DEREGULATION AND RAIL-TRUCK
COMPETITION

Evidence from a Translog Transport Demand Model for Assembled Automobiles

By Kenneth A. Lewis* and David Paul Widup†

In this paper we estimate a translog transport-demand model to measure price and quality-of-service demand elasticities for rail and motor carrier shipments of assembled automobiles. Empirical models which measure the responsiveness of shippers to changes in relative prices and in service characteristics are critical in the evaluation of public policy decisions leading to lower freight charges and/or better quality service. For example, public policy in the United States on freight transport is undergoing substantial revision. Recent deregulation of motor carriers has allowed easier entry and more discretion over rates and ratemaking; and the reforms embodied in the Staggers Rail Act help to remove barriers to improving the quality of rail service, and may pave the way for some future reduction in rail costs. Once it has been determined how far such policies affect freight charges and/or quality of service, empirical demand models can be used to assess their impact on the distribution of traffic.

Recently, cross-section models of qualitative choice (e.g., logit, probit) have been used to generate own and cross-mode price elasticities, partly as a means of avoiding the long-recognised lack of time series data on potentially important non-rate variables. Oum (1979a) has argued that linear logit models are not appropriate for estimating the price responsiveness of demand and simulating traffic allocation across modes; he suggests using more flexible forms, such as translog, generalised Leontief, and generalised quadratic functions. Oum (1979b, 1979c) and Spady and Friedlaender (1977, 1978) have estimated translog models on both time-series and cross-section data over various groupings of commodities. A unique feature of this paper is that we concentrate on an individual commodity class, assembled automobiles, the least aggregated group for which we have available both commodity data and a relative abundance of non-rate transport data.1 Assembled automobiles are defined, uniquely,

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1 Past work indicates that as the number of commodities aggregated into a single group increases, transport demand becomes more elastic. For example, see Oum's comment on Spady and Friedlaender (Oum, 1979c, p. 476). In addition, the aggregation of commodities for which certain transport characteristics have varying levels of importance often makes non-rate variables totally insignificant, though for a particular commodity they may be important.
as a special commodity grouping by the ICC; they are carried exclusively by regulated truck and/or motor carriers, which must report annual statistics on tonnage, revenue, and equipment.² The data set used here is therefore unique and cannot be reproduced at the same level of specificity on United States data for other commodities.

Section 1 below presents the basic model. The estimates and their policy implications are shown in Section 2. Appendix A describes the data sources, and Appendix B discusses difficulties in application of the analysis to other commodities.

1. THE TRANSLOG DEMAND MODEL

Oum (1979c) has provided a framework for estimating a system of cost and freight transport-demand functions for the bimodal case. He begins by specifying a general function for a shipper's entire activities in production and distribution; after simplification this function can be expressed for our purposes as

\[ UC = U(P^T, Z) \]  

where \( UC \) is the average freight-cost per auto-mile \( vis-à-vis \) the shipper, \( P^T = [P^t, P_f] \) is a \( 2 \times 1 \) vector of rail and truck freight rates, and \( Z \) is a \( 2 \times N \) matrix of quality attributes of service for each of the two modes.

As noted by Oum, two critical assumptions in the specification of the cost function are (i) that the shipper's production technology is characterised by constant returns to scale in the amounts of both transport services and other (labour, capital) inputs, and (ii) that there is complete and strict separability of transport-related variables from other inputs. The two assumptions together permit equation (1) to be written independently of the level of automobile production and of the prices of other inputs.

The empirical analysis in this paper is limited to the case of two modes (rail and truck) and four quality-of-service attributes, including shipper payments for loss and damage (\( LD \)); average shipment miles per trailer per day (\( MD \))—comparable to Oum's "speed" variable; average length of haul (\( LH \)); and the price of finished automobiles (\( PA \)) as a proxy for inventory carrying costs.³

For purposes of estimation, equation (1) is specified as a translog function. However, the general translog model, and its corresponding equations showing rail and truck revenue shares, produce a simultaneous system containing forty-five independent parameters, for which joint estimation is clearly unrealistic within the context of a time series problem. An attractive alternative, examined by both Oum

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² U.S. Army Corps of Engineers (1976) reports that barges have transported virtually no automobiles in the last ten years. While we have disaggregated with respect to commodity type, we are still aggregating data over heterogeneous links.

