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USERS' GUIDE TO THE MINNESOTA REGIONAL DEVELOPMENT SIMULATION LABORATORY

Wilbur R. Maki, Patrick D. Meagher, Leonard A. Laulainen,
and Mason Chen

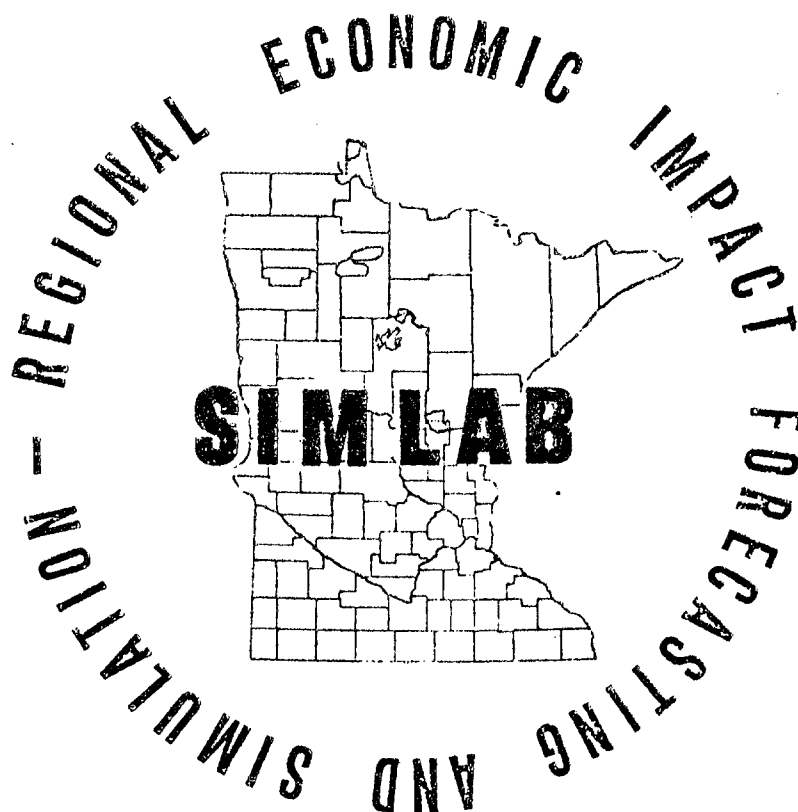


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USERS' GUIDE TO THE MINNESOTA REGIONAL
DEVELOPMENT SIMULATION LABORATORY

Wilbur R. Maki, Patrick D. Meagher, Leonard A. Laulainen, Jr., and Mason Chen



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Preface

SIMLAB is the work of many. For us this Users' Guide is acknowledgment of a certain coincidence of history. We simply have reached the end of a long fiscal year and it is time to close shop for a short rest.

Before this long year began, SIMLAB was an Iowa State computer simulation model. Richard Suttor and Jerald Barnard were its early builders. This was more than a decade ago when both were doctoral candidates in the Economics Department at Iowa State University.

With the energy crises came an opportunity to again make use of the Iowa State model, this time at the University of Minnesota. Parts of the model were rebuilt as an energy impact analysis and forecasting system for a study funded through the newly-formed Minnesota Energy Agency. A two-region input-output, also developed at Iowa State University in the 1960's, was made an integral part of this new, expanded computable economic model of a nationally-linked regional economic system.

About this time, a new course called Community Development Simulation was organized in the Resource and Community Development Program with the help of Bob Barrett, Director of the Urban Studies Institute at Mankato State University. Half of the course was built around the computer simulation model. The other half was built around a gaming simulation model -- the City Game. This was a laboratory setting for learning about the uses of social and economic information in city and regional planning through role playing. From this setting came SIMLAB -- a regional development simulation laboratory.

Since the mid 1970's, SIMLAB has been extended from primarily a teaching aid to an effective research tool. The user-interactive mode was supplanted by a batch-processing mode in its application as a regional

economic impact forecasting and simulation system.

SIMLAB has undergone a series of tests of its usefulness as a research aid. Most recently it has been used in studies of industrial renewal in the Twin Cities Metropolitan Area, irrigated agriculture in West Minnesota, peatland development in northern Minnesota, copper-nickel development in Northeast Minnesota, and the importance of the mineral industry in the State of Minnesota. In each study, some part of SIMLAB was improved so that now it has the most complete set of regional economic data and procedures heretofore available in a single computable model of a regional economic system. The complete system is now available for the use of researchers and teachers in the regional and management sciences.

We wish to share SIMLAB with others. We hope this Guide will now help us in this new purpose.

1. INTRODUCTION TO SIMLAB

This manual is a users' guide to the Minnesota Regional Development Simulation Laboratory, called SIMLAB. We introduce SIMLAB by answering a few of the most frequently asked questions about it.

What is SIMLAB?

SIMLAB is a computer-based, user-interactive regional economic forecasting and simulation system. It was built in 1975 as part of a course on Community Development Simulation. Studies of the economic base of Mower and Itasca counties -- one agricultural, the other timber and tourism -- were available for building a small computer model of the two community economic systems. A computer program was prepared for simulating the effects of changes in market conditions and government policies on industry employment, output and income in each county.

Since 1975, SIMLAB has been improved and extended in many ways. It now provides access to a growing library of computer simulation programs. Besides Mower and Itasca counties, SIMLAB is available for four Minnesota planning regions -- Northwest, Headwaters, Arrowhead and Metropolitan Council, three special studies (West Minnesota irrigated agriculture, extended Northeast Minnesota copper-nickel development, and East Range copper-nickel development) regions, and the State of Minnesota.

How is SIMLAB put together?

The computable economic model in SIMLAB is actually a series of modules-- market, investment, demand, production, value added, employment, labor force, population and household. The modules are interactive -- the output data of one module are the input data for the next module. The production module is central to system performance -- it links the regional economy to the rest of Nation.

The production module may have as many as 95 industries which relate to one or more of the remaining eight modules and the Control Module.

Each of the ten modules has a function as follows:

- Market module links production in the Region to markets in rest of Nation and, hence, it "drives" the production subsystem.
- Investment module links total private spending for plant and equipment in Region to gross output of capital-producing industries in Region.
- Demand module links final users of goods and services in the Region with gross output of all producing sectors in Region and (through imports) in rest of Nation.
- Employment module links gross output levels to labor input levels derived from the employed work force of each industry in Region.
- Value added module links gross output in Region with depreciation, business taxes, and profits of each industry in Region.
- Labor force module contains the demographic and economic data which specify the regional labor supply.
- Population module relationships include variables representing the demographic and economic forces determining changes in regional population.
- Production module contains the core regional input-output model which interacts with the other modules.
- Control module enables user interaction with each SIMLAB module.

Even in a small area, inter-sector and inter-industry linkages are important in accounting for the cumulative economic effects of resource development on local communities. The patterns of interindustry linkages will vary from year to year because of shifts in export-import balances.

Certain market conditions, for example, may improve relative to the given development assumptions. This improvement in market prospects results in more exports of a particular locally-produced industry output, provided capacity exists in this industry. Projected long-term market expansion is accompanied by increased industry capacity through expansion investment. The supply of required labor inputs increases, also, through local labor mobility, commuting and migration.

When industry output increases, the value added by locally-employed resources is recycled, in part, within the local economy. The process of income generation is accelerated and dampened as export markets expand and contract. Thus SIMLAB provides the computable model of the development region and the procedures for readily using the model in simulating the regional economic effects of foreseeable or probable changes in levels of mining activity and organization of production.

Who may use SIMLAB?

Anyone with access to the SIMLAB Library may use SIMLAB. It was used recently to simulate the local economic effects of copper-nickel development in Northeast Minnesota. It is a sophisticated research tool for the measurement of investment, demand, production, employment and related changes associated with certain prescribed changes in types and levels of mining activity in the East Range Development Regions. It is also a readily accessible, user-activated library for verifying certain statements about the local effects of copper-nickel development. It extends the use of available information on regional economic conditions to a much wider range of user clientele than simply the technicians and analysts working on environmental and economic impact studies. The wider clientele includes consultants, students, teachers, community leaders, extension workers, journalists, and

others who are willing to risk the small time commitment required to acquire user access to SIMLAB.

How is SIMLAB used?

SIMLAB is now being used in quantitative studies of the direct, indirect and induced socio-economic effects or impacts of new industry development. Direct effects include new industry employment of part of the regional labor force and purchases of inputs from area business firms. Other area business firms become indirectly affected if they furnish inputs to directly affected firms. Household spending induced by new industry payrolls affects the area retail, wholesale, and service sectors. In addition, regional population may increase through migration in response to job opportunities created by these direct, indirect, or induced effects. Demand for essential public services may also increase.

Effects from development are typical of the kind SIMLAB can trace, account for, and measure quantitatively. SIMLAB can also be used to analyze effects from existing industry expansion or contraction. This analysis can be conducted statewide, at the region or multi-county level, and for sub-county incorporated places.

Simulation models, like SIMLAB, enable the user to deal with uncertainty. SIMLAB is designed for the user who can make plausible alternative assumptions concerning present and future events. The user interprets these events in terms of changes he specified in SIMLAB variables and parameters.^{1/}

^{1/} Variables are defined as the numerical indicators of socio-economic conditions which change in value from year to year during the course of each computer run. Parameters are the numerical indicators which are held at user-specified levels during the simulation run. All variables and parameters are parts of equations representing the economic structure and activity of a region, such as interindustry transactions, business spending for new plant and equipment, household spending, and local labor market and population changes.

In the current copper-nickel study, SIMLAB had several uses. It was used, first, in organizing data collection and assembly. Existing data sources, largely in state and federal agencies, were consulted in building the regional data base. Supplementary business and household surveys were undertaken to help fill known data gaps. Secondary data, already in SIMLAB files, were used, also.

Second, SIMLAB helped in data analysis and interpretation. A series of individual models of regional activity clusters (e.g., population, labor force, and employment) are linked together into a recursively interactive computer model of a regional economic system. Local effects of given changes in local industry outputs are derived by use of the computer model. These effects are based on both the internal and the external linkages of this economy. These linkages, of course, change in magnitude and importance in the local economy and the Nation from year to year.

Third, SIMLAB was a tool for testing and validating statements about economic and demographic consequences of local effects of public policies for dealing with these consequences. In the case of a large-scale development project, such as copper-nickel mining, or an accumulation of small-scale development projects, public officials oftentimes must justify need for certain public facilities and services. Supporting statements of probable population, employment and income effects of projected private development are prepared, the adequacy of these statements can be examined in the context of the various SIMLAB simulations.

SIMLAB generates projections of future regional activity which are consistent with pre-specified socio-economic parameters. These projections are computer simulations of future conditions based on the initial conditions

and pre-specified values represented by a mathematical model of the region.^{2/}

The next chapter shows the importance and role of interindustry linkages in the SIMLAB system and the use of input-output methodology in building SIMLAB. In Chapter 3, the model equations are presented and their assumptions and data sources are documented. In Chapter 4, procedures used to construct regional input-output transactions tables are described. In Chapter 5, the computer output is explained and the reader is walked through a SIMLAB computer run.

^{2/}

The SIMLAB application of the word "simulation" is very general and is to be distinguished from the kind of system simulation done by operations researchers and industrial engineers. In system simulation, the effects of random processes on variables of interest are studied. In contrast, SIMLAB user-specified changes in model variables and parameters are likely to be non-random cyclical and/or trend representations of socio-economic processes.

2. INTERINDUSTRY LINKAGES AND THE SIMLAB SYSTEM

Interindustry linkages in a region are represented by an inter-industry transactions table. Individual columns in the table refer to the acquisitions of goods and services of each industry from itself and all other industries in the Region. The rows refer to the disbursements of each industry to itself and all other industries in the Region. The interindustry transactions in an area economy are thus disaggregated into a series of interacting industry, final demand, and import sectors.

- ° Producing industries buy raw materials, semi-finished and finished goods, capital and labor in the area to produce their products which, in turn, are sold to other producing industries, and to final users in the area.^{3/}
- ° Final demand consists of household consumption, capital formation, government purchases, and exports.
- ° Imports are purchased by producing industries, both as goods reworked into products for resale, and as capital equipment. Households and governments also purchase imports. Imports represent dollar outflows which have no further effect on regional income and profits.
- ° Households furnish labor services to producing industries and governments, receiving, in return, wages and salaries used to purchase consumer goods and services.
- ° Exports of area-producing goods provide dollar inflows which become personal income and profits and which are used, on balance of payments account, to pay for imports.

^{3/} Hollis B. Chenery and Paul G. Clark, *Interindustry Economics*, John Wiley and Sons, Inc., New York, 1959.

The dollars flow among area producing industries, households, and governments are measures of the degree of economic interdependence in a regional economy. They are used to analyze and estimate the direct, indirect and induced effects of changes in final demands for industry output in the region.

Strong linkages among local industries, coupled with low levels of imports, means a high level of regional economic self-sufficiency. With little dependence on outside sources of required goods and services, the local effects of a stimulus, such as new industry, will be strong and widespread because of a corresponding expansion in a local labor force with high expenditures for locally-available goods and services. Imports of manufactured products, however, reduce the potential impacts of the labor force expansion. Measurement of interdependencies between exports, imports, and regional household spending, therefore, is an important part of an impact analysis.

Transactions Table

In input-output analysis, an interindustry transactions table is prepared for use in measuring first-order interdependencies. Each data element x_{ij} in the transactions table shows the dollar volume of (1) purchases of each industry, i , as a user of goods produced by industry j , and (2) sales of the same goods from industry j to industry i . Thus the table cross-classifies industries into their separate roles as users and suppliers. The dollar volume of purchases is usually measured over the course of a year.

Figure 2.1 illustrates the input-output transactions table used in preparation of the SIMLAB production module. The left margin of the table lists the regional industries producing goods used in production by regional industries listed along the top margin. Thus, a typical

Figure 2.1

Regional Inter-Industry Transactions Table

Producing Sectors	Intermediate Demand				Final Demand		Gross Output
	Industry 1	Industry i	Industry n	Total	Local	Export	
	(dollars)						
Industry 1	X_{11}	X_{i1}	X_{n1}	$\sum_{j=1}^n X_{1j}$	Y_1	E_1	X_1
Sales (Inputs)				$\sum_{j=1}^n X_{1j}$			
Industry i	X_{i1}	X_{ij}	X_{in}	$\sum_{j=1}^n X_{ij}$	Y_i	E_i	X_i
Industry n	X_{n1}	X_{nj}	X_{nn}	$\sum_{j=1}^n X_{nj}$	Y_n	E_n	X_n
Value Added	V_1	V_j	V_n	$\sum_{j=1}^n V_j$	0	0	$\sum_{j=1}^n V_j$
Imports	M_1	M_j	M_n	$\sum_{j=1}^n M_j$	0	0	$\sum_{j=1}^n M_j$
Total Outlay (Column totals)	X_1	X_j	X_n	$\sum_{j=1}^n X_j$	$\sum_{i=1}^n Y_i$	$\sum_{i=1}^n E_i$	X

element in Figure 2.1 shows the dollar value of intermediate product purchased by the j^{th} sector, a user, from the i^{th} sector, a producer. Each element can be thought of as a link in a chain connecting each industry, the intermediate users of its products and households with regional industry. Households furnish inputs of labor services to industries listed along the top. Regional industries also product goods used by regional households and government or for capital investment. These users are represented by the column of entries summarily labeled "local" under "final demand". Regional industries may also export output to industries and final users located outside the region as indicated by the column of entries labeled "export" under "final demand". The sum of all purchases by an industry, including any imports of intermediate and primary products, is its total outlay as recorded in the bottom row of entries. Gross output for each industry is the sum of all sales to intermediate users, final demand, and export; and is recorded as an entry in the column at the far right. Total outlay and total outputs for a given industry are defined so as to be equal, so the transactions table provides a complete accounting of regional cash flows.

An input-output transactions table for the United States economy has been constructed by the Department of Commerce using primary data sources.^{4/} The National transactions table is used as a secondary data source in constructing regional transactions tables following methods extensively discussed in published literature.^{5/} These procedures together with

^{4/} U.S. Department of Commerce, Social and Economic Statistics Administration/Bureau of Economic Analysis, Input-Output Structure of the U.S. Economy: 1967, 3 Volumes, Washington, D.C., 1974.

^{5/} W.I. Morrison and P. Smith, "Nonsurvey Input-Output Techniques at the Small Area Level: An Evaluation," Journal of Regional Science, Vol. 14, No. 1, 1974, pp. 1-14.

supplementary information on regional industry input requirements are used in developing the transactions tables used in SIMLAB. Chapter IV discusses the technical details of this procedure, its assumptions, and resulting limitations as they affect the SIMLAB system. The resulting transactions table is the core of the SIMLAB procedure for measuring the effects of new industries and other kinds of marked change in the regional economy.

Measurement is possible because the input-output transactions table contains the necessary information and can be manipulated to yield the required measures of interindustry interactions. The next section demonstrates mathematically that this is indeed the case. The non-technical SIMLAB user should appreciate the need for this demonstration but does not need to understand its details in order to use SIMLAB. The necessary mathematical relationships are programmed into the SIMLAB computer package and are performed as needed during the course of user interaction with the system.

Input-Output Relationships

From the data in the transactions table, it is possible to calculate a series of ratios of individual industry purchases to total outlay represented as,

$$A_{ij} = \frac{x_{ij}}{x_j}, \quad \text{or } x_{ij} = x_j A_{ij} \quad (1)$$

where, x_{ij} = intermediate product sales to the j^{th} sector by the i^{th} sector;

x_j = total output of j^{th} sector (which is identical to total outlay from the same sector);

A_{ij} = intermediate product purchases from the i^{th} sector of output by the j^{th} sector.

Total sales by the i^{th} industry is represented by;

$$x_i = y_i + \sum_{j=1}^n x_{ij} \quad i = 1, \dots, n \quad (2)$$

where, y_i = final demand for product from industry i .

Since $x_{ij} = x_j A_{ij}$, the total sales equation can be rewritten as

$$x_i = y_i + \sum_j x_j A_{ij} \quad (3)$$

Hence, for all industries, total sales can be expressed in matrix form as

$$\begin{vmatrix} x_1 \\ x_2 \\ \cdot \\ \cdot \\ \cdot \\ x_n \end{vmatrix} = \begin{vmatrix} y_1 \\ y_2 \\ \cdot \\ \cdot \\ \cdot \\ y_n \end{vmatrix} + \begin{vmatrix} a_{11}, a_{12}, \dots, a_{1n} \\ a_{21}, a_{22}, \dots, a_{2n} \\ \cdot \\ \cdot \\ \cdot \\ a_{n1}, a_{n2}, \dots, a_{nn} \end{vmatrix} \begin{vmatrix} x_1 \\ x_2 \\ \cdot \\ \cdot \\ \cdot \\ x_n \end{vmatrix} \quad (4)$$

or

$$X = Y + AX \quad (5)$$

where, $X_{n \times 1}$ = vector of industry gross outputs;

$A_{n \times n}$ = matrix of interindustry coefficients A_{ij} ;

$Y_{n \times m}$ = vector of m final demands for the n goods;

Equation (4) can be rearranged algebraically to give,

$$X = (I-A)^{-1} Y \quad (6)$$

where, $I_{n \times n}$ = the identity matrix.

Equation (6) shows that total output must increase if increases in final demand are to be met. Increased final demand for product i will also require increased production of i if increased input requirements of industry j are to be met. The matrix $(I-A)^{-1}$ indicates the required

change in output of all industries if final demand in any one industry changes. This matrix is at the core of the SIMLAB procedure for measuring the effects of new industries and other kinds of marked change on the regional economy.

The coefficient A_{ij} is a measure of the linkage among regional industries. These linkages depict the outcomes of production decisions made by regional businessmen in producing their respective products, taking into account relative input prices, engineering or production technology, and market conditions. As such, the coefficient A_{ij} depicts an efficient interindustry structure insofar as it results from a profit-motivated use of intermediate goods, capital, labor, and natural resources as sparingly as technology permits in the production of a given level of output. Because technology changes slowly, the coefficients are relatively stable.

In preparation of the SIMLAB production module, the regional transactions table initially contained 95 rows and 95 columns (which were derived from the United States transactions matrix containing 95 sectors). Less sectoral detail would impair model accuracy. For some studies, the matrix has contained as many as ten additional sectors. The expanded table is then used to derive a detailed breakdown of industry in a region. Once done, the results are aggregated to 70 or fewer sectors for inclusion in SIMLAB only because of computer capacity constraints. When more computer capacity is available in the future, SIMLAB could have about 100 individual industry groups.

The matrix $[I - A]^{-1}$ measures the required change in output of all industries in final demand in any one industry changes. Because use of the matrix $[I - A]^{-1}$ hinges on knowledge of final demands, an important

part of the SIMLAB model consists of equations, with user-controlled variables and parameters, for projecting final demands. Given projected final demands, the computer is used to calculate the required outputs in preparation for further analysis. To facilitate further analysis, SIMLAB includes several auxiliary modules which the user can access. These modules contain information which, when combined with user-generated output changes, provide additional results on socio-economic impacts.

The user can interact with, and interface, the input-output modules, the demand projections module, and the impact assessment modules. To assist the user in this task, an interactive control program is also part of the SIMLAB system. Figure 2.2 shows the four basic kinds of modules in the system. All SIMLAB calculations are made in a logical sequence beginning with the demand projections modules. Thus, in Figure 2.2, the calculation sequence proceeds from left to right and then through the auxiliary modules in the order indicated.

