MODELING A REGIONAL ECONOMY

An Introduction to SIMLAB II

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INTRODUCTION

Purpose of Report

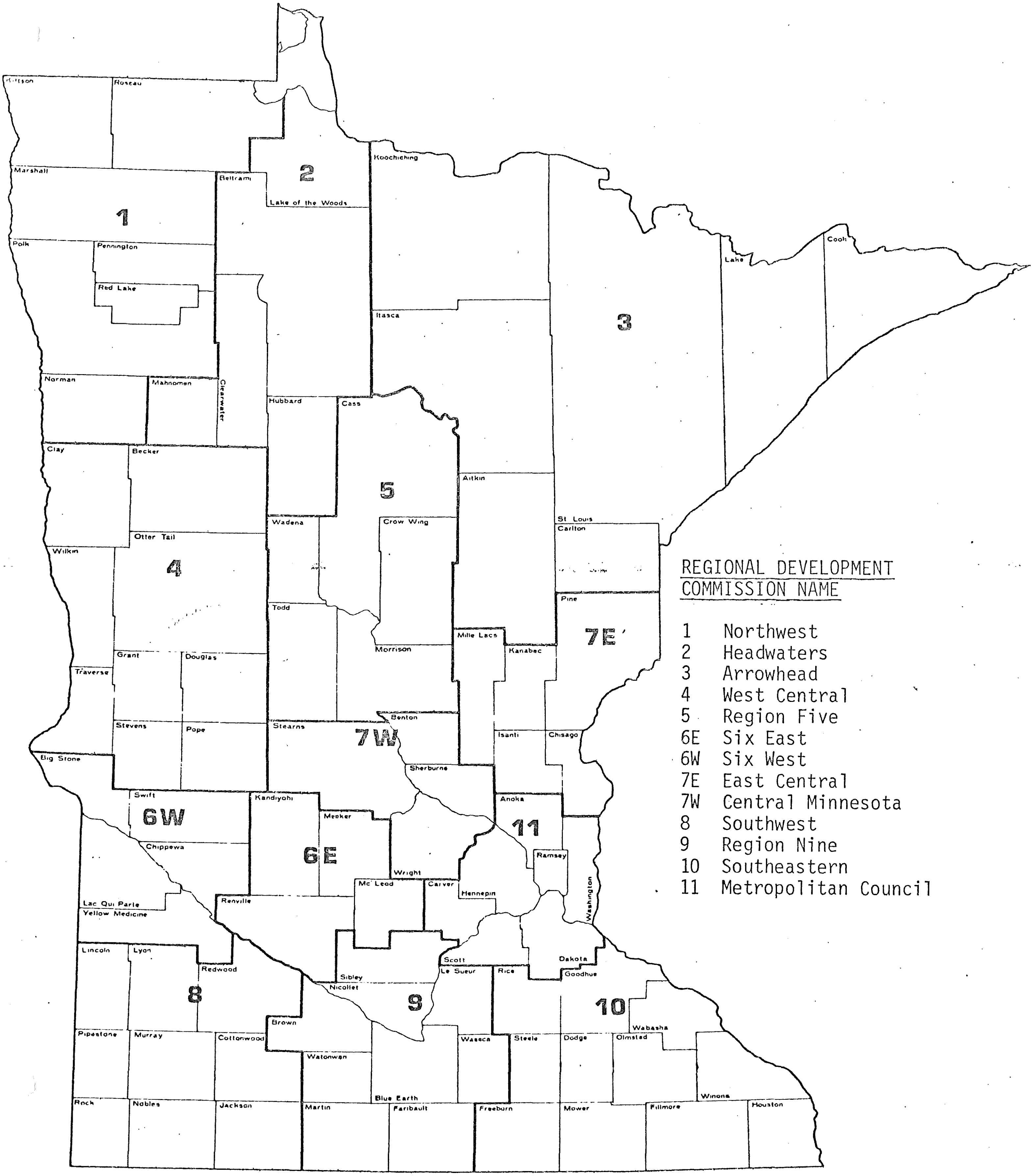
This report introduces the forecasting techniques used by the Minnesota Environmental Quality Board's Regional Copper-Nickel Study to explore the economic and demographic impacts of alternative futures reflecting varying degrees of copper-nickel mining development in northeastern Minnesota. The forecasting model used was developed by Dr. Wilbur Maki, Professor, Department of Agricultural and Applied Economics, University of Minnesota, and is called SIMLAB II (Simulation Laboratory II). SIMLAB II is presently operational for two multicounty regions plus the state as a whole. Future development plans include the modeling of each of Minnesota's thirteen development regions (Figure 1). Once modeled, the system will be made available to state planning agencies and the respective regional development commissions.

The Role of SIMLAB II in Impact Analysis

The role of SIMLAB II in the Regional Copper-Nickel Study is somewhat mechanical. The outcome of a particular forecast depends on the assumptions used in making that forecast. For example, the "baseline" forecast, against which we measure impacts, rests on the assumption that the historical relationship between the regional economy and the national economy continues. (For example, the relationship between a regional sector's gross output and the national sectors' gross output.) It is the task of the study team to develop realistic and/or potential changes in this relationship which would

MINNESOTA DEVELOPMENT REGIONS

(As of Sept. 30, 1974).



REGIONAL DEVELOPMENT COMMISSION NAME

1	Northwest
2	Headwaters
3	Arrowhead
4	West Central
5	Region Five
6E	Six East
6W	Six West
7E	East Central
7W	Central Minnesota
8	Southwest
9	Region Nine
10	Southeastern
11	Metropolitan Council

Figure 1.

alter the baseline conditions. This is referred to as developing alternative futures for the region. One could hypothesize the eventual decline in regional taconite mining and see how this would effect the region's economy. In addition, the study team must develop alternative copper-nickel mining scenarios to assess the impacts of such development. From a policy-making standpoint the important consideration is the ability to overlay these scenarios on the different alternative future forecasts to assess the impacts of copper-nickel mining under varying economic conditions. For example, a staged copper-nickel mining development of a particular scale would help offset the decline in employment resulting from taconite mining curtailment, resulting in a more stable employed work force. It is the study team's task to develop the assumptions and alternatives; SIMLAB II's role is to process them. One of the final reports generated by the study will develop this impact analysis.

