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USING A REGIONAL INPUT-OUTPUT MODEL TO FORECAST RAIL FREIGHT TRAFFIC: WITH APPLICATIONS FOR THE SUBSIDY-ABANDONMENT DECISION

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USING A REGIONAL INPUT-OUTPUT MODEL

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PREFACE

The purpose of this study is to suggest and test a method that systematically links the level of statewide economic activity with the demand for rail freight transportation services and facilities. A 20-sector input-output model of the State of Michigan is combined with commodity flow data obtained from expanded, 1 percent waybills from all of Michigan's railroad lines.

The test of the forecasting method is whether the 20-sector input-output model of Michigan can provide reliable estimates of rail traffic over a four-year period. The test is carried out not only on total rail traffic, but also on a sector-by-sector basis. The ability of the input-output model to disaggregate output projections is the key to its use in projecting rail traffic. This is so because the derived demand for rail services in a region, or on individual lines, depends in part on the output of the particular commodities that are produced in the area.

The results of the test of the rail forecasting method indicate that it is effective in producing estimates of rail traffic. The model projects rail traffic to within 1.2 percent of actual traffic over the total rail network. Additionally, the model is effective in providing sector-by-sector estimates in 11 of the 13 sectors for which rail traffic is represented in 1975 and 1980.

The testing of the forecasting procedure provides an illustration of the use of the model in regional rail planning decisions. The case of Michigan's Upper Peninsula is used to demonstrate the usefulness of having projections of rail traffic when making subsidy-abandonment, or rail rationalization decisions.

The forecasting procedure is also used to examine a specific issue on one rail segment in the Upper Peninsula: the northern Soo Line. This illustration of the uses of the input-output model emphasizes the flexibility of the method in dealing with individual rail issues. Not only is the input-output model able to disaggregate the effects of changes in specific commodity production, but through the waybill sample, it is able to isolate particular rail segments.

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I. INTRODUCTION

Problem Setting

In the last decade, federal and state governments have become increasingly involved in issues associated with preserving essential levels of rail service. Of particular concern has been the local economic impact of rail branch line abandonment. Since the shipment of agricultural commodities depends heavily on the availability of rail service, rural areas are especially affected by the decision to either subsidize or abandon a rail branch line. Since the Regional Rail Reorganization Act of 1973 (3R Act) and the Railroad Revitalization and Regulatory Reform Act of 1976 (4R Act), state governments have been charged with analyzing their rail systems and establishing priorities for lines that should be retained under subsidy.

Rail freight planning began in Michigan in 1974, in response to the bankruptcies of the Penn Central Railroad (PC) and the Ann Arbor Railroad (AA), which together comprised 35 percent of the rail mileage in Michigan. The 3R Act provided for the reorganization of six bankrupt railroads in the Northeast and Midwest regions, and for federal financial assistance to continue rail freight service on lines of the bankrupt carriers (PC and AA in Michigan) which were excluded from the federally reorganized ConRail system. The Michigan Railroad Plan, Phase II (revised and approved by the Federal Railroad Administration in June and August of 1976, respectively) was prepared to insure that Michigan would be eligible for federal rail service continuation assistance under Section 402 of the 3R Act.

Implementation of the 1976 Michigan Railroad Plan provided retention of service on 921 land miles of the 1,049 miles of bankrupt carriers which were not absorbed into the ConRail system or acquired by solvent carriers. Upon passage of the 4R Act, another 419 land route miles operated by solvent carriers were identified as being subject to abandonment proceedings. From that time to the end of the decade, 318 more route miles were filed for abandonment and 185 miles were actually abandoned.

As of September 1, 1980, the Michigan rail system consisted of 838 land route miles operated with state or federal rail service assistance, 204 land route miles which were subject to abandonment proceedings, 589 land route miles which were considered by carriers to be candidates for abandonment, and approximately 4,397 land route miles operated by solvent carriers and not potentially subject to or pending abandonment.

In Michigan, the state's 1981 Appropriations Act specifies a phase-out schedule which reduces the 1981/82 state rail freight operating assistance appropriation for currently subsidized lines by 25 percent, each year for four years. By 1985/86, the state's subsidies to these rail lines will be discontinued. This is in addition to a reduction in federal support. While the Rail Service Act of 1978 provides subsidies through 1983 on some lines, little federal money has been appropriated. In the late 1970s, federal rail subsidies were between $4-6 million per year. In 1982, that figure is $900,000, which funds only a few capital projects. Michigan is currently in the process of submitting a request for some of this capital project funding. As federal and state funds disappear, rail planners in Michigan and elsewhere are faced with the need to define an essential core of rail service and to determine which rail lines will receive the declining financial support. Consequently, rail planners require methods to estimate rail traffic and to predict profitability of currently subsidized lines.

A decline in the demand for rail service results in revenues below costs and, ultimately, abandonment. Abandonment often stems from the fact that the demand for goods in the entire economy or region has declined, causing a decline in the derived demand for transportation.[1/] Therefore, to enable rail planners to more effectively address the demand for branch line services and facilities, it is necessary that they have an understanding of the relationship between the structure of the economy (representing the requisite amount of inputs and outputs) and the associated movement of commodities throughout the state or region.

To determine whether a rail branch line should be subsidized or abandoned (the investment-disinvestment decision), a primary objective of transportation planners is to identify the minimum acceptable levels of rail service that will either be profitable to the operator or generate net economic benefits to affected communities. In the State of Michigan, for example, the approach mandated is a procedure that examines each case on a line-by-line basis, but offers little insight regarding the relationship of any given line to the total rail system. The interdependency between rail service and economic activity in the region or state is not addressed. While this type of partial approach is often employed in individual abandonment hearings, decision makers viewing the rail system from a statewide perspective require a more comprehensive framework.

[1/] Much of the literature on the abandonment of rail branch lines suggests the condition of the local economy is a crucial factor affecting abandonment of a line, e.g., Frost (1972); Sloss, Humphrey, and Krulter (1975); Allen (1975); and Vollmers and Thompson (1980).

In making appropriate long-run investment decisions on rail branch lines, decision makers also need accurate forecasts of relevant commodity movements and traffic flows. In most cases, however, future rail traffic volumes are obtained by soliciting rail users' opinions regarding their anticipated increase in rail use. Since each user has an incentive to overestimate future usage, surveys of this type tend to present an overly optimistic view of future traffic growth. In Michigan, for example, rail planners rely primarily on ad hoc projections based on shipper-carrier interviews. Traffic projections in most other states follow similar procedures (Transportation Research Board).[2/]

Therefore, improved traffic projection methods are needed to replace the predominant ad hoc procedures used, since these projections are crucial in analyzing the potential profitability of currently subsidized lines. Utilizing a more comprehensive forecasting procedure, the volume of goods that could be expected to flow over an individual rail segment could be determined for a given projection of statewide economic activity. These expected flows can then be evaluated relative to their corresponding break-even volumes.

The purpose of this study is to suggest a method of forecasting rail traffic that systematically links the level of statewide economic activity with the demand for rail freight transportation services and facilities. To accomplish this purpose: (1) the use of a two-region input-output model for transportation planning is briefly discussed; (2) a test of the forecasting capability of the input-output model is presented; and (3) the

[2/] In Washington and California, however, preliminary work has been carried out in using an input-output model to aid in rail traffic forecasting. In both cases, however, the use of the input-output forecasting procedure is more limited than the procedure discussed here.

Leontief inverse matrix $(I-A)^{-1}$ is multiplied by the final demand (Y_t) for each of the sectors in the economy for year t. The product is a vector (X_t) of total output for each commodity group. Total outputs in t+i are found by multiplying the Leontief inverse matrix by a new final demand vector (Y_{t+i}) in Equation (2). Equation (3) provides the proportionate change in total output, K, between t and t+i, by commodity. 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 a vector of tons of rail shipments for each commodity derived from the total output changes in the entire economy. (See Appendix for 20-sector I/O model and an example of its use.)

The Use of Input-Output for Transportation Planning

The structure of the Michigan input-output table was derived from the work of Hwang and Maki (1979) and was used by Adiarte and Venegas (1980) to build the 1976 Michigan model. This study employs a two-region input-output model, Michigan and Rest of Nation (RON), that was derived from a national input-output table constructed by the U.S. Department of Commerce. The industries, final demands, and primary inputs outside of Michigan were aggregated across states, but treated as distinct sectors trading among themselves with similar sectors in Michigan. Two transactions tables were produced, Michigan and RON, and developed simultaneously from estimates of four commodity flows: (1) sales within Michigan; (2) exports from Michigan; (3) imports into Michigan; and (4) sales of outside industries among themselves. Two balanced input-output tables are created when imports and exports at the industry level are combined into the import and export sectors.

input-output model is used to forecast rail traffic over selected branch lines. A Michigan case study will be used to illustrate the use of the forecasting procedure.

The Analytical Model

The model and generalized procedure of forecasting rail traffic is presented below.

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

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

(3) $(X_{t+i}-X_t) / X_t = K$

(4) $(1+K) : W_t = R_{t+i}$

where: X_t = total output vector of economy in year t;

Y_t = final demand vector facing economy in year t;

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

K = proportionate change in total output vector, by commodity, between year t and selected years in the future;

W_t = 1 percent expanded waybill sample, matched to output vector, year t;

R_{t+i} = predicted freight traffic flows vector, by commodity;

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;

X_j = total output of industry j; and

I = identity matrix.

Equation (1) gives the output required to sustain a given level of final demand and represents the solution to the input-output problem. The

The 1976 Michigan input-output model represents 44 industry groups. However, when linked to transportation data, the 1976 model was aggregated to 20 sectors to better match the mix of commodity groups moving over Michigan's rail system to the input-output sectors. This aggregation was also performed to deal with those commodities in the 44-sector model that have small absolute amounts moving over the rail system; similar commodity groups with low tonnage were aggregated to produce the 20-sector model.

The relationship between the production and consumption of a product and the demand for transportation services is obtained by matching each of the 20 sectors in the input-output model to commodity classifications on the waybill tapes, i.e., the Standard Industrial Codes (SIC) in the model are matched to the Standard Transportation Commodity Classification (STCC) codes of the transportation data. The input-output model represents the economy's structure and predicts the annual usage rate of commodities by industry. The model indicates who the suppliers of an industry are, who demands their product, and what their particular input-output relationship is to other sectors. The initial assumption is that economic activity in a particular sector or region generates the demand for the physical movement of products included in each of its input sectors in proportion to the change in that sector's output. Thus, corresponding to each of the dollar flows present in the input-output model, originating and receiving sectors can be identified on the commodity waybill tapes.

To forecast rail traffic for any year, it is necessary to estimate the final demands, by sector, for the forecast year. These final demands are used to "drive" the Michigan input-output table, producing projections of total output, by sector. This projection is accomplished through the multiplication of the new final demands by the Leontief inverse matrix derived from the input-output table. After the total outputs are generated, rail movements are predicted based on the increase or decrease in output for each commodity. For example, if the final demand in the automobile industry is decreased by 10 percent, the total output in its supplying sectors will also decline. This decline represents a decrease in the flow of input goods on the rail lines that deliver goods to the industry. If the use of foundry output decreases by 3 percent due to the decline in the automobile industry, then on each rail segment that moves foundry output, projected rail movements are decreased by 3 percent. This procedure is used to adjust the movement of goods on the state's rail lines, given the changes in total economic activity.

The use of an input-output model for forecasting rail traffic rests on the concept of the output multiplier. To forecast rail traffic, it is necessary to forecast changes in the economy, given changes in the final demand sector. The disaggregated nature of output multipliers is particularly well-suited to transportation planning because the demand for specific rail lines or segments is often commodity-dependent. A method is needed to disaggregate the effects of economic changes (final demands) on a commodity-by-commodity basis in order to estimate the future demand for rail services.

Output multipliers represent the most straightforward use of input-output and are not subject to difficulties associated with the use of income and employment multipliers. The output multiplier simply indicates the degree of structural interdependence between individual sectors and the rest of the economy. Income and employment multipliers require more data, increasing the already sizable data problems that exist, and in the case of income multipliers, the assumptions of input-output make their use problematic. The assumption of an aggregate linear homogeneous consumption function is restrictive, particularly at the theoretical level (Richardson, 1972). Further, underlying the income estimate is a questionable assumption that changes in consumer spending are proportional to changes in income, both in terms of quantity of income spent and expenditure patterns (Jones, 1978). Using this simplified consumption function tends to overstate the income effects of changes in final demand. Thus, in using input-output, one must use care in the application of multipliers.

II. TESTING THE USE OF INPUT-OUTPUT FOR RAIL TRAFFIC FORECASTING

In this sector, the analytical model and forecasting procedure is operationalized and applied to the Michigan study area. The model is first tested to determine whether it can accurately forecast rail traffic, given known rail movements. The test consists of projecting 1980 rail traffic on the basis of 1976, 1 percent waybill data and comparing that projection to the waybill sample observed for 1980. Final demands, by sector, are estimated for 1980 and substituted for the 1976 final demands. Total output, by sector, is estimated by the input-output model through the multiplication of the new final demands by the output multipliers of the inverse matrix $(I-A)^{-1}$. Projected total output is then taken as a percentage of 1976 output.

Next, the 1 percent waybills (expanded by 100), representing total rail traffic in 1976, are multiplied by the real percentage changes forecast by the input-output model. This procedure yields a projection of rail traffic for 1980. Finally, the 1980 actual traffic is compared to the projected traffic to assess how accurately, both by totals and by commodity, the model projects rail traffic.

Estimating 1980 Final Demands

Beginning with the 1976, 20-sector input-output model of Michigan, final demands for the base year of 1976 and the test year of 1980 are estimated. The 1976 final demands are those estimated when the two-region input-output model was constructed. The 1980 final demands were estimated using as much Michigan-specific data as possible. Most state input-output models rely on sharing techniques that apportion national changes in the final demand sectors to the state level.

