An Econometric Analysis of Produce Truck Transportation Supply

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The research described in this paper involves the supply of truck services to haul fresh fruits and vegetables (produce) from the Southwest region of the United States to domestic markets. The researchers made use of the U.S. Department of Agriculture's data base of produce shipments, produce unloadings, truck rates, and truck costs, as well as subjective measures of the adequacy of truck service supply. The importance of the research lies in its ability to show that truck service providers allocate efficiently in response to competitive price signals from truck service customers.

The spatial distribution of agricultural commodity producers and consumers in the United States creates a demand for agricultural commodities to be transported. More than half of these agricultural commodities by weight are fresh fruits and vegetables (FFV, also commonly called produce) (*1, 2*). The cost of transportation forms a sizable portion (~20 percent) of the overall retail price of FFV (*1,3*).

Generally, the movement of produce is difficult to manage for many reasons (*4, 5*). The two major causes are the dramatic seasonal fluctuations of produce transportation needs and the characteristics of the types of produce transportation available to the shippers. The seasonality of the harvesting of agricultural produce intensifies peaking, and the inability to store most kinds of produce prohibits shippers from dissipating shipping peaks.

These problems can be understood clearly by considering the example of a single agricultural region. The U.S. produce-growing regions have been divided according to common seasonality and geographic location by Maze (*6*), as shown in Figure 1. In this paper, the Southwest region (New Mexico, Oklahoma, and Texas) is the focus. The dramatic fluctuations in volumes of shipments of produce for this region is illustrated graphically in Figure 2. The figure shows a graph of the number of truckloads of produce shipped from the region in 1983. During the fourth week of May, 4,476 truckloads of produce were shipped from the Southwest. During the last week of September, however, shipments from the region dropped to fewer than 300 truckloads per week. This type of peaking, in the Southwest and in other regions, creates great adjustment problems for the allocation of trucks.

Trucking tends to dominate the transportation of fresh produce because of its flexibility and other qualitative characteristics. Over the last few decades, the Southwest region has become almost totally reliant on trucking for produce shipments. The increase in truck shipments of produce relative to rail shipments since the 1950s illustrates this tendency. By 1984, 99.73 percent of all produce shipments in the Southwest were made by truck. Fewer than 0.10 percent were made by rail car, and fewer than 0.17 percent by piggyback (all data from USDA, *Fresh Fruits and Vegetables: Shipments and Arrivals* and *Fresh Fruit and Vegetable Unloads* for the applicable years). Although there are alternatives to trucking that may present excellent options in the future, trucking is presently almost the only mode used to move Southwestern produce within the United States. Wyckoff and Master identified the most likely reason for this dominance when they found that truckload options are generally no more costly than rail and provide better-quality service (*7*).

To serve the special demands placed on truck carriers who ship raw agricultural commodities, these truckers were exempted from interstate economic regulations by the Motor Carrier Act of 1935 (*8*). Furthermore, to allow greater participation by agricultural carriers in traditionally regulated truck service markets, the Motor Carrier Act (MCA) of 1980 relaxed restrictions placed on carriers without Interstate Commerce Commission (ICC) certification (*9–12*). Unregulated agricultural commodity carriers are free to migrate and follow the harvesting season across the country. The ability to migrate has been widely considered to be a source of competition for truck service between regions with harvest peaks that overlap in time (*1, 6, 13*), although there is some evidence to the contrary (*14*).

The primary objective of the research described in this paper is to better understand the supply and demand of produce truck services, and possibly that of truck services in general. The research investigates the allocation of providers of produce truck service in response to price signals and in response to other related market variables. The importance of the research is twofold. First, it provides an example of the response of truck service suppliers to the demands (prices bid) of truck service consumers in a competitive environment, and second, it provides a better understanding of the mechanics of the produce truck market.

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FIGURE 1 Produce-growing regions in the continental United States.