Report Outline

Section one identifies the Regional Copper-Nickel Study area and the potential uses of regional forecasts. Section two will focus attention on the concepts and uses of simulation techniques in general, and its applicability to socioeconomic systems in particular. Section three discusses the modular approach to simulation model design, and an introduction to each SIMLAB II module. Section four identifies SIMLAB II data requirements, potential data sources, and explains procedures used in forecasting alternative development scenarios. Section five contains a summary and discusses future research potentials.

REGIONAL FORECASTING

Geographic Areas

In the past state agencies have often been accused of allowing local or regional socioeconomic impacts to be overshadowed by the larger state-wide impacts when considering policy alternatives. From the agency point of view this is understandable, and in many instances justifiable. This is not the case in the present study. The Copper-Nickel Study has the task of developing a regional socioeconomic impact analysis capability to assess the potential impacts associated with proposed copper-nickel mining activity in northeastern Minnesota.

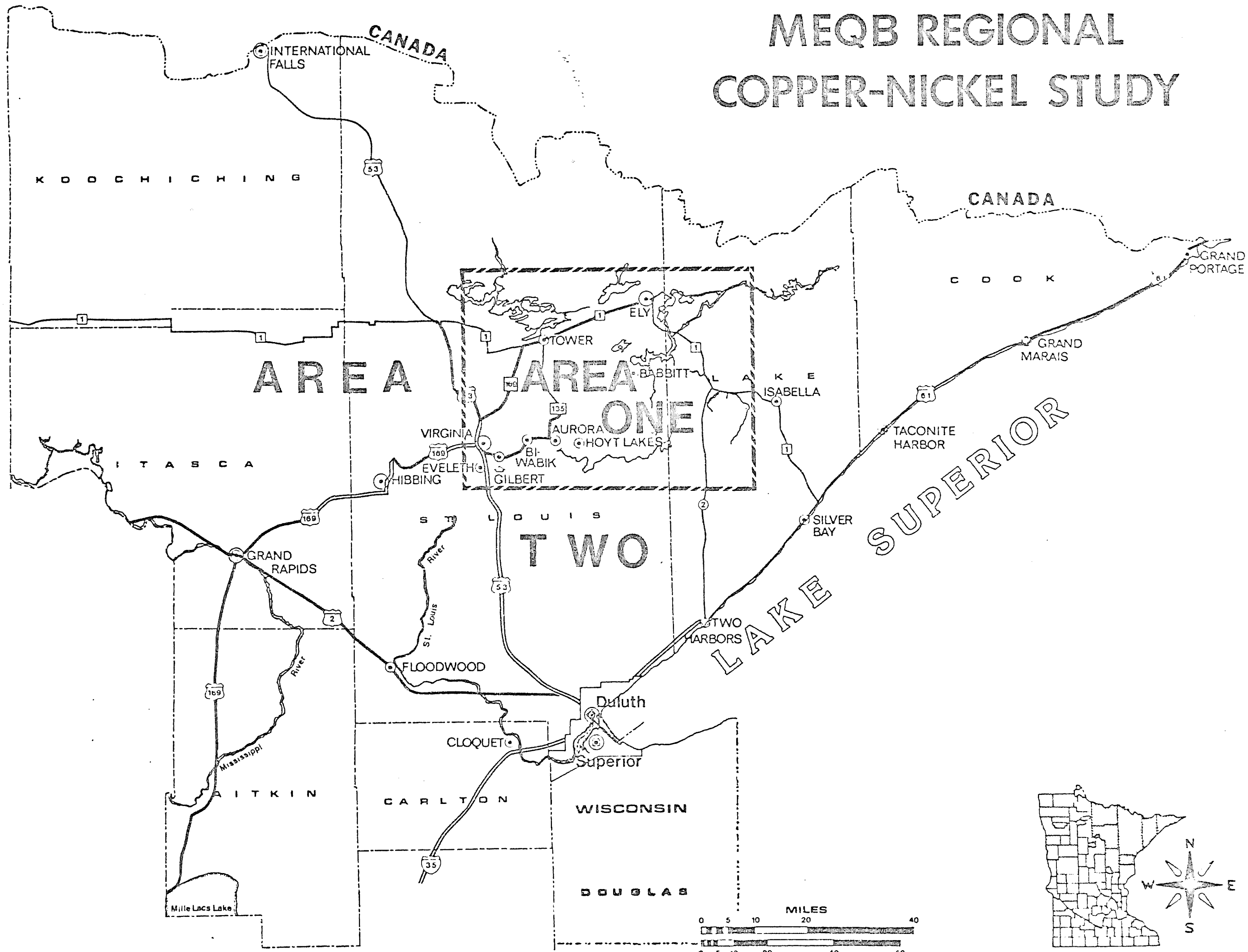
Two geographic areas have been identified for detailed analysis (Figure 2). The primary impact area, called "The Regional Copper-Nickel Study Area" (RCNSA), covers 2000 square miles and includes the following eight communities as areas of major emphasis:

1) Aurora
2) Babbitt
3) Biwabik
4) Ely
5) Eveleth
6) Gilbert
7) Hoyt Lakes
8) Virginia

Reasons for Regional Socioeconomic Forecasting

The primary rationale for selecting this area was the fact that Virginia and Ely are the two major East Range marketing areas, and the expectation that most settlement by construction employees and operations workers would occur in this area. Thus, the study area is bounded by the two communities.