There are six final demand sectors in the Michigan input-output model:

(1) Personal Consumption Expenditures

(2) Gross Private Capital Formation

(3) Net Inventory Change

(4) Net Exports

(5) State and Local Government

(6) Federal Government

All 1980 final demands are in 1976 dollars, deflated by implicit price deflators for gross national product indexes, found in the 1981 Economic Report of the President (pp. 236-237). Therefore, the dollar value for 1980 final demands represents the real change in demand, from 1976 to 1980, and can be linked to the tonnage change in Michigan's rail network. The year 1980 was chosen as the test case because it represents the most recent year in which data are available. Following is the method by which the 1980 final demands were estimated.

Personal Consumption Expenditures

To calculate the value for personal consumption expenditures, Michigan's retail sales tax collections were used as a proxy for changes in consumer spending. The Michigan Department of Treasury collects retail sales tax information in eight broad categories (building materials, general merchandise, automotive, food, apparel, furniture, miscellaneous retail, and non-retail) with subsectors in most categories. This information is reported in the yearly Economic Report of the Governor (1981, p. 33). The percentage change in sales tax collections between 1976 and 1980 was calculated and this percentage change was used to increase or decrease the personal consumption expenditure figures used in the 1976 input-output model. These figures were then deflated to 1976 dollars by the total personal consumption expenditures index of the implicit GNP deflator.

Gross Private Capital Formation

The value of gross private capital formation represents the sum of receipts for new construction and capital expenditures of the manufacturing sector. Michigan's data for 1980 were acquired from the Office of Revenue and Taxes, Department of Management and Budget. The data are from the reported capital acquisitions from the Michigan Single Business Tax. Capital acquisitions at the two-digit SIC code level were reported for depreciable assets of firms in Michigan filing the Single Business Tax and represent a value added tax on investment. Not all investors in Michigan file the Single Business Tax; for example, non-profit organizations do not. Farmers are also exempt, but estimates of farm investment were obtained from the Michigan Department of Agriculture. These estimates of investment were then deflated to 1976 dollars, using the gross private domestic investment index of the implicit GNP deflator.

Net Inventory Change

Net inventory change was obtained from various Survey of Current Business reports. The percentage change in net inventories between 1976 and 1980 was used to increase or decrease the data on net inventory contained in the 1976 input-output model. These figures were adjusted to 1976 dollars by the GNP deflator. The percentages used for net inventory changes are based on national figures and not Michigan-specific data. No Michigan data could be located for this category; however, since it is the smallest part of final demand, the use of national figures should not appreciably alter the results.

Net Exports

Agricultural export information was obtained from the Michigan Department of Agriculture and for manufacturing sectors from the Michigan Department of Commerce, Economic Development Office. Import information for the same categories was obtained from the U.S. Department of Commerce, Foreign Trade Statistics section. All data were deflated to 1976 dollars by the export index in the implicit GNP deflator.

State and Local Government

This includes the operating expenditures of state and local government agencies except: liquor stores; water transport and terminals; parking facilities; urban renewal; airports; and transit. These are included in the government enterprise sector. The state and local index in the GNP deflator was used to produce real changes. This data was obtained from the 1980 Michigan Statistical Abstract and the 1979-80 Government Finances. For both federal and state and local governments, additional data were obtained from the study by Scheppach in State Projections of the Gross National Product, 1970, 1980.

Federal Government

This 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 are from the 1980 Michigan Statistical Abstract, deflated by the federal government index of the GNP deflator.

Testing the Analytical Method

To project total outputs by sector for 1980, estimates of 1980 final demands are used to "drive" the input-output model. The results of this are shown in Table 1, which indicates the projected total output in Michigan for 1980, given the estimated final demands. Table 1 also shows the percentage change in total output from 1976 to 1980.

In constant dollar terms, Table 1 shows, for example, that total output in the livestock and products sector is down 10.59 percent from 1976, and the motor vehicle and parts sector is down 40.13 percent. On the other hand, total output in the utilities sector is up 16.32 percent, etc. It is with the percentage changes of Table 1 that rail traffic for 1980 is projected.

The actual expanded 1 percent waybills for 1976 and 1980 are shown in Table 2. To project 1980 rail traffic, the actual 1976 expanded 1 percent waybills are adjusted by the 1976-1980 percentage change in total output by sector. For example, in 1976, 1,211,200 tons of agricultural products moved over Michigan's rail lines. The 1980 total output in the agricultural products sector increased 28.24 percent over 1976 in constant dollars. Thus, it is estimated that rail movements over Michigan's rail system should also increase by 28.24 percent, or 342,042 tons. Consequently, the model estimated that rail traffic in the agricultural products sector is 1,211,200 plus 342,042 tons, or 1,553,242 tons. This procedure is carried out for each commodity sector, yielding the 1980 projections of Michigan rail traffic shown in Table 3.

In order to evaluate the rail traffic forecasting ability of the input-output model, it is necessary to compare the 1980 projected rail flows to the actual 1980 rail flows; Table 3 shows this comparison. The

Table 1

1980 Total Output Projections: Michigan
(Thousands of 1976 Dollars)

Sector	Industry	Projected Final Demand	Projected Output	Percent Change in Output
1	Livestock and Products	15,453	620,264	-10.59
2	Other Agricultural Products	446,292	904,850	28.24
3	Mining	1,231,017	1,911,251	9.94
4	Construction	2,550,125	4,003,351	-31.54
5	Food and Kindred Products	3,777,201	4,236,337	-13.03
6	Lumber, Furniture, Paper, Printing	2,176,523	4,684,377	-8.27
7	Chemicals, Drugs, Plastics	2,186,434	3,718,038	-34.14
8	Petroleum Refinery	397,726	693,082	-26.05
9	Rubber, Leather, Stone, Glass, Clay	390,786	1,934,431	-34.39
10	Primary and Fabricated Metals	3,603,676	11,109,276	-24.77
11	Machinery, Except Electrical	2,164,602	4,733,203	-28.85
12	Electrical Equipment	447,245	1,167,093	-25.81
13	Motor Vehicles and Parts	17,207,784	24,013,737	-40.31
14	Aircraft and Other Transportation Equipment	365,729	462,489	-25.19
15	Transportation and Communication	5,542,140	7,059,890	-2.77
16	Utilities	2,888,712	4,893,818	16.32
17	Wholesale, Retail, Miscellaneous Manufacturing, Including Textiles	11,459,264	14,255,054	-20.36
18	Financial, Insurance, Real Estate	8,381,690	10,838,032	3.91
19	Selected Services	6,883,459	11,186,377	-8.67
20	Government Enterprises	405,714	1,102,926	2.12
	Total		113,527,874	-21.51

Table 2

Expanded 1 Percent Waybills, Michigan, 1976, 1980, by Input-Output Sector

Sector	Industry	1976 Tons	1980 Tons
1	Livestock and Products	0	0
2	Other Agricultural Products	1,211,200	1,545,000
3	Mining	31,641,100	35,463,300
4	Construction	0	0
5	Food and Kindred Products	3,476,700	2,667,800
6	Lumber, Furniture, Paper, Printing	4,607,900	4,021,100
7	Chemicals, Drugs, Plastics	4,180,300	2,713,700
8	Petroleum Refinery	2,520,400	1,679,000
9	Rubber, Leather, Stone, Glass, Clay	2,592,600	1,798,500
10	Primary and Fabricated Metals	6,025,000	3,684,100
11	Machinery, Except Electrical	242,300	111,400
12	Electrical Equipment	134,000	97,000
13	Motor Vehicles and Parts	13,204,600	8,170,800
14	Aircraft and Other Transportation Equipment	165,100	129,800
15	Transportation and Communication	0	0
16	Utilities	0	0
17	Wholesale, Retail, Miscellaneous Manufacturing, Including Textiles	5,502,600	4,224,800
18	Financial, Insurance, Real Estate	0	0
19	Selected Services	0	0
20	Government Enterprises	0	0
	Total	75,503,800	66,306,300

Table 3

Comparison Between 1980 Actual and Projected Rail Traffic Movements in Michigan (Tons)

Sector	Industry	Projected	Actual	Difference	Percent Difference	Standard Deviation in 1980 Waybill Sample	Observations in 1980 Waybill Sample
1	Livestock and Products	0	0	0	0.00	0	0
2	Other Agricultural Products	1,553,242	1,545,000	8,242	0.53	377,300	180
3	Mining	34,786,225	35,463,300	-677,075	-1.91	5,652,600	4,232
4	Construction	0	0	0	0.00	0	0
5	Food and Kindred Products	3,023,685	2,667,800	355,885	13.34	1,346,900	662
6	Lumber, Furniture, Paper, Printing	4,226,826	4,021,100	205,726	5.12	1,798,700	878
7	Chemicals, Drugs, Plastics	2,753,145	2,713,700	39,445	1.45	851,100	368
8	Petroleum Refinery	1,863,835	1,679,000	184,835	11.01	4,005	329
9	Rubber, Leather, Stone, Glass, Clay	1,701,004	1,798,500	-97,496	-5.42	1,102,300	345
10	Primary and Fabricated Metals	4,532,607	3,684,100	848,507	23.03	1,089,500	464
11	Machinery, Except Electrical	172,396	111,400	60,996	54.75	80,200	41
12	Electrical Equipment	99,414	97,000	2,414	2.49	42,800	65
13	Motor Vehicles and Parts	7,881,825	8,170,800	-288,975	-3.54	3,873,700	3,300
14	Aircraft and Other Transportation Equipment	123,511	129,800	-6,289	-4.85	53,700	46
15	Transportation and Communication	0	0	0	0.00	0	0
16	Utilities	0	0	0	0.00	0	0
17	Wholesale, Retail, Miscellaneous Manufacturing, Including Textiles	4,382,270	4,224,800	157,470	3.73	2,559,900	1,193
18	Financial, Insurance, Real Estate	0	0	0	0.00	0	0
19	Selected Services	0	0	0	0.00	0	0
20	Government Enterprises	0	0	0	0.00	0	0
	Total	67,099,985	66,306,300	793,685	1.20	45,834,200	12,103

projected total rail flow in Michigan for 1980 is 67,099,985 tons. The actual flow in 1980 was 66,306,300 tons. (This actual total does not include 1,638,200 tons of hazardous materials.) The model's projection of rail traffic is 793,685 tons higher than the 1980 actual figures, or 1.2 percent over the 1980 actual flows.

Table 3 also includes a comparison of projected versus actual rail traffic for each commodity sector. When this method is used to project rail traffic on a regional or line-by-line basis, individual commodity groups will be important and their estimation will be crucial in producing reliable projections of rail traffic. In the Upper Peninsula, for example, rail service is used primarily by the mining, forestry, and related pulp and paper industries. The statewide projections of these industries provide confidence that U.P. rail traffic can be predicted accurately. In Table 3, the forestry sector is an important component of sector 2, other agriculture products. In this case, the model predicted rail traffic to within 0.53 percent of actual traffic. The projection for the mining sector was only 1.91 percent lower than actual traffic and the projection of rail traffic in the paper industry (within sector 6) was 5.12 percent different from the actual rail flow. Most of the commodity sectors were projected within a percentage difference that is believed to yield confidence in the use of the model on a regional or line-by-line basis.

The model was effective in providing sector-by-sector estimates in 11 of the 13 sectors in which rail traffic was represented in 1976 and 1980. In the two sectors in which the model overestimated rail traffic by approximately 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 to estimate the size of errors due to the waybill sampling procedure. In both sectors 10 and 11, the standard deviation is large, relative to its mean (30 percent and 72 percent, respectively). This indicates that for these two sectors, part of the projection error is due to waybill sampling error. Of course, the large difference between the projected and actual value in sectors 10 and 11 can also be attributed, in part, to errors in the technical coefficients in the input-output matrix and errors in the estimation of final demands. However, it does appear that a substantial portion of the projection error can be attributed to waybill sampling.

The method suggested in this study is not meant to be used in isolation from other information available to rail planners. In using this or any other forecasting procedure, balance must be maintained between a model's results and exogenous information available to rail planners about the nature of rail traffic. While the model alone cannot predict the change from high levels of traffic to zero or vice-versa, it is believed that rail planners would have additional information to complement the model's results. In any case, the majority of the sectors in the test show projections close to actual traffic, with total traffic projections very close to actual traffic.

Since the test of the method has shown its ability to forecast total rail traffic over a four-year period, the next step is to illustrate its use in aiding the subsidy-abandonment decision. The next section uses the model to predict rail traffic beyond 1980 for Michigan's Upper Peninsula region. Using estimates of final demand, various projections will be used to obtain forecasts of total output and forecasts of rail traffic in the U.P. and on a segment of the Soo Line. This will help determine whether, under any economic growth scenario, the segment of the Soo Line that is under a subsidy-abandonment study will be able to generate enough traffic to remain profitable, or, if not presently profitable, whether future rail demand will enhance its revenue position. The next section represents a guide to the use of the input-output model for future rail planning decisions.

III. APPLYING THE RAIL FORECASTING METHOD TO REGIONAL RAIL PLANNING

In this section, an illustration of how the rail traffic forecasting method tested previously can be employed to aid in the subsidy-abandonment decision will be presented. Also included is a case study of the northern Soo Line in Michigan's Upper Peninsula. The illustration is only suggestive in nature because the financial data needed to perform a full-scale analysis of the case study region is unavailable. The Upper Peninsula rail system is currently under study by the Michigan Department of Transportation[3/] as part of the rail rationalization process. The application of the rail traffic forecasting method will be accomplished in the following steps:

(1) The Michigan input-output model will be used to project total output and Upper Peninsula rail traffic for 1983, given various estimates of final demands. Additionally, total output and U.P. rail traffic will be projected to 1986, the last year of the subsidy appropriations in Michigan.

(2) The estimates for Upper Peninsula rail traffic will be used to analyze major issues facing rail planners on a system-wide basis, particularly the potential commodity growth upon which U.P. rail lines depend.

