BUREAU OF BUSINESS AND ECONOMIC RESEARCH
SCHOOL OF BUSINESS AND ECONOMICS
UNIVERSITY OF MINNESOTA, DULUTH

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SIMLAB USER'S GUIDE

by

Dr. Richard W. Lichty,
Barbara Flannery, and Peter Stenberg

Introduction

This is a User's Guide, not a User's Manual. The difference is that this guide represents a general description of a large-scale, user interactive, and dynamic simulation model called SIMLAB. This Guide will not provide the detail required for the reader to be able to use SIMLAB in a meaningful way, but rather, acquaints the reader with the structure and properties of the model. A User's Manual is planned and should be available in the Spring of 1983.

As was mentioned, SIMLAB is user interactive. That means that the computer asks questions of the user, the answers to which determine the form that the simulation will take. The simulations come out of a standard, Leontief-type of regional input-output system as it interacts with a series of modules to provide simulated forecasts of output, employment, population, housing stock demand, and a host of related variables for the region in question.

This Guide will be organized as follows: First, there will be a brief discussion of input-output analysis. This discussion will give the reader a general idea as to the properties of an input-output system as opposed to its uses.

Second, a discussion of the modules of the SIMLAB system and the way in which these modules relate to input-output will be presented. The modules will be described in such a manner as to present their components and relationships to one another. Once again, the specific uses of the modules in simulation will not be presented in this section of the Guide.

Finally, three sections will be presented that relate to specific uses to which SIMLAB has been put. These three uses relate to simulated forecasts for the forestry industry in northeast Minnesota, the development of the housing module and its anticipated uses and the development of the recreation module and its anticipated uses.

The Guide will end with a glossary of terms that will help the reader understand the concepts discussed in the Guide and a list of references that can be used by the reader that is interested in a more detailed discussion of the concepts discussed.

What is Input-Output Analysis?

An input/output table represents a still picture of economic relationships between all producers and consumers of goods and services in an economic region. It demonstrates interaction between these industries in terms of their sales to and purchases from one another. It also shows the complicated relationship between goods consumed and the amount and mix of goods produced in the region. A change in the consumption of the output of one firm will be reflected, for example, in changes in that firm's demand for the intermediate products by other firms as well as changes in that firm's demand for labor, capital equipment, and other resource inputs. This point can be clarified by means of a single example of a hypothetical input/output table.

Suppose that there are but three industrial sectors in the economy: (1) extractive; (2) manufacturing; and (3) services. These three industries buy intermediate products from one another for use in their own production and they sell some of their output as intermediate products to other firms and some as final products to consumers, governmental units, investment, or exports. In order to produce this output each industry utilizes inputs of labor, capital equipment, and land as well as inputs from other regions through imports. These sales and purchases are summarized in a "Transaction Table" (Table 1) on page 5.

Many of the complications have been removed from this example, but the basic structure is that of the most sophisticated of actual tables. Notice that the inputs (represented by the columns of the table) total for each industry equals the output (represented by the rows of the table) totals for each industry. This is an accounting type of identity which states that all outputs must be made of materials, resources, and profits.

Table 1 can be interpreted as follows: Extractive, in order to produce a total output of $5,424, must utilize $100 of its own output, $50 of the output from manufacturing, $75 worth of the output of services, $5,000 worth of labor, capital equipment, etc., and $200 worth of imports. Extractive sells $100 to itself, $700 to the manufacturing industry, $000 to the services industry, and $4,625 to final sales. This interpretation can be similarly applied to the other industrial sectors.

A table (Table 2) can be derived from Table 1 if each entry in any given industry's column of the transactions table is divided by the total for the row of that industry. The resulting number represents the dollar value of inputs required from the various industries to produce $1 of output for each industry taken separately.

The numbers appearing in the extractive column and the extractive row may be interpreted as the required dollar input of extractive products for each dollar of output. In other words, the extractive industry must spend $0.18 on its own intermediate output in order to produce $1.00 worth of goods and services. All other entries may be read in the same way. This type of a table is described by the term "Direct Requirements," and it represents a production recipe for the various industries because it shows exactly what input configuration each industry requires to produce a dollar's worth of output.

There is one more table that is generally associated with an interindustry study. This table is an extension of Table 2 in that it shows the total effect on all other regional industries resulting from an expansion in the demand for any reference producer's output. For example, if the final demand for services increases by $1, that sector would require (from Table 2) $.009 worth of input from the manufacturing industry, $0.14 worth of input from the services industry, and so on.

The analysis does not end with these direct requirements, however. The $.009 increase in the services industry's purchases from the manufacturing industry represents an increase in the demand for manufacturing. In order to provide that $.009 worth of output, the manufacturing industry must purchase resources from other industries. Each of the other industries will need, in turn, to expand their input purchases in order to fill their increased demand, and so it goes.

The composite of all of these rounds of effects can be obtained through the use of computer technologies and is presented for this example in a "Direct & Indirect Requirements" Table (Table 3), page 5. The totals at the bottom of each column represent the interindustry multipliers discussed earlier in the paper. Each element of the column represents the direct and indirect effect that the industry at the head of the column exerts on the industries for each row.

For example, for every $1,000 of the final sales by the services industry, extractive will find its direct and indirect sales increasing by $1.00. Manufacturing will find its direct and indirect sales increasing by $10.00 and services will find its output increasing by that $1,000 plus an additional $15, for a total interindustry impact of $1,026.00.

For a more complete exposition on input/output analysis and its uses, see Emerson and Lamphear, Urban and Regional Economics, Chapters 2 and 3.