Figure 2.


MEQB REGIONAL
COPPER-NICKEL STUDY
CANADA
INTERNATIONAL FALLS
KOOCHICHING
CANADA
COOK
GRAND PORTAGE
ELY
TOWER
AREA
AREA ONE
BABBITT
LAKE
ISABELLA
GRAND MARAIS
TACONITE HARBOR
VIRGINIA
AURORA
HOYT LAKES
BI-WABIK
EVELETH
GILBERT
HIBBING
ITASCA
LAKE SUPERIOR
SILVER BAY
ST LOUIS
TWO
GRAND RAPIDS
River
St. Louis
TWO HARBORS
FLOODWOOD
River
Duluth
CLOQUET
Superior
Mississippi
AITKIN
CARLTON
WISCONSIN
DOUGLAS
Mille Lacs Lake
MILES
0 5 10 20 40
0 5 10 20 40 60
KILOMETERS
N
W
E
S
KEY MAP

The secondary impact area is composed of Minnesota Economic Development Region III (Arrowhead) plus Douglas County in Wisconsin. This delineation was selected because the Copper-Nickel Study area falls within Region III, and Duluth, Minnesota is the major service center of the Arrowhead Region. Douglas County, Wisconsin, was included because of the importance of Superior, Wisconsin's port facilities and the possibility of siting a copper-nickel smelter in Douglas County.

Development of Minnesota's copper-nickel ore resources may significantly alter the economics of several northeastern communities. The massive influx of capital would create hundreds of new jobs. Initially, construction activity would attract many temporary migrants which could create a potential housing shortage. Eventually, these temporary workers would be replaced by permanent mining employees who have different housing needs and preferences as indicated by a study of coal mining development in North Dakota (Wieland, 1977). Construction and mining development payrolls would increase demand for locally produced goods and services. Such increases would provide additional business and employment opportunities. Concomitant demand for increased public services could severely strain existing facilities and capacities. Clearly, a systematic assessment of these and other socio-economic impacts is prudent and necessary.

Economic Development Tradeoffs

When state agencies are considering questions concerning economic growth and development, the tradeoffs associated with different development strategies should be a parameter examined prior to making decisions significantly affecting such growth and development. Faced with limited capital budgets, some desirable projects must be delayed or rejected. Thus, the impacts associated with a particular project should be compared to the impacts generated by other projects. Projections of project benefits like employment or regional income should be made to ensure that the agency is getting a "maximum" return on its spending. If, for example, the state was dedicated to increasing the well-being of a particular region, and had the option of promoting either a new forest products industry or building a new state park, the effects of each decision could be measured and compared. SIMLAB II was developed for this purpose. Namely, to assist decision-makers in their policy deliberations.

SIMLAB II has been selected by the Copper-Nickel Study group as the analytical tool needed to make such assessments. In order to isolate the various effects mining development would have on the impacted study area, "baseline" forecasts of relevant socioeconomic indicators must be made. Baseline forecasts are merely projections produced by the model in the absence of copper-nickel mining development. Phased construction and mining development scenarios are then introduced and the results are compared with the baseline forecasts to calculate the resultant impacts. Thus, the user can postulate an almost unlimited number of changes and isolate their impacts.

SIMULATION

Overview

Simulation makes possible predictions of how a system may behave in cases where experimentation on the system under study would be impossible. For example, the consequences of proposed economic development on a regional economy. Thus, to simulate is to duplicate the essence of the system or activity without actually attaining reality. Simulation itself is an approximation of reality, and the intent of simulation research is to reveal something about that reality. In the present case, what is needed is a systematic approach to identify and analyze those demographic and economic characteristics relevant to the study of a regional economy. A simulation consists of writing down, or otherwise agreeing upon, a set of realistic assertions. The realism of these assertions is established outside the simulating system itself (e.g. by actual observation or experience). The investigator then constructs a system which describes the simulation in mathematical terms (e.g. a mathematical model or computer program), and tests whether or not the system can predict the realistic assertions within the required degree of accuracy.

The term "simulation" is commonly used in business, economics, and other social sciences to refer to the operation of a numerical model that represents the structure of a dynamic process. Given initial values for the model parameters (variables which are specified in the model), a simulation is run to represent the behavior of the system over time. Thus, a simulation run is considered to be an experiment on the model, with the initial set of variables describing the state of the system at the beginning point in time. The results of the simulation are the values of the variables at the end of the time interval. The time period simulated can vary from one to several time periods (e.g. from one to twenty years) with the model using the results of preceding time periods as input values for successive time periods. This process is sometimes referred to as "recursive iteration," or "recurrence modeling."

There has been an increasing awareness that business and economic problems must be looked at in terms of the total economy with all the attendant interactions between the parts, and simulation offers an excellent tool for analytical purposes. Decisions and policies must be evaluated on the basis of their impact on the immediate behavior of the economy and their long run consequences on more remote parts of the economy. Thus, it is necessary to consider not only the actions in one part of the economic system, but also reactions of other components in the system.

Simulation in Economic Analysis

Economists have long sought ways of modeling the dynamic behavior of economic systems over time. Simulation is an ideal tool for long-range economic analysis. It not only allows the analyst the ability to determine the long-run state of the system, but also to analyze the time path through which the system travels to reach the final state. Economists have found it useful to distinguish between macro models (which deal with whole systems) and micro models (which deal with the behavior of individual units). Typical macro models include those which employ large econometric models of the U.S. economy, usually designed to forecase aggregate, or total Gross National Product (GNP). Alternatively, micro models attempt to forecast the gross output of various industrial sectors and then aggregate them to derive total GNP. This approach has been justified by the following:

> Predictions about aggregates are needed, but they should be obtained by aggregating behavior of elemental units rather than by attempting to aggregate behavioral relationships of these elemental units. That is, aggregates should be obtained from a simulation of the real system in a fashion analogous to the way a census or survey obtains aggregates relating to real socioeconomic systems. Given a satisfactory simulation

> of the socioeconomic system developed in terms of the elemental decision-making units, aggregation of relationships would become more nearly feasible. Such aggregation would be interesting and useful, but it would no longer be a necessity (Oncutt, 1961).