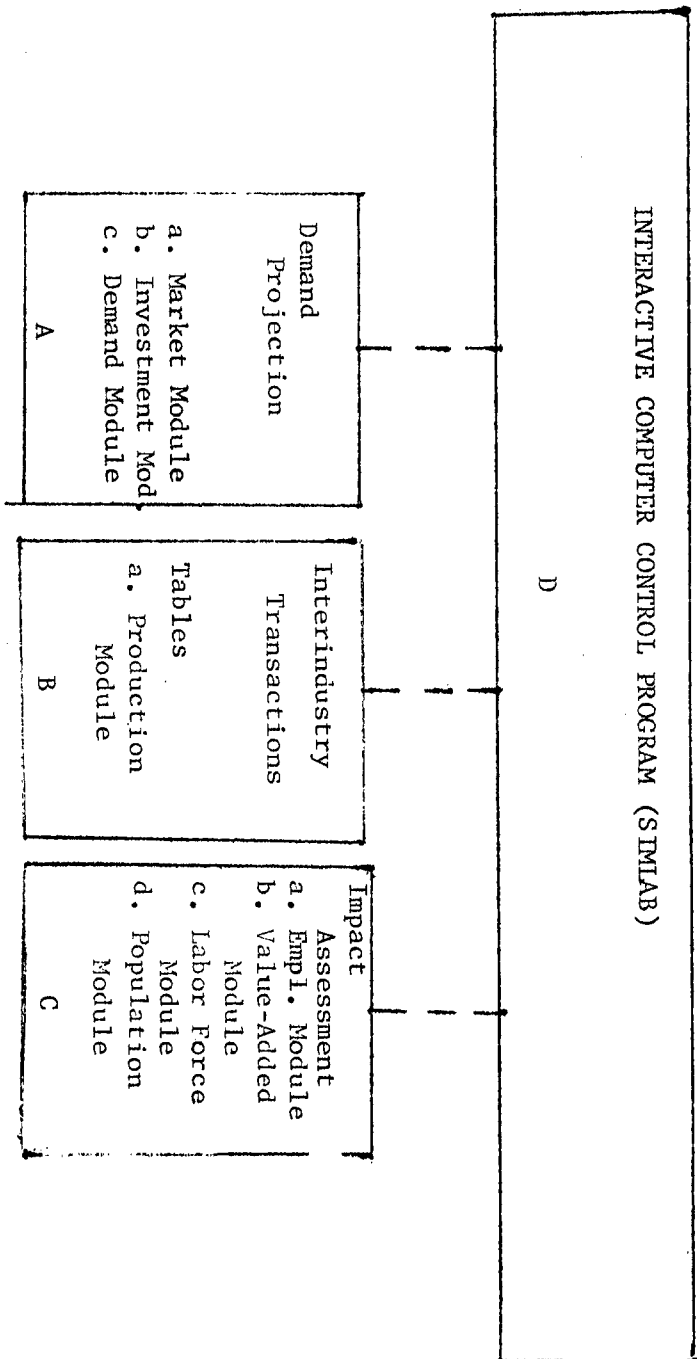
SIMLAB Overview

Use of the input-output procedures to project socio-economic variables requires, first, projections of regional final demands. In the SIMLAB model, the final demand components are exports to the rest-of-world and local investment in plant and equipment, inventory accumulation, personal or household consumption, and government purchases. The SIMLAB sequence of calculations starts with regional exports because the underlying theory is one in which the exporting industries drive the regional economy.^{6/}

^{6/} Walter Isard, *Methods of Regional Analysis: An Introduction to Regional Science*, the MIT Press, 1960, Chapter 6.

SIMLAB Module Structure

Figure 2.2



Economic base industries are those which produce goods and services for sale outside the region, generating an inflow of dollars on regional balance of payments account in the process. The inflow sustains regional economic activity and, if the inflow increases, causes the level of regional activity to grow through the system of linkages between the base industry, or industries, and other regional industries supplying the base industry. As previously shown in this chapter, the input-output coefficients provide a quantitative description of these linkages.

The input-output coefficients also provide a quantitative description of the linkages among regional industries supplying those producing for the other regional final demands, including investment in plant and equipment, changes in business inventories and household and government purchases. Because there are SIMLAB modules for projecting these final demands, as well as exports, the SIMLAB model must utilize all inter-industry linkages represented by the input-output transactions table in generating its projections.

Once all final demands have been estimated and the output required of these final demands calculated, the SIMLAB program proceeds to use the calculated output levels to project regional employment, work force, and population. The system is then closed, recursively, by using these results in the projection of final demands and production in the next year.

Simulation of Alternative Area Futures

In the SIMLAB modules, socio-economic processes and events are represented by numerical variables, parameters, and relationships. The relationships programmed into the modules have been constructed from theoretical and empirical evidence which appears in the economic

literature. This manual provides reference to the literature and a description of the effects the user can expect should he modify a given variable or parameter (see Chapter III). This description of effects illustrates the assumptions and economic logic built into the SIMLAB model.

Once the user modifies a variable or parameter, programmed interactions among the modules illustrated in Figure 2.2 require SIMLAB calculations to occur in a logical sequence consistent with the economic base theory of regional economic activity. For example, a change in the growth rate of the national economy will lead to a change in the growth in demand for regional exports, calculated in the market module. A change in regional exports will lead to calculation, in the production module, of changes in regional output required if the change in the export component of final demand is to be met. Should these calculated changes cause regional plant capacity to be exceeded, or should they require labor inputs in excess of available labor supply, SIMLAB will calculate the maximum output obtainable under the existing constraint. In the case of excess demand for labor, migration and commuting into the region will be handled in the labor market and population modules. Further discussion relevant to the question of model performance can be found at the end of this chapter.

Before studying the details of SIMLAB model performance, the user should consider his measurement problem in the context of the assumptions he is willing to make about the future evolution of the local economy. User analysis of assumptions must begin with analysis of change in regional economic indicators. This change may be characterized by, among other things, increasing demand for products produced by regional industry, change in regional market share for exported goods, and

change in total regional output. Local industries may be growing, static, or declining and local worker productivity may also be changing, leading to changing employment levels and population. Measurement against this moving background involves the use of alternative sets of user-provided assumptions in preparation of simulated alternative forecasts or futures. An overview of user preparation and interpretation of these SIMLAB projections is discussed next.

Baseline and Development Scenarios

To measure socio-economic impact in a changing local economy, a benchmark or baseline projection must be prepared first. The baseline projection must be designed to accurately represent local economic events as they would unfold in the absence of the socio-economic event the SIMLAB user has under study. Thus, the baseline projection will nearly always depict historical trends, particularly in:

1. U.S. gross output
2. Regional exports and/or market share
3. Regional worker productivity
4. Regional employment and earnings

Trends in U.S. gross output are taken into account in preparation of benchmark projections because the local economy is a part of the national economy which provides markets for regional exports. The volume of regional exports determines the local balance-of-payments-position and generates the direct and indirect effects measured by the regional input-output table as discussed above. Trends in regional market share for exported goods provide an indication of the competitive position of regional export industries. Local output per worker or worker productivity in export industries determines employment and earnings in these

industries and through induced effects, employment and earnings in local household serving industries. Employment and earnings are, in turn, significant factors in determining migration caused shifts in regional population and population mix.

In SIMLAB analysis, development assumptions or scenarios are user specified changes in the baseline trends. Fed into the system, the scenarios cause the generation of data representing the evolution of the regional economy under changed (from the baseline) circumstances. Differences in the two data sets, baseline and simulation projections, represent socio-economic impacts.

Uncertainty, as already described, in the exact shape or form of future events, such as copper-nickel development, suggests that the SIMLAB user adopt an experimental approach, feeding in alternative plausible sets of development assumptions or scenarios and observing the results. In formulating scenarios, the user should consider the different kinds of uncertainty described previously and formulate assumptions which, in the context of the problem at hand, represent the kind of uncertainty involved. If the user does not understand the nature of his uncertainty problem, then perhaps the analytical problem at hand should be reviewed and redefined. This approach will result in a systematic and thorough investigation of the problem SIMLAB is being used to analyze. It will also help avoid the pitfall inherent in routinely treating SIMLAB forecasts as explanations of area economic events. It is the user who must interpret and explain the projections generated with SIMLAB.

Because the programmed relationships within modules and the interactions among modules do not change, the only entities in SIMLAB

analysis which affect projections are the assumptions. Thus, user interpretation of porjections should focus on the simulated effects of the assumptions.

The user can change parameters in the various modules and, hence, in much of the model underlying SIMLAB. Thus, the user has responsibility to evaluate the validity of the model he has created. However, there are no generally accepted criteria for assessment of model adequacy and reliability, or model validation, because of the differing needs of various model users. A model which adequately represent regional economic structure and process with sufficient accuracy for one user may be inadequate for another. Each SIMLAB user must decide, therefore, on his performance requirements. The discussion of this subject will alert the user to the need of establishing performance requirements which meet his specific needs.

Some users may require a model which projects with a minimum level of accuracy if it is to be useful for planning and/or decision-making. Model accuracy will be of interest whenever erroneous projections will result in improper plans or decision which impose unwanted costs on the SIMLAB user. Should this be the case, the user may want to evaluate model projection error. However, this discussion can only offer some general guidelines since the exact nature of the error evaluation will depend on the needs of the user and the particular kind of error he wishes to avoid. For example, certain users may wish to avoid overly optimistic predictions. Others may wish to avoid pessimistic predictions. The SIMLAB user must identify the kind and magnitude of forecast error he wished to minimize before proceeding with error evaluation.

One general method of error evaluation consists of using the model to generate estimates of already-known historical values of the variables to be projected using historical value of user-modified variables and parameters. The model generated values are then compared with the known values. Comparison will let the user observe whether the model can be expected to consistently underpredict or overpredict actual values, whether the absolute magnitude of error is within acceptable limits, whether the magnitude of error decreases or increases with time, and whether the model tracks abrupt shifts or turning points in the historical series. Comparison of the actual and model-generated values will aid in this evaluation.

A quantitative measure of the average error in predicting the values of a variable, Y , is provided by the standard error of estimate, defined as

$$SEE = \frac{\sum_{i=1}^N (Y_i - \hat{Y}_i)^2}{N},$$

where Y_i = the actual value during period i of the variable to be predicted;
 \hat{Y}_i = predicted or model-generated value of the variable for
 period i ;

N = the number of predictions.

In addition to providing a measure of model prediction accuracy when using known historical values of parameters and variables, the standard error of estimate can be used to compare the results of simulations using alternative sets of assumptions.

However, none of these tests of model adequacy are scientifically valid. To be scientific, the SIMLAB user should make projections and then, after a suitable period of time has elapsed, compare them with

actual values of forecast variables. Waiting until the future becomes history is not often practical so scientific procedures are rarely used to evaluate forecasting models.

Scientific evaluation procedures are rarely a practical means to establishing the validity and credibility of socio-economic models. A more practical but admittedly ad hoc procedure can be used to validate the SIMLAB model. This procedure consists of adjusting model parameters so that the model projects through historical observations. Model estimates and predictions can also be compared with primary data obtained from household and business surveys. However, in following this procedure, the SIMLAB user should consider the consequences of forcing the model through historical data which are not representative of long-term trends. A recession year, for example, may not be a satisfactory choice for model calibration since many socio-economic variables, such as employment, will be below their normal or trend levels.

3. SIMLAB MODULES

This chapter explains SIMLAB model variables and parameters and documents input data sources. It also provides the SIMLAB user with a reference for variable and parameter modification. All user-modifiable variables and parameters are listed. For critical model variables, there is a discussion of effects to be expected should the user introduce changes. For many of the variables and parameters, an explanation of the real world economic circumstances under which a variable or parameter changes is also provided. From an understanding of the effects of changes, the user can devise a simulation strategy which represents economic events as they could occur. The discussion is organized around the cluster or modules of SIMLAB variables and the equations they appear in. For each module, equations are presented first. The equations are then explained, starting with the production module.

Production Module

The production module equations account for the dollar value of output producing by each regional industry. In the SIMLAB model, industry output is assumed to change as needed to satisfy final demand subject to constraints imposed by regional industry production capacity. Capacity is determined by available capital equipment and labor force. The production module equations are:

1. Total Final Demand for Industry i Product

$$\begin{aligned} FD_{i,t+1} = & REXPORT_{i,t+1} + GPCFO_{i,t+1} + BINCH_{i,t+1} + PCE_{i,t+1} \\ & + LGE_{i,t+1} + SGE_{i,t+1} + FGETO_{i,t+1} \end{aligned}$$

2. Output Required by Final Demand, Industry i

$$XD_{i,t+1} = (I-A)^{-1} * FD_{i,t+1}$$

3. The Leontief Inverse, $(I-A)^{-1}$

From regional transactions estimated by the Minnesota Two-Region Input-Output Program (See Chapter IV)

4. Regional Output Constrained by Capacity-Creating Capital, Industry i

$$XO_{i,t+1} = CCAP_{i,t+1} / CAPOUT_{i,t+1}$$

5. Regional Output Constrained by Pollution Abatement Capital, Industry i

$$XP_{i,t+1} = PACAP_{i,t+1} / CAPPOL_{i,t+1}$$

6. Realized Regional Output, Industry i

$$X_{i,t+1} = \text{MIN} (XD_{i,t+1}; XO_{i,t+1}; XP_{i,t+1})$$

Total Final Demand

In the SIMLAB input-output framework, final demand represents society's use of goods not needed to produce other goods. Goods not needed to produce other goods are the object of economic activity since they may be used to satisfy human wants. In the SIMLAB model, regional exports of the produce of industry i , shown as REXPORT, satisfy needs located outside the region. Goods held as inventories for future use are represented by the variable $BINCH_i$. Goods produced by industry i may also be installed as facilities for future production, as measured by the variable $GPCFO_i$, gross private capital formation. Individuals consume product i to satisfy their immediate wants as measured by the variable PCE_i . Local government may use product i as measured by the variable LGE_i in the process of providing services. Similarly, state government uses goods denoted by the variable SGE_i in the process

of providing governmental services. All product i used within the region by Federal government is represented by $FGETO_i$. Total final demand FD_i for the product i is the sum of these separate final demands which exhaust the list of possible uses for goods not used in production processes. Discarding some output, waste, and inefficient use are not measured in the SIMLAB input-output framework.

Regional Output Required for Final Demand. In the SIMLAB model, regional output is determined by the level of final demand subject to constraints imposed by the availability of capital stock, availability of financing for new capital formation, and the size of the available labor force.

Regional output required of final demand is that level of output of industry i needed to satisfy a given level of final demand plus the output needed as inputs in the production processes of other regional industries. Thus, regional output required of final demand is larger than final demand by the dollar value of these necessary inputs. In an input-output model this output is calculated as the product of the Leontief inverse and FD_i , where FD_i is final demand for the product of industry i . The "Leontief Inverse" ^{7/} is the matrix $(I-A)^{-1}$ discussed in Chapter 1 of this manual. Regional output required of final demand may not be attainable should regional capital stock, funding for new capital formation, and/or labor force be inadequate as explained in this chapter.

Regional Output Constrained by Output Increasing Capital. The maximum volume of production in each industry attainable from already

^{7/} The matrix $(I-A)^{-1}$ is named after Nobel Laureate Wassily Leontief who constructed the first input-output model.

installed regional plant and equipment is measured as the ratio of output increasing capital $OICAP_i$ and the capital-output ratio for each industry, an element in the capital-output vector $CAPOUTM_i$.^{8/} This formulation assumes that the capital-output ratio measures the full capacity level of output available from the existing accumulated stock of capital equipment. However, the existing stock of capital equipment cannot be fully utilized unless there is enough pollution abatement capital available to control emissions to the environment at full capacity production; and unless the existing labor force, with the aid of capital, is large enough to generate full capacity output. For these reasons, the SIMLAB model contains additional equations representing conditions which must be met before full capacity output can be achieved.

Regional Output Constrained by Pollution Abatement Capital. The

SIMLAB model assumes that regional industry will not operate its plants at levels of output which exceed the emission control capacity of pollution abatement equipment. The level of production, of product i , XP_i , attainable without exceeding emission control capacity is equal to the existing quantity of pollution abatement capital in each industry as recorded in the vector $PACAP_i$, divided by $CAPPOLM_i$, the pollution abatement capital output ratio in each industry.^{9/}

Realized Regional Output. Realized regional output X_i is the level of output consistent with final demand and the capital stock and

^{8/} SIMLAB capital output data are from Clopper Almon, Jr., et al. 1985: Interindustry Forecasts of the American Economy, D.C. Heath and Co., 1974, pp. 72-73.

^{9/} The pollution abatement capital output ratios are only estimates which the user is free to change. Literature on the quantity of pollution abatement capital needed to meet existing and future environmental regulations is almost non-existent.

financial constraints on output as explained in this chapter. This is the minimum of the three values XD_i , XO_i , XP_i . Thus, SIMLAB calculations of realized regional output in industry i , X_i , will never be larger than final demand, XD_i ; and will never be larger than the smallest feasible level of XO_i or XP_i , should XD_i exceed XO_i or XP_i . Thus, output in each regional industry will never exceed the capabilities of regional plant capacity or the ability of regional industry to finance new capital formation; nor will it ever exceed the sum of final demand plus intermediate purchases.

Regional labor force does not necessarily enter the SIMLAB model as a constraint, unless the user specifies. Since SIMLAB is intended for regional analysis it can be assumed that regional labor force requirements are met through migration and commuting, if necessary (as shown in the discussion of the population module).

Market Module

The market module takes exports or regional production for external markets into account. According to the economic base theory of regional economic activity, external economic events influence regional economic conditions through changes in the market for regional products. The SIMLAB market module allows the user to simulate the effects of changes in the markets for regional production. Projections of U.S. Gross Output by industry, the regional market share of that output, and changes in these variables provide the means for simulation of future regional industry exports.

The market module variables, parameters and equations for each industry are:

7. U.S. Gross Output, Industry i

$$USGO_{i,t+1} = USGO_{i,t} * (1 + GROTHR_{i,t+1})$$

8. Regional Exports, Industry i

$$\text{REXPOR}_{i,t+1} = \text{USGO}_{i,t+1} * \text{REGMKS}_{i,t+1}$$

9. National Growth Rate, Industry i

$$\text{GROWTHR}_i \text{ (No Equation)}$$

10. Regional Market Share, Industry i

$$\text{REGMKS}_{i,t+1} = \text{REGMKS}_{i,t} * (1 + \text{REGMKSR}_{i,t+1})$$

11. Rate of Change in Regional Market Share, Industry i

$$\text{REGMKSR}_i \text{ (No Equation)}$$

The notation "no equation" means that a particular variable or parameter is not determined within the SIMLAB model. These variables and parameters which are exogenous to the SIMLAB model may still be modified by users for simulation. The effects of user modification of market module variables and parameters will be as follows:

U.S. Gross Output. SIMLAB National gross output is measured in constant 1970 dollars. Increasing National Gross Output in regional exporting industry i will cause an increase in regional production for export with attendant increases in other regional industry output, income, and employment. Increases in National Gross Output in a specific industry will cause regional output increases in the same industry provided some regional production in that industry is for external markets. If some part of regional production in a specific industry is for external markets, that industry is part of the regional economic base. The concept of regional economic base is explained in Chapter One of this manual. Fluctuations in National Gross Output can occur as a result of business cycles, Federal government spending, or other national economic events.

Regional Exports. Increasing regional exports will cause increases in regional gross product, employment and income. Decreases in regional

exports will have the opposite effect. The level of regional exports can fluctuate with changes in demand by users of regional products or because of a decline in market share, explained below. Demand changes can be caused by change in a price of a regional product relative to the price of competing goods; by increases in the incomes of consumers; by increases in consumption of complementary goods; or by increasing consumer acceptance of substitute products produced outside the region.

National Growth Rate. The annual National growth rate for each industry is a parameter in the equation for National gross output.^{10/} Increases in the National industry *i* growth rate implies that higher levels of gross output will originate from regional industries over time. Decline in the growth rate implies the opposite. The growth rate for total National gross output may differ considerably from the growth rate of specific industries. Specific industries may grow (positive growth rate) or decline (negative growth rate) or remain static (zero growth rate) while the growth rate of total National gross output fluctuates over the course of the business cycle or in response to Federal economic policy. Because SIMLAB National gross output is measured in constant 1970 dollars, the SIMLAB National growth rate refers to change in the annual quantity of products and service produced and not to changes in their money value which is affected by changes in the price level.

Regional Market Share. Regional market share is the proportion of National annual gross output of a specific industry which is exported

^{10/} Projections of National growth rates by industry used in SIMLAB are from the U.S. Department of Labor, Bureau of Labor Statistics, The Structure of the U.S. Economy in 1980 and 1985, Bulletin 1831, Washington, D.C. 1975.

by regional producers in the same industry. Increase in regional market share implies an increase in regional output, income, and employment. A decline in regional share can have the opposite effect. Furthermore, an increase in regional market share in an industry which exhibits large fluctuations over the course of the business cycle or in response to National and international market forces can increase the amplitude and frequency of fluctuation in regional output, income, and employment.

Rate of Change in Regional Market Share. Changes in regional market share may occur, for example, because discovery of a gradual exhaustion of a primary resource or because of the appearance or disappearance of competing producers outside the region. Changes in market share are conceptually distinct from demand fluctuations, explained above, although both may cause regional industry i exports to increase or decline. Regional market share changes do not necessarily imply changes in total National output from industry i while demand fluctuations do imply changes in National output. The SIMLAB user should use changes in the National growth rate parameter to simulate the effects of demand fluctuations and confine use of regional market share changes to economic circumstances which imply market share changes.

Investment Module

The investment module generates estimates of three distinct kinds of capital formation made by each regional industry. Capacity creating, replacement, and pollution abatement capital formation by each regional industry are estimated using the following equations:

12. Capacity-Creating Investment, Industry i

$$INVC_{i,t+1} = CAPOUT_{i,t+1} * (XD_{i,t} - X_{i,t})$$

13. Capacity-Creating Capital-Output Ratio, Industry i

$$\text{CAPOUT}_{i,t+1} = \text{CAPOUT}_i * (1 + \text{CHCAPOUT}_{i,t+1})$$

14. Pollution Abatement Investment, Industry i

$$\text{INVPA}_{i,t+1} = \text{CAPPOL}_{i,t+1} * (\text{XD}_{i,t} - \text{X}_{i,t})$$

15. Pollution Abatement, Capital Output Ratio, Industry i

$$\text{PCAPPOL}_{i,t+1} = \text{PCAPPOL}_{i,t} * (1 + \text{CHCAPPOL}_{i,t+1})$$

16. Capacity-Creating Capital, Base Period, Industry i

$$\text{CCAP}_{i,t=1} = \text{CAPOUT}_{i,t=1} * \text{X}_{i,t=1}$$

17. Pollution Abatement Capital, Base Period, Industry i

$$\text{PACAP}_{i,t=1} = \text{PCAPPOL}_{i,t=1} * \text{X}_{i,t=1}$$

18. Capacity-Creating Capital Depreciation, Industry i

$$\text{CADECCA}_i = \text{DEPRCCA}_i * \text{CAPPOL}_{i,t+1} * \text{X}_{i,t+1}$$

19. Capacity-Creating Capital Depreciation Rate, Industry i

$$\text{DEPRCCA}_{i,t+1} = \text{DEPRCCA}_{i,t} * (1 + \text{CHDEPRCCA}_{i,t+1})$$

20. Pollution Abatement Capital Depreciation, Industry i

$$\text{CADEPA}_{i,t+1} = \text{DEPRPA}_i * \text{PCAPPOL}_{i,t+1} * \text{X}_{i,t+1}$$

21. Pollution Abatement Capital Depreciation Rate, Industry i

$$\text{DEPRPA}_{i,t+1} = \text{DEPRPA}_{i,t} * (1 + \text{CHDEPRPA}_{i,t+1})$$

22. Replacement Investment, Capacity Creating, Industry i

$$\text{RINVC}_{i,t+1} = \text{CADECCA}_{i,t}$$

23. Replacement Investment, Pollution Abatement, Industry i

$$\text{RINVPA}_{i,t+1} = \text{CADEPA}_{i,t}$$

24. Total Capital Depreciation, Industry i

$$\text{CADE}_{i,t+1} = \text{CADECCA}_{i,t+1} + \text{CADEPA}_{i,t+1}$$

25. Total Replacement Investment, Industry i

$$RINV_{i,t+1} = RINVC_{i,t+1} + RINVPA_{i,t+1}$$

26. Total Investment Net of Replacement, Industry i

$$INV_{i,t+1} = INVC_{i,t+1} + INVPA_{i,t+1}$$

27. Investment Constraint, Period $t+1$, Industry i

$$INV_{i,t+1} \leq INVLMC_{i,t+1} * NBUSINC_{i,t+1}$$

28. Investment Constraint, Period $t+k$, Industry i , $k=2, 3, \dots, n$

$$INV_{i,t+k} \leq INVLMC_{i,t+k} * NBUSINC_{i,t+k} + INV LMA_{i,t+k} * ACNBUSINC_{i,t+k}$$

$$INVLMC_i = 15 \forall i, k$$

$$INV LMA_i = .5 \forall i, k$$

29. Capital Goods Producing Industry i Share, Industry 1 Capital Spending

$$INVC O_{i,1} \text{ (No Equation)}$$

30. Gross Private Capital Formation, Industry i

$$GPCFO_{i,t+1} = \sum_1 INVC O_{i,1} (RINV_{1,t+1} + IWVC_{1,t+1})$$

31. Capacity-Creating Capital, Period $t+k$, Industry i , $k=2,3,\dots,n$

$$CCAP_{i,t+k} = CCAP_{i,t+k-1} + INVC_{i,t+k} - (RINVC_{i,t+k} - CADECCA_{i,t+k-1})$$

32. Pollution Abatement Capital, Period $t+k$, Industry i , $k=2,3,\dots,n$

$$PACAP_{i,t+k} = PACAP_{i,t+k-1} + INVPA_{i,t+k} - (RINVPA_{i,t+k} - CADEPA_{i,t+k})$$

Capacity-Creating Investment. Capacity-creating investment increases the capacity to produce output. In the SIMLAB model, investment in period $t+1$ is determined by $CAPOUT_i$, the industry capital output ratio, multiplied by the difference between previous period output required of final demand and realized output, $XD_{i,t} - X_{i,t}$.^{11/} This formulation

^{11/} Research on industry investment decisions indicates the existence of an approximately one year lag between an increase in sales and a corresponding increase in installed production capacity. See Michael K. Evans, "A Study of Industry Investment Decisions," The Review of Economics and Statistics, XLIX, pp. 151-164.

is consistent with the following model of business firm investment behavior which illustrates the assumptions involved.