Table 1 - Transactions

	Extractive	Manufacturing	Services	Final Sales	Total Output
Extractive	100	700	000	4,625	5,425
Manufacturing	50	200	50	6,400	6,700
Services	75	300	75	4,905	5,355
Resource Inputs	5,000	5,500	230	18,000	28,730
Imports	200	000	5,000	000	5,200
Total Inputs:	5,425	6,700	5,355	33,930	51,410

Table 2 - Direct Requirements
Dollar Value of Transactions for a Hypothetical Regional Economy

	Extractive	Manufacturing	Services	Sector Output
Extractive	.018	.104	.000	1.000
Manufacturing	.009	.030	.009	1.000
Services	.014	.045	.014	1.000
Resource Inputs	.922	.821	.043	
Imports	.037	.000	.934	
Total Inputs:	1.000	1.000	1.000	

Table 3 - Direct & Indirect Requirements
Direct Dollar and Indirect Dollar Requirements
for a Hypothetical Regional Economy

	Extractive	Manufacturing	Services
Extractive	1.019	.109	.001
Manufacturing	.010	1.032	.010
Services	.015	.049	1.015
Total Inputs:	1.044	1.190	1.026

THE SIMLAB MODEL

SIMLAB is an input-output-based simulation model where all components, including the input-output table itself, are capable of being constructed from secondary information. This section of the paper describes the basic SIMLAB model and discusses the approach taken in developing the secondary data-based input-output tables contained in SIMLAB.

Input-output tables can be theoretically linked to any linear system of equations, column or row vectors, or additional matrices to analyze the interactions between the production sectors of an economy and related data sets. The discussion of the characteristics of a two-region model implies such an interaction set by linking the production sectors of one economy to the production sectors of another economy or set of economies.

Thus, input-output production sectors could be linked to a column vector of employment/output ratios so that a forecast of outputs from an assumed change in final demand could be translated into projected changes in the level of employment. Or, capital/output ratios could be linked to projected output changes in order to project capital needs for a region. Employment projections, coupled with labor force and skill matrices, could be used to project the labor force characteristics requirements from a projected change in final demand and resulting gross outputs. The possibilities go on, through tax matrices and vectors, environmental matrices and vectors and energy matrices and vectors, just to name a few.

An input-output model called SIMLAB has been developed by Wilbur Maki and others at the University of Minnesota, St. Paul. SIMLAB is a large scale simulation laboratory model representing a significant extension of traditional input-output techniques. In fact, input-output serves as the data base for SIMLAB and makes up three of its ten modules. SIMLAB is capable of interactive analysis, i.e., analysis where the user is allowed to change parameters and to simulate impacts from these parameter modifications on regional economic and demographic variables.

SIMLAB identifies and simulates interactions between ten potential modules. Table 4 lists these modules.

Table 4
THE TEN BASIC MODULES OF SIMLAB

1. The Market Model
2. The Investment Model
3. The Demand Module
4. The Production Module
5. The Income Module
6. The Employment Module
7. The Labor Force Module
8. The Population Module
9. The Household Module
10. The Recreation Module

The Market Module relates local SIMLAB information to the rest of the nation and includes such ratios as the proportion of national output accounted for by the reference region's industries.

The Investment Module shows the capital to output requirements for each industry as well as the proportion of local supplying industries that help meet these requirements.

The Demand Module represents the final demand component of an input-output system with emphasis on exports.

The Production Module is made up of the demand multipliers of an inverse (direct and indirect) matrix.

The Income Module relates direct and indirect income changes resulting from changes in demand. This module relates to the workings of the demand and production modules.

The Employment Module contains employment to output ratios. The regional employment requirements of simulated changes in output can be determined from this module. This module also states requirements in terms of occupation, earnings per worker, etc. The Employment Module relates the Production Model to the Labor Force Module.

The Labor Force Module contains data on the sex and occupational composition of the experienced labor force 16 years of age and older. It relates the Employment Module to the Population Module. It also contains data on commuting patterns for the region.

The Population Module contains data on births, deaths, and estimated migration levels. Migration is linked to the rest of SIMLAB through employment and labor force comparisons and through computations of unemployment rates. Unemployment in the region triggers out-migration, excess employment demand (relative to supply) triggers in-migration.

The Household Module* combines the employment, labor force and population information into household categories. The housing stock and future housing requirements can be determined from this module. (It should be pointed out that this particular module is not yet fully operative in the SIMLAB system.)

The Recreation Module* breaks final demand into recreation and non-recreation components. The recreation component is further broken into a series of activity sets. These activity sets are then related to industrial output levels through final demand. (It should be pointed out that this particular module is not fully operative in the SIMLAB system.)

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*These Modules will be discussed in more detail later in the Guide.

The Financial Module is currently under discussion. Such a module would link regional industrial activity to opportunities for financial investment in the region.

Other Potential Modules are possible, as stated earlier, dealing with taxation, environmental information, social service requirements. A Financial Module is currently under discussion. Such a module would link regional industrial activity to opportunities for financial investment in the region.

SIMLAB is a recursive model. The outputs of one module serve as inputs for the others. All of the impact accounting, however, is in a pattern in which inputs and outputs are determined simultaneously. The recursive-modular approach forces consistency in forecasting, that is, consistency in projections between modules. Output cannot expand beyond employment and capital availabilities in the region. Constraints to unlimited change are built into the system. This forces the user to explain simulated changes in one module in terms of indirect changes triggered in the remaining modules. This consistency requirement represents one of the real strengths of forecasts arrived at through SIMLAB.

SIMLAB has been developed so that it can make maximum use of secondary information. The input-output component of the system is derived from a two-region input-output model constructed entirely from secondary data and based on the 1972 U.S. Department of Commerce table for the nation. The actual two-region model consists of 214 sectors (many of them equal to zero for any small region) which is then compressed to a single region, fifty-five sector table in the SIMLAB system. All other components of the SIMLAB system can be derived from secondary data sources as well.