(3) Rail traffic will be forecast for the northern Soo Line, between Trout Lake and Dollar Bay, to aid in the resolution of the issue surrounding the need for a north-south connection for Soo Line traffic.

[3/] The material for this section on the U.P. rail system is from: Michigan Department of Transportation, "Michigan Rail System Rationalization Plan: Tier II, Phase III, Upper Peninsula Report" (Draft), May 14, 1982.

In both the entire U.P. and on the northern Soo Line, the future of the rail system is sensitive to the production and movement of certain commodities. Consequently, the input-output method of forecasting rail demand by commodity is particularly well-suited to addressing the issues of the U.P. rail system. In projecting rail traffic to 1983 and 1986, most significant is the commodity-by-commodity change in traffic since 1980. To be determined is which commodities may increase by the largest percentage, and whether those commodity increases produce sufficient rail demand to create financial stability.

Service Needs in the Upper Peninsula and the Soo Line

As illustrated in Figure 1, those lines in possible jeopardy include the entire northern segment of the Soo Line. As a part of the Tier I rail rationalization screening analysis, the Michigan Department of Transportation identified specific segments in the U.P. which were designated as essential core lines. These lines provide service to significant existing traffic bases and contribute to rail system and regional service objectives to a degree consistent with the results of the screening analysis on lines elsewhere in the state. Segments designated as essential core lines through the results of the Tier I analysis are identified in Figure 2. The screening analysis also identified lines which warrant designation as non-essential for servicing existing needs. These lines serve little traffic and exhibit virtually no potential for viability in the absence of significant rail-dependent economic growth. These lines are also identified in Figure 2.

The results of the Michigan Department of Transportation's screening analysis were inconclusive for several U.P. rail segments. While these segments exhibit lower traffic densities and potential for viability, they

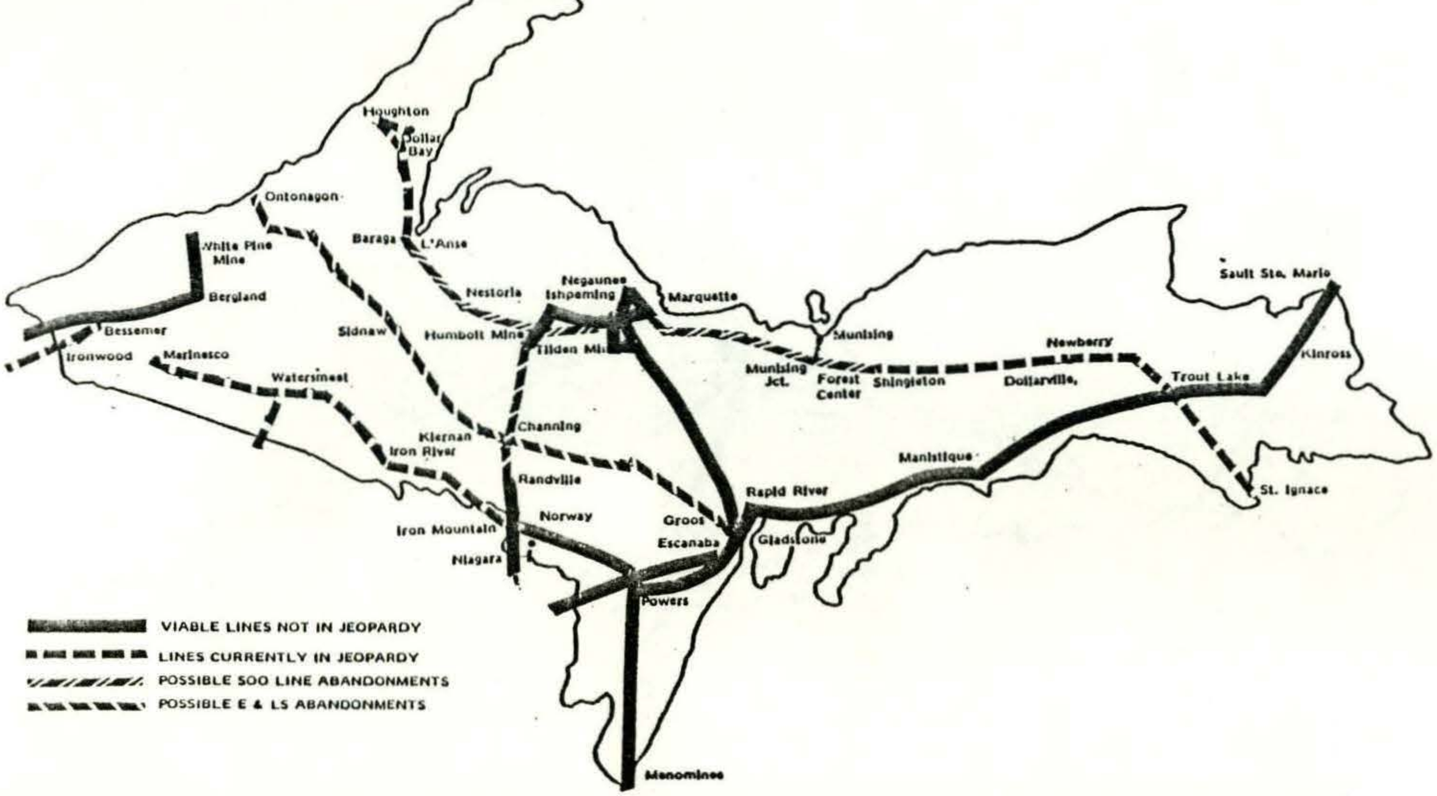

Figure 1

Upper Peninsula Lines Possibly in Jeopardy

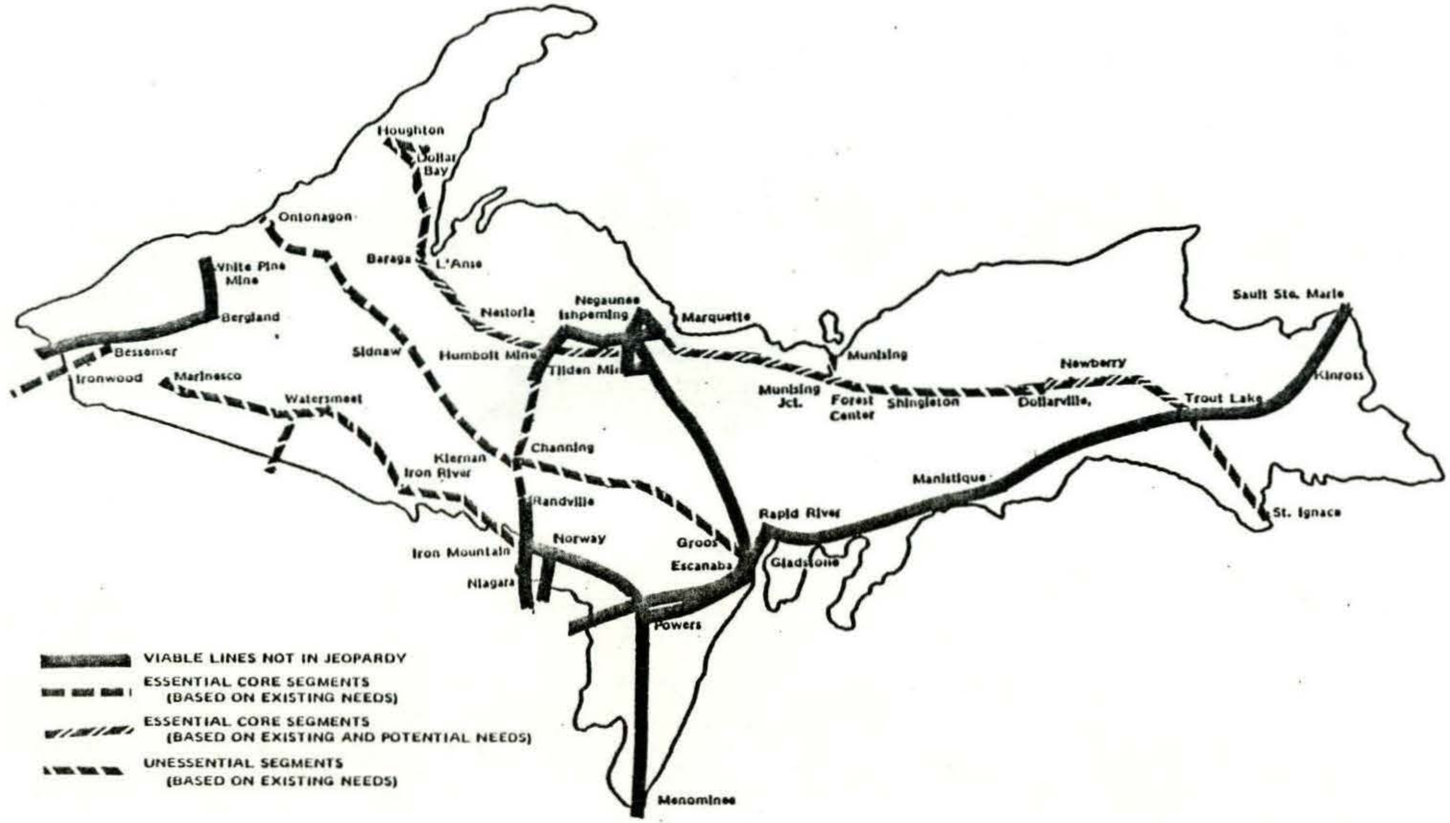

Figure 2

Existing Needs Map

provide service to rail-dependent industries which generate significant employment opportunities. These lines, shown in Figure 2, were included in the essential core system on the basis of rail-dependent industry potential. The rail traffic forecasting method suggested herein can be of value in the assessment of future rail demand based on industry potential. The results of the analysis can aid in the selection of the alternatives open to public policy decision makers.

Projecting Economic Activity, 1980-1983 and 1986

The first step in projecting rail traffic is the estimation of final demands. The final demands for 1983 and 1986 are based on national projections of economic indicators by the Research Seminar in Quantitative Economics (RSQE), University of Michigan, as reported in Economic Outlook, USA (Winter 1982). Estimates of the changes in final demands between 1980 and 1983 were used because 1983 is the last year for which projections are made. The 1980-1986 period projection was performed to reflect medium- to long-range growth prospects for a period consistent with the MDOT rail planning horizon.

The Research Seminar in Quantitative Economics projects national forecasts for personal consumption expenditures; including durable goods, automobiles and parts, furniture and household equipment, other durables, nondurable goods, and services. Forecasts of gross private domestic investment are broken down into nonresidential and residential structures categories. The RSQE also forecasts changes in business inventories, net exports, and federal, state, and local government purchases.

The projected percentage change (in constant dollars) in each of the above categories was then used to forecast 1983 and 1986 Michigan final demands. The real percentage change for the appropriate category was applied to the 1980 final demands used in the testing procedure. For example, final demand in the automobile sector (13) in 1980 was $17,207,784,000. To arrive at the 1983 estimate, the real percentage change in the automobiles and parts category of personal consumption expenditures and the nonresidential category of gross private domestic investment was used in concert with the other final demand projections to increase the 1980 final demand. In this case, RSQE projected the 1983 final demand for automobiles and parts to be 12.9 percent above the 1980 level, producing a Michigan estimate of $19,427,588,000. This procedure was repeated for each of the 20 sectors of the input-output model and results are shown in Table 4.

The final demand estimates based on national data shown in Table 4 for 1983 are considered as the high projections for Michigan. The RSQE estimates show real 1983 gross national product to be 13.7 percent above the 1980 GNP level. Due to the present condition of the Michigan economy, an overall 1983 growth of 13.7 percent above 1980 would require a high rate of growth over the next year. Consequently, if Michigan grows as much as the national economy, it would be considered a high growth scenario. The low growth scenario for 1983 assumes a zero percentage change from 1980; if the Michigan economy in 1983 matches 1980 data, it demonstrates a low rate of growth.

Since the low growth projection is the same as 1980, no separate table is needed; the percentage changes are zero. The medium-range projection of final demand is shown in Table 5 and is the average of the high and low projections. Tables 4 and 5 show the projected final demands and total

Table 4

1983 Projection of State Economic Activity and Upper Peninsula Rail Traffic: High Projection

		Statewide Economic Activity (Thousands of 1976 Dollars)		U.P. Rail Traffic Tons			
Sector	Industry	1983 Projected Final Demand	1983 Projected Output	1983 Projected Rail Traffic	Actual 1980 Rail Traffic	Projected Change in Rail Traffic	% Change 1980-1983
1	Livestock and Products	16,906	680,169	0	0	0	0.00
2	Other Agricultural Products	488,243	992,787	2,253	2,000	253	12.65
3	Mining	1,351,657	2,104,167	19,981,577	17,952,900	2,028,677	11.30
4	Construction	2,817,888	4,432,546	0	0	0	0.00
5	Food and Kindred Products	4,132,258	4,637,066	59,770	55,200	4,570	8.28
6	Lumber, Furniture, Paper, Printing	2,368,057	5,148,110	1,456,817	1,331,400	125,417	9.42
7	Chemicals, Drugs, Plastics	2,400,705	4,098,021	75,180	70,000	5,180	7.40
8	Petroleum Refinery	436,703	763,972	9,167	8,500	667	7.85
9	Rubber, Leather, Stone, Glass, Clay	429,083	2,150,938	301,999	280,200	21,799	7.78
10	Primary and Fabricated Metals	3,956,836	12,349,898	104,412	96,100	8,312	8.65
11	Machinery, Except Electrical	2,376,733	5,248,059	14,434	13,400	1,034	7.72
12	Electrical Equipment	491,075	1,295,914	0	0	0	0.00
13	Motor Vehicles and Parts	19,427,588	27,101,285	0	0	0	0.00
14	Aircraft and Other Transportation Equipment	401,570	508,874	0	0	0	0.00
15	Transportation and Communication	6,085,270	7,771,803	0	0	0	0.00
16	Utilities	3,160,251	5,378,060	0	0	0	0.00
17	Wholesale, Retail, Miscellaneous Manufacturing, Including Textiles	12,857,294	15,974,341	185,030	168,700	16,330	9.68
18	Financial, Insurance, Real Estate	9,404,256	12,144,122	0	0	0	0.00
19	Selected Services	7,723,241	12,522,290	0	0	0	0.00
20	Government Enterprises	430,868	1,203,445	0	0	0	0.00
	Total		126,505,867	22,190,639	19,978,400	2,212,239	11.07

