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PROCEEDINGS —

Twenty-third Annual Meeting

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T R F

TRANSPORTATION RESEARCH FORUM

PROCEEDINGS —
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TRANSPORTATION RESEARCH FORUM

An Analysis of Rate Variation Across Time For Identical Hauls of Unregulated Commodities

by Richard Beilock and J. Scott Shonkwiler**

TRANSPORTATION accounts for a large and growing proportion of the delivered costs of agricultural and non-agricultural goods in the U.S. Accordingly, understanding the determinants of transportation costs and rates has become a matter of widespread concern.

Many shippers rely almost exclusively upon one mode to ship a fixed set of commodities to a largely unchanging set of destinations. If unregulated, rates for these movements may vary significantly within short time periods as the underlying demand and supply conditions change. In such situations, explanations of freight rate variations based upon distance, commodity type, and intermodal competition are of little or no use. However, much of the transportation research to date has been directed at explaining the impact of distance, commodity type, and intermodal competition on annual or monthly average rate levels [e.g., Benishay and Whitaker (1966), Boles (1980) and Miklius (1967)]. While such studies have made significant contributions, their findings are of little use in explaining short term rate fluctuations faced by shippers for one commodity, employing one mode, and shipping between the same points.

This dearth of work is due in part to a lack of sufficient data, and to the fact that most rates for nonagricultural goods were rigidly regulated. With recent moves to increase rate setting flexibility, such as the "zone of rate freedom" of the Motor Carrier Act of 1980, the need increases for an understanding of rate variations over short intervals for identical shipments. For example, produce shippers generally have few choices with respect to mode, and little, if any choice with respect to shipping points. In the case of produce truck movements, a substantial amount of detailed weekly data on rates and load availabilities has been collected in recent years by the Agricultural Marketing Service of the USDA. Our analysis is directed toward explaining the weekly evolution of rates for hauling identical products to the same destination. An econometric model of freight rate determination is formulated to explain transportation rates for tomatoes, sweet corn, and grapefruit shipped from Florida to New York and the empirical findings are presented and discussed.

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PRODUCE TRANSPORTATION BACKGROUND

As with many agricultural products, the production of fresh fruits and vegetables for U.S. markets has gravitated away from consumption centers into specialized regions with more favorable climates such as California, Florida, Texas, the Pacific Northwest, and Mexico. While on-site production costs are generally lower in these regions, their remoteness from markets has elevated the importance of the transportation system. The perishable and fragile nature of produce requires that the transportation system be fast, possess specialized equipment, and be able to adapt to the seasonal fluctuations of production. For the most part these requirements have been best met by the trucking industry. Outside of California and the Pacific Northwest, trucking normally accounts for in excess of ninety or even ninety-five percent of all interstate produce shipments. For these regions in particular there is no viable alternative. Therefore, competition for hauls must be viewed as being among trucks rather than between trucks and another mode.

Produce freight rates for identical shipments may vary widely over the course of a season or even over a few weeks. Fluctuations in rates of several hundred dollars per truckload are not uncommon over a two or three week span of time, see Figure 1. Information about how and why these rates move in this way would be of obvious value to produce growers, shippers and carriers.

MODEL FORMULATION

The demand for transport services may be viewed as being determined by the margin or residual between the pri-