This does not mean that primary information cannot be incorporated into the SIMLAB system. Any of the components of the system can be strengthened through the inclusion of survey data. The strength of the model is its flexibility in this regard. That is, primary information can be collected and inserted for key sectors or for key parameters in the various modules as research budgets and interests dictate. The remaining parameters and variables can then be constructed on the basis of secondary information, cutting the overall costs of model implementation. Stages of development along these lines is the purpose of the series of projects being proposed or currently underway.

SIMLAB AND THE FOREST PRODUCTS INDUSTRIES OF NORTHEAST MINNESOTA*

SIMLAB has been put to various uses for the projection of important forestry related industries in the northeast Minnesota region of the State of Minnesota. One of these related to the paper industry and used the 1970 SIMLAB system developed for the state as a whole. A second use, which will be summarized here, dealt with the potential development of the waferboard industry in the region. This analysis used the 1977 SIMLAB system developed for the seven counties of northeast Minnesota that are in the planning jurisdiction of the Arrowhead Regional Development Commission.**

The purpose of this analysis was to project the waferboard industry (included in a general industry category termed as particleboard) to the year 2000 under various assumptions. The particleboard industry was used as a generic term for all types of processes that use wood chips to make structural or veneer plywood boards. Waferboard is a type of particleboard and is a structural building panel.

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*Development and Application of an Input-Output Simulation Model for Forest Industry Development in Northeastern Minnesota. Lichty, Flannery, and Peterson.

**The counties include Aitken, Carlton, Cook, Lake, Itasca, Koochinching, and St. Louis in the State of Minnesota.

It should be pointed out that the results of this analysis were preliminary. The classification scheme currently in the SIMLAB system aggregates at too great a level to isolate the waferboard or particleboard classifications specifically. Further, more detailed information of the projected growth of these industries would be needed to isolate the effects from changes in demand for the industries' outputs. The use of SIMLAB in this simulation did point to its usefulness for projects of this type, however. Modifications planned for the system will allow for more detailed analysis in the near future, and some of these modifications will be outlined here as well.

Before reviewing the simulation results, a general background of the particleboard industry will be presented here. Particleboard is a relative newcomer to the forest products industry. Although it was patented in 1905, it was not until 1945 that the first particleboard was produced commercially in the United States. Initially, particleboard was used in large quantities for core material in furniture. In 1975, this industrial use was still providing most of the particleboard market. However, with the addition of structural composite panels, housing and construction have become the fastest growing markets for particleboard.

One reason for increased interest in particleboard is its price compared to that of plywood. This is determined in part by cost of raw material, labor and overhead. At increasing capacities, particleboard has an advantage over plywood of reduced labor and capital cost. However, economies of scale can only be obtained to a certain point. Then, other costs make an impact, particularly those related to raw materials and transportation. These are the major concerns of the particleboard industry today. Advantages in raw material procurement and in transportation make the potential for waferboard development in Minnesota significantly high. The state of Minnesota has an abundance of roundwood (particularly aspen) which needs to be harvested. It is also close to large markets in the midwestern United States, making the transportation cost factor less of a problem than would be true in other parts of the United States.

Because of the rapid growth of this industry and the difficulty of isolating data on waferboard, the impact of the industry on Minnesota is uncertain. As the waferboard industry grows, and data become more available and interpretable, SIMLAB should prove to be a valuable tool in providing insights on the developments in the industry and their implications in terms of the Minnesota and northeast Minnesota economies.

The first step in using the SIMLAB model was to run a baseline projection series for the years 1977-2000. This series included several identified rates of growth for the 75 industrial sectors. These rates of growth were in the parameters of the SIMLAB system dealing with levels of labor productivity, levels of local investment (both capacity increasing investment and pollution abatement investment), labor force participation rates and other parameters reflecting economic and demographic behavior for the region. These parameters of the system are used to calculate variable values in a series of eight tables that can be accessed through the SIMLAB system. The eight tables relate to the ten modules of SIMLAB and are listed in Table 5.

The national growth rates for the industries were obtained from two sources out of the Department of Labor. These rates predicted an increase of a little over one hundred billion dollars in output for the wood products industry stated in 1977 prices.

One of the interesting results of this 23 year simulation is that, although the region participates in the national increase in this industry to the tune of an over one and one-half billion dollar increase in gross output, the employment in this industry for the region is seen to fall by over 450 employees. In analyzing the parameters of the system it was found that the explanation for this decrease could be attributed to two factors.

First, the rate of investment in new plants and equipment is in the most recent technologies. This leads to increases in labor productivity and decreases in the demand for labor at every level of output. Second, assumed increases in labor force participation rates leads to changing structure of employment for the region. This leads to substitution in the labor force categories. Of the two, the best explanation seems to come from the increase in labor productivity in the system.

Table 5: DATA BASE TABLES IN SIMLAB

Table Number	Table Titles
1	Export Market Indicators of Specified Industries
2	Intermediate and Local Final Demand Indicators of Specified Industries
3	Investment and Capital Stock Indicators of Specified Industries
4	Intermediate Purchasers, Imports, and Value Added Indicators of Specified Industries
5	Output, Earnings, and Employee Compensation Per Worker For Specified Industries
6	Total Employment in Specified Industries, By Occupation
7	Total Population and Labor force Indicators of Specified Sex and Age Class
8	Productivity Indicators of Specified Industries

After the baseline run was made, changes were made in certain key parameters to reflect the less rapid development of this industry in the nation than occurred under the "Department of Labor" assumptions.