Table 5

1983 Projection of State Economic Activity and Upper Peninsula Rail Traffic: Medium Projection

		Statewide Economic Activity (Thousands of 1976 Dollars)		U.P. Rail Traffic			
				Tons			
Sector	Industry	1983 Projected Final Demand	1983 Projected Output	1983 Projected Rail Traffic	Actual 1980 Rail Traffic	Projected Change in Rail Traffic	% Change 1980-1983
1	Livestock and Products	16,180	650,221	0	0	0	0.00
2	Other Agricultural Products	467,268	948,856	2,126	2,000	126	6.30
3	Mining	1,291,337	2,007,730	18,967,238	17,952,900	1,014,338	5.65
4	Construction	2,684,067	4,218,062	0	0	0	0.00
5	Food and Kindred Products	3,954,730	4,436,719	57,485	55,200	2,285	4.14
6	Lumber, Furniture, Paper, Printing	2,277,290	4,922,516	1,395,839	1,331,400	64,439	4.84
7	Chemicals, Drugs, Plastics	2,293,570	3,908,214	72,597	70,000	2,597	3.71
8	Petroleum Refinery	417,215	728,543	8,833	8,500	333	3.92
9	Rubber, Leather, Stone, Glass, Clay	409,935	2,042,779	291,127	280,200	10,927	3.90
10	Primary and Fabricated Metals	3,780,256	11,729,813	100,261	96,100	4,161	4.33
11	Machinery, Except Electrical	2,270,668	4,990,685	13,917	13,400	517	3.86
12	Electrical Equipment	469,160	1,231,513	0	0	0	0.00
13	Motor Vehicles and Parts	18,317,686	25,557,524	0	0	0	0.00
14	Aircraft and Other Transportation Equipment	383,650	485,683	0	0	0	0.00
15	Transportation and Communication	5,813,705	7,415,963	0	0	0	0.00
16	Utilities	3,024,481	5,136,035	0	0	0	0.00
17	Wholesale, Retail, Miscellaneous Manufacturing, Including Textiles	12,158,279	15,114,915	176,865	168,700	8,165	4.84
18	Financial, Insurance, Real Estate	8,892,973	11,491,196	0	0	0	0.00
19	Selected Services	7,303,350	11,854,559	0	0	0	0.00
20	Government Enterprises	418,291	1,153,209	0	0	0	0.00
	Total		120,024,735	21,086,288	19,978,400	1,107,888	5.45

output given the different growth ranges, in 1976 dollars. The projection of the final demands for 1986 are assumed to represent a high growth scenario and are based on the RSQE estimate of the 1982-83 change in real gross national product. The 1982-83 real GNP change is estimated to be 6.0 percent for the national economy. Thus, the final demands for 1983 shown in Table 4 are increased by 18 percent to yield a high estimate of final demands shown in Table 6.

It is recognized that the procedure outlined above is imprecise. However, the purpose of this chapter is to provide an illustration of how the forecasting method may be used. Further use of the method requires a better procedure for estimating final demands, as well as an updating of the input-output model itself.

Projecting Upper Peninsula Rail Traffic, 1980-1983 and 1986

The projections of total output shown in Tables 4, 5, and 6 are used to estimate the change in rail traffic between 1980 and 1983 and 1986, also shown in the three tables. Given the high growth scenario, rail traffic in the Upper Peninsula is projected to increase 11.07 percent for 1983, with the agricultural (including forestry), mining, and lumber sectors showing large increases compared to other sectors. The medium projection shows an increase in rail traffic between 1980 and 1983 of 5.45 percent. Finally, the 1986 projection shown in Table 6 estimates a total U.P. rail traffic increase of 32.78 percent. The sector changes in agriculture, mining, and lumber products are particularly important in the Upper Peninsula case study. The future of the U.P. rail system is tied to the demand for transportation generated by those industries.

Table 6

1986 Projection of State Economic Activity and Upper Peninsula Rail Traffic: High Projection

		Statewide Economic Activity (Thousands of 1976 Dollars)		U.P. Rail Traffic Tons			
Sector	Industry	1986 Projected Final Demand	1986 Projected Output	1986 Projected Rail Traffic	Actual 1980 Rail Traffic	Projected Change in Rail Traffic	% Change 1980-1986
1	Livestock and Products	19,949	802,597	0	0	0	0.00
2	Other Agricultural Products	576,127	1,171,484	2,769	2,000	769	38.45
3	Mining	1,594,955	2,482,860	23,963,530	17,952,900	6,010,630	33.48
4	Construction	3,325,108	5,230,313	0	0	0	0.00
5	Food and Kindred Products	4,876,064	5,471,731	69,281	55,200	14,081	25.51
6	Lumber, Furniture, Paper, Printing	2,794,307	6,074,430	1,707,254	1,331,400	375,854	28.23
7	Chemicals, Drugs, Plastics	2,832,832	4,835,439	85,246	70,000	15,246	21.78
8	Petroleum Refinery	515,310	901,467	10,460	8,500	1,960	23.06
9	Rubber, Leather, Stone, Glass, Clay	506,318	2,537,775	340,947	280,200	60,747	21.68
10	Primary and Fabricated Metals	4,669,066	14,571,387	119,317	96,100	23,217	24.16
11	Machinery, Except Electrical	2,804,545	6,192,306	16,330	13,400	2,930	21.87
12	Electrical Equipment	567,669	1,516,371	0	0	0	0.00
13	Motor Vehicles and Parts	22,924,554	31,979,375	0	0	0	0.00
14	Aircraft and Other Transportation Equipment	473,853	600,442	0	0	0	0.00
15	Transportation and Communication	7,180,619	9,170,570	0	0	0	0.00
16	Utilities	3,729,096	6,345,949	0	0	0	0.00
17	Wholesale, Retail, Miscellaneous Manufacturing, Including Textiles	15,171,607	18,849,273	212,325	168,700	43,625	25.86
18	Financial, Insurance, Real Estate	11,097,022	14,329,836	0	0	0	0.00
19	Selected Services	9,113,424	14,775,804	0	0	0	0.00
20	Government Enterprises	508,424	1,420,033	0	0	0	0.00
	Total		149,259,443	26,527,459	19,978,400	6,549,059	32.78

In the rail rationalization process, potential Upper Peninsula rail needs were determined by first identifying areas containing proven economic reserves of iron ore and copper, and those characterized as affording high potential for forest product industries. A second level of potential was addressed by identifying areas having proven sub-economic iron and copper deposits and medium potential for forest product industries. The areas of proven economic ore deposits and high potential for forest product industries coincide with rail lines already identified in the essential core system or lines which were marginal, but providing service to significant employment generators. The latter set was included in the definition of the essential core system based on both existing and potential needs.

The MDOT's analysis indicates that the viability of the Escanaba and Lake Superior, the Lake Superior and Ishpeming, and the Chicago and Northwestern Railroads all depend on either iron ore production or the forestry, lumber, and paper industries, or both. Thus, potential production in these sectors plays a crucial role in determining whether those lines will be able to generate sufficient traffic to remain or become profitable. The rail traffic projections produced by the input-output model indicate that those are the industries likely to generate the largest increases for all growth ranges (the lumber sector is projected to increase slightly less than sector 17). As is evident in the waybill projections in Tables 4, 5, and 6, the mining sector makes up approximately 90 percent of total U.P. rail traffic. The projected increase of rail traffic for that sector to 11.30 percent in 1983 and 33.48 percent in 1986 indicates that several already strong ore moving lines will remain viable.

The largest sector percentage increase is in the agricultural products sector. In the Upper Peninsula, most of that sector is made up of forestry products. Further, the lumber, furniture, paper, and printing sector--or forestry related industries--exhibits the fourth largest projected change. Thus, the rail forecasting method provides evidence that, at each growth rate, the sectors that are most important to the future of the U.P. rail system are those that generally show the largest gains. Consequently, there may be an incentive to continue state support rather than allow abandonment. In this manner, the input-output method of rail forecasting can be applied to the subsidy-abandonment decision. The disaggregated, commodity-by-commodity nature of the forecasting procedure does provide the type of information required in the rail planning process.

An Application to a Michigan Traffic Routing Issue

In this section, a demonstration of the use of the rail forecasting procedure is presented to analyze a specific issue related to one rail line in the Upper Peninsula. The decision involved is which of four alternatives for a Soo Line north-south routing would be most efficient. The decision depends largely on the future levels of traffic over the northern tier of the Soo Line. Therefore, the forecasting of rail traffic can aid in determining which alternative should be pursued.

The Soo Line Railroad,[4/] due to past mergers and changing traffic patterns, must move its northernmost traffic by a circuitous route over long stretches of light density track. Presently, traffic from the

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[4/] Discussion of the Soo Line from: Michigan Department of Transportation, Upper Peninsula Report, op.cit.

Houghton, L'Anse, Ishpeming/Negaunee, Marquette, and Munising areas must be routed east through Trout Lake, then west to Gladstone before it can travel through Wisconsin to major national markets via the Chicago gateway (see Figure 3).

In order to avoid circuitous routing, managers of the Soo Line have expressed a need for a more direct north-south route. Negotiations with the Chicago and Northwestern to allow the Soo to gain trackage rights over the C&NW main line from Ishpeming to north Escanaba have been held, but no agreement was reached. The Soo has also negotiated for the possible use of LS&I and E&LS trackage from Humboldt Mine to Pembine, Wisconsin. The Soo Line may attempt to abandon the light density track between Trout Lake and Shingleton without first securing a north-south outlet for northern tier traffic. This could lead to further abandonment of light density segments ultimately increasing costs to the shippers and adversely affecting potential development.

Four alternatives for a more efficient Soo Line north-south routing have been identified by the Michigan Department of Transportation and are shown in Figure 3:

(1) Shingleton to Manistique: utilizing abandoned rights-of-way now owned primarily by the state and federal governments.

(2) Munising Junction to Rapid River: utilizing rights-of-way abandoned by the LS&I and Soo Line.

(3) Ishpeming to north Escanaba: utilizing the C&NW line.

(4) Humboldt Mine to Pembine, Wisconsin: utilizing the LS&I Line from Humboldt Mine to Republic, then linking with the E&LS from Republic to Pembine.

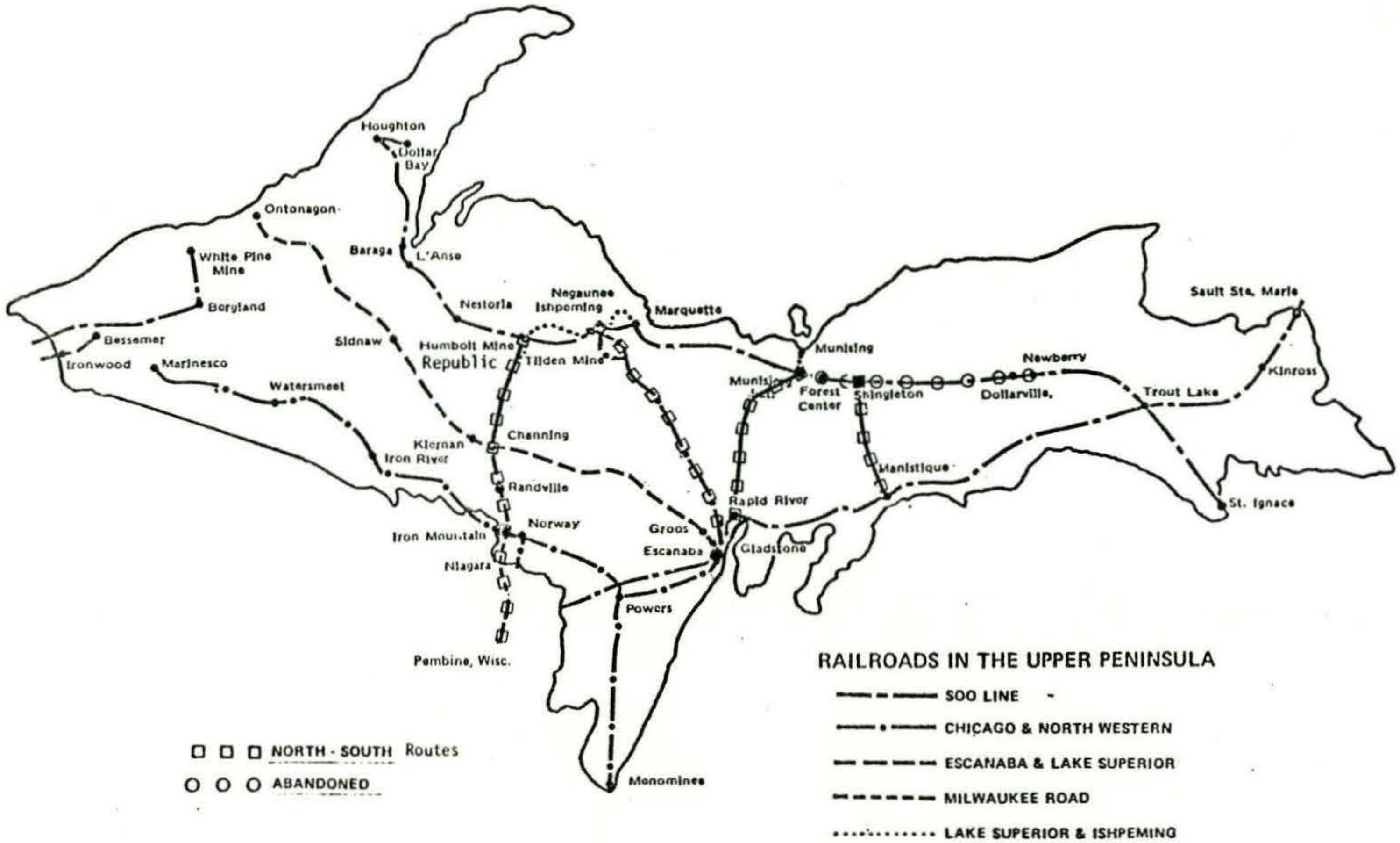

Figure 3

North-South Alternatives - Soo Line

The first alternative, Shingleton to Manistique, would require totally new construction and would most likely not be cost-effective. Most of the route is within federal and state forest areas; however, the southern five or six miles are privately owned. According to the Michigan Department of Transportation, new construction along this route would cost $375,000 per mile, excluding right-of-way purchase on the southern end. The total construction of this route would cost approximately $13.2 million.

