Explaining Truck Rate Variations for Produce Shipped to the Northeast

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Models are developed to examine the determinants of weekly truck rates for produce shipped to the Northeast from California and Florida. In the empirical work, a large proportion of the variation in rates is explained and the estimated parameters are generally consistent with a priori expectations. The total quantity of produce shipped from each state, the proportion of this total which is compatible with the commodity in question, and the F.O.B. price if the commodity were found to be the most important determinants of truck rate levels. Fuel costs have a surprisingly weak influence, at least in the short run, and for Florida origin commodities the truck rate-fuel cost relationship appears to have weakened over the 1979–1983 sample period.

Explaining economic activity over space has long been a major concern of agricultural economists. This topic has taken on increasing importance as various regions of the country have specialized in the production of certain agricultural commodities to be supplied, often over very long distances, to the remaining regions. Interest in spatial economics has also been heightened by the rapid rise in fuel costs over the 1970s, prompting questions regarding possible relocations of production regions closer to consumption points for certain commodities (Christensen (1982), and Dunn (1981)).

In their review of marketing research on economic activity over space, Helmberger, Campbell and Dobson (1981) found well over 100 studies on interregional trade in agricultural products covering virtually all major commodities and several minor ones. Overall, however, they rate the performance of these models as disappointing. In part the failure of the research to explain real world activity is ascribed to simplifying assumptions which virtually all of the models make regarding transportation costs. Transportation costs are customarily assumed to be invariate over extended periods of time or the volumes which are shipped. Obviously such models "reveal little about the agricultural transport market composed of carriers as suppliers, and agricultural shippers and receivers as demanders" (Johnson (1981)). This tangential treatment of the costs of transiting space seems incredible considering that the focus of the work is to explain economic activity across space. One reason for this can be traced to the fact that many of the tools employed to address economic activity over space were developed at a time when most transportation costs were low and fairly stable due to stable fuel costs, low inflation rates, and rigid rate regulation on movements of most goods.[1] Another reason, undoubtedly, is that a fuller treatment of the transportation market would add greatly to the complexity of already complex models, and necessitate the collection of considerably more data. Regardless of the reasons, however, the point remains that the ability to explain economic activity over space will remain severely compromised until the determinants of transportation rates are better understood.

In this paper the determinants of truck rates are examined for produce shipped from California and Florida to the Northeast. Unlike virtually all previous efforts to model transportation rates (e.g., Perkins (1980), Benishay and Whitaker (1966), Binkley and Harrar

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[1] Since the Motor Carrier Act of 1935 the interstate transport by truck of virtually all goods, but unprocessed agricultural commodities, has been subject to economic regulation, including rate regulations which precluded rapid, unexpected changes in rates. Most states have similar statutes. With the Motor Carrier Act of 1980 and subsequent procedural rulings by the Interstate Commerce Commission, however, the rate making process has been considerably liberalized for most goods. This fact enhances the importance of the current research.

(1981), Ferguson and Glorfeld (1981) and Miklius (1967)), in the current study the focus is on explaining rate variations for similar shipments across time, rather than explaining differences between rates for shipments with varying distances and commodities. It is not uncommon for rates for similar shipments of produce (i.e., same origin and destination and same commodity) to vary by ten percent or more from one week to the next and by forty percent over the course of one season (USDA, 1979–1983b). Clearly, any model which assumes these rates to be stable will be wanting.

The current study builds on the work of a previous study, Beilock and Shonkwiler (1983). In that study a model was presented and tested to explain weekly rates for produce. The current analysis is distinguished from the Beilock-Shonkwiler (B-S) study in the following ways:

1. shipments from California to the Northeast, as well as Florida to the Northeast are examined,
2. twice the amount of data is employed (four versus two years of data were available for the current study),
3. the impact on rates of the relative prices of the commodities shipped is examined, and
4. the impact on rates of the availability of compatible loads is explored.

For each origin, the rates to New York City for shipments of the two most important commodities, by weight, are modeled (citrus and lettuce for California, and grapefruit and tomatoes for Florida). The time frame for the analysis is October 1979 through May 1983, and the observations are weekly.