For example, the internal values for the parameters were seen to be too high from actual experience between the years 1977 and 1982. The industry, like many others, had simply not performed up to the expectations from the sources used for original values. Two values, in particular, were seen to be out of line on the high side: the U.S. national growth rate for 1977-1982 and the rate of change in weeks worked per year for the regional industries. These two parameters were changed to more closely fit reality and to demonstrate the model.

The Department of Labor growth rate for this industry for the years 1977-1980 was listed as being roughly 2 percent per year. The actual performance in this industry saw zero growth to be more realistic. The 2 percent stated rate of growth was, therefore, replaced with a zero percent rate of growth for the modified simulation.

The national growth rate was seen to be 2 percent for the years 1980-1985. The zero percent rate of growth for this industry was extended for three of those years, from 1980-1983. The original rate of growth from the Department of Labor sources was then reintroduced in the year 1984, assuming an end to the current recession. The Department of Labor rates were then continued throughout the remainder of the simulation.

The rate of change in weeks worked per year for the wood products industry was -.2 of 1 percent throughout the simulation period. This was consistent with the rate of change in this paramenter for most of the other industries in the region due to the importance of changing technologies in the region. This value was accelerated for the industry for the years 1977-1983 to -2 percent per year, again reflecting difficult times in the industry. The old rate of -.2 of a percent was then reintroduced in the year 1984 and continued throughout the simulation.

An interesting outcome from the simulation was that although the results did show a decline for the revised output figures as compared to the baseline figure in every case, the decline was not as great as one might originally suppose given the importance of the wood products industries in general to the region.

A review of the information over the period of analysis gave some clues as to why this might be true. In the first place, the multipliers for the industry, as shown in the inverse matrix of the input-output system, were lower than for many of the other major industries in the region. This means that the spin-off effects from decline or expansion of this industry are not as great as would be true when other industries experience change.

Second, the employment impacts from this industry are less than is the case for some others. This means that, not only are the multipliers coming out of sales between industries lower for this particular industry, but the related employment impact of the industry was less than might have been supposed without the benefit of the input-output system that is such an important element in SIMLAB.

The next question that might be asked is, "What does all of this mean for the region?" In the first place, it is not meant to be an accurate reflection of the future state of the economy in northeast Minnesota through future years. To change the parameters of a single industry would not necessarily reflect changes in the other industries in the region. That is precisely why the baseline run is so important to understanding the strengths of the system.

The baseline provides a growth path given the best-guess parameter values and relationships for the base year in the system. Until better information is obtained, this baseline represents a type of growth path for the region under those early assumptions. When the parameters for any one industry are changed, and a new growth path is obtained, the comparison between the baseline and new growth path may be attributed to those parameter changes and the related influence of that industry on the economy.

If the user wishes, and if the information can be obtained, all parameters may be changed to more closely reflect reality. Under such conditions, the SIMLAB system becomes a forecasting model for the region.

How accurate are the changes? The SIMLAB system is not a statistical model of the type generally looked at when dealing with econometric techniques. It does force one thing on the user that inferential statistical models do not, the requirement for consistency in results. The user is forced to explain the results of any simulation run, not only in terms of the economics of the change, but also in terms of the demographics and related variable values contained or computed in the system. In that sense, the system is a general equilibrium type of model that highlights the fact that everything depends on everything else in a functioning economy.

The Next Step In Forestry Analysis

SIMLAB is operational and being used in northeast Minnesota. The U.S. Forest Service, North Central Experiment Station has funded a project that intends to use SIMLAB to analyze the possibility for increased use of residual products for energy development. The following is taken from the project description for that project:

A. The Problem: Northeastern Minnesota is totally dependent on the importation of fuel for its energy needs. While it is unlikely that the region will be able to discover and develop coal or oil-based energy sources, there is a possibility for development of energy from renewable resources such as wood. Before deciding on wood burning alternatives, the economic impacts of the most cost effective and beneficial types of fuels and energy installations need to be determined.

B. Objectives

1. To utilize the information obtained in other phases of the total research project in developing scenarios for alternative futures in the region.

2. To format the scenarios for input into the SIMLAB system.

3. To utilize SIMLAB for the development of impact estimates for the region on the basis of the formulated scenarios.

4. To develop appropriate reports on the results of the simulation and to present the reports for feedback from potentially interested parties in the region.

C. Research Approach

The model SIMLAB will be used to look at alternative futures for the region, both with and without the presence of a large demand for and supply of wood residues to be used in supplying the energy needs for the region. The alternative futures will be examined for their differences in terms of employment, earnings, growth, and general economic performance to determine impacts from the development of wood based energy for the region. The results of this exercise will be combined with earlier works dealing with alternative futures in peatland development to arrive at a complete picture of the effects from local energy development on the region's economic performance.

Finally, this project will utilize the information obtained in other phases of the larger research design in developing the alternative futures. Demand, price and output estimates will be incorporated into the development of scenarios for the region upon which impacts may be estimated.

The research will form the basis for several reports on expected outcomes. These reports will be presented in both written and oral formats for possible feedback from groups interested in the economic development of the region.

Other future uses to which SIMLAB is to be put includes the analysis of housing and the analysis of recreation in the region. The next two section of this GUIDE deal with those issues.

HOUSEHOLD MODULE

The household module is currently being incorporated in the SIMLAB model. The purpose of the household module is to provide housing planners and policy makers an opportunity to use the input-output analysis of SIMLAB in simulating the effects of various housing policy decisions.

The data for the seven-county region were obtained from 1980 Census data. Variables include tenancy (owner-occupied versus renter), age of householder, and quality of housing, measured by the number of persons per room and the presence or absence of plumbing facilities. These variables were selected to provide data on specific areas of concern in housing policy and in the region.

Currently, the household module is a stand alone operation. That is, it is not interactive with the rest of the SIMLAB system. It is presently limited to the data base print option in SIMLAB.