³ Much effort was devoted to developing a measure of reliability or transit-time variance, but existing data do not provide the needed information. According to conventional wisdom in the industry, reliability may be more important in the selection of modes than any of the variables included in this analysis.
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(1979c) and Spady and Friedlaender (1978), is to specify the translog model incorporating the quality-of-service variables in the form of hedonic aggregators, under the assumption that quality-of-service attributes affect transport demand only indirectly through their impact on effective freight rates. This would make an appreciable reduction in the number of estimable parameters.

In this inventory-theoretic approach, the quality attributes are viewed as elements in the vector representing generalised shipping prices rather than as a set of technological conditions. Spady and Friedlaender have suggested that the hedonic aggregator to represent the generalised transport price for a particular model, $R$, be written in the form

$$R = P_i \phi(Z_{i1}, Z_{i2}, Z_{i3}, PA), \quad i = 1 \text{ for rail and } i = 2 \text{ for truck}$$

where $\phi$ can be approximated by a translog function. The notation for the two modes is

- $P_i = \text{per-auto-shipped freight-rate of mode } i$
- $Z_{i1} = \text{loss and damage payments of the } i\text{th mode, } LD$
- $Z_{i2} = \text{average shipment miles-per-day of the } i\text{th mode, } MD$
- $Z_{i3} = \text{average length-of-haul of the } i\text{th mode, } LH,$ and
- $PA = \text{the price of assembled automobiles}$

Instead of approximating $\phi$ by a translog function, Oum suggests that the hedonic aggregators for each mode be of a linear, logarithmic form, with the exponent of the price variable at unity as above, i.e.,

$$\theta^i = Z_{i1}^h Z_{i2}^s Z_{i3}^t PA^n$$

Imposing the Hicks-Samuelson symmetry condition and incorporating Oum’s linear, logarithmic hedonic aggregators, the two-mode translog function corresponding to the unit cost function (1) is

$$\ln UC = \ln a_0 + a_1 \ln (P_1 Z_{11}^h Z_{12}^s Z_{13}^t PA^n) + a_2 \ln (P_2 Z_{21}^h Z_{22}^s Z_{23}^t PA^n) + 1/2 [a_{11} \ln (P_1 Z_{11}^h Z_{12}^s Z_{13}^t PA^n)]^2 + a_{22} \ln (P_2 Z_{21}^h Z_{22}^s Z_{23}^t PA^n)]^2 + 2a_{12} \ln (P_1 Z_{11}^h Z_{12}^s Z_{13}^t PA^n) \ln (P_2 Z_{21}^h Z_{22}^s Z_{23}^t PA^n))$$

(2)

where the linear homogeneity and symmetry conditions imply

$$a_1 + a_2 = 1, \quad a_{11} + a_{12} = 0, \quad a_{12} + a_{22} = 0$$

The star notation notes variables expressed as deviations from their means; that is, $\ln X^* = \ln X - \ln \bar{X}$. It is convenient for purposes of estimation to adopt Oum’s convention to approximate the translog model at the unit point. Applying Shepard’s lemma to the cost function, the equation for the rail revenue share, $S_r$, is

\[ S_r = 1 - S_a \]

\[ S_r = \frac{R_1}{R_1 + R_2} \]

\[ S_r = \frac{P_1 Z_{11}^h Z_{12}^s Z_{13}^t PA^n}{P_1 Z_{11}^h Z_{12}^s Z_{13}^t PA^n + P_2 Z_{21}^h Z_{22}^s Z_{23}^t PA^n} \]

4 Consider the special case $R_1 = P_1 Z_{11}^h$. Then $\ln R_1^* = \ln R_1 - \ln R_1 = \ln (P_1 Z_{11}^h) - \ln (P_1 Z_{11}^h)$. Unfortunately, $\ln (P_1 Z_{11}^h) \neq \ln (P_1 Z_{11}^h)$ as a general rule and we cannot write $\ln R_1^*$ in the convenient form

\[ \ln R_1^* = \ln P_1 + \beta_1 \ln Z_{11} - \ln P_1 - \beta_1 \ln Z_{11} = \ln P_1 - \ln P_1 \\
\]

\[ + \beta_1 (\ln Z_{11} - \ln Z_{11}) = \ln P_1 + \beta_1 \ln Z_{11}^* \]

