Abridgment

Determinants of Freight Modal Choice

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In studying the transportation of commodities, the objective of any particular research effort should be kept in mind. A researcher may be interested only in some general notion of the overall demand for freight transportation (e.g., the annual cost of shipping goods), in which case the demand for freight services will be closely tied to the level of national output. However, this procedure starts to collapse when interest centers on the demand for freight services by particular modes (e.g., rail and truck) and becomes rather unworkable. This is true especially from the viewpoint of policy analysis—i.e., when the research effort addresses questions related to the movement of particular goods by certain modes.

Input-output analysis, as well as econometric models, allows an economist or transport planner to forecast disaggregate components of national output (e.g., output by industries). This disaggregation has not been extended to direct modeling of freight demand, because a complete data base on modal characteristics is lacking—especially among unregulated carriers. Individual shipper data are also sparse. Thus, freight forecasting lags behind urban and intercity passenger modal split modeling methodologies. For example, Morton (2) has studied the demand for transport by mode by broad commodity groups, while Nazem (3) has focused on the macro-level approach. In addition, Watson and others (5) and Roberts and others (4) have emphasized individual shipper behavior. Morton found that shipment size and average haul length (AHL) were important determinants of modal choice.

Modes of freight transportation cannot be neatly dichotomized into public and private transport, as is sometimes done in passenger studies. While other researchers have confined their examination of freight haulage to two modes, e.g., Kullman's thesis on rail-truck competition (1), any broad study of freight must deal with more than two modes. If there are n modes for any particular commodity (good f) examined, then

\[ \sum_{i=1}^{n} p_i = 1 \]

where \( p_{if} \) is the probability that a quantity of good \( f \) will move by mode \( i \). Dividing both sides of Equation 1 by a nonzero \( p_{jf} \), \( i = 1, \ldots, j, \ldots, n \), so that

\[ \sum_{i=1}^{n} \left( \frac{p_{if}}{p_{jf}} \right) = \frac{1}{p_{jf}} \]

Since \( p_{jf}/p_{jf} = 1 \), then

\[ \sum_{i=1}^{n} \left( \frac{p_{if}}{p_{jf}} \right) = \frac{1}{p_{jf}} - 1 \]

Assuming strict inequalities, so that \( 0 < p_{if} < 1 \) for all \( i \) and \( f \), then the ratios \( p_{if}/p_{jf} \) are all positive, \( 1/p_{jf} \) is greater than one, and \( p_{jf} \) is greater than zero.

Because of the first equation, there will be only n-1 modal choices in an n-mode case that can be made freely; therefore, there will be only n-1 equations. While the choice of the base mode, \( p_{jf} \), is arbitrary—and, thus, the results possibly sensitive to the base mode choice—it is desirable that the ranking of modes (in terms of lowest to highest probability of choice) remains invariant to the choice of base mode. If three modes are being studied, with probabilities \( p_{rk} \), \( p_{tk} \), and \( p_{ok} \), then three ratios could be formed: \( p_{rk}/p_{ok} \), \( p_{tk}/p_{ok} \), and \( 1/p_{ok} \). Such an approach would waste information, however, in that comparatively good data on a commodity-detail basis are available for rail and truck, whereas poor information is available for the remaining modes. Three alternative ratios could be examined: \( p_{rk}/p_{ok} \), \( p_{tk}/p_{ok} \), and \( 1/p_{ok} \). Note that as \( (p_{rk}/p_{ok}) \) \( (p_{tk}/p_{ok}) = p_{rk}/p_{ok} \), one can still use the "all else" mode as a base. This model can be summarized as follows:

\[ \ln(p_{rk}/p_{ok}) = f_{r_1, r_2, A_k} \]
\[ \ln(p_{tk}/p_{ok}) = f_{t_1, t_2, A_k} \]

*Mr. Jelavich was with Jack Faucett Associates, Chevy Chase, Maryland, when this research was performed.
\[
(p_k/p_{ok})(p_k/p_{ok}) = p_{ok}/p_{ok}
\]
(6)

\[
(p_k/p_{ok}) + (p_k/p_{ok}) + 1 = 1/p_{ok}
\]
(7)

where \(r_{tk}\) and \(r_{rk}\) are the truck and rail ton-mile rates respectively (derived below), and \(A_k\) is a vector of attributes of commodity \(k\). In Equation 5, since rate data for other modes are not readily available, the "all else" rate term has been suppressed.

