MODELING WEEKLY TRUCK RATES FOR PERISHABLES

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The transportation literature reveals several studies that attempt to model freight rates. These efforts are important as they provide insight into rate determinants and consequently assist firms in planning, provide input into transportation policy debates, and are of use in transportation and commodity research. In such studies, freight-rate variations typically are explained by differences in commodity types, competition from alternative modes, and distance (Perkins; Benishay and Whitaker; Binkley and Harrar; Ferguson and Glorfeld; Boles; Miklius). However, when shippers must rely on one mode to ship a very limited mix of goods to one or a few destinations, this approach is of little use in explaining rate variations. The produce industry is a case in point.

Freight rates for identical shipments of these commodities may vary widely over the course of a season or even over a few weeks.[1] Rate fluctuations of several hundred dollars per truckload are not uncommon over a two-or three-week span of time (Figure 1). Information about how and why these rates move over time would be of value to produce growers, shippers, carriers, policy makers, and researchers.

An approach for modeling short-term freight-rate variation is discussed in this paper. The transportation of perishables by over-the-road motor vehicles is employed as an example. A weekly model is formulated to explain transportation rates for tomatoes, sweet corn, and grapefruit shipped from Florida to New York. Empirical findings are presented and analyzed.

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 growing 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. Excluding California and the Pacific Northwest, trucking normally is employed to ship in excess of 90 percent (by weight) of all interstate produce shipments (USDA 1979–1981). For these (non-Pacific) 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.

Sweet corn, tomatoes, and grapefruit are three of the leading produce commodities shipped from Florida. Sweet corn and tomatoes normally account for over one-third of all Florida fresh vegetable shipments, and grapefruit normally comprises over half of all fresh citrus shipments (Florida Crop and Livestock Reporting

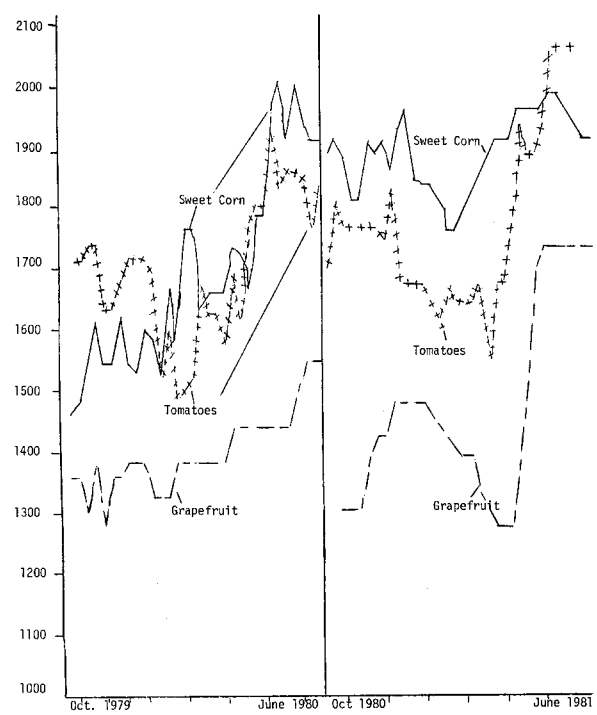

Figure 1. Weekly Truck Rates From Florida to New York City for Sweet Corn, Tomatoes and Grapefruit-Oct. 1979 to June 1980 and Oct. 1980 to June 1981.

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[1] At any given point in time, rates for identical shipments are assumed to be equal across firms and carriers. The highly competitive structure of the produce trucking services market is the basis for this assumption (see Beilock and Fletcher or Pavlovic et al.).

Service 1982a; 1982b). Because the three produce commodities 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. Florida normally accounts for 70, 80, and 90 percent of all the city's tomato, sweet corn, and grapefruit unloads, respectively. Between October 10, 1979, and June 13, 1981, the sample period for the study, truck transport accounted for more than 99 percent of all shipments of each commodity from Florida to the continental U.S. and Canada (USDA 1979–1981).

MODEL FORMULATION AND METHODOLOGY

The price of transportation services is determined by the interaction of the supply and demand relationships. On the demand side, the price (P) which a shipper is willing to pay for transportation services depends upon the costs of foregoing or delaying carriage and the quantity of transport (Q) demanded. These costs are determined by the spread or margin (M) between retail and wholesale prices and the inventory costs (INV) of holding the product

$$(1) \qquad P = D(Q, INV, M).$$

M, in turn, depends upon demand shifters at the retail level such as the prices of complements and substitutes, personal income, and so forth. INV depends primarily upon the value of the commodity and its degree of perishability.[2] Other things being equal, INV is higher the higher the value of the commodities held and the more quickly they deteriorate.