5 The truck revenue-share, $S_r = 1 - S_a$, is fully described by (3) and the homogeneity-symmetry conditions.

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\[ S_i = a_i + a_{1i} \ln \left( \frac{P_i}{P_j} \right) + a_{11}(\beta_1 \ln Z_{11} - \beta_2 \ln Z_{21}) + a_{11}(\gamma_1 \ln Z_{12} - \gamma_2 \ln Z_{22}) + a_{1i}(\eta_1 - \eta_2) \ln PA \]

\[ + a_{11}(\delta_1 \ln Z_{13} - \delta_2 \ln Z_{23}) + a_{1i}(\eta_1 - \eta_2) \ln PA \]  

(3)

Not only is the system of equations (2) and (3) based on the intuitively appealing premise that quality-of-service variables affect the inventory costs of freight transport; it also provides a framework for estimation with more simplified data requirements: that is, the system (2) and (3) has eleven independent parameters to estimate.

Within the context of a time-series demand model, it is necessary to consider the possibility of serial correlation in the disturbances and of a lag in the response of shippers' demands to price changes. Berndt and Savin (1975) have examined the problem of specification and estimation for a system of singular equations with autoregressive disturbances, and Oum (1979b) has applied this methodology to estimating transport share equations. To specify a general, dynamic system for the two share equations, we introduce a 2 × 2 matrix of partial adjustment coefficients, \( \Gamma \), and a 2 × 2 matrix of first-order autoregressive coefficients, \( RH \), which we specify as diagonal to avoid under-identification of these parameters (see Berndt and Savin, 1975). The adding-up condition over the system of share equations implies further that the diagonal elements of \( RH \) and \( \Gamma \) are identical: that is, that there will be a single autocorrelation coefficient (\( \rho \)) and a single partial-adjustment coefficient (\( \lambda \)) for both share equations.\(^6\)

The partial adjustment model for the rail share equation based on (3) is as follows. The rail subscript is dropped for convenience.

\[ S_i^* = a_i + a_{1i} \ln \left( \frac{P_i}{P_j} \right) + a_{11}(\beta_1 \ln Z_{11} - \beta_2 \ln Z_{21}) + \ldots + a_{1i}(\eta_1 - \eta_2) \ln PA + u_i \]

\[ S_i - S_{i-1} = \lambda(S_i^* - S_{i-1}) \]  

(4)

where \( S_i^* \) is the long-run, steady-state share and \( u_i \) is the disturbance term. If, in addition, we assume that \( u_i = \rho u_{i-1} + \varepsilon_i^* \) and \( \varepsilon_i = \lambda \varepsilon_i^* \), where \( \varepsilon_i \) is NID (and the rail and truck \( \varepsilon_t \) are identically distributed), then it follows that

\[ S_i = \lambda(1 - \rho)a_i + \lambda a_{1i}[\ln \left( \frac{P_i}{P_j} \right) - \rho \ln \left( \frac{P_i}{P_j} \right)_{i-1}] + \lambda a_{11}[\ln Z_{11} - \beta_2 \ln Z_{21}] - \rho(\beta_1 \ln Z_{11} - \beta_2 \ln Z_{21}) + \ldots + \lambda a_{1i}(\eta_1 - \eta_2) \ln PA_i - \rho \ln PA_{i-1} \]

\[ + (1 + \rho - \lambda)S_{i-1} + \rho(\lambda - 1)S_{i-2} + \varepsilon_i \]  

(5)

The parameters of the cost function and the share equations can be used to derive estimates of the elasticity of rail-truck substitution and the own and cross-demand elasticities with respect to various components of the transport price. The Allen partial elasticities of substitution are

\[ \sigma_{ii} = \frac{a_{ii} - S_i}{S_i^2} + 1, \text{ for } i = 1, 2 \quad \text{and} \quad \sigma_{ij} = \frac{a_{ij}}{S_i S_j} + 1, \text{ for } i \neq j \]

where \( S_i^* \) is the revenue share predicted by the model. The own and cross

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\(^6\) When these restrictions are not imposed, the ML estimate of the parameters and the likelihood ratio statistics are not invariant to the equation deleted (see Berndt and Savin, 1975).
(compensated) price elasticities of demand for the $i$th mode with respect to the price of the $j$th mode are

$$E_{ij} = \sigma_{ij} S_{pj} 	ext{ for } i, j = 1, 2 \quad (E_{ii} = -E_{ii})^7$$

