FORECASTING RAIL FREIGHT TRAFFIC FROM A STATEWIDE ECONOMIC MODEL

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Abstract

The purpose of this study was to develop a procedure for estimating future rail traffic that considers the relationship between the structure of a state's economy and rail freight traffic. The study expands the use of input-output models to include the forecasting of transportation demand. Georgia and Michigan case studies were used to test the forecasting capability of the input-output procedure. For Michigan's 1980 rail movements, the model predicted rail traffic to within 0.15 percent of actual traffic. For 1979 Georgia traffic, the model predicted within 4.3 percent of actual traffic. Various statistical tests indicate that the procedure was effective in forecasting rail freight traffic.

Key words: forecasting, rail, input-output.

In the last decade, the financial difficulties of railroads have caused federal and state governments to become increasingly involved in issues associated with rail traffic flows. Federal rail funds to states have declined since 1980, forcing rail planners to define an essential core of rail service and to determine which rail lines will receive declining financial support. Since the cost of transporting agricultural commodities depends in part on the availability of rail service, rural areas are affected by the decision to either subsidize or abandon a rail branch line. In order to address these issues, rail planners require a method to forecast rail freight traffic.

The purpose of this study is to develop a method for estimating future rail traffic that considers the relationship between the structure of a state's economy and rail freight traffic. This study concerns the impact of a state's economy on the demand for rail freight transportation, matching railroad waybill data to an input-output model. To accomplish the purpose, a test of the forecasting capability of the input-output model is presented.

The forecast accuracy of statewide rail traffic projections in the states of Michigan and Georgia is tested. Since Michigan and Georgia have substantially different economic structures, it was felt that their use would provide support to the general forecasting ability of the input-output model.

A 19-sector input-output model of the State of Georgia (Schaffer et al.) and a 20-sector input-output model of Michigan (Jordan and Thompson) were combined with the Interstate Commerce Commission's (ICC) one-percent sample of waybills. The one percent sample for Georgia and Michigan was expanded using the Interstate Commerce Commission's expansion factor for each sector, approximating the total railroad system.[1]

Rail planners and decisionmakers generally derive future rail traffic volumes by soliciting rail users' opinions regarding their anticipated rail use. Since abandonment would produce dislocations in their transportation activities, users often overestimate future demand. These

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[1] Waybills are shipping documents prepared by the originating railroad from the shipper's instruction as to the disposition of freight, and are used by the railroads as authority to move shipments and as the basis for determining and settling the freight charges among the carriers involved. The waybill in the sample used are for carloads terminated by line-haul or regular rail-haul, as distinguished from a switching move or switching company. As used here, a regular haul is between terminals and stations on the main or branch lines of the railroad, exclusive of switching moves.

For the 1-percent sample, waybills are selected by the terminating carrier on the basis of the waybill number assigned by the originating carriers (this number is for the purpose of control and identification). The waybills selected are those numbered 1 or those which have numbers ending in 01. The selection criterion is designed to capture one percent of the audited waybills.

In order to estimate population statistics, the waybill sample is expanded. Until 1979, common practice was to multiply the waybill sample by 100 to estimate the entire population. However, because of the sampling procedures used, all commodities are not evenly sampled; multiplying everything by 100 does not provide an adequate population estimate. Consequently, the Federal Railroad Administration has devised expansion factors with which individual commodities or classes of commodities can be multiplied to estimate a 100 percent sample.

Weaknesses certainly exist with the use of waybill statistics. The often wide standard deviations around a sector mean indicate the data can be used only as estimates. However, waybill statistics are one of the few sources available and their use is widespread by rail planners.

type of ad hoc procedures need to be replaced by improved traffic projection methods.[2]

Rail demand estimates for agricultural commodities are often derived from regional surplus or deficit commodity forecasts (Lazarus et al.), from the use of operation research methods (Koo et al.) and various econometric forecasting models (Johnson; Miklius et al.; Oum). While each of these forecast methods has distinct advantages and disadvantages, they can be considered partial since interindustry relationships are not explicitly modelled. Most econometric modal choice models consider factors such as freight charges, transit times, reliability of the shipper (damage rates or variance of transit time), and buyer or seller characteristics in predicting probability functions. These methods are particularly well-suited to estimating the transportation demand of specific (or a limited number of) commodities. However, they rarely include an estimation of total economic output as with input-output models.[3] Interindustry relationships are explicitly considered in the input-output procedure.