Model Formulation and Methodology

The produce truck transport industry closely approximates a competitive industry in terms of structure and behavior (Beilock and Fletcher (1983), and Pavlovic et al. (1980)). This suggests that rates (P) may be specified as being a function of costs facing carriers.[2] These may be divided into three categories: direct or variable input costs (INP), capacity considerations (CAP), and the opportunity costs of alternative uses (PA). In a competitive setting, price discrimination is not possible. Therefore, the urgency of shipping, from the standpoint of the shipper/receiver would not be considered. However, in 1977 De Vany and Saving argued that in an unregulated, competitively structured market apparent price discrimination might occur if shipper/receiver urgency resulted in their paying for expedited service. To provide such expedited services, carriers would be required to maintain larger-than-normal amounts of excess capacity or, otherwise stated, the average queues or waiting times for carriers would be longer. As compensation for waiting, carriers would require premiums over the rates paid by shipper/receivers with shorter queues. In work with cross-sectional data, Beilock (1983) found that rates did appear to be affected by the urgency of shipping (URG). Therefore, the rate model is specified as:

(1) $$P = P(INP, CAP, PA, URG).$$

Empirical Estimation

To estimate equation (1), it is first necessary to develop measurements for P, INP, CAP, PA, and URG. These are summarized in Table 1 and briefly described below. P is measured in dollars per 40,000 pound truckload. For California, observations were available for every week,[3] while for Florida, the months of June, July, and August, and part of September had no observations owing to the lack of shipments. INP includes such elements as fuel, labor, materials, and capital costs. In the context of a weekly model, however, it is felt that only fuel costs (FUEL) would exhibit sufficient variation.

CAP and PA both relate to the market value of carriage. Unfortunately direct measurements of the number of vehicles in the market or the complete spectrum of rates for alternative shipments are not available. However, several indirect measures or proxies may be specified. It is expected that rates are associated with the volume of the commodity (QC) and of all commodities shipped from the region (QR). Each type of produce may be shipped with some, but, generally, not all other types of produce. Those which can be shipped in the same load are said to be 'compatible.' For the purposes of transportation, then, the volume in a compatibility group may

[2] The use of a reduced form to explain transport rates in common in the literature (e.g. Binkley and Harrar, Ferguson and Glorfeld, and Perkins).

[3] In a few cases rates had to be interpolated for missing weeks.

Table 1. Summary of variables

Element from equation 2	Representation	Definitions and units	Source
Dependent variable	P	Rate per 40,000 pound truckload (dollars)	USDA (1979–1983b)
INP	FUEL	Diesel cost per gallon (cents)	Household Goods Carriers Bureau
	FUELTM	FUEL times a trend term equal to 1 for the first week in the sample period, 2 for the second week, etc.	
CAP, PA	QR	Total produce shipments from Florida (California) (100,000 pounds)	USDA (1979–1983a)
	PCOMPAT	Proportion of total shipped from origin state which is compatible with the commodity[1]	USDA (1979–1983a) and Pavlovic et al.
	SHORT	Dummy variable equal to one if shippers wait longer than carriers to secure carriage and loads respectively, zero otherwise	USDA (1979–1983b)
URG	PRG, PRT	The per hundredweight F.O.B. prices of grapefruit and tomatoes, respectively (Florida only)	Provided by the Florida Crop and Livestock Reporting Service
	RPR	PRG/PRT	
	STRIKE	Dummy variable equal to one if during or within two weeks of the 1983 Independent Truckers' strike, zero otherwise	N/A

[1] The compatibility groupings were modified to reflect the fact that citrus and vegetables are only rarely placed in mixed loads (Beilock and Fletcher).

be more important than the volume of each separate commodity. Indeed, due to the costs and problems involved in storing large volumes of a perishable commodity, receivers generally prefer mixed loads. In Florida, for example, it is estimated that 35 percent of all produce shipments are mixed loads (Beilock and Fletcher (1983)). Given QR, it is expected that the larger the proportion of commodities which are compatible with the commodity in question (PCOMPAT), the lower the rate *ceteris paribus*. This follows because, in addition to the opportunity cost associated with the space on a vehicle taken by a crate of produce, there is an opportunity cost associated with the use of the remaining capacity which is denied to incompatible commodities. As PCOMPAT approaches one, this additional opportunity cost approaches zero.

The closest direct measure available of the extent to which the quantity supplied of trucks is or is not sufficient for the quantity demanded is the adequacy code developed by the Agricultural Marketing Service (USDA, 1979–1983a). This five point scale, from surplus to shortage, gauges the waiting times of carriers and shippers to secure and ship loads, respectively.[4] Within the model, this measure is specified as a single dummy variable (SHORT), equal to one if shippers had to wait longer, on average, than carriers, and zero otherwise.