Suppose that capital desired by an industry, K , depends on output, Q , of that industry and the cost of capital r ; and that these variables are related as

$$K = aQr^{\sigma}$$

where "a" and " σ " are constants.^{12/} The constant "a" is a scalar. The constant σ is the elasticity of demand for capital relative to its cost. When r goes up σ percent, it can be shown that capital desired goes down by σ percent, for a given level of output Q , with labor or other inputs being substituted for capital to produce the same level of output.

Differentiating both sides of this equation with respect to time, dividing both sides by K , and re-arranging yields

$$\frac{\dot{K}}{K} = \frac{\dot{Q}}{Q} - \sigma \frac{\dot{r}}{r}$$

where the dot above a variable indicates its derivative with respect to time. Assuming that the cost of capital does not change, which is the same thing as saying that $\dot{r} = 0$, gives

$$\frac{\dot{K}}{K} = \frac{\dot{Q}}{Q} \quad \text{or} \quad \dot{K} = \dot{Q} \frac{K}{Q} .$$

This expression says that change in capital desired by firms equals the change in their output, \dot{Q} , multiplied by their capital-output ratio, K/Q , which is the SIMLAB variable CAPOUT.

The SIMLAB investment model is an approximation to this theoretical result. First, the variable \dot{K} is replaced by its discrete approximation

^{12/} Although the investment model assumptions are somewhat arbitrary, they are often made by others. For example, this model is nearly the same as that of Clopper Almon, Jr., et al., 1985: Interindustry Forecasts of the American Economy, D.C. Heath & Co., 1974, pp. 49-63.

$$\Delta K_{t+1} = K_{t+1} - K_t$$

where

$$\Delta K_{t+1} = \text{EINVOI}_{t+1}$$

and

$$K_{t+1} = \text{OICAP}_{t+1}, K_t = \text{OICAP}_t$$

in the SIMLAB model. Then the variable \dot{Q} is replaced by the approximation

$$\dot{Q}_t = \text{XD}_t - X_t$$

where XD_t and X_t are the SIMLAB variables for desired and realized output, respectively.

The substitutions for ΔK_{t+1} , K_{t+1} , K_t simply involve replacing the theoretical variables with their SIMLAB counterparts. The substitution for Q involves assuming that firms will want to add capacity for shortfalls in production. Empirical results cited above indicate it will take them about a year to install the extra capacity, thus the capital formation is assumed to be completed a year after the difference between desired and actual output occurs.

Capacity-Creating Capital Output Ratio. The capital output-ratio $\text{CAPOUT}_i^{13/}$ equals the capital output ratio in the previous period multiplied by one plus the percentage change in the capital output ratio, CHCAPOUT . Users wishing to simulate the effects of change in CAPOUT may specify non-zero values of CHCAPOUT . Values of CHCAPOUT larger than zero will have the effect of requiring larger capital investments in

^{13/} SIMLAB model capital-output ratios for each industry are adapted from Clopper Almon, Jr., et al., 1985: Interindustry Forecasts of the American Economy, D.C. Heath and Co., 1974, pp. 72-73.

order to generate an additional unit of output. Values of CHCAPOUT less than zero will have the effect of requiring smaller investments to generate additional output. Changes in the amount of investment required to generate additional output can occur because of changes in production technology, changing quality of raw material resources, or substitution^{14/} of capital equipment for labor in the production process. SIMLAB users wishing to simulate the effects of non-zero values of CHCAPOUT should establish the logical connection between economic events and the values of CHCAPOUT they wish to use. Users should be aware that changes in $CAPOUT_1$ have implications for changes in worker productivity or output per worker explained in the discussion of the employment module.

Pollution Abatement Investment. Expansion investment increases industrial capacity to produce and hence increases capacity to contaminate the environment. If this contamination is to be controlled, investment in pollution abatement equipment must accompany increases in production. The SIMLAB model assumes that expansion investment in pollution abatement capital is determined by the product of $CAPPOL_1$, the pollution abatement capital output ratio, and $XD_{i,t} - X_{i,t}$, the difference between output required of final demand and realized output. Thus, the SIMLAB model of investment in contamination control makes the same assumptions as the model of investment in output increasing capital.

^{14/} Substitution may occur because of technological change and/or because of using labor costs per unit of output relative to capital costs. Increasingly stringent worker health and safety regulations, more militant unionism, and shorter work weeks all may have the effect of increasing unit labor costs relative to capital costs.

However, SIMLAB users must understand that investment in pollution control equipment does not increase capacity to produce. The user interested in the implications of the trade-off between more pollution control per unit of output and more expansion investment can specify different values for the pollution abatement capital output ratio, CAPPOL. Increases in CAPPOL will operate to constrain simulated regional output because pollution abatement capital formation absorbs funds otherwise available for capacity creating investment.

Pollution Abatement Capital-Output Ratio. The pollution abatement capital-output ratio PCAPPOL is a measure of the installed quantity of pollution abatement equipment per unit of output. In the SIMLAB model, PCAPPOL can be user-modified by an amount $CHPCAPPOL_i$. In the real world $PCAPPOL_i$ can be expected to increase for nearly all industries as increasingly more stringent environmental regulations come into effect. However, the study of industry pollution abatement investment requirements is still in its infancy and there is relatively little literature useful as a guide to the SIMLAB user in establishing quantitative relationships between industry environmental standards and the investment in pollution abatement equipment needed to meet those standards. Tentative quantitative data in the SIMLAB model have been estimated from published information.^{15/} However, because these data reflect attachment of pollution abatement equipment to existing capital stock as well as to new plant and equipment they may have resulted in an overestimate of

^{15/} Some quantitative data appears in Frank W. Segel and Gary L. Rutledge, "Capital Expenditures for Air, Water and Solid Waste Pollution Abatement, 1975 and Planned 1976", U.S. Department of Commerce, Bureau of Economic Analysis, Survey of Current Business, July 1976, pp. 14-17.

the cost of pollution abatement equipment which must be attached to new capacity-creating plant and equipment.

Base Period Capacity-Creating Capital Stock. Base period output-increasing capital stock, $CCAP_{i,t=1}$, equals the base period capital-output ratio. $CAPOUT_{i,t=1}$, multiplied by the base period level of realized output, $X_{i,t=1}$. The base period output increasing capital stock is the initial endowment of capital needed to start the SIMLAB simulation run. The SIMLAB base year is 1970.

Base Period Pollution Abatement Capital Stock. Base period pollution abatement capital stock, $PACAP_{i,t=1}$, equals the base period pollution abatement capital output ratio multiplied by base period realized output, $X_{i,t=1}$.

Capacity-Creating Capital Depreciation. Capacity-creating capital depreciation equals the capacity-creating capital depreciation rate multiplied by the product of $CAPPOL_{i,t+1}$ and $X_{i,t+1}$.

Capacity-Creating Capital Depreciation Rate. The capacity-creating capital depreciation rate in the current period, $DEPRCCA_{i,t+1}$, equals the capacity-creating depreciation rate in the previous period multiplied by one plus the current period change, $CHDEPRCCA_{i,t+1}$.^{16/} At present, the variable $CHDEPRCCA_{i,t+1}$ is set to zero in all SUMLAB runs unless the user specifies otherwise.

Pollution Abatement Capital Depreciation. Pollution Abatement capital depreciation, $CADEPA_i$ is equal to the pollution abatement

^{16/} SIMLAB capital depreciation rates for Minnesota industries are from various issues by the Minnesota Commissioner of Revenue, The Minnesota State Corporation Income Tax, St. Paul, Minnesota.

capital depreciation rate, $DEPRA_i$, multiplied by the pollution abatement capital output ratio $PCAPPOL_i$.

Pollution Abatement Capital Depreciation Rate. The pollution abatement capital depreciation rate in the current period, $DEPRPA_{i,t+1}$ equals the depreciation rate multiplied by one plus the current period relative change in the depreciation rate, $CHDEPRPA_{i,t+1}$. At present, for lack of specific data on pollution abatement capital depreciation, $DEPRPA_i$ is set equal to $DEPRCCA_{i,t+1}$ and $CHDEPRPA_{i,t+1}$ is set equal to zero in all SIMLAB runs.

Replacement Investment, Capacity-Creating. Current period capacity creating replacement investment, $RINVC_{i,t+1}$, equals previous period capacity creating capital depreciation, $CADECCA_{i,t}$. The SIMLAB program is written so that this relationship holds as long as accumulated net business income, defined below, in each industry is as large as $CADECCA_{i,t+1}$. Should accumulated earnings fall short of this level, $RINVC_i$ is set equal to the smaller amount. Should accumulated net business income, including current period business income, fail to be large enough to pay the industry wage bill, then workers' wages are paid out of depreciation allowances. At this point, further growth in industry output does not occur. Some versions of SIMLAB lay off enough workers in this situation to eliminate any excess of gross business expense over gross revenue. In these versions, capital formation and growth in output can continue. The SIMLAB user should specify whether he wants business losses to be paid out of depreciation allowances or out of the wage bill when he arranges to use SIMLAB.

Replacement Investment, Pollution Abatement. Pollution abatement replacement investment in the current period, $RINVPA_{i,t+1}$ equals pollution

abatement capital depreciation in the previous period, $CADEPA_{i,t}$.

Total Capital Depreciation. Total capital depreciation, $CADE_i$, equals the sum of capacity-creating and pollution abatement capital depreciation.

Total Replacement Investment. Total replacement investment equals the sum of capacity-creating and pollution abatement replacement investment.

Total Investment Net of Replacement. Investment net of replacement, INV_i , equals capacity creating investment plus pollution abatement investment.

Investment Constraint, Period $t+1$. Regional capacity-creating investment INV in period $t+1$ in the year following the base year, is constrained to be less than or equal to the current period investment limit, $INVLMC_i$, multiplied by regional industry i net business income, $NBUSINC_i$. $INVLMC_i$ is set equal to 15 which is one and one-half times the average equity price earnings ratio on the New York Stock Exchange at the time of this writing. The value $INVLMC_i^1$ varies from industry to industry and from time to time over the course of the business cycle. The SIMLAB user can simulate with other values of $INVLMC_i^1$ if he likes.

Investment Constraint, Period $t+j$. Regional capacity-creating investment beginning with the second year after the base year and continuing out to year n , the number of years being simulated, is constrained to be no more than the first period investment limit plus a fraction $INCLMA_i$ of accumulated industry i net business income, $ACNBUSINC_i$. This relationship brings into the SIMLAB model the possibility of self-financing expansion investment from accumulated retained savings once simulated regional development gets underway. The fraction $INVLMB_i^1$

is set equal to .5, the approximate proportion of profits retained by corporations.^{17/}

Capital Goods Producing Industry. The capital goods producing industry i share of industry 1 capital spending, $INVC O_i$, is the parameter relating spending for capital goods by each industry 1 to final demand for the product of industry i .^{18/}

Gross Private Capital Formation. Industry i gross private capital formation equals the sum of industry 1 replacement investment, $RINV_{1,t+1}$, and industry 1 capacity creating investment, $INVC_{1,t+1}$, multiplied by the industry i share of industry 1 capital spending, $INVC O_{i,1}$, and this product is summed over all industries 1.

Industry i gross private capital formation is the use of industry i product as a capital good by other industries denoted, 1. A capital good is one which is used in the production of other goods for a period longer than one year. Capital goods are depreciated over their useful service life. The depreciation rates used in SIMLAB were explained above.

Capacity-Creating Capital, Period $t+k$. Capacity-creating capital in the second and subsequent periods after the base year equals capacity-creating capital in the previous period, $CCAP_{i,t+k-1}$, plus capacity-creating investment in the current period, $INVC_{i,t+k}$, less the difference between capacity-creating replacement investment, $RINVC_{i,t+k}$, and capacity-creating capital depreciation, $CADECCA_{i,t+k-1}$.

^{17/} U.S. Department of Commerce, Bureau of the Census, Statistical Abstract of the United States 1976, Washington, D.C., 1976, p. 522.

^{18/} Values of $INVC O_i$ included in SIMLAB are from the United States Department of Commerce, Survey of Current Business, 55(9), September 1975, pp. 9-21.

Pollution Abatement Capital, Period $t+k$. Pollution abatement capital in the second and subsequent periods after the base year equals pollution abatement capital in the previous period, $PACAP_{i,t+k-1}$ plus pollution abatement investment in the current period, $INVPA_{i,t+k}$, less the difference between pollution abatement replacement investment, $RINVPA_{i,t+k}$, and pollution abatement capital depreciation, $CADEPA_{i,t+k}$.

Demand Module

The demand module includes equations which estimate the components of final demand other than exports and gross private capital formation discussed above. All final demands constitute an ultimate use of industry output. An ultimate use of goods and services is one in which the goods are transformed into waste materials or destroyed; as distinguished from uses which transform goods into other goods as part of a production process. In an input-output accounting framework, the ultimate uses for goods and services are inventory change, capital formation, personal consumption, and local, state, and Federal activities. Goods held in inventories are not consumed or destroyed there, of course, but are held there pending final use. Goods used in capital formation are those which require more than one year to be fully used up by a production process. Personal consumption includes non-durables which are used up during the current period and durables which, like capital, last more than one year. By convention in the input-output accounting framework used by SIMLAB government, expenditures are treated as a final use.

33. Business Inventory, Industry i

$$BIN_{i,t+1} = INVOUT_{i,t+1} * (XD_{i,t} - X_{i,t})$$

34. Inventory-Output Ratio, Industry i

$$\text{INVOUT}_{i,t+1} = \text{INVOUT}_{i,t} * (1 + \text{CHINVOUT}_{i,t+1})$$

35. Business Inventory Change, Industry i

$$\text{BINCH}_{i,t+1} = \text{BIN}_{i,t+1} - \text{BIN}_{i,t}$$

36. Total Personal Consumption Expenditures

$$\text{PCE}_{t+1} = .89 \text{ DI}_t$$

37. Total Disposable Income

$$\text{DI}_t = .84 \text{ PI}_t$$

38. Total Personal Income

$$\text{PI}_t = 1.4 \text{ TEARN}_t$$

39. Personal Consumption Expenditure, Industry i Product

$$\text{PCE}_{i,t+1} = \text{PCE}_{i,t} * \left\{ 1 + \left[\left(\frac{\text{POPUL}_{t-1}}{\text{POPUL}_{t-2}} - 1 \right) + \text{ELASIN}_i \left(\frac{\text{PCE}_t}{\text{PCE}_{t-1}} - 1 \right) \right] \right\}$$

40. Elasticity of Demand With Respect to Total PCE for Industry i Product

No Equation

41. Local Government Expenditures for Industry i Product

$$LGE_{i,t+1} = LGE_{i,t} * (1 + \frac{POPUL_{t-1}}{POPUL_{t-2}})$$

42. State Government Expenditures for Industry i Product

$$SGE_{i,t+1} = SGE_{i,t} * (1 + \frac{POPUL_{t-1}}{POPUL_{t-2}})$$

43. Federal Government Expenditures for Industry i Product

$$FGETO_{i,t+1} = FGETO_{i,t} * (1 + \frac{POPUL_{t-1}}{POPUL_{t-2}})$$

Business Inventory. Business inventory in industry i, BIN_i , equals the product of the industry inventory-output ratio for the industry, $INVOUT_i$, and industry output, $X_{i,t+1}$. The industry i inventory output ratio is kept by the industry to provide the needs of intermediate and final users of its output.^{19/}

Total Personal Consumption Expenditures. Total current period personal consumption expenditures, PCE_{t+1} , equal the average propensity to consume, set at .89 in the equation, multiplied by previous period total disposable income, DI_t . Use of previous period disposable income is required in order to make the SIMLAB model recursive. The average propensity to consume was set at .89 in order to arrive at a level of personal

^{19/} SIMLAB inventory-output ratios are from the U.S. Department of Commerce, Survey of Current Business, 53(11), November 1975.

consumption expenditure consistent with Minnesota sales tax revenue data. SIMLAB users may choose alternative values for the average propensity to consume.

Total Disposable Income. Total disposable income in the previous period, DI_t , equals the decimal fraction .84 multiplied by total personal income in the previous period. Use of previous period values is necessary in order to make the SIMLAB model recursive. The value of the fraction .84 was determined by averaging the ratio of Minnesota disposable income to total personal income as reported in the Survey of Current Business.^{20/} Disposable income represents what consumers have to spend or save after taxes and/or payroll deductions.

Total Personal Income. Total personal income in the previous period equals 1.4 times total worker earnings in the previous period. By definition total personal income equals worker earnings less contributions for social insurance plus dividends, interest, and rent, plus transfer payments. Examination of Minnesota data indicated that with these adjustments, total personal income was about 1.4 times total worker earnings.^{21/} This ratio may vary from region to region so SIMLAB users should consider substituting their own relationship between earnings and personal income.

Personal Consumption Expenditures For Industry i Product. In the SIMLAB input-output model, goods and services used for personal consumption are treated as being sold to consumers by the industry of origin.

^{20/} U.S. Department of Commerce, Survey of Current Business, issues for April each year, 1971 and 1975.

^{21/} The data are from computer tapes provided by the U.S. Department of Commerce, Regional Economic Information Service.

The fact that most consumer goods move through the wholesale and retail trade sectors is taken into account by assigning trade margins for all consumer goods to the trade sectors. Similarly, transportation and shipping charges are assigned to the transportation sector. The result is to distribute personal consumption expenditures to the industry of origin in producers' prices. This procedure is an accounting convention used in the construction of the U.S. Department of Commerce input-output tables. A more realistic procedure routing all consumer goods through the trade and transportation sectors and then back to industry of origin is also possible but this requires input-output tables specifically constructed to reflect the routing of consumer goods through the trade sector. Such tables are not currently available.^{22/}

Personal consumption expenditures for the product of industry i , PCE_i , equals personal consumption expenditure for the produce of industry i in the previous period multiplied by one plus a series of variables determining change in PCE_i . The variables determining consumption expenditure change are population change $POPUL_{t-1}/POPUL_{t-2} - 1$; the elasticity of demand for commodity i , $ELASIN_i$; and change in total regional personal consumption expenditures, $PCE_t/PCE_{t-1} - 1$. This relationship attributes changes in consumption spending for commodity i to changes in regional population and to changes in the total personal consumption expenditures of regional consumers. With increasing population and/or increasing total consumption, consumption spending for commodity i increases. Estimates of regional $ELASIN_i$ which measures commodity i

^{22/} See: Hollis B. Chenery and Pual G. Clark, Interindustry Economics, Wiley and Sons, 1959, pp. 146-149; and James A. MacMillan, Chang-mei Lu, and Charles F. Framingham, Manitoba Interlake Area, A Regional Development Evaluation, Iowa State University Press, 1975, pp. 37-54.

consumption response to changes in total consumption are derived from estimates in published studies.^{23/}

The $ELASIN_i$ concept used in input-output models is not the same as that used in studies of household consumer behavior. In studies of the latter kind, expenditure categories, like "recreation", are often used. However, "recreation" may include entertainment services, fishing hooks, golf balls, and air transportation. All these are separate industries in an input-output model.

In other ways, the two kinds of consumer expenditure theories have much in common and the SIMLAB consumption expenditure equations make use of the results. For example, the long-run SIMLAB forecasting equations do not include price variables and variables representing household characteristics found in the published studies of consumption behavior. In these studies, these variables are statistically much less important than total expenditures in explaining consumption over long periods of time, probably because of the role of habit as determined by current and expected future income in determining consumer behavior.^{24/} Since these variables are relatively less important and also difficult to predict accurately, the long-run projections of the SIMLAB model may be more accurate by omitting them and relying on habit.

Local Government Expenditure. Current period expenditures of local government for the product of industry i , LGE_i , equals previous period LGE multiplied by one plus the previous period rate of change in regional

^{23/} Clopper Almon, Jr., et al., 1985: Interindustry Forecasts of the American Economy, D.C. Health and Co., 1974.

^{24/} Houthakker and Taylor, op cit., p. 165, theorize that habit and income are related through a changing consumption mix as income grows.

population. This formulation is based on the assumption that government expenditure is determined by population change. The SIMLAB model makes this assumption for expenditures of all general government activities. General government activities include the courts, the police, fire protection and other services which are provided to everyone equally. These are sometimes called "public goods". Goods and services sold only for a price are the function of government enterprises which are treated as producers in the regional input-output table.

State Government Expenditure, Industry i. Expenditure of state government for the product of industry i, SGE_i , equals previous period SGE_i multiplied by one plus the same set of variables appearing in the equation for local government expenditure.

