9.65
Forest products	69	15.05	4.08	3.76	11.13	10.92
Mine ores (not including coal)	2	14.95	4.4	4.03	10.87	10.39
Retail store delivery service	70	14.77	4.53	4.09	10.87	10.82
Dangerous or hazardous products	22	15.33	4.79	4.88	10.88	10.95
Not elsewhere classified (NEC)	442	15	4.26	4.2	10.69	10.77
Household goods carrier	113	13.3	5.04	4.52	10.32	10.97
Bulk chemical	78	16.39	4.31	4.3	12.06	11.95
General freight, local cartage	30	13.76	4.58	4.24	11.47	11.42
General freight, parcel	39	13.91	4.91	4.52	11.26	11.2
General freight, container	102	15.49	3.96	4.31	10.61	10.98

These results imply that the technical efficiency of the carriers as a whole is very low and the carriers as a group should increase the use of their inputs to improve the technical efficiency of the industry.

These results suggest that the firms are not providing their customers with technically efficient service. These results, in turn, could lead to economically inefficient service to carrier customers who might have to pay higher prices.

Table 3 shows the panel model results for the period 1999–2002. The overall mean values for the 12 carrier groups included in this analysis ranged from a high of 0.510 in 1999 to a low of 0.489 in 2002. These results imply that the technical efficiency of the carriers that stayed in the markets over the four-year study period steadily declined.

As a result, the carriers need to rearrange their input mix to improve their productivity so that they can become much more competitive in their respective shipper markets. Efficiency measures show that the refrigerated-solids group ranked fifth among the 12 carrier groups in the United States for 1999–2002. The mean values of the efficiency measure for the refrigerated solids group ranged from a high of 0.599 in 1999 to a low of 0.561 in the years 2000–2002. Although the refrigerated-solids carriers were not the least technically efficient group, these results do suggest that refrigerated-solids carriers as a whole do have an excellent opportunity for enhancing service by better using resources to improve the competitiveness of the transportation services provided to shippers in the refrigerated-solids market for the foreseeable future.

Information and data in Table 3 also show the summary ranking of truck carriers for the panel data set. Results reveal that the agricultural-commodities

Table 2. Means and Standard Deviations of Efficiency Measures by Years.

Com-mcode	Name	1999			2000			2001			2002		
		Freq	Mean	Std	Freq	Mean	Std	Freq	Mean	Std	Freq	Mean	Std
1	Gen. freight, LTL	160	0.250	0.200	170	0.263	0.197	173	0.277	0.206	140	0.265	0.205
2	Gen. freight, TL	529	0.582	0.236	804	0.583	0.229	814	0.594	0.224	678	0.593	0.238
3	Heavy machinery	31	0.390	0.274	61	0.468	0.255	58	0.421	0.235	41	0.431	0.241
4	Petroleum products (tank truck)	114	0.544	0.235	147	0.589	0.231	144	0.590	0.231	125	0.578	0.242
5	Refrigerated liquids (tank truck)	12	0.674	0.152	18	0.668	0.128	24	0.666	0.161	23	0.698	0.131
6	Refrigerated solids	117	0.635	0.220	172	0.601	0.230	157	0.620	0.204	142	0.614	0.221
7	Dump trucking	30	0.543	0.268	70	0.514	0.265	64	0.516	0.250	63	0.520	0.257
8	Agricultural commodities	33	0.675	0.213	70	0.603	0.226	61	0.573	0.268	60	0.611	0.242
9	Motor vehicles	18	0.279	0.139	19	0.310	0.189	25	0.368	0.186	22	0.333	0.128
10	Armored truck service	3	0.024	0.034	3	0.012	0.014	3	0.047	0.070	1	0.003	
11	Building materials	77	0.614	0.222	129	0.648	0.213	138	0.649	0.220	107	0.643	0.228
12	Film & associated commodities	2	0.371	0.123	1	0.382		1	0.596				
13	Forest products	11	0.565	0.244	18	0.572	0.283	22	0.522	0.230	18	0.566	0.270
14	Mine ores (not including coal)	1	0.620		1	0.775							
15	Retail store delivery service	12	0.441	0.330	23	0.430	0.304	18	0.390	0.266	17	0.444	0.335
16	Dangerous or hazardous products	5	0.405	0.214	6	0.535	0.185	5	0.493	0.160	6	0.465	0.144
17	Not elsewhere classified (NEC)	108	0.509	0.240	128	0.516	0.266	111	0.501	0.264	95	0.518	0.261
18	Household goods carrier	19	0.138	0.207	29	0.171	0.235	31	0.133	0.208	34	0.099	0.089
20	Bulk chemical				25	0.564	0.202	28	0.590	0.236	25	0.583	0.226
21	General freight, local cartage	1	0.058		12	0.099	0.131	8	0.250	0.263	9	0.241	0.322
23	General freight, parcel				10	0.227	0.314	16	0.193	0.246	13	0.160	0.243
24	General freight, container				33	0.476	0.275	34	0.493	0.279	35	0.484	0.266
	Totals (freq) and overall means	1283	0.438	0.187	1949	0.455	0.199	1935	0.431	0.200	1654	0.402	0.195

Table 3. Panel Model Results by Years.

