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

presented by

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J. Roy Black
Major professor

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

By

Jeffrey L. Jordan

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ABSTRACT

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

By

Jeffrey L. Jordan

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 1976 and 1980.

Following the testing of the forecasting procedure, the study 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.

Dedicated to

the memory of my father

Gerald J. Jordan

who instilled in me an appreciation
for the written word

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CHAPTER I

INTRODUCTION

Problem Setting

In the last decade, the financial difficulties of railroads have caused federal and state governments to become increasingly involved in issues associated with preserving essential levels of rail service. In Michigan, 16,500 people are directly employed by the 32 operating railroads. Railroads are the dominant means of transportation for manufactured products, carrying 67 percent of the state's manufactured goods, while Michigan's agricultural commodities also depend heavily on the service of the railroads. 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 region, 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

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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.

Purpose and Objectives

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 will be combined with commodity flow data obtained from expanded 1 percent waybills from all of Michigan's railroad lines. The method that is discussed and tested in this study is designed to aid rail planners in forecasting rail traffic based on economic activity in the state. In Michigan, as elsewhere, rail traffic forecasting has been predominantly ad hoc in nature and not directly related to the state of the general economy. Not only is a systematic method of predicting rail traffic necessary for rail planning, but traffic projections are needed to analyze the issue of whether to subsidize a rail line or allow its abandonment.

In accomplishing this purpose, the following objectives will be achieved:

(1) The final demand sectors of the Michigan economy will be estimated for 1980.

(2) These final demands will be used to forecast total output, by sector, for 1980 from the 1976 Michigan input-output model.[1/]

(3) The changes in total output will be used to forecast the difference in rail traffic between 1976 and 1980.

(4) The forecast results will be checked against the actual rail flows in 1980 to determine the forecasting capability of the input-output method.

(5) The method will be used to forecast rail traffic, over various economic growth scenarios, to 1983 and 1986. Special attention will be paid to the rail system in Michigan's Upper Peninsula.

(6) Finally, there will be an illustration of the method's usefulness in the rail planning process.

The Input-Output Method

The use of an input-output model to predict rail traffic is based on the relationship between the production and consumption of goods in an economy and the demand for transportation services and facilities. In order to produce a product, a given quantity of inputs is needed. Although economies of scale may be present in some industries, to produce more of a product (or less) a larger (or smaller) supply of inputs is required. A production facility must acquire and store these inputs. A retail firm can also be viewed as a production facility, where

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[1/]Model obtained from Michigan Department of Commerce, Energy Administration, "A 44-Sector Input-Output Model of the Michigan Economy," Energy Issues Analysis Series, Lansing, Michigan, March 1980.

production is the sale to final consumers. The process of acquiring inputs involves transportation. With the knowledge of inputs required for production of a good, and amounts required, it is then possible to determine what inputs (the output of other industries) and what volume must be transported. Freight transportation is a factor of production and is not desired in its own right, but only for the service it provides in the production process. The demand for transportation is, in fact, a derived demand--derived from the level of production and economic activity in a region or state.

The input-output method uses a system of accounts that represent the transactions among the sectors of the economy. These determine the interrelationships that exist between sectors of the Michigan economy and the relationship between these and the economic activity outside of the state (Rest of Nation, RON). By using this accounting method, it is possible to show how outputs in dollars from each producing sector are distributed among other sectors in Michigan and RON. In terms of transportation requirements, the input-output table also shows how (and from whom) each sector procures its inputs (both in Michigan and RON). Input-output models are consistent in that the outputs of each sector must conform with the outputs of all other sectors from whom it buys inputs and to whom it sells outputs, as well as with the total output of the economy. It is therefore possible to trace the interdependence in the economy and the required flow of goods needed in the input-output process.

Once the inputs and outputs that must move throughout the state are known (given the level of economic activity), it is necessary to link that information with data on rail transportation activity. The characteristic of consistency in the input-output model must be matched by the transportation data. This requires that total product movements in the transportation sector correspond with the dollar flows between sectors in the input-output model.

To accomplish this, an input-output model of Michigan will be 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 will be matched to commodity classifications on the waybill tapes (the Standard Industrial Codes in the model are matched to the Standard Transportation Commodity Classification codes of the transportation data, SICs and STCCs). 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 the aggregate 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 1976 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 tota

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total outputs are generated, rail movements will be 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 input 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 will be decreased by 3 percent. This procedure will be used to adjust the movement of goods on the state's rail lines given the changes in total economic activity.

Applications to the Subsidy-Abandonment Decision

To determine whether a Michigan rail line should be subsidized or abandoned (the investment-disinvestment decision), the Michigan Department of Transportation's primary objective is to identify the minimum acceptable levels of rail service along endangered lines, demonstrating either profitability to the operator or social and/or economic benefits to communities. The approach mandated by the yearly "Michigan Railroad Plan" is the use of benefit-cost impact criteria. A decision to subsidize a branch line reflects an explicit judgment by decision makers that adverse consequences of a rail abandonment justify the cost of subsidization. While this benefit-cost approach is essential in individual abandonment proceedings, decision makers viewing the rail system from a statewide perspective require a more comprehensive framework which considers spatial and commodity aspects. The procedure suggested in this study seeks to provide the link between the total frei

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freight transportation system and the economic activity throughout Michigan.

The abandonment of a rail branch line reflects not only a change in the supply of freight transportation, but also in its demand. When a rail branch line is abandoned, it demonstrates that the demand for the operator's service has declined, resulting in revenues below costs and thus, abandonment. Therefore, abandonment reflects the fact that the demand for goods in the entire economy or region has declined causing a decline in the derived demand for transportation. It follows that linking a model of the economy (representing the requisite amounts of input and output) with data on how these commodities move throughout the state, will enable planners to address the demand for transportation services and facilities.

This study is designed to aid in the answering of two questions crucial to the understanding of the relationship between the demand for rail service and the demand for intermediate and final goods in the economy:

(1) Given the necessary volume of goods that must flow over a particular rail segment in order for it to produce revenues over costs, will the projected level of economic activity in the state or region generate enough demand for intermediate and final goods to meet this volume? If projected statewide economic activity will generate such a volume, then the rail segment would be a candidate for subsidization until the projected demand occurs. If statewide activity will not generate enough volume, the line may be subject to abandonment.

(2) The corollary to the first question is, given projections of statewide economic activity, what will be the volume of the flow of goods generated for individual rail segments? Answering this question will help to identify which rail segments will eventually become profitable and which will continue to operate at a loss, providing for long-term planning.

The immediate problem facing rail planners is the loss of subsidy money over the next few years. Consequently, they are faced with a yearly decision on which lines to continue to subsidize through 1986. Interim subsidies on lines which may never become profitable may not be an "efficient" use of subsidy funds. Thus, the motivation for using the method of this study is that rail planners must know which lines have a probability of becoming profitable and which do not. While service may be justifiable on a line in a more comprehensive benefit-cost basis, the method suggested here will help determine whether a line would require permanent operating assistance. Thus, a method that can predict rail traffic can be of value in the subsidy-abandonment process.

The Upper Peninsula Rail System: Applying the Method for the Subsidy-Abandonment Decision

A demonstration of the model's usefulness in predicting rail movements and in aiding the subsidy-abandonment process will be applied to Michigan's Upper Peninsula. Michigan's Upper Peninsula was chosen as the case study for two reasons. First, the U.P. rail system is currently (spring 1982) the subject of study by the Michigan Department of Transportation. This study is part of the rail rationalization process of the transportation department, which includes decisions on subsidies and abandonments, requiring forecasts of U.P. rail traffic. Consequently, the U.P. case study is timely in that it can aid the decision-making process already underway. Further, the results of this study can be compared with the results of the rail rationalization report as a check on both methods.

Additionally, the U.P. rail system is being used as a case study because of transportation data that has recently become available. The Marine-Ports Planning Section of the Michigan Department of Transportation conducted a shipper survey of the U.P. in 1981. This data represents nearly a 100 percent survey of resource-based and manufacturing traffic generated in the U.P. Thus, it is possible to use both the rail waybill samples provided by the Federal Railroad Administration and this primary data source to demonstrate the method of forecasting U.P. rail traffic. The primary data will be used as a check against the waybill sample.

Forecasting Procedure

Once the 20-sector input-output model of Michigan is linked to rail data (expanded 1 percent waybills) by STCC and SIC codes, it is possible to use the model to project rail traffic and to aid in the subsidy-abandonment decision process. First, the model will be tested to determine whether it can accurately forecast rail traffic, given known rail movements. The test will consist 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. Second, the model will be used to forecast total state rail traffic and Upper Peninsula rail traffic beyond

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1980, with application to the subsidy-abandonment process. The procedure that will be used in both cases, with modifications, is outlined in Figure 1.1.

To forecast rail traffic for any year, the starting point is the 1976, 20-sector input-output transactions table. Final demands, by sector, are estimated for the forecast year and are substituted for the 1976 final demands. Total output, by sector, is estimated by the input-out 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.

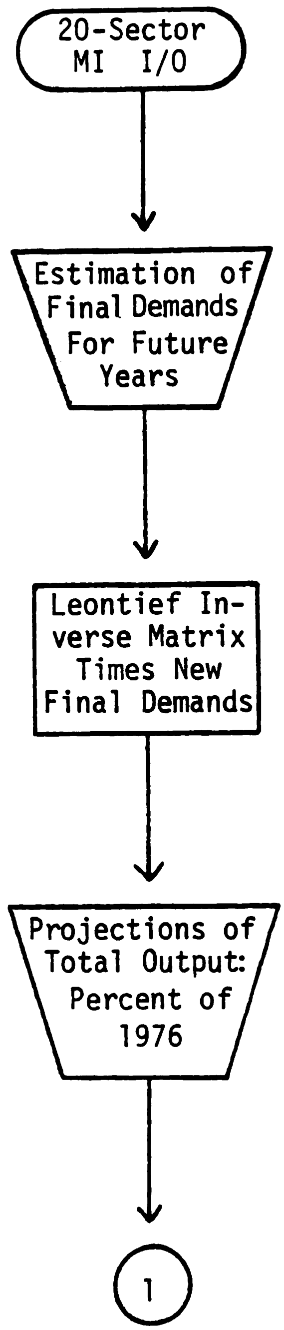
The 1 percent waybills (expanded by 100) representing total rail traffic in 1976 are then multiplied by sector, by the real percentage changes forecast by the input-output model. This procedure yields a projection of rail traffic for the forecast year. Finally, the actual traffic of the forecast year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

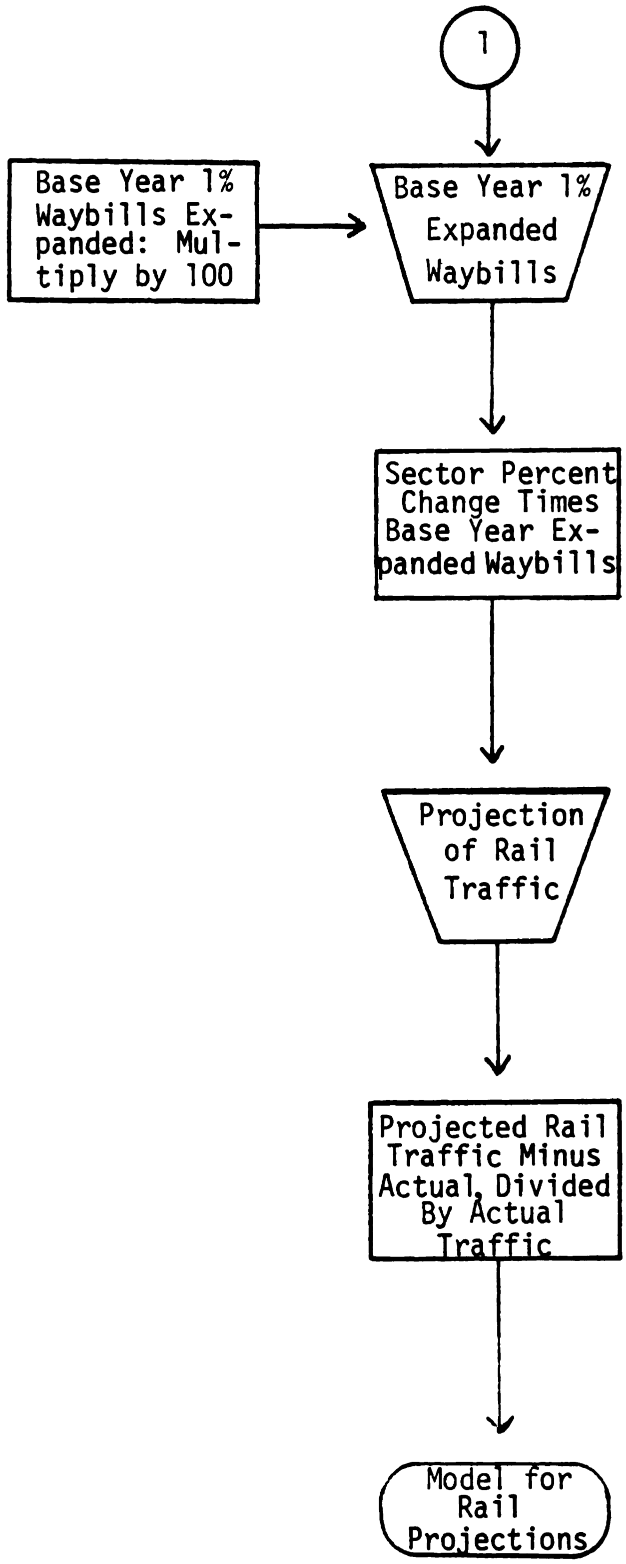
Organization of Study

The literature review in Chapter II will focus on recent literature dealing with rail traffic forecasting methods. The review will also examine studies on rail abandonments, particularly as they apply to Michigan. For the purpose of this review, the literature is divided into that which takes a structural-aggregate approach to rail freight forecasting and that which views the issue from a micro or firm level. Chapter II also includes a discussion of the estimation of rail freight traffic and the rail planning process in Michigan, with particular emphasis on a description of Michigan's two-tier rail rationalization

Figure 1.1

Flow Diagram of
Rail Traffic Forecasting Method

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Base Year 1% Waybills Expanded: Multiply by 100
Base Year 1% Expanded Waybills
Sector Percent Change Times Base Year Expanded Waybills
Projection of Rail Traffic
Projected Rail Traffic Minus Actual, Divided By Actual Traffic
Model for Rail Projections

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procedure. This latter part of Chapter II confirms the need for a more systematic method of estimating rail freight traffic.

Chapter III is a description of the Michigan rail system, with an emphasis on those rail segments and regions where abandonments or subsidization have occurred or are likely to occur. The need for estimates of future rail traffic due to the reductions in subsidy appropriations mandated by Michigan's legislature is examined. Further, Chapter III provides a description of the Upper Peninsula rail system, including a discussion of the operations of each railroad and the traffic characteristics of the U.P.

In Chapter IV, an examination is made of the economic framework of the study and the method suggested for estimating rail traffic. This chapter includes the rationale for using the input-output method for rail planning. The description of the 20-sector input-output model includes an explanation of how the input-output method projects an economy's total output through the use of the Leontief inverse matrix. After a discussion of the assumptions behind the input-output table, the construction of the table itself is examined, based on work at the University of Minnesota by Hwang and Maki. Included in this part of Chapter IV are the data requirements, updating, and aggregation procedures used to build the 1976 Michigan input-output model. Finally, Chapter IV includes a description of the procedure used to link the input-output table to commodity flow data and a description of the waybill sampling procedure.

The forecasting ability of the input-output model is tested in Chapter V using the method outlined in Figure 1.1. Included is a description of the estimation of the 1980 final demands used to f

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forecast the total output percentages that predict rail traffic. The purpose of Chapter V is to show how accurately the link between the input-output model and commodity flow data predicts rail flows. Based on this knowledge, the model will be used to forecast rail traffic beyond the test period of 1976-1980.

In Chapter VI an illustration of the use of the forecasting method for predicting rail traffic, as well as suggested applications to the subsidy-abandonment decision, is presented. Using estimates of final demands, a forecast of total U.P. rail traffic and Soo Line rail traffic for 1983 will be presented. These final demands will be estimated over various growth ranges. The procedure will be applied to the subsidy-abandonment decision by forecasting a high growth scenario to 1986. This forecast of rail traffic on selected segments will be compared to the rail traffic believed to be necessary to produce revenues over costs. It will be suggested that rail segments which may not be able to generate sufficient traffic, given high estimates for 1986, are more likely to be candidates for abandonments, whereas lines that may be able to generate enough traffic to be profitable are more likely to be candidates for continued subsidization in order that they be maintained until profitable, other things being equal.

Finally, Chapter VII will conclude with a discussion of the use of the study's results for transportation policy analysis and implications for further research.

CHAPTER II

REVIEW OF LITERATURE

In this chapter, a review of recent literature on rail traffic forecasting methods will be presented. Also included is a brief review of rail abandonment literature, particularly as it applies to Michigan. Finally, there will be a review of methods that transportation planners currently use to estimate rail freight traffic.

It was not until the 1960s that a significant volume of work began to appear on the application of theory and empirical measurement of the demand for freight transportation services (Johnson, 1975). In general, the literature agrees on two points:

(1) The demand for freight transportation is not simply a price-quantity issue; the determinants of demand involve factors such as travel time reliability, loss and damage, frequency and size of shipment, etc. A large body of the literature uses multiple regression analysis to distinguish the relative influence of each determinant.

(2) Freight transportation is a factor of production and is not desired in its own right, but only for the service it provides in the production process. The demand for transportation is best described as a derived demand.

The literature diverges, however, on the question of the proper level of aggregation from which to estimate the demand for freight tra

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transportation. One approach considers the demand within the broader structure of an economy or region. This "structural-aggregate" approach regards the derived demand for freight transportation as dependent on the state of the rest of the economy. Thus, structural variables describing macroeconomic activity in different regions are used to explain demand. A second approach regards the demand for freight transportation as the sum of individual shipper decisions. This "micro-disaggregate" approach examines the specific inputs and outputs of each production process. In these studies, determining the volume of cargo that will flow in a given market is the starting point for any analysis.

The Structural-Aggregate Approach

The Canadian Transport Commission (CTC) reported in June 1976 on "Phase II" of their Program, employing an econometric forecasting model to determine the demand for freight transport in Canada (Hariton, 1976). This aggregate model attempts to link changes in broadly defined macroeconomic variables to transport demand for specific commodity groups. The model concentrates on rail and marine modes and uses the Canadian Disaggregate Interdepartmental Econometric Model. In terms of aggregation, it divides Canada into five regions, plus the United States (for rail and truck movements), adding nine regions of the world for marine movements. In terms of commodity aggregation, commodity classes were constructed to be as large as possible, while still retaining their homogeneity. In the report, 22 commodity groups were treated, most of these comprise bulk commodities totaling over 80 percent of Canadian rail movements and over 90 percent of total marine movements.

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The CTC model considers the demand for freight transport as derived from the demand for interregional trade. The model is concerned with the movement of a given commodity from a given origin to a given destination by a given mode. The number of tons of commodity g moved from origin i to destination j by mode m during time period t is denoted by V_{gimt}. The model introduces the notion of a "link" as being characterized by a given origin, a given destination, and a given mode. Then, V_{gijmt} denotes the movement of commodity g along link ijm at time t.

Five main causal factors of the demand for freight transport for a given movement were identified: (1) excess production at the origin; (2) excess consumption at the destination; (3) transport costs; (4) complementary movements; (5) competitive (substitute) movements. In algebraic notation:

$$V_{gijmt} = f(EP_{git}, EC_{gjt}, R_{gijmt}, V_{gi'j'm't})$$

where

V_{gijmt} is defined above.

EP_{git} = excess production of commodity g in the origin region during time t, where EP_{git} is $Production_{git} - Consumption_{git} - \Delta S_{git}$ (ΔS_{git} = stockpile of commodity g at start of period).

EC_{gjt} = excess consumption of commodity g in destination region during time t, where $EC_{gjt} = Consumption_{gjt} - Production_{gjt} + \Delta S_{gjt}$.

R_{gijmt} = the cost of transporting the commodity g from origin i to destination j by mode m, where freight rates are the only component of transport costs.

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$V_{gi'j'm't}$ = the links that are either complementary or competitive. Certain movements of commodity g are complementary, resulting from transshipments either between modes or within a given mode (e.g., from lakers to ocean liners). These movements have either their origin the same as the destination or their destination the same as the origin. Certain other movements are substitutes, resulting from alternative opportunities: (1) to ship to different destinations; (2) to receive from different origins; or (3) to use different modes.

The CTC model uses macro level variables (i.e., activity in a region) with an accent on structural economic variables as the independent variables. In terms of dependent variables, the model measured, in tons, the amount shipped between regions, using a linear approximation as the functional form. The regression analysis considered alternative origins, destinations, and modes, but not different commodities (see also Canadian Transport Commission Report, 1975).

As part of the Northeast Corridor Transportation Project, the consulting firm Mathematica (Vol. II, 1969; also reported in Terziev, 1976) developed a four-stage aggregate model based on a system of linear regression equations. The Mathematica model began by projecting the total production of 16 commodity groups with 16 separate regression equations. The regressions included a time variable and projections of components of Gross National Product as independent variables. Next, the model projected the regional share of originating and terminating tonnage in each commodity group. In order to project regional demand, a regression model was used having as its independent variables population, retail sales, regional income, and per capita income.

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Two commodity groups were allocated to different regions and a distribution model was used to predict the flows of goods between regions. This involved two phases, beginning with a regression model which included as independent variables: consumption at the destination points, production at the origin, distance, and population and employment at the destination. It was found that regional flows projected in this manner did not match the total flows projected originally. Consequently, a flow adjustment algorithm was used to make the two projections consistent. The adjustment used Lagrange multipliers to minimize the flow adjustments, subject to the constraints on the total flow.

The fourth stage of the Mathematica model dealt with the modal split. A market share regression was used for rail, private truck, common carriers, air, water, and "other." The independent variables included the fraction of shipments falling into each of five weight groups, the fraction of shipments in each distance group, and the value and average gross revenue per ton of each commodity.

Terziev (1976) points out that there are two major drawbacks to this sort of sequential modeling system which attempts to address a full range of freight shipment decisions. First, some choices are made jointly rather than sequentially; for example, the choice of mode and shipment size. Secondly, when two decisions are not made jointly, there is still some feedback from short-run decisions to long-run decisions. These drawbacks brought forth joint demand models that attempt to model several choices in the same equation. As part of his study in 1964, Perle estimated a joint demand model using rail and truck flows in five commodity groups, in nine regions, during each of five years. Perle estimated a truck and rail model from the form:

$$\log(V_{m1}) = \beta_0 + \beta_1 \log(r_{m1}) + \beta_2 [\log(r_{m2})] + \sum_{i=1}^{9} c_i R_i + \sum_{j=1}^{5} d_j Y_j + \sum_{k=1}^{5} f_k C_k$$

where

V_{m1} = volume of traffic carried by mode m1;

r_{m1} = average revenue/ton on mode m1;

r_{m2} = average revenue/ton on mode m2;

R_i = 1 for region i, 0 otherwise;

Y_j = 1 for year j, 0 otherwise;

C_k = 1 for commodity k, 0 otherwise.

The results showed poor R^2 and t-statistics, partly due to the fact that the dependent variable included both the choice of production level and the choice of mode. However, as Terziev (1976) illustrates, the biggest problem with this and other joint demand models is that they do not reflect the fact that the demand for transportation is a derived demand based on the demand for goods in an economy. While the dependent variables include the volume to be shipped, the independent variables do not explain the demand for the commodities being transported.

The Micro-Disaggregate Approach

One type of disaggregate model concerns the abandonment of rail branch lines. These types of studies are included here because the abandonment of a rail branch line reflects not only a change in the supply of freight transportation, but also in its demand. When a rail branch line is abandoned, it reflects the fact that the demand for the operator's service has declined, resulting in revenues below cost, and thus, abandonment. These studies are considered as disaggregate models because they are generally commodity or region specific, focusing on a single branch line, a single commodity, or a specific geographic region.

Examining two regions in Saskatchewan, Fost (1972) found that changes in local economic conditions resulted in changes in the grain handling and transportation system. This implies that a community's economic condition first affects the transportation system, rather than abandonment causing the economic decline of an area. This conclusion is similar to the aggregate models that suggest that changes in a region's economic activity affect the derived demand for transportation. In a study that compared nine counties that lost rail service to nine counties that retained service, Sloss, Humphrey, and Krutter (1975) found that the growth rate of income in the two areas was not significantly different. The short-run impacts of rail abandonment in 10 communities was studied by Allen (1975) who discovered that in only two of the 10 communities did rail abandonment cause significant declines in employment. Allen concluded that rail abandonment caused the largest shippers (feed and fertilizer) to shift to other modes of transport, increasing the costs to farmers for shipment.

That the impact of rail line abandonment can best be seen in the costs imposed was demonstrated by Vollmers and Thompson (1980) who examined the impact of abandonment of four grain subsector branch lines in the Thumb of Michigan. Vollmers and Thompson suggested that rail abandonment forces shippers to find alternate shipping methods--probably truck--as well as a modification of destinations. It was found that abandoning the four branch lines serving the Thumb region of Michigan would increase the 1976 grain marketing costs (before farmer exit) by $473,921, or 2.5 percent. This change in distribution costs modifies the competitive environment and encourages farmers to alter marketing patterns, causing smaller elevators to exit the market. While rail abandonment may not cause the economic decline in the first place, it will impose higher distribution costs and in the long-run force some shippers from the market; thus, further affecting the employment conditions in a region.

Studies at the Regional Science Research Institute (Stevens, et al., 1979 and 1980) have used input-output models to estimate the impact of new transportation facilities. When a new highway is proposed, the input-output method is suggested as a way to examine the direct, indirect, and induced effects. The RSRI work concentrates on the use of input-output multipliers, particularly the income and employment multipliers. This differs from the approach taken in this study where only the output multipliers are used.

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

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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.

The approach to transportation demand employed by researchers at the Massachusetts Institute of Technology[1/] begins by stating that the flow of cargo in a given market is simply the sum of individual shippers' decisions. These decisions are, in turn, conditioned by the specific inputs and outputs of each of the production processes involved. This disaggregate approach estimated the output levels of firms and using input-output analysis, estimated the inputs required to produce the given output. These input-output coefficients represent the dollar value of inputs purchased from a particular industry i to produce one dollar of output in industry j. When multiplied by the output of the industry, this coefficient gives the dollar value of purchases of inputs from industry i--and hence, the amount of goods that require transportation services. The objective is to explain the individual shippers' decision on commodity k as the probability of jointly selecting the frequency (f), mode (m), size (q), and location (i) of purchases, given user location (j) and usage rate (u) required by the final demand for a good and the input requirements of the production process:

$$p^k(f,m,q,i \mid uj)$$

[1/] See: Chiang and Roberts, 1975; Chung and Roberts, 1976; Roberts, 1977; and Terziev, 1975.

Thus, determining the location of economic activity and the rate at which commodities are used in the production process is crucial to determining freight demand.

Rail Traffic Forecasting Methods and Rail Planning in Michigan[2/]

With the passage of the 1981 Michigan Appropriations Act, a reduction of 25 percent per year in financial support to currently subsidized rail lines was mandated, eliminating rail subsidies by 1986. This anticipated reduction in state support has produced a need to identify an essential core of transportation services. Consequently, a "rail rationalization" process was begun by the Michigan Department of Transportation which involves a two-tier procedure to define an essential core system of rail service and to rank all rail lines in terms of the requirements of that system.

The Tier I analysis (adopted January 27, 1982 by the State Transportation Commission) screened all lines considered as candidates for financial assistance. The intent was to use readily available data, without exhaustive investigation, to produce a rank-ordering to indicate those line segments which warrant state assistance, and those which do not.

Tier I analysis included the review, evaluation, and placement of each segment into one of the following categories:

[2/] The following discussion is taken from the following Michigan Department of Transportation documents: Annual Update, 1978; Tier I Report, 1981; Tier II, Phase I Report, 1982; Tier II, Phase II Report, 1982; Northwest Rationalization, 1980. For full citations, see Bibliography.

(1) Lines which are viable or that should be included in the essential core system because of their contribution to program objectives.

(2) Lines with questionable viability, but with the potential to be included in the essential core system.

(3) Nonviable lines, not to be included in the essential core system.

To do this, three sets of rail service indicators were used. The first set of indicators were called "service characteristics" and included the number of shippers on a line, carloads, carloads per mile, carloads team tracked, and a rail dependency factor. The second set of indicators, "service effectiveness and cost characteristics," included revenue to operating cost trends, revenue to cost ratio, revenue to operating cost ratio, reliability costs, operating subsidies, and right of way costs. The third set of indicators were "potential and existing demand" and included the growth potential and production in agriculture, forestry, and extractive products, as well as an employment dependency factor and consideration of production centers served. The procedure was designed to objectively rank rail segments with respect to service criteria and economic potentials, minimize statistical bias, and illustrate the relative contribution to the state and regional rail systems of specific rail segments.

Tier II is designed to assess benefits relative to the costs of state financial support for individual lines. A guiding concept is program opportunity costs, which addresses the question: What are the state's best investment opportunities to achieve rail service objectives, given limits on financial resources?

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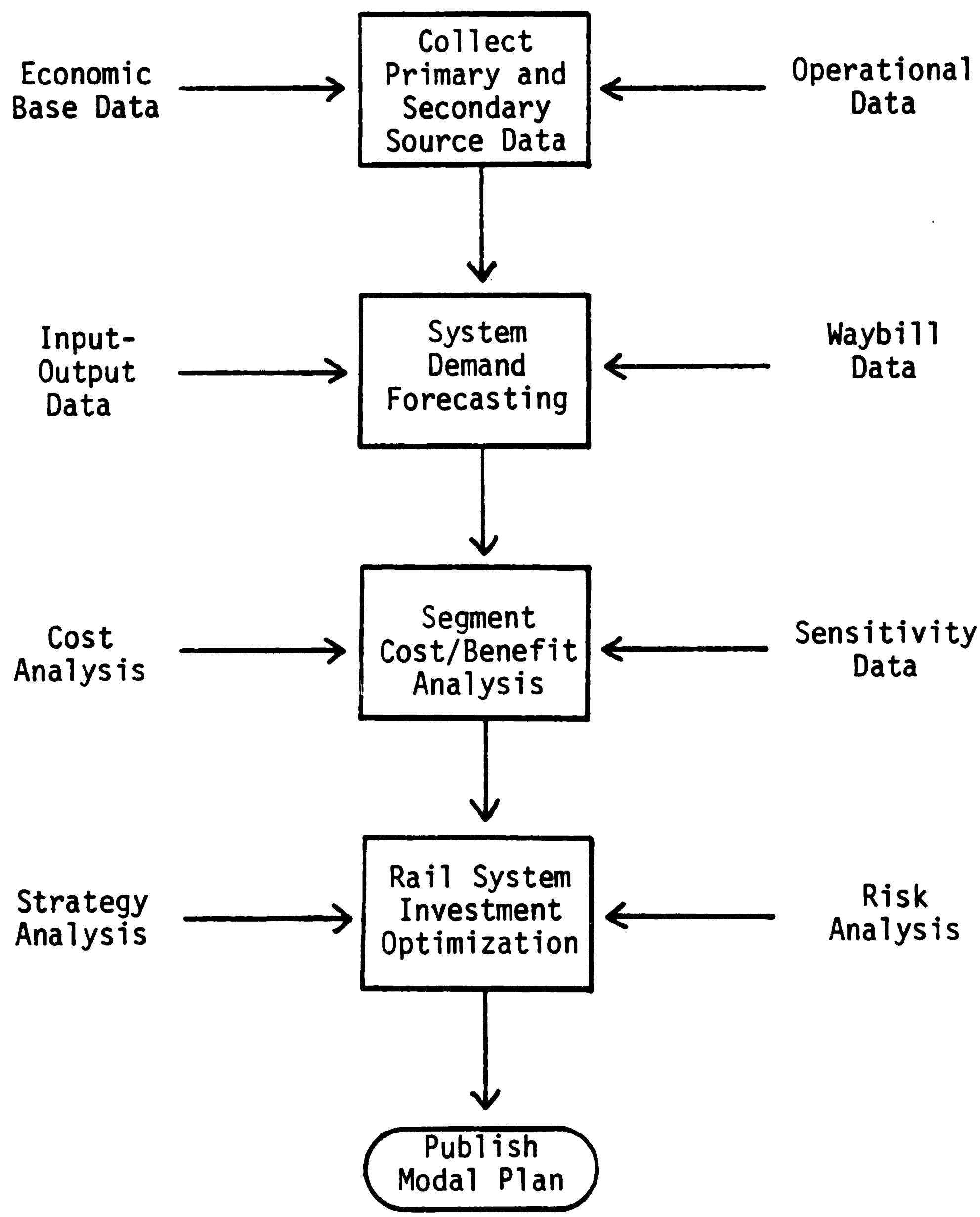
The Tier II procedure employs a decision theory approach, as summarized in Figure 2.1. The approach is applied to those rail lines that were assigned to Category II in the Tier I process. After collecting traffic, cost, and revenue data for each rail segment under question, the Tier II process attempts to forecast potential rail demand and future requirements for commodity transport services. A rail abandonment impact/cost method was adopted for use in the third step of the Tier II procedure. The impact/cost analysis compares the social and economic costs of discontinuing local rail service with the net capital and operating costs (subsidy) of continuation. For lines currently being analyzed in Michigan, both of these sets of costs can be calculated quarterly over 10 years, or 40 calendar quarters.

The method also estimates the personal income loss, state and federal tax losses, and unemployment and welfare compensation payments resulting from job losses reported by shipper surveys. The impacts are then discounted over time, which allows for the gradual reemployment of labor. Reemployment rates are determined by statistics obtained from the Michigan Employment Security Commission (MESC). The limits on reemployment potential are determined by local area unemployment rates that are also obtained from the MESC. Finally, the Tier II process includes the development of an adaptive decision process for minimizing the potential risks, or opportunity costs, associated with alternate service strategies.

While this impact/cost approach is traditionally employed in individual abandonment hearings, decision makers viewing the rail system from a statewide perspective require a more comprehensive framework which considers spatial and commodity aspects. The impact/cost

Figure 2.1

Rail Rationalization Plan
Rail Investment Decision Analysis Model
Tier II Flow Diagram



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method is by design a procedure that examines each case on a line-by-line basis and offers little insight into how significant any given line is in the total rail system. A few shippers on a line with little total traffic could bias the results of the method. It appears that the procedure is biased toward the retention of rail service. Further, the interdependency between rail service and economic activity on a line or in the entire state is not addressed. The procedure suggested in the following chapters seeks to provide the link between rail demand on a particular line or region, the total freight transportation system, and economic activity throughout Michigan.