On the supply side, the price necessary to bring forth the quantity of transport, Q, depends upon the opportunity costs of alternative uses (PA), the direct or variable input costs (INP), and capacity considerations (CAP):

$$(2) \qquad P = P(Q, PA, INP, CAP).$$

PA refers to the rates offered for carriage of alternative commodities within the region and for all commodities elsewhere. Naturally, only those commodities which may be legally and physically hauled by the equipment in question need to be considered, at least in the short run. INP includes fuel, labor and maintenance. CAP refers to the availability of sufficient numbers of trucks to handle the required or desired freight. If the available truck capacity is known, this data may be employed directly or with Q controlled in the equation or as a ratio with Q.

In cases where mixed loads may be hauled, due to demands for small lots of individual commodities or to insufficient supplies of individual commodities, load compatibilities must be considered. One commodity may not be compatible with another in mixed loads if it requires a different temperature range or respires gases which are harmful to other goods. A full load of one commodity results in an opportunity cost because the use of that vehicle is denied to any other commodity. The partial loading of a vehicle with a certain commodity has an opportunity cost in addition to that from the direct usage of capacity because the use of the remaining capacity is denied to incompatible commodities. The cost varies among commodities depending upon the value of the carriage and the volumes available of compatible and incompatible loads.

EMPIRICAL ESTIMATION

On the supply side, many carriers compete for freight (prior to Florida deregulation in 1980, in excess of 20,000 carriers were registered with the state to haul exempt goods). On the demand side, prior to deregulation, over 125 truck brokers were registered with the state, accounting for an estimated 48 percent of all trucking arrangements (Pavlovic et al.). The remaining transactions are handled primarily by direct receiver-trucker negotiation. This highly competitive structure suggests that rates are likely to correspond closely to costs. Therefore, P is specified as being a function of observable variables related to M, INV, INP, CAP, and PA.

$$(3) \qquad P = P(M, INV, INP, CAP, PA).$$

Such a reduced form approach to explain rates is common throughout transportation literature (e.g. Binkley and Harrar, Ferguson and Glorfeld, and Perkins).

The direct inclusion of the variables INV, M, and PA would likely result in simultaneous equation bias because these series are jointly determined along with P. To mitigate this problem, corresponding quantities are substituted. Due to the perishable nature of the commodities under analysis and the lag between planting and harvesting, quantities may be viewed as being predetermined and approximately equal at all marketing levels (i.e. quantity harvested = quantity shipped = quantity sold at retail). The assumption that quantities may be considered to be predetermined is common in agricultural research (Heien). The relevant quantities are the quantity shipped of the commmodity in question (Q), the total quantity of all perishables shipped from the region (QR) as well as those from competing regions (QOTH). It was felt that demand shifters, such as personal income, would not exhibit sufficient week-to-week variation to affect the analysis, and, therefore, they were not included.

A somewhat indirect measure of CAP may be constructed from the truck adequacy scale (AC) reported by the USDA in the weekly "Fruit and Vegetable Truck Rate Report." For each area, a truck adequacy scale

[2] INV would also be related to quantities if holding costs are not constant. For example, per-unit carrying costs might be related to quantities due to limited refrigerated storage facilities.

ranging from the surplus to shortage is reported. The scale is defined as follows:

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

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

Adequate 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 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 Supplies of trucks short of shippers' needs. All truckers very selective and accepting loads only to preferred destinations. Orders to many destinations delayed two or more days.

For the purpose of the analysis, a dummy variable (SHORT) was created which assumed the value of 1 if there was a shortage or slight shortage, and zero otherwise. It would be expected that the longer the time needed for shippers to arrange carriage, the higher the rates. Therefore, the expected sign for SHORT would be positive. This follows as such delays indicate that the limits of available trucking capacities are being approached while the demand for carriage is not. The result should be to bid up rates, with the most ardent bidders being those for which the costs of delay are greatest, that is, those with high INV.

Weekly diesel fuel costs (FUEL) were included as the only input cost. Some costs, such as those for labor, maintenance, and equipment, were not readily available on a weekly basis. Moreover, these costs and others which were available, such as interest-rate levels, would not be expected to display sufficient short-term variation to affect the results. Finally, fuel costs were felt to be the single most visible cost of those involved in transportation. For each commodity, the resulting equation to be estimated was:

$$P = P(Q, QR, QOTH, SHORT, FUEL). \quad (4)$$

Where:

P = weekly average truck rates in nominal dollars, USDA (1979–1981)

Q = The weekly shipments of the commodity from Florida to the rest of the U.S. and Canada
tomatoes in 1,000 cwt, USDA (1978–1981);
grapefruit in 1,000 cwt, USDA (1978–1981); and
sweet corn in 42,000-lb units, Federal-State Market News Service (1979–1981).

QR = total weekly produce shipments from Florida in 1,000 cwt, USDA (1978–1981).

QOTH = total non-Florida weekly interstate produce shipments in 1,000 cwt, USDA (1978–1981).