Studies at the Regional Science Research Institute (RSRI) (Stevens et al., 1979 and 1980) have used input-output models to estimate the impact of new transportation facilities. The RSRI work concentrates on the use of input-output multipliers, particularly the income and employment multipliers. This differs from the approach taken in this study where only the output multipliers are used.

The approach to transportation demand employed by researchers at the Massachusetts Institute of Technology (Chung and Roberts; Roberts, 1977a; Roberts, 1977b; Terziev) begins by stating that the flow of cargo in a given market is simply the sum of individual shippers' decisions. These decisions are, in turn, conditioned by the specific inputs and outputs of each of the production processes involved. This disaggregate approach was used to estimate the output levels of firms while input-output analysis was used to estimate the inputs required to produce the given output. These input-output coefficients represent the inputs purchased from a particular industry i to produce one dollar of output in industry j. When multiplied by the output of industry j, this coefficient gives the dollar value of purchased inputs from industry i and, hence, the amount of goods that require transportation services. The objective of the Massachusetts Institute of Technology research is to explain the individual shippers' decision on commodity k as the probability of jointly selecting the frequency (f), mode (m), size (q), and location (i) of purchases, given user location (j) and usage rate (u) required by the final demand for a good and the input requirements of the production process:

$$p^k(f,m,q,i \mid u,j).$$

Input-output models estimate usage rates of commodities by industry. Commodity waybill data depict the movement of commodities by origin and destination. Since the demand for transportation is derived from final product demand, it is dependent on the level of economic activity. Thus, the estimated level of economic activity can be used to explain the demand for freight transportation.[4]

THE ANALYTICAL MODEL

The model and generalized procedure of forecasting rail traffic can be represented mathematically as follows:

$$(1)\ X_t = (I\text{-}A)^{-1}\ Y_t$$

$$(2)\ X_{t+\gamma} = (I\text{-}A)^{-1}\ Y_{t+\gamma}$$

$$(3)\ (x_{jt+\gamma} - x_{jt})/x_{jt} = k_j$$

$$(4)\ (1 + k_j)\ w_{jt} = r_{t+\gamma}$$

where:

X_t = total output vector of economy in year t;

Y_t = final demand vector facing economy in year t;

$(I\text{-}A)^{-1}$ = matrix of interdependency coefficients, the Leontief inverse matrix;

γ = unspecified future time period;

k_j = proportionate change in total output of industry j between year t and selected years in the future;

w_{jt} = estimated total waybill based on a one percent sample of industry j, year t;

$r_{t+\gamma}$ = predicted freight traffic flows of industry j for time $t+\gamma$

A = matrix of technical coefficients a_{ij}'s where $a_{ij} = x_{ij}/x_j$;

x_{ij} = value of sales from industry i to industry j;

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[2]Not all states rely on ad hoc procedures. In Washington and California, preliminary work used input-output models to aid in rail traffic forecasting. In both cases, the use of the input-output model to aid in rail traffic forecasting is more limited than the procedure discussed here (Transportation Research Board).

[3]Econometric models that predict industry output for each sector in an economy can be used in the same manner as input-output models. However, in using such simultaneous equation models, more data than simply final demands are required to forecast total output.

[4]For a broader discussion of input-output models and their use in transportation planning, see Jordan.

x_j = total output of industry j; and

I = identity matrix.

Equation (1) represents the solution to the input-output problem.