Forecasting Rail Traffic and the Potential for Profitability of Currently Subsidized Lines

In both Tier I and Tier II of the Michigan Rail Rationalization Plan, it is necessary to forecast both potential commodity movements and traffic flows. In the three reports where forecasting has been used, the method has relied primarily on shipper-carrier interviews. Discussions with Michigan Northern management were used to develop forecasts of potential traffic in the Grand Rapids to Mackinac Corridor Report. In both the Northwest and Ann Arbor Reports, traffic projections for 1985 were developed for the Michigan Department of Transportation by A.T. Kearney, Inc. The projections were based on interviews of shippers in major commodity categories. A.T. Kearney used the 1979 rate structure, service quality, and traffic levels, as a base and evaluated the reported sensitivity of traffic to further rate changes and changes in the quality of service. In the Ann Arbor Report, these projections were adjusted by the Michigan Department of Transportation for changing commodity mixes.

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In all, the traffic projections used thus far in Michigan rail planning have been ad hoc in nature and not related to changes in economic activity in general. In fact, the transportation department recognizes this deficiency and is presently investigating alternate methods for estimating potential traffic changes. The foremost of the alternatives is a variation of the input-output method suggested in this study. Traffic projections in other states follow the same pattern as in Michigan. Shipper surveys are the predominant means of forecasting rail traffic in Arizona (Transportation Research Circular, p. 2), while in Tennessee most work appears to be of the impact/cost method variety, with little forecasting ability.

In Washington and California, however, preliminary work has been carried out in using an input-output model to aid in rail traffic forecasting. In Washington, an input-output table has been used to produce baseline data for use in forecasting. Thus far, the work in Washington appears limited to Standard Metropolitan Statistical Areas. Current use of the input-output model in Washington is focusing on modal choice and is based on shippers' surveys. In their West Coast Corridor Study in California, Cambridge Systematics, Inc. (1978), has made limited use of the 1967 input-output table of the United States to estimate commodity production in Pacific Region SMSAs. The California study relied entirely on the national model, rather than the two-region method, which will be discussed in Chapter IV. Further, Cambridge Systematics, Inc., relied on national census data for all of their estimates.

Thus, not only are traffic projections needed to replace the predominantly ad hoc procedures used, but traffic projections are crucial

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in analyzing the potential for profitability of currently subsidized lines. This study addresses the issue of whether future rail services on currently subsidized lines can be premised on the eventual profitability of private carriers. Existing systems with low traffic density can be justified on financial grounds only if future traffic increases are capable of overcoming existing losses.

Conclusion

The method suggested here addresses both the need to improve the systematic forecasting of rail traffic and the need to judge future profitability. It is possible to view the issue of transport forecasting as the interaction of aggregate economic variables with the disaggregate decisions by individual firms: The method suggested in this study combines both the level of analysis of the Canadian Transport Commission and Massachusetts Institute of Technology models. Abandonment literature suggests that it is the economic activity of an entire region that affects the demand for freight transportation services. As with the CTC model, changes in the economic climate of a region affects transportation demand. The use of a statewide input-output table produces projections of economic activity in a region through estimated changes in the final demands of its commodities. Once these changes occur, individual shippers then face decisions on how, whether, and at what rate to ship their commodities. The initial assumption is that economic activity in a particular sector or region generates physical movements of the aggregate of products included in each of its input sectors in proportion to the change in that sector's output.

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Once the aggregate change in economic activity has been estimated, the disaggregate structure of input-output models is amenable to elaboration of the transportation sector. Corresponding to each of the dollar flows present in the input-output model, originating and receiving sectors can be identified and an indication of the type of product which is physically moving can be derived. Further, the use of commodity flow data with the input-output model indicates over which rail lines products actually move. Consequently, the use of input-output as a forecasting method is particularly suited to the needs of transportation planners. Input-output does not simply project total economic activity using macro variables such as GNP, income, or employment. Input-output is disaggregated by commodity groups--the same commodity groups whose future production will determine the demand for individual rail service. With this information, it would be possible to both estimate future traffic and evaluate the potential for profitability on currently subsidized lines--given estimates of future rail demand.

The review of both rail forecasting literature and rail planning leads to the conclusion that there is a gap between the theoretical understanding of rail freight demand and an operational use of this understanding. A large body of work exists that deals with the factors associated with rail demand. However, this work is theoretical in nature and has not been employed in any meaningful sense in the actual estimation of rail traffic by planners. The method examined in this study seeks to bridge the gap between the theoretical and the operational. The goal is to make the link between the level of economic activity and rail demand suggested in the theoretical literature useful in the sense that rail planners have a method to address that link. In essence, the purpose of this study is to operationalize the theoretical understanding of rail freight demand.

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CHAPTER III

THE MICHIGAN RAIL SYSTEM

In this chapter, a description of the Michigan rail system is presented.[1/] Particular attention is given to those rail segments and regions where rail abandonment and/or subsidization have occurred or their occurrence is likely. Additionally, a description of the rail system in Michigan's Upper Peninsula is presented. This chapter is meant to provide a perspective on the variety and extent of the issues and problems to be addressed by the Michigan rail planning procedure.

The Michigan railroad system consists of approximately 6,028 route miles serviced by nine Class I carriers, 16 Class II carriers, and five switching and terminal railroads. Of this total, 5,654 miles represent actual first track mileage, while the remaining 374 miles are operated under trackage rights agreements. The Lower Peninsula contains 4,807 route miles and the Upper Peninsula contains 1,061 route miles. These figures are supplemented by 373 miles of active car ferry routes maintained by Michigan railroads.

In any analysis of Michigan's rail network, the state's peninsular geography must be remarked upon. Due to this geographic configuration, three distinctive characteristics of Michigan railroading have emerged.

[1/]The material in this chapter is taken from the following Michigan Department of Transportation documents: Railroad Plan, 1980; Tier I Report, 1981; Rationalization Plan, 1981. Material on the Upper Peninsula is taken from: U.P. Rail Planning Commission, 1982.

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First, Michigan, in reality, has two different railroad systems which are not physically linked by a direct rail connection. The Lower Peninsula system is oriented towards Chicago, Toledo, and Cincinnati gateways. Its traffic consists primarily of transportation equipment, bulk agricultural commodities, and chemical products which move outbound; and coal, primary metal goods, and food products which come inbound. The Upper Peninsula system serves mainly as an outbound rail route for metallic ores and pulpwood. Most of its traffic runs southerly into Wisconsin or to lake ports.

Second, since Michigan's two peninsulas have a total of 3,126 miles of Great Lake shoreline, which drastically restricts direct overland rail connections with other states and Canada, an extensive rail car ferry service has evolved in Michigan. Currently, five carriers operate eight different car ferry routes from Michigan ports. The bulk of these operations involve Lake Michigan service between Wisconsin and the Lower Peninsula. While the Great Lakes rail car ferry routes have played a major role in the development of Michigan's railroad network, the ferries' extensive capital needs and the emergence of new railroad technology and equipment now threaten the existence of this unique element of Michigan railroading.

Third, the state's peninsular geography inhibits the growth of through traffic and the resultant heavy density freight routes which are common in most Midwestern states. Therefore, a significant portion of Michigan's railroad activities involve the origination or termination of freight carloadings, i.e., a terminal or switching function. As the Northeastern rail crisis has clearly indicated, a railroad's financial

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viability is frequently endangered when this particular function becomes dominant.

As mentioned earlier, as of September 1, 1980, the 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. Figure 3.1 illustrates those rail lines which have been abandoned since 1976; Figure 3.2, the lines which were subsidized in 1981; Figure 3.3, the pending abandonments as of late 1981; and Figure 3.4, the lines which have been identified by the solvent carriers as under study for future abandonment.

Service provided, which is indicative of the level of economic activity dependent on the availability of rail, can be summarized by total carloads originating or terminating on lines in each respective category. The 838 miles to be operated with assistance under the current program originate or terminate 28,400 carloads of rail freight per year. Approximately 39,000 carloads originate or terminate on the 204 miles currently subject to abandonment proceedings, and the 589 miles which are candidates for a future attempt by the carrier to abandon account for about 11,300 carloads each year. The balance of the system accounts for approximately 1.5 million carloads of originating and terminating traffic.

In an effort to stabilize the policy and financial support structure for the continuation of essential core services on the state's rail system, a "rail rationalization" process has been implemented by

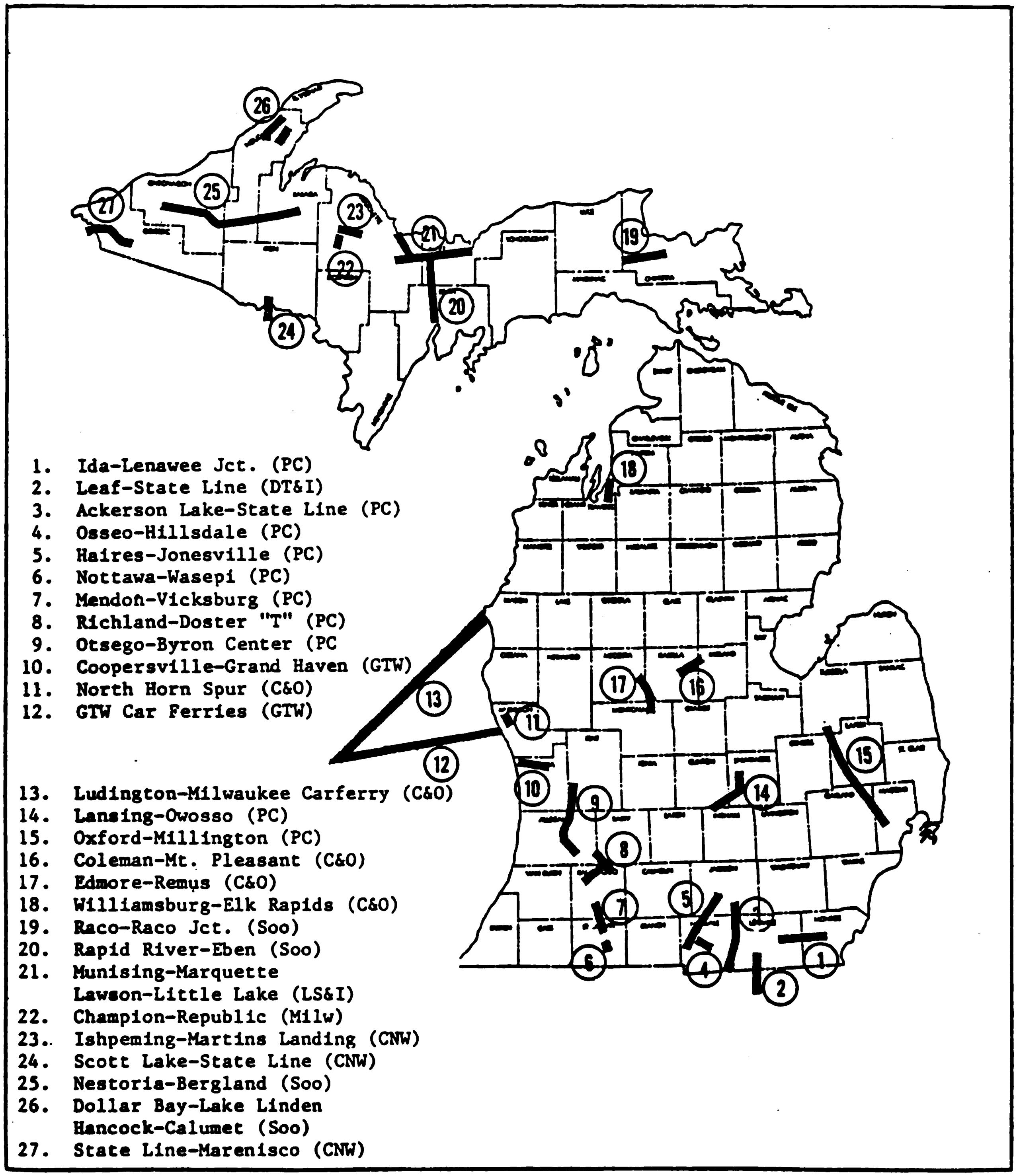

Figure 3.1

Michigan Abandonments Since 4/1/76

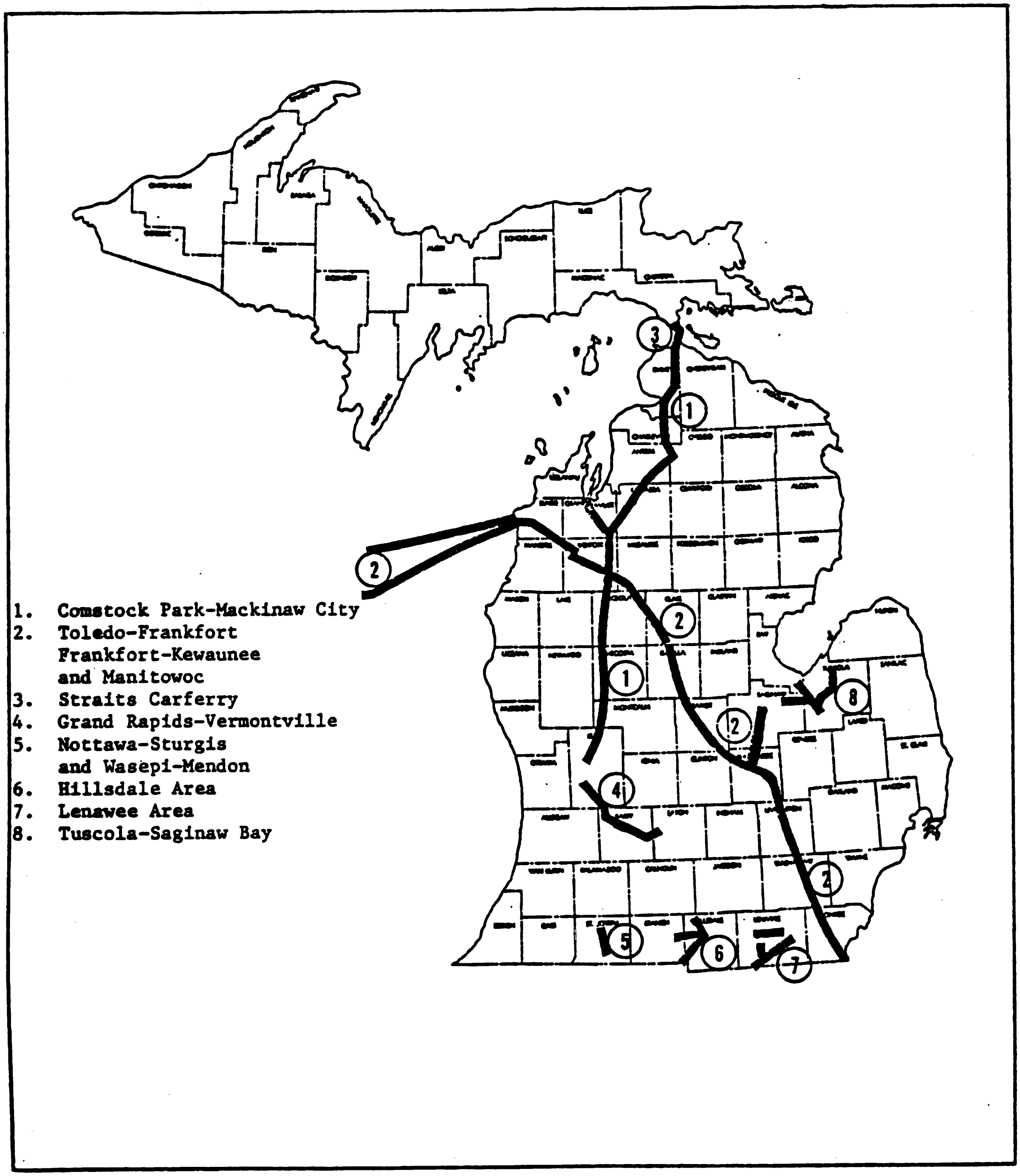

Figure 3.2

State Subsidized Lines
1981

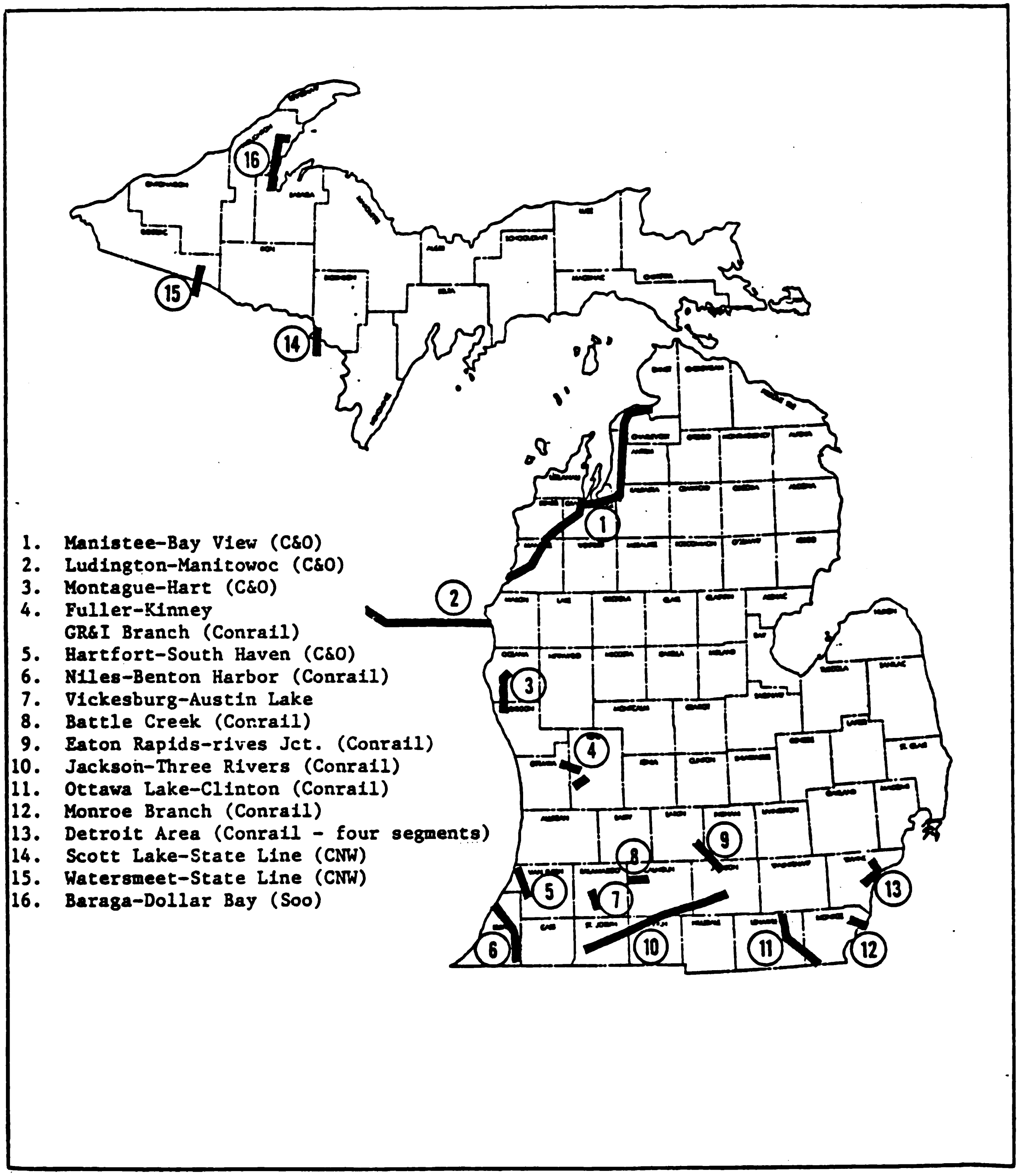

Figure 3.3

Pending Abandonments as of 11/24/81

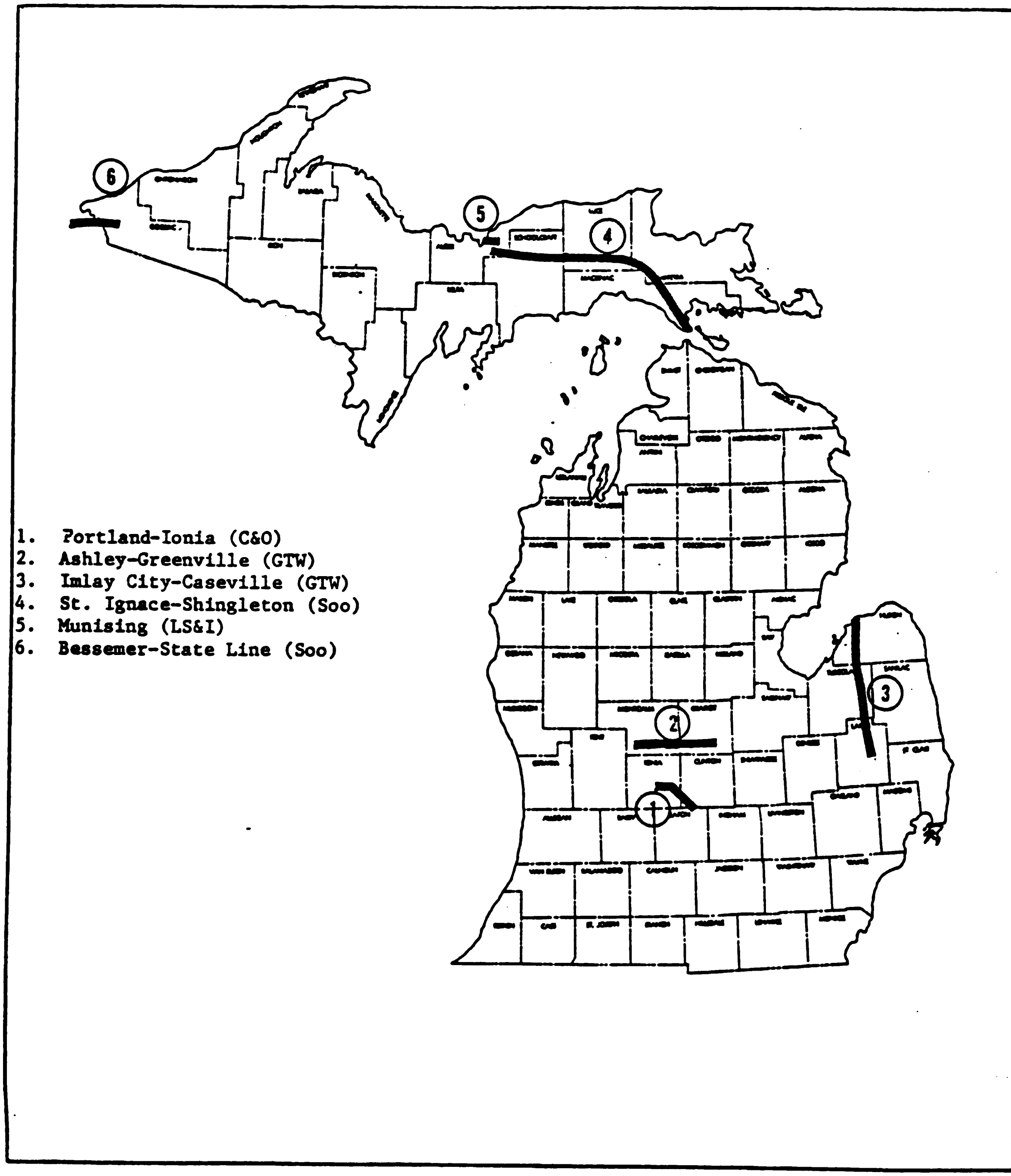

Figure 3.4

Lines Identified by Carriers
as Under Study

the Michigan Department of Transportation (MDOT) to identify those lines warranting a long-term state commitment. Rail rationalization was placed in the 1981 Michigan Appropriations Act (MPA 32) as a requirement prior to the expenditure of funds after October 1, 1981. Another section of the Appropriations Act outlined a financial reduction of 25 percent per year on the currently subsidized lines so that at the end of a five-year period, they would no longer be funded. These two legislative requirements are interpreted as requiring the Michigan Department of Transportation to reconsider the elements of the current rail preservation program and reduce its cost, while maintaining essential services.

The total of state funds available under the legislated phase-out for rail and water operating assistance, by year, is shown in Table 3.1. This phase-out of the state appropriation for operating assistance applies to state-assisted rail systems operating on the date the rail rationalization plan for the entire state is approved.

Table 3.1

Subsidy Phase-Out Schedule

Fiscal Year	Operating Assistance	Reduction from 81/82
1981-82	$11,156,100	
1982-83	8,367,075	25% ($ 2,789,025)
1983-84	5,578,050	50% (5,578,050)
1984-85	2,789,025	75% (8,367,075)
1985-86	0	100% (11,156,100)

The systems indicated[2/] are currently the subject of competitive bid proposals solicited by the MDOT to ensure the continuation of essential services over the next five years at minimal cost to the state. While the state appropriations available for continuation assistance on these systems is to decrease by 25 percent per year, there are potential economies and sources of funds yet to be exploited. Beyond economies in operation which may be possible, cost savings can be achieved through system restructure, if necessary. One potential source of funds is local financial participation by shippers and local units of government.

The Upper Peninsula Rail System

Rail service in Michigan's Upper Peninsula is used principally by the mining and forestry industries, including related pulp and paper industries (this discussion from the U.P. Rail Planning Commission, 1982). Service is characterized as light density with dispersed shipping points and low volume of shipments. Furthermore, most U.P. traffic moves north to south, rather than in the east-west direction of the railroads. Consequently, transportation costs are high because freight is often shipped over circuitous routes. This problem particularly affects freight traveling over the Soo Line from the Munising, Marquette, and Keweenaw Peninsula areas. In order to get freight from Marquette, south, the Soo Line ships east to Trout Lake, then west through Gladstone before heading south to Wisconsin.

The following is a brief discussion of the operations of each railroad in the Upper Peninsula and their traffic characteristics.

[2/]Michigan Northern, Kent-Barry-Eaton Connecting Railway, Tuscola and Saginaw Bay Railway, Hillsdale County Railroad, Lenawee County Railroad, Ann Arbor Railroad System, Straits of Mackinaw Car Ferry Service, and two ConRail segments.

Soo Line: The Soo Line operates 514 miles of right-of-way, with a main line running from Sault Ste. Marie to the Wisconsin line via Rapid River and Gladstone. Other lines provide service to points along the Lake Superior shoreline, including the Keweenaw Peninsula; the Chief Wawatam Ferry at St. Ignace; the White Pine Mine in Ontonagon County; and the Ironwood/Bessemer area. These lines provide the only link with the International Bridge at Sault Ste. Marie, and the only direct link with the Lower Peninsula via the Chief Wawatam Ferry at St. Ignace.

Chicago and Northwestern: The C&NW operates primarily north and south in the U.P. and currently maintains 282 miles of right-of-way. This railroad operates the only direct north-south route in the U.P. between Palmer and Escanaba as its main line. It also provides service along the Wisconsin border between Powers and Marenisco and owns and operates the principal ore dock in the U.P.

Escanaba and Lake Superior: The E&LS, in addition to its original line from Wells to Channing, has acquired the bulk of the property abandoned by the Milwaukee Road in the U.P. This property includes lines from Iron Mountain to Channing, Channing to Ontonagon, and Channing to Republic. Additionally, the railroad operates on the old Milwaukee Road Line from Iron Mountain to Green Bay, Wisconsin, where it links with the Milwaukee Road.

Lake Superior and Ishpeming: The LS&I primarily transports iron ore pellets from mines in western Marquette County to the Presque Isle dock in Marquette. This dock serves as a secondary alternative ore handling facility to the C&NW dock at Escanaba. Currently, 67 miles of track are maintained. This includes an island operation between

Munising and Munising Junction, which links the Kimberly Clark paper mill in Munising with the Soo Line at Munising Junction.

Milwaukee Road: While abandoning nearly all of its operations in the U.P., the Milwaukee Road still retains approximately a two-mile spur serving the City of Menominee.

Due to the peninsular geography of the U.P., most rail traffic either originates or terminates in the area. Through traffic (freight transported through the U.P. with origin and termination points outside the U.P.) is primarily transported via the Soo Line from Sault Ste. Marie south through Wisconsin. This traffic consists primarily of lumber and wood products being transported from Canada to various points in the United States. Highest densities of rail traffic occur on the C&NW Line transporting iron ore from the Marquette range to the Escanaba ore docks, the LS&I Lines transporting ore between the Marquette range and the Presque Isle dock, and the Soo Line main line between Sault Ste. Marie and Wisconsin.

Principal outbound commodities shipped by rail are: lumber and wood products; metallic concentrates; pulp, paper, and allied products. Inbound commodities consist of bentonite clay; various chemicals used by the mining, pulp, and paper industries; coal; and propane gas. Some other nonmetallic minerals (such as limestone) are shipped as well. For the most part, these commodities are high bulk and low cost per unit volume; commodities of this type can usually be shipped more profitably by rail than by truck.

As in the case in many areas, the U.P. rail system was built for a greater demand than currently exists. Thus, abandonments have occurred with most of the excess lines being eliminated. In discussing the abandonment process, the U.P. Rail Planning Commission (1982) is concerned with the piecemeal approach where only the line in question is taken into account. What is lacking, according to the Commission, is an examination of how a particular line might fit into a more efficient system. As noted in their draft report, the Commission states:

> Conceivably, some lines which when viewed in isolation appear unprofitable could be utilized in a restructured system that would reduce excessive travel distances and increase traffic densities over the entire system, both now and in the future. Continuation of piecemeal abandonments may well mean elimination of lines that could play a key role in the future growth and development of the Upper Peninsula.

It is the concern with fragmented abandonment and subsidy decisions that this study addresses. As in the case in Michigan's Upper Peninsula, a rail system should be seen from a statewide, or region-wide, perspective in order to arrive at decisions that provide the whole region, and not just pieces of it, with a viable transportation system. Not only must the system be viewed from this broader scope, but economic activity and the future demand for freight transportation must be considered in a comprehensive context as well.

In the next chapter, a method is examined that should provide transportation planners with the wider perspective necessary to make system-wide decisions.

CHAPTER IV

METHOD AND ECONOMIC FRAMEWORK

Framework of Study

The conceptual framework of this study focuses on the structural relationships in the transportation system; the location of freight transportation facilities and services, as well as the location and level of economic activity in the state. To be measured are the results of economic changes and public policy decisions which alter the structure.

Transportation facilities and economic activity are highly interdependent; a structural change in one sector of the economy or transportation system will induce changes in other sectors. Plant location decisions are based, in part, on existing and potential transportation structures, while transportation location decisions must take into consideration existing or potential demand. Investment encourages both the development of transportation systems and economic activity, while disinvestment in either element will hinder the viability of the other (Pratt and Thompson, 1979). Given an interrelationship between the location of economic activity and the transportation system, the consequences of investment-disinvestment decisions in freight transportation policy depend on the industrial structure of the state. Especially important is a knowledge of the specific inputs consumed by each industry. Therefore, determining the volume of commodities that will flow in a given market is the starting point for any quantitative analysis of transportation policy (Chiang and Roberts, 1976).

The method used here is also a structural one. On the one hand, an input-output model represents the economy's structure and predicts the annual usage rate of commodities by industry. Commodity flow data illustrates how these commodities move across the state by rail. In an input-output sense, the model identifies an industry's suppliers and its clients and the input-output relationship to other sectors. On the other hand, since the demand for transportation is a derived demand, it is dependent on the state of the rest of the economy. Thus, structural variables describing economic activity are used to explain the demand for freight transportation. Such a model allows for the investigation of changes in both economic activity and transportation facilities; it is possible to simulate the impact on rail freight demand or variations in the level of the economy (changes in final demand).

The Structure of the Input-Output Model

The model employed in this study is made up of five sectors: (1) producers, who combine intermediate goods and inputs to produce final goods (or inputs to other industries); (2) consumers, who demand final goods (as well as other industries that demand intermediate goods); (3) governments, which also demand final goods; (4) the trading sector, which is a demander of final goods for export and supplies of inputs for import between the state's economy and outside economies; and (5) carriers, who transport both final and intermediate goods spatially between supply and demand points.

In using the input-output method developed by Leontief and expanded by others (Dorfman, Samuelson, and Solow, 1958), the concept is to use a system of accounts that represent the transactions among the sectors of the economy. This determines the interrelationships that exist between sectors of the Michigan economy and the relationship between them and the economic activity outside of the state (Rest of Nation, RON). By using this accounting method, it is possible to demonstrate how outputs in dollars from each producing sector are distributed among other sectors in Michigan and RON. In terms of transportation requirements, the input-output table also shows how (and from whom) each sector procures its inputs (both in Michigan and RON). Input-output models are consistent in that the outputs of each sector must conform with the outputs of all other sectors from whom it buys inputs and sells outputs, and with the total output of the economy. It is then possible to trace the interdependence in the economy and the required flow of goods needed in the input-output process.

Following is a description of the input-output matricies and their analytical use.[1/] The 20-sector, input-output model of Michigan used in this study is reproduced in Appendix 1. Also in Appendix 1 is an example of the use of the model. In Appendix 2, a 44-sector version of the input-output model is included.

To use an input-output table, the first step is the construction of the transactions or interindustry matrix (Appendix 1, Table 1), the structure of which is outlined in Figure 4.1. The three major sectors of this table are the producing sector (X), primary inputs (W), and final demands (Y). The numerical entries are represented as variables, vectors, and matricies, in constant dollar terms:

[1/] This discussion follows the layout example from: Pratt, Smith, and Connor, 1976. The mathematical formulation is from Jones, 1978; and Adiarte and Venegas, 1980.

		Consuming Sectors 1 2 . . . . N	Final Demand Sectors 1 2 . . . . K	Total Output
Producing Sectors	1 2 . . . . N	x_{ij}	y_{ik}	$X_{i.}$
Primary Input Sectors	1 . . M	w_{mj}		w_m
Total Inputs		$X_{.j}$	$Y_{.k}$	

Figure 4.1

Structure of the Intersectoral Transaction Table
(Source: Hwang and Maki, 1979)

where:

N = the number of producing sectors;

K = the number of final demand sectors;

M = the number of primary input sectors;

X_{ij} = the purchase of the output of the i^{th} producing sector by the j^{th} consuming sector for the purpose of producing the output of j^{th} sector, $i = 1, 2, \ldots N$; $j = 1, 2, \ldots N$;

Y_{ik} = the final demand of the sector k for the output from the i^{th} producing sector or primary input class, $i = 1, 2, \ldots N+M$; $k = 1, 2, \ldots K$;

W_{mj} = the purchase of the m^{th} sector of primary input by the j^{th} consuming sector for the purpose of producing the output of the j^{th} sector, $m = 1, 2, \ldots M$; $j = 1, 2, \ldots M$;

X_i = total output of the i^{th} sector, $i = 1, 2, \ldots N$;

X_j = total input of the j^{th} sector, $j = 1, 2, \ldots N$;

Y_i = total final demand for the output of the i^{th} sector, $i = 1, 2, \ldots N+M$;

Y_k = total final demand of the sector k, $k = 1, 2, \ldots K$;

W_j = the purchase of total primary inputs by the j^{th} consuming sector for the purpose of producing the output of the corresponding j^{th} producing sector, $j = 1, 2, \ldots N$.