This process, of course, is the expressed forté of SIMLAB II.

SIMLAB II has been referred to as a simulation model. A model is simply a constructed expression of a theory or hypothesis. By constructed we mean they do not appear naturally, rather, they are the creation of man. For example, the model airplane "flown" in a wind tunnel is an expression of the theory of flight. A model of the behavior of a firm is, likewise, an expression of the economic theory of the firm. Simulation models are just a special subset of models. They exhibit certain properties in addition to all the characteristics of general models. A simulation model has the following properties:

1) It is intended to represent all or part of a system.

2) It can be executed or manipulated.

3) Time or a count of repetitions is one of the variables (i.e. the system is simulated over time).

4) Its purpose is to aid understanding of the system being simulated which means one or more of the following:
   a) it is a description of the system
   b) its use attempts to explain past behavior of the system
   c) its use attempts to predict future behavior of the system
   d) its use attempts to teach the existing theory by which the system can be understood.

As stated earlier, the purpose of economic simulation models is to aid in our understanding of the economy in which we are interested. Understanding means we can identify the important inter-relationships within the economy, and determine how variables in the economy react to changes. The ultimate test of understanding is our ability to predict future behavior of the system. If we can accurately predict its behavior, we may then be in a position to control or influence the economy to meet some predetermined set of goals. Thus, the purpose of using a simulation model such as SIMLAB II for socioeconomic forecasting of a regional economy is to aid in our understanding of the region and to aid in the development of regional policies.

There are several terms which are used by analysts who build and use simulation models. First, we define a "run" of the simulation as cycling through the operations of the model for a measureable amount of time. Next we define a "parameter" of the model as a number or symbol that remains constant during a run of the simulation (e.g. the fertility rate by age). Parameters are often called "variable constants," since they can be changed from run to run. Parameters are normally input constants. That is, they are specified by the user at the beginning of the simulation run.

Finally, we define a "variable" as an entity which can take on different values during a single simulation run. Two types of variables are used in simulation models. Input variables (which are often called exogeneous variables) are external to the model (e.g. the regional market share of an industry). That is, they must be changed by the user. Generated variables (endogeneous), on the other hand, take on values which arise as a consequence of the operations of the model (e.g. total population). These generated variables are usually the most interesting to analysts or users. Once the operations, parameters, and input variables are specified, experimentations with the model can take place. This usually consists of executing successive runs of the simulation model, changing values for the parameters or input variables between runs, and comparing the resulting values of the generated variables. Thus, the "impacts" on generated variables can be assessed for any given change in value of a parameter or input variable. Since we cannot experiment on the actual system, we can use a simulation model of the system to identify "important" parameters and exogeneous variables (in the sense that changes in their values cause significant impacts on endogeneous variables) in the system using a technique called "sensitivity analysis." Sensitivity analysis is simply comparing the results of different simulation runs having changed the value of a particular parameter or input variable, and identify those parameters which cause the greatest or most significant change on the modeling results.

SIMLAB II is a sophisticated general purpose regional socioeconomic simulation model which offers the user great experimental latitude. It enables the user to do very detailed sensitivity analysis on a specified region. SIMLAB's input requirements are demanding to say the least, however, once specified the model exhibits several highly desirable features. First, it is a user-oriented model. The program asks questions about the parameters and input values, and the user must respond. This allows the user to easily manipulate the many input variable and parameter values. Secondly, SIMLAB is a decision-oriented model. It allows the user to quickly assess the impacts on various outputs (generated variables) of the model which result from initial changes. For example, the model would indicate the change in total employment attributable to the establishment of a new mining venture in the region. Thirdly, SIMLAB allows the user to assess the impacts of alternative development scenarios. That is, the user can specify a certain development scenario (e.g. phased construction and operation of the new mining venture), then manipulate the timing or intensity of the development and compare the total impacts. Clearly, SIMLAB II is a very flexible, versatile tool for socioeconomic impact forecasting.

SIMLAB II

Modular Approach

An essential ingredient of a practical and successful simulation model is a clear and precise focus on purpose. Since SIMLAB II is a general purpose simulation model it must be adapted or modified in such a way as to make it issue specific. In the present case the express purpose of the study is to identify and analyze the economic and demographic impacts of alternative copper-nickel development strategies in northeastern Minnesota. This purpose is noted here because much of the following discussion will relate or refer directly to this research effort. Any decision, when implemented, impinges upon and changes the future state of reality from what it would be if alternative actions had taken place. Truth, in decision making, lies in the future and is beyond the grasp of present perception. Thus, the perceived outcome of present actions is a function of the confidence one has in the simulation model employed in predicting future behavior of the system. For many systems confidence is high, while in others confidence is lower. This is directly related to our understanding of the system under consideration. When systems are complex, which is the case in a study of regional socioeconomic activity, it is often more prudent to subdivide the system into several inter-related components. This, in effect, simplifies the modeling procedure by enabling the analyst to isolate sections of the system and building separate models for each section. To complete the model the analyst must then specify how the subsections "fit" together and develop a control module to manipulate the model as a whole. In essence, the control module "directs" the flow of information within the model. That is, it links the different sectors to each other when the output or result from one sector is an input or requirement of another sector. For example, the labor force module in SIMLAB II requires as an input the age/sex population distribution from the population module. Similarly, the employment module requires information from both the production module and the labor force module. While each module stands alone in the sense that it is internally consistent with existing theory, the modules are linked together to form a broader dynamic socioeconomic model.