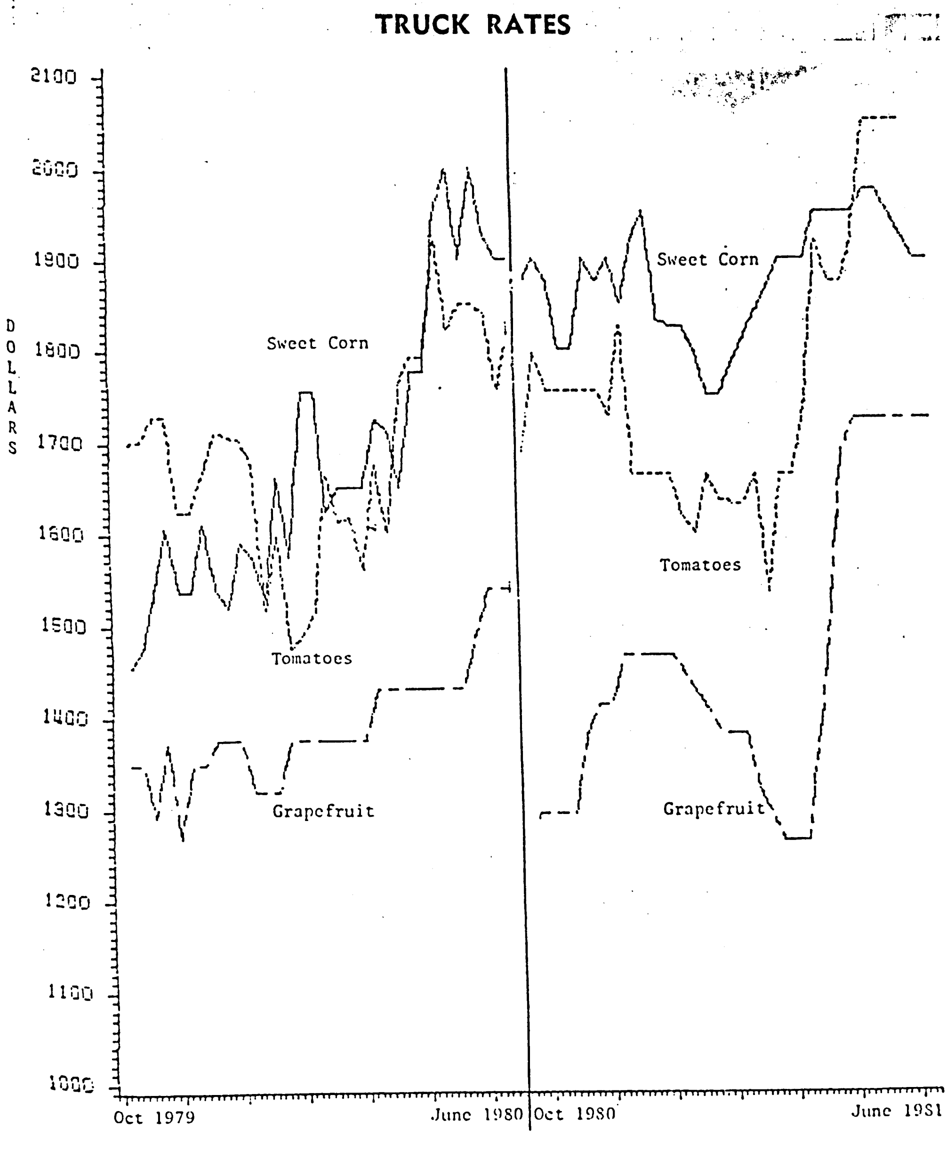

FIGURE 1

Weekly Truck Rates from Florida to New York City for Sweet Corn, Tomatoes and Grapefruit — Oct. 1979 to June 1980 and Oct. 1980 to June 1981.

mary (farm level) and retail prices. The farm and retail prices are determined by the quantity shipped (Q), marketing costs, and demand shifters at the retail level such as personal income. Due to the perishable nature of the commodities under analysis and the lag between planting and harvesting (Q) may be viewed as being predetermined and equal at all marketing levels. In the context of a weekly model, it is doubtful that most marketing or demand shifters would exhibit sufficient variation to affect the results.

On the supply side the price necessary to bring forth the desired quantity of transport, Q, depends upon the opportunity costs of alternative uses, the opportunity costs of not offering service at all, i.e., the variable input costs, and capacity considerations. Capacity is meant to include both vehicle capacity and system capacity. Vehicle capacity relates to the availability of sufficient numbers of trucks to handle the required or desired freight. System capacity refers to the ability of terminal facilities to handle produce as well as information costs arising from the need to divert vehicles in the system to adapt to unusually high or low volumes.

The price of transport services in a region may be viewed as being determined by the interaction of the regional supply and demand curves, which suggests the development of a structural model. However, in the present context interest centers on explaining short term produce shipping rates, therefore a simpler reduced form equation is proposed to capture the essential features of a structural model without introducing unnecessary complexity:

$$P_t = P(P_t, QR_t, QC_t, VC_t, w_{it})$$

where:
- P = transportation rate to a certain destination
- Q = product quantity shipped
- QR = quantity of all (perishable) commodities shipped from the region
- QC = quantity of all (perishable) commodities shipped from competing regions
- w_i = a variable input cost
- V = value of product being shipped.