The second alternative, Munising Junction to Rapid River, would require new construction to replace trackage which has been removed. Assuming a new construction cost of $375,000 per mile, reconstruction of this route would cost approximately $17,500,000. The Michigan Department of Transportation estimates that this alternative is also not likely to be cost-effective.

Use of the C&NW track (Ishpeming to north Escanaba) would probably be the least costly to implement. Information on track condition is not available, although the line is believed to be in reasonably good condition. Via this route, circuitous routing would be eliminated. Serving Forest Center via Humboldt Mine and Channing, over the E&LS, would have similar advantages. The line from Channing to Republic, however, is in poor condition. The cost of rehabilitation for 23 miles of track is estimated by the Michigan Department of Transportation at approximately $5 million.

In part, the distinction between these alternatives will depend on whether traffic density on the northern Soo Line will increase over the next few years. Higher densities and different commodity compositions would change the revenue situation for the northern Soo Line and could make any of the four alternatives feasible. It is at this point that forecasts of Soo Line traffic are needed. The 1983 and 1986 projections of Soo Line rail traffic are shown in Tables 7, 8, and 9. The actual 1980 rail traffic shown in Table 7 is 246,800 tons, carried in 4,200 cars. The 1980 traffic averaged approximately 59 tons per car. The total traffic between Trout Lake and Dollar Bay is approximately 9,300 cars, which includes 1,029 that move on the LS&I between Munising and Munising Junction. The 4,200 cars are those that appear on the 1 percent waybills and it is assumed that the traffic not on the waybills is proportionate among the commodity sectors in the same fashion shown in Table 7. Consequently, the relative changes in the Soo Line projections should remain the same. The Soo Line traffic shown in Tables 7, 8, and 9 represents only that traffic which runs on the northern tier. As was shown in Figure 1, the remainder of the Soo Line is not in jeopardy.

The forecasting method has the advantage of being disaggregated by commodity and the use of the waybill samples also allows the isolation of specific rail segments due to the identification of origins and destinations, by county.[5/] Given the average of 59 tons per car that occurred in 1980, the number of cars projected on the northern Soo Line increases to 4,380 cars in the medium projection and 4,572, given a high

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[5/] The Michigan Department of Transportation retains station designations on the waybill files for applications to circumstances which require greater specificity. To permit analysis at alternate levels of aggregation, MDOT maintains a station to 547 zone equivalence capability, which was aggregated to the county level for this study. The MDOT is currently in the process of disaggregating the rail network to the 2300 zone level.

Table 7

1983 Projection of State Economic Activity and Soo Line Rail Traffic:
Medium Projection

		Statewide Economic Activity (Thousands of 1976 Dollars)		Soo Line Rail Traffic Tons			
Sector	Industry	1983 Projected Final Demand	1983 Projected Output	1983 Projected Rail Traffic	Actual 1980 Rail Traffic	Projected Change in Rail Traffic	% Change 1980-1983
1	Livestock and Products	16,180	650,221	0	0	0	0.00
2	Other Agricultural Products	467,268	948,856	0	0	0	0.00
3	Mining	1,291,337	2,007,730	10,248	9,700	548	5.65
4	Construction	2,684,067	4,218,062	0	0	0	0.00
5	Food and Kindred Products	3,954,730	4,436,719	4,269	4,100	169	4.12
6	Lumber, Furniture, Paper, Printing	2,277,290	4,922,516	92,678	88,400	4,278	4.84
7	Chemicals, Drugs, Plastics	2,293,570	3,908,214	5,185	5,000	185	3.70
8	Petroleum Refinery	417,215	728,543	0	0	0	0.00
9	Rubber, Leather, Stone, Glass, Clay	409,935	2,042,779	36,780	35,400	1,380	3.90
10	Primary and Fabricated Metals	3,780,256	11,729,813	0	0	0	0.00
11	Machinery, Except Electrical	2,270,668	4,990,685	0	0	0	0.00
12	Electrical Equipment	469,160	1,231,513	0	0	0	0.00
13	Motor Vehicles and Parts	18,317,686	25,557,524	0	0	0	0.00
14	Aircraft and Other Transportation Equipment	383,650	485,683	0	0	0	0.00
15	Transportation and Communication	5,813,705	7,415,963	0	0	0	0.00
16	Utilities	3,024,481	5,136,035	0	0	0	0.00
17	Wholesale, Retail, Miscellaneous Manufacturing, Including Textiles	12,158,279	15,114,915	109,243	104,200	5,043	4.84
18	Financial, Insurance, Real Estate	8,892,973	11,491,196	0	0	0	0.00
19	Selected Services	7,303,350	11,854,559	0	0	0	0.00
20	Government Enterprises	418,291	1,153,209	0	0	0	0.00
	Total		120,024,735	258,403	246,800	11,603	4.70

Table 8

1983 Projection of State Economic Activity and Soo Line Rail Traffic:
High Projection

		Statewide Economic Activity (Thousands of 1976 Dollars)		Soo Line Rail Traffic Tons			
Sector	Industry	1983 Projected Final Demand	1983 Projected Output	1983 Projected Rail Traffic	Actual 1980 Rail Traffic	Projected Change in Rail Traffic	% Change 1980-1983
1	Livestock and Products	16,906	680,169	0	0	0	0.00
2	Other Agricultural Products	488,243	992,787	0	0	0	0.00
3	Mining	1,351,657	2,104,167	10,796	9,700	1,096	11.30
4	Construction	2,817,888	4,432,546	0	0	0	0.00
5	Food and Kindred Products	4,132,258	4,637,066	4,439	4,100	339	8.27
6	Lumber, Furniture, Paper, Printing	2,368,057	5,148,110	96,727	88,400	8,327	9.42
7	Chemicals, Drugs, Plastics	2,400,705	4,098,021	5,370	5,000	370	7.40
8	Petroleum Refinery	436,703	763,972	0	0	0	0.00
9	Rubber, Leather, Stone, Glass, Clay	429,038	2,150,938	38,154	35,400	2,754	7.78
10	Primary and Fabricated Metals	3,956,836	12,349,898	0	0	0	0.00
11	Machinery, Except Electrical	2,376,733	5,248,059	0	0	0	0.00
12	Electrical Equipment	491,075	1,295,914	0	0	0	0.00
13	Motor Vehicles and Parts	19,427,588	27,101,285	0	0	0	0.00
14	Aircraft and Other Transportation Equipment	401,570	508,874	0	0	0	0.00
15	Transportation and Communication	6,085,270	7,771,803	0	0	0	0.00
16	Utilities	3,160,251	5,378,060	0	0	0	0.00
17	Wholesale, Retail, Miscellaneous Manufacturing, Including Textiles	12,857,294	15,974,341	114,286	104,200	10,086	9.68
18	Financial, Insurance, Real Estate	9,404,256	12,144,122	0	0	0	0.00
19	Selected Services	7,723,241	12,522,290	0	0	0	0.00
20	Government Enterprises	430,868	1,203,445	0	0	0	0.00
	Total		126,505,867	269,772	246,800	22,972	9.31

Table 9

1986 Projection of State Economic Activity and Soo Line Rail Traffic:
High Projection

		Statewide Economic Activity (Thousands of 1976 Dollars)		Soo Line Rail Traffic Tons			
Sector	Industry	1986 Projected Final Demand	1986 Projected Output	1986 Projected Rail Traffic	Actual 1980 Rail Traffic	Projected Change in Rail Traffic	% Change 1980-1986
1	Livestock and Products	19,949	802,597	0	0	0	0.00
2	Other Agricultural Products	576,127	1,171,484	0	0	0	0.00
3	Mining	1,594,955	2,482,860	12,947	9,700	3,247	33.47
4	Construction	3,325,108	5,230,313	0	0	0	0.00
5	Food and Kindred Products	4,876,064	5,471,731	5,145	4,100	1,045	25.49
6	Lumber, Furniture, Paper, Printing	2,794,307	6,074,430	113,355	88,400	24,955	28.23
7	Chemicals, Drugs, Plastics	2,832,832	4,835,439	6,089	5,000	1,089	21.78
8	Petroleum Refinery	515,310	901,467	0	0	0	0.00
9	Rubber, Leather, Stone, Glass, Clay	506,318	2,537,775	43,074	35,400	7,674	21.68
10	Primary and Fabricated Metals	4,669,066	14,571,387	0	0	0	0.00
11	Machinery, Except Electrical	2,804,545	6,192,306	0	0	0	0.00
12	Electrical Equipment	567,669	1,516,371	0	0	0	0.00
13	Motor Vehicles and Parts	22,924,554	31,979,375	0	0	0	0.00
14	Aircraft and Other Transportation Equipment	473,853	600,442	0	0	0	0.00
15	Transportation and Communication	7,180,619	9,170,570	0	0	0	0.00
16	Utilities	3,729,096	6,345,949	0	0	0	0.00
17	Wholesale, Retail, Miscellaneous Manufacturing, Including Textiles	15,171,607	18,849,273	131,146	104,200	26,946	25.86
18	Financial, Insurance, Real Estate	11,097,022	14,329,836	0	0	0	0.00
19	Selected Services	9,113,424	14,775,804	0	0	0	0.00
20	Government Enterprises	508,424	1,420,033	0	0	0	0.00
	Total		149,259,443	311,756	246,800	64,956	26.32

economic growth scenario. The number of cars projected for 1986 is 5,284. The northern Soo Line between Trout Lake and Dollar Bay, excluding the Newberry-Forest Center segment which will probably be abandoned, is approximately 177 miles. Thus, in 1980, the northern Soo Line traffic was 23.7 cars per mile. The projections for 1983 range from 23.7 cars per mile to 25.8 cars per mile with the 1986 cars per mile estimate rising to 29.9.

Comparing this rail density projection with other rail lines in Michigan that are in financial jeopardy, it appears that the northern Soo Line will not generate sufficient traffic to become profitable. On all Michigan railroads (63 segments) that are classified in ICC categories 1-4 (from currently subsidized to segments that may be abandoned within three years), the mean rail density is 34.2 cars per mile. The majority of the 63 segments have densities below 30 cars per mile. On those segments in ICC categories 1 and 2 (those most like the northern Soo Line), the mean traffic density is 39.5 cars per mile. Under the high projections, therefore, traffic on the northern Soo Line resembles segments in Michigan that do not support profitable operations. Further, the rail density on the profitable southern Soo Line was 280 cars per mile in 1980, with a similar commodity composition as the northern Soo Line.

In order to make precise statements about future profitabillity, it is necessary to understand both the revenue and cost structure on the northern Soo Line. Revenues change with commodity composition and levels of traffic. Costs are also sensitive to traffic levels, with on-branch costs such as locomotive costs, car-day cost, and car-mile cost dependent on the number of carloads. However, the traffic densities projected for the northern Soo Line do not appear to be sufficient to generate profitability.

In terms of the north-south routing issue, as the traffic density characteristics remain virtually unchanged even over high growth projections, revenues will probably not improve. Therefore, given the costs of the various north-south route alternatives, the implementation of alternative 1, 2, or 4 would not ensure a significant improvement in the future financial stability of the northern Soo Line service. This conclusion is similar to the tentative decision of the Michigan Department of Transportation. In the Upper Peninsula report, the Michigan Department of Transportation concludes that the only proposed alternative which would both improve operations efficiency and overall system density is the joint Soo Line and C&NW operation over the C&NW track from Ishpeming to Escanaba. This alternative uses only track mileage included in the essential core, and would permit the abandonment of otherwise nonessential mileage.

The conclusion arrived at through the use of the input-output rail forecasting method indicates that if a north-south route from the Soo Line is to be pursued, the joint Soo Line and C&NW operation would be most appropriate. However, it does not appear that rail traffic in the northern tier of the Soo Line, under any economic scenario, will generate sufficient levels of traffic to become profitable. Consequently, one alternative may be to allow some abandonment on the northern Soo Line rather than to go forward with efforts to encourage a link between the Soo Line and the C&NW. The decision on whether to subsidize or abandon a line, however, revolves around issues in addition to future profitability, such as employment and noneconomic factors including political concerns. Yet, any service which may be justifiable on a more comprehensive benefit-cost basis, would likely require permanent operating assistance. The results of this study indicate that the issue of future profitability is not one that can be used to justify future subsidies.

IV. CONCLUSIONS

The purpose of this study has been to suggest, test, and illustrate the use of a method of rail traffic forecasting that systematically links the level of statewide economic activity with the demand for rail freight transportation services and facilities. The goal has been to broaden the perspective of decision makers to include a more comprehensive framework that predicts rail traffic by forecasting the total output of a state's economy. The demand for freight transportation is a derived demand dependent in part on the level of total output in an economy. The working assumption has been that activity in an economic sector generates the physical movement of the aggregate of products included in its input sectors in proportion to the change in that sector's output.

The method suggested in this study has been to link a 20-sector, input-output model of Michigan to 1 percent waybill samples showing the movements of goods on the state's rail lines. The use of input-output as a forecasting method is particularly well-suited to the needs of transportation planning. Input-output does not simply project total economic activity using macro variables, but is disaggregated by commodity groups--the same commodity group whose future production will determine the demand for individual rail service. With this information, it is possible to both estimate future rail traffic and evaluate the potential for profitability on currently subsidized lines, or lines in jeopardy.