The interrelationships in the economy expressed in the transactions matrix are as follows:

$$(1) \quad X_i = \sum_{j=1}^{n} X_{ij} + Y_i$$

The sectors of the economy are arrayed horizontally and vertically, in identical order. The purchasing sector is listed horizontally and the selling sector vertically. Thus, the distribution of a sector's product sales is read across its "row" in the matrix and the distribution of a sector's input purchases is read down its "column." The intersection of any column and row represents gross purchases from, or gross sales to the corresponding sector. The transactions matrix quantifies the intersectoral flows in thousands of dollars. The Michigan 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.

Second, it is necessary to obtain the direct requirements or technical coefficients matrix (Appendix 1, Table 2). Derivation of these technical coefficients assumes a linear relationship between purchases of an endogenous sector and the level of output of that sector:

(2) $a_{ij} = X_{ij}/X_j$ = amount of industry i's output necessary to produce one unit of industry j's output;

where:

a_{ij} = technical coefficient;

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

X_j = total output of industry j: X_j is the same as X_i in equation (1), where i=j, corresponding row and column totals in the processing sector are equal.

Technical coefficients are computed for each industry in the processing sector, yielding the following matrix:

$$A = \begin{bmatrix} a_{11} & a_{12} & \cdots\cdots\cdots & a_{1n} \\ a_{21} & a_{22} & \cdots\cdots\cdots & a_{2n} \\ & \cdot & & \\ & \cdot & & \\ & \cdot & & \\ a_{n1} & a_{n2} & \cdots\cdots\cdots & a_{nn} \end{bmatrix}$$

Where there are n sectors in the processing sectors, (A) represents the complete matrix of technical coefficients. The technical coefficients are found by dividing each column entry for the processing sectors by the corresponding column total for the sector. 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).

Third, the Leontief matrix (Appendix 1, Table 3) is found by subtracting the coefficients matrix for the processing sectors (A) from an identity matrix of the order (I-A). Each element of the coefficients matrix at the intersection of an identical horizontal and vertical sector is subtracted from one. The other elements are subtracted from zero. The coefficients matrix identifies the direct purchases that a sector must make to deliver one dollar of output to final demand. Yet, the sales of one dollar of output to final demand by one sector, require the other sectors that supply it with inputs to increase their output by more than the direct amount. Inverting the Leontief matrix produces the inverse matrix (Appendix 1, Table 4), commonly called the interdependency coefficient matrix. These coefficients yield a table of direct, indirect, and induced requirements per dollar of final demand. The coefficients are obtained from the matrix:

$$(I-A)^{-1} = \begin{bmatrix} A_{11} & A_{12} & \cdots\cdots\cdots & A_{1n} \\ A_{21} & A_{22} & \cdots\cdots\cdots & A_{2n} \\ \vdots & & & \\ A_{n1} & A_{n2} & \cdots\cdots\cdots & A_{nn} \end{bmatrix}$$

Determining the interindustry transactions or production over all sectors required to sustain a given level of final demand represents the input-output problem, solved as:

$$(3) \quad X = (I-A)^{-1} Y$$

where:

X = total output vector of economy;

Y = final demand vector facing economy;

$(I-A)^{-1}$ = matrix of interdependency coefficients.

The sum of each sector in the inverse matrix is an output multiplier. These column sums, or output multipliers, show the direct, indirect, and when the household sector is endogenous, the 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.

Assumptions of Input-Output

(1) Constant Production Coefficients for each sector: This assumption implies that the input structure of a sector remains fixed; the physical inputs for economic sectors change in the same proportion as output. From this assumption, four other relationships follow:

(a) There is no technological change which alters factor-factor or factor-product relationships. Where a relatively stable economy exists, the constant technology assumption is not a large problem. When an economy undergoes large economic changes, the input-output model can be modified, the direct requirements may be adjusted converting the model from "static" to "comparative static" (Diamond and Chappelle, 1981).

(b) Sectors cannot substitute inputs from one sector for inputs from another. This fixed rate of substitution assumption implies that relative use levels of resources do not change over time.

(c) There are no scale or size economies of production.

(d) The relative prices of all goods and services remain constant.

(2) Homogeneity of Sectors: Each sector produces only one product, with one process. It is obvious that firms in sectors have diverse input and output structures. Yet, it is not feasible to attempt a model that would incorporate all of these differences. This assumption is essentially an aggregation problem, endemic in economic analysis. There are no set rules for aggregating firms into individual sectors. The aggregation of any input-output model depends mostly on the region to be studied and the uses of the input-output model itself. The homogeneity assumption is most harmful when attempting to extend the input-output model to uses outside of its accounting framework.

In building an input-output table, most firms are grouped in sectors based on a similarity of product type and production process. This normally follows the classification of firms by Standard Industrial Classification codes. The best basis for aggregation is similarity of input structure (Chenery and Clark, 1959).

(3) Additivity and Divisibility: The outputs of each sector are assumed to be additive in that the total effect of several production activities is the sum of their separate effects (Pratt, Smith, and Conner, 1976). The output of a combination of sectors is the sum of their inputs, regardless of the combination of outputs. The direct requirements coefficients represent the only interaction between productive activities. It is also assumed that inputs are available to produce the outputs required to meet final demands.

As is the case in many forms of model building, any sector is assumed to be divisible. Sectors are assumed able, within the model, to produce a fraction of a unit of production. However, the aggregation of total output in most input-output models is large enough to minimize any departure from reality imposed by this assumption (Pratt, Smith, and Conner, 1976).

These three assumptions do not negate the usefulness of input-output analysis. However, the researcher must be aware of the limitations implied when interpreting the results.

Construction of the 20-Sector Michigan Input-Output Model

The structure of the Michigan input-output table is derived from the work of Hwang and Maki (1979). The procedure that Hwang and Maki applied to Minnesota was used to build the Michigan model by Adiarte and Venegas (1980) for the Michigan Energy Administration. (The following discussion on the building of the two-region, input-output table for Michigan is taken from these two reports.)

The procedure begins by estimating gross output for each industry sector to serve as controls for the rows and columns of the transactions table. Data on value added, personal income, taxes, etc., are

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used to fill in several cells of the table. Next, the gross outputs are distributed among all sectors using a secondary data approach. The table is then rebalanced with respect to row and column totals and the validity of the model is checked against other estimates of gross state product, personal income, employment, etc.

After the row and column totals of the transactions table are estimated, the cells representing intersectoral flows are estimated using a secondary data approach. The secondary data on industrial outputs, value added, demand components of gross state product, etc., were compiled from the U.S. Department of Commerce's Census reports and statistical publications of various state agencies. This approach builds a transactions table based on national coefficients and makes adjustments according to the existing industry mix and other differences of Michigan relative to the national average. In order to alter national coefficients for Michigan conditions, a commodity balance approach is used (Adiarte and Venegas). This approach compares industry gross output with estimated purchases using technical coefficients at the national level, and adjusts these proportionally whenever total purchases from an industry exceed the gross output of that industry. Schaffer and Chu report that comparisons with survey results show that the coefficients obtained in this manner are larger, but not statistically different, than those obtained using survey data. Finally, Adiarte and Venegas compared control totals in Michigan based on primary data, with the coefficients derived for Michigan from the national model and concluded that the derived coefficients lend confidence to the adequacy of the model for impact analysis.

Two-Region Model

In order to produce a two-region model, the national input-output table was split into two regions, Michigan and the Rest-of-Nation (RON). 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. In doing this, three additional assumptions were necessary: (1) the input structure at the national level prevails at the state level; (2) surplus output in Michigan becomes an export to RON, while deficit output in Michigan becomes an import from RON; and (3) cross-hauling of a similar product between the regions is indicated only as a net flow (Adiarte and Venegas).

The two-region procedure begins with the national transactions table, in the form of Figure 4.1. The technical and interdependence coefficients are found as described earlier. Thus, as Hwang and Maki note, the following relationships are true by the previous definitions:

$$Y_i = \sum_{k=1}^{k} Y_{ik} \quad \text{where } i = 1, 2, \ldots N+M;$$

$$W_j = \sum_{m=1}^{m} W_{mj} \quad \text{where } j = 1, 2, \ldots N.$$

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And since it is assumed that the total output of a sector is equal to the total input of the corresponding sector, the following relationships exist:

$$X_i = X_j \quad \text{when } i=j \quad \text{when } X_i = \sum_{j=1}^{n} X_{ij} + Y_i$$

$$X_j = \sum_{i=1}^{n} X_{ij} + W_j$$

When the national table is disaggregated into two regions, the result is four quadrants for each sector, primary inputs, and final demand components, as shown in Figure 4.2. The quadrants are product flows defined for: (1) first quadrant of intraregional intersector of transactions for Michigan; (2) second quadrant of interregional intersector of transactions from Michigan to RON; (3) third quadrant of interregional intersector of transactions for RON; and (4) fourth quadrant of the intraregional intersector of transactions for RON. The interregional flows assume the surplus of the region to be an export to the other, while a deficit is an import from the other region. National coefficients are used initially for both Michigan and RON, in which linear adjustments are made for estimated surpluses or deficits. The method for doing this is similar to the commodity balance approach, except for the simultaneous adjustments in the coefficients of both tables. In Figure 4.2, a single superscript indicates a particular region, and a double superscript indicates the source of flow by the first letter and the destination of flow by the second letter.

The first step in compiling the two-region transactions tables is to estimate the total consumption of a sector's output by all the consuming sectors and final demand sectors in a region. This is derived by:

REGION "p"		REGION "q"		Total
	Final Demands	Consuming	Final Demands	

			REGION "p"		REGION "q"		
			Consuming Sectors 1 2 . . . . N	Final Demands 1 2 . . . . . . K	Consuming Sectors 1 2 . . . . N	Final Demands 1 2 . . . . . . K	Total Output
REGION "p"	Producing Sectors	1 2 . . . . . . N	x^{pp}_{ij} (1st quadrant)	y^{pp}_{ik} (1st quadrant)	x^{pq}_{ij} (2nd quadrant)	y^{pq}_{ik} (2nd quadrant)	$x^{p}_{i.}$
	Primary Input Sectors	1 . . M	w^{pp}_{mj} (1st quadrant)		w^{pq}_{mj} (2nd quadrant)		
REGION "q"	Producing Sectors	1 2 . . . . . . N	x^{qp}_{ij} (3rd quadrant)	y^{qp}_{ik} (3rd quadrant)	x^{qq}_{ij} (4th quadrant)	y^{qq}_{ik} (4th quadrant)	$x^{q}_{i.}$
	Primary Input Sectors	1 . . M	w^{qp}_{mj} (3rd quadrant)		w^{qq}_{mj} (4th quadrant)		
Total Input			$X^{p}_{.j}$	$Y^{p}_{.k}$	$X^{q}_{.j}$	$Y^{q}_{.k}$	

Figure 4.2

Structure of the Interregional Intersectoral Transaction Table of the Two-Region Input-Output Model
(Source: Hwang and Maki, 1979)

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$$\overset{*}{X}{}_i^p = \sum_{j=1}^{n} a_{ij} X_j^p + \sum_{k=1}^{k} a_{ik} Y_k{}^p$$

$$\overset{*}{X}{}_i^q = \sum_{j=1}^{n} a_{ij} X_j^q + \sum_{k=1}^{k} a_{ik} Y_k^q$$

when $i = 1, 2, \ldots N+M$.

Secondly, the quantity of the surplus or deficit of a producing sector of the region is found. The surplus or deficit is the amount of the difference between the total output and the total consumption of the same producing sector. If a surplus exists for a sector in region p, then this amount is allocated proportionally to the subsectors of the corresponding consuming sector of region q. If the difference between total output and total consumption is zero, then there is no interregional flow of the output for that sector. This procedure produces technical coefficients of each region different from the national averages, and more appropriate to a particular region.

The allocation of the surpluses or deficits among industries in the two regions fills out each cell of the expanded matrix of Figure 4.2. Balanced regional tables are thus produced by constructing the import and export sectors. For the Michigan table, the sum of the second quadrant from each producing sector row represents total exports, while the sum of the third quadrant for each producing sector column estimates imports. The same is true for RON, except that the column sum of the second quadrant represents imports, while the row sums are exports.

A balanced table for Michigan and RON is organized with the first quadrant representing the interindustry transactions in Michigan and the fourth representing the interindustry transactions in the RON.

The consolidation of the second and third quadrants generates imports and exports by industry in each region. Finally, Adiarte and Venegas ran the two-region model to generate the single Michigan input-output tables. The 44-sector input-output table for 1976 in Appendix 2 represents the table produced at Minnesota for Michigan. The 20-sector table is an aggregation of the 44-sector model.

Data, Updating, and Aggregation of the Michigan Input-Output Model

The procedure described above began with the 367 sector, 1967 input-output model of the national economy, produced by the Bureau of Economic Analysis (BEA), U.S. Department of Commerce. The national model was updated by the BEA to 1970. This 367-sector model was first aggregated into 53 sectors and data for Michigan was assembled from U.S. census sources as well as Michigan specific data from the Michigan Statistical Abstracts. Michigan data was that of gross outputs for each of the 53 sectors and total expenditures of each final demand sector.

The Minnesota Energy Agency repeated the estimation procedures for a 1972 model. The updating was done by recalculating gross outputs and final demands and balancing the transactions table. Estimates of value added, gross state product, and other aggregate variables were verified during this updating process. The model was reaggregated to 47 sectors and combined with 1972 estimates of final demands and the 1972 update of the national input-output table. The estimated gross outputs were used to rerun the two-region model. The same procedure was used to update the input-output table to 1976. The sectors were further reduced to 44 industry groups, by combining pipelines with gas utilities, and commercial service sectors into selected services. Table 4.1 shows the 1976, 44-sector aggregation; this aggregation is reflected in the 44-sector model of Appendix 2.

When linked to transportation data, the 1976 model was aggregated to 20 sectors, as shown in Table 4.2. This was done to better match the mix of commodity groups moving over Michigan's rail system to the input-output sectors. Additionally, this aggregation was 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, producing the 20-sector model.

Output Multipliers and Projection of Total Output

The use of an input-output model allows for the calculation of output multipliers; the main benefit being that they are disaggregated. Aggregate multipliers, used in macroeconomic analysis, do not distinguish between the sectors in which expenditure changes begin. Input-output multipliers, on the other hand, are valuable in that they account for the fact that the total impact of changes in the economy on output will vary according to which sectors experience the initial expenditure change (Richardson, 1972).

Output multipliers represent total requirements per unit of final output. These multipliers serve as an indication of the degree of structural interdependence between each sector and the rest of the economy. The higher the multiplier, the greater the interdependence of the sector with the rest of the economy. Output multipliers measure the total value of industry requirements per unit of final demand for each industry (Richardson, 1972). As Leontief (1941) points out, the

Table 4.1

Sectors Defined by SIC, 1976 I/O Table for Michigan

Sector	Industry	Industry Number 1967 I/O	1972 SIC Code
1	Livestock and Products	1	02
2	Other Agriculture, Forestry Services	2, 3, 4	01, 07, 08
3	Metals and Minerals	5, 6, 9, 10	10, 11, 12, 14
4	Crude Petroleum, Natural Gas	8	1311, 1321
5	Construction	11, 12	part 138, 15, 16, 17
6	Meat Products	14.01	201
7	Dairy Products	14.02 - 14.06	202
8	Preserved Food	14.07 - 14.13	203
9	Grains, Bakery, Sugar, Fats	14.14-14.20, 14.24-14.32	204-207, 209
10	Beverages	14.21-14.23	208
11	Textile, Apparel	16-19	22, 23
12	Lumber, Wood	20, 21	24
13	Furniture	22, 23	25
14	Paper and Allied Products	24, 25	26
15	Printing and Publishing	26	27
16	Chemicals and Allied	27, 29.02, 29.03, 30.00	28 excluding 282, 283
17	Plastics and Synthetic	28	282
18	Drugs	29.01	283
19	Petroleum Refinery	31	29
20	Rubber and Leather Products	32-34	30, 31
21	Stone, Clay, Glass	35, 36	32
22	Foundries and Metal Products	37.02-37.04, 38	332-336, 339
23	Blast Furnace, Basic Steel	37.01	331
24	Metal Containers, Heating, Plumbing, Fabricated Metals	39.01, 40	3411, 343, 344
25	Screw Machine Products	41.01	345
26	Metal Stampings	41.02	346
27	Other Fabricated Metal	39.02, 42	342, 347-349
28	Engines and Turbines	43	3511, 3519
29	Farm and Construction Machinery	44-46	3523-353
30	Metal Working Machinery	47	354
31	Industrial and Service Machinery	48-50, 52	355, 356, 358, 359
32	Office and Computing Machines	51	357
33	Electrical Equipment	53-58	36
34	Trucks, Trailers, Motor Vehicles	59	371

Table 4.1 (cont.)

Sector	Industry	Industry Number 1967 I/O	1972 SIC Code
35	Aircraft and Parts, Other Trans.	60, 61	372-379
36	Miscellaneous Manufacturing	62-64	38, 39
37	Transportation, Communication	65-67	40-48
38	Electric Utilities	68.01	491, part 493
39	Gas Utilities	68.02	492, part 493
40	Water and Sanitary Services	68.03	494-497, part 493
41	Wholesale and Retail Trade	69	50, 52-59
42	Finance, Insurance, Real Estate	70-71	60-67
43	Services	72-77	70-89
44	Government Enterprises	78-79	

Table 4.2

1976, 20-Sector Input-Output Classification

Sector	Industry	Sector Number from 44-Sector I/O
1	Livestock and Products	1
2	Other Agricultural Products	2
3	Mining	3, 4
4	Construction	5
5	Food and Kindred Products	6-10
6	Lumber, Furniture, Paper, Printing	12-15
7	Chemicals, Drugs, Plastics	16-18
8	Petroleum Refinery	19
9	Rubber, Leather, Stone, Glass, Clay	20, 21
10	Primary and Fabricated Metals	22-27
11	Machinery, Except Electrical	28-32
12	Electrical Equipment	33
13	Motor Vehicles and Parts	34
14	Aircraft and Other Transportation Equipment	35
15	Transportation and Communication	37
16	Utilities	38-40
17	Wholesale, Retail, Miscellaneous Manufacturing, Including Textiles	11, 36, 41
18	Financial, Insurance, Real Estate	42
19	Selected Services	43
20	Government Enterprises	44

concept of final demand has as its counterpoint the concept of intermediate demand or output, while total output embraces both. The final demand for a commodity represents that part of total output which is treated as an independent variable. The derived or intermediate demand is considered to be a dependent variable.

The purpose of using 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.

The effect of the change on individual sectors of the economy, given a change in the final demand in one sector, can be evaluated. The total output multipliers produced by the inverse matrix and shown in Table 4.3 provide estimates of the total economic effects of a change in each sector. It is also possible to examine how the effect of a change in the final demand in one sector affects individual sectors in the economy. This is done by multiplying the sectors column of the inverse matrix by the change in final demand, as is done for the livestock and products sector in Table 4.4. Table 4.4 shows the impact of a $1,687,000 increase in final demand in the livestock and products sector (equivalent to the 1976-1980 change that will be discussed in Chapter V). Each product of the multiplication of $1,697,000 with the output multipliers for livestock and products indicates the effect of that change

Table 4.3

Output Multipliers Derived from the Michigan 20-Sector Input-Output Model

Sector	Industry	Output Multiplier
1	Livestock and Products	1.69
2	Other Agricultural Products	1.48
3	Mining	1.51
4	Construction	1.66
5	Food and Kindred Products	1.61
6	Lumber, Furniture, Paper, Printing	1.55
7	Chemicals, Drugs, Plastics	1.56
8	Petroleum Refinery	1.49
9	Rubber, Leather, Stone, Glass, Clay	1.52
10	Primary and Fabricated Metals	1.66
11	Machinery, Except Electrical	1.56
12	Electrical Equipment	1.48
13	Motor Vehicles and Parts	2.02
14	Aircraft and Other Transportation Equipment	1.55
15	Transportation and Communication	1.29
16	Utilities	1.52
17	Wholesale, Retail, Miscellaneous Manufacturing, Including Textiles	1.28
18	Financial, Insurance, Real Estate	1.32
19	Selected Services	1.39
20	Government Enterprises	1.47

Table 4.4

Effect of a $1,697,000 Change in the Final Demand of Livestock and Products on the Entire Economy

Sector	Industry	$(I-A)^{-1}$ Elements in Livestock and Products Sector	Change in Output
1	Livestock and Products	1.13273844	$1,922,257
2	Other Agricultural Products	0.19944936	338,466
3	Mining	0.00229381	3,893
4	Construction	0.01317304	22,355
5	Food and Kindred Products	0.12047448	204,445
6	Lumber, Furniture, Paper, Printing	0.01175515	19,948
7	Chemicals, Drugs, Plastics	0.02081888	35,330
8	Petroleum Refinery	0.00510590	8,665
9	Rubber, Leather, Stone, Glass, Clay	0.00705966	11,980
10	Primary and Fabricated Metals	0.01260634	21,393
11	Machinery, Except Electrical	0.00519639	8,818
12	Electrical Equipment	0.00118786	2,016
13	Motor Vehicles and Parts	0.00148287	2,516
14	Aircraft and Other Transportation Equipment	0.00017908	304
15	Transportation and Communication	0.02254404	38,257
16	Utilities	0.00973669	16,523
17	Wholesale, Retail, Miscellaneous Manufacturing, Including Textiles	0.05078442	86,181
18	Financial, Insurance, Real Estate	0.03286972	55,780
19	Selected Services	0.03713335	63,015
20	Government Enterprises	0.00198564	3,370
	Total	1.68857513	$2,865,512

in final demand on the rest of the sectors in the economy. The sum of these individual sector output changes will equal the total change found originally by multiplying the total sector output multiplier (here, 1.68857513) by the change in final demand. However, the disaggregation that is possible allows for an accounting of the sector-by-sector changes necessary to forecast rail traffic demand (Jones, 1978).

The results of such a process across all sectors is shown in Table 4.5. The figures under "final demands" are those estimated as part of the original process of constructing the 1976 input-output table for Michigan. When each sector's final demands are multiplied by the individual sector Leontief inverse elements, and then summed, the input-output model projects total output as shown in the column labeled "output." Table 4.5 represents the base from which the rest of this analysis proceeds. The forecasting procedure begins by estimating new final demands by sector for a year subsequent to 1976, and repeating the process outlined above to achieve total output projections. These projections will then be compared with the 1976 total output figures to forecast the change in total output.

Linking the Input-Output Table to Commodity Flow Data

In order to forecast rail traffic using the input-output model, it must be linked to data on commodity flows over the Michigan rail network. This is done by linking the 20 input-output sectors to data from rail waybill samples.

Transportation data has been compiled from a sample of audited revenue waybills (the rate of freight charges have been verified in the railroad accounting offices) submitted to the Federal Railroad

Table 4.5

1976 Final Demands and Total Outputs Derived from the Michigan Input-Output Model (Thousands of 1976 Dollars)

Sector	Industry	Final Demands	Output
1	Livestock and Products	13,766	691,909
2	Other Agricultural Products	210,555	709,533
3	Mining	926,488	1,742,344
4	Construction	4,302,101	5,837,164
5	Food and Kindred Products	4,335,922	4,869,530
6	Lumber, Furniture, Paper, Printing	2,111,828	5,095,917
7	Chemicals, Drugs, Plastics	3,416,858	5,472,216
8	Petroleum Refinery	568,180	928,370
9	Rubber, Leather, Stone, Glass, Clay	675,244	2,893,848
10	Primary and Fabricated Metals	3,576,180	14,666,321
11	Machinery, Except Electrical	2,909,304	6,661,440
12	Electrical Equipment	527,190	1,573,330
13	Motor Vehicles and Parts	28,679,640	39,769,180
14	Aircraft and Other Transportation Equipment	496,338	623,222
15	Transportation and Communication	5,382,394	7,262,402
16	Utilities	2,086,750	4,217,498
17	Wholesale, Retail, Miscellaneous Manufacturing, Including Textiles	14,185,652	17,880,538
18	Financial, Insurance, Real Estate	7,667,766	10,435,098
19	Selected Services	6,869,168	12,230,830
20	Government Enterprises	375,938	1,081,181
	Total		144,641,871

Administration (FRA) by railroads under the terms of the Interstate Commerce Commission Order 49 CFR, Section 1244. Other documents used to compile the transportation data include EM-5 reports and multiple-car statements.

Waybills are a shipping document prepared by the originating railroad from the shipper's instruction as to the disposition of freight and used by the railroads as the authority to move the shipment and as the basis for determining and settling the freight charges among the carriers involved. The waybills in the sample used are for carloads terminated by line-haul or regular rail-haul as distinguished from a switching move or switching company. As used here, a regular haul is between terminals and stations on the main or branch lines of the railroad, exclusive of switching moves. The sample also includes only those lines having $3 million or more average operating revenues over a three-year period (U.S. Department of Transportation, FRA, 1980).

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

Most waybills represent one-car shipments. Some represent multi-car shipments that vary from two to upwards of 100 cars. A sampling technique for these shipments was developed by the ICC and used by a number of reporting railroads. This technique, EM-5 sampling, provides for the selection and reporting of EM-5 forms, of data for every 100th car from waybills covering six or more carloads. Finally, some of the reporting railroads submitted multiple-car statements listing total carload movements between specific points for certain commodities such as coal, iron ore, copper ore, pulpwood logs, iron and steel scraps, and iron and steel plates. These statements are sampled by FRA with a computerized algorithm to approximate the EM-5 process (U.S. Department of Transportation, FRA, 1980).

Some types of movements are excluded from the waybill data, including:

(1) Canadian and Mexican originations.

(2) Mail and express traffic.

(3) Less than carload traffic.

(4) Shipments weighing less than 10,000 pounds and moving on "any-quantity" rates.

(5) Nonrevenue movements.

(6) "Dead-head" traffic (company material whose movement is entirely on one road).

(7) Empty cars returned for reloading.

(8) Movements in substitute services, e.g., truck in lieu of rail.

The data received from the railroad industry is processed by the Waybill Information Processing System, which combines manual and computer procedures to ensure that resultant tabulated data are accurate and statistically valid. The accuracy and validity of carload data for each commodity grouping is verified by use of regression analysis techniques. The waybill data is classified by commodity using the seven-digit STCC code, which is based on the SIC code.

The first step in using input-output to forecast rail traffic is to link the input-output sectors based on SIC codes to waybill samples, based on STCC codes. Table 4.6 shows the STCC categories in each of the 20 input-output sectors. After the input-output and waybill samples are linked, the 1 percent waybills are expanded, by multiplying by 100, to obtain an estimate of total rail traffic in Michigan. Table 4.7 shows the expanded waybill sample for Michigan for the years 1976 and 1980.

The Use of Input-Output for Transportation Planning

The assumptions of input-output stress the consistency of the economy; the outputs of all sectors must be consistent with all the other sectors from whom it buys inputs and to whom it sells outputs. This feature of input-output analysis emphasizes the interdependence of the sectors of the economy. The value of the output of final goods and services can be traced back through the intermediate flows of goods and services necessary to produce final demand. This flow of goods and services for both intermediate and final demand must move in space from sector to sector and firm to firm.

It is important that the assumption of consistency in the input-output model be met in the transportation model. Corresponding to each dollar flow between sectors in the input-output model, originating and receiving sectors can be identified showing the type of product that is being physically moved.

The initial assumption is that economic activity in a sector generates physical movements of products in each of the sector's inputs, in proportion to the change in the sector's output. The input-output

Table 4.6

STCC Codes in Each Input-Output Sector

Sector	Industry	STCC Code Contained in I/O Sector
1	Livestock and Products	014, 015
2	Other Agricultural Products	011, 012, 013, 019, 084, 086, 091
3	Mining	10, 14, 111, 112, 122
4	Construction	
5	Food and Kindred Products	201, 202, 2032-2035, 2037-2039, 204-209
6	Lumber, Furniture, Paper, Printing	24-27
7	Chemicals, Drugs, Plastics	281, 284-286, 289, 282, 283, 287
8	Petroleum Refinery	29
9	Rubber, Leather, Stone, Glass, Clay	30-32
10	Primary and Fabricated Metals	332, 333, 335, 336, 339, 331, 3431, 3432, 34331, 34333-34336, 34339, 344-346, 341, 342, 348, 349, 191, 192, 196
11	Machinery, Except Electrical	351-359, 34332
12	Electrical Equipment	36
13	Motor Vehicles and Parts	371
14	Aircraft and Other Transportation Equipment	372-376, 379, 193
15	Transportation and Communication	
16	Utilities	
17	Wholesale, Retail, Miscellaneous Manufacturing, Including Textiles	22, 23, 38, 39, 211, 212, 401, 402, 441, 412, 421, 422, 431, 441, 451, 461, 462, 471
18	Financial, Insurance, Real Estate	
19	Selected Services	
20	Government Enterprises	

Table 4.7

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

model of Michigan will be linked with commodity flow data to determine how movements of inputs flow on the state's rail network. By changing the final demands in the 1976 input-output model to reflect subsequent years, such as 1980, it is possible to estimate changes in the total output of the 20 sectors. With these changes, it is then possible to forecast changes in rail traffic due to the change in commodity production and the demand for the movement of these commodities. This procedure was outlined in Chapter I and will be tested in Chapter V.

CHAPTER V

TESTING THE USE OF INPUT-OUTPUT FOR RAIL TRAFFIC FORECASTING

The procedure used to test the forecasting ability of the input-output model is summarized in Figure 5.1. 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.

Estimating 1980 Final Demands

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

(1) Personal Consumption Expenditures.

(2) Gross Private Capital Formation.

(3) Net Inventory Changes.

(4) Net Exports.

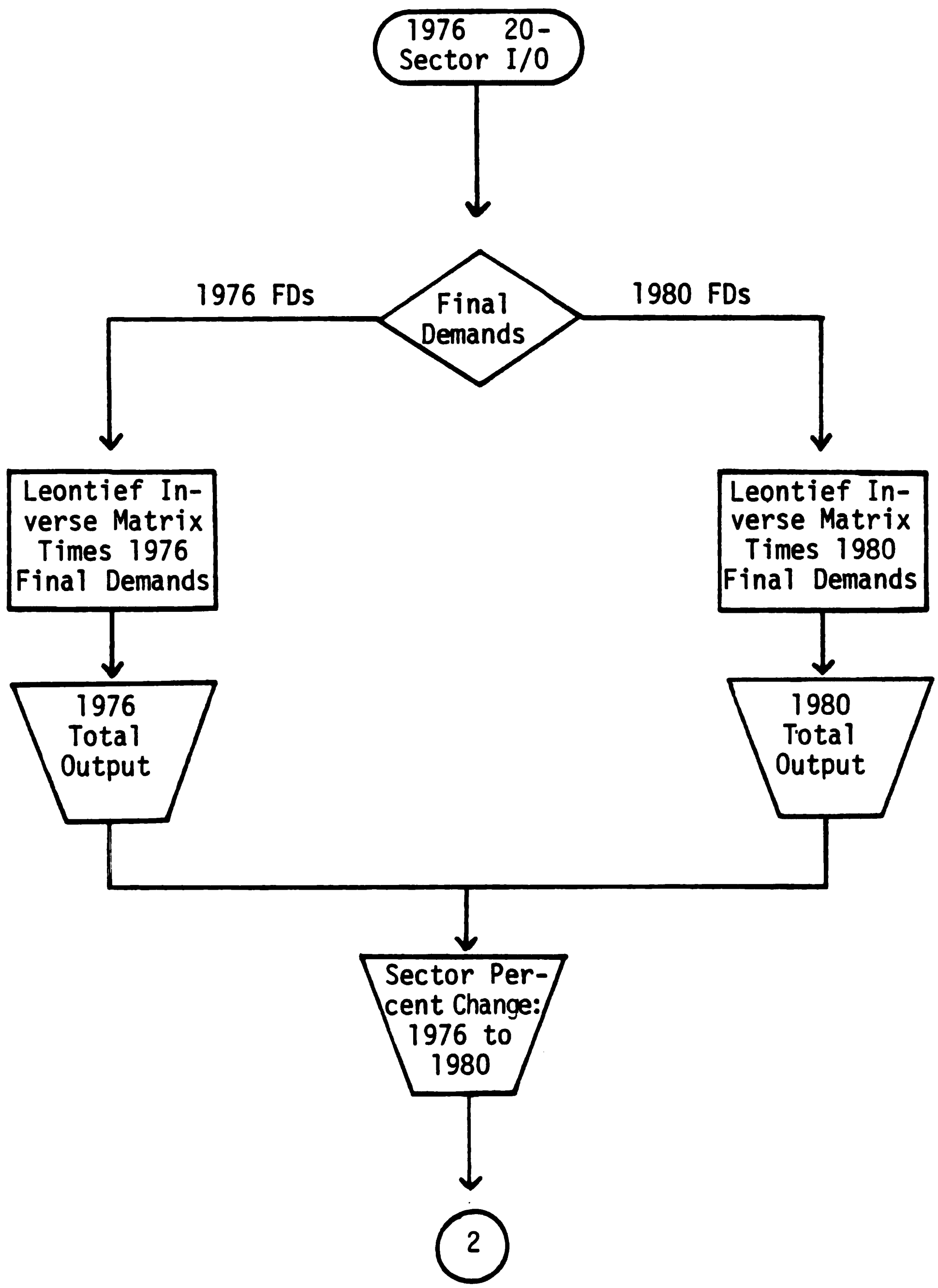
(5) State and Local Government.