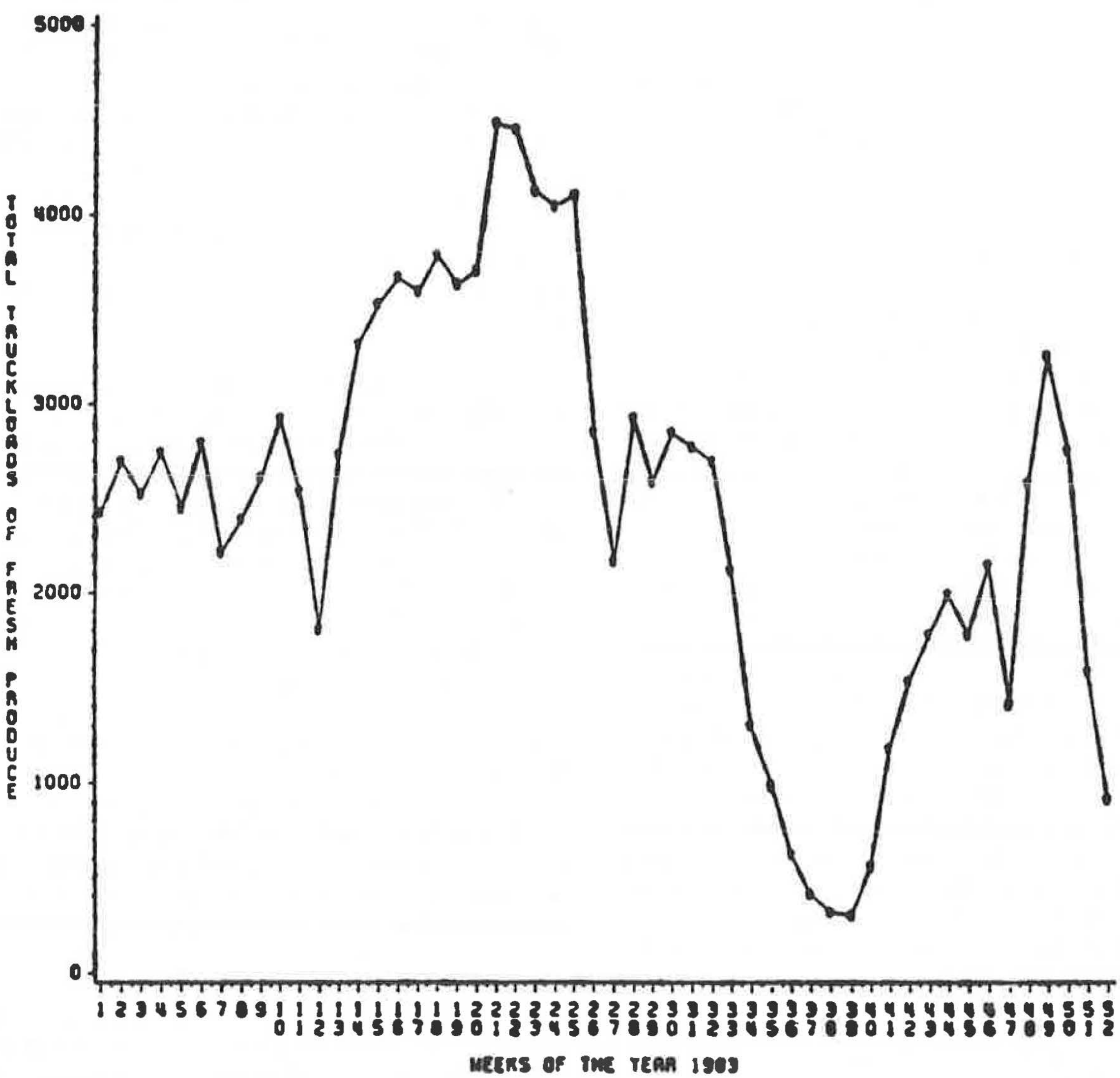

FIGURE 2 Weekly produce shipments by truck from the Southwest region.

This second factor will offer aid to the U.S. Department of Agriculture (USDA) and state departments of agriculture in advising shippers of market conditions for produce transportation.

Although there have been many studies of unregulated agricultural truck transportation, these studies are usually devoted to determining whether the quality and cost of unregulated truck services are comparable to those of regulated markets (*15–25*). Generally, the answer is that the average performance of unregulated truck service markets is superior to the average performance of their regulated counterparts. Studies of unregulated agricultural truck service markets, however, seldom focus on market issues. Specifically, these studies seldom examine whether truck service suppliers respond efficiently to competitive price signals from truck service consumers. Additionally, the issue of the magnitude of the possible relationship is rarely considered.

The dearth of research in this area is probably attributable to the past lack of data on the produce truck transportation market. Conditions have changed, however, and data on the produce truck service market are currently being collected. In June 1979, USDA began collecting produce truck service market data on a weekly basis (published as *Fruit and Vegetable Unloads Truck Rate and Cost Summary* and *Fruit and Vegetable Unloads Truck Rate Report*). In this paper, the truck produce service market from the Southwest region to six major domestic market destinations (Atlanta, Chicago, Dallas, Denver, New York, and Los Angeles) is analyzed. In this research, the USDA data are used to conduct an empirical econometric analysis of produce truck transportation services. Seemingly unrelated regression (SUR) models of the truck service models are developed for each destination, for each of the growing subregions within the Southwest region, and for each of the major types of produce grown in the Southwest.

The models developed in this paper indicate that exempt truckers allocate their trucks with respect to rate signals, so that the market follows the traditional micro-economic theory of the market. It has also been found that the availability (adequacy) of trucks at a shipping region and the truck operating costs play an important part in setting rates. Although the scope of this research is limited to the Southwest region, the findings can be extended to other regions.

DATA DESCRIPTION

A major resource for this research is the data base that is being collected by the Market News Branch, Fruit and Vegetable Division, Agricultural Marketing Service and Office of Transportation, of the U.S. Department of Agriculture, as mentioned earlier. Five years of data (1979–1984) are coded and stored in a form that is compatible with a standard statistical package (i.e., the Statistical Analysis System, or SAS). The prepared data base includes the following elements.

Shipment Data

The raw data of the Market News Branch are listed as thousands of pounds of each commodity on a weekly basis. In all, 39 different types of produce are reported. Because the focus of this research is truck transportation services and not the produce types themselves, the USDA data are converted from 1,000-lb lots to truckloads.

Unloading Data

The raw data of the Market News Branch are listed as thousands of pounds of each commodity unloaded at a major consuming city. Originally, the unloading data were collected for 42 major U.S. cities. Subsequently, because of a reduction in the funding level, USDA reduced the number of cities to 21. The unloading data for the six major destinations used in this study, however, are included in all the years under consideration. Unloadings are reported on a monthly basis. To convert unloading volumes to weekly data, to be compatible with weekly shipment data, the unloadings made each week are assumed to be proportional to the month's volume.

Freight Rate Data

Freight rates (prices) for trucking services from major producing subregions to the six major destinations mentioned previously are collected on a weekly basis by USDA. The rates are normally quoted as a typical truckload carrying 40,000 pounds of produce. The weekly rate is given on a range basis, with minimum and maximum values, and in some cases only one value is reported (normally the maximum rate).

Truck Availability (Adequacy) Data

For each area, a truck adequacy scale, ranging from surplus to shortage, is reported to the Market News Branch. The scale is defined as follows:

- Surplus (supplies of trucks exceed shippers' needs),
- Slight surplus (supplies of truck slightly exceed shippers' needs),
- Adequate (supplies of trucks are generally in good balance with shippers' needs),
- Slight shortage (supplies of trucks are short of shippers' needs), or
- Shortage (supplies of trucks are far below shippers' needs).

Operating Cost Data

Operating cost information is reported by the Office of Transportation, USDA. The USDA report supplies information on both truck fleet costs and truck owner-operator costs. Because the majority of produce is hauled by exempt truck owner-operators, the corresponding truck owner-operator costs (in cents per mile) are considered in the analysis. The cost is reported as the summation of fixed costs (interest, insurance, and license), variable costs (depreciation and driver wage), and operating costs (fuel, maintenance, and miscellaneous expenses). The cost of fuel, which accounts for approximately 20 percent of the overall operating costs, is generally more variable than other costs. The truck-operating cost per mile is reported on a monthly basis, and it is assumed that weekly operating costs are equal to the cost reported for the entire month.