Data used to estimate the model's equations appeared in the 1972 Census of Transportation, the 1972 Census of Manufactures, and the 1972 Interstate Commerce Commission's Freight Commodity Statistics reports on rail and regulated trucking. The data in the transport census cover only the 48 contiguous states and shipments to Alaska and Hawaii. The transport census covers only manufactured goods, and pipelines are not included in the modal coverage.

Table 1. Ordinary least-squares estimates of modal split equations.

<table>
<thead>
<tr>
<th>Dependent Variable</th>
<th>Equation No. 1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
</tr>
</thead>
<tbody>
<tr>
<td>(\ln(p/p_k))</td>
<td>-0.015 92</td>
<td>(0.003 04)</td>
<td>0.020 52</td>
<td>(0.007 25)</td>
<td>-0.206 82(W)</td>
<td>(1.011 40)</td>
</tr>
<tr>
<td>ln(RRTRA)</td>
<td>-0.679 34</td>
<td>(0.349 83)</td>
<td>-0.491 12</td>
<td>(0.926 04)</td>
<td>0.022 05</td>
<td>(0.018 45)</td>
</tr>
<tr>
<td>TRTA</td>
<td>0.637 75*</td>
<td>(0.392 96)</td>
<td>-0.136 91(W)</td>
<td>(0.802 03)</td>
<td>0.000 10*</td>
<td>(0.000 04)</td>
</tr>
<tr>
<td>MLBS</td>
<td>0.174 72</td>
<td>(0.221 60)</td>
<td>1.221 59*</td>
<td>(0.587 13)</td>
<td>0.100 00</td>
<td>(0.000 04)</td>
</tr>
<tr>
<td>ln(MLBS)</td>
<td>-0.000 04*</td>
<td>(0.000 02)</td>
<td>5.068 84*</td>
<td>(2.265 59)</td>
<td>-0.155 80</td>
<td>(0.017 26)</td>
</tr>
<tr>
<td>RLBS</td>
<td>0.020 02*</td>
<td>(0.064 77)</td>
<td>0.001 00</td>
<td>(0.000 04)</td>
<td>1.257 17*</td>
<td>(0.064 21)</td>
</tr>
<tr>
<td>ln(RLBS)</td>
<td>0.154 72</td>
<td>(0.029 60)</td>
<td>0.002 24</td>
<td>(0.040 16)</td>
<td>0.588 43</td>
<td>(0.045 89)</td>
</tr>
<tr>
<td>VALS</td>
<td>-0.060 92*</td>
<td>(0.029 60)</td>
<td>0.002 24</td>
<td>(0.040 16)</td>
<td>0.588 43</td>
<td>(0.045 89)</td>
</tr>
<tr>
<td>ln(VALS)</td>
<td>0.440 24</td>
<td>(0.030 38)</td>
<td>1.173 39*</td>
<td>(0.032 31)</td>
<td>0.341 96</td>
<td>(0.004 24)</td>
</tr>
<tr>
<td>AIL</td>
<td>0.020 02*</td>
<td>(0.064 77)</td>
<td>0.001 00</td>
<td>(0.000 04)</td>
<td>1.257 17*</td>
<td>(0.064 21)</td>
</tr>
<tr>
<td>ln(AIL)</td>
<td>0.375 15</td>
<td>(0.357 15)</td>
<td>1.249 98</td>
<td>(0.945 42)</td>
<td>0.341 96</td>
<td>(0.004 24)</td>
</tr>
<tr>
<td>COSTDF</td>
<td>0.000 024(W)</td>
<td>(0.000 01)</td>
<td>0.000 02</td>
<td>(0.000 01)</td>
<td>0.000 024(W)</td>
<td>(0.000 01)</td>
</tr>
<tr>
<td>DA</td>
<td>0.704 05</td>
<td>(0.443 04)</td>
<td>0.130 69</td>
<td>(0.307 41)</td>
<td>1.146 33</td>
<td>(1.172 76)</td>
</tr>
<tr>
<td>DB</td>
<td>0.093 48</td>
<td>(0.360 66)</td>
<td>0.060 92*</td>
<td>(0.245 58)</td>
<td>0.296 79</td>
<td>(0.139 63)</td>
</tr>
<tr>
<td>DC</td>
<td>0.825 62*</td>
<td>(0.305 66)</td>
<td>0.060 92*</td>
<td>(0.245 58)</td>
<td>0.296 79</td>
<td>(0.139 63)</td>
</tr>
<tr>
<td>Constant</td>
<td>-3.455 99</td>
<td>(0.317 95)</td>
<td>-2.595 23</td>
<td>(0.342 66)</td>
<td>-7.425 14</td>
<td>(0.342 66)</td>
</tr>
<tr>
<td>(R^2)</td>
<td>0.593 92</td>
<td>(0.593 92)</td>
<td>0.365 66</td>
<td>(0.460 16)</td>
<td>0.239 07</td>
<td>(0.324 01)</td>
</tr>
</tbody>
</table>