[4] 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 undesirable 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.

modity price levels, and anticipated price changes. Given the perishability of the commodity, URG would be expected to be positively related to the price level and negatively related to expected price changes. The F.O.B. prices for grapefruit (PRG) and tomatoes (PRT) are, therefore, included as explanatory variables in their respective equations in the Florida system. Unfortunately it was not possible to develop a weekly commodity price expectations model. As URG increases for one commodity relative to others, shippers of that commodity strive harder to outbid other shippers for available vehicles. To capture this effect the ratio of PRG and PRT (RPR) is included in the Florida equations. It was expected that the sign of the associated parameter would be positive and negative in the grapefruit and tomato equations, respectively. Unfortunately, commodity price data were not available for California.

An additional independent variable is included to control for the effects of the 1983 independent truckers' strike. To account for pre and post strike adjustments, a dummy variable (STRIKE) is specified equal to one for the strike period and the preceding and ensuing two weeks, and zero otherwise.

The resulting general form of the equation to be estimated for each commodity is as follows:

$$(2)\quad P = P(\text{FUEL}, \text{PCOMPAT}, \text{QR}, \text{SHORT}, \text{RPR}, \text{STRIKE}).$$

In Table 1 the data sources and definitions of these variables are summarized. The two equations for each origin are estimated as a seemingly unrelated system (i.e., a separate SUR system for each origin). The seemingly unrelated regression specifications are felt to be appropriate as it seems likely that the disturbances would be correlated for the equations associated with commodities shipped over the same period and between the same two points (Kmenta, p. 518). The Durbin-Watson statistic, in preliminary O.L.S. runs, indicated the presence of autocorrelation in the California equations, but not for the Florida equations. A first order serial correlation system was estimated via maximum likelihood methods to correct for this in the California equations. The resulting system was nonlinear in the parameters (Kmenta, p. 258).

The urgency of shipping (URG) depends upon the losses inherent in shipping delays. Such losses depend upon perishability, com-

Results

Tables 2(a) and (b) present the results of estimating the truck rate equations. The parameter estimates presented were derived using a linear functional form in actual numbers. Semi and double log specifications were also estimated, with no gain in the fit of the data or appreciable changes in the signs or obtained significance levels of the estimated parameters. In the absence of any clear theoretical justification for selecting one form over another, the linear form was chosen. In terms of explanatory value, the equations are highly satisfactory with R^2s ranging from .62 for Florida-origin tomatoes to .89 for California-origin citrus.

Fuel

While the estimated parameters associated with FUEL have the anticipated positive sign in three out of four equations, none is significantly different from zero at the .10 level. Assuming 4.5 miles per gallon (Boles (1980)), a one cent increase in FUEL translates into approximately a \$3.40 and \$6.70 increase in one way costs from Florida and California, respec-

Table 2a. Results of seemingly unrelated regression estimation of selected weekly truck rates for produce from California to New York City (dollars per truckload): October 1979–June 1983.

Item	Lettuce	Citrus
Intercept	1071.***	240.6
	(241.6)	(232.6)
FUEL	1.832	10.49
	(2.605)	(10.50)
QR	.3376***	.1696***
	(.03171)	(.06859)
PCOMPAT	−1000.***	167.1
	(238.7)	(427.6)
SHORT	288.9***	337.3***
	(43.29)	(68.40)
STRIKE	16.33	−6.107
	(110.1)	165.3)
Autoregressive parameter	.5124	.8320
	(.0712)	(.0434)
R^2	.79	.89
Number of observations	186	186

Note: Standard errors are in parentheses.
*** Significantly different from zero at the .01 level.

Table 2b. Results of seemingly unrelated regression estimation of selected weekly truck rates for produce from Florida to New York City (dollars per truckload): October 1979–June 1983.

Item	Tomatoes	Grapefruit	Tomatoes	Grapefruit
Intercept	1223.***	1148.***	1060.***	1049.***
	(89.41)	(87.20)	(106.8)	(90.35)
FUEL	.8393	−.5659	2.387***	.8547
	(.7505)	(.6194)	(.9190)	(.7770)
FUELTM			−.005564***	−.004724***
			(.002044)	(.001589)
QR	.07464***	.08279***	.07914***	.08500***
	(.01371)	(.01247)	(.01347)	(.01212)
PCOMPAT	217.4***	−256.4***	274.7***	−275.1***
	(67.92)	(34.59)	(69.96)	(34.12)
SHORT	50.05***	20.15	48.91***	22.08
	(19.14)	(14.79)	(18.74)	(14.37)
STRIKE	55.22*	62.25**	79.62**	84.19***
	(33.80)	(26.95)	(34.16)	(27.05)
PRT, PRG	9.529***	48.16***	10.54***	44.04***
	(3.094)	(14.59)	(3.073)	(14.33)
RPR	190.3***	83.72***	169.75***	63.95***
	(44.78)	(22.26)	(44.01)	(22.47)
R^2	.62	.78	.64	.80
Number of observations	128	128	128	128