SIMLAB II utilizes the control module to execute the simulation model computer program. As noted above, the control module directs the flow of information through the simulation. The modular approach was selected for two reasons: 1) because it facilitates understanding of the model itself (i.e. it attempts to simplify the total model); and 2) it enables future development to be easily adopted. For example, a tax module which analyzes the financing and delivery of local government service could be readily incorporated into the existing model framework. The remainder of this section will focus on a discussion of each of the nine modules, identifying their major data input requirements, how they are linked to other modules and their relative importance to the total model, and finally the major assumptions underlying the theory each module attempts to model.

Economic activity is defined as the process of producing and consuming goods and services. In the absence of human wants (or needs) the concept of economic activity would be irrelevant. It is precisely this demand by people which calls forth the production of consumer goods and services. As will be seen shortly, the production module "drives" the socioeconomic system we are seeking to model, and herein lies the heart of SIMLAB II.

Regional economists have long recognized the role exports play in supporting the economic activity within a region (Tiebout, 1956). Exports of goods and services represent sales to consumers outside the region (or tourists visiting the region). The revenue generated by this export production enables workers residing in the region to purchase locally produced goods and services. These purchases in turn provide employment opportunities and further spending within the region. Thus, the first task is to identify these various transactions. This is accomplished by utilizing an accounting framework called Input-Output Analysis (I-O). Development of the framework is attributed to Nobel Prize Winner, Wassily Leontief (1951). Basically, Input-Output Analysis (hereafter referred to as Interindustry Transactions) identifies the purchases and sales of homogeneous sectors within the economy. These purchases (and hence sales) represent the input structure of the producing sectors. Economists generally refer to these purchasing patterns as "production functions." Production functions represent the input requirements for an industry enabling that industry to produce its output products. For example, one important input to the automobile industry is sheet metal. In the interindustry transaction table (a table that records purchases and sales between all sectors), this would be represented by a purchase by the automobile industry from (and hence a sale by) the fabricated metals industry. Once we have identified all these interindustry purchases we can begin to analyze the impacts on all industries which result from the expansion of output from any given industry. These impacts are divided into primary and secondary impacts. Primary or direct impacts represent the direct purchases of the producing industry. Secondary or indirect impacts refer to the increase in output required from industries who supply inputs to those sectors directly supplying the producing industry. In the case of an expansion in the automobile industry, increased demand for sheet metal would represent a direct impact, while increased demand for iron ore mining (an input for sheet metal producers) represents an indirect impact. The total impact of increased production is derived by utilizing a mathematical technique called the "Leontiff Inverse" and is often referred to as the industry "multiplier." This multiplier measures the total impact of expanding the output of any given industry to meet the increased demand of final users.

Thus, the initial task is to produce, for the region, an interindustry transaction table which represents the transactions which take place between firms <u>within the region</u>. This point is important since it is only purchases and sales among firms within the region which give rise to multiplier effects. Purchases made from outside the region (imports) represent "leakages" within the economy. That is, it is money which escapes the local economy.

Regional Input-Output Transaction Table Development

Regional interindustry transaction tables can be constructed from either primary or secondary data sources. Primary data collection represents a considerable expenditure of time and money. After identifying the sector classification system to be used (i.e. assigning regional firms to producing sectors) a sample of firms from each sector must be contacted. Purchases and sales data must be collected and analyzed and a sector production function developed. Because of the sizable costs involved in primary collection, techniques which utilize secondary (or limited primary) data have been developed which utilize published U.S. transactions data to derive a regional transaction table (Hwang, 1976). Two critical assumptions must be adopted when using these techniques. First, we assume that the purchasing pattern of sector firms within the region are the same as sector firms in the U.S. as a whole (i.e. their production function is the same). Secondly, we assume that if an input requirement is produced locally it will be purchased locally. This assumption rests on the proposition that the producing industry will buy from the least cost seller, and since local producers would have a comparative price advantage (lower transportation costs), the buyer would purchase the input locally.

In addition to the U.S. transaction table we need estimates of total regional gross output by sector and estimates of final demand (that portion of output purchased by final users, i.e. households and government). Once we know the amount of output produced we can derive the level of inputs necessary to produce that output (from the first assumption above). If input requirements can be met from local sources they will be satisfied locally (second assumption). If the gross output of a firm exceeds the amount required locally the residual is assumed to be exported out of the region. This distribution of gross output results in the derivation of a regional interindustry transactions table, which is, of course, the heart of the production module.

Introduction to SIMLAB II Modules

SIMLAB II, as presently constructed, consists of the following nine modules:

1) Production
2) Market
3) Demand
4) Investment
5) Population
6) Labor Force
7) Employment
8) Value Added
9) Household

In addition, the model has the control module discussed above. While each module can stand apart, it is the interaction between the modules which produces our regional socioeconomic forecasts. Each of the specified modules and how they interact will be discussed below.

Production Module--The derived interindustry transaction table identifies the economic linkages which exist between firms within the region. These linkages, or endogeneous transactions, are assumed to hold over time and level of output. That is, the purchasing pattern of a given sector remains constant, and an increase (or decrease) in output production results in a corresponding proportional increase (or decrease) in purchases from all other sectors (referred to as a "linear" production). While this "static" nature of the economic system has been criticized it remains tenable at least in the short run. The user, however, does have an option. In light of superior information, he can adjust the production function in the original transaction table and produce a new set of relationships. This is representative of the strength of SIMLAB II. That is, the ability to quickly and easily modify the program parameters or variables.

