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Estimating Truck Rates for Refrigerated Food Products

by

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Abstract

Food companies and analysts often need transportation rate data to explore market opportunities. In some cases, it may not be practical or necessary to obtain actual rates for all routes under consideration. This study provides analysis of truck rate patterns and alternative rate-estimating equations. The original objective was to provide shipping cost estimates for a national beef-marketing model involving 30 regions of the United States.

The data set is 254 rates for refrigerated shipments of boxed fresh meat throughout the United States in 1988. Distance of the routes range from 50 to 2,923 miles. The average route is 1,181 miles, at a cost of $1,324 per load or $3.31 per cwt. The average cost per 100 miles was $0.28 per cwt. This simple average underestimates the short hauls and overestimates the long hauls.

To improve on this simple procedure, both arithmetic and log equations were fitted to the data. Dummy variables were added to improve the estimates when shipping to different areas in the United States. Highest cost delivery for constant miles was for the areas including the Carolinas north through New England. The lowest cost delivery was the mid-section of the country. The estimating equations explained up to 79 percent of the actual cost. Most of the equations considered performed well in the 500 to 1,500-mile distance, but the quadratic and the double log functions, with dummy variables, performed the best over 2,500 miles. Obviously, these estimating methods are not sufficiently accurate (or necessary) for commercial transactions where only a few routes are under final consideration. Their main value should be to identify rate patterns and for market analysis and planning.

Introduction

Food companies and analysts often need transportation rate data to explore market opportunities. In some cases, it may not be practical (or necessary) to obtain current rates for all routes under consideration. The original problem was to estimate the cost of shipping boxed fresh beef for a national beef-marketing model containing 30 regions, involving 900 possible routes. A survey of 254 truck rates for boxed meat was conducted and used to develop a model to estimate the 900 rates.

Specific transport rates vary by distance, plus a variety of factors, including perishability and value of the product, nature of the competition for the specific route, season of the year, availability of backhauls, destination area, ease of delivery and a variety of standard cost factors.

Truck rates change over time due to changes in fuel cost, inflation, etc.; however, estimation equations can be updated with a sample of rates or an index of changes in transportation costs.

Problem Statement

The problem addressed by this paper is to use the rates from the survey to develop and evaluate a set of estimation equations to predict rates for routes where rates were not readily available. In previous studies, a variety of functional forms have been used, depending on the data. A review of literature did not find any equations for boxed meat. The equations to be evaluated are linear, quadratic and cubic smooth equations, with dummy variables added to evaluate the costs of delivering product to different areas of the United States.

Objectives

The general objective of this paper is to analyze alternative estimating procedures for refrigerated truck rates and to contribute to the understanding of truck rate patterns for refrigerated food products in the United States. Specific objectives include:

1. Evaluate smooth estimating equations where rate is a function of distance.
2. Estimate rate differences due to different costs and competitive factors in different areas of the country.

Methodology

Regression analysis is used to estimate the change in transportation rates as the trip distance changes. There is a fixed charge for loading and other aspects in beginning the trip so that a positive intercept estimate is expected. In addition, one would expect that the rate increases at a slightly decreasing rate on longer trips. Beyond some distance, however, there may be added expense due to adding a second driver and operating at such a long distance from the home base. It seems logical that these long-distance trips would tend to increase in cost. This assumption suggests a cubic form, where shorter distances might imply a quadratic equation. A log linear functional form also appears to be appropriate, because such a form would be curvilinear in arithmetic terms.

Farris and King (1961) compared linear, quadratic and cubic functions of distance for estimating refrigerated truck rates for fresh vegetables. Perhaps the fact that the 133 observations were mostly from one source is the reason that the equations based on distance alone explained up to 96 percent of the variability in rates. The cubic form of the equations provided the best accuracy overall for distances within the United States. On the other hand, Clary, Dietrich and Farris (1984) found that linear functions of distance were more satisfactory than quadratic or cubic ones for estimating interregional truck rates for shipping live cattle, feed grain and fed-beef carcasses; R^2 was .56, .57 and .73, respectively.