Price Index

The truck rates and operating costs are adjusted to derive constant dollar values. The Transportation Consumer Service Price Index is used to deflate monthly dollar values to constant dollars (1967 dollars are indexed at 100). The Transportation Consumer Price Index is given in the Consumer Price Index *Detailed Report* (published by the Bureau of Labor Statistics, U.S. Department of Labor) on a monthly basis. The weekly figures obtained from the monthly values are based on the assumption that inflation increases or decreases uniformly within each month.

Auxiliary Data

State-level reports published by several state agencies are also used to arrive at volumes of shipments from produce-growing subregions within each state of the Southwest (*26–31*). *The Census of Agriculture* is also used to supplement data whenever necessary (*32*).

METHODOLOGY

Before an empirical aggregate model is constructed, an abstract conceptual model is hypothesized to provide direction for the specification of the empirical model. The rates may be viewed as being determined by the interaction of the regional supply and demand curves of transportation services. In the analysis, the truck rate is therefore hypothesized to measure the supply of truck service to various destinations. Moreover, it is also hypothesized that trucking firm decision makers (suppliers of truck services) respond to the expected profit per unit of time when they allocate their trucks. The expected profit is actually the difference between the rate (revenue) and the cost of operation. In some instances the expected revenue would be almost equal to or less than the operating cost, which means zero profit (breaking even) or even a loss.

The cost of operating trucks involves not only the costs given in the USDA report but also other incidental expenses, such as the costs associated with delays of multiple load pickups, waiting time while the produce is packed, and multiple deliveries. These expenses may vary from destination to destination and from time to time, depending on the season. Sometimes truckers are compensated for these special services, but most truckers bear these expenses without added compensation (*23*). These special services lead to inefficiencies, and they reduce the profits earned by truckers.

It should be noted that the supply of truck service has to be considered as the interaction of two parties, the buyer and the supplier. As buyers of truck services (buyer broker, truck broker, or both) want more trucks to haul produce, they increase rates to attract more trucks. The suppliers (truckers) then compare the different rates offered to them, the costs of providing the service or not providing the service, and the cost of offering service to one destination as compared to that for other possible destinations. Moreover, as the operating costs increase, the suppliers are likely to seek a higher truck rate, if it is assumed that all other factors remain constant (*13*).

The rate offered for truck service from a produce-growing area to a destination city can be considered as the appropriate proxy value for the supply of truck services. As the rate offered for truck service to a particular destination increases, more truckers should be attracted to that particular destination, if it is assumed that costs remain constant.

If decision makers at trucking firms allocate their trucks to different destinations on the basis of anticipated profits per unit time, then the quantity of truck service supplied (the quantity of produce truck loads actually shipped) to the Southwest to haul a specific type of produce is dependent on the rate (revenue) offered for one truckload of that type of produce, if it is assumed that the cost of operation is relatively constant over a short time (i.e., 1 week). Furthermore, the rate is hypothesized to be dependent on the total quantity of produce (all types of produce) shipped from the growing area, quantity of competing produce (other produce types) shipped from within the same growing area, truck rates in competing growing areas, relative availability of trucks, and the operating costs of trucks. The hypothesized model of truck service supplied to the Southwest (measured by a proxy variable, truck rate) is expressed by the following equation:

$$\mathrm{MTR}_{ijkt} = F(\mathrm{TRSH}_{ijkt}, \mathrm{TCSH}_{ijt}, \mathrm{TWSH}_{ijt}, \mathrm{ADECOD}_{ijkt}, \mathrm{OPCOST}_{t})$$

where

i = producing (growing) area,
j = destination city,
k = produce type,
t = time period,
MTR = mean truck rate,
TRSH = total regional quantity shipped,
TCSH = total competing area quantity shipped,
TWSH = total competing produce quantity shipped within the area,
ADECOD = adequacy of trucks,
OPCOST = operating cost of trucks, and
F = abstract aggregate supply function.

EMPIRICAL ANALYSIS

The modeling process is divided into two stages. In the first stage the data set is prepared, and a list of candidate variables is chosen by using preliminary analysis. In the second stage, a seemingly unrelated regression (SUR) technique is considered for the final model development, using the set of chosen variables.

Data Set Development

The numerous variables included in the data set compiled for the analysis must be reduced to a reasonable number. For example, the USDA shipment reports include 39 different types of produce. An attempted model for the truck service supplied to carry each commodity would be unmanageable. Instead, variables are classified into categories. Produce, for example, is classified into four major varieties. Data are classified by subregions within the Southwest, by shipping destinations, by produce type, and by time period, as follows.

Producing Subregions

The produce-growing subregions are classified as follows:

- Lower Rio Grande Valley, Texas;
- Winter Garden, Texas;
- Panhandle/Hereford, Texas; and
- New Mexico.

The USDA report did not list any shipment data for the state of Oklahoma.

Competing Subregions

The competing subregions can be classified by reference to the subregion that is being studied. For example, if the truck service is supplied to the Lower Rio Grande Valley, then the remaining subregions (Winter Garden, Panhandle/Hereford, and New Mexico) are considered to be competing subregions.

Destination Cities

Not all of the available fresh fruits and vegetables are shipped to all six major destination cities every year. For instance, the Panhandle/Hereford subregion shipped FFV consistently to New York, Chicago, Atlanta, and Dallas during 1979–1984. In contrast, shipments from the Panhandle/Hereford subregion to Los Angles and Denver are only recorded during 1979 and 1980. Models are actually estimated only if there is a long enough data record to allow the estimation of model parameters with an ample number of degrees of freedom.