Once these technical relationships have been specified the production module is linked to national markets via the market module (see following discussion) which calculates the "regional market share" of each sector, which represents the sectors' share of U.S. production. In addition, a percentage change in regional market share is calculated using historical time series data and trend analysis. Together, these translate into future regional industry exports when linked to independent projections of U.S. gross output by sector. Thus, there is a critical link established between the regional economy and the national economy as a whole. The remaining components of final demand (see following discussion) or demand for locally produced outputs are internally derived and taken as a whole, "drive"the production module.

There are, however, constraints within the model which could prevent the attainment of demanded gross output. First, there is an output-increasing capacity limit. If gross output demanded exceeds the region's ability to produce because of insufficient plant and equipment investment in new capital must be undertaken. The production module, however, recognizes that there is a limit on the amount of new plant capacity which can be installed in a given time period. In addition, environmental constraints require some industries to include investment in pollution abatement equipment which also limits the amount of new output-capacity expansion which can be undertaken. The third and final production constraint recognizes the potential absence of skilled labor inputs. If the resident labor force is insufficient to meet industry labor requirements, and this deficiency cannot be overcome through in-commuting, gross output demanded will not be realized. The relevant output of the production module is, therefore, realized gross output by industrial sector.

Market Module--In an open economy (where trade is an important proportion of total economic activity) the viability of a region is heavily dependent upon its export base. Regions, however delineated, inside the U.S. are considered open economies and must, therefore, engage in trade in order to survive. The money generated by regional export sales goes to pay for imports of raw materials or semifinished goods. Wages paid to employees in the export industries enable local households to purchase goods and services produced locally (as well as imports of finished goods). The market module is used to link the regional economy to the national economy by comparing regional production by industrial sector to national production by that sector. This comparison yields a "regional market share" for each regional industry. Together with an estimate of how that market share changes over time (i.e. annual percentage change in regional market share), and independent projections of U.S. gross output by sector, demand (by the rest of the nation) for regional production can be derived. This derived demand by sector represents the projected export column in the table of final demands. This table is the subject of the next module.

Demand Module--Producers of goods and services in a competitive free market economy respond to the desires of final consumers. Without demand for its output the firm or industry will not survive.

The demand module provides the entries necessary to complete the final demand table referred to in the production module. In addition to producing goods and services for export markets, regional production also satisfies intra-regional demands of final consumers. Final consumers are defined here as the final user of the product or service. That is, the final consumer does not purchase the product for further processing, but rather represents the end use of a product. Final users are generally classified as household consumer (or personal consumption expenditures, PCE), state and local governments, federal government, and business (private fixed capital formation, PFCF). The business sector contributes to final demand in two ways. First, a column representing net inventory change which represents business investment in inventory. These are goods produced but not yet delivered to one of the other final users. It is the difference between current production (gross output) and net deliveries (net sales) for each producing sector. The second business final demand column represents business investment in new or replacement plant and equipment, commonly called private capital formation. These entries are derived in a separate investment module (see following discussion). Personal consumption expenditures represent purchases by households for current use. The level of household expenditures depends on a lagged relationship between consumption in the previous period and personal income in the present period. The distribution of purchases to producing industries is accomplished using information on consumer purchases published by the U.S. Department of Labor and the U.S. Census Bureau. State and local government expenditures are similarly derived utilizing nationally prepared distributions of purchase to producing sectors. The level of expenditures is also based on a lagged relationship between historic per capita expenditures and current government revenue (which is based on personal and business taxes and payments). Another component of final demand is federal government expenditures. Federal expenditures are considered independent (or exogeneous) to the regional economy, and the level of regional expenditures is based on an estimate of previous per capita federal government expenditures and annual rates of change in per capita expenditures. Again, the distribution of purchases to producing industries is based on published federal sources (i.e. Bureau of Economic Analysis). A much more comprehensive fiscal (government) module is presently being developed and will be incorporated into SIMLAB II.

The last component of final demand is the business investment referred to above. The next section will cover the derivation of this column in more detail. The result of the foregoing analysis is final demand table. It represents the sales made by each producing sector to each final user. This final demand table (or matrix as it is often called) is used in the production module to determine the gross output demanded from each producing sector in the regional economy (and coincidentally regional exports and imports). The reader is reminded here that output demanded need not be output realized. Constraints within the production module (referred to elsewhere) are applied to determine the actual (realized) gross output produced. We now turn our attention to the investment module.

Investment Module--In order for a firm to maintain its productive capacity it must continually replace worn-out plant and equipment. To increase its capacity the firm must usually add to existing plant and equipment. This "investment" in capital (producing) goods is accounted for in the investment module. As noted above, investment is a component of final demand and is a column of transactions which represents sales of capital goods to business users. There are four types of investment in the investment module. The first type is replacement capital, and the assumption adopted is that firms will purchase enough capital goods to maintain present capacity. That is, purchases will at least equal current depreciation.

In addition, if demand for its output increases firms will attempt to purchase new plant and equipment for expansion of capacity, which is the second type of investment. Investment in pollution abatement capital is isolated in SIMLAB II and constitutes the third and fourth types of investment. Again, investment in pollution abatement equipment will be at least sufficient to maintain present output capacity. If output increasing capital is purchased a corresponding amount of investment in new pollution abatement capital is necessary. Capital producing sectors are identified according to the classification system adopted, and total investment is allocated to the relevant sectors using a capital requirements matrix and, as indicated above, represent sales by capital-producing sectors to final demand.

Population Module--The dynamics of regional population change requires considerable interaction with the production module. This interaction is necessary to calculate the migration component of the population module. Initially, the standard cohort survival technique is employed to calculate the natural increase in regional population. Thus, population at the beginning of the time period depends on the previous initial population, plus births during the interval minus deaths during the interval. Births are calculated by applying fertility rates developed by the State Demographer. Deaths are calculated by applying standard actuarial tables to each cohort (age/sex group). The migration component of the population module is perhaps the most difficult to forecast. There are many reasons why people move which cannot effectively be modeled (e.g. to be closer to relatives). Thus, the assumptions which underlie the migration component are the most tenable. SIMLAB II assumes that migration is associated with employment opportunities.