This study has been specifically targeted at the estimation of rail traffic in Michigan and Michigan's Upper Peninsula. The projections used in rail planning decision making have been ad hoc in nature and not related to changes in economic activity in general. In Michigan and elsewhere, rail traffic projections have been based on shipper surveys whose interests are generally to retain rail lines. Consequently, there is a perceived need to operationalize a method to forecast rail traffic.

In this study, a conceptual framework of the forecasting method was established that links the structure of an economy to the demand for rail freight services. A 20-sector, input-output model of Michigan was linked with commodity flow data to determine movements of inputs on the state's rail network. Each of the 20 sectors in the input-output model was matched to commodity classifications on 1 percent waybill samples through SICs and STCCs. Changes in total output projected by estimates of final demands in the input-output were used to project rail traffic given by the waybill data. The major point of this study has been to test the use of the input-output method in forecasting rail traffic. The test consisted of projecting 1980 rail traffic on the basis of 1976, 1 percent waybill data and comparing that projection to the waybill sample observed for 1980. Starting with the 1976, 20-sector, input-output model of Michigan, final demands, by sector, were estimated for 1980 and substituted for the 1976 final demands. Total output, by sector, was estimated by the input-output model through the multiplication of the new final demands by the elements of the inverse matrix. The expanded 1 percent waybills representing total rail traffic in 1976 were then multiplied by sector, by the real percentage changes forecast by the input-output model. This procedure produced the 1980 rail traffic projections which were compared to the actual 1980 waybill data. The major conclusion of the test and, thus, of this study is that:

> A rail forecasting method based on a two-region input-output model is effective in producing estimates of rail traffic; the model projected rail traffic to within 1.2 percent of actual traffic over the total rail network. Additionally, the model was effective in providing sector-by-sector estimates of rail traffic moving over Michigan's rail lines in 1980. These

sector-by-sector estimates are crucial in predicting rail traffic in regions within a state where rail demand is based on a few specific commodities.

After the testing of the forecasting procedure, the study provided an illustration of the use of the model in regional rail planning decisions. The case of Michigan's Upper Peninsula was used to demonstrate the usefulness of having projections of rail traffic when making subsidy-abandonment, or rail rationalization decisions. In the case study, it was projected that for the entire U.P. rail system, those commodities that are necessary for system viability are those whose production will increase by the largest amounts. Mining activities, forestry, and lumber and paper related industries are three of the four industries whose total output is projected to increase significantly. Therefore, for the case study region, future economic activity may provide sufficient levels of total output to improve the financial viability of the region's rail system.

The forecasting procedure was also used to examine a specific issue on one rail segment in the Upper Peninsula, the northern Soo Line. The illustration of the uses of the input-output model emphasizes the flexibility of the method in dealing with individual rail issues. Not only is the input-output model able to disaggregate the effects of changes in specific commodity production, but through the waybill sample it is able to isolate particular county-to-county rail segments. The case study indicated, with its estimates of rail traffic, that the traffic along the northern Soo Line will remain similar to other rail segments in Michigan in financial difficulty over all levels of projected economic activity. This conclusion aids in the transportation planning procedure by providing rail planners with the information needed to determine which north-south route alternative is most efficient. The results of the case study further indicated that the traffic density on the northern Soo Line will remain so low that permanent operating assistance will be required if service is continued for reasons other than future profitability.

The second major conclusion of this study, therefore, is:

> A rail forecasting method based on a two-region input-output model can be effective in aiding rail planners in region rail decisions, as well as line-by-line issues revolving around subsidization or abandonment.

Implications for the Use of the Method in Rail Planning

When rail planners study a line segment for subsidy or abandonment, the procedure involves a detailed analysis of the costs and revenues associated with a given level of rail service. Usually, future rail traffic is estimated at various hypothetical levels and a cost-revenue analysis is conducted. The ability to project changes in tonnage and rail traffic by commodity is essential to accurately reflect costs that vary by tonnage and car type. To the extent that commodity composition changes as a result of different growth rates by commodity--due to the input-output multipliers--financial projections will reflect changes in the revenue-cost relationship.

In order to analyze the future profitability of a rail line, rail planners require an ability to project rail traffic. Not only are rail traffic projections necessary, but the projections must be commodity specific. Revenues are sensitive to the commodity composition on a rail line. To project revenues, planners need to distinguish between changes in high bulk-low value products from high value manufactured products. The input-output method can aid in projecting whether changes in economic activity will have a favorable or adverse effect on the composition of commodities on a rail line. Each sector in the input-output model has a unique impact on the economy. Large changes in specific sectors could cause a change in the commodity composition of a line.

Costs are also sensitive to the commodity composition on lines, as well as the level of traffic. The equipment type used on a rail line is determined by the commodity composition. As equipment types change, so do the costs associated with individual lines. The change in tonnage shipped over a rail line affects the required frequency of service and the required locomotive power; higher tonnage requires more frequent trips or more locomotive power. Further, maintenance costs on rail lines vary with tonnage; the higher the tonnage, the more wear on the track. Thus, the ability to project the level and composition of rail traffic can allow more accurate estimates of rail costs and revenues.

It is recommended that the forecasting method presented be operationalized in the rail planning process by linking the procedure to the analysis of costs and revenues. The input-output method can forecast rail traffic by commodity and those forecasts can be used to generate cost and revenue estimates based on traffic levels and composition. In many states, the estimates of costs and revenues are arrived at "by hand" using various costs and revenues depending on traffic levels and compositions. This is an extremely time-consuming process that depends on hypothetical levels of traffic. It is recommended that the procedure be operationalized through the linking of the input-output program to a computer algorithm which generates cost-revenue estimates. With this capability, rail planners could analyze any rail line or rail segment using projections of economic activity. They could also change any single commodity projection, or set of commodities, as economic developments take place. This ability would both streamline the rail planning process and make subsidy-abandonment decisions more accurate. Policy decisions could be made with more precision and over a much wider range of economic scenarios than is presently possible.

Implications for Further Research

In order to use the forecasting method in future years, the following steps are required:

(1) The Michigan input-output transactions table should be updated to 1980 using the forthcoming U.S. and Michigan census data.

(2) Efforts should commence to collect as much Michigan specific data as possible. It is suggested that the transactions table itself be based on primary industry data where available. The data gathering capabilities of various state agencies could be harnessed and coordinated to build an input-output table based on more Michigan specific data than is presently the case.

(3) In order to project total output as accurately as possible, better forecasts of final demand are required. Research that establishes procedures for collecting final demand data is required.

(4) The test of the forecasting method was conducted on only one year, 1980. Research should continue to test the forecasting procedure over subsequent years as transportation and economic data become available.

In general, further research is recommended to test the capabilities and flexibility of the input-output method; data are currently being collected, for example, from forestry firms in Michigan. This information can be added to the transactions table to produce a more accurate table. The input-output method can also be expanded to make projections on income and employment changes due to changes in final demands. The input-output method can be further used to simulate changes in the location of economic activity by reflecting this in estimates of regional final demands.

Research has begun on the use of quadratic programming to make the input-output model sensitive to price changes (Harrington, 1973). This research could aid in the use of the method for rail traffic forecasting, given changes in the price of energy and the cost of transportation services. Also, the method should be expanded to include consideration of multi-network commodity flows.

One of the aims of the rail rationalization process is to suggest various configurations of rail lines best suited to the most efficient use of the rail system. In doing this, it would be useful to have a method to estimate the optimal flow of goods on the state's rail network. Research is warranted to link the estimates of rail traffic produced by the input-output model to an optimization program similar to the linear programming process.

Finally, the most obvious deficiency of this study has been the lack of data on transportation services other than rail, particularly truck transportation. Not only should research on the trucking industry be conducted, but consideration of the factors that influence the split between modes is necessary. A method to include modal split estimates in the input-output procedure would be useful. Given the data limitations at this time, it is believed that the rail traffic forecasting method based on the use of an input-output model does provide useful estimates of rail demand and can aid in the rail planning process.

APPENDIX

1976, 20-SECTOR INPUT-OUTPUT MODEL OF MICHIGAN WITH AN EXAMPLE OF ITS USE

EXAMPLE OF THE USE OF THE 20-SECTOR INPUT-OUTPUT MODEL

Beginning with the transactions matrix, the intersection of Row 1 (livestock and products) with Column 2 (other agricultural products) in Table A.1 shows that the agricultural products sector makes purchases of \$18,059,000 from the livestock sector, while the livestock sector makes sales of \$18,059,000 of output to the agricultural products sector. The table is divided into the processing sectors, 1-20 and the payments and final demand sectors, 21-23. Row/Column 24 represents the total sales and total purchases in the economy.

The technical coefficients are found by dividing each column and entry for the processing sectors by the corresponding column total for the sector. For example, total sales in livestock are \$671,181,000 (Column 1, Row 24, Table A.1). Purchases from agricultural products are \$108,562,000 (Column 1, Row 2, Table A.1). The direct requirements for livestock and agricultural products are .16174773 (Column 1, Row 2, Table A.2, 108,562,000/671,181,000). Each element in the coefficient matrix indicates the dollars of inputs required from each selling sector (horizontal) in order to produce one additional dollar of output in the purchasing sector (vertical). Thus, one dollar of livestock output requires \$0.16 of output from agricultural products.

The Leontief matrix of Table A.3 is found by subtracting the coefficients matrix for the processing sector (A) from an identity matrix of the order (I-A). Inverting the Leontief matrix, produces the inverse matrix, Table A.4. The inverse matrix is read by columns. In the first column of Table A.4, it is indicated that livestock must increase its output by a total of \$1.32 (Column 1, Row 1, Table A.4) in order to sell \$1.00 of output to final demand. Other agricultural products must increase its output by \$0.20 (Column 1, Row 2, Table A.4) for livestock to deliver one additional dollar of output to final demand. All sectors must produce a combined output of \$1.69 (Column 1, Row 21, Table A.4), the sum of the first column. It can then be said that \$1.69 of economic activity is generated by an additional \$1.00 of output to final demand by the livestock and products sector. The sum of each sector in the inverse matrix is thus an output multiplier. These column sums, or output multipliers (Row 21, Table A.4), show the direct, indirect, and induced economic activity that will be generated by the economic system as a whole for each sector to meet an increase of one dollar in final demand.

Table A.1

20-Sector

TRANSACTIONS MATRIX

ROW/COL	1 LIVESTOCK & PRODS	2 OTHER AG PRODUCTS	3 MINING	4 CONSTRUCT	5 FOOD & KIN PRODUCTS	6 LUMB FURN PAP PRINT	7 CHEM DRUGS PLASTICS	8 PETROLEUM REFINERY	9 RUB LEA ST GLASS CLAY	10 PRIMARY & FAB METALS
1	67450.	18059.	0.	0.	531158.	0.	429.	0.	401.	0.
2	108562.	36014.	0.	8230.	215160.	23659.	3488.	0.	0.	0.
3	28.	2045.	107843.	37500.	773.	4490.	29704.	98534.	50796.	358976.
4	4184.	7000.	33557.	1807.	15250.	22694.	20440.	16563.	15284.	120552.
5	66352.	932.	0.	0.	303719.	9078.	21850.	582.	9442.	735.
6	521.	3915.	8329.	245605.	126751.	905662.	70184.	6216.	73511.	261791.
7	1974.	39213.	33949.	69384.	33664.	99824.	556754.	23044.	170469.	193937.
8	1227.	6896.	6757.	41695.	3096.	6328.	41841.	24923.	3551.	16540.
9	744.	2837.	36395.	395536.	88573.	50606.	46492.	3796.	188386.	121822.
10	1289.	2039.	46626.	765518.	111688.	106630.	81291.	5045.	44958.	2753885.
11	274.	6903.	59360.	117219.	11073.	21195.	24026.	3363.	25851.	478318.
12	151.	475.	4234.	71684.	108.	1971.	1083.	207.	2537.	92046.
13	146.	169.	1246.	206.	116.	514.	1081.	111.	2086.	384083.
14	1.	145.	189.	15.	0.	424.	45.	0.	1178.	28392.
15	8832.	7036.	24514.	87247.	84391.	67971.	40919.	42729.	47393.	218810.
16	1861.	4739[illegible]	47880.	3795.	30855.	43145.	52728.	17791.	45792.	262853.
17	20412.	26107.	23690.	355987.	120308.	128587.	63558.	9098.	94704.	449691.
18	9176.	31905.	99728.	45473.	31722.	59157.	54108.	21706.	30413.	141541.
19	8104.	29754.	55286.	291098.	145093.	115706.	222607.	31061.	72009.	87210.
20	61.	66.	927.	2412.	2475.	9211.	3088.	408.	2059.	8454.
21	144931.	330892.	207600.	1625300.	633300.	1099200.	520100.	36100.	567800.	3379700.
22	165785.	116477.	417027.	717989.	1153026.	550144.	414284.	464522.	367579.	1964567.
23	58816.	19538.	492300.	921500.	1070100.	1251200.	1338500.	106700.	706900.	3095400.
24	671181.	693156.	1707437.	5805200.	4712399.	4577396.	3608600.	912499.	2523099.	14419303.