Types of Produce

On the basis of the produce types listed in the USDA truck rate reports, the produce types are consolidated into a manageable number of categories. Produce shipped from the Southwest regions is grouped into one of the following categories:

- Citrus,
- Vegetables,
- Dry onions, or
- Lettuce.

Time Periods

The time period considered in the analysis is from July 1979 to December 1984. It should be noted that a few types of FFV are shipped only during certain portions of the analysis period. For example, USDA only reported vegetable shipments during 1979 and 1980 from the Winter Garden subregion.

Model Development

The abstract conceptual model identifies the variables that determine exempt truck service supply to the Southwest region. By using the abstract model for guidance, an empirical model is specified to account for the truck service supply from the produce-growing subregion (i) to a destination city (j) for a particular type of produce (k) during a specific time period (t).

The mean truck rate is used as the dependent variable, and independent variables are sought to describe its behavior. The "best" independent variables are selected by reviewing two-dimensional plots, correlation coefficients, and partial correlation coefficients between the dependent variable and the candidate independent variables and their common transformations.

Because of the short (weekly) observation periods, serial correlation should be present in the empirical model. The resulting empirical model specification is presented in the following equation:

$$\begin{aligned} \text{MTRD}(i, j, k, t) = P_0 &+ P_1 * \text{TRSH}(i, k, t) \\ &+ P_2 * \text{TCSH}(i, t) \\ &+ P_3 * \text{TWSH}(i, k, t) \\ &+ P_4 * \text{ADECOD}(i, j, k, t) \\ &+ P_5 * \text{OPCOSTD}(t) \\ &+ U(i, j, k, t) \end{aligned}$$

where

i = origin (growing/producing subregion, e.g., Lower Rio Grande, Texas);
j = destination (consumer area, e.g., Atlanta);
k = produce type (e.g., citrus, vegetables);

t = time period (weeks of a year);
MTRD = mean truck rate (indexed to 1967 dollars);
OPCOSTD = cost of production inputs of truck (i.e., fuel price, wage rate, etc.) per mile in cents (indexed to 1967 dollars);
ADECOD = truck availability at a growing subregion (i), to a destination (j) for a produce type (k) at time (i) [adequacy code is a qualitative variable ranging from surplus (1) to shortage (5)];
TRSH = total shipments of produce type (k) from a growing subregion;
TCSH = total shipments of all produce types from a competing subregion;
TWSH = total shipments of competing produce types within the growing subregion (all types of produce other than k);
$P_0, P_1, P_2, P_3, P_4, P_5$ = regression parameter estimates;
$U(i, j, k, t) = Q_0 * U(i, j, k, t-1) + V(t)$ (autocorrelated error term);
Q_0 = autoregression coefficient;
$U(i, j, k, t-1)$ = lagged autocorrelated error term (LRS); and
$V(t)$ = random error term.

Analysis Procedure

The SAS routine "Autoregression" (AUTOREG) (*33*) is used with the best independent variables to estimate the parameters for single-equation models for each combination of producing area, produce classification, and destination city. The residuals are then obtained from the AUTOREG procedure for each destination, after correcting the first-order autocorrelation. Then the first order lagged values of the residuals are deduced from each model's residuals.

A SUR system model is run on the combined data set of the original best variables and the lagged first order residuals to obtain the coefficients of the system. The SUR procedure was introduced by Zellner, and it is preferred for situations in which there are omitted variables that are common to a system of equations (*34*). Beilock and Shonkweiler used SUR to model truck service supply under similar conditions (*35*). A system of simultaneous equations is used to model truck rates from each producing subregion for each commodity classification to the six destinations as a seemingly unrelated system to allow information to be transmitted between equations through the error structure. The estimation of parameters is done through the maximum likelihood method (*36*). The model that best fits the data is chosen by repeated experimentation with the available data on the basis of logical and statistical criteria (*37*).

As indicated earlier, one of the main problems is the lack of uniformity in the data, a condition that leads to an unequal number of missing observations. This problem has been addressed by many researchers (*38–44*). The SAS procedure used for modeling here takes the missing data into account through the MISS/NOMISS option (*33*).

EMPIRICAL MODELS

An equation system is estimated for each origin to all six destinations and for each produce classification for which there is a data set of sufficient size. In the following material, general interpretations for the system model estimated are provided. A more lengthy discussion of each equation within the system is provided elsewhere by Devadoss (*45*).

Lower Rio Grande Valley: Truck Rate Analysis for Vegetables

The Lower Rio Grande Valley is the predominating major produce-growing subregion in the Southwest and is the only citrus-growing subregion in the region. Hence citrus and vegetable producers compete with each other to attract truck services during certain periods of the year.

The model specifications developed for truck rates for Lower Rio Grande Valley vegetables to each of the major destination cities are given in the following equations. The estimated parameters, their standard errors, t values, and corresponding probability values for each equation and the entire system are presented in Table 1.

New York

$$\text{MTRD} = A_0 + A_1(\text{OPCOSTD}) + A_3(\text{TCSH}) + A_4(\text{ADECOD}) + A_5(\text{LRS})$$

Chicago

$$\text{MTRD} = B_0 + B_1(\text{OPCOSTD}) + B_2(\text{TRSH}) + B_3(\text{TCSH}) + B_4(\text{ADECOD}) + B_5(\text{LRS})$$

Atlanta

$$\text{MTRD} = C_0 + C_1(\text{OPCOSTD}) + C_2(\text{TRSH}) + C_3(\text{TCSH}) + C_4(\text{ADECOD}) + C_5(\text{LRS})$$

Denver

$$\text{MTRD} = D_0 + D_1(\text{OPCOSTD}) - D_2(\text{TRSH}) + D_4(\text{ADECOD}) + D_5(\text{LRS})$$