Federal Government Expenditure. Expenditure of Federal government for the product of industry i, $FGETO_i$, is explained in the same way as expenditures of local and state government. This equation works well enough in Minnesota which has relatively little defense industry or other industry selling a large share of its product to the Federal Government. The assumption being made is that Federal purchases in the region are exclusively to serve regional needs determined by population change.

Employment Module

The employment module includes SIMLAB equations for estimating regional industry employment, output per worker, and earnings per worker.

44. Total Employment, Industry i

$$EMPLOY_{i,t+1} = X_{i,t+1} / OUTPWK_{i,t+1}$$

45. Output Per Worker, Industry i

$$\text{OUTPWK}_{i,t+1} = (1 + \text{CHOUTPWK}_{i,t+1}) * \text{OUTPWK}_{i,t}$$

46. Earnings Per Worker, Industry i

$$\text{EARPWK}_{i,t+1} = (1 + \text{CHEARPWK}_{i,t+1}) * \text{EARPWK}_{i,t}$$

47. Total Earnings, Industry i

$$\text{TEARN}_{i,t+1} = \text{EARNPWK}_{i,t+1} * \text{EMPLOY}_{i,t+1}$$

48. Total Earnings, Region

$$\text{TEARN}_{t+1} = \sum_i \text{TEARN}_{i,t+1}$$

49. Resident Labor Force, by Age and Sex, Region

$$\text{RLBF}_{a,s,t+1} = \text{LFPAR}_{a,s,t+1} * \text{POPL}_{a,s,t+1}$$

50. Resident Total Labor Force, Region

$$\text{RTOTLBF}_{t+1} = \sum_{k=1}^{12} \text{RLBF}_{a,s,t+1}$$

51. Labor Force Participation Rate, by Age and Sex

$$\text{LFPAR}_{a,s,t+1} = (1 + \text{PCHLFPAR}_{a,s,t+1}) * \text{LFPAR}_{a,s,t}$$

52. Labor Demand, Occupation j

$$\text{EMPLOYD}_{j,t+1} = \sum_i \text{OCCUPM}_{i,j,t+1} * (\text{OUTPWK}_{i,t+1})^{-1} *$$

$$\text{MIN}(\text{XD}_{i,t+1}, \text{XO}_{i,t+1}, \text{XP}_{i,t+1})$$

$$i = 1, \dots, 52 \quad j = 1, \dots, 9$$

53. Work Force Supply, Occupation j, j = 1, ..., 9

$$\text{EMPLOYS}_{j,t+1} = \text{LFOCCUP}_{j,t+1} * \text{RTOTLBF}_{t+1} + (\text{INCOEM}_{j,t+1} - \text{OUTCOEM}_{j,t+1})$$

54. Employment, Occupation j, j = 1, ..., 9

$$\text{EMPLOY}_{j,t+1} = \text{MIN}(\text{EMPLOYD}_{j,t+1}, \text{EMPLOYS}_{j,t+1})$$

55. Total Employment, Region

$$\text{REMPLOY}_{t+1} = \sum_{j=1}^9 \text{EMPLOY}_{j,t+1}$$

56. Industry Required Occupational Mix, Industry i

$$\text{OCCUPM}_{i,j,t+1} = (1 + \text{PCHOCCUPM}_{i,j,t+1}) * \text{OCCUPM}_{i,j,t}$$

$$\text{subject to } \sum_{j=1}^9 \text{OCCUPM}_{i,j,t+1} = 1$$

57. Regional Resident Work Force Supplied Occupational Mix, Occupation j

$$\text{LFOCCUP}_{j,t+1} = \frac{\text{EMPLOYS}_{j,t} + \text{INMIG}_{j,t} - \text{OUTMIG}_{j,t}}{\text{RTOTLF}_t}$$

$$\text{subject to } \sum_{j=1}^9 \text{LFOCCUP}_{j,t+1} = 1$$

58. Unemployment, Occupation j, j= 1, ..., 9

$$\text{UNEMLF}_{j,t+1} = \text{EMPLOYS}_{j,t+1} - \text{EMPLOY}_{j,t+1}$$

$$\text{subject to } \text{UNEMLF}_{j,t+1} \geq 0$$

59. Unemployment, Region

$$\text{UNEMLF}_{t+1} = \sum_{j=1}^9 \text{UNEMLF}_{j,t+1}$$

60. Incommuting Workers, Occupation j

$$\text{INCOEM}_{j,t+1} = \text{INCOMR}_{j,t+1} * (\text{EMPLOYD}_{j,t} - \text{EMPLOYS}_{j,t})$$

$$j = 1, \dots, 9 \quad \text{subject to } \text{INCOEM} \geq 0$$

61. Incommuting Rate, Occupation j

$$\text{INCOMR}_{j,t+1} = (1 + \text{PCHINCOMB}_{i,t+1}) * \text{INCOMR}_{j,t}$$

$$\text{subject to } \text{INCOMR}_{j,t+1} \leq 1$$

62. Outcommuting Workers, Occupation j

$$\text{OUTCOEM}_{j,t+1} = \text{OUTCOMR}_{j,t+1} * (\text{EMPLOYS}_{j,t} - \text{EMPLOY}_{j,t})$$

$$\text{subject to } \text{OUTCOEM}_{j,t+1} \geq 0$$

63. Outcommuting Rate, Occupation j

$$\text{OUTCOMR}_{j,t+1} = (1 + \text{PCHOUTCOMR}_{j,t+1}) * \text{OUTCOMR}_{j,t}$$

$$\text{subject to } \text{OUTCOMR}_{j,t+1} \leq 1$$

Regional Employment. Regional employment in each industry i , EMPLOY_i ^{25/} is equal to realized regional output in each industry i , X_i multiplied by output per worker in each industry i , OUTPWK_i . This equation simply says that given the level of industry realized output from the production module, industry employment is determined by worker productivity in that industry. In other words, increased industry output requires more workers.

This assumption will not always hold true since industries can also increase output by installing capital equipment which produces larger volumes of output using the same or fewer workers. However, the substitution of capital for labor nearly always has the effect of increasing output per worker. SIMLAB users wishing to simulate the effects of capital substitution can specify larger output per worker ratios. To remain consistent, users should then consider whether larger capital output ratios should be specified in the investment and production modules. Changes in the capital output ratio, CAPOUT are discussed in the section of this chapter on the investment module.

The user who wishes to simulate the effects of increasing output per worker caused by substitution of capital for labor must be prepared to make an assumption as to why free enterprise firms would want to do this. Reasons for substitution include technological improvements which

^{25/} Minnesota data on employment in each industry are derived from data in various annual issues of the U.S. Department of Commerce, County Business Patterns and from data furnished by the Minnesota Department of Employment Security.

increase returns to investment in plant and equipment; government policies and other events which reduce the cost of corporate borrowing; and labor market events which increase labor costs per unit of output relative to the cost of capital per unit of output.

Output Per Worker. Output per worker in each regional industry i equals one plus the relative change in output per worker, $CHOUTPWK_{i,t+1}$ multiplied by output per worker in the previous year, $OUTPWK_{i,t}$.^{26/} Users wishing to simulate the effects of increasing or declining levels of output per worker must specify positive or negative values, respectively, of $CHOUTPWK$.

Earnings Per Worker. Earnings per worker in industry i , $EARPWK_{i,t+1}$ equal one plus the relative change in industry earnings per worker, $CHEARPWK_{i,t+1}$ multiplied by industry earnings per worker in the previous period, $EARPWK_{i,t}$.^{27/} SIMLAB users can simulate the effects of changing earnings per worker by specifying positive or negative values of $CHEARPWK_{i,t+1}$.

^{26/} Initial estimates of regional output per worker by industry may be their National counterparts calculated from output data in the U.S. Department of Commerce, Bureau of Economic Analysis, Summary Input-Output Tables of the U.S. Economy: 1968, 1969, 1970, BEA Staff Paper No. 27, Washington, D.C., September 1975. Employment data are from the U.S. Department of Labor, Bureau of Labor Statistics, The Structure of the U.S. Economy in 1980 and 1985, Bulletin 1831, Washington, D.C., 1975. These estimates can then be adjusted upward or downward to correspond to what is known about regional productivity.

^{27/} Estimates of regional $EARPWK_i$ may be their National counterparts calculated from earnings data in U.S. Water Resources Council, 1972 OBERS Projections, Regional Economic Activity in the U.S., Volume 1 Washington, D.C., April 1974. Employment data is from U.S. Department of Labor, Bureau of Labor Statistics, The Structure of the U.S. Economy in 1980 and 1985, op.cit. These estimates can then be adjusted upward or downward to correspond to regional earnings data supplied by the U.S. Department of Commerce, Regional Economic Information System.

Total Earnings, Industry. Total current period earnings in industry i $TEARN_{i,t+1}$, equal current period earnings per worker in industry i , $EARPWK_{i,t+1}$, multiplied by current period employment in industry i , $EMPLOY_{i,t+1}$.

Total Earnings, Region. Total regional current period earnings, $TEARN_{t+1}$, equal the sum of total earnings in all industries, $TEARN_{i,t+1}$.

Resident Labor Force, by Age and Sex. The resident regional labor force by age and sex, $RLBF_{a,s,t+1}$, equals the regional labor force participation rate by age and sex, $LFPAR_{a,s,t+1}$, multiplied by the regional population by age and sex, $POPL_{a,s,t+1}$. The labor force participation rate is the proportion of the regional population age 16 and over which is working or seeking work. Individual decisions concerning the value of leisure, the number of years of education, the number of children, early versus late retirement, and other things, determine the labor force participation rate. Projected changes in the labor force participation rate are discussed below. Information on the regional population by age and sex is from the Census.^{28/} SIMLAB projects future developments in regional population characteristics as explained below in the discussion of the population module. These characteristics are important during the initial part of the simulation run in determining the size of the regional labor force. Gradually, during the simulation run, the importance of initial characteristics diminishes as population composition changes because of the joint effects of births, deaths, and migration due to economic opportunities associated with changes in the

^{28/} U.S. Department of Commerce, Bureau of the Census, General Social and Economic Characteristics, Minnesota, Washington, D.C., March, 1972.

regional economy. The reader can see that the SIMLAB model is constructed so that regional economic changes cause changes in regional population characteristics and that the link between the two is the regional labor force.

Resident Total Labor Force, Region. The resident total regional labor force, $RTOTLBF_{t+1}$, equals the sum of the labor force age-sex components, $RLBF_{a,s,t+1}$.

Labor Force Participation Rate. The regional labor force participation rate in the current period, $LFPAR_{a,s,t+1}$, equals one plus the relative change in the labor force participation rate, $PCHLFPAR_{a,s,t+1}$, multiplied by the labor force participation rate in the previous period, $LFPAR_{a,s,t}$. Labor force participation rates are projected to change, both Nationally and in Minnesota during the rest of this century. The SIMLAB model takes projected changes in regional labor force participation rates into account during simulation runs. Increases in labor force participation have the effect of reducing the size of regional population needed to fill a given number of available jobs.

Labor Demand, Occupation. SIMLAB estimates regional labor demand by occupation. There are nine occupations:

1. Professional
2. Managerial
3. Sales Worker
4. Clerical
5. Crafts
6. Operatives
7. Other Nonfarm, nonmine
8. Service
9. Farm

Labor demand in occupation j , $EMPLOYD_{j,t+1}$, equals labor demand for occupation j summed over all industries i . Labor demand for occupation j in industry i is the product of three variables; the proportion of industry i work force in occupation j , $OCCUPM_{i,t+1}$; the inverse of industry i output-per-worker, $OUTPWK_{i,t+1}^{-1}$; and realized industry i output, $\text{MIN}(XD_{i,t+1}, XO_{i,t+1}, XP_{i,t+1})$. The variables $OUTPWK_{i,t+1}$ and $\text{MIN}(XD_{i,t+1}, XO_{i,t+1}, XP_{i,t+1})$ have already been discussed in this chapter. Data on the variable $OCCUPM_{i,j,t+1}$ is from the U.S. Department of Labor.^{29/}

Work Force Supply, Occupation. SIMLAB estimates regional work supply by occupation. Work force supply in occupation j , $EMPLOYS_{j,t+1}$, equals the proportion of the regional labor force in occupation j , $LFOCCUP_{j,t+1}$, multiplied by the total labor force, $RTOTLBF_{t+1}$, plus the difference between incommuting and outcommuting by workers in occupation j , $\text{INCOEM}_{j,t+1} - \text{OUTCOEM}_{j,t+1}$. Base year values of $LFOCCUP_j$ are from the Census.^{30/} Values of $LFOCCUP_j$ subsequent to the base year are endogenous to the SIMLAB model because of immigration and outmigration estimated in the population module.

Employment, Occupation. Employment in occupation j in the current period, $EMPLOY_{j,t+1}$, is the minimum of $EMPLOYD_{j,t+1}$ and $EMPLOYS_{j,t+1}$. This simply means that no more workers can work than are available to work or employers are willing to hire.

^{29/} U.S. Department of Labor, Bureau of Labor Statistics, Tomorrow's Manpower Needs, Volume II, National Trends and Outlook: Industry Employment and Occupational Structure, Bulletin 1606, Washington, D.C., 1969.

^{30/} Bureau of the Census. General Social and Economic Characteristics, Minnesota, op.cit.

Total Regional Employment. Total regional employment, $REMPLOY^{t+1}$, equals the sum of employment in all nine occupations.

Industry Regional Occupational Mix. The occupational mix required by industry i , $OCCUPM_{i,j,t+1}$ equals one plus the relative change in the occupation mix, $PCHOCCUPM_{i,j,t+1}$, multiplied by the occupational mix in the previous period, $OCCUPM_{i,j,t}$, subject to the constraint that $OCCUPM_{i,j,t+1}$ summed over the nine occupations equal unity. In SIMLAB runs the variable $PCHOCCUPM_{i,j,t+1}$ is set equal to zero unless other values are specified by the user.

Regional Resident Labor Force Supplied Occupational Mix. In periods subsequent to the base period, the current period labor force supplied in occupation j , $LFOCCUP_{j,t+1}$, equals labor force supplied in occupation j in the previous period, $EMPLOYS_{j,t}$, plus the difference between occupation j immigration and outmigration, in the previous period, $INMIG_{j,t} - OUTMIG_{j,t}$, divided by the previous period resident total labor force, $RTOTLF_t$. Values of $INMIG_{j,t}$ and $OUTMIG_{j,t}$ are estimated in the SIMLAB population module discussed in this chapter.

The regional resident labor force equation is lagged in order to make the SIMLAB model recursive. This may lead to a slight inaccuracy in estimation of the regional labor force supplied occupational mix should the rate of deaths and retirements vary among the occupations from year to year. Deaths and retirements are taken into account, however, since $RTOTLF_t$ depends on regional population and deaths and retirements are calculated in the population module.

Unemployment, Occupation. Unemployment by occupation, $UNEMLF_j$, equals the difference between labor supply in occupation j and employment in occupation j , $EMPLOYS_{j,t+1} - EMPLOY_{j,t+1}$ subject to the restriction that unemployment be greater than or equal to zero.

Unemployment, Region. Regional unemployment, $UNEMLF_{t+1}$, equals the sum of unemployment in the nine occupations. This limited concept of unemployment is to be distinguished from those more broad concepts which specifically allow for underemployment, unemployment resulting from job turnover, and unemployment resulting from unemployed workers not having information on available job openings.

Incommuting Workers, Occupation. Current period incommuting workers in occupation j , $INCOEM_{j,t+1}$, equal the incommuting rate, $INCOMR_{j,t+1}$, multiplied by the pervious period difference between labor demand and labor supply in occupation j , $EMPLOYD_{j,t} - EMPLOYS_{j,t}$, subject to the restriction that incommuting be greater than or equal to zero.

Incommuting Rate, Occupation. The incommuting rate in the current period, $INCOMR_{j,t+1}$, equals one plus the percentage change in the incommuting rate, $PCHINCOMB_{j,t+1}$, multiplied by the previous period incommuting rate. Published data for the variable $INCOMR_j$ is not generally available. This variable is not the same as the Census travel-to-work concept. Rather, it is a measure of the proportion of regional job openings which would be filled by commuters. Therefore, SIMLAB users wishing to take commuting into account, must consider taking a survey or using some other approach to estimation of $INCOMR_j$. In many cases, estimation of $INCOMR_j$ may not be worth the expense. For example, in some regions the number of incommuting may not be a significant portion of the regional work force.

Outcommuting Workers, Occupation. Current period outcommuting workers in occupation j , $OUTCOEM_{j,t+1}$, equal the out-commuting rate, $OUTCOMR_{j,t+1}$, multiplied by the previous period difference between regional labor supply in occupation j , $EMPLOYS_{j,t}$ and regional employment in occupation j , $EMPLOY_{j,t}$, subject to the restriction that out-

commuting be greater than or equal to zero. This specification assumes that a fraction of workers in excess supply within the region will work outside and commute.

Outcommuting Rate, Occupation. The current period outcommuting rate, $OUTCOMR_{j,t+1}$, equals one plus the relative change in the outcommuting rate, $PCHOUTCOMR_{j,t+1}$, multiplied by the previous period outcommuting rate, $OUTCOMR_{j,t}$.

Value Added Module

Value-added module equations for each industry estimate the pool of funds from which depreciation, taxes, and any profits must be drawn. For each regional industry, value added plus the cost of materials, supplies, and services purchased from regional industries, plus labor services and goods purchased from suppliers outside the region (imports) equals the gross value of industry production in producer's prices. In an input-output framework, gross value of industry production calculated in this manner must equal the sum of industry sales to other regional industries plus final demand.

64. Total Value Added, Industry i

$$VA_{i,t+1} = VAR_{i,t+1} * X_{i,t+1}$$

65. Value-Added Rate, Industry i

From Minnesota Two-Region Input-Output Program

66. Imports, Industry i

$$IMPORT_{i,t+1} = REGIMPR_{i,t+1} * X_{i,t+1}$$

67. Import Rate, Industry i

From Minnesota Two-Region Input-Output Program

68. Business Taxes, Industry i

$$BTAX_{i,t+1} = BTAXR_{i,t+1} * X_{i,t+1}$$

69. Business Tax Rate, Industry i

$$BTAXR_{i,t+1} = (1 + CHBTAXR_{i,t+1}) * BTAXR_{i,t}$$

70. Net Business Income, Industry i

$$NBUSINC_{i,t+1} = VA_{i,t+1} - [TEARN_{i,t+1} + BTAX_{i,t+1} + CADE_{i,t+1}]$$

Total Value Added. Total industry i value added in the current period, $VA_{i,t+1}$, equals the rate, $VAR_{i,t+1}$, multiplied by current period industry i realized output, $X_{i,t+1}$.

Value-Added Rate. The SIMLAB industry i value-added rate is calculated by the Minnesota Two-Region Input-Output Program. This program is explained in Chapter 5.

Imports. Regional industry i imports are goods and services needed in production which are not available from regional suppliers. Imports by industry i, $IMPORT_i$, equal the regional industry i import rate, $REGIMPR_{i,t+1}$, multiplied by regional industry i realized output, $X_{i,t+1}$.

Import Rate. The SIMLAB industry i import rate is calculated by the Two-Region Input-Output Program explained in Chapter 5.

Business Taxes. Regional industry i business taxes equal the regional industry i business tax rate, $BTAXR_{i,t+1}$, multiplied by realized industry i gross product, $X_{i,t+1}$.

Business Tax Rate. The regional industry i business tax rate, $BTAXR_{i,t+1}$, equals one plus the relative change in the business tax rate, $CHBTAXR_{i,t+1}$, multiplied by the previous period business tax rate, $BTAXR_{i,t}$.^{31/}

^{31/} Business tax rates as a fraction of industry gross sales are from various annual issues of the Minnesota Department of Revenue, The Minnesota State Corporation Income Tax, St. Paul. Minnesota.

Net Business Income. Industry i net business income in the current period, $NBUSINC_{i,t+1}$, equals value added, $VA_{i,t+1}$, less the sum of total earnings, $TEARN_{i,t+1}$, business taxes, $BTAX_{i,t+1}$, and capital depreciation, $CADE_{i,t+1}$. The concept of net business income is similar to, but not the same as, the concept of profit. Profit is an industry-wide concept and there can be more than one firm in an industry. Thus, some firms in an industry with positive net business income may experience negative profits or losses.

Net business income can be viewed as an estimate of net regional industry i cash flow from operations. This variable is important in determining the limits to regional borrowing for investment purposes. This limit is expressed in the two investment limit equations found in the investment module.

The role of $NBUSINC_i$ in the investment limit equation suggests the effects of simulating higher $TEARN_i$, $BTAX_i$, and $CADE_i$. These variables reduce net business income and hence regional accumulation of cash assets. This reduction reduces regional ability to service debt and hence imposes constraints on regional borrowing for expansion and pollution abatement capital. SIMLAB users experimenting with the effects of higher rates of business taxation may find the investment limit constraining growth in regional output. This result is realistic since it is often suggested that high local tax rates discourage investment and expansion by business firms.

Population Module

The SIMLAB population module is an age-cohort survival model. Population module equations represent regional demographic characteristics. The population module calculations for each year in the simulation run

occur after all other calculations have been completed because of the assumption that regional economic conditions as they affect employment determine trends in regional population characteristics. Results of the population module calculations provide the user with an opportunity to quickly and easily check the validity of his assumptions since detailed regional demographic data is readily available.^{32/} Population module equations are as follows:

71. Regional Population by Age and Sex

$$\begin{aligned} RPOPUL_{a,s,t+1} = & RPOPUL_{a,s,t} + BIRTH_{a,s,t+1} - DEATH_{a,s,t+1} \\ & + INMIG_{a,s,t+1} - OUTMIG_{a,s,t+1} \\ a = & 1, \dots, 66 \quad s = 1, \text{ males}; s = 2, \text{ females} \end{aligned}$$

72. Births by Sex, Region

$$\begin{aligned} BIRTH_{s,t+1} = & [BIRTHR_{a',2,t+1} * POPUL_{a',2,t}] * MFBIRTHR_s \\ s = & 1, 2 \quad a' = 14, \dots, 50 \end{aligned}$$

73. Total Births, Region

$$TBIRTH_{t+1} = \sum_{s=1}^2 BIRTH_{s,t+1}$$

74. Birth Rate, Female Age 14-50, Region

$$\begin{aligned} BIRTHR_{a',2,t+1} = & (1 + PCHBIRTHR_{a',2,t+1}) * BIRTHR_{a',2,t} \\ a' = & 14, \dots, 50 \end{aligned}$$

75. Deaths, Age and Sex, Region

$$DEATH_{a,s,t+1} = DEATHR_{a,s,t+1} * POPUL_{a,s,t}$$

76. Total Deaths, Region

$$TDEATH_{t+1} = \sum_a \sum_s DEATH_{a,s,t+1}$$

^{32/} For example, see the U.S. Department of Commerce, Bureau of the Census, Current Population Reports, Population Estimates and Projections, Series P-25, Washington, D.C. In Minnesota, the State Planning Agency has extensive survey data on demographic characteristics.