20-Sector

TRANSACTIONS MATRIX

ROW/COL	11 MACHINERY	12 ELECTRICAL EQUIP.	13 MOTOR VEH AND PARTS	14 ACFT,OTH TRANS EQP	15 TRANS. & COMM	16 UTILITIES	17 WHOLE,RET. MISC. MANF	18 F.I.R.E.	19 SELECTED SERVICES	20 GOVT ENTERPRISE
1	0.	0.	0.	0.	181.	0.	2699.	34043.	2991.	0.
2	0.	0.	0.	0.	4578.	0.	21878.	49309.	11593.	132.
3	0.	142.	0.	0.	2313.	80964.	609.	5943.	0.	178.
4	22115.	5331.	100911.	2591.	163077.	137207.	60108.	511778.	116953.	125697.
5	326.	0.	0.	0.	19469.	62.	45387.	6863.	22407.	0.
6	29600.	25639.	149107.	14726.	15539.	4401.	218199.	47901.	600948.	3710.
7	13791.	16965.	163191.	2261.	7795.	4301.	136760.	24657.	114346.	8107.
8	9052.	1154.	22258.	922.	52786.	13471.	42487.	17734.	19321.	2872.
9	87195.	35466.	837908.	7731.	18614.	1762.	87874.	10345.	83559.	1991.
10	941614.	145897.	5348975.	90196.	120530.	6998.	97604.	14646.	67122.	1159.
11	993683.	36945.	1713336.	53795.	20226.	3741.	53539.	32208.	104679.	2049.
12	159220.	131058.	463869.	14537.	18043.	4074.	32963.	9817.	37262.	663.
13	65365.	7441.	9773407.	7876.	5346.	272.	9214.	9110.	102709.	881.
14	24943.	3008.	13757.	42116.	15466.	0.	7276.	2065.	650.	67.
15	47731.	12395.	368084.	6709.	239161.	43114.	173209.	81200.	167233.	43084.
16	33844.	9284.	155278.	3734.	65305.	769971.	218780.	49800.	175554.	70477.
17	177521.	43045.	922993.	23269.	104056.	18247.	543400.	105766.	341303.	7491.
18	76018.	18678.	164848.	8042.	129784.	28459.	623667.	714756.	399654.	23141.
19	144679.	47566.	1109533.	19945.	360683.	46719.	1043373.	488154.	784424.	39180.
20	3955.	1198.	25185.	552.	71472.	269075.	144531.	84581.	63948.	1000.
21	2038800.	413900.	5382800.	195900.	1899327.	645309.	7585348.	1815491.	6613108.	582092.
22	865348.	310589.	3911059.	188401.	2081113.	552092.	1502391.	629369.	844696.	104281.
23	2119800.	442400.	6409800.	153100.	1779289.	1519980.	5268352.	5634509.	1336892.	52348.
24	7854600.	1708101.	37036299.	836403.	7194153.	4150219.	17919648.	10380045.	12011352.	1070600.

20-Sector
TRANSACTIONS MATRIX

ROW/COL	21 PER CONSUM EXPEN.	22 INVESTMENT INVENTORY	23 NET EXPORT FED,ST,LOC	
1	13336.	291.	139.	671177.
2	278690.	515.	-68650.	693158.
3	34562.	453298.	438628.	1707326.
4	0.	2632790.	1669311.	5805200.
5	3319191.	97000.	919731.	4843126.
6	1392473.	194500.	524855.	4924083.
7	2092485.	301400.	1022973.	5131244.
8	516658.	-4200.	55722.	903091.
9	547837.	71100.	56307.	2782876.
10	137619.	490800.	2947761.	14329890.
11	87931.	276800.	2544573.	6671087.
12	269394.	67500.	190296.	1573192.
13	1527419.	1747800.	25404121.	39051019.
14	69785.	16600.	409953.	636075.
15	1870518.	239663.	3272213.	7194156.
16	1732216.	0.	354534.	4150216.
17	13398758.	534419.	252475.	17764885.
18	7433163.	128915.	105688.	10380042.
19	5723002.	-191.	1146357.	12011352.
20	312435.	0.	63503.	1070596.
21	523462.	0.	4933470.	41173930.
22	21522338.	1158637.	1992024.	41993738.
23	559311.	211122.	8620566.	43168423.
24	63362583.	8618759.	56856850.	0.

Table A.2

20-Sector

COEFFICIENT MATRIX

ROW/COL	1 LIVESTOCK & PRODS	2 OTHER AG PRODUCTS	3 MINING	4 CONSTRUCT	5 FOOD & KIN PRODUCTS	6 LUMB FURN PAP PRINT	7 CHEM DRUGS PLASTICS	8 PETROLEUM REFINERY	9 RUB LEA ST GLASS CLAY	10 PRIMARY & FAB METALS
1	0.10049150	0.02605330	0.00000000	0.00000000	0.11271199	0.00000000	0.00011888	0.00000000	0.00015893	0.00000000
2	0.16174773	0.05195656	0.00000000	0.00141769	0.04565827	0.00516866	0.00096658	0.00000000	0.00000000	0.00000000
3	0.00004172	0.00295027	0.06316075	0.00645973	0.00016404	0.00098091	0.00823145	0.10798258	0.02013238	0.02489552
4	0.00623379	0.01009874	0.01965343	0.00031127	0.00323614	0.00495784	0.00566425	0.01815125	0.00605763	0.00836046
5	0.09885858	0.00134457	0.00000000	0.00000000	0.06445104	0.00198322	0.00605498	0.00063781	0.00374222	0.00005097
6	0.00077621	0.00564808	0.00487807	0.04230776	0.02689734	0.19785529	0.01944909	0.00681206	0.02913520	0.01815559
7	0.00294108	0.05657168	0.01988302	0.01195204	0.00714371	0.02180803	0.15428532	0.02525373	0.06756334	0.01344982
8	0.00182812	0.00994870	0.00395739	0.00718235	0.00065699	0.00138245	0.01159480	0.02731291	0.00140740	0.00114707
9	0.00116849	0.00409287	0.02131557	0.06813478	0.01879573	0.01105563	0.01288367	0.00416000	0.07466453	0.00844854
10	0.00192050	0.00294162	0.02730760	0.13186764	0.02370088	0.02329490	0.02252702	0.00552877	0.01781856	0.19098600
11	0.00040824	0.00995880	0.03476556	0.02019207	0.00234976	0.00463036	0.00665798	0.00368548	0.01024573	0.03317206
12	0.00022498	0.00068527	0.00247974	0.01234824	0.00002292	0.00043059	0.00030012	0.00022685	0.00100551	0.00638353
13	0.00021753	0.00024381	0.00072975	0.00003549	0.00002462	0.00011229	0.00029956	0.00012164	0.00082676	0.02663672
14	0.00000149	0.00020919	0.00011069	0.00000258	0.00000000	0.00009263	0.00001247	0.00000000	0.00046689	0.00196903
15	0.01315889	0.01015067	0.01435719	0.01502911	0.01790829	0.01484927	0.01133930	0.04682635	0.01878365	0.01517480
16	0.00277272	0.00683684	0.02804203	0.00065372	0.00654762	0.00942566	0.01461176	0.01949701	0.01814911	0.01822924
17	0.03041206	0.03766396	0.01387460	0.06132209	0.02553010	0.02809174	0.01761292	0.00997042	0.03753479	0.03118674
18	0.01411840	0.04602860	0.05840801	0.00783315	0.00673160	0.01292372	0.01499418	0.02378742	0.01205383	0.00981608
19	0.01207424	0.04292540	0.03237953	0.05014435	0.03078963	0.02527769	0.06168791	0.03403949	0.02853990	0.00604814
20	0.00009088	0.00009522	0.00054292	0.00041549	0.00052521	0.00201228	0.00085573	0.00044712	0.00081606	0.00058630
21	0.21593430	0.47737017	0.12158575	0.27997313	0.13439015	0.24013653	0.14412792	0.03956169	0.22504071	0.23438720
22	0.24700191	0.16803865	0.24424152	0.12368032	0.24467920	0.12018711	0.11480463	0.50906576	0.14568552	0.13624563
23	0.08763061	0.02818702	0.28832689	0.15873699	0.22708179	0.27334318	0.37091947	0.11693163	0.28017133	0.21467057
24	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000

20-Sector

COEFFICIENT MATRIX

ROW/COL	11 MACHINERY	12 ELECTRICAL EQUIP.	13 MOTOR VEH AND PARTS	14 ACFT,OTH TRANS EQP	15 TRANS. & COMM	16 UTILITIES	17 WHOLE,RET. MISC. MANF	18 F.I.R.E.	19 SELECTED SERVICES	20 GOVT ENTERPRISE
1	0.00000000	0.00000000	0.00000000	0.00000000	0.00002516	0.00000000	0.00015062	0.00327966	0.00024901	0.00000000
2	0.00000000	0.00000000	0.00000000	0.00000000	0.00063635	0.00000000	0.00122089	0.00475036	0.00096517	0.00012330
3	0.00000000	0.00008313	0.00000000	0.00000000	0.00032151	0.01950837	0.00003399	0.00057254	0.00000000	0.00016626
4	0.00281555	0.00312401	0.00272465	0.00309779	0.02266799	0.03306018	0.00335431	0.04930403	0.00973687	0.11740800
5	0.00004150	0.00000000	0.00000000	0.00000000	0.00270623	0.00001494	0.00253281	0.00066117	0.00186549	0.00000000
6	0.00376849	0.01501024	0.00402597	0.01760635	0.00215995	0.00106043	0.01217652	0.00461472	0.05003167	0.00346535
7	0.00175579	0.00993208	0.00440624	0.00270324	0.00108352	0.00103633	0.00763185	0.00237542	0.00951983	0.00757239
8	0.00115245	0.00067560	0.00060098	0.00110234	0.00733735	0.00324585	0.00237097	0.00170847	0.00160856	0.00268261
9	0.01110114	0.02076341	0.02262397	0.00924315	0.00258738	0.00042456	0.00490378	0.00099662	0.00695667	0.00185970
10	0.11988058	0.08541474	0.14442520	0.10783797	0.01675388	0.00168618	0.00544676	0.00141098	0.00558821	0.00108257
11	0.12650369	0.02162928	0.04626099	0.06431708	0.00281145	0.00090140	0.00298773	0.00310288	0.00871501	0.00191388
12	0.02027092	0.07672731	0.01252471	0.01738038	0.00250801	0.00098163	0.00183949	0.00094576	0.00310223	0.00061928
13	0.00832188	0.00435630	0.26388725	0.00941651	0.00074310	0.00006554	0.00051418	0.00087765	0.00855099	0.00082290
14	0.00117559	0.00176102	0.00037145	0.05035372	0.00214980	0.00000000	0.00040603	0.00019894	0.00005412	0.00006258
15	0.00507682	0.00725660	0.00993847	0.00802125	0.03324380	0.01038837	0.00966587	0.00782270	0.01392291	0.04024285
16	0.00130881	0.00543528	0.00419259	0.00446436	0.00907751	0.18552539	0.01220895	0.00479767	0.01461567	0.06582944
17	0.02260090	0.02520050	0.02492131	0.02782032	0.01446397	0.00439664	0.03032426	0.01018936	0.02841504	0.00699701
18	0.00967815	0.01093495	0.00445098	0.00961498	0.01804021	0.00685723	0.03480353	0.06885866	0.03327302	0.02161498
19	0.01841965	0.02784730	0.02995799	0.02384616	0.05013558	0.01125700	0.05822508	0.04702812	0.06530689	0.03659630
20	0.00050353	0.00070136	0.00068001	0.00065997	0.00993473	0.06483393	0.00806550	0.00814842	0.00532396	0.00093106
21	0.25956764	0.24231588	0.14533850	0.23421724	0.26400981	0.15548794	0.42329782	0.17490204	0.55057149	0.54370633
22	0.11017086	0.18183292	0.10560070	0.22525146	0.28927839	0.13302720	0.08384043	0.06063259	0.07032481	0.09710426
23	0.26988007	0.25900108	0.17306805	0.18304573	0.24732432	0.36624091	0.29399863	0.54282125	0.11130237	0.04889595
24	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000

20-Sector

COEFFICIENT MATRIX

ROW/COL	21 PER CONSUM EXPEN	22 INVESTMENT INVENTORY	23 NET EXPORT FED,ST,LOC
1	0.00021047	0.00003376	0.00000244
2	0.00439834	0.00005975	-0.00120742
3	0.00654546	0.05259435	0.00771460
4	0.00000000	0.30547205	0.02935989
5	0.05238409	0.01125452	0.01617626
6	0.02197627	0.02256705	0.00923117
7	0.03302399	0.03497023	0.01799208
8	0.00815399	-0.00048731	0.00098004
9	0.00864606	0.00824945	0.00099033
10	0.00217193	0.05694555	0.05184531
11	0.00138774	0.03211599	0.04475403
12	0.00125163	0.00783175	0.00334693
13	0.02110601	0.20279022	0.44681373
14	0.00110136	0.00192603	0.00721027
15	0.02952086	0.02780714	0.05755178
16	0.02733815	0.00000000	0.00623555
17	0.21146168	0.06200649	0.00444054
18	0.11731155	0.01495749	0.00185884
19	0.09032118	-0.00002216	0.02016216
20	0.00493091	0.00000000	0.00111689
21	0.00826137	0.00000000	0.08677002
22	0.33966952	0.13443200	0.03503578
23	0.00882715	0.02449564	0.15161878
24	1.00000000	1.00000000	1.00000000