The demand elasticities with respect to the quality attributes, written as $E^q_{ij}$ (the elasticity of demand for the $i$th mode with respect to the $k$th quality characteristic of the $j$th mode), are

$$E^D_{ij} = E_{ij} \beta_j$$
$$E^{MD}_{ij} = E_{ij} \gamma_j$$
$$E^{H}_{ij} = E_{ij} \delta_j \text{ for } i, j = 1, 2, \text{ and }$$
$$E^{PA}_{i} = E_{ii} \eta_i \text{ for } i = 1, 2$$

2. COEFFICIENT AND ELASTICITY ESTIMATES AND POLICY IMPLICATIONS

Annual data from 1955 to 1975 are used to estimate jointly equations (2) and (3), the static model, and (2) and (5), the dynamic model. The data sources and variable definitions are listed in Appendix A. As noted above, even the more restricted system, containing equations (2) and (3), has eleven independent parameters to be estimated, including eight "quality-of-service" coefficients. When this system is estimated, the service variables, as a group, perform poorly. Only two service coefficients are clearly significant at the 95% level, and the null hypotheses cannot be rejected that the service coefficients as a group are jointly equal to zero, using Theil’s asymptotic likelihood ratio test. We simplify the model by eliminating those variables which are not contributing significantly to its explanatory power, and examine the extent to which its explanatory power is improved by the inclusion of selected service variables.

The estimated coefficients and elasticities for several different specifications are presented in Table 1. The estimated coefficients for the relative price variable, $\alpha_{rt}$, and for the quality-of-service variable for rail average shipment miles-per-day, $\gamma_{ro}$, are significant across the alternative specifications, while the estimates of $\eta_2$ are of borderline significance at the 95% level. In the dynamic form of the model the estimated coefficient of adjustment, $\lambda$, is significant and of reasonable magnitude, while the autocorrelation coefficient, $\rho$, is of borderline significance.

In all five specifications presented in Table 1, the estimated rail and truck price elasticities are less than or very close to one in absolute value, and are roughly half as large again for rails as for trucks. A very striking result is the intramodal stability of the own-price elasticities, whether or not any or all of the quality-of-service variables

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7 These partial elasticities ignore the effect of relative factor price changes upon the price of the commodity and the resulting change in output and factor demand. However, transport costs have been only a minor portion of total costs for finished automobiles. For example, Oum’s (1979c) estimated Marshallian elasticities for the metallic and non-metallic product commodity classifications are very close to the compensated elasticities.

8 Each equation system is estimated by means of the full information maximum likelihood estimator (FIML) from TSP.
### Table 1

**Coefficient and Elasticity Estimates**

(t values in parentheses)

<table>
<thead>
<tr>
<th>Variable</th>
<th>Parameter/ Elasticity</th>
<th>Static Models Equations (2) and (3)</th>
<th>Dynamic Models Equations (2) and (5)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(673.0)</td>
<td>(35.8)</td>
<td>(11.20)</td>
</tr>
<tr>
<td>$a_1$</td>
<td>$0.306$</td>
<td>$-0.494$</td>
<td>$-0.025$</td>
</tr>
<tr>
<td></td>
<td>(3.02)</td>
<td>(2.91)</td>
<td>(0.08)</td>
</tr>
<tr>
<td>$P_R/P_T$</td>
<td>$\alpha_{11}$</td>
<td>$-0.103$</td>
<td>$-0.159$</td>
</tr>
<tr>
<td></td>
<td>(3.02)</td>
<td>(7.33)</td>
<td>(7.72)</td>
</tr>
<tr>
<td>$Z_{13}$</td>
<td>$\gamma_1$</td>
<td>$-1.050$</td>
<td>$-1.050$</td>
</tr>
<tr>
<td></td>
<td>(3.05)</td>
<td>(3.19)</td>
<td>(2.91)</td>
</tr>
<tr>
<td>$PA$</td>
<td>$n_2$</td>
<td>$-0.378$</td>
<td>$-0.533$</td>
</tr>
<tr>
<td></td>
<td>(2.10)</td>
<td>(2.05)</td>
<td></td>
</tr>
<tr>
<td>$\rho$</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\lambda$</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\sigma_{RT}$</td>
<td>1.45</td>
<td>1.67</td>
<td>1.71</td>
</tr>
<tr>
<td>$E_{RR}$</td>
<td>$-0.92$</td>
<td>$-1.03$</td>
<td>$-1.08$</td>
</tr>
<tr>
<td>$E_{RT}$</td>
<td>$-0.52$</td>
<td>$-0.64$</td>
<td>$-0.63$</td>
</tr>
<tr>
<td>$E_{RD}$</td>
<td>$1.08$</td>
<td>$1.13$</td>
<td>$1.63$</td>
</tr>
<tr>
<td>$E_{RD}$</td>
<td>$-0.67$</td>
<td>$-0.66$</td>
<td>$-1.09$</td>
</tr>
<tr>
<td>$S_R^A$</td>
<td>0.36</td>
<td>0.38</td>
<td>0.37</td>
</tr>
<tr>
<td>$S_T$</td>
<td>0.64</td>
<td>0.62</td>
<td>0.63</td>
</tr>
</tbody>
</table>