TABLE 1 ESTIMATED SUR COEFFICIENTS FOR TRUCK RATES: VEGETABLES FROM THE LOWER RIO GRANDE VALLEY

Destination	Variables	Parameter Estimate	Standard Error	t-Ratio	Prob>|t| (alpha)
New York City	INTERCEPT(Ao)	472.275	20.13	23.46	0.0001
	OPCOSTD(A1)	5.014	0.411	12.19	0.0001
	TCSH(A3)	0.298	0.008	3.86	0.0007
	ADECOD(A4)	12.371	3.163	3.91	0.0006
	LRS(A5)	0.202	0.067	3.01	0.0056
Chicago	INTERCEPT(Bo)	280.543	16.32	17.19	0.0001
	OPCOSTD(B1)	5.014	0.411	12.19	0.0001
	TRSH(B2)	0.011	0.003	3.84	0.0007
	TCSH(B3)	0.0089	0.003	3.06	0.0050
	ADECOD(B4)	3.788	1.249	3.03	0.0053
	LRS(B5)	0.202	0.067	3.01	0.0056
Atalanta	INTERCEPT(Co)	168.036	17.19	9.77	0.0001
	OPCOSTD(C1)	5.014	0.411	12.19	0.0001
	TRSH(C2)	0.014	0.004	3.34	0.0025
	TCSH(C3)	0.0209	0.004	5.04	0.0001
	ADECOD(C4)	8.647	1.727	5.01	0.0001
	LRS(C5)	0.202	0.067	3.01	0.0056
Denver	INTERCEPT(Do)	199.979	19.38	10.32	0.0001
	OPCOSTD(D1)	5.014	0.411	12.19	0.0001
	TRSH(D2)	-0.0158	0.007	-2.13	0.0421
	TCSH(D3)	N.S	N.S	N.S	N.S
	ADECOD(D4)	9.783	3.064	3.19	0.0036
	LRS(D5)	0.202	0.067	3.01	0.0056
Los Angeles	INTERCEPT(Eo)	252.753	19.29	13.10	0.0001
	OPCOSTD(E1)	5.014	0.411	12.19	0.0001
	TRSH(E2)	N.S	N.S	N.S	N.S
	TCSH(E3)	0.010	0.007	1.44	0.1625
	ADECOD(E4)	7.332	2.822	2.59	0.0150
	LRS(E5)	0.202	0.067	3.01	0.0056
Dallas	INTERCEPT(Fo)	N.S	N.S	N.S	N.S
	OPCOSTD(F1)	5.014	0.411	12.19	0.0001
	TRSH(F2)	N.S	N.S	N.S	N.S
	TCSH(F3)	0.0099	0.0038	2.59	0.0154
	ADECOD(F4)	8.590	1.614	5.32	0.0001
	LRS(F5)	0.202	0.067	3.01	0.0056

System weighted M.S.E is 1.15442 with 172 degrees of freedom.
System weighted R-square is 0.6267.
N.S - Not Significant

Los Angeles

$$\text{MTRD} = E_0 + E_1(\text{OPCOSTD}) + E_3(\text{TCSH}) + E_4(\text{ADECOD}) + E_5(\text{LRS})$$

Dallas

$$\text{MTRD} = F_1(\text{OPCOSTD}) + F_3(\text{TCSH}) + F_4(\text{ADECOD}) + F_5(\text{LRS})$$

From the analysis, it can be seen that the truck rate is mainly dependent on operating cost and on total shipments of produce from this subregion.

Lower Rio Grande Valley: Truck Rate Analysis for Citrus

The model developed for truck rates for carrying citrus from the Lower Rio Grande Valley subregion to various destinations, and their estimated parameters, standard errors, *t* values, and the corresponding probability values for each equation and the entire system are presented in Table 2. In general, the citrus truck rates are dependent on the operating costs of the trucks and on volumes of shipments from competing subregions. The dependence on the volume of shipments from the competing subregion may be due, in part, to the relatively nonperishable nature of citrus fruit in comparison to other fruits and vegetables. For example, when there is a shortage of truck services, vegetable shippers must bid up the rate so that they can immediately attract a large enough number of truckers to haul the highly perishable fresh vegetables to the market destinations. Citrus shippers can postpone shipping for a few days and wait for a more favorable truck service market.

The system model specification for Lower Rio Grande Valley citrus truck rates is as follows:

New York

$$\text{MTRD} = A_0 + A_1(\text{OPCOSTD}) + A_2(\text{TWSH}) + A_3(\text{TCSH}) + A_4(\text{ADECOD}) + A_5(\text{LRS})$$

Chicago

$$\text{MTRD} = B_0 + B_1(\text{OPCOSTD}) + B_4(\text{ADECOD}) + B_5(\text{LRS})$$

Atlanta

$$\text{MTRD} = C_0 + C_1(\text{OPCOSTD}) + C_2(\text{TWSH}) + C_3(\text{TCSH}) + C_5(\text{LRS})$$

Denver

$$\text{MTRD} = D_0 + D_1(\text{OPCOSTD}) + D_2(\text{TWSH}) + D_3(\text{TCSH}) + D_5(\text{LRS})$$

Los Angeles

$$\text{MTRD} = E_0 + E_1(\text{OPCOSTD}) + E_2(\text{TWSH}) + E_3(\text{TCSH}) + E_5(\text{LRS})$$

Dallas

$$\text{MTRD} = F_0 + F_1(\text{OPCOSTD}) + F_5(\text{LRS})$$

From the analysis, it may be seen that the truck rates are mainly dependent on the operating cost and on volumes of produce shipments from this subregion. Truck rates are also generally dependent on the total volume of shipments from competing subregions (outside the Lower Rio Grande Valley) and on the volume of competing vegetable shipments within the subregion.

Lower Rio Grande Valley: Truck Rate Analysis for Dry Onions

Shipments of dry onions from the Lower Rio Grande Valley subregion to the six major destinations are only reported for 1982 and 1983. Because of the limited number of observations, the results of this analysis should be interpreted cautiously. The statistically significant variables and their estimated parameters, standard errors, *t* values, and corresponding probability values are presented in Table 3.