Fuller, Makus and Lamkin (1983) developed refrigerated truck rates for produce that were stated as a linear function of distance, with dummy variables to change the intercept (fixed rate per trip). This fixed rate per ton mile was lowest for citrus, 1.64 cents higher for cantaloupes and 0.72 cents higher for cabbage. These differences were statistically significant, and the models had R^2s ranging from .66 to .94. Their results support the hypothesis that differences in product value or perishability result in different rates.

Beilock, MacDonald and Powers (1988) surveyed 3,068 drivers of produce trucks with loads originating in Florida from 1985 to 1986. They fitted a quadratic function of distance with several dummy variable sets to the data. These rates varied significantly by seasons of the year and by numbers of pickups, but the higher rate for refrigerated loads versus non-refrigerated loads was not statistically significant. Due to the variability in type of load surveyed, the R^2 was only .66. This study reported that destination regions accounted for rate differences. Rates were higher to the East Coast by $94 per load than to the Great Lakes states and $175 more than hauling produce directly to the West. The authors speculated that the higher East Coast rates were related to lower probabilities for a back-haul than for other areas.

Since the data for this paper was collected in the fall of 1988 and involved only boxed meat, only the destination area was identified by dummy variables. Dummy variables were added to the smooth equations to investigate the likelihood of rates varying by area of the country. The dummy variable technique allows for regressions on qualitative subgroups, defined in this case as geographic areas. If differences in rates exist by area subgroups, they will be reflected in the intercept and the constants for each subgroup.

Estimating Equations

Six equations were evaluated on cost as a function of distance to estimate regional transportation costs. Estimating equations include:

1. Linear: $Y = \beta_0 + \beta_1 X_1 + \mu$

2. Quadratic: $Y = \beta_0 + \beta_1 X_1 + \beta_2 X_1^2 + \mu$

3. Cubic: $Y = \beta_0 + \beta_1 X_1 + \beta_2 X_1^2 + \beta_3 X_1^3 + \mu$

4. Linear Log: $Y = \beta_0 + \beta_1 \ln X_1 + \mu$

5. Log Linear: $\ln Y = \beta_0 + \beta_1 X_1 + \mu$

6. Double Log Linear: $\ln Y = \beta_0 + \beta_1 \ln X_1 + \mu$

Where:

Y = Transportation cost per cwt. per trip

X_1 = Mileage between shipping and receiving points.

Dummy variables were incorporated to contrast the shipping costs from the Plains States areas to all other areas of the United States (Figure 1). The base area is denoted as D_3, where D_1, D_2, D_4, D_5, D_6, D_7, D_8, D_9 are destination areas remaining in the equation to be fitted. This functional form assumes that the regression differs only in the intercept and not in the slope coefficient. The dummy variables include:

D_1 = The West Coast States of Washington, Oregon and California

D_2 = The Intermountain States.

D_3 = The Plains States.

D_4 = The area east of the Plains and west of the Mississippi River.

D_5 = The area east of the Mississippi River and west of the Appalachian Mountains.

D_6 = Pennsylvania east and north through New England.

D_7 = The Carolinas and Virginia.

D_8 = Florida.

Dummy variables were added to each of the estimating equations listed above. To illustrate the functional form of the complete equations, the double log with dummy variable equation is written below:

Figure 1. Dummy Variable Delivery Area Delineation

$$\ln Y = \beta_0 + \beta_1 D_1 + \beta_2 D_2 + \beta_3 D_3 + \beta_4 D_4 + \beta_5 D_5 + \beta_6 D_6 + \beta_7 D_7 + \beta_8 D_8 + \beta_9 \ln X_1 + \mu$$

where $D_3 = 0$ and the intercept $= B_0 + B_3$.

Data

Several firms involved in the fabrication, distribution, and buying of wholesale beef provided refrigerated transportation rates between shipping and receiving points. The data set contains 254 observations for routes with mileage ranging from 50 to 2,923 miles and cost per trip varying from $.35 to $7.80 per cwt., for an average of $3.31 at 1,181 miles. Costs are represented in dollar-per-hundred pounds, based on a standard 40,000 lb. to 44,000 lb.-capacity refrigerated trailer over the length of the trip.