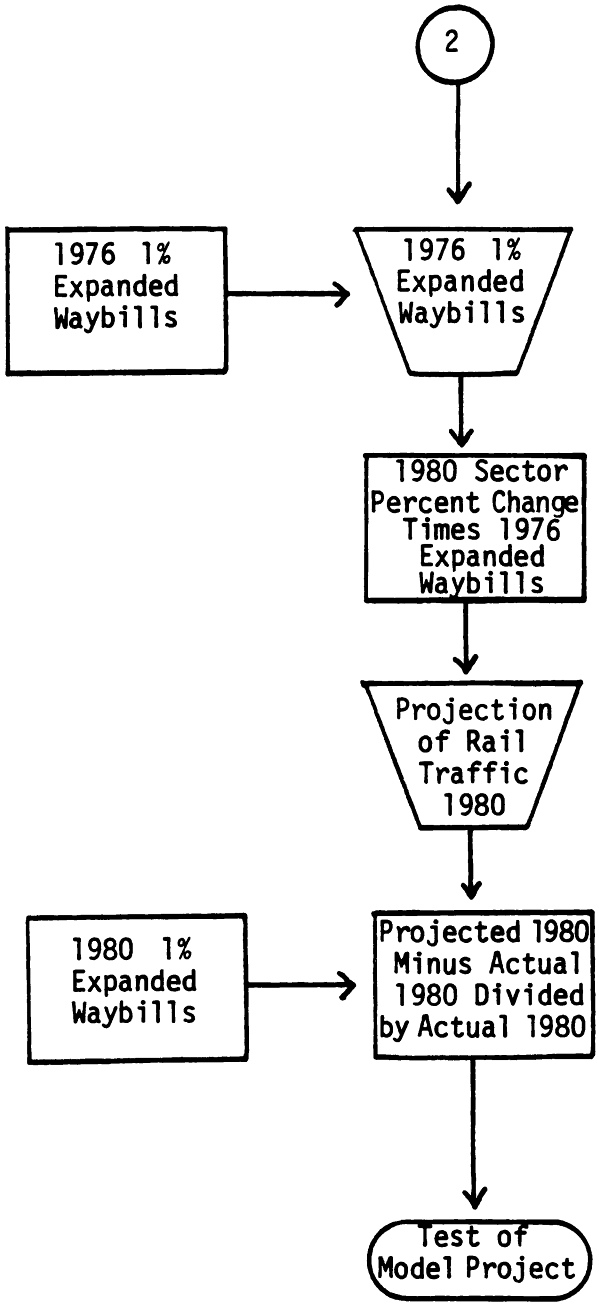
(6) Federal Government.

All 1980 final demands are in 1976 dollars, deflated by implicit price deflators for gross national product indexes, found in the 1981 Economic

Figure 5.1

Flow Diagram of Rail
Traffic Forecasting Test




2
1976 1% Expanded Waybills
1976 1% Expanded Waybills
1980 Sector Percent Change Times 1976 Expanded Waybills
Projection of Rail Traffic 1980
1980 1% Expanded Waybills
Projected 1980 Minus Actual 1980 Divided by Actual 1980
Test of Model Project

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 on 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 nonretail) 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 was acquired from the Office of Revenue and Taxes, Department of Management and Budget. The data is 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 represents a value added tax on investment. Not all investors in Michigan file the Single Business Tax; for example, nonprofit 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 was deflated to 1976 dollars by the export index in the implicit GNP deflator.

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 veteran's benefits and services. These categories are included in the government enterprises sector. Data is from the 1980 Michigan Statistical Abstract, deflated by the federal government index of the 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 was obtained from the study by Scheppach in State Projections of the Gross National Product, 1970, 1980.

Once the two sets of final demands are estimated, the following steps represent the testing procedure:

(1) 1980 final demands are multiplied by the Leontief Inverse Matrix of the 20-sector, input-output model to obtain 1980 estimates of total outputs. These total outputs are also calculated in terms of the percentage change from 1976.

(2) These 1980 total output estimates are then used to obtain projections, by sector, of 1980 rail traffic in Michigan. The sector percentage changes in total output are multiplied by the 1976, 1 percent expanded waybills. The results are 1980 rail projections.

(3) The 1980 rail projections are then compared to the actual 1 percent expanded waybills for 1980, yielding both the difference in total tons and the percentage difference between the actual total movement of rail traffic in Michigan and the projections of rail traffic.

Testing the Rail Traffic Forecasting 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 5.1, which indicates the projected total output in Michigan for 1980, given the estimated final demands. Table 5.1 also shows the percentage change in total output from 1976 to 1980.

In constant dollar terms, Table 5.1 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 5.1 that rail traffic for 1980 is projected.

The actual expanded 1 percent waybills for 1976 and 1980 are shown in Table 5.2. 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

Table 5.1

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 5.2

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

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 5.3.

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 5.3 shows this comparison. The projected total rail flow in Michigan for 1980 is 67,099,985 tons. The actual rail 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. The same procedure was carried out for the 44-sector input-output model and is shown in Appendix 2.

Table 5.3 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

Table 5.3

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

be predicted accurately. In Table 5.3, 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.

Only two sectors--number 10, primary and fabricated metals, and number 11, machinery (except electrical)--produced estimates substantially different than actual figures, on a percentage basis. In the machinery sector, while the percent difference between the projection and actual rail traffic is 54.75 percent, the actual tonnage difference is only 60,996 tons. This absolute tonnage difference is not large compared to total traffic, representing only 0.09 percent of total traffic. The large percentage difference can be explained by looking at the individual industries that make up these two aggregate sectors. The primary and fabricated metals sector in the 20-sector, input-output model is the aggregation of six of the sectors in the 44-sector model (see Appendix 2): foundries and metal products; blast furnace; basic steel; metal containers, heating, plumbing, fabricated metals; screw machine products; metal stamping; and other fabricated metals. Of these industries, large differences between actual and projected rail flows occur in three: metal containers, etc.; screw machine products; and metal stamping. The actual traffic in 1980 for metal containers was 6,400 tons, while the 1980 projection was 90,883, or 1,320 percent higher. In the other two sectors the actual traffic was zero, down from 1976. What occurred in these three industries between 1976 and 1980 was an extremely large drop in rail traffic--to zero in two cases--that was not predicted by the input-output model. In these industries, rail traffic dropped much more than the estimated total output for the sectors. The problem appears to be in the waybill sample. Small absolute totals of rail traffic are less likely to be accurately reflected in the 1 percent sample. While this presents problems to decision makers in a few cases, the 1 percent waybill data is the best available to rail planners and must be used in lieu of more complete rail information.

While the input-output model can predict rail flows in industries that exist on the lines between 1976 and 1980, it is unable to forecast traffic from some level to zero. However, this degree of change would be difficult to predict with any rail traffic model and it is not felt that the example of these sectors invalidates the usefulness of the model.

A similar problem occurs in the machinery sector. Sector 11 is made up of the following industries: engines and turbines; farm and construction machinery; metal working machinery; industrial and service machinery; and office and computing machines. Two of the industries show the largest change, engines and turbines and industrial service machinery (see Appendix 2). In the case of engines and turbines, rail traffic in 1976 was zero; so the projection was zero. However, between 1976 and 1980, engines and turbine traffic again appeared in the waybill sample. In the industrial and service machinery sector, traffic dropped dramatically between 1976 and 1980, much more than the projected total output. Again, it is felt that these cases are such that no model could predict such changes. 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 values 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.

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, 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.

Conclusions

The purpose of this chapter has been to test a method that systematically links the projected level of statewide economic activity with the demand for rail freight transportation services and facilities. The goal is to broaden the perspective of decision makers to include a more comprehensive and systematic method of forecasting rail traffic in Michigan.

The test was whether the 20-sector, input-output model of Michigan could provide reliable estimates of rail traffic over a four-year period. The test was 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 demand for rail services in a region, or on individual lines, depends 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 flows. 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 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 difficulty projecting. However, the method suggested in this study is not meant to be used in isolation from other information available to rail planners. Thus, it is believed that this model can be of value, along with additional data, in aiding decision makers in forecasting rail 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 chapter 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 chapter represents a guide to the use of the input-output model for future rail planning decisions.

CHAPTER VI

APPLYING THE RAIL FORECASTING METHOD TO REGIONAL RAIL PLANNING

In this chapter, an illustration will be presented demonstrating how the rail traffic forecasting method tested previously can be employed to aid in the subsidy-abandonment decision. 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[1/] as part of the rail rationalization process. The application of the rail traffic forecasting method will be accomplished in the following steps:

(1) A description of the Upper Peninsula rail system will be presented with particular emphasis on those rail lines facing financial difficulties.

(2) 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

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[1/] The material for this chapter 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.

1986, the last year of the subsidy appropriations in Michigan.

(3) 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.

(4) Rail traffic will be forecast for the 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.

In both the entire U.P. and on the 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.

The Upper Peninsula Rail System

The Upper Peninsula rail system consists of approximately 1,061 route miles with freight service provided by five railroad companies: the Chicago and Northwestern Transportation Company (C&NW); the Chicago, Milwaukee, St. Paul, and Pacific Railroad Company (Milwaukee Road); the Escanaba and Lake Superior Railroad (E&LS); the Lake Superior and Ishpeming Railroad (LS&I); and the Soo Line Railroad

Company (Soo Line). Three of these railroads (the C&NW, the Soo Line, and the Milwaukee Road) are major Class I carriers, while the LS&I is a Class II railroad and the E&LS is classified by the Interstate Commerce Commission as a Class III railroad, or "short line." Service provided by these railroads links the Upper Peninsula with Wisconsin and the Chicago gateway, with Canada at Sault Ste. Marie, and with the Lower Peninsula at St. Ignace utilizing the Straits of Mackinac car ferry service. The Upper Peninsula system functions mainly as an outbound rail route for metallic ores, forest products, and paper and pulp products. Most Upper Peninsula traffic moves southerly into Wisconsin or to ore locks located at Marquette and Escanaba.

The Upper Peninsula rail system has experienced a steady contraction in the last two decades. In 1965, the network consisted of 1,641 route miles served by eight carriers and three car ferry links to the Lower Peninsula. By 1976, six carriers remained, operating a total of 1,358 route miles, including the Straits of Mackinac interpeninsula car ferry route. The current system serves 1,061 route miles with 43 miles subject to active abandonment proceedings and 198 miles under study for possible abandonment. The map in Figure 6.1 depicts the current rail network in the Upper Peninsula. Abandonments since 1976 and current abandonment activities for the region are described in Tables 6.1, 6.2, and 6.3 [the source of the maps and tables is the Michigan Department of Transportation (MDOT) Upper Peninsula Report].

While years of piecemeal regulatory action have eliminated many light-density lines not essential to future needs, continued uncoordinated abandonment may threaten the essential core system of the

Figure 6.1

Railroads in the Upper Peninsula

Table 6.1

Upper Peninsula Rail Line Abandonments
Since April 1, 1976

Railroad	Location	Year	Miles
CNW	Scott Lake-Wisconsin Line	1979	0.20
CNW	Martins Landing-Ishpeming	1980	15.10
CNW	Marenisco-Ironwood	1981	25.40
CNW	Ironwood-Hurley	1981	2.40
LS&I	Munising Jct.-Marquette Lawson-Little Lake	1979	52.60
Milwaukee Road	Republic-Champion	1976	.99
Milwaukee Road	Channing-Republic	1980	23.10
Soo Line	Raco-Raco Jct.	1977	20.00
Soo Line	Rapid River-Eben Jct.	1979	30.54
Soo Line	Hancock-Calumet Dollar Bay-Lake Linden	1979	18.43
Soo Line	Nestoria-Bergland	1981	67.21
	Total Upper Peninsula Miles Abandoned Since April 1, 1976		269.97

Table 6.2

Upper Peninsula Rail Lines Currently Under Study for Possible Abandonment Applications

Railroad	Line	Segment	Miles	Category
CNW	Antoine and Marenisco Sub.	Antoine-Marenisco	88.30 (in MI)	1-Red
Soo Line	Ninth Subdivision	St. Ignace-Trout Lake	27.12	1-Red
Soo Line	Ninth Subdivision	Trout Lake-Forest Ctr.	76.10	2-Green
Soo Line	Sixth Subdivision	Bessemer-Mellen, WI	6.86 (in MI)	2-Green

ICC System Diagram Categories

1 - (Red) - Lines which carrier anticipates will be subject to an abandonment or discontinuance application within the next three years.

2 - (Green) - Lines under study and potentially subject to abandonment application.

Table 6.3

Upper Peninsula Rail Lines Subject to a Pending Abandonment Application

Railroad	Line	Location	Miles Involved	ICC Docket	Filing Date	Comments
CNW	Eagle River and Ironwood Subs.	Watersmeet-Land O'Lakes, WI	9.20 (MI)	AB-1 (115 F)	11/26/80	Abandonment Authority Not Yet Exercised
Milwaukee Road	Sixth Sub.	Green Bay, WI-Iron Mountain	2.00 (MI)	AB-7 (85 F)	12/28/78	Sale to E&LS Pending in Lieu of Physical Abandonment
Soo Line	Eighth Sub.	Baraga-Houghton-Dollar Bay	30.59	AB-57 (7)	09/27/77	Abandonment Postponed Due to MDOT Subsidy in Effect Through 9-30-82
Soo Line	Old Main	At Ishpeming	1.05	RR-182	10/08/81	MDOT Interstate Abandonment

Upper Peninsula.[2/] A major consideration in U.P. rail restructuring is the extent of proven reserves of both metallic ores and forest products. The objective in restructuring is to ensure adequate access to rail-dependent economic activities and areas of significant future resource development.

Service Needs in the Upper Peninsula and the Soo Line

As illustrated in Figure 6.2, those lines identified in Tables 6.2 and 6.3 as 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 6.3. The screening analysis also identified lines which warrant designation as nonessential 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 6.3.

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 provide service to rail dependent industries which generate

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[2/]Michigan Department of Transportation, Upper Peninsula Report, op. cit.

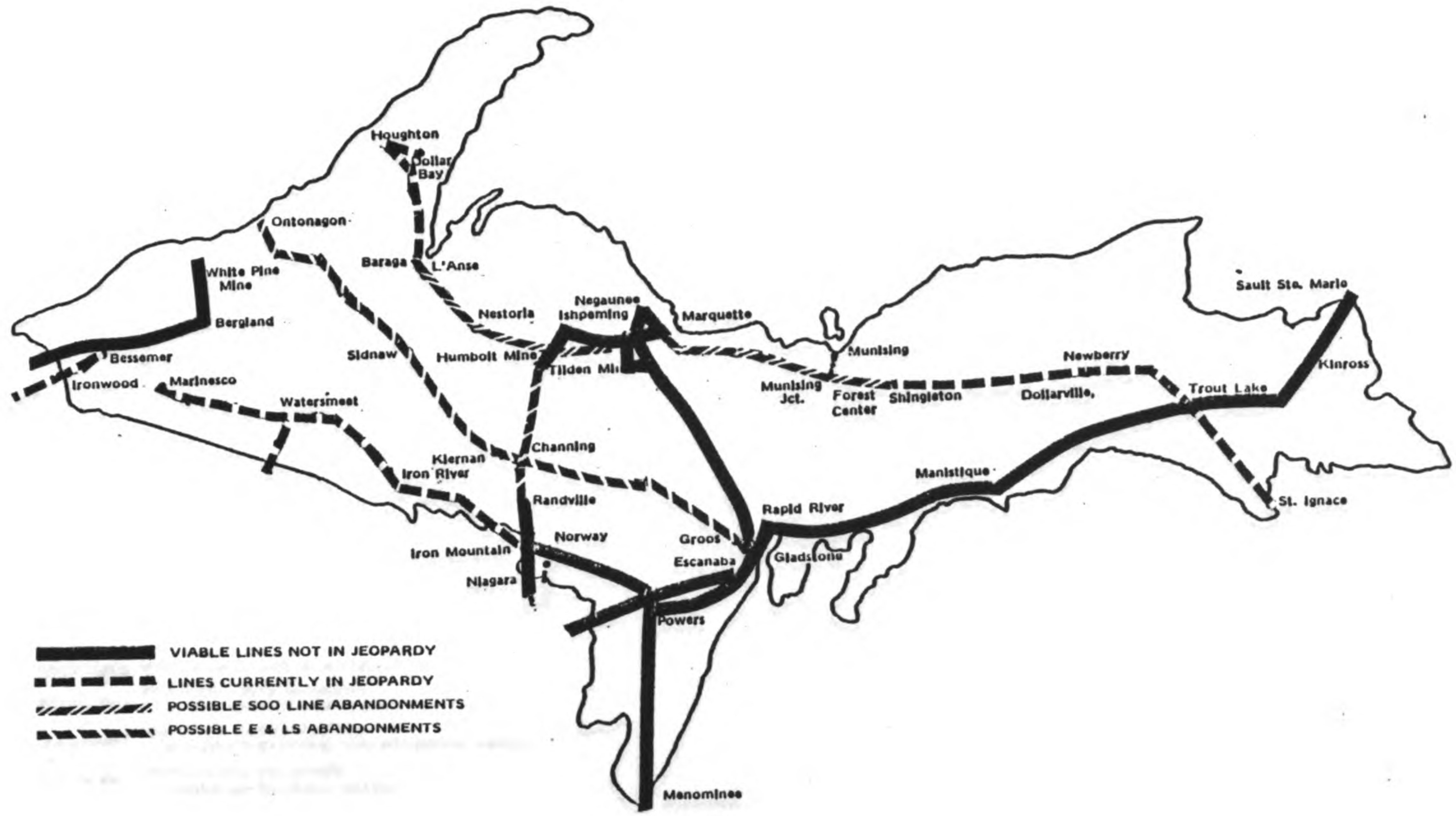

Figure 6.2

Upper Peninsula Lines Possibly in Jeopardy

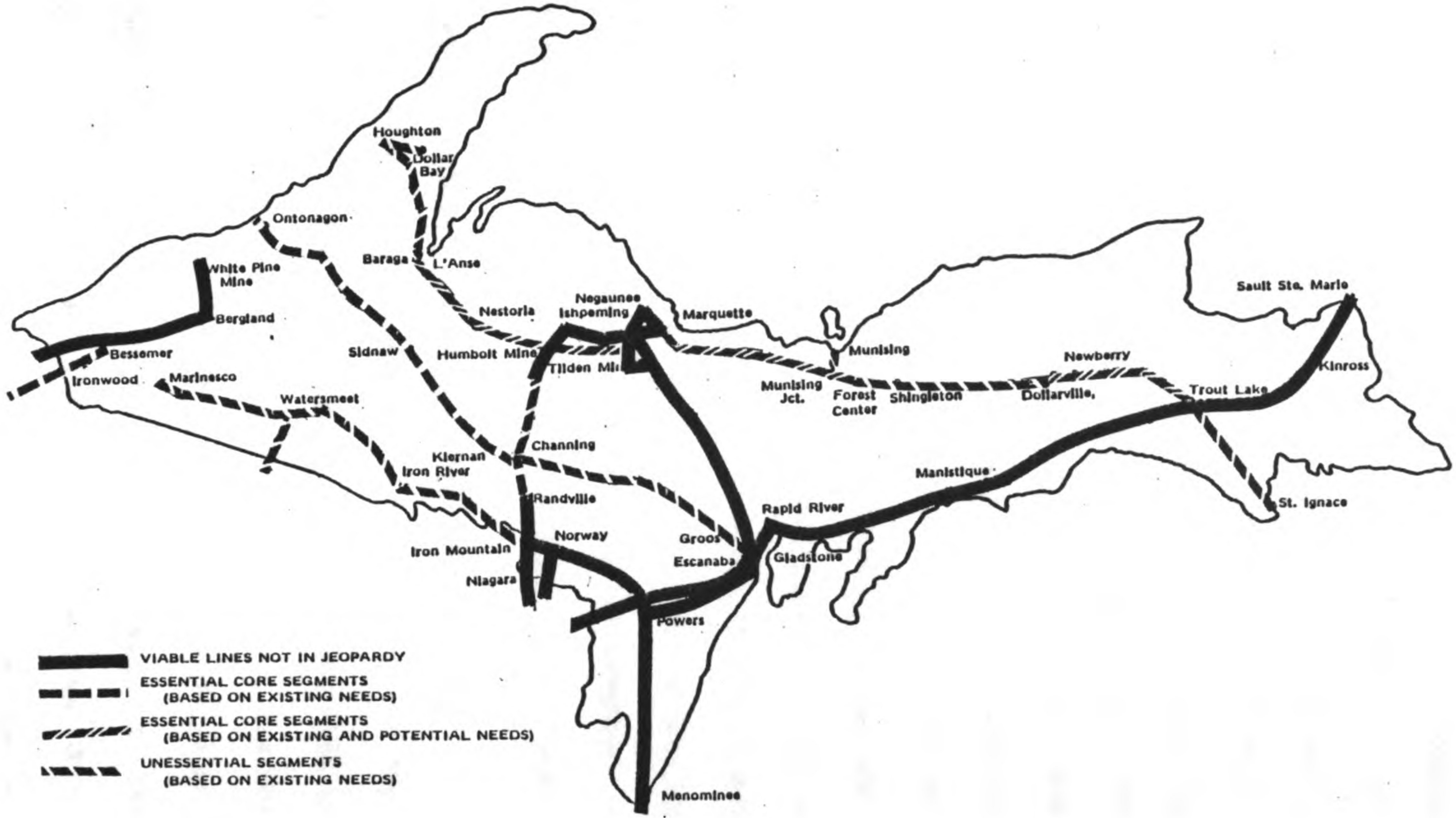

Figure 6.3

Existing Needs Map

significant employment opportunities. These lines, shown in Figure 6.3, 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.

Thus far, Michigan has emphasized rail service continuation subsidies, public acquisition of rights-of-way, track rehabilitation, and support facility rehabilitation and construction. With declining appropriations, whether to continue rail service subsidies is an important decision. Subsidies provide a negotiated level of service by the state, reimbursing the railroad for any operating losses and for an adequate rate of return on property. This assistance is most appropriate where the carrier is actively seeking abandonment, but significant traffic growth may develop in the future, or where a unique public benefit from rail service clearly outweighs the subsidy expenses. Whether significant traffic growth is likely to develop is the focus of this study.

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 of Chapter V. 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 on 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 6.4.

The final demand estimates based on national data shown in Table 6.4 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

Table 6.4

1983 Projection of State Economic Activity and Upper Peninsula Rail Traffic: High Projection (Base Year = 1980)

		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

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 to be 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 6.5 and is the average of the high and low projections. Tables 6.4 and 6.5 show the projected final demands and total 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 6.4 are increased by 18 percent to yield a high estimate of final demands shown in Table 6.6.

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 6.4, 6.5, and 6.6 (projections of total state rail traffic are shown in Appendix 3) 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,

Table 6.5

1983 Projection of State Economic Activity and Upper Peninsula Rail Traffic: Medium Projection (Base Year = 1980)

		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

Table 6.6

1986 Projection of State Economic Activity and Upper Peninsula Rail Traffic: High Projection (Base Year = 1980)

		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

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 6.6 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.

In analyzing the service needs of each of the Upper Peninsula rail lines, the Michigan Department of Transportation has emphasized the potential development of particular commodities. In the Upper Peninsula, the principal industries are highly dependent on rail service. Therefore, an adequate rail system is necessary to provide for the future development of the U.P. resource-based industries.

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 subeconomic 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 Railroad, the Lake Superior and Ishpeming, and the Chicago and Northwestern 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 predicted 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 6.4, 6.5, and 6.6, 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.

The Soo Line and the North-South Route 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,[3/] 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 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 6.4).

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

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

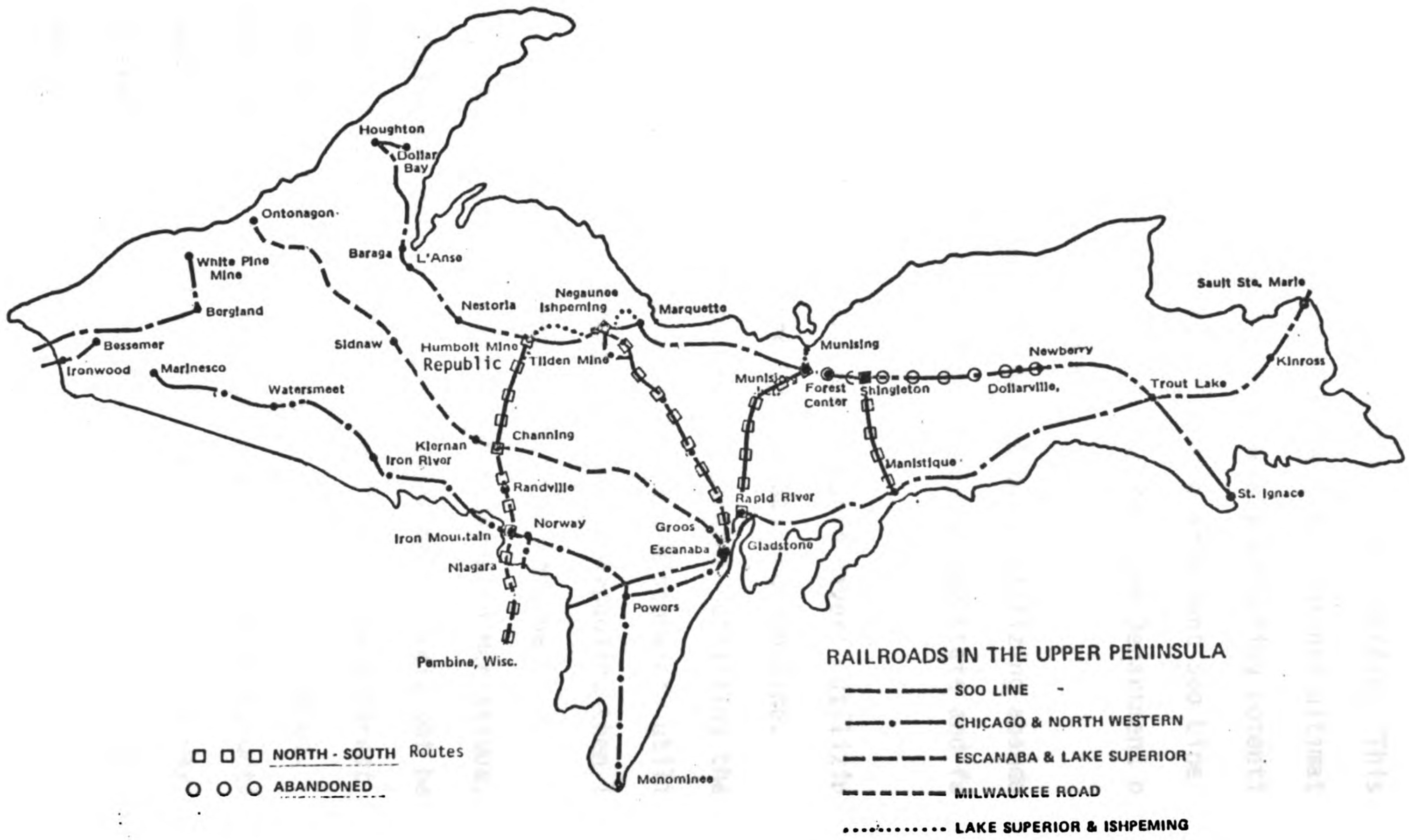

Figure 6.4

North-South Alternatives - Soo Line

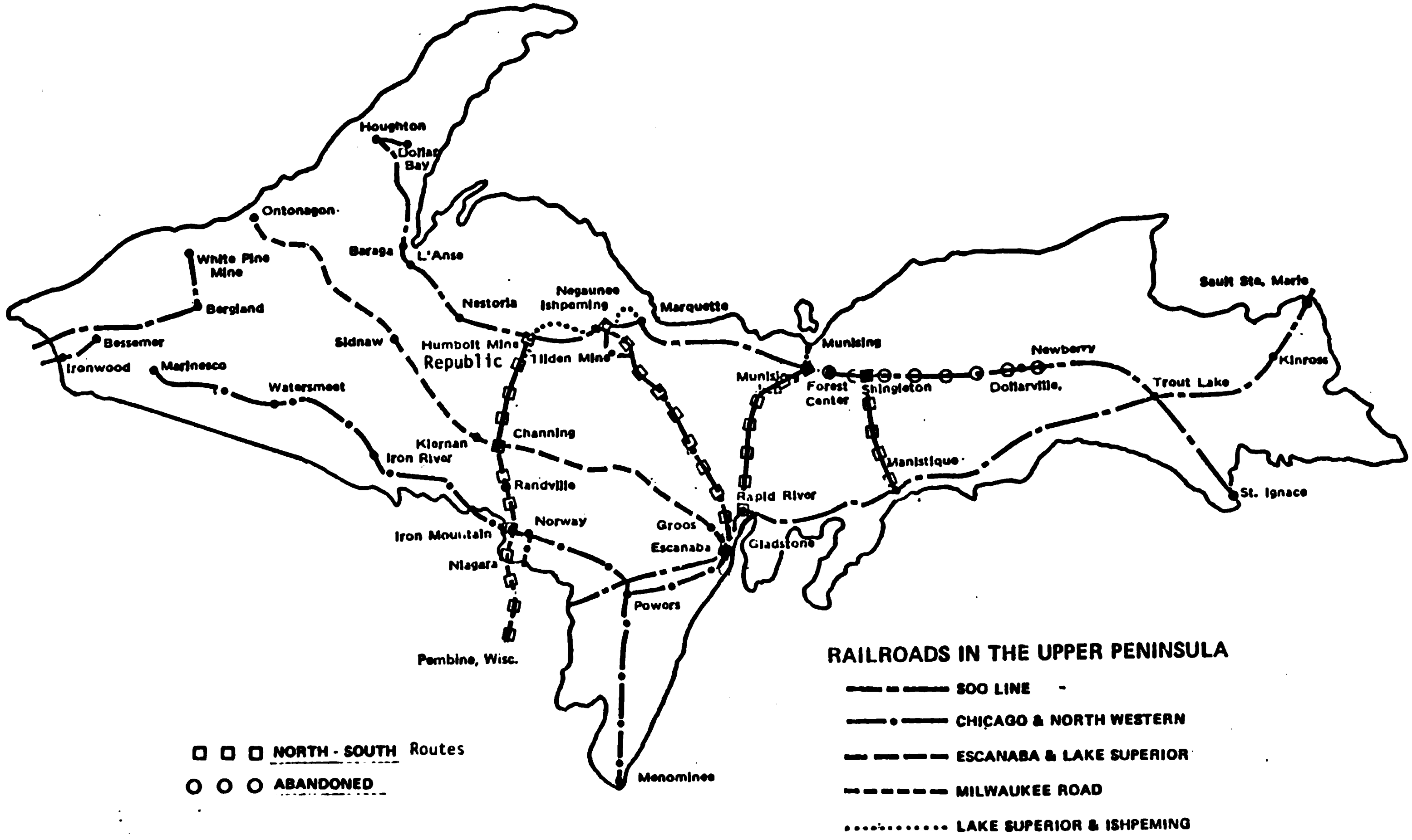

Figure 6.4

North-South Alternatives - Soo Line

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 6.4:

(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.

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 6.7, 6.8, and 6.9. The actual 1980 rail traffic shown in Table 6.7 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

Table 6.7

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 6.8

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

Sector	Industry	Statewide Economic Activity (Thousands of 1976 Dollars)		Soo Line Rail Traffic — Tons			
		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 6.9

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

in Table 6.7. Consequently, the relative changes in the Soo Line projections should remain the same. The Soo Line traffic shown in Tables 6.7, 6.8, and 6.9 represents only that traffic which runs on the northern tier. As was shown in Figure 6.2, 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.[4/] 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 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 these rail density projections 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. Figure 6.5 shows the frequency distribution of rail density on all

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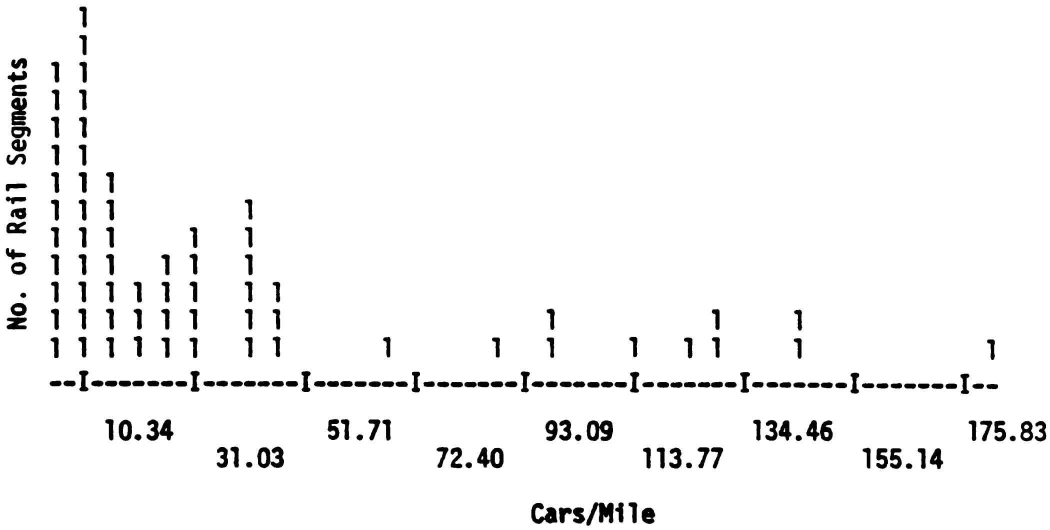
[4/]The Michigan Department of Transportation retains station designations on the waybill files for applications to circumstances which require greater specificity. To permit analysis at alternate levels of aggregation, MDOT maintains a station to 547 zone equivalence capability, which was aggregated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



ICC Category - System Diagram Classification:

1 - Carrier anticipates line segment will be subject to an abandonment or discontinuance within the next three years.

2 - Line segment under study and potentially subject to abandonment application.

3 - Line segment for which an abandonment or discontinuance is currently pending before the ICC.

4 - Line segment being operated under the 4R Act.

Figure 6.5

Frequency Distribution of Rail Density on All Michigan Railroads Classified in ICC Categories 1-4

Michigan railroads (63 segments) that are classified in ICC categories 1-4; from currently subsidized lines to segments that may be abandoned within the next three years. On these 63 segments, the mean rail density is 34.2 cars per mile; the majority of 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 any of the economic growth scenarios, the traffic on the northern Soo Line resembles segments 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.

In order to make precise statements about future profitability, 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.

CHAPTER VII

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 retail 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 using various costs and revenues depending on traffic levels and compositions "by hand." 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 is 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 1

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 1.1, 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 is $671,181,000 (Column 1, Row 24, Table A 1.1). Purchases from agricultural products are $108,562,000 (Column 1, Row 2, Table A 1.1). The direct requirements for livestock and agricultural products is .16174773 (Column 1, Row, Table A 1.2, 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 1.3 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 1.4. The inverse matrix is read by columns. In the first column of Table A 1.4, it is indicated that livestock must increase its output by a total of $1.32 (Column 1, Row 1, Table A 1.4) 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 1.4) 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 1.4), 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 1.4), 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 1.1

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(	47880.	3795.	30855.	43145.	52728.	17791.	45792.	262853.
17	20412.	26107.	23690.	355987.	120308.	128587.	63558.	9098.	94704.	449691.
18	9476.	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.