Equation (2) estimates total outputs in $t+\gamma$ by multiplying the inverse matrix by a new final demand vector $(Y_{t+\gamma})$. The proportionate change in total output, k_j, between t and $t+\gamma$, for industry j is shown in Equation (3). The total output changes are then used to forecast rail freight traffic by multiplying them by the amount of traffic shown on the expanded waybill sample in year t, as is done in Equation (4). This yields the tons of rail shipments for each commodity derived from the total output changes in the entire economy.

DATA

The final demands used in the Georgia model are in 1970 dollars while they are in 1976 dollars in the Michigan model. Both were deflated by implicit price deflators for the appropriate gross national product index *(Economic Report of the President)*. The dollar values for final demands represent the real change in demand and can be linked to the tonnage change on Georgia's and Michigan's railroads.

There are six final demand sectors in the input-output model; personal consumption expenditures, net exports, state and local government, federal government, gross private capital formation, and net inventory change. Retail sales tax collections were used as a proxy for changes in personal consumption expenditures. The percentage change in sales tax collections between 1970 and 1981 was calculated and this percentage change was used to increase or decrease the personal consumption expenditure figures used in the input-output model for the study years.

Export information was obtained from the Crop Reporting Service, the Georgia Department of Industry and Trade, and the Michigan Department of Commerce for manufacturing sectors. Import information was obtained from the U.S. Department of Commerce, Foreign Trade Statistics section, by state at the two-digit SIC level.[5]

State and local government spending includes the operating expenditures of state and local government agencies except those included in the government enterprise sector: liquor stores; water transport and terminals; parking facilities; urban renewal; airports; and transit. Data were obtained from state *Statistical Abstract's* and various issues of Government Finances. (Akioka; Vernay; and U.S. Department of Commerce, Bureau of the Census).

Federal government spending includes the total federal government disbursements minus the disbursements of the following federal government enterprises: post office; farm income stabilization, rural housing and public facilities; agricultural land and water resources; maintenance of housing and mortgage market; and veterans' benefits and services. These categories are included in the government enterprises sector. Data were collected from state *Statistical Abstract's* (Akioka and Vernay).

Net inventory change was based on national figures and are not Georgia or Michigan specific. They were obtained from various *Survey of Current Business* reports. (U.S. Department of Commerce, Bureau of Economic Analysis). The percentage change in net inventories between 1970 and 1981 was used to increase or decrease the data on net inventory contained in the 1970 Georgia input-output model (Schaffer et al.). Similarly, Michigan's data were estimated for 1976-1980.

The value of gross private capital formation in Georgia was also based on national figures. For the Michigan model, however, data were available from the Michigan Office of Revenue and Taxes, Department of Management and Budget, based on capital acquisitions of firms in Michigan filing the Single Business Tax. Nonprofit organizations and farmers, among others, do not pay the Michigan Single Business Tax. Estimates of farm investment were obtained from the Michigan Department of Agriculture.

RESULTS

The model was tested to determine whether it could accurately forecast rail traffic for a single year, given known rail movements. The procedure was statistically evaluated by regression techniques, hypothesis testing and analysis of variance, using projections for Georgia's rail movement for 1978-1981.

The Michigan test consisted of projecting 1980 rail traffic on the basis of 1976 commodity flow data. For Georgia, rail traffic was projected for 1979 from the base year 1978 and projected traffic was compared to the 1979 observed traffic. The basis for both projections was the ICC expanded waybill sample. Consequently, for the purposes of this study, known (or current) final demands are being used to estimate known (or current) rail activity, rather than truly forecasting the future. This procedure is aimed at providing tests of the models capabilities based

[5]Georgia's retail sales tax collections, information from the Georgia Department of Industry and Trade and the U.S. Department of Commerce export information were all obtained via phone conversation.