Results

The quadratic and double log equations with area delivery dummy variables were judged to be the best, with little difference between them. All of the five continuous equations considered had generally acceptable statistical results. All of the intercepts, linear, and quadratic coefficients were statistically significant. The cubic term was not statistically significant, and the addition of the cubic term scarcely increased the R^2 (Table 1). All of the five continuous equations explained more than 70 percent of the variation in the truck rate, except for the linear-log equation at 68 percent, where cost per cwt. (the dependent variable) was transformed to natural logs, but mileage remained in arithmetic form.

The linear equation produced an intercept of $1.01 per cwt. per trip, which appeared to overestimate most of the short-haul data points. These ranged from $0.35 to $1.00 per cwt. for 50 miles. When the dummy variables were added to the linear equation, this intercept increased to $1.10 per cwt., but it appears that this intercept should be no more than $0.50 per cwt. When the dummy variables were added to the five continuous equations all R^2s were increased slightly, as would be expected. A general Wald test of the error sum of squares showed that the unrestricted model (those that included dummy variables) had increased the error sum of squares a statistically significant amount over the restricted models (continuous equations). This alteration justifies (from a statistical standpoint) the use of the dummy variables (Ramanathan, pp. 170-71).

Although some of the destination area effects are not statistically different from the Plains States at the 5 percent level of probability, they provide some useful information. The coefficients were rather stable for all of the equation forms. Clearly, the Virginias and Carolinas have higher rates than the Plains for a constant mileage (perhaps up to $0.50 per cwt.), while Pennsylvania up through New England are about the same. This area had fewer observations in the data set and that fact may explain why the estimates were not statistically significant (Table 2).

Except for Florida, which had few observations, the mid-section of the United States (the areas west of the Appalachian Mountains to the east side of the Plains States) had the lowest rate. The Intermountain area destinations had the next lowest (Table 2). Even though most of the dummy variables are not significantly different from the Plains delivery area, they are still maximum likelihood estimates, and the patterns provide some useful hypotheses for further testing. Examination of Figure 3 adds further evidence of their value. The net range in the difference among rates by area of destination appears to be about $.75 per cwt. from west of the Appalachian to the East Coast for a constant mileage. This is about 23 percent of the average rate.

All of the functional forms appear to provide reasonably accurate estimates from about 500 to 1,500; however, some do poorly at the extremes (Figure 2). There is little difference between the intercept of the quadratic and cubic equations in Panel A of Figure 2: they both appear to be in line with the data. The linear equation has an unacceptable intercept. Estimating beyond 2,000 miles is done best by the quadratic equation, while the cubic and linear equations overestimate the actual data. This fact can be seen by comparing Figure 2 Panel A with the actual data (Figure 3). The double log equation is

Table 1. Comparison of Statistical Estimates for Transportation Rate Models, 1988

Model	Model d.f.	Intercept[a]	x[a] (Miles per trip = x)	x^2	x^3	Ln. x[a]	F=Value[b]	R^2	adj. R^2
Linear	1	1.0106	.00194				682.5	.730	.729
Linear + D.V.	8	1.1084	.00185				96.8	.760	.752
Quadratic	1	0.6218	.00278	-3.35E-07[a]			361.7	.742	.740
Quadratic + D.V.	8	0.7589	.00258	-2.93E-07[a]			89.9	.768	.760
Cubic	1	0.4903	.00329	-8.02E-07[a]	1.162E-10[c]		241.1	.743	.740
Cubic + D.V.	8	0.6093	.00311	-7.84E-07[a]	1.212E-10[c]		80.9	.769	.760
Log Cost	1	0.2481	.000706				530.9	.678	.677
Log Cost + D.V.	8	0.3347	.000682				72.4	.703	.693
Double Log	1	-3.0058				0.5954	863.5	.774	.773
Double Log + D.V.	8	-2.7533				0.5588	118.3	.794	.787

Data characteristics:
Mean cost/cwt = $3.31 Mean miles = 1181 Total observations = 254
Mean cost per 100 miles = $0.28/cwt

[a] Coefficients were Prob>|T| = .001
[b] All model F values were Prob>F = .0001
[c] Not significant

D.V. = Dummy variable

Table 2. Effect of Area of Destination on Refrigerated Truck Rates, 1988.