From the analysis it should be noted that the supply of truck services (truck rate) depends on the operating cost, adequacy code, volume of shipments from the Lower Rio Grande Valley subregion, and volume of shipments from competing subregions. The final system model specification is as follows:

New York

$$\text{MTRD} = A_0 + A_1(\text{OPCOSTD}) + A_4(\text{ADECOD}) + A_5(\text{LRS})$$

Chicago

$$\text{MTRD} = B_0 + B_1(\text{OPCOSTD}) - B_2(\text{TRSH}) - B_3(\text{TCSH}) + B_4(\text{ADECOD}) + B_5(\text{LRS})$$

Atlanta

$$\text{MTRD} = C_0 + C_1(\text{OPCOSTD}) + C_5(\text{LRS})$$

TABLE 2 ESTIMATED SUR COEFFICIENTS FOR TRUCK RATES: CITRUS FROM THE LOWER RIO GRANDE VALLEY

Destination	Variables	Parameter Estimate	Standard Error	t-Ratio	Prob≤|t| (alpha)
New York City	INTERCEPT(Ao)	581.00	80.24	7.24	0.0002
	OPCOSTD(A1)	3.109	1.173	2.65	0.0329
	TWSH(A2)	0.044	0.028	1.58	0.1581
	TCSH(A3)	0.073	0.032	2.29	0.0556
	ADECOD(A4)	N.S	N.S	N.S	N.S
	LRS(A5)	0.271	0.107	2.53	0.0390
Chicago	INTERCEPT(Bo)	390.055	65.06	5.995	0.0005
	OPCOSTD(B1)	3.109	1.173	2.65	0.0329
	TWSH(B2)	N.S	N.S	N.S	N.S
	TCSH(B3)	N.S	N.S	N.S	N.S
	ADECOD(B4)	9.866	4.162	2.37	0.0496
	LRS(B5)	0.271	0.107	2.53	0.0390
Atlanta	INTERCEPT(Co)	270.740	60.19	4.498	0.0028
	OPCOSTD(C1)	3.109	1.173	2.65	0.0329
	TWSH(C2)	0.040	0.014	2.790	0.0269
	TCSH(C3)	0.051	0.017	3.070	0.0181
	ADECOD(C4)	N.S	N.S	N.S	N.S
	LRS(C5)	0.271	0.107	2.53	0.0390
Denver	INTERCEPT(Do)	242.654	59.82	4.056	0.0048
	OPCOSTD(D1)	3.109	1.173	2.65	0.0329
	TWSH(D2)	0.040	0.014	1.703	0.1323
	TCSH(D3)	0.035	0.016	2.139	0.0698
	ADECOD(D4)	N.S	N.S	N.S	N.S
	LRS(D5)	0.271	0.107	2.53	0.0390
Los Angeles	INTERCEPT(Eo)	322.131	67.00	4.808	0.0019
	OPCOSTD(E1)	3.109	1.173	2.65	0.0329
	TWSH(E2)	N.S	N.S	N.S	N.S
	TCSH(E3)	0.043	0.022	1.917	0.0968
	ADECOD(E4)	N.S	N.S	N.S	N.S
	LRS(E5)	0.271	0.107	2.53	0.0390
Dallas	INTERCEPT(Fo)	123.025	53.13	2.315	0.0493
	OPCOSTD(F1)	3.109	1.173	2.65	0.0329
	TWSH(F2)	N.S	N.S	N.S	N.S
	TCSH(F3)	N.S	N.S	N.S	N.S
	ADECOD(F4)	N.A	N.A	N.A	N.A
	LRS(F5)	0.271	0.107	2.53	0.0390

System weighted M.S.E is 1.5300 with 53 degrees of freedom.
System weighted R-square is 0.3985
N.S - Not Significant
N.A - Not Applicable

TABLE 3 ESTIMATED SUR COEFFICIENTS FOR TRUCK RATES: DRY ONIONS FROM THE LOWER RIO GRANDE VALLEY

Destination	Variables	Parameter Estimate	Standard Error	t-Ratio	Prob≤|t| (alpha)
New York City	INTERCEPT(Ao)	499.185	24.37	20.49	0.0001
	OPCOSTD(A1)	3.866	0.328	11.79	0.0001
	TRSH(A2)	-0.018	0.011	-1.63	0.1420
	TCSH(A3)	-0.018	0.011	-1.63	0.1427
	ADECOD(A4)	6.371	3.163	3.91	0.0006
	LRS(A5)	0.488	0.143	3.42	0.0091
Chicago	INTERCEPT(Bo)	317.369	17.23	18.43	0.0001
	OPCOSTD(B1)	3.866	0.328	11.79	0.0001
	TRSH(B2)	-0.021	0.0055	-3.76	0.0055
	TCSH(B3)	-0.020	0.0054	-3.66	0.0064
	ADECOD(B4)	5.171	1.143	4.52	0.0019
	LRS(B5)	0.488	0.143	3.42	0.0091
Atalanta	INTERCEPT(Co)	208.267	17.19	12.11	0.0001
	OPCOSTD(C1)	3.866	0.328	11.79	0.0001
	TRSH(C2)	N.S	N.S	N.S	N.S
	TCSH(C3)	N.S	N.S	N.S	N.S
	ADECOD(C4)	N.S	N.S	N.S	N.S
	LRS(C5)	0.488	0.143	3.42	0.0091
Denver	INTERCEPT(Do)	196.761	15.50	12.69	0.0001
	OPCOSTD(D1)	3.866	0.328	11.79	0.0001
	TRSH(D2)	N.S	N.S	N.S	N.S
	TCSH(D3)	N.S	N.S	N.S	N.S
	ADECOD(D4)	N.S	N.S	N.S	N.S
	LRS(D5)	0.488	0.143	3.42	0.0091
Los Angeles	INTERCEPT(Eo)	229.562	54.05	4.25	0.0028
	OPCOSTD(E1)	3.866	0.328	11.79	0.0001
	TRSH(E2)	N.S	N.S	N.S	N.S
	TCSH(E3)	N.S	N.S	N.S	N.S
	ADECOD(E4)	N.S	N.S	N.S	N.S
	LRS(E5)	0.488	0.143	3.42	0.0091
Dallas	INTERCEPT(Fo)	69.424	14.199	4.89	0.0009
	OPCOSTD(F1)	3.866	0.328	11.79	0.0001
	TRSH(F2)	N.S	N.S	N.S	N.S
	TCSH(F3)	-0.0012	0.0009	-1.366	0.2050
	ADECOD(F4)	N.A	N.A	N.A	N.A
	LRS(F5)	0.488	0.143	3.42	0.0076