77. Immigration By Age and Sex, Region

$$\begin{aligned} \text{INMIG}_{a,s,t+1} &= \text{NEMPDEPR}_{t+1} * \text{POPUL}_{a,s,t+1} \\ &+ \sum_{j=1}^9 \left[(1 - \text{INCOMR}_{j,t+1}) * (\text{EMPLOYD}_{j,t} - \text{EMPLOYS}_{j,t}) \right] \\ \text{subject to } \text{EMPLOYD}_{j,t} - \text{EMPLOYS}_{j,t} &\geq 0 \end{aligned}$$

78. Immigrant Age-Sex Distribution, Region

$$\begin{aligned} \text{INPOPUL}_{a,s,t+1} &= (1 + \text{PCHIPOPUL}_{a,s,t+1}) * \text{IPOPUL}_{a,s,t} \\ \text{subject to } \sum_a \sum_s \text{INPOPUL}_{t+1} &= 1 \end{aligned}$$

79. Immigrating Employee Dependent Rate

$$\text{EMPDEPR}_{t+1} = (1 + \text{PCHEMPDEPR}_{t+1}) * \text{EMPDEPR}_t$$

80. Outmigration By Age and Sex

$$\begin{aligned} \text{OUTMIG}_{a,s,t+1} &= \text{OEMPDEPR}_{t+1} * \text{OPOPUL}_{a,s,t} * \sum_{j=1}^9 \left[(1 - \text{OUTCDMR}_{j,t+1}) \right. \\ &\quad \left. * (\text{EMPLOYS}_{j,t} - \text{EMPLOYD}_{j,t}) \right] \\ \text{subject to } \text{EMPLOYS}_{j,t} - \text{EMPLOYD}_{j,t} &\geq 0 \end{aligned}$$

81. Outmigrant Age-Sex Distribution, Region

$$\begin{aligned} \text{POPUL}_{a,s,t+1} &= (1 + \text{PCHOPOPUL}_{a,s,t+1}) * \text{OPOPUL}_{a,s,t} \\ \text{subject to } \sum_a \sum_s \text{OPOPUL}_{a,s,t+1} &= 1 \end{aligned}$$

Regional Population. Regional population by age and sex in the current period, $\text{RPOPUL}_{a,s,t+1}$, equals regional population by age and sex in the previous period, $\text{RPOPUL}_{a,s,t}$, plus current period births, $\text{BIRTH}_{a,s,t+1}$, minus deaths, $\text{DEATH}_{a,s,t+1}$, plus immigration, $\text{INMIG}_{a,s,t+1}$, minus outmigration, $\text{OUTMIG}_{a,s,t+1}$.

Births, by Sex. Regional current period births by sex, $\text{BIRTH}_{s,t+1}$, equals the regional fertility rate for each 1,000 females between the

ages of 14 and 50, $BIRTHR_{a',2,t+1}$, multiplied by the number of females between the ages of 14 and 50 in the previous period, $POPUL_{a',2,t}$; with the result of this multiplication multiplied by proportion of new babies which are female and the proportion which are males, $MFIRTHR_s$.^{33/} Use of the number females ages 14 to 50 in the previous period, $POPUL_{a',2,t}$, is necessary in order to make the SIMLAB model recursive. This may result in a slight through not significant overestimate of the number of births since some previous period females ages 14 to 50 have died. To some extent this error may be offset by not including births to current period immigrating females. Not including births to current period immigrating females is also necessary in order to make the SIMLAB model recursive.

Total Births, Region. Total regional births, $TIRTH_{i+1}$, equals the sum of male and female babies born, $BIRTH_{s,t+1}$.

Birth Rate. The current period fertility rate per 1,000 females between ages 14 to 50, $BIRTHR_{a',2,t+2}$, equals one plus the current period relative change in the birth rate, $PCHIRTHR_{a',2,t+1}$, multiplied by the birth rate in the previous period, $BIRTHR_{a',s,t}$.^{34/} With different assumptions concerning $PCHIRTHR_{a',2}$, the SIMLAB user can simulate the effects of different fertility levels on regional labor force and population.

Deaths, Age and Sex. Regional deaths by age and sex in the current period, $DEATH_{a,s,t+1}$, equal the regional current period death rate by age and sex, $DEATHR_{a,s,t+1}$, multiplied by previous period regional popu-

^{33/} Minnesota data on births are from the State Department of Health. These data are available for each county.

^{34/} Values of the variable $PCHIRTHR_{a',2}$ used by SIMLAB in the absence of user assumptions to the contrary are consistent with the Census "Series II" population projections for the United States.

lation by age and sex, $POPUL_{a,s,t}$.^{35/} Use of the previous period value of the variable $POPUL_{a,s,t}$, instead of the current-period value, is necessary in order to make the SIMLAB model recursive.

Total Deaths, Region. Total current period regional deaths, $TDEATH_{t+1}$, equal the sum of current period deaths by age and sex, $DEATH_{a,s,t+1}$.

Immigration, By Age and Sex. Regional current period immigration by age and sex, $INMIG_{a,s,t+1}$, equals the number of dependents per worker, $NEMPDEPR_{t+1}$, multiplied by the age-sex distribution of regional immigrants in the five year period before the most recent Census, $IPOPUL_{a,s,t+1}$, multiplied by a quantity which is the previous period regional demand for workers by occupation in excess of those available from the regional population, $EMPLOYD_{j,t} - EMPLOYS_{j,t}$, adjusted for incommuting by occupation, $1 - INCOMR_{j,t+1}$. Thus, regional immigration is assumed to occur in response to unfilled job openings. The SIMLAB program is written so that only positive or zero levels of worker excess demand are admissible.

Inmigrant, Age-Sex Distribution. The regional immigrant age-sex distribution, $IPOPUL_{a,s,t+1}$, equals one plus the relative change in the age-sex component, $PCHIPOPUL_{a,s,t+1}$, multiplied by the age-sex distribution in the previous period, $IPOPUL_{a,s,t}$. In the absence of user assumptions, the variable $PCHIPOPUL_{a,s,t+1}$ is set to zero. Values of the variable $IPOPUL_{a,s,t+1}$ are from the U.S. Census of Population.^{36/} Use of these values involves the assumption that persons who immigrate to the

^{35/} In Minnesota, death rates by age and sex for each county are obtained from the State Department of Health.

^{36/} U.S. Bureau of the Census, Subject Reports, Migration Between State Economic Areas, PC(2)-2E, Washington, D.C., July 1972.

region in response to future unfilled job openings will have the same age-sex characteristics as those who found the region sufficiently attractive to move there during the five years prior to the 1970 Census.

In-migrating, Employee-Dependent Rate. The immigrating employee dependent rate, $EMPDEPR_{t+1}$, is the number of persons the average immigrating worker brings with him. The current period value of the dependent rate equals one plus the current period percentage change in the rate, $PCHEMPDEPR_{t+1}$, multiplied by the previous period rate, $EMPDEPR_t$. The variable $PCHEMPDEPR_{t+1}$ is set to zero in simulation runs unless the user specified otherwise. Values of $EMPDEPR_{t+1}$ may be obtained from survey work. Alternatively, Census data on household size can be used as approximate estimates of the value of $EMPDEPR_{t+1}$ and projections of household size can be used to estimate future values of $PCHEMPDEPR_{t+1}$.^{37/} These data are only surrogate estimates of the immigrating employee dependent rate because the household characteristics of the job seeker who would move may depend on the region he or she is moving to; and upon the region he or she is moving from. Household characteristics of the job seeker may also depend on his or her education and occupation. Thus, SIMLAB users should consider possibilities for independent verification of assumptions concerning the employee dependent rate.^{38/}

Out-migration, By Age and Sex. Outmigration by age and sex, $OUTMIG_{a,s,t+1}$, equals the outmigrating worker dependent rate, $OEMPDEPR_{t+1}$,

^{37/} Projections of the number of persons per household in Minnesota are available from the Minnesota State Planning Agency, Office of the State Demographer, Minnesota Population Projections 1970-2000, St. Paul, Minnesota, November, 1975.

^{38/} In Minnesota, a 1977 State Planning Agency population survey provided estimates of county and sub-county population characteristics (consistent with the 1970 Census of Population estimates), through which WIMLAB demographic curves are fitted by adjusting the dependent rate and other variables.

multiplied by the regional population age-sex distribution, $RPOPUL_{a,s,t}$; and this product is multiplied by a quantity which is the previous period regional supply of workers in each occupation who are in excess of regional demand, $EMPLOY_{j,t} - EMPLOYD_{j,t}$, adjusted for current period outcommuting by occupation, $(1-OUTCOMR_{j,t+1})$. Thus, regional outmigration is assumed to occur in response to a shortage of job openings relative to the number of persons in each occupation who are seeking work. The SIMLAB program is written so that only positive or zero levels of excess supply of workers are admissible. Because of a similar restriction on excess demand for workers, explained above, there can only be either immigration or outmigration or no migration of workers in a given occupation during any given year. However, immigration of workers in one occupation and outmigration of those in another is permitted by the model.

This migration theory works for Minnesota. In SIMLAB runs on Minnesota data a fraction of persons age 20 to 24 and of those age 66 and over are subtracted in each year. These adjustments are made to take into account college-going, military service, and retirement to other areas. Correct values of the adjustments are determined by trial and error in comparison with Census and the State Planning Agency population survey data already cited.

Out-migrant Age-Sex Distribution. The regional outmigrant age-sex distribution, $OPOPUL_{a,s,t+1}$, equals one plus the relative change in each age-sex component, $PCHOPOPUL_{a,s,t+1}$, multiplied by the age-sex distribution in the previous period, $OPOPUL_{a,s,t}$. In the absence of user assumptions, the variable $PCHOPOPUL_{a,s,t+1}$ is set to zero. Values

of the variable $OPOPUL_{a,s,t+1}$ are from the Census.^{39/} Use of these values involves the assumption that persons who outmigrate from the region because of an excess supply of workers in their occupations will have the same age-sex characteristics of those who left the region during the five years prior to the 1970 Census.

^{39/} U.S. Bureau of the Census, Subject Reports, Migration Between State Economic Areas, op. cit.

4. CONSTRUCTION OF REGIONAL INPUT-OUTPUT TABLES

This chapter explains procedures used to construct regional transactions tables. Two kinds of transactions tables are constructed for SIMLAB. One kind represents regional interindustry interactions as they are at present or at some specific time in the past. SIMLAB uses this table in generating baseline projections of regional economic activity; and in generating projections which include the impacts of user-specified deviations in baseline trends in cases where changes in interindustry interactions or the appearance of new industry is not involved. A second sort of transactions table represents regional interindustry interactions as they would be in the presence of user-specified new regional industry. SIMLAB uses this table to generate projections of regional economic activity which include the impacts of new industry.

Two-Region Input-Output Model

SIMLAB input-output tables representing existing regional industry are developed using the detailed 367 industry U.S. input-output tables as a secondary data base.^{40/} These tables are appregated to about 100 industrial sectors because of computer capacity constraints. All calculations are made using a Fortran program called the Minnesota Two Region Input-Output Model run on a Control Data Cyber 74 computer. The program requires about 140 K of core and executes in about 90 seconds of central processor time. Out-of-pocket computer cost is less than 50 dollars. Various data problems often make multiple runs necessary.

^{40/} U.S. Department of Commerce, Social and Economic Statistics Administration/Bureau of Economic Analysis, Input-Output Structure of the U.S. Economy, 1967, U.S. Government Printing Office, Washington, D.C., 1974.

Assumptions underlying these calculations are as follows:

1. There are no joint products;
2. Each product is supplied by one sector;
3. The quantity of each input used in a sector is in fixed relationship to the level of output of the sector;
4. The input structure at the National level prevails at the regional level;
5. That an output surplus in the region becomes an export to the National economy;
6. That an input or consumption deficit in the region becomes an import from the National economy.

The computational sequence may be summarized as follows:

1. Calculate total use or consumption of each sector output by using sectors and final demands in the region.
2. Calculate inter-regional flows of output as the difference between total output and total use in each producing sector.

The results of the calculations is the two-region input-output model displayed in Table 4.1. In the table, study region is designated as Region A. The rest of the Nation is designated Region B. Quadrant I represents the final demands for industry outputs produced in Region A. Quadrant II represents intermediate demands in Region A. Quadrant III contains the primary inputs and imports of intermediate goods by Region A industries. Quadrant IV includes the final demands, interindustry transactions, and primary inputs of the rest-of-Nation economy. The input-output tables in the printouts include the dollar values of all inter-industry and inter-sectional flows of goods and services bought and sold within the specified region and the rest of the Nation.

• •

[illegible]

The technical coefficients appearing in each quadrant of Table 4.1 are unique. Adopting the notation that a single superscript indicates a particular region and that a double superscript indicates the source of a flow by the first letter and the destination of the flow by the second letter, the technical coefficients in the four quadrants are defined as:

1. $a_{ij}^{AA} = \frac{X_{ij}^{AA}}{X_{\cdot j}^A}$ in Quadrant I;
2. $a_{ij}^{AB} = \frac{X_{ij}^{AB}}{X_{\cdot j}^B}$ in Quadrant II;
3. $a_{ij}^{BA} = \frac{X_{ij}^{BA}}{X_{\cdot j}^A}$ in Quadrant III;
4. $a_{ij}^{BB} = \frac{X_{ij}^{BB}}{X_{\cdot j}^B}$ in Quadrant IV;

where X_{ij} = purchases of output of the i -th sector by the j -th sector

$X_{\cdot j}$ = total input of the j -th sector

The relationships among the technical coefficients are:

1. $a_{ij}^A = a_{ij}^{AA} + a_{ij}^{BA}$
2. $a_{ij}^B = a_{ij}^{BB} + a_{ij}^{AB}$
3. $a^A = a_{ij}^B$

From these relationships it can be seen that a component attributable to inter-regional flow is isolated from the regional and National

intersectoral transactions. Thus, the regional technical coefficients in Quadrant I are unique to each region.^{41/}

Implementation of the two-region input-output program requires user identification and specification of base year regional gross product by industry and preparation of estimates of base year final demands. Final demand multipliers from the regional transactions table are calculated and inserted in the simulation model described in the previous chapter of this manual.

The regional input-output table calculated in this manner may be modified using information on existing industries from other sources. In addition, the tables may be modified, using procedures described in the next subsection, to include new, hypothetical, industry. These modified tables may then be used in SIMLAB calculations of the socio-economic impacts of new regional industry.

New Industry Adjustments

Representing new regional industry in an input-output transactions table requires specification of new industry gross product and inputs, calculation of additional regional industry outputs needed to supply the new industry, and calculation of regional interindustry interactions as they would be once regional producers are supplying the new industry inputs. This done, adjustments to final demands may be required in order to balance regional industry sales with disbursements.

^{41/} This discussion is drawn from Henry H. Hwang and Wilbur R. Maki, A Users' Guide to the Minnesota Two-Region Input-Output Computer Model, (in process), Department of Agricultural and Applied Economics and Agricultural Experiment Station, University of Minnesota, St. Paul, 1978.

All SIMLAB economic variables measured in monetary terms are in 1970 dollars. Therefore new industry gross product and the dollar value of new industry inputs must be specified in 1970 dollars. New industry gross product estimates are developed from user-specified levels of physical output. Initial specification of new industry inputs must be comprehensive and without regard to availability from regional suppliers. All required inputs must be classified according to the Standard Industrial Code of 1967 (SIC).^{42/} This list is then compared with a comprehensive list of regional industries also classified according to the 1967 SIC. Regional producers of new industry required inputs are assumed to be the new industry suppliers unless the SIMLAB user specifies otherwise. Required inputs not produced within the region must be assumed to be imported unless the SIMLAB user specifies that a new regional supplying industry will come into existence to serve the new industry.

If the new regional industry will employ existing technology, then the inputs shown in the U.S. National input-output tables for the same industry are used in SIMLAB. If the new regional industry will employ yet-to-be developed technology, engineering studies must be used to estimate inputs. Both approaches have been used in SIMLAB studies.

The additional regional gross product required to produce the new industry inputs is calculated using an auxiliary SIMLAB computer program. This program calculates modifications to the existing regional

^{42/} Executive Office of the President, Bureau of the Budget, Standard Industrial Classification Manual 1967, U.S. Government Printing Office, Washington, D.C., 1967.

industry (baseline) input-output table according to the following procedure:

Let,

$$A_T = \begin{bmatrix} a_{11}, a_{12}, a_{13}, \dots a_{1N} \\ a_{21}, a_{22}, \dots \\ a_{31} \\ \vdots \\ a_{N1}, a_{N2}, \dots a_{NN} \end{bmatrix}$$

denotes the table of existing regional N-industry transactions derived using the Two-Region Input-Output Program already described. Then, let

$$A_D = \begin{bmatrix} A_{11}, A_{12}, A_{13}, \dots A_{1N} \\ A_{21}, A_{22}, \dots \\ \vdots \\ A_{N1}, A_{N2}, \dots A_{NN} \end{bmatrix}$$

be the regional direct requirements table, derived from A_T , and let

$$\hat{A}^o = \begin{bmatrix} \hat{a}_1^o \\ \hat{a}_2^o \\ \hat{a}_3^o \\ \vdots \\ \hat{a}_N^o \end{bmatrix}$$

be the NXI vector of new industry inputs (in 1970 dollars).

Then,

$$(I - A_D)^{-1} \hat{A}^o = \hat{A} = \begin{bmatrix} \hat{A}_1 \\ \hat{A}_2 \\ \hat{A}_3 \\ \vdots \\ \hat{A}_N^o \end{bmatrix}$$

is the NXI vector of additional regional outputs required if regional industry is to produce the new industry inputs. The next step is to calculate a new set of regional interindustry interactions as they would be once regional producers are supplying the new industry inputs.

Regional interindustry interactions can change in at least two ways as a result of the appearance of new industry. One set of changes occur as a result of increases in regional industry output required to supply the new industry inputs. A second set of changes occurs if the new industry supplies inputs to existing regional industry which previously were imported from other regions.

Changes of the first kind are calculated for SIMLAB as follows. Using the direct requirements table A_D defined above and the NXI vector of additional regional outputs, \hat{A} , the matrix

$$Z = \begin{bmatrix} A_{11}\hat{A}_1, A_{12}\hat{A}_2, \dots & A_{1N}\hat{A}_N \\ A_{21}\hat{A}_1, A_{22}\hat{A}_2 & \dots \\ A_{31}\hat{A}_1, \dots \\ \vdots \\ A_{N1}\hat{A}_1, \dots & A_{NN}\hat{A}_N \end{bmatrix}$$

is calculated. Then, recalling the regional transactions table A_T defined above, a second transactions table

$$\hat{A}_T = A_T + Z$$

is calculated. The vector of new industry inputs \hat{A}^0 is then inserted as an additional column in \hat{A}_T . This completes calculations needed to take changes of the first kind into account.

No changes of the second kind need to be taken into account if the new industry makes no intermediate sales to other regional industry. In this case, new industry sales are to one or more regional final demands, as discussed later on in this chapter. If intermediate sales are made to other regional industry, these are entered in the appropriate places and new column totals of intermediate purchases are calculated. If the new industry sells product to regional industry which previously was an imported input then industry imports are reduced by a corresponding amount.

Special problems arise in cases where the new industry sells a required input at a higher unit price than it could be imported for. This can occur, for example, when a locally produced input must be substituted for an imported one because of shortages or other supply interruptions. Fossil fuels could one day be a case in point in Minnesota. In this case other adjustments are needed to take the difference in the price of the imported good and the regionally produced good into account. If the regionally produced good has a higher unit price, the imports being substituted for are reduced by an amount corresponding to the physical quantity of goods involved; and the remaining difference attributable to the different unit prices is subtracted from purchasing industry value added, or added to purchasing industry gross product; or subtracted from industry payments to households (labor), or combinations

of these three possibilities. The decision in this case hinges on who can be expected to bear the additional cost of the more expensive input. Reducing purchasing industry value-added implies that the owners of capital in the industry will bear the cost. In the SIMLAB model, investment in plant and equipment by that industry will then be reduced and the level of industry output will, through time, be lower. If industry gross product is increased, this implies that purchasers of the product will accept a higher unit price. Special adjustments must be made to the SIMLAB model if it is to accept this scenario. For example, the assumed level of output per worker must be increased; otherwise industry price level increases will cause increases in industry employment, an unlikely event. Finally, if industry payments to households are reduced, this implies that industry can offset material input cost increases by reducing the wage bill. Reducing the wage bill can be accomplished by reducing the work force, or reducing the wage rate, or both. In practice, the rate of growth of the wage bill rather than its level may be reduced. The SIMLAB user must be prepared to make decisions concerning all these possibilities based on evidence he has assembled.

New levels of regional interindustry disbursements and disbursements to households, producers of imported goods, and to value added may require adjustments to final demands in order to reconcile regional industry sales with disbursements. If higher levels of gross product are involved, for example, the SIMLAB user must be prepared to specify how that extra product will be consumed. Among all the categories of final demand, the SIMLAB model is particularly sensitive to adjustments to the level of exports made by regional base industries. In particular, if the SIMLAB user assumes that new industry input requirements are met by diverting output from exports then, over time, the level of regional output and

employment may be lower than indicated in the baseline run. This occurs when the regional multiplier effort of growing national markets is stronger than the effect of an additional regional industry. Negative impacts, as it were, may be the result of regional base industry market share is reduced by diverting exports to local consumption. This is not the result of a flaw in the model, only a consequence of the user's assumptions.

5. OPERATING SIMLAB

This chapter explains SIMLAB computer output and walks the reader through a SIMLAB trial run. The trial run illustrates the role of the interactive control module in the SIMLAB system. A series of eight tabular summaries are produced, starting with export market indicators. Export markets "drive" the regional economy and, hence, they are presented first, followed immediately by intermediate and local final demand indicators and investment and capital stock indicators. Other tables show: intermediate purchases, imports and value added; output, earnings and employee compensation; industry employment, by occupation; total population and labor force, by sex and age class; and hours worked and output per hour.

The SIMLAB output presented in this chapter is from an actual SIMLAB run of the Minnesota economic model. Socio-economic indicators found in SIMLAB output are defined in the following discussion.

Export Market Indicators

Export market indicators for the 55 Minnesota industries are presented in Table 5.1. Detailed attributes of this table are as follows:

- a. Gross output for each industry is the total annual dollar value of industry sales measured in producer's prices. Both National and regional industry gross output are printed out.
- b. Regional exports are the annual dollar value of regional goods and services sold to the rest of the Nation and to foreign countries.
- c. Actual market share for each industry is the ratio of regional exports by each industry to total National gross output from the same industry.