TABLE 1. ACTUAL AND PROJECTED 1980 RAIL TRAFFIC MOVEMENT IN MICHIGAN[a]

Sector/industry	Projected	Actual	Difference	Percent difference
	tons			
Other agricultural products	1,552,486	1,574,500	-22,014	-1.40
Mining	34,356,050	35,463,300	-1,107,250	-3.12
Food and kindred products	3,021,844	2,667,800	354,044	13.27
Lumber, furniture, paper, printing	4,209,298	4,021,100	188,198	4.68
Chemicals, drugs, plastics	2,750,960	2,719,300	31,660	1.16
Petroleum refinery	1,858,318	1,679,000	179,318	10.68
Rubber, leather, stone, glass, clay	1,694,469	1,962,600	-268,131	-13.66
Primary and fabricated metal	4,529,518	3,684,100	845,418	22.94
Machinery, except electrical	172,223	111,400	60,823	54.60
Electrical equipment	99,379	97,000	2,379	2.45
Motor vehicles and parts	7,872,833	8,194,300	-321,467	-3.92
Air and other transportation	123,367	129,800	-6,433	4.96
Transportation and commerce	82,394	84,100	-1,706	-2.03
Wholesale, retail, manufacturing, textile	4,311,884	4,142,700	169,184	4.08
TOTAL	66,635,023	66,531,000	104,023	0.15

[a]No rail traffic data were available for 6 of the 20 sectors in the Michigan input-output model.

on known data. When forecasting beyond known data, final demands can be estimated in ranges (low-, medium-, or high-growth rates).

The comparison between the actual and estimated total traffic in Michigan is shown in Table 1. The projected total rail flow for 1980 is 66,635,023 tons while the actual rail flow was 66,531,000 tons. Thus, the model's projection of rail traffic is 0.15 percent over the 1980 actual flows.

In two sectors (primary and fabricated metals and machinery), the model overestimated rail traffic, respectively, by 23 percent and 55 percent. It is believed that the waybill sample displayed rail traffic changes between 1976 and 1980 which any forecasting model based on commodity demand would have had difficulty projecting. Standard deviations for each sector in the waybill sample were calculated during the previous 9-year period. Both sectors which exhibited poor forecasting performance have standard deviations which are large relative to the other sectors, illustrating one of the problems in using waybill data. However, for the machinery (except electrical) sector, the large percentage difference is due in part to the relatively small magnitude of the sector.

The statewide comparison between the actual and estimated total traffic in Georgia is shown in Table 2. The projected total rail flow in Georgia for 1979 was 83,685,401 tons while the actual rail flow was 80,249,260 tons. The model's projection of rail traffic was 4.3 percent over the 1979 actual flows.[6] Projected versus actual rail traffic for each commodity sector is also shown in Table 2.[7]

In the printing and publishing sector and the electrical, transportation equipment (including miscellaneous manufacturing) sector, rail traffic was overestimated by approximately 41 percent and 47 percent, respectively. While the percent difference is high for printing and publishing, this is due, in part, to low absolute numbers. Of course, estimation of 1979 output could also be a source of error.

In order to examine the sensitivity of the models results to errors in forecasts of final demand, the 1979 Georgia projections were made with the final demand for agriculture (the largest sector) increased by 10 and 20 percent. Table 3 shows the results in terms of the sector percent differences produced by the change in final demand. On a sector-by-sector basis, even a 20 percent error in final demand for agriculture does not change the results to any great degree. Only in the agricultural sector itself is the percent difference between the actual and projected levels of rail traffic movement altered

[6]The Georgia projection includes all traffic that flows on the state's rail lines. A similar procedure was used for just nonbridge rail traffic and is reported in Jordan. In that case, the model's projection was 0.19 percent over the 1979 actual flows.

[7]In the Michigan and Georgia cases, truck flow data were not available. However, truck/rail modal shares remained relatively constant during the study period. Thus, modal share was assumed constant and was not a factor in arriving at the test projections. In situations where modal shares change over time, a method to include modal split estimates in the input-output procedure is required. One such method would be to adjust the final demands used in the input-output model based on projections of intermodal substitution. If projections of intermodal substitution indicate that agricultural shippers will be switching 10 percent of their commodities to truck in the forecast year, the final demand for agricultural goods used in the input-output model would be decreased 10 percent. If no intermodal change is forecasted, the projected rail traffic is a function of economic activity. If intermodal substitution is occurring, projected rail traffic is then a function of economic activity, plus or minus the new amount of the commodities moving on another mode. By adjusting final demands, it is possible to include in this model an intermodal substitution component that is on a sector-by-sector basis and is also affected by the interindustry relationships that affect shipping. Further, technological change in transportation methods (such as piggyback rail movements) can be included in the model in a similar fashion.