SHORT = Dummy variable indicating a shortage of trucks (see text).

FUEL = weekly U.S. average retail diesel prices in nominal cents per gallon, from weekly average fuel costs maintained internally by the Interstate Commerce Commission.

Weekly shipments by states of origin and destination are not readily available. Therefore, weekly shipments to all destinations were used for Q. As the Northeast normally comprises in excess of 40 percent of the total shipments for these commodities from Florida (USDA 1978-1981), it was felt that this substitution was appropriate. A total of 52 weekly observations were available for the period of analysis.

The equations for the commodities were estimated as a seemingly unrelated system to allow information to be transmitted between equations through the error structure. The weekly unit of observation suggested that serial correlation would be present. Maximum likelihood methods were employed to estimate the three-equation, seemingly unrelated system, which, after correcting for serial correlation, was nonlinear in the parameters (Kmenta, p. 258).

RESULTS

Preliminary regressions indicate that out-of-state volumes shipped (QOTH) did not impact significantly upon any of the commodities, suggesting that truckers serving Florida on a week-to-week basis are unaffected by the shipping activity in other regions, at least in the short run. In some of the final equations, SHORT, QR, or Q were omitted as their inclusion did not add appreciably to the explanatory value of the model, and their removal conserved degrees of freedom without markedly altering the magnitudes of the remaining parameters. The rationales for removal of these variables are explained in the following discussion.

The estimated coefficients associated with the fuel price were positive, and all were significant at the 5-percent level (Table 1). As would be expected, considering that the same equipment and routes are employed to haul the three commodities, the three parameter estimates were not significantly different from one another at any conventional level. The magnitude of the coefficients (8.72, 10.0, and 9.35 in the sweet corn, tomato, and grapefruit equations, respectively) suggests that exempt truck rates are very responsive to this cost or that fuel costs also are capturing the effects of other costs, such as labor and mainte-

Table 1. Results of Seemingly Unrelated Regression Estimation of Weekly Truck Rates from Florida to New York for Sweet Corn, Tomatoes, and Grapefruit: Oct. 1979–June 1981.

Item	Weekly Florida-to-New York Truck Rates (dollars)		
	Sweet Corn b values (std. error)	Tomatoes b values (std. error)	Grapefruit b values (std. error)
Intercept	192.* (111.)	115. (159.)	89.4 (91.5)
Fuel costs (FUEL)	8.72*** (3.39)	10.0** (4.91)	9.35*** (2.80)
Quantity of commodity shipped from Florida	.243*** (.104)	-	-.202*** (.0654)
Truck Shortage Dummy (SHORT)	-	67.1** (29.9)	-
Quantity of produce shipped from Florida (QR)	-	.0270 (.0285)	.0404** (.0196)
Autoregressive[a] parameter	.731*** (.0881)	.775*** (.0963)	.760*** (.0709)
Standard error of the equation (dollars)	59.3	61.4	40.4

[a] The error structure of the ith equation is 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.

Note: * = significantly different from zero at the .10 level.
** = significantly different from zero at the .05 level.
*** = significantly different from zero at the .01 level.
- = omited in final model.

nance, or both. Assuming a round trip of 2,600 miles and 4.8 miles per gallon, a one-cent increase in fuel costs increases gross trip costs by $5.42, while the estimated coefficients indicate that a one-cent increase in per gallon fuel costs results in an increase in the transport rate of between $8.72 and $10.00. This result is important in view of the often-voiced concerns of truckers that they have not been fully compensated for fuel costs increases.

SHORT was found to be of very limited explanatory value in all but the tomato equation. This had not been totally unexpected. SHORT indicates a deficit of trucks as indicated by higher-than-normal amounts of time necessary to arrange carriage. It follows that shippers with more perishable and valuable cargoes (i.e. higher INV) would react more strongly to these delays in that they would be more willing to offer higher rates in order to bid trucks away from competing users. Judging by perishability and value, tomatoes have the highest INV costs of the three commodities. Grapefruit may be stored for up to six weeks, versus roughly one week of sweet corn and tomatoes. A truck-load of tomatoes, sweet corn, and grapefruit would have been worth $8,773, $4,590 and $1,882, respectively, at their average 1980–81 Florida farm value and assuming 40,000-pound truckloads (Florida Crop and Livestock Reporting Service 1982a; 1982b). Based upon the preliminary results and the above rationale, SHORT was dropped from the sweet corn and grapefruit equations in the final model. The estimated coefficient for SHORT in the tomato equation was of the expected sign, of reasonable magnitude (−67.1), and was significant at the 5-percent level. The coefficient indicates that, *ceteris paribus,* carriers receive $67.07 more per load if trucks are in short supply.