Table A 1.1

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	9476.	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.	25404421.	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 1.2

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	0.10049450	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	0.00077624	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	0.00110849	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	0.00013059	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	0.24700491	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	0.00312101	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	0.00402597	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	0.12650969	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	0.00317559	0.00176102	0.00037145	0.05035372	0.00214980	0.00000000	0.00040603	0.00019894	0.00005412	0.00006258
15	0.00607682	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	0.00093406
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	0.09740426
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	0.00054546	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	0.00425163	0.00783175	0.00334693
13	0.02410601	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	0.09032148	-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 1.3

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	-0.00004172	-0.00295027	0.93683925	-0.00645973	-0.00016404	-0.00098091	-0.00823145	-0.10798258	-0.02013238	-0.02489552
4	-0.00623379	-0.01009874	-0.01965343	0.99968873	-0.00323614	-0.00495784	-0.00566425	-0.01815125	-0.00605763	-0.00836046
5	-0.09985858	-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	-0.00294108	-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	-0.00110849	-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	-0.00022498	-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

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	-0.00175036	-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	0.87349031	-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	-0.00430881	-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 1.4

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	0.19944936	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	0.00291965	0.00401308	0.01442494	0.12080270	0.02629579	0.03526087
4	0.01317304	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	0.04675874
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	0.00973669	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	0.00770198	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	0.00436009	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	0.06244532	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	1.55435728	1.28729558	1.51973914	1.28016325	1.32054459	1.39027575	1.46825240

APPENDIX 2

1976, 44-SECTOR INPUT-OUTPUT MODEL OF MICHIGAN:

TRANSACTIONS MATRIX
COEFFICIENT MATRIX
LEONTIEF MATRIX
INVERSE MATRIX

Table A 2.1

44-Sector

TRANSACTIONS MATRIX

ROW/COL	1 LIVESTOCK AND PRODS.	2 OTHER AGRI PRODUCTS	3 METAL & MIN MINING	4 CRUDE PETR & NAT GAS	5 CONSTRUCTI ON	6 MEAT PRODUCTS	7 DAIRY PRODUCTS	8 PRESERVED FOOD	9 GRAINS,BAK ERY,SUGAR	10 BEVERAGES
1	67450.	18059.	0.	0.	0.	460649.	70457.	52.	0.	0.
2	108562.	36014.	0.	0.	8230.	121.	1071.	63527.	132358.	18083.
3	28.	2045.	105193.	0.	37500.	129.	1.	0.	643.	0.
4	0.	0.	0.	2650.	0.	0.	0.	0.	0.	0.
5	4184.	7000.	18696.	14861.	1807.	2635.	1711.	2490.	3058.	5356.
6	121.	0.	0.	0.	0.	7531.	538.	15168.	1362.	7.
7	3773.	211.	0.	0.	0.	54.	64552.	1056.	12977.	1878.
8	0.	0.	0.	0.	0.	149.	86.	19263.	16266.	6441.
9	62273.	657.	0.	0.	0.	60.	7631.	32180.	82589.	5960.
10	185.	64.	0.	0.	0.	50.	834.	2421.	1469.	23197.
11	81.	1587.	1251.	65.	6009.	1148.	172.	252.	1795.	115.
12	58.	1307.	2996.	0.	197207.	811.	0.	188.	0.	4069.
13	0.	0.	0.	0.	33441.	0.	0.	0.	0.	0.
14	341.	2387.	5206.	30.	14856.	20254.	23555.	17634.	22955.	19235.
15	122.	221.	81.	16.	101.	3184.	1215.	5181.	1438.	7032.
16	1336.	39213.	29401.	4548.	69384.	8489.	863.	4339.	9364.	4038.
17	0.	0.	0.	0.	0.	0.	1037.	349.	0.	0.
18	638.	0.	0.	0.	0.	0.	20.	24.	4475.	666.
19	1227.	6896.	6366.	391.	41695.	563.	1019.	276.	321.	917.
20	595.	2343.	9605.	758.	31462.	9625.	2209.	3606.	1708.	1560.
21	149.	494.	23361.	2671.	364074.	261.	356.	10753.	21.	58474.
22	21.	16.	7177.	0.	128223.	0.	244.	0.	0.	0.
23	0.	0.	26159.	3810.	80244.	110.	0.	0.	0.	104.
24	0.	0.	1029.	1602.	473764.	0.	0.	0.	0.	0.
25	0.	0.	1944.	0.	3168.	0.	2124.	0.	0.	0.
26	470.	0.	0.	0.	613.	0.	0.	0.	0.	9711.
27	798.	2023.	3248.	1657.	79506.	8447.	4282.	23927.	6107.	56632.
28	0.	129.	11093.	2179.	7750.	0.	0.	0.	0.	0.
29	170.	6653.	17151.	1777.	36835.	87.	72.	43.	156.	62.
30	0.	0.	938.	156.	110.	693.	386.	553.	668.	557.
31	104.	121.	20503.	5563.	72524.	3339.	928.	903.	1410.	1216.
32	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
33	151.	475.	1242.	2992.	71684.	24.	24.	16.	22.	22.
34	146.	169.	1246.	0.	206.	0.	85.	0.	0.	31.
35	1.	145.	189.	0.	15.	0.	0.	0.	0.	0.
36	20.	69.	213.	156.	12917.	204.	77.	56.	27.	47.
37	8832.	7036.	21788.	2726.	87247.	4884.	57294.	0.	15674.	6539.
38	1585.	1395.	29984.	3449.	2265.	4783.	2053.	1459.	7492.	2584.
39	163.	193.	11406.	1416.	552.	2989.	1682.	1553.	2657.	1210.
40	113.	3151.	1218.	407.	978.	731.	219.	353.	260.	830.
41	20311.	24451.	17768.	4237.	337061.	22069.	15010.	23494.	36693.	19149.
42	9176.	31905.	50425.	49303.	45473.	6338.	5465.	4072.	4420.	11427.
43	8101.	29754.	46183.	9103.	281098.	17179.	10025.	0.	34986.	82903.
44	61.	66.	796.	131.	2412.	575.	477.	302.	420.	701.
45	144931.	330892.	105900.	101700.	1625300.	93600.	62300.	63100.	322300.	92000.
46	165785.	116477.	333874.	83153.	717989.	484436.	253524.	148909.	182011.	84146.
47	58816.	19538.	217800.	274500.	921500.	113900.	157400.	187200.	417000.	194600.
48	671181.	693156.	1131430.	576007.	5805200.	1280101.	750998.	634699.	1325102.	721499.

44-Sector

TRANSACTIONS MATRIX

ROW/COL	11 TEXTILE & APPAREL	12 LUMBER AND WOOD PROD	13 FURNITURE	14 PAPER & ALLIED PROD.	15 PRINTING, PUBLISHING	16 CHEM,ALLIED PROD.	17 PLASTICS & SYN. MAT.	18 DRUGS	19 PETROLEUM REFINERY	20 RUBBER & LEATHER
1	2699.	0.	0.	0.	0.	263.	0.	166.	0.	401.
2	15117.	23659.	0.	0.	0.	3384.	11.	93.	0.	0.
3	17.	47.	0.	4443.	0.	28977.	26.	0.	1949.	701.
4	0.	0.	0.	0.	0.	701.	0.	0.	96585.	0.
5	2937.	2502.	2857.	13425.	3910.	14127.	2569.	3744.	16563.	4524.
6	0.	0.	0.	0.	0.	2577.	0.	1306.	44.	9207.
7	0.	0.	154.	0.	0.	2478.	877.	245.	538.	11.
8	107.	0.	0.	602.	0.	6362.	0.	245.	0.	0.
9	848.	0.	0.	8313.	0.	5760.	0.	1713.	0.	49.
10	2.	9.	0.	0.	0.	164.	0.	123.	0.	0.
11	205998.	512.	16871.	7360.	1822.	1050.	798.	102.	42.	30923.
12	337.	87588.	53080.	70843.	169.	2392.	189.	0.	44.	4681.
13	357.	1367.	19318.	177.	189.	0.	0.	0.	0.	825.
14	11070.	3244.	9772.	422095.	148185.	42382.	12586.	10741.	6090	26754.
15	460.	72.	171.	10271.	79121.	1240.	71.	583.	82.	600.
16	13577.	6525.	9084.	55089.	15188.	323196.	98347.	34158.	22901	34019.
17	60343.	373.	589.	11292.	1341.	41647.	6848.	570.	132.	112196.
18	0.	0.	0.	328.	15.	18048.	5.	33935.	11.	431.
19	521.	1278.	330.	4115.	605.	39790.	1599.	452.	24923.	663.
20	5422.	1364.	17648.	16097.	2439.	15324.	4704.	5897.	1541.	67484.
21	2254.	3399.	7190.	2469.	0.	13133.	241.	7193.	2255.	6766.
22	29.	373.	3819.	1334.	1247.	19491.	1049.	167.	1231.	816.
23	2.	1106.	27676.	2530.	421.	8889.	0.	0.	270.	2728.
24	14.	563.	1064.	19.	0.	93.	15.	0.	82.	660.
25	0.	663.	4315.	0.	44.	0.	0.	0.	0.	1890.
26	985.	1024	1519.	78.	44.	2375.	30.	771.	4.	4623.
27	853.	4874.	28810.	16379.	8728.	42591.	488.	5332.	3458.	13931.
28	0.	0.	60.	0.	0.	0.	0.	0.	0.	0.
29	91.	279.	1263.	1261.	23.	1507.	94.	54.	682.	568.
30	1328.	514.	1811.	4501.	534.	1299.	672.	154.	186.	5322
31	2752.	1496.	1977.	6443.	775.	17725.	2132.	299.	2495.	3585.
32	0.	5.	97.	144.	12.	90.	0.	0.	0.	58.
33	234.	230.	922.	554.	265.	984.	45.	54.	207.	827.
34	80.	168.	346.	0.	0.	1081.	0.	0.	111.	1093.
35	10	72.	336.	0.	16.	34.	11.	0.	0.	1160.
36	5047.	338.	2355.	1704.	4039.	2032.	67.	1052.	352.	5323.
37	10965.	8648.	9062.	38113.	12148.	31377.	4694.	4848.	42729.	14436.
38	6410.	2813.	2873.	15512.	3471.	22031.	2907.	2081.	5319.	8667.
39	1636.	1068.	1007.	10611.	1071.	20398.	1564.	553.	11105.	2213.
40	636.	76.	105.	4186.	352.	2548.	338.	308.	1367.	792.
41	27979.	11815.	20635.	42869.	18237.	38662.	7673.	12122.	8701.	32213.
42	11666.	4090.	8268.	19444.	27355.	35691.	5109.	13308.	21706.	13564.
43	20070.	8873.	17746.	44382.	44705.	145313.	11078.	66216.	31061.	40026.
44	1277.	209.	530.	1136.	7336.	2252.	148.	688.	408.	1110.
45	353100.	126700.	237100.	316500.	418900.	335500.	64900.	118700.	36100.	315200.
46	412570.	101932.	107341.	253180.	87691.	322543.	44115.	47626.	464522.	238960
47	386000.	129000.	264200.	368400.	489600.	824000.	91200.	423300.	106700.	352500.
48	1565800.	538898.	882301.	1776199.	1379998.	2441501.	367200.	799899.	812499.	1362500.

44-Sector

TRANSACTIONS MATRIX

ROW/COL	21 GLASS,STONE,CLAY	22 FOUNDRIES, METAL PROD	23 IRON,STEEL MANUFACT.	24 HTNG,PLMBG ,FAB PROD	25 SCREW MACH PROD	26 METAL STAMPINGS	27 FAB METAL PROD	28 ENGINES & TURBINES	29 FARM & CONST MACH	30 METALWORKING MACH
1	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
2	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
3	50095.	83308.	275138.	31.	0.	0.	499.	0.	0.	0.
4	0.	0.	0.	0.	0.	0.	0.	0.	0.	0
5	10760.	9912.	51017.	2644.	940.	51218.	4821.	3316.	6266.	5032.
6	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
7	163.	0.	0.	0.	24.	0.	22.	0.	0.	0
8	0.	0.	0.	0.	0.	0.	9.	0.	0.	0
9	12.	680.	0.	0.	0.	0.	0.	0.	0.	0.
10	0.	0.	0.	0.	0.	0.	0.	0.	0.	0
11	2187.	917.	1014.	283.	99.	6027.	1623.	204.	593.	517.
12	3516.	6070.	9862.	1449.	38.	51584.	6178.	0.	2129.	984
13	1246.	102.	81.	1838.	18.	14315.	2420.	331.	730.	160.
14	35651.	3658.	2206.	4412.	1397.	121841.	20910.	3088.	2228.	1795
15	238.	872.	280.	70.	28.	2496.	9666.	55.	170.	161
16	21139.	16678.	50938.	5883.	521.	65506.	28409.	1141.	3127.	3062.
17	2507.	7539.	36.	0.	0.	18005.	415.	0.	0.	107.
18	177.	0.	0.	0.	0.	0.	7.	0.	0.	0
19	2888.	2113.	6565.	677.	260.	5219.	1706.	1437.	1744.	2441.
20	9210.	3636.	2839.	871.	1081.	42544.	12638.	1228.	21627.	7602.
21	104926.	5039.	14129.	5103.	781.	26348.	6813.	7446.	7996.	13108.
22	3417.	502440.	103882.	42333.	181024.	0.	95659.	84376.	110157.	62990.
23	8481.	89566.	733908.	155928.	0.	0.	236136.	23524.	120657.	59761.
24	824.	5167.	535.	16343.	348.	31389.	6664.	3279.	11359.	4661.
25	25.	19187.	0.	10104.	2908.	59328.	11420.	7957.	13132.	9535.
26	202.	0.	0.	5562.	756.	149677.	13770.	8236.	10521.	43895.
27	7361.	17687.	47239.	15835.	3460.	129537.	66093.	13540.	23202.	22886.
28	810.	1053.	0.	1762.	800.	2226.	1579.	92638.	73810.	1106.
29	4925.	5530.	7280.	4292.	474.	11770.	4790.	37010.	132354.	5737.
30	6423.	24623.	19055.	3521.	8436.	106253.	20432.	11290.	26361.	92918.
31	4160.	38367.	49395.	24699.	8366.	97187.	25757.	58088.	131264.	53911.
32	0.	0.	451.	184.	28.	9954.	54.	0.	33.	94.
33	1710.	13944.	20683.	5091.	375.	36313.	15640.	20809.	18297.	20965.
34	993.	13511.	0.	3018.	2759.	357248.	7547.	19386.	16655.	13397.
35	18.	240.	238.	1718.	91.	3733.	22372.	15086.	3087.	1184.
36	1911.	1123.	4466.	2021.	293.	30580.	6029.	772.	4525.	1749.
37	32957.	175293.	0.	8745.	17488.	0.	17284.	6474.	15128.	8886.
38	13787.	26252.	54107.	3010.	1366.	61811.	7966.	2823.	5880.	5865.
39	19808.	15867.	53061.	1922.	562.	19722.	3828.	1099.	2851.	1891.
40	525.	1639.	4556.	189.	70.	6205.	720.	331.	551.	497.
41	22147.	64017.	112985.	18299.	3584.	166851.	29480.	24589.	46596.	30105.
42	16849.	17445.	20684.	8800.	3043.	77407.	14162.	5044.	20719.	15845.
43	31983.	21339.	0.	17313.	3244.	0.	45314.	17462.	46268.	28892.
44	949.	951.	2328.	404.	161.	3556.	1054.	544.	1164.	792.
45	252600.	882900.	533500.	201900.	159800.	1025600.	576000.	194700.	283900.	768700.
46	128619.	545434.	557345.	72147.	94075.	459653.	235913.	148595.	208619.	149567.
47	354400.	698300.	403000.	190900.	200900.	1014700.	587600.	313600.	269100.	644600.
48	1160599.	3322399.	3142803.	839301.	699598.	4265803.	2149399.	1129498.	1642800.	2085401.

44-Sector

TRANSACTIONS MATRIX

ROW/COL	31 SPEC & GEN IND. MACH	32 OFFICE,ACC &COMP MACH	33 ELECTRICAL EQUIP	34 MOTOR VEH. & PARTS	35 ACFT,OTH. TRAN EQUIP	36 MISC. MANF	37 TRAN,WHSNG ,& COMM.	38 ELECTRICAL UTILITIES	39 GAS UTILIT IES	40 WATER & SANITARY S
1	0.	0.	0.	0.	0.	0.	181.	0.	0.	0.
2	0.	0.	0.	0.	0.	328.	4578.	0.	0.	0.
3	0.	0.	142.	0.	0.	210.	68.	80.	0.	0.
4	0.	0.	0.	0.	0.	0.	2245.	0.	80884.	0.
5	6824.	677.	5331.	100911.	2591.	2183.	163077.	88827.	41129.	7251.
6	140.	0.	0.	0.	0.	613.	4007.	12.	0.	0.
7	170.	0.	0.	0.	0.	0.	15045.	0.	0.	0.
8	0.	0.	0.	0.	0.	99.	0.	30.	0.	0.
9	16.	0.	0.	0.	0.	2.	162.	10.	0.	0.
10	0.	0.	0.	0.	0.	0.	255.	10.	0.	0.
11	1225.	52.	859.	244381.	1254.	4482.	5438.	473.	232.	51.
12	4241.	43.	1649.	28812.	10163.	3458.	119.	56.	0.	0.
13	1397.	273.	6978.	37822.	3069.	1114.	0.	10.	0.	0.
14	6527.	1521.	15616.	80852.	1390.	19923.	10313.	2699.	854.	149.
15	581.	3183.	1396.	1621.	104.	887.	5107.	475.	150.	8.
16	5865.	259.	11786.	149710.	1417.	9430.	7795.	3647.	0.	518.
17	75.	155.	5179.	13481.	844.	5330.	0.	136.	0.	0.
18	0.	0.	0.	0.	0.	1240.	0.	0.	0.	0.
19	3333.	97.	1154.	22258.	922.	466.	52786.	12638.	710.	123.
20	9533.	1223.	15150.	476634.	4879.	10968.	13960.	1573.	68.	63.
21	17228.	204.	20316.	361274.	2852.	3759.	4654.	58.	0.	0.
22	104102.	2850.	53943.	1403653.	30134.	17982.	98990.	783.	0.	0.
23	100958.	2451.	38805.	1200719.	19688.	10714.	0.	2006.	2257.	0.
24	31433.	844.	2299.	24869.	10290.	406.	0.	10.	0.	0.
25	13265.	628.	12317.	245924.	6288.	3599.	7323.	0.	0.	0.
26	9602.	2503.	17658.	1680122.	4777.	3829.	0.	0.	0.	0.
27	37614.	1696.	20875.	793688.	19019.	9798.	14217.	1645.	0.	297.
28	13038.	0.	3776.	265371.	12150.	0.	6923.	148.	0.	0.
29	17668.	30.	1628.	90039.	2378.	774.	129.	78.	0.	0.
30	36476.	3042.	12748.	329609.	9935.	2016.	382.	0.	0.	0.
31	182158.	4806.	15917.	1027949.	29256.	3380.	12792.	3138.	0.	377.
32	472.	19379.	2876.	368.	76.	445.	0.	0.	0.	0.
33	77995.	21154.	131058.	463869.	14537.	11365.	18043.	4019.	52.	3.
34	15856.	71.	7441.	9773407.	7876.	1702.	5346.	272.	0.	0.
35	5569.	17.	3008.	13757.	42116.	849.	15466.	0.	0.	0.
36	6528.	411.	6854.	71714.	5111.	20658.	3495.	8.	0.	0.
37	15593.	1650.	12395.	368084.	6709.	5481.	239161.	39412.	3324.	378.
38	7993.	545.	6546.	101990.	2625.	2078.	47617.	467317.	142.	5663.
39	2920.	123.	1920.	37133.	680.	554.	11363.	262488.	24733.	4108.
40	453.	22.	818.	16155.	429.	112.	6325.	5338.	22.	160.
41	51912.	7743.	35332.	606898.	16904.	17192.	95123.	15662.	1410.	411.
42	27546.	6864.	18678.	164848.	8042.	7963.	129784.	13926.	12633.	1900.
43	45409.	6648.	47566.	1109533.	19945.	23970.	360683.	25458.	19171.	2090.
44	1273.	182.	1198.	25185.	552.	628.	71472.	189479.	29188.	50408.
45	700900.	90600.	413900.	5382800.	195900.	239200.	1899327.	437350.	198343.	9616.
46	294114.	64453.	310589.	3911059.	188401.	124415.	2081113.	225574.	289338.	37180.
47	838200.	54300.	442400.	6409800.	153100.	235400.	1779289.	633935.	865217.	20828.
48	2696202.	300699.	1708101.	37036299.	836403.	809002.	7194153.	2438780.	1569857.	141582.

44-Sector

TRANSACTIONS MATRIX

ROW/COL	41 WHOLESALE & RETAIL	42 F.I.R.E.	43 SELECT SERVICES	44 GOVT ENTERPRISES	45 HOUSEHOLDS	46 IMPORTS/EXPORTS	47 VALUE ADD/INVESTMENT	
1	0.	34043.	2991.	0.	13336.	291.	139.	671177.
2	6433.	49309.	11593.	132.	278690.	515.	-68650.	693158.
3	382.	3062.	0.	178.	34562.	63237.	438628.	1131319.
4	0.	2881.	0.	0.	0.	390061.	0.	576007.
5	54988.	511778.	116953.	125697.	0.	2632790.	1669311.	5805200.
6	7408.	651.	14470.	0.	1196442.	1900.	18435.	1281939.
7	13561.	2002.	3243.	0.	617777.	9900.	13179.	763890.
8	5602.	726.	0.	0.	583191.	21300.	7353.	667831.
9	12388.	1006.	4025.	0.	229313.	41500.	878780.	1375927.
10	4757.	2478.	669.	0.	692468.	22400.	1984.	753539.
11	9366.	2129.	7809.	591.	934375.	-46800.	23873.	1481207.
12	11400.	1964.	207.	0.	78837.	34000.	10523.	693241.
13	4584.	568.	0.	0.	432842.	12100.	171444.	749116.
14	138078.	18743.	28600.	1228.	331386.	78500.	222994.	1975931.
15	26531.	26626.	572141.	2482.	549408.	69900.	119894.	1505795.
16	41175.	18764.	111342.	7972.	1734853.	266700.	531837.	3882533.
17	1081.	2653.	0.	0.	24994.	1000.	68158.	388412.
18	4584.	3240.	3004.	135.	332638.	33700.	422978.	860299.
19	41500.	17734.	19321.	2872.	516658.	-4200.	55722.	903091.
20	42855.	6448.	55676.	1588.	390755.	13300.	30583.	1379923.
21	22616.	3897.	27883.	403.	157082.	57800.	25724.	1402953.
22	4266.	3455.	282.	352.	-126.	163300.	-516.	3234965.
23	2511.	4127.	0.	5.	-19.	142100.	-968.	3107364.
24	15880.	3398.	0.	15.	15714.	2500.	23320.	690452.
25	1089.	513.	32717.	10.	25799.	14300.	211293.	722809.
26	3656.	548.	0.	380.	66599.	136200.	1878266.	4059006.
27	21991.	2605.	34123.	397.	29652.	32400.	836366.	2515294.
28	3844.	1316.	10205.	921.	19578.	50400.	542973.	1127638.
29	7552.	4553.	25214.	616.	4035.	86300.	681062.	1205046.
30	5072.	1297.	3394.	45.	8188.	79100.	1147371.	1978369.
31	22461.	12150.	59997.	392.	50125.	69400.	128769.	2260551.
32	3824.	12892.	5869.	75.	6005.	-8400.	44398.	99483.
33	21364.	9817.	37262.	663.	269394.	67500.	190296.	1573192.
34	7432.	9110.	102709.	881.	1527419.	1747800.	25404421.	39051019.
35	6117.	2065.	650.	67.	69785.	16600.	409953.	636075.
36	20476.	3139.	77071.	217.	320933.	28900.	83749.	738828.
37	156763.	81200.	167233.	43084.	1870518.	239663.	3272213.	7194156.
38	145606.	24481.	110739.	53035.	961365.	0.	189038.	2438780.
39	37026.	7763.	33064.	14751.	770550.	0.	165022.	1569856.
40	24722.	17556.	31751.	2691.	301.	0.	474.	141580.
41	232202.	100498.	256423.	6683.	12143450.	552319.	144853.	15544850.
42	604038.	714756.	399654.	23141.	7433163.	128915.	105688.	10380042.
43	999333.	488154.	784424.	39180.	5723002.	-191.	1146357.	12011352.
44	142626.	84581.	63948.	1000.	312435.	0.	63503.	1070596.
45	6993048.	1815491.	6613108.	582092.	523462.	0.	4933470.	41173930.
46	965406.	629369.	844696.	104281.	21522338.	1158637.	1992024.	41993738.
47	4646952.	5634509.	1336892.	52348.	559311.	211122.	8620566.	43168423.
48	15544846.	10380045.	12011352.	1070600.	63362583.	8618759.	56856850.	0.

Table A 2.2

44-Sector

COEFFICIENT MATRIX

ROW/COL	1 LIVESTOCK AND PRODS.	2 OTHER AGRI PRODUCTS	3 METAL & MIN MINING	4 CRUDE PETR & NAT GAS	5 CONSTRUCTI ON	6 MEAT PRODUCTS	7 DAIRY PRODUCTS	8 PRESERVED FOOD	9 GRAINS,BAK ERY,SUGAR	10 BEVERAGES
1	0.10049450	0.02605330	0.00000000	0.00000000	0.00000000	0.35985364	0.09381783	0.00008193	0.00000000	0.00000000
2	0.16174773	0.05195656	0.00000000	0.00000000	0.00141769	0.00009452	0.00142610	0.10008996	0.09988514	0.02506310
3	0.00004172	0.00295027	0.09297349	0.00000000	0.00645973	0.00010077	0.00000133	0.00000000	0.00048525	0.00000000
4	0.00000000	0.00000000	0.00000000	0.00460064	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
5	0.00623379	0.01009874	0.01652422	0.02580003	0.00031127	0.00205843	0.00227830	0.00392312	0.00230775	0.00742343
6	0.00018028	0.00000000	0.00000000	0.00000000	0.00000000	0.00588313	0.00071638	0.02389794	0.00102785	0.00000970
7	0.00562143	0.00030440	0.00000000	0.00000000	0.00000000	0.00004218	0.08595496	0.00166378	0.00979321	0.00260291
8	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00011640	0.00011451	0.03034982	0.01227528	0.00892725
9	0.09278123	0.00094784	0.00000000	0.00000000	0.00000000	0.00004687	0.01016115	0.05070120	0.06232652	0.00826058
10	0.00027563	0.00009233	0.00000000	0.00000000	0.00000000	0.00003906	0.00111052	0.00381441	0.00110859	0.03215112
11	0.00012068	0.00228953	0.00110568	0.00011285	0.00103511	0.00089680	0.00022903	0.00039704	0.00135461	0.00015939
12	0.00008641	0.00188558	0.00264798	0.00000000	0.03397075	0.00063354	0.00000000	0.00029620	0.00000000	0.00563965
13	0.00000000	0.00000000	0.00000000	0.00000000	0.00576053	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
14	0.00050806	0.00344367	0.00460126	0.00005208	0.00255908	0.01582219	0.03136493	0.02778325	0.01732319	0.02665977
15	0.00018177	0.00031883	0.00007159	0.00002778	0.00001740	0.00248730	0.00161785	0.00816292	0.00108520	0.00974638
16	0.00199052	0.05657168	0.02598570	0.00789574	0.01195204	0.00663151	0.00114914	0.00683631	0.00706663	0.00559668
17	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00138083	0.00054987	0.00000000	0.00000000
18	0.00095056	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00002663	0.00003781	0.00337710	0.00092308
19	0.00182812	0.00994870	0.00562651	0.00067881	0.00718235	0.00043981	0.00135686	0.00043485	0.00024225	0.00127097
20	0.00088650	0.00338019	0.00848926	0.00131596	0.00541962	0.00751894	0.00294142	0.00568143	0.00128896	0.00216217
21	0.00022200	0.00071268	0.02064732	0.00463710	0.06271515	0.00020389	0.00047404	0.01694189	0.00001585	0.08104516
22	0.00003129	0.00002308	0.00634330	0.00000000	0.02208761	0.00000000	0.00032490	0.00000000	0.00000000	0.00000000
23	0.00000000	0.00000000	0.02312030	0.00661450	0.01382278	0.00008593	0.00000000	0.00000000	0.00000000	0.00014414
24	0.00000000	0.00000000	0.00090947	0.00278122	0.08161028	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
25	0.00000000	0.00000000	0.00171818	0.00000000	0.00054572	0.00000000	0.00282824	0.00000000	0.00000000	0.00000000
26	0.00070026	0.00000000	0.00000000	0.00000000	0.00010559	0.00000000	0.00000000	0.00000000	0.00000000	0.01345948
27	0.00118895	0.00291853	0.00287070	0.00287670	0.01369565	0.00659870	0.00570175	0.03769818	0.00460870	0.07849214
28	0.00000000	0.00018611	0.00980441	0.00378294	0.00133501	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
29	0.00025328	0.00959813	0.01515869	0.00308503	0.00634517	0.00006796	0.00009587	0.00006775	0.00011773	0.00008593
30	0.00000000	0.00000000	0.00082904	0.00027083	0.00001895	0.00054136	0.00051398	0.00087128	0.00050411	0.00077200
31	0.00015495	0.00017456	0.01812132	0.00965787	0.01249294	0.00260839	0.00123569	0.00142272	0.00106407	0.00168538
32	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
33	0.00022498	0.00068527	0.00109773	0.00519438	0.01234824	0.00001875	0.00003196	0.00002521	0.00001660	0.00003049
34	0.00021753	0.00024381	0.00110126	0.00000000	0.00003549	0.00000000	0.00011318	0.00000000	0.00000000	0.00004297
35	0.00000149	0.00020919	0.00016705	0.00000000	0.00000258	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
36	0.00002980	0.00009954	0.00018826	0.00027083	0.00222507	0.00015936	0.00010253	0.00008823	0.00002038	0.00006514
37	0.01315889	0.01015067	0.01925705	0.00473258	0.01502911	0.00381532	0.07629048	0.00000000	0.01182852	0.00906308
38	0.00236151	0.00201253	0.02650098	0.00598777	0.00039017	0.00373642	0.00273370	0.00229873	0.00565390	0.00358143
39	0.00024286	0.00027844	0.01008105	0.00245830	0.00009509	0.00233497	0.00223969	0.00244683	0.00200513	0.00167706
40	0.00016836	0.00454587	0.00107651	0.00070659	0.00016847	0.00057105	0.00029161	0.00055617	0.00019621	0.00115038
41	0.03026158	0.03527489	0.01570402	0.00735581	0.05806191	0.01724005	0.01998674	0.03701597	0.02769070	0.02654058
42	0.01411840	0.04602860	0.04456749	0.08559445	0.00783315	0.00495117	0.00727698	0.00641564	0.00333559	0.01583786
43	0.01207424	0.04292540	0.04081826	0.01580363	0.05014435	0.01342003	0.01334890	0.00000000	0.02640250	0.11490383
44	0.00009088	0.00009522	0.00070353	0.00022743	0.00041549	0.00044918	0.00063515	0.00047582	0.00031696	0.00097159
45	0.21593430	0.47737017	0.09359837	0.17656035	0.27997313	0.07311923	0.08295628	0.09941720	0.24322656	0.12751230
46	0.24700491	0.16803865	0.29509028	0.14436109	0.12368032	0.37843576	0.33758279	0.23461357	0.13735622	0.11662663
47	0.08763061	0.02818702	0.19249976	0.47655671	0.15873699	0.08897735	0.20958778	0.29494296	0.31469276	0.26971624
48	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000