There are three tables for household information in addition to the eight described on page 13. All three are printed out when table 6 is specified (data base option).

The first table (6A) is the distribution of householder by age versus owner or renter status. It is based on percentages of householders for each age group. This relationship is held fixed throughout a simulation. Table 6A is derived from this matrix and the population figures from the population module.

The second table (6B) is the distribution of head of household by age versus owner or renter with each tenure status broken down by persons per room. Persons per room are value ranges. This matrix is based on two other matrices. One is simply table 6A. The other is the distribution of persons per household versus owner, renter, and age of head of household.

The final table (6C), is like the second table, but instead of persons per room, tenure forms are broken down by plumbing facilities. In this case it is with or without plumbing facilities. This matrix is, also, based on two other matrices. One is table 6A. The other matrix is the distribution of with or without plumbing facilities versus owner, renter, and age of householder.

Eventually a household module will be developed that feeds back into the other variables and parameters of SIMLAB. Demand for housing would be in the form of a function based on tenancy, age of householder and quality of housing. Quality of housing is based on persons per room and plumbing facilities. With the determination of the demand, the demand then would feed back to the rest of SIMLAB by changing the corresponding construction sectors in gross private capital function (i.e. increase final demand).

Table 6A Head of Household by Age
Arrowhead , 1977

Age	Owner	Renter	Total
1	0.	0.	0.
2	2148.	234.	2381.
3	20464.	7038.	27502.

Table 6B Persons Per Room by Occupancy Status
Arrowhead , 1977

Age	Owner			Renter		
	<=1	1.01-1.5	>1.5	<=1	1.01-1.5	>1.5
1	0.	0.	0.	0.	0.	0.
2	2084.	53.	10.	227.	5.	2.
3	19862.	505.	97.	6830.	147.	62.

Table 6C Occupancy Status by Plumbing Facilities
Arrowhead , 1977

Age	Owner With	Owner Without	Renter With	Renter Without
1	0.	0.	0.	0.
2	2082.	66.	215.	18.
3	19837.	627.	6486.	552.

Recreation Module

The tourism/recreation module provides for the inclusion of specialized data on selected elements of the regional economy, in this case, tourism/recreation activities. These activities are "facility-focused", that is, each activity is defined with reference to the unique set of private and public facilities it requires. A total of ten types of activities are delineated, each with two or more individual activities, as follows:

Trail: bicycling; hiking; backpacking; horseback riding; driving; off-road vehicles; berry picking; ski touring; snowmobiling.

Water: Canoeing; motor boating; waterskiing; sailing; swimming.

Licensed: Fishing; hunting.

Park: Developed camping; wilderness camping; picnicking; cooking.

Resort: Golf; tennis; swimming pool; sauna; downhill ski.

Urban: Movies; live entertainment; community events; dining for pleasure; shopping.

Educational: Visit historic sites; visit interpretive centers; going on industry tours.

Driving: Getting "there"; driving for pleasure

Personal: Sunbathing; reading; jogging; observing nature; socializing with people; taking pictures; watching Lake Superior.

Staying Over: Residing at final destination; residing at intermediate destination.

Final demand sector expenditures are listed by expenditure class and type of activity for three local sectors -- personal consumption expenditures, gross private capital formation, and government, federal, and state and local -- and the local visitor part of the export sector. Two rectangular matrices -- an expenditure-activity coefficient matrix and an industry-expenditure coefficients matrix are included in the module along with a tourism/recreation activity vec tor. User paramater change options are allowed as well as changes in any one or more of the ten activity types.

APPENDIX

INPUT-OUTPUT MODELS

The input-output model was originally developed in the 1940's by Wassily Leontief. In theory, the model attempts to make operational the concept of general equilibrium. General equilibrium recognizes that every economic unit in an economy relates, directly or indirectly, with every other unit. When the demand for corn increases, for example, the price of corn is expected to rise, while everything else is held constant. Everything is not constant for very long, however. The rising price of corn entices entrepreneurs to put additional resources into the production of that commodity. Farmers respond to higher corn prices by bidding resources out of non-corn related production. This means that the price of resources in corn production will increase relative to other production options. It also means a shift of resources out of alternate production options in favor of corn-growing activities.

The demand for corn might have increased for any number of reasons. There might have been an increase in the price of wheat, causing consumers to switch to corn because of its relatively low cost. Or, there might have been an increase in tastes related to corn consumption. Or, new customers might have entered the market for corn, as was the case when the Soviet Union began to purchase grains from the United States.

Whatever the reason, relative prices of corn and other commodities change, relative productions change (as the resources are taken out of other forms of production and put into corn), and relative prices of resources change, all as a result of the initial change in demand. In fact, if there are unemployed resources, or if new resources are put into the market because of higher resource returns, there is even a change in the general level of resource use associated with this change in demand.

In short, virtually every sector of the economy is changed, at least somewhat, due to this initial change in demand for one commodity. These changes continue to occur until the total adjustment to the initial change has had time to play itself out and the economy settles down into a new "equilibrium" position. General equilibrium would simultaneously solve for all of these changes and would simultaneously estimate new variable values associated with the shifting demands and supplies for all goods, services, and resources.

Although the general equilibrium model is conceptually complete, it has the deficiency of being non-operational for empirical analysis. No computer yet exists with the memory capacity to simultaneously solve for all prices and quantities in an economy. Even if there were a computer large enough for such a task, the data requirements of such a model would be out of reach. However, the alternative of looking at a change in one industry or resource market at a time, assuming all other markets to be constant and unaffected, creates an extremely unrealistic estimate from another direction.