If unemployment in the region exceeds a specified level out-migration will occur. Alternatively, if unemployment is low, representing a deficiency in the supply of labor, in-migration will occur.

The upper and lower unemployment bounds which "trigger" this migration are subjective and depend on the region under study as well as the national rate of unemployment. The model user is asked to specify these bounds prior to the simulation run. This demand for labor services (employment) is directly tied to demand for regional production. Final demand determines the output level required by each sector. This output level requires labor inputs which are specified by the industries' occupational profile and output per worker ratios. These labor requirements, by occupation, are used by the labor force module which in turn determines the level of employment (and unemployment). The population module then uses this information to calculate the migration component of population change. Thus, it can be seen that considerable interaction between several modules must occur before population change can be determined.

<u>Labor Force Module</u>--The primary function of the labor force module is to calculate the available supply of regional labor by occupation class. The production module can then draw on this labor pool to satisfy its demand for labor. The initial labor force and occupational structure are identified using existing secondary data (census of population) supplemented by primary data sources where available. In the Copper-Nickel Study a comprehensive household survey was conducted. Labor force participation rates are calculated for each age/sex cohort. The number of individuals in the residential labor force are then derived by applying these rates to the residential population. Since labor force participation rates are

sometimes highly volatile, the model allows easy access to the labor force module to change these rates when supplemental information suggests adjustments are necessary. Estimates of out-commuting workers reduce the available local labor supply while in-commuters add to the pool. Once the available labor force is identified (by occupation class), it is matched with the labor demand schedule generated by the production module. If the supply of a particular occupation class is greater than the demand for that class, the excess is assigned to an unemployment submodule. If the supply of an occupation class is insufficient the deficiency is assigned to the unemployment submodule as a negative entry. This unemployment submodule is then used to select the occupation of migrants. For example, if the unemployment rate for a given occupation exceeds a specified level some members of that occupation class will migrate out of the region. Alternatively, if there is an insufficient number of workers in the available labor force (negative entries) this demand will be met during succeeding time periods through additional in-commuting and in-migration. Thus, the overall model allows for adjustments in the occupational profile of the residential labor force toward some equilibrium (i.e. trigger rates selected by the user). These values are then utilized by the population module to determine future population changes.

Employment Module--The employment module links the production module with the labor force module via an estimate of output per worker for each producing sector. In addition, an industry profile matrix is used to estimate the required number of workers by broad occupational categories for each sector. The occupational requirements of each sector are then summed and compared with the residential labor pool. If, after allowing for commuting and limited migration, the necessary workers are not available, gross output is constrained (this is the labor constraint alluded to in the production module). The employment module allows for reduced labor requirements over time by applying Bureau of Labor Statistics increases in labor productivity. The occupational profile for each industry, however, remains constant. Earnings per worker are also calculated by applying the productivity increases to the industry wage bill. This assumes that wage increases parallel productivity gains. The earnings per worker calculations are used in the value added module which is used to distribute business income.

Value Added Module--Value added refers to that portion of the value of a product which is attributed to the producing (selling) industry. For example, a bakery will purchase flour and other ingredients to produce bread, which it then sells to final consumers. The difference between what the bakery paid for the necessary inputs and the selling price is referred to as the "value added." Raw materials may pass through several stages of production with each successive stage contributing some value added. Ultimately, the cost of production inputs (materials) plus the value added must equal the selling price, which final users must pay. This value added must then be allocated to various categories which is the function of the value added module.

The value added module calculates employee compensation (wages, salaries, and fringe benefits) plus proprietory income (earning of self-employed persons). Indirect taxes are related to gross output and historical trends in tax rates. Depreciation of capital, both production and pollution abatement, is calculated (and used as an input to the investment module).

Business profit is the residual of gross output minus employee compensation minus indirect taxes minus depreciation and minus imports (which are calculated in the production module). Imports being production input requirements which are not locally available. Total personal income is then adjusted for governmental transfer payments and income derived from other sources (e.g. stock dividends) to equal published Bureau of Economic Analysis Regional Economic Information System Control totals. This total income figure is then distributed to households in the ninth and final module.

Household Module--Personal consumption expenditures are derived on a household basis, which means it is necessary to allocate regional population to household formations. Based on census data and primary data sources (i.e. the Copper-Nickel Study household survey), the number of consumer units (people) per household are derived by occupation and income class (which is based on occupation). Personal consumption expenditures are derived for each household income class and is used in the demand module as a component of future final demand. Income taxes and indirect taxes (i.e. sales tax) are also derived with personal savings being the residual. These outputs will be used in the fiscal module currently being developed.

LOADING SIMLAB II

Data Base Requirements

In order to produce baseline forecasts for a region SIMLAB II must be "loaded" with certain data elements which are specified by the model. While some SIMLAB parameters are already specified based on national or state data (e.g. industry capital/output ratios, or age cohort fertility rates) these may be readily modified by the user where regional conditions suggest these values are significantly different. Table 1 lists the input data requirements, and Table 2 lists the Copper-Nickel Study Industrial Classification System. Once specified, baseline forecasts are made for the following indicators (by year).

1) Population by age/sex cohort (14 cohorts).
2) Residential labor force by age/sex cohort (6 cohorts).
3) Employment by industrial sector and occupation.
4) Personal income per capita.
5) Gross output by industrial sector.
6) Value of exports by industrial sector.
7) Value added by industrial sector.

Table 1. SIMLAB data base.