Coefficient significant at 95 percent confidence (t-statistics appear in parentheses).
The specifications of the equations are

\[ \ln(p_i/p_o) = f(RRTA, TRTA, RLBS, MLBS, VALSV, DA, DB, DC) \]  
(8)

\[ \ln(p_i/p_o) = g(TRTA, RRTA, AHL, RLBS, MLBS, VALSV, DA, DB, DC) \]  
(9)

It is hypothesized that \( f \) and \( g \) are linear in their independent variables, and that \( \text{COSTDF} \) replaces one of the rate variables in some cases. Table 1 presents estimates of these equations, along with some logarithmic transformations of the independent variables.

The general form of the equations can also be modified by dropping the variables \( DA \) and \( DB \) and substituting the following value dummy variables:

- \( DAA = \text{unity if the value of shipments per ton for a commodity is between } $1000 \text{ and } $3000 \text{ inclusive, zero otherwise}; \)

Table 2 gives the parameter estimates of the modified equations.

Table 2. Alternative estimates of modal split equations under new value format.

<table>
<thead>
<tr>
<th>Equation No.</th>
<th>RRRTA</th>
<th>TRTA</th>
<th>RLBS</th>
<th>MLBS</th>
<th>VALSV</th>
<th>AHL</th>
<th>COSTDF</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>-0.016 59*</td>
<td>0.016 20</td>
<td>0.016 86</td>
<td>0.016 85</td>
<td>0.000 04</td>
<td>0.000 04</td>
<td>0.000 03</td>
</tr>
<tr>
<td>2</td>
<td>-0.016 59*</td>
<td>0.016 20</td>
<td>0.016 86</td>
<td>0.016 85</td>
<td>0.000 04</td>
<td>0.000 04</td>
<td>0.000 03</td>
</tr>
<tr>
<td>3</td>
<td>-0.016 59*</td>
<td>0.016 20</td>
<td>0.016 86</td>
<td>0.016 85</td>
<td>0.000 04</td>
<td>0.000 04</td>
<td>0.000 03</td>
</tr>
</tbody>
</table>

*Coefficient significant at 95 percent confidence (t-statistics appear in parentheses).

Table 3 gives the results, in summary form, of those equations with multiple correlation coefficients ("R-squares") above 0.4. The determination of the correctness of sign was based on a priori speculation as to the sign of each particular coefficient. What is most apparent is that rate variables do not play much of a role in this model; rather, value of shipment, weight, and, to a lesser extent, average haul length variables are the major determinants of modal choice.

This research implies that, in order to forecast freight commodity flows accurately, it is necessary to take individual commodity characteristics such as shipment size and value into account. The type of mode chosen by a shipper will depend greatly on the commodity to be transported; in turn, this will help determine modal choice. Input-output models provide commodity-group output forecasts that can be used as a starting point to forecast demand for transportation by mode at a commodity level; an appropriate modal split algorithm can—after converting value of output to tons—estimate the tonnage carried by each mode. This methodology is preferable to more macro-related methodologies when research is focusing, for example, on the effects of energy or regulatory policies; it may be that in many cases government actions will not alter shipper choice because of a shipper's perception of transport.