System Weighted M.S.E is 2.1348 with 59 degrees of freedom
System weighted R-squre is 0.8697
N.S - Not Significant
N.A - Not Applicable

Denver

$$MTRD = D_0 + D_1(OPCOSTD) + D_5(LRS)$$

Los Angeles

$$MTRD = E_0 + E_1(OPCOSTD) + E_5(LRS)$$

Dallas

$$MTRD = F_0 + F_1(OPCOSTD) + F_5(LRS)$$

Winter Garden:
Truck Rate Analysis for Produce

USDA reported truck service rates for vegetables shipments from the Winter Garden subregion to only four of the six destination cities: New York, Chicago, Atlanta, and Dallas. No rates were reported for shipments to Denver or Los Angeles. Because of the low number of observations, a separate analysis of truck rates for each type of produce is not feasible. A combined analysis that did not distinguish among types of produce was therefore carried out. The statistically significant explanatory variables and their estimated parameters, standard errors, *t* values, and corresponding probability values are presented in Table 4.

From the analysis, it can be observed that the truck rate is dependent on the operating costs of the trucks, volume of shipments from competing subregions, and total volume of shipments from the subregion itself. The final system model modification is as follows:

New York

$$MTRD = A_0 + A_1(OPCOSTD) + A_3(TCSH)$$

Chicago

$$MTRD = B_1(OPCOSTD) + B_2(TRSH) + B_3(TCSH)$$

Atlanta

$$MTRD = C_1(OPCOSTD) + C_2(TRSH) + C_3(TCSH)$$

TABLE 4 ESTIMATED SUR COEFFICIENTS FOR TRUCK RATES: FFV FROM WINTER GARDEN

Destination	Variables	Parameter Estimate	Standard Error	t-Ratio	Prob>|t| (alpha)
New York City	INTERCEPT(Ao)	428.172	21.69	19.75	0.0003
	OPCOSTD(A1)	2.075	0.251	8.27	0.0037
	TRSH(A2)	0.287	0.149	1.93	0.1486
	TCSH(A3)	0.063	0.019	3.33	0.0449
	LRS(A5)	0.054	0.284	0.19	0.8612
Chicago	OPCOSTD(B1)	2.075	0.251	8.27	0.0037
	TRSH(B2)	0.934	0.208	4.49	0.0109
	TCSH(B3)	0.145	0.025	5.69	0.0047
	LRS(B5)	0.054	0.284	0.19	0.8612
Atalanta	OPCOSTD(C1)	2.075	0.251	8.27	0.0037
	TRSH(C2)	0.521	0.176	2.96	0.0415
	TCSH(C3)	0.165	0.028	7.57	0.0016
	LRS(C5)	0.054	0.284	0.19	0.8612
Dallas	OPCOSTD(F1)	2.075	0.251	8.27	0.0037
	TRSH(F2)	0.175	0.074	2.37	0.0771
	TCSH(F3)	0.055	0.010	5.50	0.0053
	LRS(F5)	0.054	0.284	0.19	0.8612

System weighted M.S.E is 9.6497 with 21 degrees of freedom.
System weighted R-square is 0.8455.
Note the Non-significant Intercept terms have been omitted.

Dallas

$$\text{MTRD} = F_1(\text{OPCOSTD}) + F_2(\text{TRSH}) + F_3(\text{TCSH})$$

Panhandle/Hereford Truck Rate Analysis

The Panhandle/Hereford subregion shipped vegetables in 1979 and 1980. Potatoes and dry onions were shipped during 1981–1984. In 1984, potato and dry onion shipments were reported from the Hereford region alone. Because Hereford is located within the Panhandle subregion, the Hereford data are assumed to be part of the data for the Panhandle/Hereford subregion. There were very few observations in each category, so all types of produce were combined together in modeling the truck rates.

The rates for Denver and for Los Angeles were not consistently reported (especially those for Los Angeles), so these destinations were eliminated from the analysis. The statistically significant explanatory variables and their estimated parameters, standard errors, *t* values, and corresponding probability values are presented in Table 5.

From the analysis, it can be observed that the truck rates are dependent on the operating costs of the trucks, the total volume of shipments from the subregion itself, and on the volume of shipments from competing subregions. The final system model modification is as follows:

New York

$$\text{MTRD} = A_1(\text{OPCOSTD}) + A_2(\text{TRSH}) + A_3(\text{TCSH}) - A_5(\text{LRS})$$

Chicago

$$\text{MTRD} = B_1(\text{OPCOSTD}) + B_2(\text{TRSH}) + B_3(\text{TCSH}) - B_5(\text{LRS})$$

Atlanta

$$\text{MTRD} = C_1(\text{OPCOSTD}) + C_2(\text{TRSH}) + C_3(\text{TCSH}) - C_5(\text{LRS})$$

Dallas

$$\text{MTRD} = F_1(\text{OPCOSTD}) + F_2(\text{TRSH}) + F_3(\text{TCSH}) - F_5(\text{LRS})$$