Input-output attempts to move toward general equilibrium while staying within the data and computational capabilities of most research projects. Certain assumptions have to be made in order to make general equilibrium more operational:

(1) Prices are assumed to be constant. This means that the model no longer solves for this variable, but, rather, makes price a parameter to the equation system, thereby eliminating the solution requirements for one-set variables.

(2) Individual firms are assumed to be capable of being meaningfully aggregated into industrial sectors. This eliminates the requirement of solving for output levels of every firm in the economy and reduces the number of production equations to a manageable size.

(3) The production function for the region is assumed to be linear and homogeneous. This simply means that the production input pattern is constant for all levels of regional output. A doubling of output requires that all inputs also be doubled, a tripling of output requires that all inputs be tripled, and

so on.

(4) Production coefficients, per dollar of output, are assumed to be constant. This means that if industrial sector A requires 10¢ of input from sector B, in order to produce $1 worth of sector A's output, it will require 10¢ per dollar no matter how many total dollars of A's output are produced.

(5) Intermediate production requirements by local industries from other local industries are assumed constant. This means there is no substitution through changing trade patterns between regions.

These assumptions have the effect of greatly reducing the number of computations necessary for the implementation of a full-scale general equilibrium model. Now, instead of having a separate equation for every firm in the market, there are only as many equations as there are identified aggregate industrial sectors. Instead of a separate equation for every resource market, the resources are lumped into an exogenous final payments sector.

The model is triggered by changes in final demand; that is, demand for goods or services related to final uses. The components of final demand are exogenous to the model's structural characteristics in much the same way as final payments are, but the role of final demand as an initiator of impacts gives it a very unique role in the input-output scheme.

The basic input-output model consists of a series of three separate tables. The first is called the transactions table. The transactions table lists all industrial sectors defined for the purposes of the analysis being conducted. It should be noted that these sectors have to be defined so as to account for every firm in the region. The individual sectors should be relatively homogeneous in terms of their input requirements and output distributions. They should generally be disaggregated enough to highlight the true structure of the region without being so disaggregated as to cause significant problems in data collection or in disclosure of the operations of any one firm in the region.

The transactions table also contains values for final demand, as discussed briefly earlier, as well as the values for final payments. The grand totals of such a table contain the gross outputs for each industrial sector and the gross inputs required to produce those outputs.

Table 4 represents the structure of a hypothetical input-output table with three industrial sectors: Extractive, Manufacturing, and Services. Remember, the sectors should be defined so as to account for every firm in the region. The sectors should also, ideally, be as disaggregated as possible. For these reasons, Table 4 represents a very unrealistic example of an actual table. Keeping the size of the model to just three industries, however, makes required computations much simpler. The structure and use of larger tables remains much the same.

TABLE 4

DOLLAR VALUE OF TRANSACTIONS FOR A HYPOTHETICAL REGIONAL ECONOMY

Industrial Sector	Extractive	Manufacturing	Services	Final Demand	Gross Output
Extractive	100	700	000	4,625	5,425
Manufacturing	50	200	50	6,400	6,700
Services	75	300	75	4,905	5,355
Value Added	5,000	5,500	230	18,000	28,730
Imports	200	000	5,000	000	5,200
Total Inputs	5,425	6,700	5,355	33,930	

One of the most important things to remember when reading an input-output table is that the rows of the table represent sales and the columns of the table represent purchases. Thus, the 700 that appears in the Extractive row and the Manufacturing column indicates that firms in the Extractive industry sold $700 worth of goods and services to firms in the Manufacturing sector. Looked at the other way, we could say that the 700 also represents a $700 purchase by the firms in the Manufacturing sector from firms in the Extractive sector. The 50 in the Manufacturing row and the Services column represents a $50 transaction between Manufacturing (the seller) and Services (the buyer), and so on.

The same industrial sectors are identified on the left hand margin of the table as appear along the top of the table. The sales and purchases between these sectors represent sales and purchases of "intermediate" goods and services. These are goods and services produced for the purpose of facilitating further production. Semi-finished goods would be an obvious example of intermediate production, but so would the services of lawyers, bankers, transportation agencies (in all cases not involving a final transportation use), and any other sectoral input or output oriented towards helping other industries with their own production.

The Value Added row of the table represents another form of sale--the sale of resources of production to each sector. In a theoretical sense, the resources of production include land, labor, capital, and enterprise. In a more practical sense, this row generally includes the income received by local households for whatever contribution they make to the production process. These resource inputs are not generally considered to be intermediate even though the sale takes place so further production can take place. Rather, they represent final inputs that add to the income of households as opposed to industrial sectors.

Imports represent sales to local industries by industries and resource holders outside of the locality's defined boundaries. Imports (and exports, too, for that matter) are defined in terms of payments. Thus, any time a local industry buys something that results in a payment going outside of the locality, the purchase constitutes an import into the reference economy.

Finally, final demand consists of sales for final uses. The usual categories making up final demand include Household Consumption (by households located in the region), Government Purchases of Goods and Services, Gross Private Domestic Investment (including inventory changes), and Exports (again, defined in terms of the payment made).

The gross output and total input values are equal. This is due to the fact that the transactions table really represents a type of cost accounting sheet for a regional economy--debits equal credits. The elements in the table that forces this balance (which is a balance by definition) are profits or losses. This is because the final value of output is made up of all the costs that go into production, with profits and losses making up the difference.

In summary, the transactions table has three identifiable parts: the intermediate transactions component, representing sales and purchases between firms; the final payments plus imports component, representing resource inputs into the firm's production plus inputs from outside of the region; and the final demand, representing the sale of goods and services for final use. The table balances between inputs and outputs, with profit as the balancing mechanism.