TABLE 2. COMPARISON BETWEEN 1979 ACTUAL AND PROJECTED RAIL TRAFFIC MOVEMENT IN GEORGIA[a]

Sector/industry	Projected	Actual	Difference	Percent difference
	----------	tons	----------	
Agriculture, forestry, food	27,505,182	27,479,099	26,083	0.09
Mining and petroleum	24,861,749	22,825,656	2,036,093	8.92
Furniture and paper	7,154,528	6,975,930	178,598	2.56
Printing and publishing	21,473	15,176	6,297	41.49
Chemicals and allied products	7,173,711	7,088,536	85,175	1.20
Rubber, stone, clay, glass	9,929,182	9,860,472	68,710	0.69
Primary and fabricated metal	2,018,387	1,931,199	87,188	4.52
Machine and non. elec.	67,118	65,478	1,640	2.51
Electrical and transportation equip., misc. man.	2,889,775	1,968,066	921,709	46.83
Wholesale, retail, inc. textiles	2,064,297	2,039,648	24,649	1.21
TOTAL	83,685,401	80,249,260	3,436,141	4.28

[a]No rail traffic data were available for 9 of the 19 sectors in the Georgia input-output model.

appreciably. Since the agricultural sector is the largest in the Georgia model, the total percent differences for both the 10 percent and 20 percent errors are substantially higher than in the original projections.

The input-output method was further evaluated using the Georgia data by regressing the projected tonnages in each sector, and by year, on the actual volumes for 1978-1981 projections. Since the variances of the 36 pooled observations for each sector were not equal, weighted least squares (using standard deviations) was used to ensure that the disturbances were homoscedastic. Regressions were conducted for all years pooled by year and by sector. Differences between sector projections and between yearly projections were also tested using analysis of variance.

In the model $P = \alpha + \beta A$, where: P = projected values and A = actual values, the joint null hypothesis $\alpha = \beta = o$ was tested. In all cases, it was found that the constant term, α, was not significantly different from zero. When, the model is reestimated with no intercept, it can be written: $P = \beta A$, the null hypothesis being $\beta = 0$. If the null hypothesis is not rejected, that is, if $\beta = 0$, then the procedure does not project accurately. If, however, the null hypothesis is rejected, and β is approximately equal to one, the test would indicate the procedure provides accurate projections.

For all years, 1978-1981, the results were:

$$(5)\quad P = \underset{(412.41)}{1.14}\,A \qquad \bar{R}^2 = .9996$$

The number in parentheses is the calculated t-ratio. The standard error of the parameter estimate was .0028. The probability that $\beta = 0$ is .0001. A further test was conducted on the hypothesis $\beta = 1.0$. If this is rejected, the procedure does not project accurately. The standard hypothesis for testing whether the parameter estimate of the slope is equal to the point value of one was tested with the equation: (β − point estimate)/(standard error of β). This was tested at the appropriate degrees of freedom for $\alpha = .05$. The results indicate that the t−value is greater than the tabular t−value and hence the null hypothesis that slope = 1 cannot be rejected.[8]

Theil's inequality coefficient was also used to measure the accuracy of the predictions. The modified Theil "U" statistic, the U_2 (Leuthold), was employed to test whether the predictive capability of the model was better than a naive forecast of $P_t = A_{t-1}$. For the overall Georgia data for years 1978-1981, the U_2 statistic was .143, indicating the input-output model's forecasts are better than can be obtained from a naive model.