TABLE 5 ESTIMATED SUR COEFFICIENTS FOR TRUCK RATES: PRODUCE FROM HEREFORD/PANHANDLE

Destination	Variables	Parameter Estimate	Standard Error	t-Ratio	Prob≤|t| (alpha)
New York City	OPCOSTD(A1)	4.957	0.140	35.31	0.0001
	TRSH(A2)	0.339	0.044	7.80	0.0001
	TCSH(A3)	0.245	0.008	31.09	0.0001
	LRS(A5)	-0.145	0.043	-3.42	0.0051
Chicago	OPCOSTD(B1)	4.957	0.140	35.31	0.0001
	TRSH(B2)	0.162	0.021	7.78	0.0001
	TCSH(B3)	0.106	0.004	22.82	0.0001
	LRS(35)	-0.145	0.043	-3.42	0.0051
Atalanta	OPCOSTD(C1)	4.957	0.140	35.31	0.0001
	TRSH(C2)	0.160	0.026	6.15	0.0001
	TCSH(C3)	0.110	0.005	20.66	0.0001
	LRS(C5)	-0.145	0.043	-3.42	0.0051
Dallas	OPCOSTD(F1)	4.957	0.140	35.31	0.0001
	TRSH(F2)	N.S	N.S	N.S	N.S
	TCSH(F3)	-0.015	0.004	-3.95	0.0019
	LRS(F5)	-0.145	0.043	-3.42	0.0051

System weighted M.S.E is 29.2999 with 54 degrees of freedom.
System weighted (modified) R-square is 0.9596
N.S - Not Significant
Note the Non-significant Intercept terms have been omitted.

New Mexico: Truck Rate Analysis for Dry Onions and Lettuce

The major commodities shipped from the New Mexico subregion are dry onions and lettuce. Because the USDA rate data do not explicitly distinguish between these two crops, they are not analyzed separately. In general, produce shipments have been reported from New Mexico to all of the major destinations, but not for all years. For example, truck rates were not reported for service from New Mexico to Los Angeles for 1982 or 1983, and truck rates to Denver are not available for 1981 or 1982. Because there was a negligible number of observations for Los Angeles, that destination was omitted from the analysis. The statistically significant explanatory variables and their estimated parameters, standard errors, *t* values, and corresponding probability values are presented in Table 6.

In general, the truck rates to the various destinations depend mainly on the operating costs of the trucks and the volume of shipments from competing subregions. To increase the supply of trucks, the truck rates offered in New Mexico must be increased in comparison to the rates offered in the Texas subregions. As the volume of shipments from Texas increases (Texas accounts for ~95 percent of all produce shipments from the Southwest), the supply of trucks to New Mexico can generally be expected to decrease, if all other factors remain constant.

The final specification for the system of equations for various shipments to destinations from the New Mexico subregion is as follows:

New York

$$\text{MTRD} = A_0 + A_1(\text{OPCOSTD}) - A_3(\text{TCSH}) - A_5(\text{LRS})$$

Chicago

$$\text{MTRD} = B_0 + B_1(\text{OPCOSTD}) - B_3(\text{TCSH}) - B_5(\text{LRS})$$

Atlanta

$$\text{MTRD} = C_0 + C_1(\text{OPCOSTD}) - C_3(\text{TCSH}) - C_5(\text{LRS})$$

Denver

$$\text{MTRD} = D_1(\text{OPCOSTD}) - D_3(\text{TCSH}) - D_5(\text{LRS})$$

TABLE 6 ESTIMATED SUR COEFFICIENTS FOR TRUCK RATES: DRY ONIONS AND LETTUCE FROM NEW MEXICO

Destination	Variables	Parameter Estimate	Standard Error	t-Ratio	Prob≤|t| (alpha)
New York City	INTERCEPT(Ao)	606.692	72.67	8.34	0.0011
	OPCOSTD(A1)	13.243	0.829	15.98	0.0001
	TCSH(A3)	-0.271	0.048	-5.55	0.0052
	LRS(A5)	-1.632	0.091	-17.93	0.0001
Chicago	INTERCEPT(Bo)	339.418	52.63	6.45	0.0030
	OPCOSTD(B1)	13.243	0.829	15.98	0.0001
	TCSH(B3)	-0.249	0.031	-8.07	0.0013
	LRS(B5)	-1.632	0.091	-17.93	0.0001
Atalanta	INTERCEPT(Co)	288.229	43.21	6.67	0.0026
	OPCOSTD(C1)	13.243	0.829	15.98	0.0001
	TCSH(C3)	-0.228	0.021	-10.87	0.0004
	LRS(C5)	-1.632	0.091	-17.93	0.0001
Denver	OPCOSTD(D1)	13.243	0.829	15.98	0.0001
	TCSH(D3)	-0.132	0.022	-5.93	0.0041
	LRS(D5)	-1.632	0.091	-17.93	0.0001
Dallas	OPCOSTD(F1)	13.243	0.829	15.98	0.0001
	TCSH(F3)	-0.169	0.027	-6.15	0.0035
	LRS(F5)	-1.632	0.091	-17.93	0.0001

System weighted MSE is 11.8426 with 28 degrees of freedom.
System weighted R-square is 0.8328.

Dallas

$$MTRD = F_1(OPCOSTD) - F_3(TCSH) - F_5(LRS)$$

Summary of Model Interpretation

The results of this research demonstrate that the determinants of truck supply are not uniform across all the destination cities. Furthermore, truck rates within a single region tend to be more sensitive to trucking volumes in competing subregions when the commodity that is being shipped is not highly perishable. The strong relationship between price and quantity of truck services supplied (as measured by truckloads of produce shipped) indicates that in a competitive market, truckers seem to allocate their equipment efficiently in response to rate signals. Unregulated truck service supply appears to respond to fluctuations, thus confirming that the truck service market follows the traditional micro-economic model of a market. This result implies that in the existing unregulated truck service market, buyers can purchase services efficiently through competitive price signals.

CONCLUSIONS

The determination of the responsiveness of the supply of produce transportation providers to price signals provides a better understanding of the transportation system at the regional and, possibly, at the national level. The insight into the transportation service market supplied by this research should provide transportation policy makers with knowledge of the relative health of competitive transportation markets. Similar research on a national level is also likely to reinforce these findings on the allocation of truck services in the Southwest region.

Other policy implications are related to USDA's continuous attempts to improve agricultural transportation systems. Better knowledge of the mechanics of the market will aid USDA and state departments of agriculture in advising produce shippers of the national transportation picture.

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