Comm code	Name	1999		2000		2001		2002		Average Values (1999–2002)	
		Mean	Std	Mean	Std	Mean	Std	Mean	Std	Mean	Std
8	Agricultural commodities	0.621	0.147	0.643	0.164	0.675	0.199	0.675	0.199	0.645	0.200
11	Building materials	0.617	0.139	0.617	0.139	0.647	0.155	0.647	0.155	0.640	0.155
4	Petroleum products	0.615	0.201	0.615	0.201	0.593	0.231	0.594	0.231	0.600	0.233
5	Refrigerated liquids	0.604	0.234	0.607	0.238	0.582	0.133	0.582	0.133	0.600	0.136
6	Refrigerated solids	0.599	0.207	0.561	0.235	0.561	0.223	0.561	0.223	0.571	0.222
2	Gen. freight, TL	0.546	0.245	0.580	0.224	0.559	0.233	0.563	0.229	0.562	0.233
3	Heavy machinery	0.525	0.290	0.493	0.285	0.518	0.254	0.550	0.244	0.518	0.248
9	Motor vehicles	0.501	0.189	0.501	0.189	0.501	0.189	0.501	0.189	0.501	0.189
7	Dump trucking	0.495	0.255	0.402	0.226	0.423	0.275	0.424	0.275	0.466	0.281
17	Not elsewhere classified (NEC)	0.484	0.240	0.518	0.254	0.405	0.231	0.395	0.229	0.424	0.235
1	Gen. freight, LTL	0.310	0.190	0.302	0.187	0.308	0.202	0.308	0.202	0.307	0.195
18	Household goods carrier	0.201	0.202	0.181	0.227	0.181	0.227	0.068	0.024	0.158	0.170
	Overall means	0.510	0.212	0.502	0.214	0.496	0.213	0.489	0.194	0.499	0.208

carrier group ranked first, with an overall mean value 0.645 and a standard deviation value of 0.2 for the study period. The carriers serving the building-materials industry ranked second, with an overall mean of 0.640 and a standard deviation value almost 0.16. These results indicate that these two carrier groups did a better job of utilizing their resources than did the remaining carrier groups.

Petroleum-products and refrigerated-liquids carriers were tied for third, with an overall mean value of 0.600 with standard deviation values of 0.233 and 0.136, respectively. Refrigerated-solids carriers, with an overall mean value 0.571 and a standard deviation value 0.222, followed these two groups of carriers. This result reveals that refrigerated-solids carriers are quite far from the production frontier. Thus the carriers need to reevaluate how their firms are being operated to enhance the efficiency of this segment. A better mix of the use of inputs by the carriers should enable them to move closer to the production frontier, thereby allowing them to provide more-efficient service to their customers.

As stated earlier in this paper, technical efficiency is a prerequisite for economic efficiency. Therefore the carriers should, as a whole and individually, strive to convert their technical-inefficiency disadvantages into economical-efficiency advantages so that they will be able to provide their agribusiness customers with high-quality service at reasonable prices. This, in turn, will enable the agribusiness firms to purchase the required transportation services at reasonable rates so that they can continue to serve their customers at profitable levels. Enabling agribusiness firms to move agricultural commodities and products to their customers at reasonable rates will allow these firms to generate employment, tax revenues, output, and incomes not only to the refrigerated solids carriers serving them but also to their employees and the general public.

Summary and Conclusions

The purpose of this study was to evaluate the technical efficiency of agribusiness trucking carriers that haul food products on a compensational basis. In this analysis, the parametric-efficiency measures were estimated by decomposing them into technical efficiency and scale efficiency using the panel framework for different carrier groups in the United States for 1999–2002.

Results reveal that the trucking industry in general was technically inefficient during the study period, with an overall mean value ranging from a high of 0.455 in 2000 to a low of 0.402 in 2002. Mean values of the technical efficiency measures ranged from a high of 0.645 for agricultural-commodities truck carriers to a low of almost 0.16 for household-goods carriers. The refrigerated-solids trucking companies had a mean value of 0.571, implying that the refrigerated-solid truck carriers as a whole in the United States did not perform that well from a technically efficient point of view. Therefore, the carriers in this category need to make sure that they transform this technical inefficiency into an economically efficient process by combining their various external as well as internal resources into a service that provides economic value to their agribusiness customers in this highly competitive industry. This in turn will allow the agribusiness trucking companies in this segment to generate long-term profits by meeting the needs of their customers in the agribusiness sector.

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