44-Sector

COEFFICIENT MATRIX

ROW/COL	11 TEXTILE & APPAREL	12 LUMBER AND WOOD PROD	13 FURNITURE	14 PAPER & AL LIED PROD.	15 PRINTING, PUBLISHING	16 CHEM,ALLIE D PROD.	17 PLASTICS & SYN. MAT.	18 DRUGS	19 PETROLEUM REFINERY	20 RUBBER & LEATHER
1	0.00172372	0.00000000	0.00000000	0.00000000	0.00000000	0.00010772	0.00000000	0.00020753	0.00000000	0.00029431
2	0.00965449	0.04390256	0.00000000	0.00000000	0.00000000	0.00138603	0.00002996	0.00011626	0.00000000	0.00000000
3	0.00001086	0.00008722	0.00000000	0.00250141	0.00000000	0.01186852	0.00007081	0.00000000	0.00213589	0.00051450
4	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00028712	0.00000000	0.00000000	0.10584669	0.00000000
5	0.00187572	0.00464281	0.00323812	0.00755827	0.00283334	0.00578619	0.00699619	0.00468059	0.01815125	0.00332037
6	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00105550	0.00000000	0.00163271	0.00004822	0.00675743
7	0.00000000	0.00000000	0.00017454	0.00000000	0.00000000	0.00101495	0.00238834	0.00030629	0.00058959	0.00000807
8	0.00006834	0.00000000	0.00000000	0.00033893	0.00000000	0.00260577	0.00000000	0.00030629	0.00000000	0.00000000
9	0.00054158	0.00000000	0.00000000	0.00468022	0.00000000	0.00235920	0.00000000	0.00214152	0.00000000	0.00003596
10	0.00000128	0.00001670	0.00000000	0.00000000	0.00000000	0.00006717	0.00000000	0.00015377	0.00000000	0.00000000
11	0.13156086	0.00095009	0.01912159	0.00414368	0.00132029	0.00043006	0.00217320	0.00012752	0.00004603	0.02269578
12	0.00021523	0.16253169	0.06016087	0.03988461	0.00012246	0.00097973	0.00051471	0.00000000	0.00004822	0.00343560
13	0.00022800	0.00253666	0.02189502	0.00009965	0.00013696	0.00000000	0.00000000	0.00000000	0.00000000	0.00060550
14	0.00706987	0.00601969	0.01107559	0.23763948	0.10738059	0.01735899	0.03427560	0.01342795	0.00667398	0.01963596
15	0.00029378	0.00013361	0.00019381	0.00578257	0.05733414	0.00050788	0.00019336	0.00072884	0.00008986	0.00044037
16	0.00867097	0.01210804	0.01029581	0.03101511	0.01100581	0.13237594	0.26782952	0.04270289	0.02509701	0.02496807
17	0.03853813	0.00069215	0.00066757	0.00635740	0.00097174	0.01705795	0.01864924	0.00071259	0.00014166	0.08231569
18	0.00000000	0.00000000	0.00000000	0.00018466	0.00001087	0.00739217	0.00001362	0.04242411	0.00001205	0.00031633
19	0.00033274	0.00237151	0.00037402	0.00231674	0.00043841	0.01629735	0.00435458	0.00056507	0.02731291	0.00048661
20	0.00346277	0.00253109	0.02000224	0.00906261	0.00176739	0.00627647	0.01281046	0.00737218	0.00168877	0.01952954
21	0.00143952	0.00630732	0.00814915	0.00139005	0.00000000	0.00537907	0.00065632	0.00899239	0.00247124	0.00496587
22	0.00001852	0.00069215	0.00432845	0.00075104	0.00090362	0.00798320	0.00285675	0.00020878	0.00134904	0.00059890
23	0.00000128	0.00205234	0.03136798	0.00142439	0.00030507	0.00364079	0.00000000	0.00000000	0.00029589	0.00200220
24	0.00000894	0.00104472	0.00120594	0.00001070	0.00000000	0.00003809	0.00004085	0.00000000	0.00008986	0.00048440
25	0.00000000	0.00123029	0.00489062	0.00000000	0.00003188	0.00000000	0.00000000	0.00000000	0.00000000	0.00138716
26	0.00062907	0.00190017	0.00172163	0.00004391	0.00003188	0.00097276	0.00008170	0.00096387	0.00000438	0.00339303
27	0.00054477	0.00904438	0.03265326	0.00922138	0.00632465	0.01744460	0.00132898	0.00666584	0.00378959	0.01022459
28	0.00000000	0.00000000	0.00006800	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
29	0.00005812	0.00051772	0.00143148	0.00070994	0.00001667	0.00061724	0.00025599	0.00006751	0.00074740	0.00041688
30	0.00084813	0.00095380	0.00205259	0.00253406	0.00038696	0.00053205	0.00183007	0.00019252	0.00020384	0.00390606
31	0.00175757	0.00277604	0.00224073	0.00362741	0.00056160	0.00725988	0.00580610	0.00037380	0.00273425	0.00263119
32	0.00000000	0.00000928	0.00010994	0.00008107	0.00000870	0.00003686	0.00000000	0.00000000	0.00000000	0.00004257
33	0.00014944	0.00042680	0.00104499	0.00031190	0.00019203	0.00010303	0.00012255	0.00006751	0.00022685	0.00060697
34	0.00005109	0.00031175	0.00039216	0.00000000	0.00000000	0.00044276	0.00000000	0.00000000	0.00012164	0.00080220
35	0.00000639	0.00013361	0.00038082	0.00000000	0.00001159	0.00001393	0.00002996	0.00000000	0.00000000	0.00085138
36	0.00322327	0.00062721	0.00266916	0.00095935	0.00292682	0.00083227	0.00018246	0.00131517	0.00038575	0.00390679
37	0.00700281	0.01604756	0.01027087	0.02145762	0.00880291	0.01285152	0.01278322	0.00606077	0.04682635	0.01059523
38	0.00409375	0.00521991	0.00325626	0.00873326	0.00251522	0.00902355	0.00791667	0.00260158	0.00582905	0.00636110
39	0.00104483	0.00198182	0.00114133	0.00597399	0.00077609	0.00835470	0.00425926	0.00069134	0.01216988	0.00162422
40	0.00040618	0.00014103	0.00011901	0.00235672	0.00025507	0.00104362	0.00092048	0.00038505	0.00149808	0.00058128
41	0.01786882	0.02198004	0.02338771	0.02413525	0.01321524	0.01583534	0.02089597	0.01515441	0.00953864	0.02364257
42	0.00745050	0.00758956	0.00937095	0.01094697	0.01982249	0.01461847	0.01391340	0.01663710	0.02378742	0.00995523
43	0.01281773	0.01616508	0.02011332	0.02498707	0.03239497	0.05951789	0.03016885	0.08278045	0.03403949	0.02937688
44	0.00081556	0.00038783	0.00060070	0.00063957	0.00531595	0.00092238	0.00040305	0.00086011	0.00044712	0.00081468
45	0.22550773	0.23510943	0.26872915	0.17818949	0.30355116	0.13741547	0.17674292	0.14964389	0.03956169	0.23133945
46	0.26348831	0.18914897	0.12166030	0.14254033	0.06354429	0.13210849	0.12013889	0.05954002	0.50906576	0.17538349
47	0.24651935	0.23937740	0.29944429	0.20740919	0.35478312	0.33749730	0.24836601	0.52919181	0.11693163	0.25871560
48	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000

44-Sector

COEFFICIENT MATRIX

ROW/COL	21 GLASS,STON E,CLAY	22 FOUNDRIES, METAL PROD	23 IRON,STEEL MANUFACT.	24 HTNG,PLMBG .FAB PROD	25 SCREW MACH PROD	26 METAL STAMPINGS	27 FAB METAL PROD	28 ENGINES & TURBINES	29 FARM & CONST MACH	30 METALWORKI NG MACH
1	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
2	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
3	0.04316306	0.02507465	0.08754542	0.00003694	0.00000000	0.00000000	0.00023216	0.00000000	0.00000000	0.00000000
4	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
5	0.00927107	0.00298339	0.01623296	0.00315024	0.00134363	0.01200665	0.00224295	0.00293582	0.00381422	0.00241297
6	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
7	0.00014044	0.00000000	0.00000000	0.00000000	0.00003431	0.00000000	0.00001024	0.00000000	0.00000000	0.00000000
8	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000419	0.00000000	0.00000000	0.00000000
9	0.00001034	0.00020467	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
10	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
11	0.00188437	0.00027601	0.00032264	0.00033719	0.00014151	0.00141286	0.00075509	0.00018061	0.00036097	0.00024791
12	0.00302947	0.00182699	0.00313796	0.00172644	0.00005432	0.01209245	0.00287429	0.00000000	0.00129596	0.00047185
13	0.00107358	0.00003070	0.00002577	0.00218992	0.00002573	0.00335576	0.00112590	0.00029305	0.00044436	0.00007672
14	0.03071776	0.00110101	0.00070192	0.00525676	0.00199686	0.02856227	0.00972830	0.00273396	0.00135622	0.00086075
15	0.00020507	0.00026246	0.00008909	0.00008340	0.00004002	0.00058512	0.00449707	0.00004869	0.00010348	0.00007864
16	0.01821387	0.00501987	0.01620782	0.00700940	0.00074471	0.01535608	0.01321718	0.00101018	0.00190346	0.00146830
17	0.00216009	0.00226914	0.00001145	0.00000000	0.00000000	0.00422078	0.00019308	0.00000000	0.00000000	0.00005131
18	0.00015251	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000326	0.00000000	0.00000000	0.00000000
19	0.00248837	0.00063599	0.00208890	0.00080662	0.00037164	0.00122345	0.00079371	0.00127225	0.00106160	0.00117052
20	0.00793556	0.00109439	0.00090333	0.00103777	0.00154517	0.00997327	0.00587978	0.00108721	0.01316472	0.00361534
21	0.09040676	0.00151668	0.00149567	0.00608006	0.00111636	0.00617656	0.00316972	0.00659231	0.00486730	0.00628560
22	0.00294417	0.15122807	0.03305393	0.05043840	0.25875431	0.00000000	0.04450500	0.07470221	0.06705442	0.03020522
23	0.00730743	0.02695823	0.23352020	0.18578317	0.00000000	0.00000000	0.10986141	0.02082695	0.07344595	0.02865684
24	0.00070998	0.00155520	0.00017023	0.01947216	0.00049743	0.00735829	0.00310040	0.00290306	0.00691441	0.00223506
25	0.00002154	0.00577501	0.00000000	0.01203859	0.00415667	0.01390782	0.00531311	0.00704472	0.00799367	0.00457226
26	0.00017405	0.00000000	0.00000000	0.00662694	0.00108062	0.03508765	0.00640644	0.00729173	0.00640431	0.02104871
27	0.00634241	0.00532356	0.01503085	0.01886689	0.00494570	0.03036638	0.03074953	0.01198763	0.01412345	0.01097439
28	0.00069792	0.00031694	0.00000000	0.00209937	0.00114351	0.00052182	0.00073462	0.08201697	0.04492939	0.00053035
29	0.00424350	0.00166446	0.00231640	0.00511378	0.00067753	0.00275915	0.00222853	0.03276677	0.08056611	0.00275103
30	0.00553121	0.00741121	0.00606306	0.00419516	0.01205835	0.02490809	0.00950591	0.00999559	0.01604638	0.04155642
31	0.00358436	0.01154798	0.01571686	0.02942806	0.01195830	0.02278281	0.01198335	0.05142816	0.07990261	0.02585162
32	0.00000000	0.00000000	0.00014350	0.00021923	0.00004002	0.00233344	0.00002512	0.00000000	0.00002009	0.00004508
33	0.00147338	0.00419697	0.00658107	0.00606576	0.00053602	0.00851258	0.00727645	0.01842323	0.01113769	0.01005322
34	0.00085559	0.00406664	0.00000000	0.00359585	0.00394369	0.08374695	0.00351121	0.01716338	0.01013818	0.00612418
35	0.00001551	0.00007224	0.00007573	0.00204694	0.00013007	0.00087510	0.01040849	0.01335638	0.00187911	0.00056776
36	0.00164656	0.00033801	0.00142102	0.00240796	0.00041881	0.00716864	0.00280497	0.00068349	0.00275444	0.00083869
37	0.02839654	0.05276097	0.00000000	0.01041938	0.02499721	0.00000000	0.00804132	0.00573175	0.00920867	0.00126105
38	0.01187921	0.00790152	0.01721616	0.00358632	0.00195255	0.01448989	0.00370615	0.00249934	0.00357925	0.00281241
39	0.01706705	0.00477577	0.01688334	0.00229000	0.00080332	0.00462328	0.00178096	0.00097300	0.00173545	0.00090678
40	0.00015235	0.00049332	0.00141966	0.00022519	0.00010006	0.00145459	0.00033498	0.00029305	0.00033540	0.00023832
41	0.01908239	0.01926831	0.03595039	0.02180267	0.00512294	0.03911362	0.01371546	0.02176985	0.02836377	0.01443607
42	0.01451750	0.00525072	0.00658139	0.01048492	0.00434964	0.01814594	0.00658882	0.00446570	0.01261200	0.00759806
43	0.02755732	0.00642277	0.00000000	0.02062788	0.00463695	0.00000000	0.02108217	0.01545997	0.02816411	0.01385441
44	0.00081768	0.00028624	0.00074074	0.00048135	0.00023013	0.00083361	0.00049037	0.00048163	0.00070855	0.00037978
45	0.21764623	0.26574171	0.16975292	0.24055732	0.22841689	0.24042367	0.26798189	0.17237746	0.17281471	0.36861016
46	0.11082122	0.16416872	0.17734010	0.08596082	0.13447008	0.10775298	0.10975766	0.13155844	0.12698990	0.07172098
47	0.30535956	0.21017945	0.12822948	0.22745118	0.28716481	0.23786846	0.27337874	0.27764547	0.16380570	0.30910122
48	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000

44-Sector

COEFFICIENT MATRIX

ROW/COL	31 SPEC & GEN IND. MACH	32 OFFICE,ACC &COMP MACH	33 ELECTRICAL EQUIP	34 MOTOR VEH. & PARTS	35 ACFT,OTH. TRAN EQUIP	36 MISC. MANF	37 TRAN,WHSNG ,& COMM.	38 ELECTRICAL UTILITIES	39 GAS UTILIT IES	40 WATER & SANITARY S
1	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00002516	0.00000000	0.00000000	0.00000000
2	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00040544	0.00063635	0.00000000	0.00000000	0.00000000
3	0.00000000	0.00000000	0.00008313	0.00000000	0.00000000	0.00025958	0.00000945	0.00003280	0.00000000	0.00000000
4	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00031206	0.00000000	0.05152316	0.00000000
5	0.00253097	0.00225142	0.00312101	0.00272465	0.00309779	0.00269839	0.02266799	0.03642272	0.02619920	0.05121414
6	0.00005192	0.00000000	0.00000000	0.00000000	0.00000000	0.00075772	0.00055698	0.00000492	0.00000000	0.00000000
7	0.00006305	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00209128	0.00000000	0.00000000	0.00000000
8	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00012237	0.00000000	0.00001230	0.00000000	0.00000000
9	0.00000593	0.00000000	0.00000000	0.00000000	0.00000000	0.00000247	0.00002252	0.00000410	0.00000000	0.00000000
10	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00003545	0.00000410	0.00000000	0.00000000
11	0.00045434	0.00017293	0.00050290	0.00659842	0.00149928	0.00554016	0.00075589	0.00019395	0.00014778	0.00036022
12	0.00157295	0.00014300	0.00096540	0.00077784	0.01215084	0.00427440	0.00001654	0.00002296	0.00000000	0.00000000
13	0.00051814	0.00090788	0.00408524	0.00102121	0.00366928	0.00137701	0.00000000	0.00000410	0.00000000	0.00000000
14	0.00242081	0.00505821	0.00914232	0.00218305	0.00166188	0.02462664	0.00143353	0.00110670	0.00054400	0.00105239
15	0.00021549	0.01058534	0.00081728	0.00004377	0.00012434	0.00109641	0.00070988	0.00019477	0.00009555	0.00005650
16	0.00217528	0.00086133	0.00690006	0.00404225	0.00169416	0.01165634	0.00108352	0.00149542	0.00000000	0.00365866
17	0.00002782	0.00051547	0.00303202	0.00036399	0.00100908	0.00658836	0.00000000	0.00005577	0.00000000	0.00000000
18	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00153275	0.00000000	0.00000000	0.00000000	0.00000000
19	0.00123618	0.00032258	0.00067560	0.00060098	0.00110234	0.00057602	0.00733735	0.00518210	0.00045227	0.00086875
20	0.00353571	0.00406719	0.00886950	0.01286937	0.00583331	0.01355744	0.00194046	0.00064499	0.00004332	0.00044497
21	0.00638973	0.00067842	0.01189391	0.00975459	0.00340984	0.00464647	0.00064691	0.00002378	0.00000000	0.00000000
22	0.03861061	0.00947792	0.03158069	0.03789939	0.03602809	0.02222739	0.01375979	0.00032106	0.00000000	0.00000000
23	0.03744452	0.00815101	0.02271821	0.03242006	0.02353889	0.01324348	0.00000000	0.00082254	0.00143771	0.00000000
24	0.01165825	0.00280679	0.00134594	0.00067148	0.01230268	0.00050185	0.00000000	0.00000410	0.00000000	0.00000000
25	0.00491988	0.00208847	0.00721093	0.00664008	0.00751791	0.00444869	0.00101791	0.00000000	0.00000000	0.00000000
26	0.00356131	0.00832394	0.01033780	0.04536420	0.00571136	0.00473299	0.00000000	0.00000000	0.00000000	0.00000000
27	0.01395074	0.00564019	0.01222117	0.02143000	0.02273904	0.01211122	0.00197619	0.00067452	0.00000000	0.00209772
28	0.00483569	0.00000000	0.00221064	0.00716516	0.01452649	0.00000000	0.00096231	0.00006069	0.00000000	0.00000000
29	0.00655292	0.00009977	0.00095311	0.00243110	0.00284313	0.00095673	0.00001793	0.00003198	0.00000000	0.00000000
30	0.01352866	0.01011643	0.00746326	0.00889962	0.01187825	0.00249196	0.00005310	0.00000000	0.00000000	0.00000000
31	0.06756096	0.01598276	0.00931854	0.02775518	0.03497835	0.00417799	0.00177811	0.00128671	0.00000000	0.00266277
32	0.00017506	0.06444651	0.00168374	0.00000994	0.00009087	0.00055006	0.00000000	0.00000000	0.00000000	0.00000000
33	0.02892773	0.07034942	0.07672731	0.01252471	0.01738038	0.01404817	0.00250801	0.00164796	0.00003312	0.00002119
34	0.00588087	0.00023612	0.00435630	0.26388725	0.00941651	0.00210383	0.00074310	0.00011153	0.00000000	0.00000000
35	0.00206550	0.00005653	0.00176102	0.00037145	0.05035372	0.00104944	0.00214980	0.00000000	0.00000000	0.00000000
36	0.00242118	0.00136682	0.00401264	0.00193632	0.00611069	0.02553517	0.00048581	0.00000328	0.00000000	0.00000000
37	0.00578332	0.00548721	0.00725660	0.00993847	0.00802125	0.00677501	0.03324380	0.01616054	0.00211739	0.00266983
38	0.00296454	0.00181244	0.00383233	0.00275378	0.00313844	0.00256860	0.00661885	0.19161917	0.00009045	0.03999802
39	0.00108300	0.00040905	0.00112406	0.00100261	0.00081301	0.00068479	0.00157948	0.10763086	0.01575494	0.02901499
40	0.00016801	0.00007316	0.00047889	0.00043619	0.00051291	0.00013844	0.00087919	0.00218880	0.00001401	0.00113009
41	0.01925375	0.02575000	0.02068496	0.01638657	0.02021035	0.02125087	0.01322227	0.00642206	0.00089817	0.00290291
42	0.01021659	0.02282681	0.01093495	0.00445098	0.00961498	0.00984299	0.01804021	0.00571023	0.00804723	0.01341979
43	0.01684184	0.02210849	0.02784730	0.02995799	0.02384616	0.02962910	0.05013558	0.01043883	0.01221194	0.01476176
44	0.00047215	0.00060526	0.00070136	0.00068001	0.00065997	0.00077627	0.00993473	0.07769117	0.01859278	0.35603396
45	0.25995827	0.30129798	0.24231588	0.14533850	0.23421724	0.29567294	0.26400981	0.17933147	0.12634463	0.06791824
46	0.10908456	0.21434391	0.18183292	0.10560070	0.22525146	0.15378825	0.28927839	0.09249461	0.18430851	0.26260400
47	0.31088175	0.18057925	0.25900108	0.17306805	0.18304573	0.29097579	0.24732432	0.25993940	0.55114383	0.14710910
48	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000

44-Sector

COEFFICIENT MATRIX

ROW/COL	41 WHOLESALE & RETAIL	42 F.I.R.E.	43 SELECT SERVICES	44 GOVT ENTERPRISES	45 HOUSEHOLDS	46 IMPORTS/ EXPORTS	47 VALUE ADD/ INVESTMENT
1	0.00000000	0.00327966	0.00024901	0.00000000	0.00021047	0.00003376	0.00000244
2	0.00041383	0.00475036	0.00096517	0.00012330	0.00439834	0.00005975	-0.00120742
3	0.00002457	0.00029499	0.00000000	0.00016626	0.00054546	0.00733714	0.00771460
4	0.00000000	0.00027755	0.00000000	0.00000000	0.00000000	0.04525721	0.00000000
5	0.00353738	0.04930403	0.00973687	0.11740800	0.00000000	0.30547205	0.02935989
6	0.00047656	0.00006272	0.00120469	0.00000000	0.01888247	0.00022045	0.00032424
7	0.00087238	0.00019287	0.00026999	0.00000000	0.00974987	0.00114866	0.00023179
8	0.00036038	0.00006994	0.00000000	0.00000000	0.00920403	0.00247135	0.00012932
9	0.00079692	0.00009692	0.00033510	0.00000000	0.00361906	0.00481508	0.01545601
10	0.00030602	0.00023873	0.00005570	0.00000000	0.01092866	0.00259898	0.00003489
11	0.00060251	0.00020511	0.00065013	0.00055203	0.01474648	-0.00543002	0.00041988
12	0.00073336	0.00018921	0.00001723	0.00000000	0.00124422	0.00394488	0.00018508
13	0.00029489	0.00005472	0.00000000	0.00000000	0.00683119	0.00140391	0.00301536
14	0.00888256	0.00180568	0.00238108	0.00114702	0.00523000	0.00910804	0.00392203
15	0.00170674	0.00256511	0.04763336	0.00231833	0.00867086	0.00811022	0.00210870
16	0.00264879	0.00180770	0.00926973	0.00744629	0.02737977	0.03094413	0.00935397
17	0.00006954	0.00025559	0.00000000	0.00000000	0.00039446	0.00011603	0.00119876
18	0.00029489	0.00031214	0.00025010	0.00012610	0.00524975	0.00391008	0.00743936
19	0.00266970	0.00170847	0.00160856	0.00268261	0.00815399	-0.00048731	0.00098004
20	0.00275686	0.00062119	0.00463528	0.00148328	0.00616697	0.00154315	0.00053789
21	0.00145489	0.00037543	0.00232139	0.00037642	0.00247910	0.00670630	0.00045243
22	0.00027443	0.00033285	0.00002348	0.00032879	-0.00000199	0.01894704	-0.00000908
23	0.00016153	0.00039759	0.00000000	0.00000467	-0.00000030	0.01648729	-0.00001703
24	0.00102156	0.00032736	0.00000000	0.00001401	0.00024800	0.00029006	0.00041015
25	0.00007006	0.00004942	0.00272384	0.00000934	0.00040716	0.00165917	0.00371623
26	0.00023519	0.00005279	0.00000000	0.00035494	0.00105108	0.01580274	0.03303500
27	0.00141468	0.00025096	0.00284090	0.00037082	0.00046797	0.00375924	0.01471003
28	0.00024728	0.00012678	0.00084961	0.00086027	0.00030898	0.00584771	0.00954983
29	0.00048582	0.00043863	0.00209918	0.00057538	0.00006368	0.01001304	0.01197854
30	0.00032628	0.00012495	0.00028257	0.00004203	0.00012922	0.00917766	0.02018000
31	0.00144492	0.00117052	0.00499502	0.00036615	0.00079108	0.00805220	0.00226479
32	0.00021600	0.00124200	0.00018862	0.00007005	0.00009477	-0.00097462	0.00078087
33	0.00137435	0.00094576	0.00310223	0.00061928	0.00425163	0.00783175	0.00334693
34	0.00047810	0.00087765	0.00855099	0.00082290	0.02410601	0.20279022	0.44681373
35	0.00041281	0.00019894	0.00005412	0.00006258	0.00110136	0.00192603	0.00721027
36	0.00131722	0.00030241	0.00641651	0.00020269	0.00506502	0.00335315	0.00147298
37	0.01008456	0.00782270	0.01392291	0.04024285	0.02952086	0.02780714	0.05755178
38	0.00936683	0.00235847	0.00921953	0.04953764	0.01517244	0.00000000	0.00332481
39	0.00238188	0.00074788	0.00275273	0.01377826	0.01216096	0.00000000	0.00290241
40	0.00159037	0.00169132	0.00264342	0.00251354	0.00000475	0.00000000	0.00000834
41	0.01493756	0.00968185	0.02134839	0.00624229	0.19165017	0.06408336	0.00254768
42	0.03885777	0.06885866	0.03327302	0.02161498	0.11731155	0.01495749	0.00185884
43	0.06428710	0.04702812	0.06530689	0.03659630	0.09032148	-0.00002216	0.02016216
44	0.00917513	0.00814842	0.00532396	0.00093406	0.00493091	0.00000000	0.00111689
45	0.44986280	0.17490204	0.55057149	0.54370633	0.00826137	0.00000000	0.08677002
46	0.06210457	0.06063259	0.07032481	0.09740426	0.33966952	0.13443200	0.03503578
47	0.29893844	0.54282125	0.11130237	0.04889595	0.00882715	0.02449564	0.15161878
48	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000

44-Sector

COEFFICIENT MATRIX

ROW/COL	41 WHOLESALE & RETAIL	42 F.I.R.E.	43 SELECT SERVICES	44 GOVT ENTERPRISES	45 HOUSEHOLDS	46 IMPORTS/EXPORTS	47 VALUE ADD/INVESTMENT
1	0.00000000	0.00327966	0.00024901	0.00000000	0.00021047	0.00003376	0.00000244
2	0.00041383	0.00475036	0.00096517	0.00012330	0.00439834	0.00005975	-0.00120742
3	0.00002457	0.00029499	0.00000000	0.00016626	0.00054546	0.00733714	0.00771460
4	0.00000000	0.00027755	0.00000000	0.00000000	0.00000000	0.04525721	0.00000000
5	0.00353738	0.04930403	0.00973687	0.11740800	0.00000000	0.30547205	0.02935989
6	0.00047656	0.00006272	0.00120469	0.00000000	0.01888247	0.00022045	0.00032424
7	0.00087238	0.00019287	0.00026999	0.00000000	0.00974987	0.00114866	0.00023179
8	0.00036038	0.00006994	0.00000000	0.00000000	0.00920403	0.00247135	0.00012932
9	0.00079692	0.00009692	0.00033510	0.00000000	0.00361906	0.00481508	0.01545601
10	0.00030602	0.00023873	0.00005570	0.00000000	0.01092866	0.00259898	0.00003489
11	0.00060251	0.00020511	0.00065013	0.00055203	0.01474648	-0.00543002	0.00041988
12	0.00073336	0.00018921	0.00001723	0.00000000	0.00124422	0.00394488	0.00018508
13	0.00029489	0.00005472	0.00000000	0.00000000	0.00683119	0.00140391	0.00301536
14	0.00888256	0.00180568	0.00238108	0.00114702	0.00523000	0.00910804	0.00392203
15	0.00170674	0.00256511	0.04763336	0.00231833	0.00867086	0.00811022	0.00210870
16	0.00264879	0.00180770	0.00926973	0.00744629	0.02737977	0.03094413	0.00935397
17	0.00006954	0.00025559	0.00000000	0.00000000	0.00039446	0.00011603	0.00119876
18	0.00029489	0.00031214	0.00025010	0.00012610	0.00524975	0.00391008	0.00743935
19	0.00266970	0.00170847	0.00160856	0.00268261	0.00815399	-0.00048731	0.00098004
20	0.00275686	0.00062119	0.00463528	0.00148328	0.00616697	0.00154315	0.00053789
21	0.00145489	0.00037543	0.00232139	0.00037642	0.00247910	0.00670630	0.00045243
22	0.00027443	0.00033285	0.00002348	0.00032879	-0.00000199	0.01894704	-0.00000908
23	0.00016153	0.00039759	0.00000000	0.00000467	-0.00000030	0.01648729	-0.00001703
24	0.00102156	0.00032736	0.00000000	0.00001401	0.00024800	0.00029006	0.00041015
25	0.00007006	0.00004942	0.00272384	0.00000934	0.00040716	0.00165917	0.00371623
26	0.00023519	0.00005279	0.00000000	0.00035494	0.00105108	0.01580274	0.03303500
27	0.00141468	0.00025096	0.00284090	0.00037082	0.00046797	0.00375924	0.01471003
28	0.00024728	0.00012678	0.00084961	0.00086027	0.00030898	0.00584771	0.00954983
29	0.00048582	0.00043863	0.00209918	0.00057538	0.00006368	0.01001304	0.01197854
30	0.00032628	0.00012495	0.00028257	0.00004203	0.00012922	0.00917766	0.02018000
31	0.00144492	0.00117052	0.00499502	0.00036615	0.00079108	0.00805220	0.00226479
32	0.00024600	0.00124200	0.00048862	0.00007005	0.00009477	-0.00097462	0.00078087
33	0.00137435	0.00094576	0.00310223	0.00061928	0.00425163	0.00783175	0.00334693
34	0.00047810	0.00087765	0.00855099	0.00082290	0.02410601	0.20279022	0.44681373
35	0.00041281	0.00019894	0.00005412	0.00006258	0.00110136	0.00192603	0.00721027
36	0.00131722	0.00030241	0.00641651	0.00020269	0.00506502	0.00335315	0.00147298
37	0.01008456	0.00782270	0.01392291	0.04024285	0.02952086	0.02780714	0.05755178
38	0.00936683	0.00235847	0.00921953	0.04953764	0.01517244	0.00000000	0.00332481
39	0.00238188	0.00074788	0.00275273	0.01377826	0.01216096	0.00000000	0.00290241
40	0.00159037	0.00169132	0.00264342	0.00251354	0.00000475	0.00000000	0.00000834
41	0.01493756	0.00968185	0.02134839	0.00624229	0.19165017	0.06408336	0.00254768
42	0.03885777	0.06885866	0.03327302	0.02161498	0.11731155	0.01495749	0.00185884
43	0.06428710	0.04702812	0.06530689	0.03659630	0.09032148	-0.00002216	0.02016216
44	0.00917513	0.00814842	0.00532396	0.00093406	0.00493091	0.00000000	0.00111689
45	0.44986280	0.17490204	0.55057149	0.54370633	0.00826137	0.00000000	0.08677002
46	0.06210457	0.06063259	0.07032481	0.09740426	0.33966952	0.13443200	0.03503578
47	0.29893844	0.54282125	0.11130237	0.04889595	0.00882715	0.02449564	0.15161878
48	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000

Table A 2.3

44-Sector

LEONTIEF MATRIX

ROW/COL	1 LIVESTOCK AND PRODS.	2 OTHER AGRI PRODUCTS	3 METAL & MIN MINING	4 CRUDE PETR & NAT GAS	5 CONSTRUCTI ON	6 MEAT PRODUCTS	7 DAIRY PRODUCTS	8 PRESERVED FOOD	9 GRAINS,BAK ERY,SUGAR	10 BEVERAGES
1	0.89950550	-0.02605330	0.00000000	0.00000000	0.00000000	-0.35985364	-0.09381783	-0.00008193	0.00000000	0.00000000
2	-0.16174773	0.94804344	0.00000000	0.00000000	-0.00141769	-0.00009452	-0.00142610	-0.10008996	-0.09988514	-0.02506310
3	-0.00004172	-0.00295027	0.90702651	0.00000000	-0.00645973	-0.00010077	-0.00000133	0.00000000	-0.00048525	0.00000000
4	0.00000000	0.00000000	0.00000000	0.99539936	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
5	-0.00623379	-0.01009874	-0.01652422	-0.02580003	0.99968873	-0.00205843	-0.00227830	-0.00392312	-0.00230775	-0.00742343
6	-0.00018028	0.00000000	0.00000000	0.00000000	0.00000000	0.99411687	-0.00071638	-0.02389794	-0.00102785	-0.00000970
7	-0.00562143	-0.00030440	0.00000000	0.00000000	0.00000000	-0.00004218	0.91404504	-0.00166378	-0.00979321	-0.00260291
8	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	-0.00011640	-0.00011451	0.96965018	-0.01227528	-0.00892725
9	-0.09278123	-0.00094784	0.00000000	0.00000000	0.00000000	-0.00004687	-0.01016115	-0.05070120	0.93767348	-0.00826058
10	-0.00027563	-0.00009233	0.00000000	0.00000000	0.00000000	-0.00003906	-0.00111052	-0.00381441	-0.00110859	0.96781888
11	-0.00012068	-0.00228953	-0.00110568	-0.00011285	-0.00103511	-0.00089680	-0.00022903	-0.00039704	-0.00135461	-0.00015939
12	-0.00008641	-0.00188558	-0.00264798	0.00000000	-0.03397075	-0.00063354	0.00000000	-0.00029620	0.00000000	-0.00563965
13	0.00000000	0.00000000	0.00000000	0.00000000	-0.00576053	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
14	-0.00050806	-0.00344367	-0.00460126	-0.00005208	-0.00255908	-0.01582219	-0.03136493	-0.02778325	-0.01732319	-0.02665977
15	-0.00018177	-0.00031883	-0.00007159	-0.00002778	-0.00001740	-0.00248730	-0.00161785	-0.00816292	-0.00108520	-0.00974638
16	-0.00199052	-0.05657168	-0.02598570	-0.00789574	-0.01195204	-0.00663151	-0.00114914	-0.00683631	-0.00706663	-0.00559668
17	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	-0.00138083	-0.00054987	0.00000000	0.00000000
18	-0.00095056	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	-0.00002663	-0.00003781	-0.00337710	-0.00092308
19	-0.00182812	-0.00994870	-0.00562651	-0.00067881	-0.00718235	-0.00043981	-0.00135686	-0.00043485	-0.00024225	-0.00127097
20	-0.00088650	-0.00338019	-0.00848926	-0.00131596	-0.00541962	-0.00751894	-0.00294142	-0.00568143	-0.00128896	-0.00216217
21	-0.00022200	-0.00071268	-0.02064732	-0.00463710	-0.06271515	-0.00020389	-0.00047404	-0.01694189	-0.00001585	-0.08104516
22	-0.00003129	-0.00002308	-0.00634330	0.00000000	-0.02208761	0.00000000	-0.00032490	0.00000000	0.00000000	0.00000000
23	0.00000000	0.00000000	-0.02312030	-0.00661450	-0.01382278	-0.00008593	0.00000000	0.00000000	0.00000000	-0.00014414
24	0.00000000	0.00000000	-0.00090947	-0.00278122	-0.08161028	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
25	0.00000000	0.00000000	-0.00171818	0.00000000	-0.00054572	0.00000000	-0.00282824	0.00000000	0.00000000	0.00000000
26	-0.00070026	0.00000000	0.00000000	0.00000000	-0.00010559	0.00000000	0.00000000	0.00000000	0.00000000	-0.01315948
27	-0.00118895	-0.00291853	-0.00287070	-0.00287670	-0.01369565	-0.00659870	-0.00570175	-0.03769818	-0.00460870	-0.07849214
28	0.00000000	-0.00018611	-0.00980441	-0.00378294	-0.00133501	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
29	-0.00025328	-0.00959813	-0.01515869	-0.00308503	-0.00634517	-0.00006796	-0.00009587	-0.00006775	-0.00011773	-0.00008593
30	0.00000000	0.00000000	-0.00082904	-0.00027083	-0.00001895	-0.00054136	-0.00051398	-0.00087128	-0.00050411	-0.00077200
31	-0.00015495	-0.00017456	-0.01812132	-0.00965787	-0.01249294	-0.00260839	-0.00123569	-0.00142272	-0.00106107	-0.00168538
32	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
33	-0.00022498	-0.00068527	-0.00109773	-0.00519438	-0.01234824	-0.00001875	-0.00003196	-0.00002521	-0.00001660	-0.00003049
34	-0.00021753	-0.00024381	-0.00110126	0.00000000	-0.00003549	0.00000000	-0.00011318	0.00000000	0.00000000	-0.00004297
35	-0.00000149	-0.00020919	-0.00016705	0.00000000	-0.00000258	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
36	-0.00002980	-0.00009954	-0.00018826	-0.00027083	-0.00222507	-0.00015936	-0.00010253	-0.00008823	-0.00002038	-0.00006514
37	-0.01315889	-0.01015067	-0.01925705	-0.00473258	-0.01502911	-0.00381532	-0.07629048	0.00000000	-0.01182852	-0.00906308
38	-0.00236151	-0.00201253	-0.02650098	-0.00598777	-0.00039017	-0.00373642	-0.00273370	-0.00229873	-0.00565390	-0.00358143
39	-0.00024286	-0.00027844	-0.01008105	-0.00245830	-0.00009509	-0.00233497	-0.00223969	-0.00244683	-0.00200513	-0.00167706
40	-0.00016836	-0.00454587	-0.00107651	-0.00070659	-0.00016847	-0.00057105	-0.00029161	-0.00055617	-0.00019621	-0.00115038
41	-0.03026158	-0.03527489	-0.01570402	-0.00735581	-0.05806191	-0.01724005	-0.01998674	-0.03701597	-0.02769070	-0.02654058
42	-0.01411840	-0.04602860	-0.04456749	-0.08559445	-0.00783315	-0.00495117	-0.00727698	-0.00641564	-0.00333559	-0.01583786
43	-0.01207424	-0.04292540	-0.04081826	-0.01580363	-0.05014435	-0.01342003	-0.01334890	0.00000000	-0.02640250	-0.11490383
44	-0.00009088	-0.00009522	-0.00070353	-0.00022743	-0.00041549	-0.00044918	-0.00063515	-0.00047582	-0.00031696	-0.00097159