Table 5.1. EXPORT MARKET INDICATORS OF SPECIFIED INDUSTRIES
MINNESOTA , 1970

INDUSTRY		GROSS OUTPUT		ACTUAL MARKET SHARE		POT. MARKET SHARE	
No.	Title	UNITED STATES	TOTAL REGION	REGIONAL EXPORTS	PERCENT OF U.S. GROSS OUTPUT	ANNUAL CHANGE EXPORTS	PERCENT OF U.S. GROSS OUTPUT
		(MIL)	(HUND)	(HUND)	(PCT)	(PCT)	(HUND) (PCT)
1	LIVESTOCK	375.21099000.	1014360.	27.0474	0	1014361.	27.0474
2	OTHER AG	302.11361000.	919120.	30.4397	0	919121.	30.4397
3	AG.,FOR.,	53. 504590.	0	0	0	0	0
4	IRON ONES	19. 5714880.	5711370.	2960.4903	0	5711370.	2360.4903
5	OTHER MET	16. 79320.	23260.	14.4168	0	23260.	14.4168
6	COPPER OR	15. 0	0	0	0	0	0
7	NON-METAL	264. 672640.	26050.	.9861	0	26051.	.9861
8	CONSTRUCT	1277.24112130.	4316255.	33.7956	0	4316256.	33.7956
9	ORDNANCE	91. 5683640.	3591810.	394.2235	0	3591810.	394.2235
10	FOOD AND	558.18867380.	5712260.	102.3607	0	5712253.	102.3607
11	MEAT PROD	240.17308000.	12284530.	512.7699	0	12284531.	512.7699
12	GRAIN MIL	110. 7585940.	3393530.	308.7188	0	3393530.	308.7188
13	BEVERAGES	228. 3081000.	0	0	0	0	0
14	APPAREL A	530. 2078000.	3170.	.0598	0	3171.	.0598
15	LOGGING	88. 906700.	0	0	0	0	0
16	WOOD PROD	163. 2347370.	98399.	6.0394	0	98399.	6.0394
17	PAPER PRO	268.14085350.	6431170.	239.8098	0	6431171.	239.8098
18	PRINTING	260. 6432000.	2336200.	89.8642	0	2336200.	89.8642
19	CHEMICALS	557. 4560900.	0	0	0	0	0
20	PETROLEUM	318. 2733000.	56300.	1.7726	0	56299.	1.7726
21	RUBBER AN	227. 4905180.	1718308.	75.7865	0	1718307.	75.7865
22	STONE,CLA	175. 2308000.	0	0	0	0	0
23	PRIMARY I	350. 1567200.	0	0	0	0	0
24	PRIMARY C	32. 0	0	0	0	0	0
25	OTHER PRI	229. 1311800.	393179.	17.1726	0	393179.	17.1726
26	METAL FAB	435. 6941900.	0	0	0	0	0
27	MACHINERY	648.22028790.	10705978.	165.2287	0	10705977.	165.2287
28	ELECTRIC	549. 8422340.	318630.	5.8061	0	318632.	5.8061
29	MOTOR VEH	478. 4262000.	0	0	0	0	0
30	AIRCRAFT	210. 202630.	0	0	0	0	0
31	OTHER TRA	100. 2014380.	455491.	45.5641	0	455491.	45.5641
32	INSTRUMEN	130. 3734000.	1656135.	127.5431	0	1656134.	127.5431
33	MISC. MAN	112. 1599560.	0	0	0	0	0
34	TRANSPORTA	140. 796730.	14841.	1.0624	0	14841.	1.0624
35	RAIL TRAN	154. 4451520.	1538424.	100.1761	0	1538424.	100.1761
36	LOCAL TRA	57. 1076350.	0	0	0	0	0
37	TRUCK TRA	204. 3759800.	41642.	2.0443	0	41642.	2.0443
38	AIR TRANS	103. 2275050.	1069312.	103.9994	0	1069311.	103.9994
39	COMMUNICA	296. 3991680.	12099.	.4092	0	12099.	.4092
40	ELECTRICA	293. 3355500.	0	0	0	0	0
41	GAS UTILI	141. 2824150.	71110.	5.0601	0	71111.	5.0601
42	WATER UTI	45. 2628360.	1665310.	372.3610	0	1665310.	372.3610
43	WHOLESALE	820.36673170.	18815223.	229.5917	0	18815223.	229.5917
44	RETAIL TR	1252.35201130.	9032039.	72.1687	0	9032043.	72.1687
45	FINANCE,	655.12051080.	0	0	0	0	0
46	REAL ESTA	1432.19756490.	3421.	.0239	0	3422.	.0239
47	HOTELS,LO	236. 4105880.	522940.	22.1293	0	522940.	22.1293
48	BUSINESS	690. 9332780.	0	0	0	0	0
49	CAR REPAI	184. 3577940.	0	0	0	0	0
50	AMUSEMENT	117. 1377650.	0	0	0	0	0
51	MEDICAL,E	686.13517160.	0	0	0	0	0
52	FEDERAL G	98. 1890850.	0	0	0	0	0
53	STATE AND	119. 6257770.	3248780.	273.8190	0	3248780.	273.8190
54	OTHER IND	190. 2236740.	0	0	0	0	0
55	OTHER GOVT	18915.40333000.	0	0	0	0	0
TOTAL		36231.*	.42E+0997201243.	26.8285		097201255.	26.8286

- d. Annual change in market share is the historical or user-specified annual compound rate of change in regional market share.
- e. Potential market share represents the level of regional exports attainable in the absence of labor and capital constraints on regional gross output. Operation of these constraints within the SIMLAB model is explained in Chapter 3.

Intermediate and Local Final Demand Indicators

Intermediate and final demand indicators for the 55 Minnesota industries in Table 5.2 show the individual industry and sector requirements of industry output produced in Minnesota. Attributes of these demands are as follows:

- a. Intermediate purchases are the annual value of regional industry sales to other regional industries.
- b. Personal consumption expenditures are annual regional industry sales to regional households and/or individuals. In the SIMLAB economic accounts, each industry producing a consumer good is treated as selling directly to consumers. Trade margins then become the gross output of the wholesale and retail trade sectors.
- c. Gross private capital formation is the annual value of regional industry product used as capital goods by other regional industries. Capital goods are goods used to produce other goods. Capital goods take longer than one year to wear out or be used up. Industry intermediate purchases are used up on one year or less.
- d. Inventory change is the annual change in the value of goods held by industries for future delivery.

Table 5.2. INTERMEDIATE AND LOCAL FINAL DEMAND INDICATORS OF SPECIFIED INDUSTRIES
MINNESOTA , 1970

		FINAL LOCAL DEMAND						
		INTER- MEDIATE PURCHASES	P.C.E.	GROSS PRIVATE CAPITAL FORM.	INVEN- TORY CHANGE	GOVERNMENT		TOTAL
No.	Industry Title					STATE AND LOCAL	FEDERAL	
		(HUND)	(HUND)	(HUND)	(HUND)	(HUND)	(HUND)	(HUND)
1	LIVESTOCK	19297400.	465140.	0	315190.	5640.	1270.	787240.
2	OTHER AG	9625030.	833900.	0	190380.	31230.	-238660.	816850.
3	AG., FOR.,	458230.	65990.	0	1040.	4640.	-25310.	46360.
4	IRON ORES	0	0	0	2910.	0	0	2910.
5	OTHER MET	46030.	0	0	110.	0	9920.	10030.
6	COPPER OR	0	0	0	0	0	0	0
7	NON-METAL	637150.	1360.	0	620.	7730.	-270.	9440.
8	CONSTRUCT	5167510.	0	6219955.	63560.	7311050.	1033800.	14628365.
9	OKDNANCE	489420.	100730.	2430.	14110.	2430.	1482710.	1602410.
10	FOOD AND	5451750.	7484410.	0	47690.	100190.	71080.	7703370.
11	MEAT PROD	881060.	4012470.	0	43750.	65700.	19490.	4142410.
12	GRAIN MIL	3522640.	638170.	0	19170.	4590.	7840.	669770.
13	BEVERAGES	469450.	2594690.	0	7790.	5760.	2310.	2611550.
14	APPAREL A	483910.	1529130.	0	8910.	9860.	43020.	1590920.
15	LOGGING	898790.	340.	0	4590.	0	2980.	7910.
16	WOOD PROD	1350410.	442220.	318551.	12530.	99550.	25610.	898561.
17	PAPER PRO	7076910.	399650.	0	70070.	75840.	31710.	577270.
18	PRINTING	2971710.	865620.	0	24660.	237880.	46030.	1174090.
19	CHEMICALS	2918590.	1259920.	0	38790.	164770.	178830.	1642310.
20	PETROLEUM	1531350.	1011350.	0	2270.	45290.	8540.	1145350.
21	RUBBER AN	1993500.	1064020.	7092.	52240.	33600.	36420.	1193372.
22	STONE, CLA	2211390.	69600.	0	12120.	9450.	5440.	96610.
23	PRIMARY I	1558630.	2000.	0	1090.	160.	5320.	8570.
24	PRIMARY C	0	0	0	0	0	0	0
25	OTHER PRI	902600.	2040.	3321.	10510.	50.	0	16021.
26	METAL FAB	6532900.	0	323281.	67170.	-60241.	78790.	409000.
27	MACHINERY	5392920.	156590.	5040372.	291730.	143590.	292610.	5929892.
28	ELECTRIC	4792150.	1370900.	1167690.	92240.	75620.	607110.	3311560.
29	MOTOR VEH	1416730.	1176517.	1281013.	32730.	217240.	137770.	2845270.
30	AIRCRAFT	65900.	0	38765.	3040.	-15515.	108440.	136730.
31	OTHER TRA	251950.	339120.	589520.	31710.	6460.	340130.	1306940.
32	INSTRUMEN	846820.	320720.	525765.	45880.	101720.	236960.	1231045.
33	MISC. MAN	606720.	772268.	140742.	13210.	48740.	17880.	992840.
34	TRANSPORT	588160.	114440.	1949.	550.	3820.	72870.	193729.
35	RAIL TRAN	2235930.	539580.	37656.	3960.	22600.	73370.	677166.
36	LOCAL TRA	209470.	585048.	112912.	520.	162790.	5610.	866880.
37	TRUCK TRA	2796330.	650890.	5528.	4810.	75510.	187090.	921828.
38	AIR TRANS	360050.	586860.	12888.	6080.	64710.	175150.	845688.
39	COMMUNICA	2260500.	1362930.	106091.	20210.	129430.	100420.	1719081.
40	ELECTRICA	2233130.	805550.	0	11650.	264810.	40360.	1122370.
41	GAS UTILI	1484560.	1135420.	0	2520.	135930.	13510.	1288480.
42	WATER UTI	476190.	465830.	0	850.	9650.	10530.	486860.
43	WHOLESALE	8802150.	6876540.	812827.	796540.	327150.	242740.	9055797.
44	RETAIL TR	3838410.	21309000.	529581.	646290.	-150540.	-3650.	22330681.
45	FINANCE,	6180170.	5720798.	702.	1230.	137100.	11080.	5870910.
46	REAL ESTA	6628510.	12896170.	4319.	3160.	171930.	48980.	13124559.
47	HOTELS, LO	620970.	2797800.	0	4330.	35700.	122540.	2961970.
48	BUSINESS	7730080.	961170.	0	10850.	353480.	327200.	1652700.
49	CAR REPAI	1703250.	1809940.	0	4080.	51390.	9280.	1874690.
50	AMUSEMENT	382370.	1037740.	0	3920.	-70890.	24510.	995280.
51	MEDICAL, E	590760.	11266050.	0	850.	1219970.	440530.	12926400.
52	FEDERAL G	1444850.	310410.	0	0	83060.	46530.	446000.
53	STATE AND	2744260.	254880.	0	0	7410.	2440.	264730.
54	OTHER IND	1896180.	211060.	0	0	140570.	-11070.	340560.
55	OTHER GOVT	26216450.	0	0	0	012039594.	2077956.	14116550.
	TOTAL	* .17E+09	98676971.	17282952.	3045210.	23960098.	8662646.*	.15E+09

- e. Government use of regional industry product is broken into state/local and Federal. In the SIMLAB system of accounts, only government use of regional industry product within the region is treated in this way. Thus, for example, regional industry production of ordnance and other items used in National defense is treated as an export.

Investment and Capital Stock Indicators

Investment and capital stock requirements of the 55 Minnesota industries are listed in Table 5.3. Output-increasing investment is differentiated into pollution-abatement investment and expansion from replacement investment as follows:

- a. Output increasing investment is the annual value of industry purchases and installation of capital goods. Expansion investment leads to increases in capacity to produce. Replacement investment offsets depreciation of installed capacity. If only replacement investment occurs, then production capacity does not increase. The SIMLAB model does not take the "vintage" of capital equipment into account so, "old" capital is assumed to be as productive as "new" capital. Total expansion plus replacement output increasing investment is also printed out.
- b. Pollution abatement investment is the annual value of industry purchases of goods or equipment used to control emission of harmful substances to the environment. Both expansion and replacement investment in pollution abatement are taken into account. Total expansion plus replacement pollution abatement investment is also printed out.
- c. Capital stock is the sum of past annual investment and installation of capacity-creating and pollution-controlling goods

Table 5.3. INVESTMENT AND CAPITAL STOCK INDICATORS OF SPECIFIED INDUSTRIES
MINNESOTA, 1970

NO.	INDUSTRY TITLE	OUTPUT INCREASING			POLLUTION ABATEMENT			CAPITAL STOCKS		
		EXPAN	REPLACE	TOTAL	EXPAN	REPLACE	TOTAL	OUTPUT POLL.	TOTAL	
		SION	MENT		SION	MENT		INCREASE ABAT.		
		(THOU)	(THOU)	(THOU)	(THOU)	(THOU)	(THOU)	(MIL.)	(MIL.)	(MIL.)
1	LIVESTOCK	63001.	41987.	104988.	857.	571.	1423.	1917.4	26.1	1943.5
2	OTHER AG	38053.	22638.	60661.	518.	308.	825.	1032.5	14.0	1046.5
3	AG.,FOR.,	0	802.	802.	0	11.	11.	45.9	.6	46.5
4	IRON ORES	2101.	23202.	25303.	29.	316.	345.	713.8	9.7	723.5
5	OTHER MET	20394.	322.	20716.	285.	4.	289.	9.9	.1	10.0
6	COPPER OR	742.	0	742.	10.	0	10.	0	0	0
7	NON-METAL	0	2731.	2731.	0	37.	37.	84.0	1.2	85.2
8	CONSTRUCT	3331.	39785.	43116.	45.	542.	587.	2309.0	31.4	2340.4
9	ORDNANCE	0	23076.	23076.	0	3265.	3265.	70.0	9.9	79.9
10	FOOD AND	33440.	31320.	64760.	455.	426.	881.	416.9	5.7	422.6
11	MEAT PROD	4067.	28731.	32798.	55.	391.	446.	382.5	5.2	387.7
12	GRAIN MIL	11277.	12593.	23870.	153.	171.	324.	167.6	2.3	169.9
13	BEVERAGES	10345.	5114.	15459.	141.	70.	211.	68.1	.9	69.0
14	APPAREL A	2740.	3117.	5857.	37.	42.	79.	27.8	.4	28.1
15	LOGGING	2756.	3613.	6374.	37.	49.	85.	30.0	.4	30.4
16	WOOD PROD	1639.	9366.	11005.	22.	127.	149.	50.8	.7	51.5
17	PAPER PRO	2789.	63525.	66314.	38.	853.	901.	1088.4	14.8	1103.2
18	PRINTING	3563.	16205.	19768.	48.	220.	263.	272.6	3.7	276.3
19	CHEMICALS	35584.	25952.	61536.	485.	354.	839.	250.5	3.4	253.9
20	PETROLEUM	6052.	9101.	15153.	82.	124.	205.	54.2	.7	55.0
21	RUBBER AN	17418.	18542.	35960.	237.	252.	489.	270.6	3.7	274.2
22	STONE,CLA	0	12002.	12002.	0	153.	153.	182.5	2.5	185.0
23	PRIMARY I	0	8588.	8588.	0	117.	117.	155.5	2.1	157.6
24	PRIMARY C	1123.	0	1123.	15.	0	15.	0	0	0
25	OTHER PRI	18043.	7189.	25232.	245.	98.	343.	56.6	.8	57.4
26	METAL FAB	2678.	19368.	22046.	36.	263.	299.	188.4	2.6	190.9
27	MACHINERY	1828.	106840.	108668.	25.	1454.	1479.	679.7	9.2	688.9
28	ELECTRIC	0	24088.	24088.	0	327.	327.	197.9	2.7	200.6
29	MOTOR VEH	0	10740.	10740.	0	146.	146.	98.7	1.3	100.1
30	AIRCRAFT	1627.	511.	2138.	24.	7.	31.	4.4	.1	4.5
31	OTHER TRA	8636.	5076.	13712.	125.	74.	199.	43.8	.6	44.4
32	INSTRUMEN	34631.	9410.	44041.	471.	128.	599.	86.6	1.2	87.7
33	MISC. MAN	7360.	4031.	11391.	164.	90.	254.	22.6	.5	23.2
34	TRANSPORTA	30482.	6071.	36553.	415.	33.	448.	149.6	2.0	151.6
35	RAIL TRAN	2345.	22925.	25270.	32.	312.	344.	693.4	9.4	702.8
36	LOCAL TRA	29534.	5898.	35432.	402.	80.	482.	202.1	2.7	204.8
37	TRUCK TRA	6166.	16130.	22296.	84.	219.	303.	101.9	1.4	103.2
38	AIR TRANS	11617.	24639.	36256.	158.	335.	493.	403.5	5.5	409.0
39	COMMUNICA	5406.	47222.	52628.	74.	643.	717.	875.1	11.9	887.1
40	ELECTRICA	24365.	36508.	60873.	335.	502.	837.	541.7	7.4	549.2
41	GAS UTILI	729.	30727.	31456.	10.	418.	429.	104.5	1.4	106.0
42	WATER UTI	6786.	17847.	24633.	92.	243.	335.	97.3	1.3	98.6
43	WHOLESALE	20319.	23838.	44157.	276.	324.	600.	3217.2	43.8	3261.0
44	RETAIL TR	16137.	47522.	63659.	220.	646.	866.	2095.7	28.5	2124.2
45	FINANCE,	10070.	11087.	21157.	137.	151.	288.	503.0	6.8	509.8
46	REAL ESTA	2268.	18176.	20444.	31.	247.	278.	824.6	11.2	835.8
47	HOTELS,LO	0	23075.	23075.	0	314.	314.	171.4	2.3	173.7
48	BUSINESS	731.	114376.	115107.	10.	1556.	1566.	391.6	5.3	396.9
49	CAR REPAI	79156.	65047.	144203.	1078.	885.	1963.	149.3	2.0	151.4
50	AMUSEMENT	64225.	2246.	66471.	874.	31.	905.	57.5	.8	58.3
51	MEDICAL,E	24527.	122330.	146857.	334.	1654.	1998.	564.2	7.7	571.8
52	FEDERAL G	31591.	0	31591.	572.	0	572.	59.6	1.1	60.6
53	STATE AND	6441.	0	6441.	88.	0	88.	231.6	3.1	234.8
54	OTHER IND	14078.	0	14078.	192.	0	192.	51.8	.7	52.5
55	OTHER GOVT	0	0	0	0	0	0	0	0	0
TOTAL		722191.	*****	*****	10053.	19663.	29715.	22465.	315.	22781.

and equipment less the sum of annual depreciation charges.

Capital stock is not measured at an annual rate, like investment, but as the sum total of annual investment, less accumulated depreciation. Output-increasing capital stock is the value of net available, or working, production capacity.

Pollution abatement capital stock is net available, or working, pollution-control capacity. Total capital stock is the sum of the value of output-increasing and pollution-abatement capital stock.

Intermediate Purchases, Imports and Value Added Indicators

Intermediate purchases, imports and value added of the 55 Minnesota industries are presented in Table 5.4. The individual outlays are identified as follows:

- a. Intermediate purchases are the annual value of products purchased by area industries from other supplying industries located in the region. These purchases are those made on current account and do not include capital goods purchased.
- b. Value added can be viewed as a theoretical concept and as a practical accounting concept. Economic theory defines value added as a measure of the annual contribution of labor and invested capital (including capital held by government for public use) to the annual value of industry output measured in producer's prices. From an accounting point of view, value added represents the part of the proceeds from the sale of output left over after payment is made to suppliers for area-produced intermediate products and imported intermediate products used in the production process. From value added, each indus-

Table 5.4. INTERMEDIATE PURCHASES, IMPORTS, AND VALUE ADDED INDICATORS
OF SPECIFIED INDUSTRIES
MINNESOTA, 1970

INDUSTRY		VALUE ADDED				IMPORTS	
NO.	TITLE	INTER	EARNINGS		OTHER		TOTAL
		MEDIATE PURCHASES					
		(HUND)	(HUND)	(HUND)	(HUND)	(HUND)	
1	LIVESTOCK	14274122.	4627870.	1558758.	6186628.	638250.	
2	OTHER AG	4112775.	4217550.	1328015.	5545555.	1702660.	
3	AG.,FOR.,	146970.	255130.	73510.	328640.	28980.	
4	IRON ORES	1250821.	1203240.	2095069.	3298309.	1165750.	
5	OTHER MET	17580.	13360.	35100.	48460.	13280.	
6	COPPER OR	0	0	0	0	0	
7	NON-METAL	188330.	284510.	118800.	403310.	81000.	
8	CONSTRUCT	10027066.	8042090.	3136944.	11179034.	2906030.	
9	ORDNANCE	1678859.	1048650.	1608611.	2657231.	1347520.	
10	FOOD AND	12572285.	2257700.	2857115.	5114815.	1180280.	
11	MEAT PROD	13756518.	1559420.	1518012.	3077432.	474050.	
12	GRAIN MIL	5174513.	711040.	1328797.	2039837.	371590.	
13	BEVERAGES	926771.	422620.	1398269.	1820839.	333340.	
14	APPAREL A	464019.	580760.	137181.	717941.	896040.	
15	LOGGING	278740.	127420.	279160.	406530.	221380.	
16	WOOD PROD	871590.	677690.	386770.	1064450.	411320.	
17	PAPER PRO	6436092.	3331520.	2584538.	5916058.	1733200.	
18	PRINTING	2893433.	2114650.	904037.	3018637.	569880.	
19	CHEMICALS	1832461.	601830.	1023679.	1625509.	1102930.	
20	PETROLEUM	655901.	224170.	503549.	727719.	1349380.	
21	RUBBER AN	1930862.	495890.	1726318.	2222208.	752110.	
22	STONE, CLA	948271.	674030.	439619.	1113649.	246080.	
23	PRIMARY I	466570.	426140.	271140.	697280.	403350.	
24	PRIMARY C	0	0	0	0	0	
25	OTHER PRI	518940.	237080.	257550.	494630.	298230.	
26	METAL FAB	2165732.	1726290.	1258248.	2984538.	1791630.	
27	MACHINERY	9311051.	6328730.	3042449.	9371179.	3346560.	
28	ELECTRIC	3214910.	2689760.	983770.	3673530.	1533900.	
29	MOTOR VEH	2039831.	478850.	917019.	1395859.	826300.	
30	AIRCRAFT	54600.	38720.	46470.	85130.	62840.	
31	OTHER TRA	824170.	408080.	385280.	793360.	396850.	
32	INSTRUMEN	1268019.	1755440.	106661.	1862101.	603880.	
33	MISC. MAN	589469.	563280.	196561.	759841.	250250.	
34	TRANSPORTA	242360.	286380.	104350.	390730.	163640.	
35	RAIL TRAN	1155599.	2107240.	870631.	2977871.	318050.	
36	LOCAL TRA	285520.	640820.	103510.	744330.	46500.	
37	TRUCK TRA	962571.	1923250.	589439.	2512689.	284540.	
38	AIR TRANS	609380.	672470.	657190.	1329660.	336010.	
39	COMMUNICA	637470.	1438090.	1656620.	3094710.	259500.	
40	ELECTRICA	1473750.	586930.	754190.	1341120.	540630.	
41	GAS UTILI	328211.	463520.	1385849.	1849339.	646570.	
42	WATER UTI	1986700.	348630.	188110.	536740.	104920.	
43	WHOLESALE	8599026.	8787670.	16007794.	24795454.	3278660.	
44	RETAIL TR	6267622.	12994480.	13770418.	26764898.	2168610.	
45	FINANCE,	4082528.	5019040.	1935072.	6954112.	1014440.	
46	REAL ESTA	4563956.	840880.	13468034.	14308914.	877620.	
47	HOTELS, LO	1332949.	1967940.	335381.	2303321.	469610.	
48	BUSINESS	3488832.	2274340.	2672778.	4947118.	946830.	
49	CAR REPAI	1352260.	435790.	1522170.	1957950.	267720.	
50	AMUSEMENT	444949.	614790.	149171.	763951.	168740.	
51	MEDICAL, E	2191402.	10609170.	216588.	10825738.	500000.	
52	FEDERAL G	434089.	1196500.	141621.	1338121.	118640.	
53	STATE AND	2417440.	1863350.	1391560.	3254910.	585420.	
54	OTHER IND	1282019.	755940.	37461.	793401.	161320.	
55	OTHER GOVT	0	14116550.	26216450.	40333000.	0	
	TOTAL	145035907.	118067280.	116681383.	234748653.	40296830.	

try pays wages, salaries, dividends and taxes; accumulates retained earnings; and deducts depreciation charges. The input-output treatment of value added is most consistent with the accounting point of view because, by convention, interest payments are included in the list of intermediate purchases. This treatment of interest is equivalent to viewing cash acquired by business using bonds, loans, and notes as an intermediate good. In the computer printout, total value added is grouped into earnings, and other value added. Earnings are regional industry payments of wages and salaries. Other value added is the sum of business retained earnings, dividends, indirect taxes paid by business, and depreciation charges.