Note: Standard errors in parentheses.
*** Significantly different from zero at the .01 level.
** Significantly different from zero at the .05 level.
* Significantly different from zero at the .10 level.

tively. Therefore, only the point estimate for California-origin citrus is of a magnitude (10.49) which would indicate that carriers recoup completely the costs of a fuel cost increase. These results have important policy implications, as carriers, and, in particular, owner-operators have been quite vocal in asserting that the unregulated market does not allow them to recover fully fuel cost increases.

The results for FUEL were at variance with those of the B-S study, where rates were found to be strongly and positively affected by FUEL. This suggests that over time the responsiveness of P to FUEL has declined. To investigate this, the Florida equations were rerun with the addition of a new variable which was an interaction term between FUEL and time (FUELTM), see Tables 1 and 2(b). In this run and in both equations the estimated parameters for FUEL are positive and considerably larger than previously (and significant at the .01 level in the tomato equation), while those for FUELTM are negative and significant. These results are consistent with the hypothesis that the FUEL-P relationship has weakened since 1979. It should be noted, however, that during the first two years of the sample period fuel prices rose, while they were stable or falling over the last two years. Therefore, these results may reflect asymmetric responses to rising and falling fuel costs or otherwise be an artifact of the differences in the behavior of FUEL in the two periods. Similar runs for the California equations (not shown), however, reveal no such relationship as the parameter associated with FUEL remains essentially unchanged, while those associated with FUELTM are of very small magnitude and highly insignificant.

One possible explanation for the apparent weakening of the FUEL-P relationship in Florida is that the reemergence of rail competition since 1981 has progressively limited the ability of truckers to pass fuel and fuel-related cost increases on to shippers. From 1979 to 1981, the sample period of the B-S study, trailer-on-flatcar produce shipments from Florida fell from 866 to 757 1,000 hundredweight, but from 1981 to 1983 they rose threefold to 2,263 1,000 hundredweight (Federal-State Market News Service). In California rail shipments of produce were important and were growing steadily over the entire 1979–1983 period. Therefore, it is not surprising that the FUEL-P relationship in California has remained largely unchanged over the sample period.

In every equation the parameter estimate associated with QR is positive, as expected, and significant at the .01 percent level. In California, for every additional 40,000 pound truckload of produce shipped, rates are estimated to rise by $.135 and $.068 for lettuce and citrus, respectively. In Florida (employing the equations not including FUELTM) for every additional 40,000 pound truckload, rates are estimated to rise by $.030 and $.033 for tomatoes and grapefruit, respectively.[5]

Proportion of Compatible Produce (PCOMPAT)

For the California system, the parameter estimate associated with PCOMPAT is negative, as expected, and significantly different from zero at the one percent level for lettuce. As the percentage of the total amount of produce shipped from California which is compatible with lettuce increases by ten (i.e. PCOMPAT increases by .1), per truckload rates fall by $100. Presumably this reflects the reduced opportunity costs associated with filling out a mixed load containing lettuce. In the citrus equation, however, the estimated parameter is positive (167.1), but insignificantly different from zero at conventional levels.

In the Florida system the appropriate parameters in each equation are significant at the .01 percent level and of roughly the same magnitude. However, while the parameter for grapefruit has the expected negative sign (−256.4), that for tomatoes is positive (217.4). No rationale for the positive P-PCOMPAT relationship in the tomato equation is immediately apparent.

Shortage of Trucks (SHORT)

The estimated parameter associated with SHORT has the expected positive sign in all of the equations, indicating that P increases when vehicles are in short supply. Moreover, except for the Florida grapefruit equation, the parameters were significantly different from zero at the .01 percent level. Judging from the magnitudes of the t-ratios, SHORT was of greater importance in the California system (6.67 and 4.93 for California lettuce and citrus, respectively, and 2.61 and 1.36 for Florida tomatoes and citrus, respectively). These differences are thought by the authors to reflect the fact that delays in shipping of a perishable are more critical when the transit times are longer.