Model	West Coast	Inter. Mt. States	Plains States	East of Plains West of Miss. R.	East of Miss. R. West of Appl. Mts.	Penn. & New England	Virginas & Carolinas	Florida[a]
	D_1	D_2	D_3	D_4	D_5	D_6	D_7	D_8
			(differences from Plains States in $/cwt per trip)					
Linear + D.V.	-.01	-.17	0	-.30	-.36	.56	.60*	-.58
Quadratic + D.V.	.02	-.18	0	-.17	-.28	.46	.57*	-.66
Cubic + D.V.	.05	-.17	0	-.15	-.28	.46	.59*	-.68
Log Cost + D.V.	-.08	-.09	0	-.25*	-.23*	.20	.10	-.14
Dbl. Log + D.V.	.03	-.07	0	-.17†	-.17*	.13	.13*	-.22

*Difference from Plains States, Prob>|T|<.05

†Difference from Plains States, Prob>|T|<.05

D.V. = Dummy variable set.

[a]Florida did not have sufficient observations.

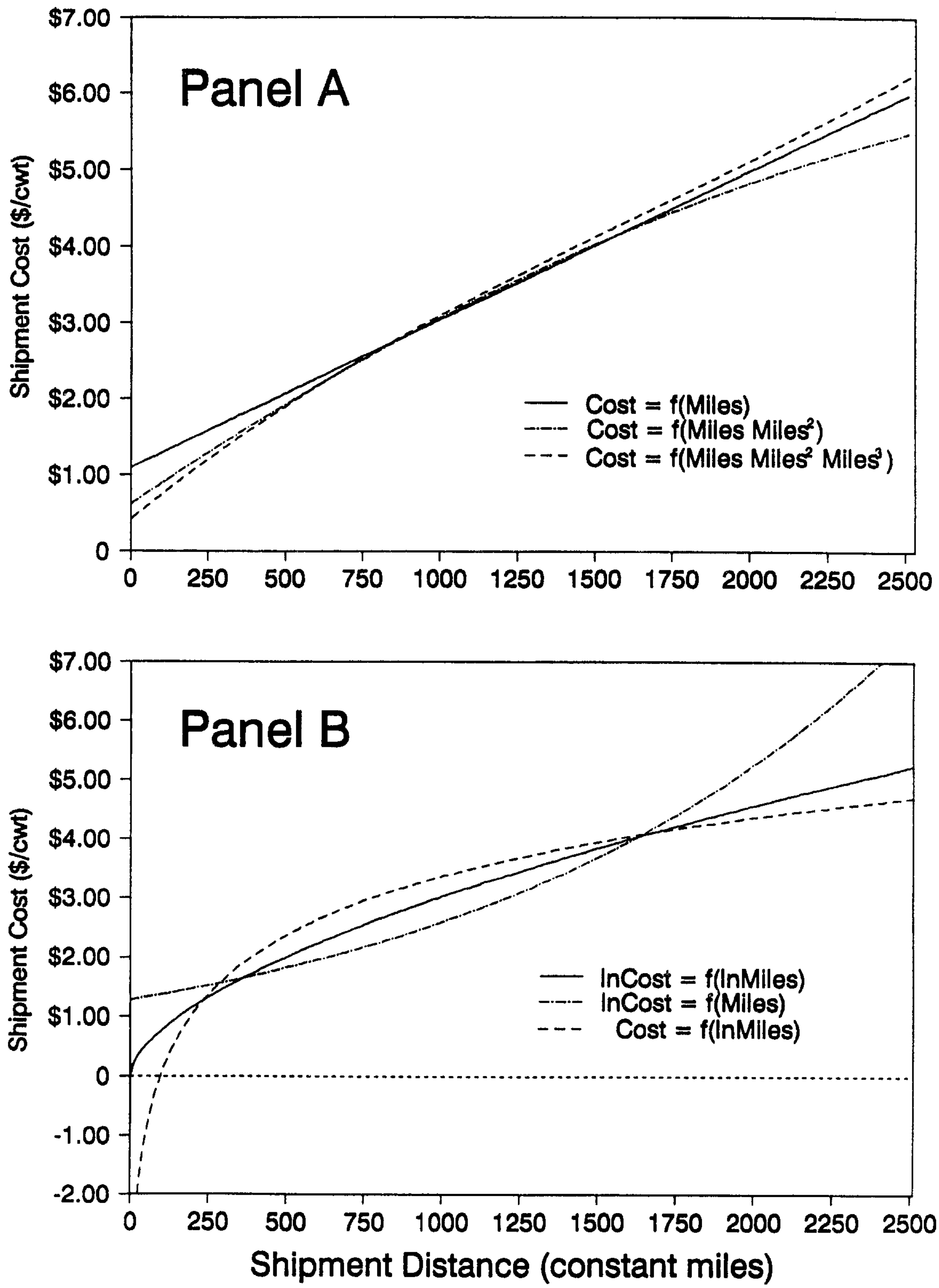

Figure 2. Estimating Equations Evaluated

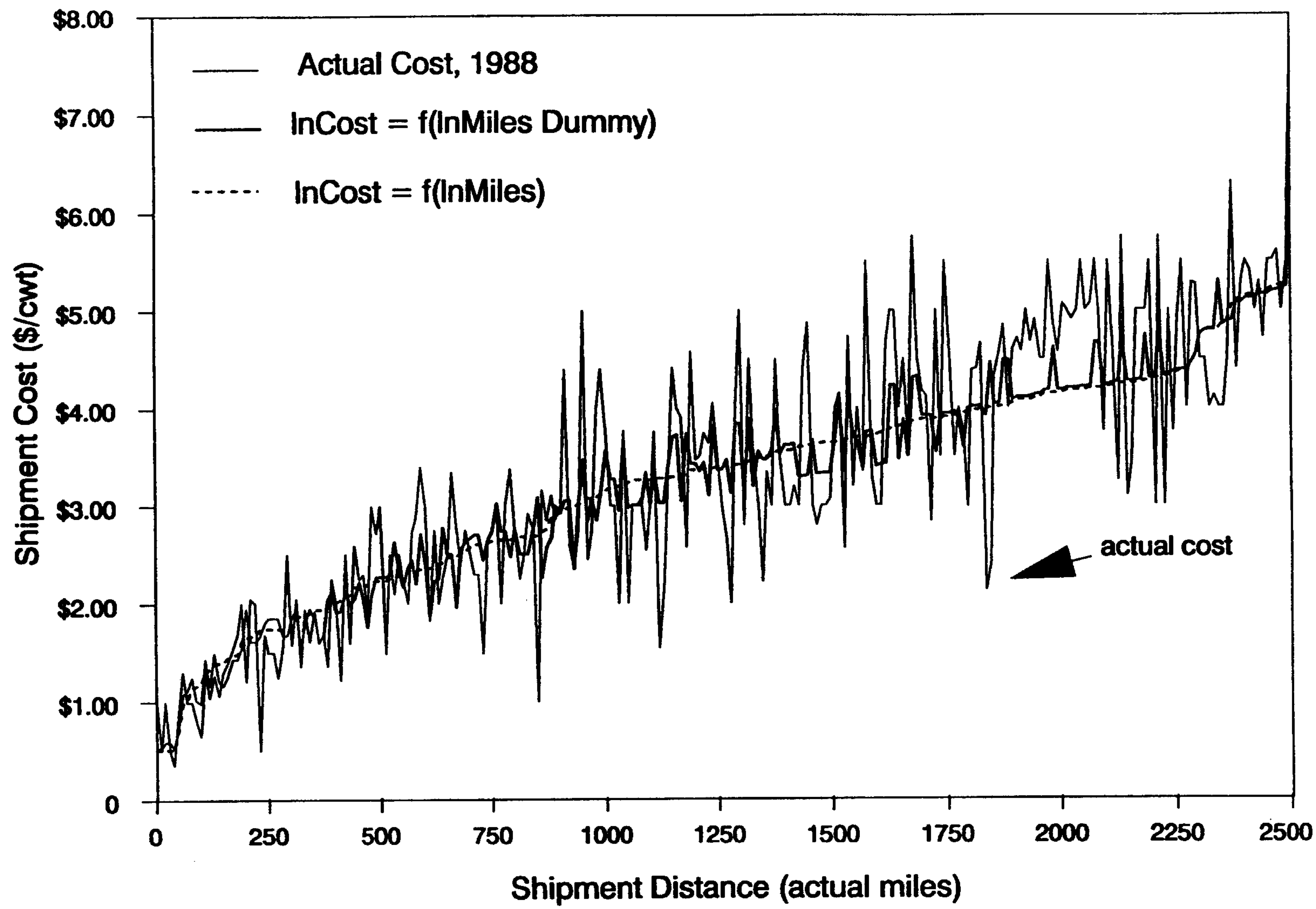

Figure 3. Comparison of Estimated Rates From Log Functions with or without Dummy Variables

the only one among the log forms in Panel B that is acceptable in estimating the extremes. When the dummy variables are added to this double log equation, they improve the estimates, as can be seen from studying Figure 3. Despite a great deal of variability in rates, the dummy variables appear to improve the estimates over the double log equation without the dummy variables.