Table 4 shows the parameter estimates for each year were significantly different from zero, and the 95 percent confidence interval of the parameter estimates includes one in three of the four years. The goodness of fit ($\bar{R}^2$) ranges from .72 to .99. This test indicates the level of accuracy of the procedure over the four projection years. The Theil U_2 statistics for each year are all under 1, indicating the model forecasts better than a naive forecast. Of course, when implementing this procedure, rail planners will hopefully have a more recent input-output model than used here. However, given a 1970 model, it appears the projection capabilities may provide rail planners with reasonable estimates.

The same statistical tests were conducted for each sector in the model, over the four years of projections, using non-weighted least squares, Table 5. For all sectors, except printing and

[8]The results were:

$H_o{:}\beta = 1$

$$t_{.05/2},\ 75\ DF = (1/S.E.\ \hat{\beta})\ (\hat{\beta}-1)$$
$$= (1/.002766786)\ (1.141046-1),$$
$$= 50.975\ (\text{Tabular } t = 1.995).$$

Table 3. Effects on Projections of 10 and 20 Percent Change in Agricultural Final Demand in Georgia, 1979

Sector/industry	Base projection	10 percent increase in agr. final demand	20 percent increase in agr. final demand
	Percent difference		
	------------tons------------		
Agriculture, forestry, food	0.09	8.35	16.61
Mining and petroleum	8.92	9.14	9.35
Furniture and paper	2.56	2.79	3.01
Printing and publishing	41.49	41.73	41.97
Chemicals and allied products	1.20	1.43	1.67
Rubber, stone, clay, glass	0.69	1.10	1.49
Primary and fabricated metal	4.52	4.82	5.13
Machine and non. elec.	2.51	2.56	2.61
Electrical and transportation equip., misc. man.	46.83	46.85	46.86
Wholesale, retail, inc. textiles	1.21	1.36	1.52
TOTAL	4.28	7.28	10.27

Table 4. Test of Forecast Significance, Georgia: 1978-1981; Weighted Least Squares Regression: $P = \beta A$

Year of projection	Parameter* estimate	Standard error	$\bar{R}^2$	Prob > $\lvert t \rvert : \beta = 0$	Theil's U_2 statistic
1978	1.040	0.017	.9945	.0001	.087
1979	1.074	0.104	.8355	.0001	.483
1980	1.620	0.143	.8601	.0001	.906
1981	1.170	0.158	.7244	.0001	.747

publishing, the parameter estimates are significantly different from zero, and the 95 percent confidence interval of each of the parameter estimates includes one. The goodness of fit ($\bar{R}^2$) for each sector over the four years ranged from .95 to .99. The Theil U_2 statistics for each sector were all under 1, indicating the model forecasts better than the naive forecast.

Using a student's t test, the hypothesis tested was H_0: mean of the projected values by sector = the mean of the actual rail flows, Table 6. Assuming equal variance between the actual and projected values within a sector, the hypothesis cannot be rejected in all sectors. Given a 95 percent confidence interval, the mean of the projected values over 1978-1981 equal the mean of the actual values.

An analysis-of-variance was conducted on the projected tonnage with discrete variables of sector and year and the interactions involving both factors.[9] An F-value of 320.36 with degrees of freedom of 18 and 18 was calculated for the sectors indicating a highly significant difference between sectors. An F-value of 2.74 with degrees of freedom of 3 and 54 was calculated for years, indicating no significant difference between predictions from year to year.

CONCLUSIONS

The purpose of this paper was to test and evaluate a method to estimate future rail traffic flows using input-output models and commodity waybill data. The appropriate level of aggregation when using this method in other states will depend upon the structure of the economy under study. The number of input-output sectors can be expanded or contracted depending on how specialized are the firms using a region's rail lines. This flexibility allows the researcher to account for diversity within the study region.

Any forecasting procedure must also be flexible enough to handle structural changes within an economy. A model must be able to handle adjustments resulting from relative commodity and output price adjustments, possible input substitution, and mixes of goods within sectors. The assumption of constant production coefficients in input-output analysis implies that there is no technological change which alters factor-factor or factor-product relationships. Where a relatively stable economy exists, the constant technology assumption is not a large problem. When an economy undergoes structural changes, the direct requirements table can be modified to account for such changes. Thus, the input-output model can be converted from a "static" to a "comparative static" model (Diamond and Chappelle). Input-output models can be constructed to be sensitive to price changes through the use of quadratic programming (Harrington).