- c. Imports are the annual value of area industry purchases of products purchased from supplying industries located in other regions. Thus, by accounting for purchases from suppliers located inside and outside the region plus wages, salaries, dividends, interest, and taxes, Table 5.4 presents a breakdown of area industry current account expenses showing the destination of each category of expense.

Output and Earnings Per Worker Indicators

Output and earnings per worker levels and rates of change are listed in Table 5.5. These data show productivity trends as follows:

- a. Output per worker in annual industry gross output (shown in Table 5.1) divided by average annual industry employment. Output per worker is often referred to as "productivity".
- b. Annual change in output per worker is a measure of labor productivity -- the increase in output which justifies the increase in real earnings.

Table 5.5. OUTPUT, EARNINGS AND EMPLOYEE COMPENSATION PER WORKER
FOR SPECIFIED INDUSTRIES
MINNESOTA, 1970

INDUSTRY		OUTPUT PER WORKER		EARNINGS PER WORKER		EMPLOYEE COMPENSATION PER WORKER	
		TOTAL	ANNUAL CHANGE	TOTAL	ANNUAL CHANGE	TOTAL	ANNUAL CHANGE
NO.	TITLE	(DOLLAR)	(PCT.)	(DOLLAR)	(PCT.)	(DOLLAR)	(PCT.)
1	LIVESTOCK	26940.	0	5909.	0	5909.	0
2	OTHER AG	15917.	0	5909.	0	5909.	0
3	AG., FOR.,	15300.	0	7736.	0	7736.	0
4	IRON ORES	43449.	0	9148.	0	9148.	0
5	OTHER MET	54329.	0	9151.	0	9151.	0
6	COPPER OR	0	0	0	0	0	0
7	NON-METAL	30616.	0	12950.	0	12950.	0
8	CONSTRUCT	30720.	0	10246.	0	10246.	0
9	ORDNANCE	45799.	0	8450.	0	8450.	0
10	FOOD AND	75112.	0	8988.	0	8988.	0
11	MEAT PROD	99758.	0	8988.	0	8388.	0
12	GRAIN MIL	95891.	0	8988.	0	8988.	0
13	BEVERAGES	65525.	0	8988.	0	8988.	0
14	APPAREL A	18785.	0	5250.	0	5250.	0
15	LOGGING	52776.	0	7417.	0	7417.	0
16	WOOD PROD	25691.	0	7417.	0	7417.	0
17	PAPER PRO	44761.	0	10587.	0	10587.	0
18	PRINTING	26815.	0	8748.	0	8748.	0
19	CHEMICALS	69115.	0	9120.	0	9120.	0
20	PETROLEUM	134498.	0	11032.	0	11032.	0
21	RUBBER AN	59973.	0	6063.	0	6063.	0
22	STONE, CLA	29010.	0	8472.	0	8472.	0
23	PRIMARY I	34084.	0	9268.	0	9268.	0
24	PRIMARY C	0	0	0	0	0	0
25	OTHER PRI	51282.	0	9268.	0	9268.	0
26	METAL FAB	33984.	0	8451.	0	8451.	0
27	MACHINERY	33896.	0	9738.	0	9738.	0
28	ELECTRIC	29675.	0	9477.	0	9477.	0
29	MOTOR VEH	88533.	0	9947.	0	9947.	0
30	AIRCRAFT	40045.	0	7652.	0	7652.	0
31	OTHER TRA	37772.	0	7652.	0	7652.	0
32	INSTRUMEN	26597.	0	12504.	0	12504.	0
33	MISC. MAN	21511.	0	7575.	0	7575.	0
34	TRANSPORTA	24530.	0	8817.	0	8817.	0
35	RAIL TRAN	22010.	0	10419.	0	10419.	0
36	LOCAL TRA	14809.	0	8817.	0	8817.	0
37	TRUCK TRA	19199.	0	9821.	0	9821.	0
38	AIR TRANS	29829.	0	8817.	0	8817.	0
39	COMMUNICA	23327.	0	8404.	0	8404.	0
40	ELECTRICA	62104.	0	10863.	0	10863.	0
41	GAS UTILI	66186.	0	10863.	0	10863.	0
42	WATER UTI	81906.	0	10864.	0	10864.	0
43	WHOLESALE	39237.	0	9402.	0	9402.	0
44	RETAIL TR	13041.	0	4814.	0	4814.	0
45	FINANCE,	20078.	0	8362.	0	8362.	0
46	REAL ESTA	196465.	0	8362.	0	8362.	0
47	HOTELS, LO	10077.	0	4830.	0	4830.	0
48	BUSINESS	22529.	0	5461.	0	5461.	0
49	CAR REPAI	44836.	0	5461.	0	5461.	0
50	AMUSEMENT	10415.	0	4648.	0	4648.	0
51	MEDICAL, E	8651.	0	6790.	0	6790.	0
52	FEDERAL G	10950.	0	6929.	0	6929.	0
53	STATE AND	23270.	0	6929.	0	6929.	0
54	OTHER IND	10510.	0	3552.	0	3552.	0
55	OTHER GOVT	20000.	0	7000.	0	7000.	0
	AVERAGE	25959.	0	7296.	0	7296.	0

- c. Earnings per worker are gross wage, salary, and other labor income plus the earnings of proprietorship which can be important in sectors where small businesses are numerous.
- d. Annual change is a measure of the historical trend in earnings per worker.
- e. Employee compensation is the annual total of wages, salaries and other employee remuneration paid directly to employees and indirectly for them by the business firms which make up each industry. Unless the SIMLAB user specified his assumption as to the ratio of employee compensation to wages and salaries, SIMLAB will equate earnings per worker and compensation per worker.

Total Employment Indicators

Industry employment requirements are listed by occupation in Table 5.6. Nearly all users should find these occupational classifications to be reasonably self-explanatory so no further explanation will be attempted here.

Total Population and Labor Force Indicators

Total population and labor in the State is summarized by sex and age class in Table 5.7. Attributes of these data are as follows:

- a. Population is cross-classified by age and sex.
- b. The labor force consists of those male and female members of the non-industrial population age 16 to 65 years who are employed or who are able to work and are seeking work.
- c. The labor force participation rate is the percentage of the population in each age/sex category which is also part of the labor force. School-age workers and older workers typically

Table 5.6. TOTAL EMPLOYMENT IN SPECIFIED INDUSTRIES, BY OCCUPATION
MINNESOTA, 1970

INDUSTRY	PROFES	MANA-	SALES	CLERI	CRAFTS	OPERA	NONFARM	SER-	FARM	TOTALS
No. - Title	SIONAL	GERIAL	WORKER	CAL		ITIVES	NONMINE	VICE		
	(NO.)	(NO.)	(NO.)	(NO.)	(NO.)	(NO.)	(NO.)	(NO.)	(NO.)	(NO.)
1 LIVESTOCK	1803.	749.	467.	582.	749.	2411.	6153.	230.	65170.	78319.
2 OTHER AG	1643.	683.	425.	530.	683.	2136.	5613.	210.	59393.	71375.
3 AG., FOR.,	76.	31.	19.	24.	31.	101.	253.	9.	2746.	3298.
4 IRON ORES	1105.	790.	15.	807.	4370.	5788.	0	278.	0	13153.
5 OTHER MET	12.	9.	0	9.	49.	65.	0	2.	0	146.
6 COPPER OR	0	0	0	0	0	0	0	0	0	0
7 NON-METAL	346.	217.	27.	489.	277.	656.	95.	92.	0	2197.
8 CONSTRUCT	3503.	6259.	815.	4938.	48858.	7517.	4750.	1851.	0	78490.
9 ORDANCE	1023.	750.	0	750.	4159.	5523.	0	205.	0	12410.
10 FOOD AND	2442.	2478.	831.	3096.	2656.	9253.	1400.	2952.	0	25119.
11 MEAT PROD	1687.	1711.	574.	2139.	1835.	6398.	967.	2039.	0	17350.
12 GRAIN MIL	769.	780.	262.	975.	837.	2917.	441.	930.	0	7911.
13 BEVERAGES	457.	464.	156.	580.	497.	1734.	262.	553.	0	4702.
14 APPAREL A	1980.	670.	187.	1088.	1719.	4509.	272.	636.	0	11062.
15 LOGGING	109.	114.	89.	181.	359.	605.	75.	186.	0	1718.
16 WOOD PROD	578.	608.	472.	963.	1910.	3217.	400.	990.	0	9137.
17 PAPER PRO	8388.	2402.	640.	4821.	3763.	4992.	4139.	2324.	0	31468.
18 PRINTING	1656.	1107.	969.	3513.	10345.	3896.	1114.	1572.	0	24173.
19 CHEMICALS	1640.	692.	212.	1408.	597.	901.	762.	386.	0	6599.
20 PETROLEUM	459.	158.	66.	367.	313.	387.	124.	156.	0	2032.
21 RUBBER AN	1464.	495.	138.	804.	1271.	3334.	201.	470.	0	8179.
22 STONE, CLA	1416.	513.	175.	924.	1315.	2551.	385.	676.	0	7956.
23 PRIMARY I	37.	155.	40.	234.	1692.	1436.	563.	241.	0	4598.
24 PRIMARY C	0	0	0	0	0	0	0	0	0	0
25 OTHER PRI	20.	86.	22.	130.	1053.	799.	315.	134.	0	2558.
26 METAL FAB	1424.	805.	436.	1535.	5133.	9253.	810.	1030.	0	20427.
27 MACHINERY	21729.	4212.	734.	7102.	12818.	14817.	565.	3013.	0	64990.
28 ELECTRIC	7539.	2432.	428.	3165.	4764.	8344.	327.	1383.	0	28382.
29 MOTOR VEH	862.	292.	81.	473.	748.	1962.	113.	277.	0	4814.
30 AIRCRAFT	91.	31.	9.	50.	79.	206.	12.	29.	0	506.
31 OTHER TRA	955.	323.	90.	524.	829.	2174.	131.	307.	0	5333.
32 INSTRUMEN	2513.	850.	237.	1381.	2182.	5722.	345.	808.	0	14039.
33 MISC. MAN	1331.	450.	126.	731.	1156.	3031.	185.	428.	0	7436.
34 TRANSPORTA	202.	550.	53.	311.	698.	875.	37.	522.	0	3248.
35 RAIL TRAN	1809.	1967.	49.	6876.	5138.	2738.	777.	811.	0	20225.
36 LOCAL TRA	452.	1230.	119.	696.	1562.	1957.	83.	1168.	0	7268.
37 TRUCK TRA	611.	1002.	239.	2922.	1986.	10820.	1627.	375.	0	19583.
38 AIR TRANS	474.	1291.	125.	731.	1639.	2054.	87.	1226.	0	7627.
39 COMMUNICA	2618.	1363.	314.	7556.	4812.	192.	44.	213.	0	17112.
40 ELECTRICAL	652.	378.	55.	829.	2383.	652.	265.	179.	0	5403.
41 GAS UTILI	499.	277.	90.	770.	1609.	527.	435.	59.	0	4267.
42 WATER UTI	96.	153.	3.	201.	494.	676.	1565.	19.	0	3209.
43 WHOLESALE	10046.	14088.	14200.	22498.	9977.	14582.	4771.	3305.	0	93466.
44 RETAIL TR	11425.	28784.	55594.	48601.	23003.	27652.	12481.	62382.	0	269931.
45 FINANCE,	6780.	10308.	10341.	27393.	1007.	230.	345.	3571.	0	60022.
46 REAL ESTA	1136.	1727.	1732.	4589.	169.	47.	57.	598.	0	10056.
47 HOTELS, LO	2772.	2142.	623.	5951.	2348.	7604.	243.	19001.	0	40744.
48 BUSINESS	17882.	2961.	998.	10061.	2323.	3681.	342.	3399.	0	41647.
49 CAR REPAI	3374.	410.	46.	1553.	547.	376.	172.	1501.	0	7980.
50 AMUSEMENT	5593.	680.	76.	2575.	907.	623.	285.	2489.	0	13227.
51 MEDICAL	273609.	6710.	509.	21413.	2211.	2933.	440.	48373.	0	156247.
52 FEDERAL G	3457.	1712.	29.	7820.	1775.	694.	1305.	477.	0	17268.
53 STATE AND	4640.	3962.	75.	6197.	1832.	803.	1594.	7791.	0	26892.
54 OTHER IND	8999.	1094.	123.	4143.	1459.	1002.	453.	4004.	0	21282.
55 OTHER GOVT	90548.	15528.	202.	52836.	5647.	3025.	2823.	31056.	0	201665.
TOTALS	316729.	129633.	94339.	280835.	190773.	200686.	61025.	216916.	127309.	*****

TABLE 5.7. TOTAL POPULATION AND LABOR FORCE INDICATORS OF SPECIFIED SEX
AND AGE CLASS
MINNESOTA , 1970

AGE GROUP	----POPULATION----		----LABOR FORCE----		PARTICIPATION RATE	
	MALE	FEMALE	MALE	FEMALE	MALE	FEMALE
					(PCT)	
1 1-13	546223.	523009.				
2 14-15	81876.	77754.				
3 16-17	77772.	74853.	21465.	17276.	27.600	23.080
4 18-19	67257.	74088.	47726.	43956.	70.960	59.330
5 20-24	133440.	158597.	117427.	116680.	88.000	73.570
6 25-29	123848.	125668.	118089.	54465.	95.350	43.340
7 30-34	103114.	103655.	98319.	44924.	95.350	43.340
8 35-44	196598.	198975.	189855.	98393.	96.570	49.450
9 45-54	195210.	201650.	174205.	101652.	89.240	50.410
10 55-59	86181.	90830.	76908.	45787.	89.240	50.410
11 60-64	74314.	81140.	66318.	40903.	89.240	50.410
12 65+	177977.	230942.	43355.	24919.	24.360	10.790
TOTALS	1863810.	1941161.	953667.	588955.	51.168	30.340

have males although, historically, the female participation rate has been rising.

Total Hours Worked and Output Per Hour Indicators

Total hours worked and output per hour for the 55 Minnesota industries are presented in Table 5.8. Attributes of these measures, which are used, also, as productivity indicators, are as follows:

Length of the workweek and the number of weeks worked per year are reported in Table 5.8. Unless the SIMLAB user specifies otherwise, a standard forty-four week and a fifty-week working year are assumed to prevail in all industries. Future versions of SIMLAB will include results from individual industry studies of hours worked per year by full-time and part-time work force.

Other SIMLAB tables designed to meet user specifications can be obtained through modification of the SIMLAB computer program. Tables 5.1 to 5.8 are illustrative of the possibilities.

SIMLAB Trail Run

SIMLAB user assumptions are inputted into the system as responses to a series of queries from the computer. This section explains the steps in the SIMLAB query sequence. Each query requires a response from the user. Responses may consist of a typed-in "yes" or "no" or an instruction for parameter modification as explained below. The discussion which follows illustrates and explains what can happen during a SIMLAB run. However, the exact sequence of events experienced by users will vary somewhat depending on user responses to queries from the computer.

Computer Hook-Up. SIMLAB users can access the computer via telephone using a portable teletype. After dialing, a tone signals the user to place the telephone handset in the holder located in the back of the

Table 5.8. PRODUCTIVITY INDICATORS OF SPECIFIED INDUSTRIES, CONTINUED
MINNESOTA, 1970 (continued)

INDUSTRY NO TITLE	TOTAL HOURS PER YEAR		OUTPUT PER WORKER		TOTAL OUTPUT
	PER WORKER	ALL WORKERS	PER HOUR	PER YEAR	
	(NO)	(THOU)	(NO)	(NO)	(THOU)
1 LIVESTOCK	2000.0	156638.0	13.47	26940.	2109900.
2 OTHER AG	2000.0	142750.0	7.96	15917.	1136100.
3 AG., FOR.,	2000.0	6596.0	7.65	15300.	50459.
4 IRON ORES	2000.0	26306.0	21.72	43449.	571488.
5 OTHER MET	2000.0	292.0	27.16	54329.	7932.
6 COPPER OR	2000.0	0	0	0	0
7 NON-METAL	2000.0	4394.0	15.31	30616.	67264.
8 CONSTRUCT	2000.0	156980.0	15.36	30720.	2411213.
9 ORDNANCE	2000.0	24820.0	22.90	45799.	568364.
10 FOOD AND	2000.0	50238.0	37.56	75112.	1886738.
11 MEAT PROD	2000.0	34700.0	49.88	99758.	1730800.
12 GRAIN MIL	2000.0	15822.0	47.95	95891.	758594.
13 BEVERAGES	2000.0	9404.0	32.76	65525.	308100.
14 APPAREL A	2000.0	22124.0	9.39	18785.	207800.
15 LOGGING	2000.0	3436.0	26.39	52776.	90670.
16 WOOD PROD	2000.0	18274.0	12.85	25691.	234737.
17 PAPER PRO	2000.0	62936.0	22.38	44761.	1408535.
18 PRINTING	2000.0	48346.0	13.41	26815.	648200.
19 CHEMICALS	2000.0	13198.0	34.56	69115.	456090.
20 PETROLEUM	2000.0	4064.0	67.25	134498.	273300.
21 RUBBER AN	2000.0	16358.0	29.99	59973.	490518.
22 STONE, CLA	2000.0	15912.0	14.50	29010.	230800.
23 PRIMARY I	2000.0	9196.0	17.04	34084.	156720.
24 PRIMARY C	2000.0	0	0	0	0
25 OTHER PRI	2000.0	5116.0	25.64	51282.	131180.
26 METAL FAB	2000.0	40854.0	16.99	33984.	694190.
27 MACHINERY	2000.0	129980.0	16.95	33896.	2202879.
28 ELECTRIC	2000.0	56764.0	14.84	29675.	842234.
29 MOTOR VEH	2000.0	9628.0	44.27	88533.	426200.
30 AIRCRAFT	2000.0	1012.0	20.02	40045.	20263.
31 OTHER TRA	2000.0	10666.0	18.89	37772.	201438.
32 INSTRUMEN	2000.0	28078.0	13.30	26597.	373400.
33 MISC. MAN	2000.0	14872.0	10.76	21511.	159956.
34 TRANSPORTA	2000.0	6496.0	12.26	24530.	79673.
35 RAIL TRAN	2000.0	40450.0	11.00	22010.	445152.
36 LOCAL TRA	2000.0	14536.0	7.40	14809.	107635.
37 TRUCK TRA	2000.0	39166.0	9.60	19199.	375980.
38 AIR TRANS	2000.0	15254.0	14.91	29829.	227505.
39 COMMUNICA	2000.0	34224.0	11.66	23327.	339168.
40 ELECTRICAL	2000.0	10806.0	31.05	62104.	335550.
41 GAS UTILI	2000.0	8534.0	33.09	66186.	282415.
42 WATER UTI	2000.0	6418.0	40.95	81906.	262836.
43 WHOLESALE	2000.0	186932.0	19.62	39237.	3667317.
44 RETAIL TR	2000.0	539862.0	6.52	13041.	3520113.
45 FINANCE,	2000.0	120044.0	10.04	20078.	1205108.
46 REAL ESTA	2000.0	20112.0	98.23	196465.	1975649.
47 HOTELS, LO	2000.0	81488.0	5.04	10077.	410588.
48 BUSINESS	2000.0	83294.0	11.26	22529.	938278.
49 CAR REPAI	2000.0	15960.0	22.42	44836.	357794.
50 AMUSEMENT	2000.0	26454.0	5.21	10415.	137735.
51 MEDICAL, E	2000.0	312494.0	4.33	8651.	1351716.
52 FEDERAL G	2000.0	34536.0	5.48	10950.	189085.
53 STATE AND	2000.0	53784.0	11.64	23270.	625777.
54 OTHER IND	2000.0	42564.0	5.26	10510.	223674.
55 OTHER GOVT	2000.0	403330.0	10.00	20000.	4033300.