The transactions table contains a great deal of useful information in its own right. The regional balance of trade (exports - imports) can be discerned from this table as can gross regional product (the dollar value of all final goods and services produced with the economy minus imports). The level of interaction between local industries and between industries in the region and households can be seen in this table. Finally, the relation between local household income and production is depicted in the transactions matrix.

The principal use for this table is found in the construction of the other two tables of the input-output system, however. As mentioned, the transactions table alone represents a cost accounting sheet for the region, nothing more or less. It is descriptive rather than analytical, and it does not allow for general equilibrium analysis of the type previously described without further modification. The next step uses the transactions table to construct a table of direct requirements, often called the technical coefficients matrix.

The question answered by the technical coefficients table is as follows: "If each local industrial sector sells to other local industrial sectors some total amount in intermediate goods and services so that the purchasing sectors can produce their own output, how much do the purchasing sectors require from the other local sectors per dollar of output?" For example, Manufacturing purchased $300 worth of intermediate output from the Services sector in order to facilitate its own production of $6,700 worth of intermediate and final outputs. How much did Manufacturing buy from Services per dollar of gross output? The answer is 300/6,700 = $.045. The same computation can be made for each intermediate sale and purchase in the transactions table. The result of these divisions is shown in Table 5.

TABLE 5

DIRECT DOLLAR REQUIREMENTS FOR A HYPOTHETICAL REGIONAL ECONOMY

Industrial Sector	Extractive	Manufacturing	Services
Extractive	.018	.104	.000
Manufacturing	.009	.030	.009
Services	.014	.045	.014

The rows are still read as sales and the columns as purchases. Only now the sales are in terms of cents per dollar, and the purchases have the special interpretation of "input requirements" per dollar of output. We call these "input requirements" because they represent requirements during the period of analysis in order for each sector to produce their own outputs, scaled down to a "dollar of output" basis.

The technical coefficients matrix represents a recipe for production. In order to produce one dollar's worth of output, the Extractive industry needed a pinch (1.8¢) of its own intermediate output, a dash (.9¢) of the intermediate output of the Manufacturing sector, and a smidgen (1.4¢) of the intermediate products of the Services industry. In order for Manufacturing to produce a dollar's worth of output, it required a pinch (10.4¢) from the Extractive firms, a dash (3¢) from Manufacturing, and a smidgen (4.5¢) from Services. And so it goes through all of the identified industries for the region.

One of the key assumptions of input-output analysis, mentioned earlier, is that this recipe does not change, regardless of the level of output. Thus, if the extractive industry were to experience an increase in final sales equal to $10,000, it would require another $180 worth of intermediate products from its own firms, $90 from Manufacturing, and $140 from Services. It should be emphasized that this process starts with a change in the final sales of an industry, or from "exogenous" forces. The coefficients in the interindustry section of the table represent the "endogenous" component of the table.

It can be seen that this first computed table gives the analyst limited ability for impact analysis. He or she could go through the process of assuming any number of changes in the final sales of the identified industries, multiply these assumed changes times the direct requirements coefficients, and come up with estimates as to the direct effects from these changing final sales on each identified industry in the region. Just to make sure that there is understanding of this process, the question might be asked: "What is the direct effect on each regional industry from an increase in the exports from the Manufacturing sector equal to $10,000,000?". The answer is that Manufacturing would increase by $10,000,000 plus a direct intermediate production effect of $300,000, for a total of $10,300,000; the Extractive industry would find its intermediate production increasing by $1,400,000; and the Services industry would see its intermediate production increase by $450,000.

But this is not the end of the story. If each industry has to increase its output in order to service the increase in final sales of the Manufacturing industry, then each must, in turn, increase their intermediate purchases and sales from and to one another to service this second-round expansion in activity. The second round must then be serviced by a third round of outputs. Each round is smaller than the last due to leakages to imports and to local value added, until the process has completely played itself out. The first three rounds of such an increase will be shown below.

Table 6 shows the first round of increase in intermediate and final production from an increase in the final sales of Manufacturing of $10,000,000.

TABLE 6

ROUND ONE FROM AN INCREASE IN MANUFACTURING FINAL SALES EQUAL TO $10,000,000

	Final Sales Change	Intermediate Sales Change
Manufacturing	$10,000,000	$ 300,000
Extractive	---	1,040,000
Services	---	450,000
Total	$10,000,000	$2,150,000

Note that the only exogenous change is the initial change in final demand assumed for the Manufacturing industry. The rest of the sales represent the direct first round results from those sales on the intermediate output of all industries in the region including Manufacturing. These are recipe requirements in order for Manufacturing to produce the hypothesized increased final sales.

Table 7 presents second round totals. Note that Manufacturing requires still more intermediate inputs from its own firms, this time to service the additional $300,000 of output it had to produce to directly allow for the initial $10,000,000 increase in final sales. Similarly, the Services industry needs to buy from each of the other industries to enable it to produce the additional $450,000 directly required by Manufacturing. Finally, the Extractive industry must have additional inputs to produce its additional $1,040,000 for Manufacturing. The rounds of production in Table 7 are indirect impacts.

TABLE 7

ROUND TWO FROM AN INCREASE IN MANUFACTURING FINAL SALES EQUAL TO $10,000,000

	Manufacturing	Extractive	Services	Total
Extractive	$31,200	$18,720	$ 000	$49,920
Manufacturing	9,000	9,360	4,050	22,410
Services	4,200	14,560	6,300	25,060

Now, Manufacturing has increased its sales three times: the $10,000,000 that was initially assumed, the $300,000 needed to directly service that increase in final sales, and the $22,410 to service the $300,000 in the first round. The Extractive industry has increased its sales by $1,040,000 to service the final sales change for Manufacturing plus the $49,920 to service that first round increase, for a total of $1,089,920 to this point. And so it goes.