Table 5. Test of Sector Forecast Significance, Georgia: 1978-1981; Least Squares Regression: $P = \beta A$

Sector/industry	Parameter* estimate	Standard error	$\bar{R}^2$	Prob > $\lvert t \rvert : \beta = 0$	Theil's U_2 statistic
Agriculture, forestry, food	1.085	0.051	.9935	.0002	.015
Mining and petroleum	1.143	0.079	.9859	.0007	.039
Furniture and paper	1.111	0.079	.9719	.0008	.031
Printing and publishing	1.196	0.343	.8591	.0731	.273
Chemicals and allied products	1.126	0.071	.9882	.0005	.031
Rubber, stone, clay, glass	1.138	0.079	.9858	.0007	.038
Primary and fabricated metal	1.153	0.151	.9509	.0047	.092
Machine and non. elec.	1.321	0.149	.9631	.0030	.170
Electrical and transportation equip., misc. man.	1.322	0.122	.9751	.0017	.148
Wholesale, retail, inc. textiles	1.070	0.084	.9820	.0010	.026

[9] The interaction between sector and tonnage was used as the denominator in the F-test in order to test the significance of the main effects of sector. The interaction between sector and year was used to test whether a significant difference was found between all years. These interactions were chosen as the appropriate error terms due to their significance when tested by the third order interaction.

TABLE 6. STUDENT'S t TEST OF H_0: MEAN OF PROJECTED = MEAN OF ACTUAL TONNAGE, GEORGIA, 1978-1981 (DF=6.0)

Sector/industry	t	Prob > |t|
		percent
Agriculture, forestry, food	0.8354	0.4472
Mining and petroleum	−1.4294	0.2220
Furniture and paper	−1.2400	0.2631
Printing and publishing	−0.9976	0.3598
Chemicals and allied products	−1.2944	0.2483
Rubber, stone, clay, glass	−1.3798	0.2183
Primary and fabricated metal	−1.0233	0.3462
Machine and non. elec.	−1.8521	0.1137
Electrical and transportation equip., miscellaneous man.	1.4661	0.1957
Wholesale, retail, inc. textiles	− .4653	0.6663

Although the input-output forecasting procedure has limitations,[10] the examples in this study and the results of the statistical tests indicate that in cases where recent input-output tables exist, rail traffic can be estimated so as to aid decisionmakers.

REFERENCES

Akioka, L. M., ed. *1982 Georgia Statistical Abstract.* Division of Research, College of Business Administration, University of Georgia: Athens, Georgia, 1982.

Chung, C. C. and Paul O. Roberts. "Design of a Structure and Data Analysis Scheme for Intercity Freight Demand Forecasting." *Center for Transportation Studies Report 75-15,* Cambridge, Massachusetts: Massachusetts Institute of Technology, 1975.

Diamond, J. and D. Chappelle. "Application of an Input-Output Model Based on Secondary Data in Local Planning: The Case of Maistee County." *Agr. Exp. Sta. Res. Rep. No. 409,* East Lansing, Michigan State University, 1981.

Economic Report of the Governor, Retail Sales Tax Collections, Lansing, Michigan: 1977-1981.

Economic Report of the President, Washington, DC: Superintendent of Documents, U.S. Government Printing Office, 1983.

Georgia Crop Reporting Service. *Georgia Agricultural Facts,* Athens, Georgia: 1978 and 1982.

Harrington, D. H. "Quadratic Input-Output Analysis: Methodology for Empirical General Equilibrium Model." Ph.D. Dissertation, Purdue University, 1973.

Johnson, Marc A. "Estimating the Influence of Service Quality on Transportation Demand." *Amer. J. Agr. Econ.,* 58:496-503, 1976.