*The estimated elasticities are evaluated using the estimated rail and truck shares for 1975. The actual shares were 0.38 and 0.62, respectively.*

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are included in the model (even the estimated elasticities for the model with all eight service coefficients, not reported in Table 1, are $-0.94$ for rails and $-0.62$ for trucks). The estimated price elasticities for railroads are somewhat less than Oum's (1979c) 1970 cross-section estimate for metallic products of $-1.18$. The truck price elasticities are consistently lower than those for rail, but the 1975 estimates between $-0.52$ and $-0.66$ are almost double Oum's 1970 estimate of $-0.33$ for metallic products. Differences between rail and truck in the estimated price elasticities are less pronounced, and the truck elasticities are significantly larger in absolute value here than for Oum. By using estimated revenue shares from earlier years in the sample, we can calculate the price elasticities for the earlier years. Over the period of the sample,
estimated rail price elasticities have gradually declined in absolute value (from approximately 1.15 in 1960), while estimated motor-carrier elasticities have risen (from approximately 0.57 in 1960). The lessened sensitivity to rail rates, and the increased sensitivity to the higher truck rates, between the 1960 and 1975 estimates correspond to an increase in the rail share of revenue over the same period.

The estimates for the elasticity of substitution, $\sigma_{RT}$, are similar for the five specifications in Table 1. These estimates are very close to that calculated by Oum (1979c) for cross-section 1970 Canadian data for metallic and for non-metallic products, and indicate that rail and truck transport are competitive and potentially highly interchangeable in the shipment of assembled automobiles.

It was expected that at least some of the non-rate quality-of-service variables would be important for assembled automobiles, since motor carriers, with much higher average rates, continue to hold approximately 49% of the market in terms of automobiles shipped. In addition, Oum (1979c) has found that quality variables are important for commodities of relatively high value. Of the eight quality-of-service coefficients, however, only that for rail miles-per-day is consistently significant over various specifications. The very high miles-per-day elasticity of rail indicates that, ceteris paribus, improvement in rail speed can have a considerable impact on traffic distribution. For example, using 1975 traffic data, a 2% increase in rail miles-per-day of two and one-third miles would result in an increase in rail shipments of approximately 125,000 automobiles, or 1.5% of the total 1975 market. The question remains, however, whether such a ceteris paribus change is feasible and at what cost. Over the last ten years of the sample, average rail miles-per-day have varied between 105 and 128. This variation may be due to aggregation over alternative routes. An increase of 2% in the average appears to be feasible, holding capital stock constant, but presumably with some increase in operating costs. We have found no firm estimate of the impact of rail speed upon operating costs and thus upon rates, but a compensating 2% increase in rail rates would lead by itself to a decrease in rail shipments of approximately 90,000 automobiles. The net effect would be an increase in rail shipments of approximately 35,000 automobiles, or 0.4% of the total 1975 market and 0.8% of the 1975 rail share. Even when the own-price effects are taken into account, non-rate competition, by means of reasonably small changes in average speed, is a viable means of changing the model split in favour of rail. This result contrasts with Oum’s finding (1979c) of a clear pattern that the effects of improving various truck attributes are uniformly higher than those for rail.