The model explicitly relates the regional truck rate for a commodity to the volume of the commodity shipped, the total amount shipped from the region, the amount shipped from competing regions, and variable input costs of trucking.

Quantities are specified as being predetermined for two reasons. First, as previously noted, the lag between planting decisions and harvest as well as the highly perishable nature of the commodities allows the quantities produced and shipped over a week to be treated as being both equal and exogenous. Secondly, note that the dependent variable is the produce truck rate to a single fixed destination, rather than an average aggregate rate which would be more likely to be simultaneously related to quantities shipped **in toto.**

It is expected that as QR increases, P increases, **ceteris paribus.** This follows because as QR rises added pressure is being placed on the supply of trucking services, thereby bidding up prices. For similar reasons, QC and P would be expected to be positively correlated. However, as Q rises P may rise or fall. With QR controlled for, the net effect of changes in Q will depend upon the convenience or inconvenience associated with shifting capacity to or from the commodity. For example, if straight, i.e. nonmixed, loads are desirable, then Q and P should be negatively related.

Variable input costs include such things as fuel, labor, maintenance, etc. Only diesel fuel costs were specified in the final model. This was done for three reasons. First, some of the costs are not readily available on a weekly basis. Second, other costs, which are available, would not be likely to exhibit sufficient week-to-week variation to affect the results. Finally, fuel costs were felt to be the single most 'visible' cost to those involved in transportation. As rising input costs should shift transportation service supply functions to the left, fuel costs are expected to be positively correlated with P.

The last and most troublesome specification problem is that of determining the proper measure for truck capacity or availability (VC). For perishables, this problem is complicated by the fact that the number of vehicles is both unknown and fluctuating. Independent carriers may temporarily leave the business by leasing for some period to regulated carriers or simply by shutting down. Moreover, regulated carriers are free to haul exempt loads which often provide backhauls for them. As the produce transport industry is unregulated, these occurrences are apt to be recorded.

A crude measure of vehicle availability may be derived by inquiring of truckers as to the amount of time they must wait in order to secure a haul. Just such a procedure is followed in the USDA Office of Transportation "Fruit and Vegetable Truck Rate Report" which is published weekly. For each area a truck adequacy scale ranging from surplus to shortage is reported. The scale is defined as follows:

Surplus (5) Supplies of trucks exceed shippers' needs. Many truckers waiting two or more days for a load, willing to accept loads to undesirable destinations.

Slight Surplus (4) Supplies of trucks slightly exceed shippers' needs. Truckers more selective of destinations, but shippers having little difficulty obtaining trucks to all destinations.

Adequate (3) Supplies of trucks in generally good balance with shippers' needs. Most truckers obtaining a load within 24 hours. Truckers selective, but shippers locating trucks for most orders within 24 hours.

Slight Shortage (2) Supplies of trucks slightly short of shippers' needs. Practically all truckers obtaining loads within 24 hours. Truckers selective and many refusing loads to undesirable destinations. Some orders to less desirable destinations delayed two or more days.

Shortage (1) Supplies of trucks short of shippers' needs. All truckers obtaining loads within 24 hours. Truckers very selective and accepting loads only to preferred destinations. Orders to many destinations delayed two or more days.

It would be expected that the longer the time needed to arrange carriage, the higher the rates. This is true both because of the usual opportunity costs of holding any inventory and, in particular, to the added factor of perishability. The more quickly a product deteriorates over time, the larger the losses resulting from delays in arranging carriage. Therefore, it would be expected that rates would be more responsive to truck adequacy the more perishable the commodity, **ceteris paribus.**

COMMODITY BACKGROUND

Sweet corn, tomatoes and grapefruit are three of the leading produce commodities shipped from Florida and normally account for over one-third of all Florida fresh vegetable shipments and over half of all fresh citrus shipments. Because they are shipped during the same months (late October through June) and are grown predominantly in the southern and central peninsula of Florida, they compete for the same transport services. According to USDA unload data, for all three commodities New York City is the most important single market, which they dominate. Florida normally accounts for around 70, 80 and 90 percent of all N.Y.C. tomato, sweet corn, and grapefruit unloads, respectively. Finally, for all three commodities reliance on truck transportation is complete. Between October 10, 1979 and June 13, 1981, the sample period for the study, truck transport was employed for in excess of ninety-nine percent of all shipments of each commodity from Florida to the continental U.S. and Canada.