Independent Truckers' Strike (STRIKE)

From January 31, 1983 to February 10, 1983 the Independent Truckers' Association staged a strike in protest to recently increased federal road use and fuel taxes. According to various news services and other information, the strike appeared to be limited largely to the East Coast. Considering this, it is not surprising that the parameters associated with STRIKE are only significant, at conventional levels, in the Florida equations. For tomatoes and grapefruit, respectively, P is $55.22 and $62.25 higher during and immediately before and after the strike period, *ceteris paribus*—approximately a four percent increase over average rate levels. It cannot, however, be inferred that this represents the true extent of the effect on P of the strike. In a recently completed study, it was found that, due to hoarding, the quantity of produce demanded and delivered actually increased during the strike period, and decreased briefly, in compensation, immediately thereafter (Beilock, Comer, and Butler). Therefore, the full impact of the strike on P is that reflected in the parameter associated with STRIKE plus changes resulting from strike-induced aberrations in QR.

Commodity Prices (PRG and PRT, and RPR)

Earlier, it was hypothesized that F.O.B. prices could be employed as an imperfect proxy for shipping urgency, and that rates for a commodity would increase as the urgency of shipping for that commodity increased relative to other commodities. To capture this effect the F.O.B. per hundredweight prices for grapefruit (PRG) and tomatoes (PRT) are employed in their respective Florida equation. Additionally, in both equations the ratio of

[5] The estimates for rate response per 40,000 pound truckload were calculated as follows:

	response/ 100,000 pounds (from Tables 2a & 2b)	*	40,000/ 100,000	=	rate responses/ truckload
California lettuce	$.3376	*	.4	=	$.135
California citrus	$.1696	*	.4	=	$.068
Florida tomatoes	$.07464	*	.4	=	$.030
Florida citrus	$.08279	*	.4	=	$.033

these prices (RPR = PRG/PRT) is included. Similar data, however, was not available for the California commodities.

In both equations the commodity's F.O.B. price exerts a positive influence on P, as expected. The estimated parameters associated with PRG and PRT are significant at the .01 level. The results with respect to the relative prices (RPR), however, are mixed. In the grapefruit equation the parameter estimate (83.72) is positive and significant at the .01 level. This is as expected as it indicates that grapefruit rates rise as the price of grapefruit rises relative to tomatoes. In the tomato equation, however, the parameter estimate (190.3) is also positive and significant at the .01 percent level. This indicates that tomato rates also rise as the price of grapefruit rises relative to tomatoes—an unexpected result. It may be that this variable is also capturing some seasonal effect. However, no satisfactory explanation for the results in the tomato equation can be offered.

Summary and Conclusions

This paper presents the model and results of a study of the determinants of rate levels for produce shipped from California and Florida to the Northeast. Weekly models are developed for California-origin lettuce and citrus, and Florida-origin tomatoes and grapefruit. The equations for each state are estimated as seemingly unrelated systems. The models presented in this paper explain much of the week-to-week variation in produce truck rates from California and Florida to the Northeast (the R^2's ranged from .62 to .89). Moreover, the majority of the estimated relationships are of the expected sign and of reasonable magnitude.

The estimated parameters associated with FUEL are positive, as expected in all but one equation, but all are statistically insignificant. The results of reestimating the Florida system with the inclusion of an interaction term between FUEL and time suggest that the FUEL-rate relationship has weakened over the 1979 to 1983 sample period. This may be due to increasing competition from railroads during the study period.

The total volume of produce shipped from each state is found to have a strong and positive influence on rates. In three of the four equations the proportion of those shipments which are compatible with the commodity strongly affects the rate for that commodity. It was hypothesized that as the proportion of compatible commodities rose, the opportunity costs associated with completing partial loads would fall, resulting in a negative relationship between this variable and rates. However, in one of these equations, that for Florida-origin tomatoes, the parameter sign is positive, which is contrary to expectations.

Both the measures for vehicle shortage (SHORT) and the dummy variable for the period surrounding the 1983 independent truckers' strike (STRIKE) have positive impacts on rates in all equations. As expected the impact of SHORT is greater for California-origin commodities, while that for STRIKE is greater for Florida-origin commodities.

In the Florida equations, the F.O.B. grapefruit and tomato prices are employed to proxy the urgency of shipping the commodities. The results indicate that, as expected, truck rates are positively influenced by F.O.B. prices. Moreover as the F.O.B. price of grapefruit rises relative to tomatoes, truck rates for both grapefruit and tomatoes rise. This result had been expected for grapefruit, but not for tomatoes.

This work should be viewed as exploratory in nature as little work on short term rate variation has been done. Further research needs to be focused on deriving improved measures of shipping urgency, capacity, and alternative activities available to carriers. Moreover, development of a structural model, with explicit demand and supply functions, would likely reveal much about the operation of transportation markets. This, in turn, could be employed to enhance our ability to explain economic activity over space.

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