The other quality-of-service coefficient that appears in Table 1, $n_2$, is of only borderline significance at the 95% level. The estimate provides some indication, however, that a change in automobile prices will lead to a modal shift toward trucks as shippers attempt to reduce the costs of holding inventory. For example, the inventory-cost effect of a ceteris paribus 10% increase in automobile prices is an increase in truck shipments of approximately 125,000 automobiles, or roughly 1.5% of the total 1975 market. For purposes of comparison, if rail and truck rates were also to rise by 10%, the combined rail-truck rate change by itself would lead to a net increase of approximately 180,000 automobiles shipped by truck, or roughly 2.1% of

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8 This calculation and those below are based on an average of the estimated elasticities in Table 1 for the last four specifications and use traffic data for 1975, the last year in the sample.
the total 1975 market. According to these calculations, the relative-rate effect is larger than the inventory-cost effect, and both result in a modal shift toward trucks. It is important to remember that the calculation of the inventory cost effect is tentative, in view of the borderline significance of the estimate of \( n_2 \).

We have found evidence for the general propositions that, in the shipment of assembled automobiles, railroads have much to gain from improving speed and from keeping rates down and that the demand for truck transport is more sensitive than perhaps was previously thought to changes in motor carrier rates. The elasticity estimates provide a framework in which we can begin to assess the possible impact of transport deregulation, to the extent that deregulation leads to lower charges and/or improved quality of service in the deregulated mode.

An important policy implication of this paper is that, because of the high price and selected quality-of-service elasticities, transport deregulation which leads to lower rates or higher speed can have a significant impact on the market shares for assembled automobiles. For example, a recent study of motor carriage in New Jersey indicates that rates in unregulated truck transport have been consistently 10% or more below regulated rates for the same commodities (see Allen, 1979). Calculations based on the estimates of Table 1 indicate that a 10% decrease in the truck transport rate for assembled automobiles would lead to an increase of approximately 266,000 in automobiles shipped by truck, or 3.13% of the total 1975 market and 6.45% of the truck market.\(^{10}\) To counteract that modal shift, the railroads would have to reduce rates by approximately 6% or increase speed by approximately 4%, or achieve some combination of these changes.

These results suggest that, in the absence of effective rail deregulation that would permit reduced transit times and significant cost reductions, lower motor carrier charges resulting from truck deregulation would impair the financial stability of the railroads in the market for assembled automobiles. However, if there were effective rail deregulation resulting in comparable lower charges and increased speed, railroads would stand a good chance of offsetting those effects of truck deregulation and of maintaining their market share. The resultant traffic distribution in this market would depend, of course, on the actual impact of deregulation on rates and service speed for each of the two modes. But it does appear that effective reform of rail regulation can significantly affect modal shares and help to offset the damaging implications for railroads of truck deregulation.

It is necessary to keep the empirical results in proper perspective. Since the analysis here is for one particular commodity and the estimated coefficients on which the elasticities are based have limited degrees of freedom, it would be desirable to see whether similar results hold for other commodity groups over extended time periods. Appendix B explains why, with United States data, this is at present impracticable.

\(^{10}\) If we allow for a 30% increase in fuel prices and assume a constant margin over operating costs, motor carrier rates would increase by an estimated 5%. Thus, even with sizeable increases in fuel prices, a hypothetical 10% decrease in price due to deregulation would still have a net effect on traffic of approximately 1.57% of the total market and 3.22% of the truck market, using 1975 traffic data. In these calculations, we use relative costs and fuel consumption rates from *Trinc’s Blue Book*, 1978, and *American Trucking Trends*, 1977.
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APPENDIX A

Data Sources


Motor carrier revenue per automobile shipped, R_t, and rail revenue per automobile shipped, R_r, were computed from the total revenue sources noted above and the number of automobiles shipped by motor carrier and rail. The source for the shipment data is Motor Vehicle Manufacturers' Association (1978).

The average wholesale price of automobiles, P_A, was computed from the wholesale price index for automobiles and the average wholesale price for automobiles in 1967. The price index is as reported by Bureau of Labor Statistics, U.S. Department of Labor, Washington, D.C. The information on the 1967 average wholesale price of automobiles can be found in Motor Vehicles Manufacturers' Association (1977), p. 79.