In Figure 1 average weekly truck rates from Florida to N.Y.C. for the three commodities during the sample period are presented. At a glance it can be seen that rate levels may change by several hundred dollars over a few weeks. The differences in rate levels and patterns for the three commodities are also of interest, and are thought to be attributable to three major factors. First, a cost of allocating space to one commodity is the loss of opportunity to carry another, incompatible commodity.[1] As sweet corn is not compatible with tomatoes and grapefruit, these costs will be different. Second, the three may be held for different lengths of time, with tomatoes being the most perishable, and grapefruit the least.[2] Third, the average values of the loads differ greatly.[3] Therefore the holding or inventory costs are different.

EMPIRICAL RESULTS

A total of 52 weekly observations were available for the period of analysis. It was decided to estimate the equations as a seemingly unrelated system in order to allow information to be transmitted between equations through the error structure. The short weekly observation periods suggested that serial correlation would be present and should be adjusted for. Maximum likelihood methods were used to estimate the three equation, seemingly unrelated system which, after correcting for serial correlation, was non-linear in the parameters (Kmenta, p. 528). In the absence of clear theoretical guidelines as to the proper specification of the model, particularly with respect to volume or capacity factors, some experimentation was necessary. In this pretesting it was found that out-of-state volumes shipped (QC) did not impact significantly upon any of the commodities, suggesting that the truckers serving Florida on a week-to-week basis are unaffected by the shipping activity in other regions. The results of the estimated models are presented in Table 1.

Two restrictions were imposed on the final model: that the autoregressive processes were the same in each equation ($r_1 = r_2 = r_3$) and that the impacts of fuel costs across commodities were identical ($a_1 = b_1 = c_1$). The first restriction allows a common stochastic process to represent the unexplained variation in each equation. The second restriction requires that the effect of fuel costs be identical across the equations. Considering that the commodities described in the equations are all shipped from the same state to the same city, over the same period of time, and

TABLE 1

Equations

Sweet Corn

$$PC_t = a_0 + a_1 FUEL_t + a_2 QC_t + e_{1t} + r_1 u_{1t-1}$$

Tomatoes

$$PT_t = b_0 + b_1 FUEL_t + c_2 QFL_t + b_3 AC_t + e_{2t} + r_2 u_{2t-1}$$

Grapefruit

$$PG_t = c_0 + c_1 FUEL_t + c_2 QG_t + c_3 QFL_t + e_{3t} + r_3 u_{3t-1}$$

Parameters	Estimated Coefficients	Standard Errors
a_0	154.8**	73.2
$a_1 = b_1 = c_1$	9.651***	2.04
a_2	.206**	.102
b_0	141.*	75.6
b_2	.0498*	.0277
b_3	—13.61	11.4
c_0	82.41	65.0
c_2	—.1884***	.0613
c_3	.4086**	.187
$r_1 = r_2 = r_3$	.750***	.047

Where PC, PT and PG represent the produce truck rates for sweetcorn, tomatoes and grapefruit, FUEL is diesel fuel price in cents per gallon, QC is the total quantity of Florida sweetcorn shipments, QFL is the quantity of total produce shipments from Florida, AC is the adequacy code, QG is the total quantity of Florida grapefruit shipments, and the error structure of the i^{th} equation is of the form $u_{it} = e_{it} + r_i u_{it-1}$, and e_{it} is independently and identically distributed with zero mean and constant variance $_i$.

*—Significantly different from zero at the .01 level
**—Significantly different from zero at the .05 level
***—Significantly different from zero at the .10 level

in similar equipment, these restrictions appeared to be reasonable. Using a likelihood ratio test (Theil, p 396), the hypothesis that these restrictions were consistent with the underlying structure yielded a chi-square statistic of .158 with four degrees of freedom. Thus the null hypothesis cannot be rejected at any conventional level of probability, thereby lending credence to the reasonableness of the restrictions.