WOULD YOU LIKE TO CHANGE PARAMETERS?
(YES OR NO)

Table 5.8 PRODUCTIVITY INDICATORS OF SPECIFIED INDUSTRIES
MINNESOTA , 1970 (concluded)

INDUSTRY	EMPLOYMENT	HOURS WORKED PER WEEK			WEEKS WORKED PER YEAR	
		REGULAR	OVERTIME	TOTAL	POTENTIAL	ACTUAL
		POTENTIAL	REPORTED			
NO	TITLE	(NO)	(NO)	(NO)	(NO)	(NO)
1	LIVESTOCK	78319.	40.00	0	0	0
2	OTHER AG	71375.	40.00	0	0	0
3	AG.,FOR.,	3298.	40.00	0	0	0
4	IRON ORES	13153.	40.00	0	0	0
5	OTHER MET	146.	40.00	0	0	0
6	COPPER OR	0	40.00	0	0	0
7	NON-METAL	2197.	40.00	0	0	0
8	CONSTRUCT	78490.	40.00	0	0	0
9	ORDNANCE	12410.	40.00	0	0	0
10	FOOD AND	25119.	40.00	0	0	0
11	MEAT PROU	17350.	40.00	0	0	0
12	GRAIN MIL	7911.	40.00	0	0	0
13	BEVERAGES	4702.	40.00	0	0	0
14	APPAREL A	11062.	40.00	0	0	0
15	LOGGING	1718.	40.00	0	0	0
16	WOOD PROU	9137.	40.00	0	0	0
17	PAPER PRO	31468.	40.00	0	0	0
18	PRINTING	24173.	40.00	0	0	0
19	CHEMICALS	6599.	40.00	0	0	0
20	PETROLEUM	2032.	40.00	0	0	0
21	RUBBER AN	8179.	40.00	0	0	0
22	STONE,CLA	7956.	40.00	0	0	0
23	PRIMARY I	4598.	40.00	0	0	0
24	PRIMARY C	0	40.00	0	0	0
25	OTHER PRI	2558.	40.00	0	0	0
26	METAL FAB	20427.	40.00	0	0	0
27	MACHINERY	64990.	40.00	0	0	0
28	ELECTRIC	28382.	40.00	0	0	0
29	MOTOR VEH	4814.	40.00	0	0	0
30	AIRCRAFT	506.	40.00	0	0	0
31	OTHER TRA	5333.	40.00	0	0	0
32	INSTRUMEN	14039.	40.00	0	0	0
33	MISC. MAN	7436.	40.00	0	0	0
34	TRANSPORTA	3248.	40.00	0	0	0
35	RAIL TRAN	20225.	40.00	0	0	0
36	LOCAL TRA	7268.	40.00	0	0	0
37	TRUCK TRA	19583.	40.00	0	0	0
38	AIR TRANS	7627.	40.00	0	0	0
39	COMMUNICA	17112.	40.00	0	0	0
40	ELECTRICA	5403.	40.00	0	0	0
41	GAS UTILI	4267.	40.00	0	0	0
42	WATER UTI	3209.	40.00	0	0	0
43	WHOLESALE	93466.	40.00	0	0	0
44	RETAIL TR	269931.	40.00	0	0	0
45	FINANCE,	60022.	40.00	0	0	0
46	REAL ESTA	10056.	40.00	0	0	0
47	HOTELS,LO	40744.	40.00	0	0	0
48	BUSINESS	41647.	40.00	0	0	0
49	CAR REPAI	7980.	40.00	0	0	0
50	AMUSEMENT	13227.	40.00	0	0	0
51	MEDICAL,E	156247.	40.00	0	0	0
52	FEDERAL G	17268.	40.00	0	0	0
53	STATE AND	26892.	40.00	0	0	0
54	OTHER IND	21282.	40.00	0	0	0
55	OTHER GOVT	201665.	40.00	0	0	0

teletype. This connects the teletype to the University of Minnesota computer. Users of a hardwired teletype must follow dialing instructions at the teletype site. The University Computer Center telephone number to be used depends on user affiliation and whether 30-character or 10-character print-cut is desired.

Computer Access. Once teletype hook-up is achieved, the user types in his account number, a password, and other information in order to call-up SIMLAB. This procedure will vary with the affiliation of the user and the current version of SIMLAB. Users obtain this information upon arranging to use SIMLAB.

User access to SIMLAB is limited to the interactive control module. There is no access to the underlying model or its program, except by special arrangement for a "future option" of SIMLAB as explained below. The user responds to queries from the control module with a "yes" or "no", except when following instructions for parameter modification as explained below. A typical encounter with SIMLAB may go more or less like the following one, depending on user responses.

"Do you want your output formatted for use on a teletype?"

Teletype users must answer yes unless they have arranged to dispose regular computer printout.

"Would you like to access the information module?"

Users will generally want to answer "yes" in order to review data already in SIMLAB and to have an opportunity for data modification. A positive response will automatically lead to the next question.

"Would you like to see a listing of parameters?"

A positive response will result in a printout of all SIMLAB variable and parameter names grouped according to the module they appear in as follows:

Market (Rest of Nation)^{43/}

1. U.S. Gross Output (USGO)
2. Regional Exports (REXPOR)
- *3. National Growth Rate (GROWTHR)
4. Regional Market Share (REGMKS)
- *5. Rate of Change in Regional Market Share (REGMSR)

Investment (Region)

6. Replacement Investment, Output Increasing (RINVC)
7. Expansion Investment, Output Increasing (INVC)
8. Replacement Investment, Pollution Abatement (RINPA)
9. Expansion Investment, Pollution Abatement (INVPA)
10. Output Increasing Capital (CCAP)
11. Pollution Abatement Capital (PACAP)
- *12. Output Increasing Capital/Output Ratio (CAPOUT)
- *13. Pollution Abatement Capital/Output Ratio (PCAPPOL)
- *14. Rate of Change for Capital/Output Ratio (CHCAPOUT)
- *15. Investment Limit on Net Business Income (INVLNC)
- *16. Investment Limit on Accumulated Net Business Income (INVLMA)
- *17. Investment Matrix (INVCO)

Demand (Region)

18. Business Inventory Change (BINCH)
19. Gross Private Capital Formation (GPCF)
20. Personal Consumption Expenditure (PCE)
21. State and Local Government Purchases (SGOVE)
22. Federal Government Purchases (FGOVE)
- *23. Exogenous Final Demand (No Symbol)

^{43/}

Asterisk(*) demotes parameter which can be modified by the user during the simulation run. Parameter modifications result in changed values during the run.

- 24. Total Final Demand by Sector (FD)
- 25. Rate of Change for Exogenous Final Demand (Consult SIMLAB Staff)
- *26. Rate of Change for State and Local Government Purchases Per Capita (RSGEMP)
- *27. Rate of Change for Federal Government Purchases Per Capita (RFCEMP)
- *28. Business Inventory/Output Ratio (INVOUT)
- 29. A variable to be included in a future SIMLAB
- *30. Personal Income Elasticity Coefficient (ELASIN)
- 31. A variable to be included in a future SIMLAB
- 32. A variable to be included in a future SIMLAB

Value Added (Region)

- *33. Value Added Rate (VAR)
- 34. Earnings (EARNINGS)
- 35. Earnings Per Worker (EARPWK)
- *36. Rate of Change in Earnings Per Worker (EARPWKR)
- 37. Employee Compensation (No Symbol)
- *38. Employee Compensation Rate (No Symbol)
- *39. Annual Percentage Change in Employee Compensation Rate (No Symbol)
- *40. Business Tax Rate (BTAXR)
- 41. Business Income (NBUSINC)
- 42. Accumulated Net Business Income (ACNBUSINC)
- *43. Annual Percentage Change in Business Tax Rate (CHBTAXR)
- 44. Regional Imports (IMPORT)
- *45. Regional Import Rate (REGIMPR)
- *46. Capital Depreciation Rate, Output-Increasing (DEPRCCA)
- *47. Capital Depreciation Rate, Pollution Abatement (CADEPA)
- 48. Maximum Income Available for Investment (No Symbol)
- 49. Total Personal Income (No Symbol)
- 50. Non-Resident Personal Consumption Expenditures (No Symbol)

- *51. Personal Income/Earnings Ratio (No Symbol)
- *52. Unemployment Compensation Rate (No Symbol)
- *53. Transfer Payments Rate (No Symbol)
- *54. Proprietorial Income Rate (No Symbol)
- *55. P.C.E. / Savings Ratio

Employment (Region)

- 56. Employment by Industry (EMPLOY)
- *57. Output Per Worker Ratio (OUTPWKR)
- *58. Output Per Hour Worked (OUTPHW)
- *59. Rate of Change in Output Per Worker Ratio
- *60. Hours Worked Per Week (HRWPW)
- *61. Rate of Change in Hours Worked Per Week (HRWPWR)
- *62. Hours Worked Per Year (HRWPY)
- *63. Weeks Worked Per Year (WKWPY)
- *64. Rate of Change in Weeks Worker Per Year (WKWPYR)
- 65. Employment Supplied by Occupation (EMPLOY)
- 66. Employment Demanded by Occupation (EMPLOYD)
- 67. Unemployment by Occupation (UNEMPLF)
- 68. Household Workers (No Symbol)
- *69. Household Workers/Population Ratio (No Symbol)
- *70. Rate of Change in Household Workers/Population Ratio (No Symbol)
- 71. Other State and Local Government Employment (No Symbol)
- *72. Other State and Local Government Employment/P.C.E. Ratio
- *73. Rate of Change in Other State & Local Government Employment/P.C.E. Ratio
- 74. Other Federal Civilian Government Employment (No Symbol)
- * 75. Other Federal Civilian Government Employment/Population Ratio
- * 76. Rate of Change in Other Federal Civilian Government Employment/
Population Ratio

- 77. Federal Military Employment (No Symbol)
- 78. Other Government and Household Workers Final Demand Distribution
- *79. Industry Occupation Matrix

Labor Force (Region)

- 80. Total Labor Force
- 81. Labor Force Distribution by Occupation (LBFOCUR in Base Year, LFOCCUP during simulation run)
- 82. Labor Force Age Distribution (LBFAGEG)
- *83. Labor Force Participation Rate Male (LFPARM)
- *84. Rate of Change in the Labor Force Participation Rate Male (LFPARMR)
- *85. Labor Force Participation Rate Female (LFPARF)
- *86. Rate of Change in the Labor Force Participation Rate Female (LFPARFF)

Population (Region)

- 87. Population by Age (Male) (POPM)
- 88. Population by Age (Female) (POPF)
- *89. Fertility Rate by Age (Female) (FERTILY)
- *90. Annual Change in Fertility Rate (ACFERTY)
- *91. Male/Female Birth Ratio (MFBIRTHR)
- *92. Death Rate by Age (Male) (DEATHRM)
- *93. Death Rate by Age (Female) (DEATHRF)
- *94. National Migration Distribution by Age and Sex (NMIGDIS)
- *95. Rate of Change in National Migration Distribution (NMIGDR)
- *96. National Employee Dependent Rate (NEMPDEPR)
- *97. Rate of Change in National Employee Dependent Rate (PCHNEMPDEPR)
- *98. Regional Migration Distribution by Age and Sex
- *99. Rate of Change in Regional Migration Distribution
- *100. Regional Employee Dependent Rate (EMPDEPR)
- *101. Rate of Change in Regional Employee Dependent Rate (PCHEMPDEPR)

- 102. Immigration/Employment Equilibrium Relationship by Occupation
- 103. Outmigration/Employment Equilibrium Relationship by Occupation
- 104. Immigration by Occupation (INMIGOC)
- 105. Outmigration by Occupation (OIMIGOC)
- 106. Incommuting (COMIN)
- *107. Incommuting/Immigration Ratio (COMINR)
- *108. Rate of Change in Incommuter/Immigration Ratio (RCOMINR)
- 109. Out-Commuting (COMOUT)
- *110. Out-Commuting/Outmigration Ratio (COMOUTR)
- 111. Rate of Change in Out-Commuting/Outmigration Ratio (RCOMOTR)
- *112. In/Out Male Cohort Movement by Age (\pm CONTMVM)
- *113. In/Out Female Cohort Movement by Age (\pm CORTMVF)

Production (Region)

- 114. Gross Regional Product (Current Year) (X_t)
- 115. Gross Regional Product (Previous Year) (X_{t-1})
- 116. Required Output of Final Demand (XD)
- 117. Output Constraint by Capital Stocks (XO)
- *118. Leontief (Inverse) Matrix $(I - A)^{-1}$

At the end of the parameter print-out, SIMLAB will ask,

"Would you like instructions for parameter changes?"

A positive response will result in printout of the following instructions for parameter changes:

Class A Class B

0 = END (END MODIFICATION OF THIS PARAMETER)

1,Z,X,Y = ADD AMOUNT Z TO SECTOR X,Y

2,X,Y,Z = REPLACE SECTOR X,Y WITH AMOUNT Z

3,X,Y,Z = CHANGE SECTOR X,Y BY Z PERCENT

4,Z,Y = ADD AMOUNT Z TO COLUMN Y TOTAL
 5,Y,Z = REPLACE COLUMN Y TOTAL WITH AMOUNT Z
 6,Y,Z = CHANGE COLUMN Y TOTAL BY Z PERCENT
 7 = STOP (PROGRAM TERMINATE)
 8 = PRINT (CURRENT PARAMETER PRINT OUT)

These instructions refer to the SIMLAB data base. See Table 5.9 for a sample data base. In the data base, variables are arranged by sector number or row number (denoted X) and column number (denoted Y). All users interactive variables and parameters are in the data base where they are labeled using the same notation appearing in Chapter 3 of this manual. SIMLAB users must have the correct data base in order to successfully modify parameters. Data bases can be obtained when arranging to use SIMLAB.

The next question is,

"Would you like to see a list of tables?"

A positive response and a comma, followed by typing in the numbers 1-9, each separated by a comma, will result in printout of the table titles. This is for reference in answering further questions.

"Would you like a list of the possible groupings of economic indicators that you can track?"

A positive response will result in printout of a list of truncated versions of the eight tables in the SIMLAB output. The user can monitor his simulation run by electing this option. At this point, a positive response only gets the list for reference.

At this point the information routine is exhausted and, the control module queries resume:

"Would you like to access future options of SIMLAB?"

Table 5.9. Computer Print-Out of Selected User-Modified Parameters in SIMLAB.

	EMPLOY (NO)	OUTPWK (B)	OUTPWKR (RATE) 1970-80	OUTPWKR (RATE) 1980-85	OUTPWKR (RATE) 1985-90	OUTPWKR (RATE) 1990-95	OUTPWKR (RATE) 95-2000
1	78319.	26940.	.078700	.050200	.051200	.051500	.051300
2	71375.	15917.	.079200	.055100	.055500	.055500	.055700
3	5298.	15300.	.015200	.029000	-.007200	.010500	.010900
4	13153.	43449.	.020000	.047400	.048800	.050400	.052300
5	146.	54329.	.062600	.051500	.050200	.051400	.052500
6	0	0	0	0	0	0	0
7	2197.	30616.	.057600	.041700	.041500	.040700	.039800
8	78490.	30720.	.048300	.019500	.019700	.020100	.020300
9	2240.	45799.	.024000	.015000	.015000	.015000	.015000
10	25119.	75112.	.027500	.025300	.025300	.025300	.025300
11	17350.	99758.	.027500	.025300	.025300	.025300	.025300
12	7911.	95891.	.027500	.025300	.025300	.025300	.025300
13	4702.	65525.	.027500	.025300	.025300	.025300	.025300
14	11062.	18785.	.029400	.028300	.027200	.029000	.028100
15	1718.	52776.	.048600	.044600	.044100	.043900	.044200
16	9137.	25631.	.028400	.029900	.029300	.028000	.027200
17	31468.	44761.	.026700	.024000	.024200	.024300	.024100
18	24173.	26815.	.034100	.022300	.022400	.022300	.022300
19	6599.	69115.	.053300	.043800	.040400	.040500	.040700
20	2032.	134498.	.024300	.022300	.022600	.022800	.023000
21	8179.	59973.	.048100	.042300	.042800	.042700	.042900
22	7956.	29010.	.025800	.021900	.022200	.022200	.022200
23	4598.	34084.	.043600	.023900	.024400	.024300	.024100
24	0	0	0	0	0	0	0
25	2558.	51282.	.049700	.035100	.035700	.035400	.035600
26	20427.	33984.	.030400	.019700	.017600	.015600	.019800
27	64990.	33890.	.054200	.028800	.029000	.029200	.029700
28	26382.	29675.	.052100	.038600	.038400	.038300	.038000
29	4614.	88533.	.017000	.031000	.031000	.031000	.031000
30	506.	40045.	.024000	.024000	.024000	.024000	.024000
31	5333.	37772.	.042000	.025000	.025000	.025000	.025000
32	14039.	26597.	.022000	.020000	.020000	.020000	.020000
33	7436.	21511.	.040000	.032000	.032000	.032000	.032000
34	3248.	24530.	.027200	.016400	.015900	.016500	.016000
35	20225.	22010.	.069300	.058300	.059100	.059200	.058000
36	7268.	14809.	.013100	.006000	.006100	.006000	.006000
37	19583.	19199.	.024500	.020900	.021300	.021100	.021200
38	7627.	29829.	.074400	.062400	.062600	.062700	.062900
39	17112.	23327.	.055900	.050600	.051000	.051100	.051300
40	5403.	62104.	.069000	.055000	.055400	.055400	.055100
41	4267.	66186.	.013200	.009500	.008600	.009900	.008100
42	3209.	81906.	.013300	.007200	.006400	.007800	.007200
43	93466.	39237.	.040000	.025200	.025300	.025300	.025300
44	269931.	13041.	.046800	.021200	.021200	.021300	.021100
45	60022.	20078.	.020000	.017400	.017100	.017100	.017100
46	10056.	196465.	.033300	.014500	.014100	.014000	.014000
47	40744.	10077.	.028100	.015200	.015400	.015200	.015100
48	41647.	22529.	.019300	-.000400	-.002000	-.002000	-.002000
49	7980.	44836.	.008700	.010600	.010100	.010300	.009900
50	13227.	10415.	.016800	.020900	.021300	.021300	.021300
51	156247.	8651.	.012400	0	0	0	0
52	17268.	10950.	0	0	0	0	0
53	26892.	23270.	.010000	0	0	0	0
54	21282.	10510.	.010000	0	0	0	0
55	201665.	784.	.025000	.025000	.025000	.025000	.025000

Users should make a positive response only if they have arranged for a special version of SIMLAB. Otherwise, there will be nothing to access. A negative response will suppress the following questions:

"Do you want to run SIMLAB for baseline tables?"

"Would you like to printout the XD calculation?"

"Would you like to print out PCEIMP?"

"Would you like to print out BUSINC?"

"Would you like to print out the GPCF calculations?"

"Would you like to use the exogenous final demand vector to make a special computation?"

"Would you like to make a special multiplication of a transposed Leontief matrix?"

"Would you like to exclude capital constraints?"

"Would you like to print out the demographics?"

"Would you like to print out the constraining and forecasted gross Outputs?"

"Would you like to see the population calculations?"

"Would you like to freeze earnings in declining industries rather than debt financing?"

These queries are intended for user specified problems. The user must pre-arrange their use so appropriate modifications to the control module and/or the underlying model can be made. The normal query sequence resumes with:

"What region would you like to simulate? Type in the number which represents that region"

A list of available regions is then printed out.

"File name?"

User must respond with a file name if he wants to preserve his SIMLAB output for later reference.

"Would you like to see the data base?"

At this point the user has selected the region of interest. A positive response to this question will result in data base printout. The user who wants to modify variables and parameters will almost certainly want to see the data base.

"What tables would you like to see?"

This question is redundant if the user has accessed the information module.

"How many years would you like to simulate?"

The user must type in a number.

"How often do you want to modify parameters?"

The user types in a number representing the number of years to his first parameter change only. He is given another opportunity to answer this question before the run resumes after the first parameter change is made, if he elects to continue the run as explained below.

SIMLAB will now run for the shortest period of time specified in response to the last two questions. The answers to both questions must be integers less than fifty representing calendar years; and the answer to the second question must be an integer smaller than the answer to the first question. If no parameter is to be modified, the answer to the second question is zero, typed in as 0. If this response is given, the SIMLAB run automatically commences.

After the run is complete, the user is presented with the following series of questions:

Year XXXX has been reached

Would you like to see the new data base? (yes or no)

no

Save new data base?

No

Continue run?

No

It has been a pleasure to play with you

Thank you, have a nice day

Stop

The "no" answers illustrated here have the effect of terminating the simulation run. Should the user want to save the data generated during simulation, he must have ready a file number to type in when asked for it. If the user chooses to continue the run, he will be asked for parameter modifications.

At any time, the user may abort the simulation run by typing in the alternative instructions:

TERMINATED

or STOP

The user types in

BYE

to log off.

The SIMLAB data base is modified using the parameter change instructions which SIMLAB will print out on command. These instructions are used to manipulate SIMLAB according to user wishes.

Upon gaining access to SIMLAB the user must first respond to the SIMLAB queries explained in Chapter 5. The query sequence can vary, depending on user responses. Provided the SIMLAB run is not terminated, the user is presented with the query, "What parameters do you want to modify?" This query is presented each time the user has pre-indicated

in response to the question "How often do you want to modify parameters?"

For example, suppose the user has responded to this question with the answer, "5", indicating that he wishes to modify parameters each five years, beginning with the base year.

SIMLAB then waits for instructions. For example, suppose the user wishes to modify the 1970 to 1980 rate of change in output per worker for the Construction sector which is sector 8. The user examines the data base until he locates the variable OUTPWKR. (The reader should now look for this parameter in the sample data base included with this appendix.)

This variable appears in the SIMLAB data base, which is segmented into blocks of data. The parameter change instructions (see, pp. 99) refer to these blocks. Thus, OUTPWKR occurs in a block with the variables EMPLOY and OUTPWKR. The rate of change in OUTPWKR for the construction industry for 1970-80 is variable number 57 (see the list of variables pp. 95-99). This variable occurs in column 3 of its particular data block. If the user wants to change this variable from its present value, which is .04830, to, say, .05001, the appropriate instruction is:

57, 2, 8, 3, .05001

The other parameter change instructions are implemented in the same way. After the parameter change instruction, the user must type in a zero (0) indicating that no further changes to variable 57 will be made. The user is then free to specify changes to another variable if he wishes. When all changes are complete, the user types in "yes" which indicates that the run is to continue until the next pre-selected stop.

SIMLAB users will quickly discover that laying out all query responses and parameter change instructions on paper before computer

hook-up is the best way to proceed since some mistakes will be avoided and computer costs reduced. Cost for a single SIMLAB run of 25 years may reach 30 dollars (1979) depending on the amount of paper used in printout. The print command (see page 99) is instruction number 8. Potential SIMLAB users should practice creating their simulation scenarios on paper using the sample data base included in this manual.