The volume of all produce shipped from Florida (QR) had a positive impact on tomato and grapefruit transport rates (estimated coefficients of 0.0270 and 0.0404, respectfully). The coefficient in the grapefruit equation was significantly different from zero at the 5-percent level of probability. That for tomatoes was of a relatively low level of significance; however, its inclusion was felt to be theoretically justified, and its omission altered the magnitude of some of the remaining parameters. These results indicate that each additional truckload of produce leaving Florida raises tomato and grapefruit truck rates by between one and two cents.[3] The finding that grapefruit and, to a lesser degree, tomato rates respond to changes in total Florida shipments may be due to the fact that they are compatible loads and that the compatibility group in which these commodities belong make up a substantial share of total Florida produce shipments, approximately 45 percent by weight (USDA 1978–1981).

Sweet corn, on the other hand, is compatible with a comparatively small group of commodities, accounting for roughly 8 percent of all Florida shipments (USDA 1978–1981). As such, the relationship between total shipments and sweet corn and shipments compatible with sweet corn would be slight. Therefore, the contribution of total Florida shipments to explaining sweet-corn truck rates depends upon the ability of other commodity shippers to bid truckers away from sweet-corn hauls. Preliminary regressions indicated that total Florida produce shipments did not add to the explanatory power of the sweet-corn equation and that its omission did not noticeably alter the remaining parameters. This may indicate that certain truckers tend to concentrate on sweet corn. On the assumption that this result does indicate a short-run reluctance on the part of truckers to switch commodity or, at least, compatibility group, the variable was omitted from the sweet corn equation.

The volume of sweet corn shipped from the region, Q, impacted positively upon rates. The estimated coefficient (0.243) was significantly different from zero at the one-percent level. Therefore, an increase in sweet-corn shipments of one truckload increases rates by $0.23 per load.[4] Preliminary regressions showed that tomato-shipment volumes did not contribute to the explanatory value of the tomato truck equation. Considering the large proportion of total Florida produce shipments with which tomatoes are substitutes in transport (that is, are compatible), it was felt that total produce volumes shipped from Florida, rather than those for tomatoes alone, had captured the impacts of quantity. That is, the total volume of the mixed goods available for haul, rather than that for tomatoes alone, are most important. Conclusive data is not available regarding the proportion of mixed and straight tomato loads. However, as tomatoes are valuable and highly

[3] Asssuming 40,000-lb truckloads:
tomatoes - $.027 × (40,000/100,000) = $.010
grapefruit - $.0404 × (40,000/100,000) = $.016

[4] Assuming 40,000-lb truckloads:
$.243 × (40,000/42,000) = $.231

perishable, it would seem likely that receivers would favor small lots, and encourage mixed-load deliveries. Given the preliminary results, and the above reasoning, the quantity shipped of tomatoes was omitted in the final model.

Grapefruit shipment volumes had a negative impact on grapefruit transport rates. The estimated coefficient (−0.202) was significant at the one-percent level, indicating that for every additional truckload of grapefruit shipped from Florida rates fall by 8.0 cents, *ceteris paribus*.[5] This seemingly contradictory result may reflect 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 the 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 are vegetable shippers to have a variety of commodities with which to fill out a mixed load. In addition, certain fungicides (such as biphenyl) used on grapefruit and other citrus may affect the taste of other commodities. Finally, since grapefruit has a long shelf life and is of low value per pound relative to most other produce, the costs to receivers of accepting and storing full truckload lots are comparatively low.

Overall, the results are reasonable. Moreover, the small standard errors of the equations indicate that a large amount of the weekly variations in rates was being explained. The standard errors of the estimated models range from $40.40 for grapefruit to $61.40 for tomatoes. In all cases, the standard deviations of the dependent variables were two to three times greater.

SUMMARY AND CONCLUSIONS

The problem of modeling weekly transport rates assuming one mode and one destination point has been discussed in this paper. This situation is typical of the transportation requirements for agricultural perishables. It was argued that rates may be specified as being functions of quantities shipped within and outside the production region, indicators of vehicle and system adequacy or capacity, and fuel costs.

A model was developed to estimate weekly rates from Florida to New York for sweet corn, tomatoes, and grapefruit. The inability of out-of-state quantities shipped to explain rates for any of the commodities suggests that truckers are not very responsive to demands from other regions, at least in the short run. As expected, the most perishable and valuable crop (tomatoes) proved to be the most sensitive to vehicle adequacy. Tomato and grapefruit rates responded similarly to total produce quantities shipped from Florida. This was thought to be due to the fact that they are compatible (in mixed loads) with a large percentage of all Florida produce. Finally, as would be expected, rates for all three commodities responded positively to changes in fuel costs. The magnitude of the relationship suggests that, contrary to the beliefs of many carriers, truckers in unregulated markets are fully compensated for fuel cost increases.

[5] Assuming 40,000-lb truckloads:
$\$-.202 \times (40{,}000/100{,}000) = \$-.080$.

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