ACKNOWLEDGMENTS

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REFERENCES

Estimating Effects of Railroad Abandonment

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John E. Harman, U.S. Department of Transportation

Estimates were developed of the potential for rail-service termination and of the probable transport-related effects that such loss of rail service would have on the freight-transport system, transport costs of affected rail users, resulting public- and private-sector investment requirements, and energy consumption. All estimates were developed for lines on which service either had been recently terminated or might be terminated in the future. A survey was conducted of a sample of users of these lines. Estimates of the overall effects of abandonment were developed by a computer program from an analysis of survey responses and from waybill data for shipments originating or terminating on the lines under study. About 80 percent of present rail shipments to or from facilities that lose rail service would continue to be made to or from these facilities by another mode, with most of these made entirely by truck or by a combination of truck and rail. About half of the remaining shipments would continue to be made to or from other locations in the general area. The average increase in transport-related expenditures of affected rail users would be about 17 percent of present railroad charges. It was also estimated that abandonment of the lightest density lines under study would generally result in a small reduction in fuel consumption, while abandonment of uneconomic lines with more moderate traffic densities would result in increased fuel consumption.

The Railroad Revitalization and Regulatory Reform Act of 1976 (4R Act) and other recently enacted legislation contain provisions that can result in increased rates of abandonment of unprofitable branch lines by railroads and that will permit subsidies for continued service on many of these lines. The purpose of this legislation, of course, is to improve the financial health of the currently ailing railroad industry. However, any increase in the rate at which branch-line service is terminated can be expected to have side effects on the rest of the transport industry, on the present users of affected lines, and on the local economies of the predominantly rural areas served by these lines.

This paper presents the methodology used in a recently completed study (1) designed to produce information about the extent of some of these effects. In particular, estimates were developed of the potential effects of railroad abandonment on traffic on the remainder of the freight transport system, transport costs of affected rail users, resulting public- and private-sector investment requirements, and energy consumption. Some of the major results of the study are presented here. Additional data may be found in Weinblatt and others (2) and in the complete report (1).

METHOD OF ANALYSIS

For this study, four sets of lines, which had either recently lost rail service or could lose service in the future, were identified:

1. Excluded lines: 8500 km (5282 miles) of line in the Northeast excluded from the Final System Plan (FSP) for Consolidated Rail Corporation (Conrail) (3);
2. Abandoned lines: approximately 4200 km (2600 miles) of line in the Northeast excluded from FSP on which service was discontinued on April 1, 1976;
3. Lines with petitions pending (PP): 9752 km (6060 miles) of non-Conrail lines located throughout the country on which abandonment petitions were pending as of July 23, 1976; and
4. Apparently uneconomic (AU) lines: 48 900 km (30 400 miles) of non-Conrail lines located throughout the country that appeared to be uneconomic on the basis of a computer analysis of traffic data.

For each of the four sets of study lines, estimates of the annual volume of shipments originating or terminating on these lines were obtained for seven regions and 16 commodity groups. For the abandoned and excluded lines, shipment data were acquired from the United States Railway Association waybill files for 1973; for lines with petitions pending and uneconomic lines, data were obtained from the Federal Railroad Administration One-Percent Waybill Sample for 1972, 1973, and 1974. Kilometer and shipment data for the PP and AU lines have been detailed in Weinblatt (4), along with a description of the procedure used in determining the apparently uneconomic lines. Preliminary estimates of the volume of shipments generated by the portions of these two sets of lines in 31 southern and western states were also included in the Transportation Secretary's Report to Congress, mandated under section 904 of the 4R Act (5,6).

Due to space limitations, the results in the latter part of this paper will be presented only for a fifth set of lines, consisting of the apparently uneconomic lines plus those excluded lines that had not already been abandoned. Thus, this fifth set consists of those lines in service in the summer of 1976 that could lose service in the next few years.

*Mr. Weinblatt was with CONSAD Research Corporation, Pittsburgh, Pennsylvania, when this research was performed.