Jordan, Jeffrey L. *A Generalized Procedure for Estimating State Rail Freight Traffic,* Ga. Exp. Sta. Res. Bull. 311, July 1984.

Jordan, Jeffrey L. and Stanley R. Thompson. "Using a Regional Input-Output Model to Forecast Rail Freight Traffic: With Applications for the Subsidy-Abandonment Decision." *Agricultural Economics Report* No. 420, E. Lansing: Michigan State University, 1982.

Koo, W. W., S. R. Thompson and D. W. Larson. *An Analysis of Selected Changes in the U.S. Transportation System, 1990,* No. Cent. Reg. Res. Bull. (NC-137, forthcoming).

Lazarus, S. S., L. D. Hill and S. R. Thompson. *Grain Production and Consumption for Feed in the North Central and Southern States with Projections for 1985, 1990, 2000,* Agr. Exp. Sta. Bull. 763, Univ. of Illinois, 1980.

Leuthold, R. M. "On the Use of Theil's Inequality Coefficients." *Amer. J. Agr. Econ.,* 57:344-346, 1975.

Michigan Department of Agriculture. *Michigan Agricultural Statistics,* Lansing, Michigan: 1978 and 1981.

Miklius, W., K. L. Casavant and P. V. Garrod. "Estimation of Demand for Transportation of Agricultural Commodities." *Amer. J. Agr. Econ.,* 58:217-223, 1976.

Oum, T. H. "A Cross Sectional Study of Freight Transport Demand and Rail- Truck Competition in Canada." *The Bell J. of Econ.,* 10:463-482, 1979.

Roberts, Paul O. "Disaggregate Demand Modelling: Theoretical Tantalizer or Practical Problem Solver." *Center for Transportation Studies Report No. 77-29,* Cambridge, Massachusetts: Massachusetts Institute of Technology, 1977a.

Roberts, Paul O. "Freight Demand Response to Changes in the U.S. Transportation System." *Center for Transportation Studies Report No. 77-28,* Cambridge, Massachusetts: Massachusetts Institute of Technology, 1977b.

Schaffer, W. A., E. A. Laurent and E. M. Sutter. *Using the Georgia Economic Model,* Atlanta: Georgia Institute of Technology, 1972.

[10]The limitations of the input-output forecasting procedure follow from the limitations of input-output analysis in general. The input-output assumptions of constant production coefficients, homogeneity, divisibility and additivity of sectors, remain.

Stevens, B. H., J. Kindahl, M. Woelfel and D. Ehrlich. *Basic Regional Input-Output for Transportation Impact Analysis: Handbook One of Regional Economic Analysis for Transportation Planning,* Amherst, Massachusetts: Regional Science Research Institute, 1979.

Stevens, B. H., J. Kindahl, M. Woelfel and D. Ehrlich. "Introductory Input-Output Methods for the Measurement of Regional Impacts with Emphasis on Transportation Facilities." *Regional Science Research Institute Discussion Paper No. 122,* Amherst, Massachusetts: Regional Science Research Institute, 1980.

Terziev, Marc N. "Modeling the Demand for Freight Transportation." M.S. Thesis, Massachusetts Institute of Technology, 1976.

Theil, H. *Applied Economic Forecasting,* Chicago: Rand-McNally and Co., 1966.

Transportation Research Board, National Academy of Sciences. "Local Rail Services Program: Perspectives of States and Railroads." Circular 209, 1979.

U.S. Department of Commerce, Bureau of the Census. *State Government Finances,* Washington, DC: U.S. Government Printing Office, 1981- 82.

U.S. Department of Commerce, Bureau of Economic Analyses. *Survey of Current Business,* Washington, DC. Vol. 59, No. 2, 4, 7, 12, 1979; Vol. 61, No. 7, 10, 11, 12, 1981.

U.S. Department of Transportation, Federal Railroad Administration. *Carload Waybill Statistics,* 1980.

Vernay, D. I., ed. *Michigan Statistical Abstract.* Division of Research, Graduate School of Business Administration, Michigan State University, E. Lansing, Michigan: 1979.