44-Sector

LEONTIEF MATRIX

ROW/COL	11 TEXTILE & APPAREL	12 LUMBER AND WOOD PROD	13 FURNITURE	14 PAPER & ALLIED PROD.	15 PRINTING, PUBLISHING	16 CHEM.ALLIED PROD.	17 PLASTICS & SYN. MAT.	18 DRUGS	19 PETROLEUM REFINERY	20 RUBBER & LEATHER
1	-0.00172372	0.00000000	0.00000000	0.00000000	0.00000000	-0.00010772	0.00000000	-0.00020753	0.00000000	-0.00029431
2	-0.00965449	-0.04390256	0.00000000	0.00000000	0.00000000	-0.00138603	-0.00002996	-0.00011626	0.00000000	0.00000000
3	-0.00001086	-0.00008722	0.00000000	-0.00250141	0.00000000	-0.01186852	-0.00007081	0.00000000	-0.00213589	-0.00051450
4	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	-0.00028712	0.00000000	0.00000000	-0.10584669	0.00000000
5	-0.00187572	-0.00464281	-0.00323812	-0.00755827	-0.00283334	-0.00578619	-0.00699619	-0.00468059	-0.01815125	-0.00332037
6	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	-0.00105550	0.00000000	-0.00163271	-0.00004822	-0.00675743
7	0.00000000	0.00000000	-0.00017454	0.00000000	0.00000000	-0.00101495	-0.00238834	-0.00030629	-0.00058959	-0.00000807
8	-0.00006834	0.00000000	0.00000000	-0.00033893	0.00000000	-0.00260577	0.00000000	-0.00030629	0.00000000	0.00000000
9	-0.00054158	0.00000000	0.00000000	-0.00468022	0.00000000	-0.00235920	0.00000000	-0.00214152	0.00000000	-0.00003596
10	-0.00000128	-0.00001670	0.00000000	0.00000000	0.00000000	-0.00006717	0.00000000	-0.00015377	0.00000000	0.00000000
11	0.86843914	-0.00095009	-0.01912159	-0.00414368	-0.00132029	-0.00043006	-0.00217320	-0.00012752	-0.00004603	-0.02269578
12	-0.00021523	0.83746831	-0.06016087	-0.03988461	-0.00012246	-0.00097973	-0.00051471	0.00000000	-0.00004822	-0.00343560
13	-0.00022800	-0.00253666	0.97810498	-0.00009965	-0.00013696	0.00000000	0.00000000	0.00000000	0.00000000	-0.00060550
14	-0.00706987	-0.00601969	-0.01107559	0.76236052	-0.10738059	-0.01735899	-0.03427560	-0.01342795	-0.00667398	-0.01963596
15	-0.00029378	-0.00013361	-0.00019381	-0.00578257	0.94266586	-0.00050788	-0.00019336	-0.00072884	-0.00008986	-0.00014037
16	-0.00867097	-0.01210804	-0.01029581	-0.03101511	-0.01100581	0.86762406	-0.26782952	-0.04270289	-0.02509701	-0.02496807
17	-0.03853813	-0.00069215	-0.00066757	-0.00635740	-0.00097174	-0.01705795	0.98135076	-0.00071259	-0.00014466	-0.08234569
18	0.00000000	0.00000000	0.00000000	-0.00018466	-0.00001087	-0.00739217	-0.00001362	0.95757589	-0.00001205	-0.00031633
19	-0.00033274	-0.00237151	-0.00037402	-0.00231674	-0.00043841	-0.01629735	-0.00435458	-0.00056507	0.97268709	-0.00048661
20	-0.00346277	-0.00253109	-0.02000224	-0.00906261	-0.00176739	-0.00627647	-0.01281046	-0.00737218	-0.00168877	0.95047046
21	-0.00143952	-0.00630732	-0.00814915	-0.00139005	0.00000000	-0.00537907	-0.00065632	-0.00899239	-0.00247124	-0.00496587
22	-0.00001852	-0.00069215	-0.00432845	-0.00075104	-0.00090362	-0.00798320	-0.00285675	-0.00020878	-0.00134904	-0.00059890
23	-0.00000128	-0.00205234	-0.03136798	-0.00142439	-0.00030507	-0.00364078	0.00000000	0.00000000	-0.00029589	-0.00200220
24	-0.00000894	-0.00104472	-0.00120594	-0.00001070	0.00000000	-0.00003809	-0.00004085	0.00000000	-0.00008986	-0.00048410
25	0.00000000	-0.00123029	-0.00489062	0.00000000	-0.00003188	0.00000000	0.00000000	0.00000000	0.00000000	-0.00138716
26	-0.00062907	-0.00190017	-0.00172163	-0.00004391	-0.00003188	-0.00097276	-0.00008170	-0.00096387	-0.00000438	-0.00339303
27	-0.00051477	-0.00904438	-0.03265326	-0.00922138	-0.00632465	-0.01744160	-0.00132898	-0.00666584	-0.00378959	-0.01022459
28	0.00000000	0.00000000	-0.00006800	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
29	-0.00005812	-0.00051772	-0.00143148	-0.00070994	-0.00001667	-0.00061724	-0.00025599	-0.00006751	-0.00074740	-0.00041688
30	-0.00084813	-0.00095380	-0.00205259	-0.00253406	-0.00038696	-0.00053205	-0.00183007	-0.00019252	-0.00020384	-0.00390606
31	-0.00175757	-0.00277604	-0.00224073	-0.00362741	-0.00056160	-0.00725988	-0.00580610	-0.00037380	-0.00273425	-0.00263119
32	0.00000000	-0.00000928	-0.00010994	-0.00008107	-0.00000870	-0.00003686	0.00000000	0.00000000	0.00000000	-0.00004257
33	-0.00014944	-0.00042680	-0.00104499	-0.00031190	-0.00019203	-0.00040303	-0.00012255	-0.00006751	-0.00022685	-0.00060697
34	-0.00005109	-0.00031175	-0.00039216	0.00000000	0.00000000	-0.00044276	0.00000000	0.00000000	-0.00012164	-0.00080220
35	-0.00000639	-0.00013361	-0.00038082	0.00000000	-0.00001159	-0.00001393	-0.00002996	0.00000000	0.00000000	-0.00085138
36	-0.00322327	-0.00062721	-0.00266916	-0.00095935	-0.00292682	-0.00083227	-0.00018246	-0.00131517	-0.00038575	-0.00390679
37	-0.00700281	-0.01604756	-0.01027087	-0.02145762	-0.00880291	-0.01285152	-0.01278322	-0.00606077	-0.04682635	-0.01059523
38	-0.00409375	-0.00521991	-0.00325626	-0.00873326	-0.00251522	-0.00902355	-0.00791667	-0.00260158	-0.00582905	-0.00636110
39	-0.00104483	-0.00198182	-0.00114133	-0.00597399	-0.00077609	-0.00835470	-0.00425926	-0.00069134	-0.01216988	-0.00162422
40	-0.00040618	-0.00014103	-0.00011901	-0.00235672	-0.00025507	-0.00104362	-0.00092048	-0.00038505	-0.00149808	-0.00058128
41	-0.01786882	-0.02198004	-0.02338771	-0.02413525	-0.01321524	-0.01583534	-0.02089597	-0.01515441	-0.00953864	-0.02364257
42	-0.00745050	-0.00758956	-0.00937095	-0.01094697	-0.01982249	-0.01461847	-0.01391340	-0.01663710	-0.02378742	-0.00995523
43	-0.01281773	-0.01646508	-0.02011332	-0.02498707	-0.03239497	-0.05951789	-0.03016885	-0.08278045	-0.03403949	-0.02937688
44	-0.00081556	-0.00038783	-0.00060070	-0.00063957	-0.00531595	-0.00092238	-0.00040305	-0.00086011	-0.00014712	-0.00081468

44-Sector

LEONTIEF MATRIX

ROW/COL	21 GLASS,STON E,CLAY	22 FOUNDRIES, METAL PROD	23 IRON,STEEL MANUFACT.	24 HTNG,PLMBG FAB PROD	25 SCREW MACH PROD	26 METAL STAMPINGS	27 FAB METAL PROD	28 ENGINES & TURBINES	29 FARM'S CONST MACH	30 METALWORKI NG MACH
1	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
2	0.00000000	-0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
3	-0.04316306	-0.02507465	-0.08754542	-0.00003694	0.00000000	0.00000000	-0.00023216	0.00000000	0.00000000	0.00000000
4	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
5	-0.00927107	-0.00298339	-0.01623296	-0.00315024	-0.00134363	-0.01200665	-0.00224295	-0.00293582	-0.00381422	-0.00241297
6	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
7	-0.00014044	0.00000000	0.00000000	0.00000000	-0.00003431	0.00000000	-0.00001024	0.00000000	0.00000000	0.00000000
8	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	-0.00000419	0.00000000	0.00000000	0.00000000
9	-0.00001034	-0.00020467	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
10	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
11	-0.00188437	-0.00027601	-0.00032264	-0.00033719	-0.00014151	-0.00141286	-0.00075509	-0.00018061	-0.00036097	-0.00024791
12	-0.00302947	-0.00182699	-0.00313796	-0.00172644	-0.00005432	-0.01209245	-0.00287429	0.00000000	-0.00129596	-0.00047185
13	-0.00107358	-0.00003070	-0.00002577	-0.00218992	-0.00002573	-0.00335576	-0.00112590	-0.00029305	-0.00044436	-0.00007672
14	-0.03071776	-0.00110101	-0.00070192	-0.00525676	-0.00199686	-0.02856227	-0.00972830	-0.00273396	-0.00135622	-0.00086075
15	-0.00020507	-0.00026246	-0.00008909	-0.00008340	-0.00004002	-0.00058512	-0.00449707	-0.00004869	-0.00010348	-0.00007864
16	-0.01821387	-0.00501987	-0.01620782	-0.00700940	-0.00074471	-0.01535608	-0.01321718	-0.00101018	-0.00190346	-0.00146830
17	-0.00216009	-0.00226914	-0.00001145	0.00000000	0.00000000	-0.00422078	-0.00019308	0.00000000	0.00000000	-0.00005131
18	-0.00015251	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	-0.00000326	0.00000000	0.00000000	0.00000000
19	-0.00248837	-0.00063599	-0.00208890	-0.00080662	-0.00037164	-0.00122345	-0.00079371	-0.00127225	-0.00106160	-0.00117052
20	-0.00793556	-0.00109439	-0.00080330	-0.00103777	-0.00154517	-0.00997327	-0.00587978	-0.00108721	-0.01316472	-0.00361534
21	0.90959324	-0.00151668	-0.00449567	-0.00608006	-0.00111636	-0.00617656	-0.00316972	-0.00659231	-0.00486730	-0.00628560
22	-0.00294417	0.84877193	-0.03005998	-0.05048840	-0.25875431	0.00000000	-0.04450500	-0.07470221	-0.06705442	-0.03020522
23	-0.00730743	-0.02695823	0.76647980	-0.18578317	0.00000000	0.00000000	-0.10986141	-0.02082695	-0.07344595	-0.02865684
24	-0.00070998	-0.00155520	-0.00017020	0.98052784	-0.00049743	-0.00735829	-0.00310040	-0.00290306	-0.00691441	-0.00223506
25	-0.00002154	-0.00577504	0.00000000	-0.01203859	0.99584333	-0.01390782	-0.00531311	-0.00704172	-0.00799367	-0.00457226
26	-0.00017405	0.00000000	0.00000000	-0.00662694	-0.00108062	0.96491235	-0.00640644	-0.00729173	-0.00640431	-0.02104871
27	-0.00634241	-0.00532356	-0.01503085	-0.01886689	-0.00494570	-0.03036638	0.96925047	-0.01198763	-0.01412345	-0.01097439
28	-0.00069792	-0.00031694	0.00000000	-0.00209937	-0.00114351	-0.00052182	-0.00073462	0.91798303	-0.04492939	-0.00053035
29	-0.00424350	-0.00166446	-0.00231640	-0.00511378	-0.00067753	-0.00275915	-0.00222853	-0.03276677	0.91943389	-0.00275103
30	-0.00553421	-0.00741121	-0.00606306	-0.00419516	-0.01205835	-0.02490809	-0.00950591	-0.00999559	-0.01604638	0.95544358
31	-0.00358436	-0.01154798	-0.01571686	-0.02942806	-0.01195830	-0.02278281	-0.01198335	-0.05142816	-0.07990261	-0.02585162
32	0.00000000	0.00000000	-0.00014350	-0.00021923	-0.00004002	-0.00233344	-0.00002512	0.00000000	-0.00002009	-0.00001508
33	-0.00147338	-0.00419697	-0.00658107	-0.00606576	-0.00053602	-0.00851258	-0.00727645	-0.01842323	-0.01113769	-0.01005322
34	-0.00085559	-0.00406664	0.00000000	-0.00359585	-0.00394369	-0.08374695	-0.00351121	-0.01716338	-0.01013818	-0.00642418
35	-0.00001551	-0.00007224	-0.00007573	-0.00204694	-0.00013007	-0.00087510	-0.01040849	-0.01335638	-0.00187911	-0.00056776
36	-0.00164656	-0.00033801	-0.00142102	-0.00240796	-0.00041881	-0.00716864	-0.00280497	-0.00068349	-0.00275444	-0.00083869
37	-0.02839654	-0.05276097	0.00000000	-0.01041938	-0.02499721	0.00000000	-0.00804132	-0.00573175	-0.00920867	-0.00426105
38	-0.01187921	-0.00790152	-0.01721616	-0.00358632	-0.00195255	-0.01448989	-0.00370615	-0.00249934	-0.00357925	-0.00281241
39	-0.01706705	-0.00477577	-0.01688334	-0.00229000	-0.00080332	-0.00462328	-0.00178096	-0.00097300	-0.00173545	-0.00090678
40	-0.00045235	-0.00049332	-0.00144966	-0.00022519	-0.00010006	-0.00145459	-0.00033498	-0.00029305	-0.00033540	-0.00023832
41	-0.01908239	-0.01926831	-0.03595039	-0.02180267	-0.00512294	-0.03911362	-0.01371546	-0.02176985	-0.02836377	-0.01443607
42	-0.01451750	-0.00525072	-0.00658139	-0.01048492	-0.00434964	-0.01814594	-0.00658882	-0.00446570	-0.01261200	-0.00759806
43	-0.02755732	-0.00642277	0.00000000	-0.02062788	-0.00463695	0.00000000	-0.02108217	-0.01545997	-0.02816411	-0.01385441
44	-0.00081768	-0.00028624	-0.00074074	-0.00048135	-0.00023013	-0.00083361	-0.00049037	-0.00048163	-0.00070855	-0.00037978

44-Sector

LEONTIEF MATRIX

ROW/COL	31 SPEC & GEN IND. MACH	32 OFFICE,ACC &COMP MACH	33 ELECTRICAL EQUIP	34 MOTOR VEH. & PARTS	35 ACFT,OTH. TRAN EQUIP	36 MISC. MANF	37 TRAN,WHSNG ,& COMM.	38 ELECTRICAL UTILITIES	39 GAS UTILIT IES	40 WATER & SANITARY S
1	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	-0.00002516	0.00000000	0.00000000	0.00000000
2	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	-0.00040544	-0.00063636	0.00000000	0.00000000	0.00000000
3	0.00000000	0.00000000	-0.00008313	0.00000000	0.00000000	-0.00025958	-0.00000945	-0.00003280	0.00000000	0.00000000
4	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	-0.00031206	0.00000000	-0.05152316	0.00000000
5	-0.00253097	-0.00225142	-0.00312101	-0.00272465	-0.00309779	-0.00269839	-0.02266799	-0.03642272	-0.02619920	-0.05121414
6	-0.00005192	0.00000000	0.00000000	0.00000000	0.00000000	-0.00075772	-0.00055698	-0.00000492	0.00000000	0.00000000
7	-0.00006305	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	-0.00209128	0.00000000	0.00000000	0.00000000
8	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	-0.00012237	0.00000000	-0.00001230	0.00000000	0.00000000
9	-0.00000593	0.00000000	0.00000000	0.00000000	0.00000000	-0.00000247	-0.00002252	-0.00000410	0.00000000	0.00000000
10	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	-0.00003545	-0.00000410	0.00000000	0.00000000
11	-0.00045434	-0.00017293	-0.00050290	-0.00659842	-0.00149928	-0.00554016	-0.00075589	-0.00019395	-0.00014778	-0.00036022
12	-0.00157295	-0.00014300	-0.00096540	-0.00077794	-0.01215084	-0.00427440	-0.00001654	-0.00002296	0.00000000	0.00000000
13	-0.00051814	-0.00090788	-0.00408524	-0.00102121	-0.00366928	-0.00137701	0.00000000	-0.00000410	0.00000000	0.00000000
14	-0.00242081	-0.00505821	-0.00914232	-0.00218305	-0.00166188	-0.02462664	-0.00143353	-0.00110670	-0.00054400	-0.00105239
15	-0.00021549	-0.01058534	-0.00081728	-0.00004377	-0.00012434	-0.00109641	-0.00070988	-0.00019477	-0.00009555	-0.00005650
16	-0.00217528	-0.00086133	-0.00690006	-0.00404225	-0.00169416	-0.01165634	-0.00108352	-0.00149542	0.00000000	-0.00365866
17	-0.00002782	-0.00051547	-0.00303202	-0.00036399	-0.00100908	-0.00658836	0.00000000	-0.00005577	0.00000000	0.00000000
18	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	-0.00153275	0.00000000	0.00000000	0.00000000	0.00000000
19	-0.00123618	-0.00032258	-0.00067560	-0.00060098	-0.00110234	-0.00057602	-0.00733735	-0.00518210	-0.00045227	-0.00086875
20	-0.00353571	-0.00406719	-0.00886950	-0.01286937	-0.00583331	-0.01355744	-0.00194046	-0.00064499	-0.00004332	-0.00014497
21	-0.00638973	-0.00067842	-0.01189391	-0.00975459	-0.00340984	-0.00464647	-0.00064691	-0.00002378	0.00000000	0.00000000
22	-0.03861061	-0.00947792	-0.03158069	-0.03789939	-0.03602809	-0.02222739	-0.01375979	-0.00032106	0.00000000	0.00000000
23	-0.03744452	-0.00815101	-0.02271821	-0.03242006	-0.02353889	-0.01324348	0.00000000	-0.00082254	-0.00143771	0.00000000
24	-0.01165825	-0.00280679	-0.00134594	-0.00067148	-0.01230268	-0.00050185	0.00000000	-0.00000410	0.00000000	0.00000000
25	-0.00491988	-0.00208847	-0.00721093	-0.00664008	-0.00751791	-0.00141869	-0.00101791	0.00000000	0.00000000	0.00000000
26	-0.00356131	-0.00832394	-0.01033780	-0.04536420	-0.00571136	-0.00473299	0.00000000	0.00000000	0.00000000	0.00000000
27	-0.01395074	-0.00564019	-0.01222117	-0.02143000	-0.02273904	-0.01211122	-0.00197619	-0.00067452	0.00000000	-0.00209772
28	-0.00483569	0.00000000	-0.00221064	-0.00716516	-0.01452649	0.00000000	-0.00096231	-0.00006069	0.00000000	0.00000000
29	-0.00655292	-0.00009977	-0.00095311	-0.00243110	-0.00284313	-0.00095673	-0.00001793	-0.00003198	0.00000000	0.00000000
30	-0.01352866	-0.01011643	-0.00746326	-0.00889962	-0.01187825	-0.00249196	-0.00005310	0.00000000	0.00000000	0.00000000
31	0.93243904	-0.01598276	-0.00931854	-0.02775518	-0.03497835	-0.00417799	-0.00177811	-0.00128671	0.00000000	-0.00266277
32	-0.00017506	0.93555349	-0.00168374	-0.00000994	-0.00009087	-0.00055006	0.00000000	0.00000000	0.00000000	0.00000000
33	-0.02892773	-0.07034942	0.92327269	-0.01252471	-0.01738038	-0.01404817	-0.00250801	-0.00164796	-0.00003312	-0.00002119
34	-0.00588087	-0.00023612	-0.00435630	0.73611275	-0.00941651	-0.00210383	-0.00074310	-0.00011153	0.00000000	0.00000000
35	-0.00206550	-0.00005653	-0.00176102	-0.00037145	0.94964628	-0.00104944	-0.00214980	0.00000000	0.00000000	0.00000000
36	-0.00242118	-0.00136682	-0.00401264	-0.00193632	-0.00611069	0.97446483	-0.00048581	-0.00000328	0.00000000	0.00000000
37	-0.00578332	-0.00548721	-0.00725660	-0.00993847	-0.00802125	-0.00677501	0.96675620	-0.01616054	-0.00211739	-0.00266983
38	-0.00296454	-0.00181244	-0.00383233	-0.00275378	-0.00313844	-0.00256860	-0.00661885	0.80838083	-0.00009045	-0.03399802
39	-0.00108300	-0.00040905	-0.00112406	-0.00100261	-0.00081301	-0.00068479	-0.00157948	-0.10763086	0.98424506	-0.02901499
40	-0.00016801	-0.00007316	-0.00047889	-0.00043619	-0.00051291	-0.00013814	-0.00087919	-0.00218880	-0.00001401	0.99886991
41	-0.01925375	-0.02575000	-0.02068496	-0.01638657	-0.02021035	-0.02125087	-0.01322227	-0.00642206	-0.00089817	-0.00290291
42	-0.01021659	-0.02282681	-0.01093495	-0.00445098	-0.00961498	-0.00984299	-0.01804021	-0.00571023	-0.00804723	-0.01311979
43	-0.01684184	-0.02210849	-0.02784730	-0.02995799	-0.02384616	-0.02962910	-0.05013558	-0.01043883	-0.01221194	-0.01476176
44	-0.00047215	-0.00060526	-0.00070136	-0.00068001	-0.00065997	-0.00077627	-0.00993473	-0.07769417	-0.01859278	-0.35603396

44-Sector

LEONTIEF MATRIX

ROW/COL	41 WHOLESALE & RETAIL	42 F.I.R.E.	43 SELECT SERVICES	44 GOVT ENTERPRISES
1	0.00000000	-0.00327866	-0.00024901	0.00000000
2	-0.00041383	-0.00475006	-0.00006517	-0.00012330
3	-0.00002457	-0.00029499	0.00000000	-0.00016626
4	0.00000000	-0.00027755	0.00000000	0.00000000
5	-0.00353738	-0.04930403	-0.00973687	-0.11740800
6	-0.00047656	-0.00006272	-0.00120469	0.00000000
7	-0.00087238	-0.00019287	-0.00026999	0.00000000
8	-0.00036038	-0.00006994	0.00000000	0.00000000
9	-0.00079692	-0.00009692	-0.00033510	0.00000000
10	-0.00030602	-0.00023873	-0.00005570	0.00000000
11	-0.00060251	-0.00020511	-0.00065013	-0.00055203
12	-0.00073336	-0.00018921	-0.00001723	0.00000000
13	-0.00029489	-0.00005472	0.00000000	0.00000000
14	-0.00888256	-0.00180568	-0.00238108	-0.00114702
15	-0.00170674	-0.00256511	-0.04763336	-0.00231833
16	-0.00264879	-0.00180770	-0.00926973	-0.00744629
17	-0.00006954	-0.00025558	0.00000000	0.00000000
18	-0.00029489	-0.00031214	-0.00025010	-0.00012610
19	-0.00266970	-0.00170847	-0.00160856	-0.00268261
20	-0.00275686	-0.00062118	-0.00463528	-0.00148328
21	-0.00145489	-0.00037543	-0.00202139	-0.00037642
22	-0.00027443	-0.00033286	-0.00002348	-0.00032879
23	-0.00016153	-0.00039759	0.00000000	-0.00000467
24	-0.00102156	-0.00032736	0.00000000	-0.00001401
25	-0.00007006	-0.00004942	-0.00272384	-0.00000934
26	-0.00023518	-0.00005279	0.00000000	-0.00035494
27	-0.00141468	-0.00025096	-0.00284090	-0.00037082
28	-0.00024728	-0.00012678	-0.00084961	-0.00086027
29	-0.00048582	-0.00043863	-0.00209918	-0.00057538
30	-0.00032628	-0.00012495	-0.00028257	-0.00004203
31	-0.00144492	-0.00117052	-0.00499502	-0.00036615
32	-0.00024600	-0.00124200	-0.00048862	-0.00007005
33	-0.00137435	-0.00094576	-0.00310223	-0.00061928
34	-0.00047810	-0.00087765	-0.00855099	-0.00082290
35	-0.00041281	-0.00019894	-0.00005412	-0.00006258
36	-0.00131722	-0.00030241	-0.00641651	-0.00020269
37	-0.01008456	-0.00782270	-0.01392291	-0.04024285
38	-0.00936683	-0.00235847	-0.00921953	-0.04953764
39	-0.00238188	-0.00074788	-0.00275273	-0.01377826
40	-0.00159037	-0.00169132	-0.00264342	-0.00251354
41	0.98506244	-0.00968185	-0.02134839	-0.00624229
42	-0.03885777	0.93114134	-0.03327302	-0.02161498
43	-0.06428710	-0.04702812	0.93469311	-0.03659630
44	-0.00917513	-0.00814842	-0.00532396	0.99906594

Table A 2.4

44-Sector

INVERSE MATRIX

ROW/COL	1 LIVESTOCK AND PRODS.	2 OTHER AGRI PRODUCTS	3 METAL & MIN MINING	4 CRUDE PETR & NAT GAS	5 CONSTRUCTI ON	6 MEAT PRODUCTS	7 DAIRY PRODUCTS	8 PRESERVED FOOD	9 GRAINS,BAK ERY,SUGAR	10 BEVERAGES
1	1.11879899	0.03118056	0.00039619	0.00042260	0.00032954	0.40509379	0.11541724	0.01388486	0.00526065	0.00160399
2	0.20315125	1.06137435	0.00090042	0.00075661	0.00386808	0.07390572	0.02427878	0.11790761	0.11524185	0.03061600
3	0.00147770	0.00523858	1.10911049	0.00220583	0.01662596	0.00113306	0.00083282	0.00278828	0.00166222	0.00694227
4	0.00067631	0.00155621	0.00187216	1.00505696	0.00123094	0.00053411	0.00060605	0.00056217	0.00048555	0.00071638
5	0.01304332	0.01727779	0.02743533	0.03259614	1.00672459	0.00853858	0.00835199	0.00892816	0.00687347	0.01532517
6	0.00048420	0.00024795	0.00024016	0.00008122	0.00022588	1.00620359	0.00099381	0.02501115	0.00157265	0 00053037
7	0.00828585	0.00080330	0.00019113	0.00008144	0.00020829	0.00310431	1.09528543	0.00274381	0.01166668	0.00326827
8	0.00148750	0.00027886	0.00012638	0.00004523	0.00009498	0.00070528	0.00049144	1.03216593	0.01361548	0.00972755
9	0.11122709	0.00448398	0.00026245	0.00011767	0.00025455	0.04049781	0.02365495	0.05770481	1.06823059	0.01023405
10	0.00050867	0.00015617	0.00003288	0.00003117	0.00003649	0.00023620	0.00134124	0.00417708	0.00132434	1.03330816
11	0.00112918	0.00323775	0.00213877	0.00038373	0.00216150	0.00186044	0.00095792	0.00156048	0.00233678	0.00130820
12	0.00158837	0.00382031	0.00576412	0.00167206	0.04290708	0.00269392	0.00284893	0.00361245	0.00203806	0.01106164
13	0.00012300	0.00017033	0.00030432	0.00027982	0.00646418	0.00010442	0.00009968	0.00017926	0.00008453	0.00043545
14	0.00569725	0.00897174	0.01121708	0.00198008	0.01093055	0.02493904	0.04790986	0.04492037	0.02803683	0.04737756
15	0.00257582	0.00405517	0.00376163	0.00178674	0.00413714	0.00481196	0.00404145	0.01079995	0.00401938	0.01909218
16	0.01869309	0.07274930	0.03834550	0.01139095	0.02181788	0.01660263	0.00738065	0.02134229	0.01918026	0.01808991
17	0.00070053	0.00196979	0.00198614	0.00050848	0.00163536	0.00136867	0.00246286	0.00211278	0.00091749	0.00156264
18	0.00168683	0.00066542	0.00035629	0.00013535	0.00024020	0.00070965	0.00032300	0.00047035	0.00395906	0.00126549
19	0.00515288	0.01290556	0.00835541	0.00163556	0.00914144	0.00279567	0.00327036	0.00272934	0.00237562	0.00333363
20	0.00281197	0.00546395	0.01191732	0.00231597	0.00848249	0.00959648	0.00484548	0.00844012	0.00303113	0.00600225
21	0.00193339	0.00321002	0.02853170	0.00805829	0.07214818	0.00154983	0.00184622	0.02109849	0.00153703	0.09497545
22	0.00188264	0.00365411	0.01755022	0.00412157	0.03887019	0.00185103	0.00427143	0.00403978	0.00173376	0.00818751
23	0.00184254	0.00384133	0.04122756	0.01325241	0.04733217	0.00254242	0.00226244	0.00783791	0.00207696	0.01622304
24	0.00122567	0.00169246	0.00399097	0.00585797	0.08450519	0.00087072	0.00083086	0.00105292	0.00070353	0.00195616
25	0.00028223	0.00046602	0.00282915	0.00043982	0.00264429	0.00026911	0.00343639	0.00043923	0.00029756	0.00136697
26	0.00101041	0.00041521	0.00081663	0.00036781	0.00153729	0.00053456	0.00031005	0.00057183	0.00022138	0.01547818
27	0.00382641	0.00592140	0.00716022	0.00474912	0.01989356	0.00908953	0.00830621	0.04312233	0.00740700	0.08791423
28	0.00032482	0.00103275	0.01321479	0.00459151	0.00266351	0.00020996	0.00024867	0.00029803	0.00024453	0.00063100
29	0.00277861	0.01170247	0.01973902	0.00416422	0.00887723	0.00127674	0.00071223	0.00185591	0.00166228	0.00193945
30	0.00035484	0.00060139	0.00275855	0.00095815	0.00252858	0.00099742	0.00106665	0.00196967	0.00092689	0.00333796
31	0.00165468	0.00323452	0.02694428	0.01264651	0.02064701	0.00409902	0.00280265	0.00372671	0.00248863	0.00643814
32	0 00008263	0.00013750	0.00014920	0.00016626	0.00015479	0.00006154	0.00005689	0.00006163	0.00006005	0.00018585
33	0.00112520	0.00192907	0.00418965	0.00714978	0.01630560	0.00085791	0.00091951	0.00113777	0.00074795	0.00252591
34	0.00116586	0.00164510	0.00372932	0.00092076	0.00254267	0.00080648	0.00090164	0.00078331	0.00078168	0.00439306
35	0.00019310	0.00043590	0.00069194	0.00023142	0.00066835	0.00020041	0.00034685	0.00057516	0.00019146	0.00111747
36	0.00051704	0.00088423	0.00120744	0.00076433	0.00366700	0.00064579	0.00058706	0.00068266	0.00054360	0.00191312
37	0.02216982	0.01682814	0.02924276	0.00823345	0.02599460	0.01388268	0.09190466	0.00688983	0.01830564	0.02009229
38	0.00666327	0.00647748	0.04096449	0.00939035	0.00723055	0.00835404	0.00700850	0.00674378	0.01005921	0.01134837
39	0.00206662	0.00271931	0.01828415	0.00441621	0.00461134	0.00429212	0.00429855	0.00499016	0.00420237	0.00659831
40	0.00147018	0.00537572	0.00185252	0.00107257	0.00083684	0.00131004	0.00087075	0.00152627	0.00110629	0.00218569
41	0.04845540	0.04539365	0.02788179	0.01324257	0.07146890	0.03747287	0.03218134	0.05063706	0.03874733	0.04171565
42	0.03248660	0.06051808	0.06111394	0.09570146	0.02060271	0.01979189	0.01739160	0.01913474	0.01485052	0.03171231
43	0.03661953	0.06468846	0.06419891	0.02760461	0.07214754	0.03236720	0.03070334	0.01922984	0.04418386	0.14511850
44	0.00243113	0.00414525	0.00655509	0.00263653	0.00312099	0.00261262	0.00325497	0.00266936	0.00259867	0.00475355
45	1.67286242	1.48355661	1.64953846	1.29422129	1.66851619	1.75138125	1.56191338	1.56311562	1.44759079	1.73390935