Conclusions

This analysis shows that about 74 percent of the variability in refrigerated truck rates for meat is related to distance of the trip. The form of the equation used in the estimation must have good statistical properties, and it must also be selected to provide good estimates at the extremes. The quadratic and double log forms were judged to meet these criteria best. The addition of dummy variables accounted for about $.75 per cwt. of the rate differences associated with delivering to different areas, or 23 percent of the average rate of $3.31 per cwt. Availability of back-hauls for refrigerated food products may be an important factor in these dummy variable rate differences. Isolating these effects would require additional research.

Results suggest that delivering to the Midsection of the United States (east of the Plains States and west of the Appalachian Mountains) had the lowest refrigerated truck rates. The highest rates were on the East Coast, from South Carolina through Pennsylvania and New England. The Plains states and the West Coast were in between.

The average rate per 100 miles was $0.28 per cwt., but this underestimates the short hauls and overestimates the long hauls. This is the reason that a curvilinear estimating equation improves the estimates. Obviously, any estimation procedure might not be sufficiently accurate for commercial transactions. However, the procedures outlined here are generally regarded as being sufficiently accurate for exploring marketing opportunities, for planning and for analysis.

References

Beilock, R., J. MacDonald and N. Powers, "An Analysis of Produce Transportation: A Florida Case Study," CED, ERS, U.S. Dept. of Agriculture, Washington, D.C., A.E. Report No. 597, 1988.

Clary, G. M., R. A. Dietrich and D. E. Farris, "Interregional Competition in the U.S. Cattle Feeding Fed-Beef Economy," Texas Agricultural Experiment Station, College Station, TX. B-1487, Nov. 1984, 59 pp.

Farris, D. E. and R. A. King, "Interregional Competition in Marketing Green Peppers," Department of Agricultural Economics, North Carolina State University, Raleigh, N.C., A.E. Inf. Series No. 87, Dec. 1961.

Fuller, S., L. Makus and J. Lamkin, "An Evaluation of Agriculture Motor Carrier Economic Regulation in Texas," Tex. Agri. Exp. Sta. and Tex. Transportation Inst., Texas A&M Univ. Sys., College Station, TX, B-1435, 137 pp., 1983.

Ramanathan, Ramu, "Introductory Econometrics with Applications," *HBJ*, 1989.

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