We will now run through one more round of increased production, this time to service the second round. Table 8 presents this third round.

TABLE 8

ROUND THREE FROM AN INCREASE IN MANUFACTURING FINAL SALES EQUAL TO $10,000,000

	Manufacturing	Extractive	Services	Total
Extractive	$ 2,331	$ 899	$ 000	$3,230
Manufacturing	672	449	225	1,346
Services	1,008	699	351	2,058

Each additional round is computed in the manner shown above, and the totals are added to determine the total direct and indirect effects from the initial assumed change in the final sales of one of the regional industries. This process is obviously cumbersome. It would even be more difficult, impossible probably, to work such an iterative scheme for a larger number of industries or for higher direct coefficient values. Fortunately, the system of simultaneous equations represented by an input-output system can be solved using high speed computers in a matter of seconds, even for the largest of tables. The solution for the system in this example appears as Table 9.

The diagonal of the table shows "ones" plus some other factor. These "ones" represent the dollar increase to final sales of the industry for which such an exogenous change is assumed. The numbers appearing after the decimal represent the direct (shown in Table 5) plus indirect effects from each assumed change in final sales. Thus, the $10,000,000 change for the example using Manufacturing turns into a $10,320,000 total increase in Manufacturing sales: $10,000,000 to final sales, $300,000 in direct sales, and $20,000 in indirect sales. That $10,000,000 in Manufacturing sales turns into an increase of $1,090,000 in sales by the Extractive industry: $1,040,000 of that directly and $50,000 indirectly.

Finally, the $10,000,000 assumed increase in Manufacturing leads to an increase of $490,000 in the sales of Services: $450,000 of that direct and $40,000 of that indirect.

TABLE 9
DIRECT AND INDIRECT DOLLAR REQUIREMENTS FOR A HYPOTHETICAL REGIONAL ECONOMY

	Extractive	Manufacturing	Services
Extractive	1.019	.109	.001
Manufacturing	.010	1.032	.010
Services	.015	.049	1.015
Total	1.044	1.190	1.026

The total impact on all of the industries in the region combined is $11,900,000 (1.190 x 10,000,000). The 1.190 is called the demand multiplier for Manufacturing, or the total direct and indirect purchases this sector must make from itself and from the other regional industries in order to produce one dollar's final output. To conduct an impact study, simply take an assumed change in final demand for any of the industries times the demand multiplier for that same industry. This indicates the direct and indirect effects on the region resulting from the assumed change. The impacts stem from the fact that industries in a region interact with one another through their purchases and sales from and to one another. The greater this level of interaction, the greater the industrial demand multiplier.

THE TWO-REGIONAL MODEL

Many extensions of the basic input-output model are possible, each providing more detailed analysis than the Direct and Indirect table taken alone. One of these extensions is to take interregional trade impacts into account in the endogenous portion of the table rather than as an exogenous factor, as trade was taken to be in the previous examples. A discussion of this interregional table is presented here since this extension will be made in the construction of the input-output model for the region being investigated.

Input-output analysis has many strengths in terms of its ability to predict impacts of changes in the final demand component of a regional economy. Its success as a predictive tool is weakened somewhat by the restrictive assumptions necessary for the table's construction. Three important limitations are continually mentioned in this regard: (1) all production relationships are assumed to be linear in form, (2) the element of time is completely ignored, and (3) the "feedback" effects resulting from interregional trade are not taken into account.

Experts in the field are currently working on the changes required to answer some of these criticisms. Much of this work has been directed toward the third limitation--omission of interregional feedback effects.

The essence of the work dealing with interregional feedback is this: the single-region models so prevalent in the United States today do an excellent job of tracing through internally transmitted impacts. In other words, single-region models treat local economies as being free of effects from trade patterns resulting from locally induced production. Trade with other regions is treated as an exogenous component of the model.

Assume, for example, that there are two defined regions, each with its own internal industrial structure and each carrying on trade with the other. Region A has an input-output table with exports as an exogenous component of final demand and imports as an exogenous component of final payments. Region B has the same. Now assume that Region B increases its demand for the products of Region A. This represents an increase in the final demand for a certain set of Region A's industrial outputs.

Region A, with its single-region input-output model, will provide a strong capability for tracing through the rounds of internal changes required to satisfy B's increased demand. This is certainly useful information for the planners of Region A, but it falls short of a full analysis for the two regions taken together.

In order for Region A to increase production, its industries will need to buy more from one another as well as increase their intermediate imports from other regions, including Region B. What is more, local households in Region A will find their incomes increasing as a result of increased industrial activity, and they, too, will buy more products locally and from other regions. In turn, Region B should find that its exports to Region A are increasing as a secondary impact of its original changing demands for A's output. The increased activity in Region B will then indirectly affect the level of Region A's output, and so on, until the trade multiplier effect has worked itself out.

Unfortunately, single-region models for the two regions are only capable of analyzing the impacts on Region A from the original demand change on the part of Region B, as if Region A were an isolated economy reacting only to exogenous changes. No "feedback" analysis is possible with respect to Region B, thereby understating the total changes that affect the two regions taken together.

One response might be to create a combined table for the two regions, making them into one larger region. This logic may eventually lead us to the conclusion that only national tables are worthwhile, since any sub-national table would ignore the trade patterns and their impact. This would leave smaller regions without the ability to analyze specific effects from changing demands on their local industries. Region A and Region B may be different enough from one another so that separate tables would be useful to their individual planning needs.

An alternative approach to constructing a single table is to make the trade components either more detailed in their exogenous capacity or to make trade an endogenous component of each region's tables. Each region would retain their capacities for analyzing internal impacts from changing demands while the greater region will be capable of more accurate and detailed analysis.