44-Sector

INVERSE MATRIX

ROW/COL	11 TEXTILE & APPAREL	12 LUMBER AND WOOD PROD	13 FURNITURE	14 PAPER & AL LIED PROD.	15 PRINTING, PUBLISHING	16 CHEM.ALLIE D PROD.	17 PLASTICS & SYN. MAT.	18 DRUGS	19 PETROLEUM REFINERY	20 RUBBER & LEATHER
1	0.00271177	0.00177003	0.00037690	0.00039277	0.00021862	0.00113277	0.00078239	0.00126685	0.00036955	0.00351866
2	0.01256740	0.05594296	0.00401747	0.00420595	0.00079686	0.00306767	0.00138209	0.00114518	0.00059270	0.00159510
3	0.00080679	0.00198213	0.00614997	0.00556599	0.00123481	0.01750062	0.00557280	0.00178631	0.00399551	0.00276586
4	0.00033919	0.00073228	0.00041252	0.00117968	0.00037148	0.00324183	0.00180072	0.00040970	0.11032745	0.00057808
5	0.00507714	0.00951015	0.00781738	0.01562757	0.00817218	0.01290449	0.01427837	0.00914241	0.02735987	0.00838494
6	0.00012749	0.00012898	0.00025125	0.00028365	0.00013885	0.00153397	0.00060141	0.00200286	0.00021566	0.00733695
7	0.00024798	0.00016888	0.00032165	0.00031092	0.00012166	0.00152732	0.00318128	0.00054613	0.00087513	0.00044268
8	0.00018779	0.00008600	0.00007809	0.00071187	0.00013302	0.00320215	0.00091840	0.00053654	0.00010717	0.00020782
9	0.00113703	0.00040261	0.00025432	0.00686178	0.00088419	0.00347373	0.00131981	0.00286267	0.00023544	0.00080759
10	0.00002110	0.00004651	0.00002143	0.00003920	0.00002075	0.00012231	0.00005393	0.00019623	0.00002492	0.00002720
11	1.15199129	0.00188038	0.02355667	0.00703002	0.00262772	0.00131730	0.00366021	0.00076899	0.00043945	0.02824763
12	0.00144221	1.19567897	0.07538044	0.06378179	0.00790207	0.00379116	0.00454973	0.00174078	0.00194031	0.00684029
13	0.00033766	0.00322786	1.02275887	0.00046418	0.00027273	0.00017515	0.00016491	0.00011837	0.00021556	0.00081105
14	0.01475302	0.01226070	0.01927245	1.31765369	0.15171155	0.03100031	0.05624710	0.02263996	0.01158991	0.03533719
15	0.00184324	0.00212154	0.00239710	0.01095666	1.06440821	0.00551131	0.00422256	0.00637454	0.00302509	0.00346672
16	0.02818926	0.02313593	0.01928846	0.05439172	0.02144389	1.16490828	0.32195683	0.05568231	0.03352284	0.06215332
17	0.04635221	0.00184701	0.00420316	0.01106916	0.00292864	0.02143546	1.02665159	0.00279737	0.00115691	0.09106901
18	0.00025586	0.00021390	0.00019432	0.00074153	0.00024765	0.00906095	0.00256166	1.04480103	0.00031173	0.00088194
19	0.00158871	0.00449290	0.00168282	0.00514681	0.00171259	0.02059619	0.01090017	0.00217772	1.02973476	0.00269316
20	0.00563859	0.00447832	0.02322967	0.01424296	0.00425629	0.00970717	0.01747293	0.00973146	0.00320951	1.05518181
21	0.00270034	0.00965996	0.01145026	0.00461310	0.00136659	0.00920803	0.00454760	0.01192459	0.00599562	0.00751635
22	0.00147926	0.00423148	0.01285591	0.00505580	0.00315738	0.01501176	0.00921472	0.00251005	0.00513789	0.00487597
23	0.00121935	0.00703642	0.05006085	0.00714596	0.00310170	0.01182170	0.00514082	0.00273069	0.00472101	0.00693820
24	0.00054290	0.00228170	0.00234340	0.00163956	0.00080833	0.00148121	0.00151815	0.00089919	0.00285718	0.00148373
25	0.00019242	0.00186247	0.00574121	0.00054294	0.00034510	0.00070112	0.00049839	0.00046830	0.00041608	0.00195276
26	0.00094132	0.00268882	0.00264021	0.00064666	0.00028515	0.00165373	0.00078054	0.00135363	0.00026945	0.00425731
27	0.00197480	0.01294700	0.03771219	0.01550777	0.00951477	0.02314481	0.00916427	0.00949160	0.00628408	0.01399547
28	0.00012104	0.00027964	0.00046084	0.00035628	0.00016546	0.00055496	0.00034154	0.00023662	0.00081378	0.00027913
29	0.00044913	0.00168061	0.00238254	0.00168938	0.00046936	0.00177524	0.00114671	0.00064189	0.00181533	0.00104847
30	0.00137689	0.00180388	0.00368977	0.00419538	0.00114239	0.00167395	0.00288639	0.00072352	0.00070488	0.00526712
31	0.00332998	0.00516004	0.00579287	0.00752072	0.00237225	0.01176715	0.01073738	0.00230405	0.00605941	0.00581722
32	0.00004805	0.00007639	0.00019787	0.00019549	0.00009981	0.00015164	0.00010636	0.00010674	0.00009764	0.00013389
33	0.00072941	0.00149940	0.00273382	0.00172048	0.00098590	0.00207869	0.00152866	0.00100055	0.00209457	0.00182715
34	0.00064040	0.00152373	0.00184631	0.00110918	0.00081823	0.00239680	0.00140649	0.00159173	0.00114867	0.00258848
35	0.00009996	0.00043499	0.00096444	0.00033789	0.00019565	0.00040932	0.00027479	0.00018025	0.00025680	0.00120723
36	0.00414461	0.00126896	0.00364357	0.00206551	0.00383636	0.00194358	0.00124997	0.00236790	0.00104873	0.00499251
37	0.01138203	0.02363445	0.01660961	0.03483747	0.01582752	0.02224832	0.02346194	0.01125521	0.05410764	0.01759979
38	0.00796642	0.01014324	0.00844071	0.01816266	0.00711944	0.01720009	0.01691239	0.00668333	0.01097378	0.01260464
39	0.00298784	0.00455209	0.00421345	0.01157724	0.00328877	0.01354618	0.01031267	0.00292370	0.01528804	0.00507887
40	0.00081278	0.00073999	0.00057275	0.00358361	0.00094101	0.00182399	0.00182477	0.00094139	0.00203517	0.00118096
41	0.02512701	0.03278792	0.03325284	0.03998287	0.02153803	0.02655989	0.03344847	0.02225307	0.01677308	0.03370188
42	0.01397089	0.01727357	0.01690285	0.02338796	0.02865178	0.02712785	0.02731402	0.02585805	0.04200171	0.01923970
43	0.02450707	0.03230081	0.03349958	0.05024875	0.04813926	0.08606929	0.06410883	0.10273411	0.05124426	0.04841759
44	0.00258115	0.00254481	0.00254846	0.00512298	0.00760821	0.00461581	0.00409865	0.00302755	0.00375379	0.00346656
45	1.38494076	1.49852040	1.47222124	1.76190355	1.43138224	1.60017525	1.71030441	1.38093515	1.46514806	1.51781799

44-Sector

INVERSE MATRIX

ROW/COL	21 GLASS,STON E,CLAY	22 FOUNDRIES, METAL PROD	23 IRON,STEEL MANUFACT.	24 HTNG,PLMBG .FAB PROD	25 SCREW MACH PROD	26 METAL STAMPINGS	27 FAB METAL PROD	28 ENGINES & TURBINES	29 FARM & CONST MACH	30 METALWORKI NG MACH
1	0.00026923	0.00014163	0.00017872	0.00017081	0.00010052	0.00025365	0.00016079	0.00012145	0.00024029	0.00011092
2	0.00077728	0.00042494	0.00067097	0.00052056	0.00022531	0.00127158	0.00053836	0.00028782	0.00051345	0.00025623
3	0.05504911	0.03785263	0.13018243	0.02828840	0.01035734	0.00353508	0.01792868	0.00855316	0.01580744	0.00643057
4	0.00174047	0.00075017	0.00207376	0.00082278	0.00036843	0.00080797	0.00063451	0.00050419	0.00068684	0.00040278
5	0.01712707	0.00917890	0.02921713	0.01222436	0.00538442	0.01828912	0.00867768	0.00779225	0.01151428	0.00611675
6	0.00021155	0.00011229	0.00012666	0.00012362	0.00007736	0.00019616	0.00015055	0.00010507	0.00023726	0.00009190
7	0.00036142	0.00022307	0.00013875	0.00013207	0.00017427	0.00014203	0.00012496	0.00010542	0.00014714	0.00006931
8	0.00011758	0.00004923	0.00011427	0.00007057	0.00002278	0.00011484	0.00008606	0.00003557	0.00005220	0.00002735
9	0.00041570	0.00036378	0.00020683	0.00018977	0.00013622	0.00038273	0.00021801	0.00013716	0.00017517	0.00008856
10	0.00002388	0.00001827	0.00002859	0.00002273	0.00001062	0.00002847	0.00001723	0.00001786	0.00002634	0.00001292
11	0.00325898	0.00078228	0.00107556	0.00106035	0.00056678	0.00363590	0.00159916	0.00094214	0.00154394	0.00079103
12	0.00754360	0.00366218	0.00732279	0.00505395	0.00145532	0.01896042	0.00611632	0.00202388	0.00404635	0.00197796
13	0.00140529	0.00019335	0.00037879	0.00257131	0.00014278	0.00408118	0.00144774	0.00074687	0.00090629	0.00035448
14	0.04773105	0.00399890	0.00553766	0.01089566	0.00445446	0.04401078	0.01705309	0.00742934	0.00670851	0.00421647
15	0.00319944	0.00159676	0.00153638	0.00232868	0.00102817	0.00237634	0.00695318	0.00197858	0.00303908	0.00149259
16	0.03032501	0.01137942	0.03181527	0.01743458	0.00474191	0.02639199	0.02262964	0.00607194	0.01000920	0.00551349
17	0.00442496	0.00329425	0.00123000	0.00104419	0.00114061	0.00688530	0.00176327	0.00100415	0.00221542	0.00097327
18	0.00045950	0.00011254	0.00028608	0.00017538	0.00005290	0.00026581	0.00021488	0.00007887	0.00013029	0.00006738
19	0.00466961	0.00222534	0.00507594	0.00266726	0.00136773	0.00285604	0.00230986	0.00248045	0.00276508	0.00197758
20	0.01139501	0.00279665	0.00399297	0.00341167	0.00287625	0.01487932	0.00823043	0.00402536	0.01769372	0.00549753
21	1.10285083	0.00446909	0.01267353	0.01098122	0.00306462	0.01144959	0.00657898	0.01108663	0.01028629	0.00918030
22	0.00890840	1.18697464	0.05843051	0.08172368	0.31127363	0.01890138	0.06690106	0.11315373	0.10969403	0.04566798
23	0.01693008	0.04746538	1.31878144	0.25995611	0.01533550	0.01887828	0.15617591	0.04888424	0.12447993	0.04748697
24	0.00257122	0.00306478	0.00348662	1.02193797	0.00182891	0.01027380	0.00473581	0.00569425	0.01064453	0.00372727
25	0.00067800	0.00747230	0.00121170	0.01379440	1.00647028	0.01648464	0.00670280	0.01011137	0.01136001	0.00605319
26	0.00080944	0.00089455	0.00087364	0.00822560	0.00208654	1.04358037	0.00796079	0.01113008	0.01010926	0.02399654
27	0.01006647	0.00898407	0.02362859	0.02716144	0.00841792	0.03924516	1.03726771	0.01926378	0.02340248	0.01532999
28	0.00198284	0.00131168	0.00207363	0.00355182	0.00184533	0.00221977	0.00172260	1.09250993	0.05464289	0.00131694
29	0.00661016	0.00335637	0.00638266	0.00783482	0.00193891	0.00455622	0.00393199	0.04044822	1.09171340	0.00409100
30	0.00730816	0.01031373	0.01004314	0.00857960	0.01586175	0.03033115	0.01300735	0.01575299	0.02332962	1.04907870
31	0.00817683	0.01815968	0.02817174	0.04128820	0.01882254	0.03350432	0.01990310	0.06969019	0.10379750	0.03297702
32	0.00008915	0.00006610	0.00029232	0.00039216	0.00008826	0.00271783	0.00014888	0.00014773	0.00020530	0.00018850
33	0.00329449	0.00724795	0.01196199	0.01155682	0.00348264	0.01427512	0.01135158	0.02692630	0.02049362	0.01396464
34	0.00255335	0.00753753	0.00164588	0.00785428	0.00804696	0.12030580	0.00738462	0.02961284	0.02022187	0.01305131
35	0.00034080	0.00047072	0.00059489	0.00280575	0.00046764	0.00170188	0.01158208	0.01598264	0.00362642	0.00100756
36	0.00258243	0.00091989	0.00258053	0.00371050	0.00089364	0.00873605	0.00392781	0.00194854	0.00450026	0.00166651
37	0.03853508	0.06812148	0.01031442	0.02005736	0.04480863	0.00823796	0.01603666	0.01696716	0.02182018	0.00972459
38	0.02140864	0.01591113	0.03563796	0.01439137	0.00750144	0.02314942	0.01159633	0.00847601	0.01248185	0.00724083
39	0.02348696	0.00937154	0.02927650	0.01008394	0.00395536	0.00939311	0.00721068	0.00443863	0.00726639	0.00355697
40	0.00108592	0.00097947	0.00246915	0.00103843	0.00047212	0.00207686	0.00095222	0.00078555	0.00106212	0.00058938
41	0.02941052	0.02961480	0.05722769	0.03993939	0.01505059	0.05232087	0.02682227	0.03568767	0.04755582	0.02257802
42	0.02645472	0.01368364	0.02226670	0.02109078	0.01017482	0.02823693	0.01471095	0.01294754	0.02498542	0.01342712
43	0.04744327	0.01997498	0.01955211	0.03524625	0.01413273	0.01907508	0.03369636	0.03079789	0.04861914	0.02269769
44	0.00469670	0.00340180	0.00632006	0.00346224	0.00196227	0.00477542	0.00288110	0.00257232	0.00371969	0.00192958
45	1.55878022	1.54892390	1.88708694	1.74587279	1.53266719	1.67379170	1.57004405	1.66945775	1.86847631	1.38699768

44-Sector

INVERSE MATRIX

ROW/COL	31 SPEC & GEN IND. MACH	32 OFFICE,ACC &COMP.MACH	33 ELECTRICAL EQUIP	34 MOTOR VEH. & PARTS	35 ACFT.OTH. TRAN.EQUIP	36 MISC. MANF	37 TRAN.WHSNG ,& COMM	38 ELECTRICAL UTILITIES	39 GAS UTILIT IES	40 WATER & SANITARY S
1	0.00017171	0.00020094	0.00018561	0.00024736	0.00018464	0.00054583	0.00070860	0.00012542	0.00008735	0.00019359
2	0.00038386	0.00037939	0.00043358	0.00059744	0.00104596	0.00122862	0.00117797	0.00042566	0.00024426	0.00069262
3	0.00858869	0.00272740	0.00637166	0.01027103	0.00682879	0.00426529	0.00129465	0.00147702	0.00083191	0.00203592
4	0.00047629	0.00024285	0.00042409	0.00056241	0.00044708	0.00035446	0.00143239	0.00801675	0.05274986	0.00265983
5	0.00709682	0.00648906	0.00777805	0.01015711	0.00781300	0.00657323	0.02803201	0.06344733	0.03167288	0.10100490
6	0.00016481	0.00012166	0.00017776	0.00026938	0.00014699	0.00099996	0.00069751	0.00008552	0.00003483	0.00010455
7	0.00016207	0.00009108	0.00011806	0.00014747	0.00010665	0.00013404	0.00243835	0.00010605	0.00002837	0.00010632
8	0.00003651	0.00003549	0.00006109	0.00006231	0.00003804	0.00021766	0.00002438	0.00003979	0.00000866	0.00004064
9	0.00013074	0.00014775	0.00020020	0.00020069	0.00012946	0.00036757	0.00020009	0.00008026	0.00003437	0.00010593
10	0.00001706	0.00002235	0.00001913	0.00002177	0.00001854	0.00002001	0.00005762	0.00001743	0.00000686	0.00001677
11	0.00109985	0.00073839	0.00147042	0.01151643	0.00261581	0.00744488	0.00118833	0.00062814	0.00030479	0.00103000
12	0.00350339	0.00170455	0.00350564	0.00429655	0.01708424	0.00792657	0.00155397	0.00293831	0.00143209	0.00452961
13	0.00090887	0.00148579	0.00473661	0.00197033	0.00432835	0.00166899	0.00022658	0.00043573	0.00021049	0.00066820
14	0.00652084	0.01209941	0.01693484	0.01102194	0.00608144	0.03694686	0.00392313	0.00361311	0.00146519	0.00429040
15	0.00204305	0.01421092	0.00345379	0.00345901	0.00245766	0.00383827	0.00414080	0.00209139	0.00116970	0.00334115
16	0.00720179	0.00497503	0.01439369	0.01453296	0.00732977	0.02114638	0.00384122	0.00545862	0.00175990	0.01073062
17	0.00106784	0.00170313	0.00503372	0.00370394	0.00242336	0.00936496	0.00048869	0.00042286	0.00012289	0.00052107
18	0.00008947	0.00007928	0.00015734	0.00016451	0.00010046	0.00184883	0.00006741	0.00007605	0.00002911	0.00016075
19	0.00226076	0.00108045	0.00177710	0.00227129	0.00220666	0.00168425	0.00849881	0.00794982	0.00098612	0.00368642
20	0.00573982	0.00645469	0.01186650	0.02137231	0.00855791	0.01639428	0.00302848	0.00192063	0.00057669	0.00238971
21	0.00998711	0.00324709	0.01610837	0.01813915	0.00680976	0.00701389	0.00321900	0.00492173	0.00265834	0.00769754
22	0.06001209	0.01988804	0.04864117	0.07591700	0.05913032	0.03268744	0.01934292	0.00398216	0.00159484	0.00512024
23	0.06489989	0.01914091	0.03981905	0.07226776	0.04834572	0.02358747	0.00306869	0.00525457	0.00409848	0.00582393
24	0.01390338	0.00422465	0.00271737	0.00335897	0.01493219	0.00144997	0.00251099	0.00541829	0.00283338	0.00857675
25	0.00672499	0.00356505	0.00890252	0.01161546	0.00972988	0.00538434	0.00153489	0.00032681	0.00015606	0.00016208
26	0.00568240	0.01079518	0.01266954	0.06570899	0.00840322	0.00582669	0.00028144	0.00023883	0.00009149	0.00041206
27	0.01925979	0.00946169	0.01703577	0.03680884	0.02930275	0.01563599	0.00350356	0.00265041	0.00098688	0.00491553
28	0.00658369	0.00053133	0.00312776	0.01164918	0.01761755	0.00039224	0.00136389	0.00017857	0.00036727	0.00074451
29	0.00882136	0.00083945	0.00210320	0.00562477	0.00510950	0.00171619	0.00061811	0.00082878	0.00055176	0.00131326
30	0.01742084	0.01317505	0.01041517	0.01744816	0.01600756	0.00409174	0.00054614	0.00031921	0.00016408	0.00045361
31	1.07831380	0.02148684	0.01482446	0.04829215	0.04567003	0.00752134	0.00371363	0.00362766	0.00146664	0.00578466
32	0.00034584	1.06914586	0.00205786	0.00031011	0.00024590	0.00071295	0.00008305	0.00005810	0.00003730	0.00010274
33	0.03587745	0.08318010	1.08538870	0.02303205	0.02365071	0.01698947	0.00392828	0.00369580	0.00101899	0.00247442
34	0.01090601	0.00309424	0.00923662	1.36849712	0.01672401	0.00473865	0.00215662	0.00087606	0.00034900	0.00126215
35	0.00285340	0.00046735	0.00238923	0.00145642	1.05388993	0.00144759	0.00245820	0.00015104	0.00004874	0.00020126
36	0.00349085	0.00248567	0.00527364	0.00438177	0.00759730	1.02699169	0.00115516	0.00049904	0.00027149	0.00076926
37	0.01307680	0.01051096	0.01464595	0.02322169	0.01613878	0.01299291	1.03912084	0.02826688	0.00468636	0.02324162
38	0.00824684	0.00544340	0.00922826	0.01158909	0.00851030	0.00684291	0.01103176	1.24485094	0.00234777	0.07370535
39	0.00434260	0.00220719	0.00427125	0.00588968	0.00386982	0.00310062	0.00376401	0.13826208	1.01694999	0.04345904
40	0.00059547	0.00047010	0.00096254	0.00126323	0.00098010	0.00059346	0.00127524	0.00320137	0.00021874	1.00249509
41	0.02962781	0.03488517	0.03059317	0.03687105	0.03144014	0.02922076	0.01896390	0.01506352	0.00452808	0.01492803
42	0.01769092	0.03219959	0.01896481	0.01637288	0.01774741	0.01685716	0.02496604	0.01555063	0.01566043	0.02852166
43	0.02893238	0.03591388	0.04189892	0.05677013	0.03808302	0.04266914	0.06242629	0.02826488	0.01863992	0.04294349
44	0.00233406	0.00237789	0.00288148	0.00370844	0.00279185	0.00253134	0.01250112	0.10129376	0.01954811	0.36473464
45	1.49759399	1.44372630	1.48325568	2.01704033	1.55267253	1.39386691	1.28655476	1.70743705	1.19303044	1.77845193

44-Sector

INVERSE MATRIX

ROW/COL	41 WHOLESALE & RETAIL	42 F.I.R.E.	43 SELECT SERVICES	44 GOVT ENTERPRISES
1	0.00059849	0.00425214	0.00112361	0.00023433
2	0.00117279	0.00653289	0.00174892	0.00091559
3	0.00062260	0.00157756	0.00104090	0.00258839
4	0.00064269	0.00072564	0.00059752	0.00170317
5	0.00961963	0.05629240	0.01588995	0.12541499
6	0.00063966	0.00018215	0.00140716	0.00014414
7	0.00106704	0.00033750	0.00043708	0.00017474
8	0.00042039	0.00011124	0.00006802	0.00004803
9	0.00108313	0.00062764	0.00064292	0.00012698
10	0.00034392	0.00027955	0.00008578	0.00002023
11	0.00105518	0.00056376	0.00140227	0.00113212
12	0.00209284	0.00292782	0.00155269	0.00557983
13	0.00040843	0.00044750	0.00019168	0.00082816
14	0.01393380	0.00479113	0.01307532	0.00459845
15	0.00601506	0.00620854	0.05502395	0.00552490
16	0.00574403	0.00534667	0.01462034	0.01281581
17	0.00068825	0.00062535	0.00110138	0.00065493
18	0.00040791	0.00042668	0.00014107	0.00026790
19	0.00349150	0.00285814	0.00271827	0.00496599
20	0.00387762	0.00178072	0.00643626	0.00326625
21	0.00282729	0.00485603	0.00453598	0.00978007
22	0.00193032	0.00347322	0.00426409	0.00669216
23	0.00196853	0.00395232	0.00340666	0.00670469
24	0.00196103	0.00515556	0.00155279	0.01061196
25	0.00044457	0.00045360	0.00332671	0.00059358
26	0.00048212	0.00033729	0.00090093	0.00072849
27	0.00263768	0.00205599	0.00521126	0.00363305
28	0.00050343	0.00046631	0.00139968	0.00146318
29	0.00094913	0.00129763	0.00290636	0.00196882
30	0.00065525	0.00047573	0.00100247	0.00054371
31	0.00282013	0.00325947	0.00760126	0.00389143
32	0.00038132	0.00147987	0.00065134	0.00016370
33	0.00232153	0.00256587	0.00482493	0.00331868
34	0.00182253	0.00223971	0.01306616	0.00223087
35	0.00055174	0.00032813	0.00026234	0.00030420
36	0.00204182	0.00101379	0.00756620	0.00108604
37	0.01421904	0.01240130	0.01930132	0.04804011
38	0.01434461	0.00551441	0.01469761	0.06427211
39	0.00487203	0.00222867	0.00552798	0.02217691
40	0.00205063	0.00215249	0.00316225	0.00304274
41	1.01964012	0.01718373	0.02821583	0.01838162
42	0.04707322	1.07923571	0.04326820	0.03027472
43	0.07654064	0.06184509	1.08176425	0.05546397
44	0.01230898	0.01074302	0.00931189	1.00875877
45	1.26927266	1.32161002	1.38733357	1.47513051

Table A 2.5

1976 and 1980 Total Output Projections: Michigan 44 Sectors (Thousands of Dollars)

Sector	Industry	1976 Final Demands	1976 Output	1980 Final Demands	% Change in Output 1976-1980
1	Livestock and Products	13,766	676,266	15,453	-11.24
2	Other Agricultural Products	210,555	717,211	446,292	23.10
3	Metal and Mineral Mining	536,427	1,171,389	820,223	9.40
4	Crude Petroleum and Natural Gas	390,061	580,694	410,794	2.39
5	Construction	4,302,101	5,837,234	2,550,125	-31.61
6	Meat Products	1,216,777	1,285,652	994,557	-18.06
7	Dairy Products	640,856	768,407	743,953	13.15
8	Preserved Food	611,844	674,786	618,409	-0.76
9	Grains, Bakery, Sugar	1,149,593	1,388,836	646,571	-39.98
10	Beverages	716,852	755,044	773,711	7.58
11	Textile and Apparel	911,448	1,490,915	728,514	-23.63
12	Lumber and Wood Products	123,360	732,595	37,926	-30.28
13	Furniture	616,386	747,814	720,629	9.70
14	Paper and Allied Products	632,880	2,123,447	799,827	-0.80
15	Printing, Publishing	739,202	1,528,430	618,141	-12.85
16	Chemicals, Allied Products	2,533,390	4,166,521	140,189	-40.06
17	Plastics and Synthetic Materials	94,152	423,786	28,442	-39.28
18	Drugs	789,316	876,688	756,101	-5.81
19	Petroleum Refinery	568,180	936,637	397,726	-26.81
20	Rubber and Leather	434,638	1,425,328	329,149	-28.37
21	Glass, Stone, Clay	240,606	1,466,356	61,637	-38.21
22	Foundries, Metal Products	162,658	3,306,102	54,460	-35.13
23	Iron, Steel Manufacturing	141,113	3,162,451	27,897	-38.42
24	Heating, Plumbing, Fabricated Products	41,534	681,189	39,130	-27.17
25	Screw Machine Products	251,392	730,860	285,471	-14.15
26	Metal Stampings	2,081,065	4,171,972	2,827,297	-0.20
27	Fabricated Metal Products	898,418	2,600,614	369,421	-40.68
28	Engines and Turbines	612,951	1,120,825	878,557	12.33
29	Farm and Construction Machinery	771,397	1,173,876	531,720	-27.43
30	Metalworking Machinery	1,234,659	1,984,468	248,322	-62.17
31	Specialized and General Industrial Machinery	248,294	2,272,081	426,342	-19.68
32	Office, Accounting and Computing Machinery	42,003	85,272	79,661	38.22
33	Electrical Equipment	527,190	1,562,108	447,245	-24.48
34	Motor Vehicles and Parts	28,679,640	39,753,666	17,207,784	-40.03
35	Aircraft and Other Transportation Equipment	496,338	628,944	365,729	-24.97
36	Miscellaneous Manufacturing	433,582	742,331	458,252	-5.12
37	Transportation, Whsng. and Communication	5,382,394	7,267,088	5,542,140	-2.94
38	Electrical Utilities	1,150,403	2,478,933	1,535,801	11.67
39	Gas Utilities	935,572	1,600,496	1,352,073	23.44
40	Water and Sanitary Services	775	146,458	838	-13.66
41	Wholesale and Retail	12,840,622	15,614,762	10,272,498	-20.57
42	Financial, Insurance, Real Estate	7,667,766	10,431,554	8,381,690	3.99
43	Selected Services	6,869,168	12,232,862	6,883,459	-8.58
44	Government Enterprises	375,938	1,083,000	405,714	0.00
	Total		144,605,947		

Table A 2.6

Comparison Between 1980 Actual and Projected Rail Traffic Movements in Michigan, 44 Sectors (Tons)

Sector	Industry	Projected	Actual	Difference	% Difference
1	Livestock and Products	0	0	0	0.00
2	Other Agricultural Products	1,490,963	1,545,000	-54,037	-3.50
3	Metal and Mineral Mining	34,615,317	35,463,300	-847,983	-2.39
4	Crude Petroleum and Natural Gas	0	0	0	0.00
5	Construction	0	0	0	0.00
6	Meat Products	108,155	62,400	45,755	73.33
7	Dairy Products	95,041	154,400	-59,359	-38.44
8	Preserved Food	370,349	312,600	57,749	18.47
9	Grains, Bakery, Sugar	1,505,115	1,661,700	-156,585	-9.42
10	Beverages	408,463	476,700	-68,237	-14.31
11	Textile and Apparel	131,648	82,500	49,148	59.57
12	Lumber and Wood Products	1,432,274	1,209,500	222,774	18.42
13	Furniture	132,938	64,600	68,338	105.79
14	Paper and Allied Products	2,410,505	2,744,100	-333,595	-12.16
15	Printing, Publishing	2,004	2,900	-896	-30.90
16	Chemicals, Allied Products	2,243,970	2,330,300	-86,330	-3.70
17	Plastics and Synthetic Materials	260,110	379,300	-119,190	-31.42
18	Drugs	7,628	4,100	3,528	86.05
19	Petroleum Refinery	1,344,646	1,679,000	165,646	9.87
20	Rubber and Leather	249,178	221,300	27,878	12.60
21	Glass, Stone, Clay	1,386,956	1,577,200	-190,244	-12.06
22	Foundried, Metal Products	770,381	590,000	180,381	30.57
23	Iron, Steel Manufacturing	2,846,324	3,046,700	-200,376	-6.58
24	Heating, Plumbing, Fabricated Products	90,883	6,400	84,483	1,320.05
25	Screw Machine Products	7,812	0	7,812	999.99
26	Metal Stampings	2,095	0	2,095	999.99
27	Fabricated Metal Products	46,971	41,000	5,971	14.56
28	Engines and Turbines	0	8,400	-8,400	-100.00
29	Farm and Construction Machinery	133,440	90,900	42,540	46.80
30	Metalworking Machinery	6,997	3,700	3,297	89.11
31	Specialized and General Industrial Machinery	32,043	8,400	23,643	281.46
32	Office, Accounting and Computing Machinery	0	0	0	0.00
33	Electrical Equipment	101,181	97,000	4,181	4.31
34	Motor Vehicles and Parts	7,918,706	8,170,800	-252,094	-3.09
35	Aircraft and Other Transportation Equipment	123,860	129,800	-5,940	-4.58
36	Miscellaneous Manufacturing	18,117	6,700	11,417	170.40
37	Transportation Whsng. and Communication	0	0	0	0.00
38	Electrical Utilities	0	0	0	0.00
39	Gas Utilities	0	0	0	0.00
40	Water and Sanitary Services	0	0	0	0.00
41	Wholesale and Retail	4,218,512	4,135,600	82,912	2.00
42	Financial, Insurance, Real Estate	0	0	0	0.00
43	Selected Services	0	0	0	0.00
44	Government Enterprises	0	0	0	0.00
	Total	65,012,582	66,306,300	-1,293,718	-1.95

APPENDIX 3

1983 AND 1986 PROJECTIONS OF STATE ECONOMIC ACTIVITY AND TOTAL STATE RAIL TRAFFIC

Table A 3.1

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

(Base Year = 1980)

		Statewide Economic Activity (Thousands of 1976 Dollars)		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	% Difference 1980-1983
1	Livestock and Products	16,906	680,169	0	0	0	0.00
2	Other Agricultural Products	488,243	992,787	1,741,060	1,545,000	196,060	12.69
3	Mining	1,351,657	2,104,167	39,470,652	35,463,300	4,007,352	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	2,888,693	2,667,800	220,893	8.28
6	Lumber, Furniture, Paper, Printing	2,368,057	5,148,110	4,399,887	4,021,100	378,787	9.42
7	Chemicals, Drugs, Plastics	2,400,705	4,098,021	2,914,513	2,713,700	200,813	7.40
8	Petroleum Refinery	436,703	763,972	1,810,801	1,679,000	131,801	7.85
9	Rubber, Leather, Stone, Glass, Clay	429,083	2,150,938	1,938,423	1,798,500	139,923	7.78
10	Primary and Fabricated Metals	3,956,836	12,349,898	4,002,774	3,684,100	318,674	8.65
11	Machinery, Except Electrical	2,376,733	5,248,059	120,000	111,400	8,600	7.72
12	Electrical Equipment	491,075	1,295,914	104,934	97,000	7,934	8.18
13	Motor Vehicles and Parts	19,427,588	27,101,285	8,817,110	8,170,800	646,310	7.91
14	Aircraft and Other Transportation Equipment	401,570	508,874	139,262	129,800	9,462	7.29
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	4,633,760	4,224,800	408,960	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	72,981,869	66,306,300	6,675,569	10.07

Table A 3.2

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

(Base Year = 1980)

		Statewide Economic Activity (Thousands of 1976 Dollars)		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	% Difference 1980-1983
1	Livestock and Products	16,180	650,221	0	0	0	0.00
2	Other Agricultural Products	467,268	948,856	1,643,107	1,545,000	98,107	6.35
3	Mining	1,291,337	2,007,730	37,466,976	35,463,300	2,003,676	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	2,778,246	2,667,800	110,446	4.14
6	Lumber, Furniture, Paper, Printing	2,277,290	4,922,516	4,215,721	4,021,100	194,621	4.84
7	Chemicals, Drugs, Plastics	2,293,570	3,908,214	2,814,378	2,713,700	100,678	3.71
8	Petroleum Refinery	417,215	728,543	1,744,816	1,679,000	65,816	3.92
9	Rubber, Leather, Stone, Glass, Clay	409,935	2,042,779	1,868,641	1,798,500	70,141	3.90
10	Primary and Fabricated Metals	3,780,256	11,729,813	3,843,621	3,684,100	159,521	4.33
11	Machinery, Except Electrical	2,270,668	4,990,685	115,700	111,400	4,300	3.86
12	Electrical Equipment	469,160	1,231,513	100,967	97,000	3,967	4.09
13	Motor Vehicles and Parts	18,317,686	25,557,524	8,494,363	8,170,800	323,563	3.96
14	Aircraft and Other Transportation Equipment	383,650	485,683	134,537	129,800	4,737	3.65
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	4,429,280	4,224,800	204,480	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	69,650,353	66,306,300	3,344,053	5.04

Table A 3.3

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

(Base Year = 1980)

Sector	Industry	Statewide Economic Activity (Thousands of 1976 Dollars): 1986 Projected Final Demand	1986 Projected Output	Rail Traffic (Tons): 1986 Projected Rail Traffic	Actual 1980 Rail Traffic	Projected Change in Rail Traffic	% Difference 1980-1986
1	Livestock and Products	19,949	802,597	0	0	0	0.00
2	Other Agricultural Products	576,127	1,171,484	2,139,361	1,545,000	594,361	38.47
3	Mining	1,594,955	2,482,860	47,336,412	35,463,300	11,873,112	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	3,348,355	2,667,800	680,555	25.51
6	Lumber, Furniture, Paper, Printing	2,794,307	6,074,430	5,156,256	4,021,100	1,135,156	28.23
7	Chemicals, Drugs, Plastics	2,832,832	4,835,439	3,304,743	2,713,700	591,043	21.78
8	Petroleum Refinery	515,310	901,467	2,066,345	1,679,000	387,345	23.07
9	Rubber, Leather, Stone, Glass, Clay	506,318	2,537,775	2,188,414	1,798,500	389,914	21.68
10	Primary and Fabricated Metals	4,669,066	14,571,387	4,574,178	3,684,100	890,078	24.16
11	Machinery, Except Electrical	2,804,545	6,192,306	135,763	111,400	24,363	21.87
12	Electrical Equipment	567,669	1,516,371	118,534	97,000	21,534	22.20
13	Motor Vehicles and Parts	22,924,554	31,979,375	9,837,643	8,170,800	1,666,843	20.40
14	Aircraft and Other Transportation Equipment	473,853	600,442	157,953	129,800	28,153	21.69
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	5,317,333	4,224,800	1,092.533	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	85,681,290	66,306,300	19,374,990	29.22

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