The estimated coefficient associated with fuel prices was positive, as expected, and significant at the one percent level. The magnitude of the coefficient (9.651) suggests that exempt truck rates are very responsive to costs or that fuel costs are capturing the effects of other costs as well, or both. Assuming a round trip of 2600 miles and 4.8 miles per gallon, a one cent increase in fuel cost increases trip costs by $5.42 while the estimated coefficient indicated that a one cent increase in per gallon fuel costs results in an increase of $9.65 in the transport rate.

The truck adequacy code was found to be of explanatory value in the tomato equation only but this was not entirely unexpected. The adequacy code indicates the amount of time needed to arrange carriage; therefore it would be expected to be more important the more perishable and valuable the commodity. The coefficient was of the expected sign and of reasonable magnitude (—13.61). As vehicle adequacy goes from shortage to surplus, rates paid to haul tomatoes rise by $54.45, ceteris paribus.

For sweet corn the volume of the

commodity shipped from the region impacts positively upon rates. An increase in sweet corn shipments of one truckload increases rates by approximately $ .20.[4]

The volume of all produce shipped from Florida had a positive impact on tomato and grapefruit transport rates (estimated coefficients of .049813 and .0408602 respectively). Each additional truckload of produce leaving Florida raised tomato and grapefruit rates by between one and two cents.[5] The finding that grapefruit and tomato rates react in similar fashion to changes to total Florida shipments may be due to the fact that they are compatible loads and that grapefruit and tomato shipments together make up a substantial share of total Florida FF&V shipments.

Grapefruit shipment volumes had a negative impact on grapefruit transport rates. The estimated coefficient (—.188432) was significant at five percent level and indicated that for every additional truckload of grapefruit shipped from Florida, rates fall by 7.5 cents, ceteris paribus.[6] This result probably reflects the advantages of hauling straight rather than mixed loads. With larger volumes of grapefruit, fewer carriers may need to incur the costs of making multiple stops with resulting savings being reflected in lower rates. The advantages are particularly important for grapefruit since grapefruit can stand somewhat rougher handling than most other produce, and citrus shippers are less likely than vegetable shippers to have alternative products with which to fill out a mixed load.

Overall the results conformed to expectations. Moreover, the small standard errors of the equations indicated that a large amount of the weekly variations in rates was being explained. The standard errors ranged from $40.06 for grapefruit to $64.09 for tomatoes. In all cases the standard deviations of the dependent variables were two or three times greater.

SUMMARY AND CONCLUSIONS

In this paper the problem of modeling weekly transport rates assuming one mode and one destination point has been discussed. This situation is typical of much if not most of the transportation situations for agricultural products. It was argued that rates may be specified as being functions of quantities shipped within and outside the production region, indicators of vehicle adequacy, and fuel costs.

A model was developed to estimate weekly truck rates from Florida to New York City for sweet corn, tomatoes, and grapefruit. Results were found to be highly uniform across the commodities studied. This finding was expected because of the similarity of the commodities. Finally, the signs and magnitudes of the estimated coefficients were generally in accord with expectations.

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FOOTNOTES

1 One commodity may be incompatible with another in mixed loads if it requires a different temperature range or if it respires gases which are harmful to the other good.

2 Grapefruit may be stored for up to six weeks versus about one week for tomatoes.

3 Assuming 40,000 pound truckloads, the average 1980 farm value of a truckload of grapefruit was about $2,000 as opposed to over $9,000 for tomatoes.

4 The estimated coefficient was .206447 and the unit of measure for corn shipments was 42,000 pounds. Assuming 40,000 pound truck loads, the per load impact on rates would be:
$.206447 * (40,000/42,000) = $.20

5 The unit of measure for Florida shipments in 100,000 pounds. Using calculations analogous to footnote 3, the per truckload rate change would be:
tomatoes : $.049813 * (40,000/100,00) = $.02
grapefruit: $.0408602 * (40,000/100,000 = $.016

6 The unit of measurement for grapefruit shipments was 100,000 pounds. Therefore, a one truckload impact on rates is as follows:
$.188432 * (40,000/100,000) = $.075