Table A.3

20-Sector

LEONTIEF MATRIX

ROW/COL	1 LIVESTOCK & PRODS.	2 OTHER AG PRODUCTS	3 MINING	4 CONSTRUCT	5 FOOD & KIN PRODUCTS	6 LUMB FURN PAP PRINT	7 CHEM DRUGS PLASTICS	8 PETROLEUM REFINERY	9 RUB LEA ST GLASS CLAY	10 PRIMARY & FAB METALS
1	0.89950550	-0.02605330	0.00000000	0.00000000	-0.11271499	0.00000000	-0.00011888	0.00000000	-0.00015893	0.00000000
2	-0.16174773	0.94804344	0.00000000	-0.00141769	-0.04565827	-0.00516866	-0.00096658	0.00000000	0.00000000	0.00000000
3	-0.00001172	-0.00295027	0.93683925	-0.00645973	-0.00016404	-0.00098091	-0.00823145	-0.10798258	-0.02013238	-0.02489552
4	-0.06623379	-0.01009874	-0.01965343	0.99968873	-0.00323614	-0.00495784	-0.00566425	-0.01815125	-0.00605763	-0.00836046
5	-0.09385858	-0.00134457	0.00000000	0.00000000	0.93554896	-0.00198322	-0.00605498	-0.00063781	-0.00374222	-0.00005097
6	-0.00077624	-0.00564808	-0.00487807	-0.04230776	-0.02689734	0.80214471	-0.01944909	-0.00681206	-0.02913520	-0.01815559
7	-0.00291108	-0.05657168	-0.01988302	-0.01195204	-0.00714371	-0.02180803	0.84571468	-0.02525373	-0.06756334	-0.01344982
8	-0.00182812	-0.00994870	-0.00395739	-0.00718235	-0.00065699	-0.00138245	-0.01159480	0.97268709	-0.00140740	-0.00114707
9	-0.00110819	-0.00409287	-0.02131557	-0.06813478	-0.01879573	-0.01105563	-0.01288367	-0.00416000	0.92533547	-0.00844854
10	-0.00192050	-0.00294162	-0.02730760	-0.13186764	-0.02370088	-0.02329490	-0.02252702	-0.00552877	-0.01781856	0.80901400
11	-0.00010824	-0.00995880	-0.03476556	-0.02019207	-0.00234976	-0.00463036	-0.00665798	-0.00368548	-0.01024573	-0.03317206
12	-0.00022198	-0.00068527	-0.00247974	-0.01234824	-0.00002292	-0.00043059	-0.00030012	-0.00022685	-0.00100551	-0.00638353
13	-0.00021753	-0.00024381	-0.00072975	-0.00003549	-0.00002462	-0.00011229	-0.00029956	-0.00012164	-0.00082676	-0.02663672
14	0.00000149	-0.00020919	-0.00011069	-0.00000258	0.00000000	-0.00009263	-0.00001247	0.00000000	-0.00016689	-0.00196903
15	-0.01315889	-0.01015067	-0.01435719	-0.01502911	-0.01790829	-0.01484927	-0.01133930	-0.04682635	-0.01878365	-0.01517480
16	-0.00277272	-0.00683684	-0.02801203	-0.00065372	-0.00654762	-0.00942566	-0.01461176	-0.01949701	-0.01814911	-0.01822924
17	-0.03041206	-0.03766396	-0.01387460	-0.06132209	-0.02553010	-0.02809174	-0.01761292	-0.00997042	-0.03753479	-0.03118674
18	-0.01111840	-0.01602860	-0.05840801	-0.00783315	-0.00673160	-0.01292372	-0.01499418	-0.02378742	-0.01205383	-0.00981608
19	-0.01207424	-0.04292540	-0.03237953	-0.05014435	-0.03078963	-0.02527769	-0.06168791	-0.03403949	-0.02853990	-0.00604814
20	-0.00009088	-0.00009522	-0.00054292	-0.00041549	-0.00052521	-0.00201228	-0.00085573	-0.00044712	-0.00081606	-0.00058630

20-Sector

LEONTIEF MATRIX

ROW/COL	11 MACHINERY	12 ELECTRICAL EQUIP.	13 MOTOR VEH AND PARTS	14 ACFT OTH TRANS EQP	15 TRANS. & COMM	16 UTILITIES	17 WHOLE,RET. MISC. MANF	18 F.I.R.E.	19 SELECTED SERVICES	20 GOVT ENTERPRISE
1	0.00000000	0.00000000	0.00000000	0.00000000	-0.00002516	0.00000000	-0.00015062	-0.00327966	-0.00024901	0.00000000
2	0.00000000	0.00000000	0.00000000	0.00000000	-0.00063635	0.00000000	-0.00122089	-0.00475036	-0.00096517	-0.00012330
3	0.00000000	-0.00008313	0.00000000	0.00000000	-0.00032151	-0.01950837	-0.00003399	-0.00057254	0.00000000	-0.00016626
4	-0.00281555	-0.00312101	-0.00272465	-0.00309779	-0.02266799	-0.03306018	-0.00335431	-0.04930403	-0.00973687	-0.11740800
5	-0.00004150	0.00000000	0.00000000	0.00000000	-0.00270623	-0.00001494	-0.00253281	-0.00066117	-0.00186549	0.00000000
6	-0.00376849	-0.01501024	-0.00102597	-0.01760635	-0.00215995	-0.00106043	-0.01217652	-0.00461472	-0.05003167	-0.00346535
7	-0.00175579	-0.00993208	-0.00440624	-0.00270324	-0.00108352	-0.00103633	-0.00763185	-0.00237542	-0.00951983	-0.00757239
8	-0.00115245	-0.00067560	-0.00060098	-0.00110234	-0.00733735	-0.00324585	-0.00237097	-0.00170847	-0.00160856	-0.00268261
9	-0.01110114	-0.02076341	-0.02262397	-0.00924315	-0.00258738	-0.00042456	-0.00490378	-0.00099662	-0.00695667	-0.00185970
10	-0.11988058	-0.08541474	-0.14442520	-0.10783797	-0.01675388	-0.00168618	-0.00544676	-0.00141098	-0.00558821	-0.00108257
11	0.87319031	-0.02162928	-0.04626099	-0.06431708	-0.00281145	-0.00090140	-0.00298773	-0.00310288	-0.00871501	-0.00191388
12	-0.02027092	0.92327269	-0.01252471	-0.01738038	-0.00250801	-0.00098163	-0.00183949	-0.00094576	-0.00310223	-0.00061928
13	-0.00832188	-0.00435630	0.73611275	-0.00941651	-0.00074310	-0.00006554	-0.00051418	-0.00087765	-0.00855099	-0.00082290
14	-0.00317559	-0.00176102	-0.00037145	0.94964628	-0.00214980	0.00000000	-0.00040603	-0.00019894	-0.00005412	-0.00006258
15	-0.00607682	-0.00725660	-0.00993847	-0.00802125	0.96675620	-0.01038837	-0.00966587	-0.00782270	-0.01392291	-0.04024285
16	-0.00150881	-0.00543528	-0.00419259	-0.00446436	-0.00907751	0.81447461	-0.01220895	-0.00479767	-0.01461567	-0.06582944
17	-0.02260090	-0.02520050	-0.02492131	-0.02782032	-0.01446397	-0.00439664	0.96967574	-0.01018936	-0.02841504	-0.00699701
18	-0.00967815	-0.01093495	-0.00445098	-0.00961498	-0.01804021	-0.00685723	-0.03480353	0.93114134	-0.03327302	-0.02161498
19	-0.01841965	-0.02784730	-0.02995799	-0.02384616	-0.05013558	-0.01125700	-0.05822508	-0.04702812	0.93469311	-0.03659630
20	-0.00050353	-0.00070136	-0.00068001	-0.00065997	-0.00993473	-0.06483393	-0.00806550	-0.00814842	-0.00532396	0.99906594

Table A.4

20-Sector

INVERSE MATRIX

ROW/COL	1 LIVESTOCK & PRODS.	2 OTHER AG PRODUCTS	3 MINING	4 CONSTRUCT	5 FOOD & KIN PRODUCTS	6 LUMB FURN PAP PRINT	7 CHEM DRUGS PLASTICS	8 PETROLEUM REFINERY	9 RUB LEA ST GLASS CLAY	10 PRIMARY & FAB METALS
1	1.13273844	0.03171879	0.00040322	0.00033732	0.13817490	0.00074747	0.00140329	0.00036580	0.00102821	0.00019534
2	0.19911936	1.06112956	0.00072885	0.00230990	0.07629053	0.00741021	0.00235485	0.00061705	0.00106032	0.00050685
3	0.00229381	0.00648962	1.07152871	0.01503636	0.00294965	0.00401308	0.01442494	0.12080270	0.02629579	0.03526087
4	0.01417304	0.01694859	0.02885985	1.00674361	0.00912656	0.01061088	0.01214822	0.02704678	0.01222668	0.01557565
5	0.12047448	0.00579399·	0.00068640	0.00114141	1.08423861	0.00334541	0.00834784	0.00141220	0.00547532	0.00065573
6	0.01175515	0.01650720	0.01558915	0.06732613	0.04395611	1.25367720	0.03793432	0.01694893	0.04774875	0.03397629
7	0.02081888	0.07473260	0.03072762	0.02790105	0.01993724	0.03638668	1.18835848	0.03681951	0.09082141	0.02479830
8	0.00510590	0.01254632	0.00572696	0.00891585	0.00272770	0.00294993	0.01500966	1.03004637	0.00356214	0.00272070
9	0.00705966	0.00882153	0.02942492	0.07941871	0.02533135	0.01775688	0.02005872	0.01131840	1.08561236	0.01685901
10	0.01260634	0.01408293	0.05247813	0.17910717	0.03927680	0.04286018	0.04156006	0.02152981	0.03582644	1.26087100
11	0.00519639	0.01541140	0.04737640	0.03427717	0.00736573	0.01024489	0.01344713	0.01224782	0.01759043	0.05378833
12	0.00118786	0.00199338	0.00518904	0.01625071	0.00113850	0.00168034	0.00173030	0.00187038	0.00256371	0.01123178
13	0.00148287	0.00198935	0.00131253	0.00808788	0.00233970	0.00251666	0.00329719	0.00200221	0.00348316	0.04675974
14	0.00017908	0.00040174	0.00049767	0.00066894	0.00022967	0.00033884	0.00023441	0.00025717	0.00077148	0.00293116
15	0.02254404	0.01648040	0.02128006	0.02474414	0.02677536	0.02298433	0.01926324	0.05532443	0.02641723	0.02427851
16	0.00173669	0.01439708	0.04228703	0.01207671	0.01456335	0.01912414	0.02691627	0.03297709	0.03078111	0.03319959
17	0.05078442	0.04961190	0.02528511	0.07959686	0.04282335	0.04256864	0.03002120	0.01978052	0.05045635	0.04845057
18	0.03286972	0.06038003	0.07347579	0.02082099	0.01992107	0.02349833	0.02704514	0.03959730	0.02323380	0.02118863
19	0.03713335	0.06438661	0.05097411	0.07128215	0.05087645	0.04422965	0.08761052	0.05371806	0.04942429	0.02234433
20	0.00198564	0.00258104	0.00477151	0.00301784	0.00274270	0.00485527	0.00403788	0.00409438	0.00423976	0.00401833
21	1.68857513	1.47640405	1.51160305	1.65906090	1.61078533	1.55179904	1.55520363	1.48877691	1.51861874	1.65960971

20-Sector

INVERSE MATRIX

ROW/COL	11 MACHINERY	12 ELECTRICAL EQUIP.	13 MOTOR VEH AND PARTS	14 ACFT,OTH TRANS EQP	15 TRANS. & COMM	16 UTILITIES	17 WHOLE,RET. MISC. MANF	18 F.I.R.E.	19 SELECTED SERVICES	20 GOVT ENTERPRISE
1	0.00015335	0.00018045	0.00019535	0.00016292	0.00060066	0.00010994	0.00082395	0.00433870	0.00087283	0.00022359
2	0.00032830	0.00044448	0.00043847	0.00044674	0.00128163	0.00030138	0.00207901	0.00648793	0.00208864	0.00075447
3	0.00590491	0.00481251	0.00878659	0.00541126	0.00286050	0.02733242	0.00153544	0.00221062	0.00191899	0.00454787
4	0.00766463	0.00776198	0.01001200	0.00799607	0.02805164	0.05280341	0.00897575	0.05618034	0.01586672	0.12505524
5	0.00045390	0.00056649	0.00068817	0.00047722	0.00335523	0.00026280	0.00326928	0.00154364	0.00274903	0.00053581
6	0.01432399	0.02879250	0.02080240	0.03232279	0.01012934	0.00768598	0.02211723	0.01437083	0.07086115	0.01676426
7	0.00869138	0.01912827	0.01721100	0.00991454	0.00460227	0.00524097	0.01227861	0.00660271	0.01649368	0.01412837
8	0.00217716	0.00169575	0.00217577	0.00215693	0.00848272	0.00521032	0.00322912	0.00283483	0.00271920	0.00482535
9	0.01818902	0.02813685	0.03973042	0.01595644	0.00651780	0.00605597	0.00766985	0.00665849	0.01160719	0.01299272
10	0.18160444	0.12645699	0.26507581	0.16361291	0.02985916	0.01469984	0.01229399	0.01463135	0.01879168	0.02693036
11	1.15515802	0.03419212	0.08551952	0.08701896	0.00673438	0.00505091	0.00580372	0.00705341	0.01387138	0.00791476
12	0.02737490	1.08539537	0.02293771	0.02361224	0.00396581	0.00257330	0.00281511	0.00248009	0.00473164	0.00327337
13	0.02031742	0.01202435	1.37001937	0.02107500	0.00306226	0.00119258	0.00218262	0.00269046	0.01357617	0.00299655
14	0.00136009	0.00246481	0.00151714	1.05377600	0.00246731	0.00011902	0.00054586	0.00033240	0.00024455	0.00029134
15	0.01278651	0.01339855	0.02249500	0.01488298	1.03828175	0.01936319	0.01370801	0.01228799	0.01946197	0.04758858
16	0.01306009	0.01366206	0.01785100	0.01314464	0.01561553	1.23709158	0.01924763	0.00980577	0.02328240	0.08527121
17	0.03741849	0.03805484	0.05195105	0.04267608	0.02179709	0.01244857	1.03682692	0.01906272	0.03805254	0.02084587
18	0.01841082	0.01938105	0.01696498	0.01860899	0.02505797	0.01557214	0.04318020	1.07915927	0.04313851	0.03025379
19	0.03195441	0.04219456	0.05755916	0.03844135	0.06241532	0.02570918	0.07101132	0.06168658	1.08161250	0.05526973
20	0.00238071	0.00267749	0.00349431	0.00266324	0.01212721	0.08091566	0.01056962	0.01012645	0.00833498	1.00778917
21	1.56271254	1.48136147	2.01542521	1.55135728	1.28729558	1.51973914	1.28016325	1.32054459	1.39027575	1.46825240

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