Rail loss and damage claims per automobile shipped via rail carriers, RLD, is from Association of American Railroads, Freight Claims and Damage Prevention Division, Washington, D.C. For the years 1955 to 1963, claims for automobiles were reported in aggregated data which also included claims for automobile parts. Estimates for the claims for automobiles alone were obtained from regression analysis of claims for automobiles and auto parts in subsequent years for which separate figures were reported.

Motor carrier loss and damage expenses per automobile shipped, TLD, are determined from reported annual payments by motor carriers of automobiles for loss and damage, from cargo loss, damage and theft insurance payments, and from shipments of automobiles from factories by motor carriers. The annual loss and damage figure is reported in Trinc's Blue Book of the Trucking Industry, 1955–1975. The reported figure includes both insurance premiums and payments by carriers for self-insured and/or noncovered damage. To the extent that insurance premiums represent a substantial portion of this expense, payment levels represent past loss and damage experience and volume levels.

Rail miles per trailer per day, RMD, was computed from two sources. For the years 1959 to 1975 the source is Trailer Train Company, "Long Range Projections 1978–1990," April 1978. For previous years, no automobile multi-level trailers were in use and the figure for boxcars was instead used. The source for years 1955 to 1958 is Association of American Railroads (1968–1978).

Motor carrier average miles per tractor per day, TMD, is computed from annual miles and average number of tractors for specialised carriers of automobiles as reported in Trinc's Blue Book of the Trucking Industry, 1955–1975.

Rail average length of haul, RLH, was computed from several sources. For the years 1958 to 1966, the source is Interstate Commerce Commission (1958–1966). For the years 1969, 1972, and 1975, the source was U.S. Department of Commerce.
(1969–1976). For all other years, the estimate was obtained by linear extrapolation between reported observations.

Motor carrier average length of haul, TLH, was computed from *Trinc’s Blue Book of the Trucking Industry*, 1955–1975. The estimate for average length of haul is determined by dividing total ton-miles by total tons for specialised carriers of automobiles. The resultant series is strictly interpreted as the average miles per ton shipped, and is an accurate approximation of average length of haul weighted by tonnage. It should be noted that the average length of haul thus computed is much lower than that reported in the *Census of Transportation* (U.S. Department of Commerce, 1963, 1967 and 1972). This is due to the nature of the Census sampling procedure and the definitions employed for “shipment” and “primary mode”. The resultant differences between the two sources are irreconcilable.

**APPENDIX B**

**Applying the Analysis to other Commodities**

The time series analysis of the text cannot be reproduced from United States data for any other commodity at the same level of specificity, given the available data and the industrial structure in the transport industry. Our analysis was possible as a result of several unrelated aspects of automobile transport, the most important of which is that the ICC has chosen to segment specialised motor carriers of automobiles into a separate group for reporting purposes. Coupled with the fact that these carriers are not involved in the transport of other commodities, this allowed carrier-grouped data to be applied to a specific commodity. The remaining ICC specialised commodity groupings of petroleum products, refrigerated products, agricultural commodities, building materials, and other specialised products represent substantially more aggregated sets of commodities.

In addition, for most other commodities, unregulated motor carriage, private motor carriage, and unregulated barge transport are alternatives to regulated rail and motor carriage. For these unregulated transport modes, virtually no data on revenue and characteristics of shipments are available on a commodity basis, and only sporadic estimates of tonnage are to be found. While estimates of current activity could, with some difficulty, be obtained, the historical data required for time-series analysis are not reasonably available. The success of the translog model applied to automobiles is encouraging, especially in view of its strong theoretical underpinning. But the lack of data needed to complete the analysis for other commodity groups casts doubt on its practicality for extended time-series analysis.

Often data exist before the need for information arises. This is not so for transport. At the opening of a decade which may see massive structural changes in the transport industry and in its role in the economy, the analytics are available to produce

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11 The *Census of Transportation* is taken only every five years and contains no revenue information. The definitional and interpretative categories employed by the Census differ substantially from those used by regulatory agencies which report data on an annual basis; this renders cross classification virtually impossible without heroic assumptions.
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meaningful and valuable information, but the necessary data are lacking. Further research should deal initially with the design and resources required for developing a national transport data base, so that the benefits and costs of implementation can more accurately be determined.

REFERENCES