1) Population, by age (1 to 65 and over) and sex.
2) Migration probability, by age and sex.
3) Death rate, by age and sex.
4) Fertility rate, per 1000 females.
5) Labor force participation rate, by sex and age group.
6) Total unemployment data, by occupation.
7) Total employment, by industry.
8) Total gross output, by industry.
9) Total output per worker, by industry.
10) Rate of change in output per worker, by industry.
11) Total (U.S.) gross output, by industry.
12) Regional market share, by industry.
13) Rate of change in regional market share, by industry.
14) Total (U.S.) growth rate, by industry.
15) Total regional final demand, by industry.
    - 15.1 personal consumption expenditure
    - 15.2 gross private capital formation
    - 15.3 business inventory change
    - 15.4 export (to rest of nation)
    - 15.5 state and local government expenditure
    - 15.6 federal government expenditure
16) Earnings per worker, by industry.

Table 1. (contd.)

17) Rate of change in earnings per worker, by industry.

18) Income elasticity of demand, by industry.

19) Own-price elasticity of demand, by industry.

20) Output producing capital, by industry.

21) Output-increasing capital-output ratio, by industry.

22) Expansion investment, output-increasing, by industry.

23) Replacement investment, output-producing, by industry.

24) Rate of change in output-increasing capital-output ratio, by industry.

25) Depreciation rate, output-producing capital, by industry.

26) Pollution Abatement capital, by industry.

27) Pollution abatement capital-output ratio, by industry.

28) Expansion investment, pollution abatement, by industry.

29) Replacement investment, pollution abatement, by industry.

30) Rate of change in pollution abatement capital-output ratio, by industry.

31) Depreciation rate, pollution abatement capital, by industry.

32) Total primary input, by industry.

    32.1 employee compensation
    32.2 imports
    32.3 other value added

33) Employee compensation-output ratio, by industry.

34) Rate of change in employee compensation-output ratio, by industry.

35) Regional import-output ratio, by industry.

36) Business income, by industry.

37) Indirect tax-output ratio, by industry.

38) Rate of change in indirect tax-output ratio, by industry.

39) Inverse matrix.

40) Miscellaneous data.

Table 2. Sector classification system, Copper-Nickel Study.

SECTOR NUMBER	SECTOR NAME	1972 SIC CODE
	<u>Agriculture, Forestry, Fisheries</u>	
1	All Agricultural, Forestry and Fishery Products and Services	01,02,07-09
	<u>Mining and Construction</u>	
2	Iron and Ferro Alloy Ores	101,106
3	Copper Ore Mining	102
4	Other Nonferrous Metal Mining	103,104,105,108,109
5	All Other Mining and Quarrying	11,12,13,14
6	Construction	15,16,17
	<u>Manufacturing</u>	
7	Timber Operations and Sawmills	241,242
8	Food and Kindred Products	20,21
9	Other Lumber and Furniture	243-249,25
10	Paper and Allied Products	26
11	Printing, Publishing, and Allied Industries	27
12	Chemical and Allied Products	28
13	Petroleum Refining and Related Industries	29
14	Stone, Clay, Glass, and Concrete Products	32
15	Primary Smelting and Refining of Copper	3331
16	Primary production of Aluminum	3334
17	Other Primary Metal Industries	331,332,333 (except 3331 & 3334),334,336,339
18	Rolling, Drawing, and Extruding of Copper	3351
19	Rolling, Drawing, and Extruding of Aluminum	3353,3354,3355
20	Rolling, Drawing, and Extruding of Nonferrous Metals	3356,3357
21	Fabricated Metal Products	34
22	Machinery, Except Electrical	35
23	Electrical and Electronic Machinery	36
24	All Other Manufacturing	22,23,30,31,37,38,39
	<u>Transportation, Communication, and Utilities</u>	
25	Railroad Transportation	40
26	Motor Freight Transportation and Warehousing	42
27	Other Transportation	41,44,45,46,47

Table 2. (contd.)

SECTOR NUMBER	SECTOR NAME	1972 SIC CODE
	Transportation, Communication, and Utilities (contd.)	
28	Communication	48
29	Electric Utilities	491,4931
30	Gas Utilities	492,4932
31	Other Utilities	497
	Trade, Finance, and Services	
32	Wholesale Trade	50,51
33	Automotive Dealers and Service Stations	55
34	Eating and Drinking Places	58
35	All Other Retail Trade	52,53,54,56,57,59
36	Finance, Insurance, and Real Estate	60-67
37	Hotels, Motels, and Lodging Places	70
38	Personal and Repair Services	72,76
39	Business and Miscellaneous Professional Services	73,81,89 (except 982)
40	Automotive Repair Services and Garages	75
41	Amusements and Recreational Services	78,79
42	Medical, Educational Services, and Nonprofit Organizations	80,82-86,892
43	State and Local Government Enterprise[a]	---
44	Federal Government Enterprise[a]	---
45	Dummy Industry	---

SOURCE: Standard Industrial Classification Manual, 1972, Executive Office of the President: Office of Management and Budget.

[a]Federal, state, and local government enterprise are listed as separate sectors under the 1967 SIC classification system; however, in 1972 the output of these enterprises is transferred to their respective private sector counterpart. When the SIMLAB base is updated to 1972 these two sectors (43,44) will be eliminated.

Baseline Forecasts

If we are going to be successful in identifying significant impacts of alternative development strategies which could be adopted for the region it is essential that we produce an accurate forecast of the region's economy without proposed development. The ultimate value of SIMLAB II forecasts is directly dependent on the confidence the user has in those forecasts. It is, therefore, essential that the most up-to-date information available be used when making the baseline forecasts. The significance, for example, of an increase of 1000 new workers added to an employed work force of 5000 is considerably greater than when added to an employed work force of 5,000,000, and to address this question of significance some kind of validation of our baseline conditions must be made. Considerable time and energy has been expended by the Copper-Nickel staff to collect the necessary input data. Primary data surveys of both households and industries will supplement the data derived from secondary sources (e.g. published reports and records of state and federal agencies). Independent projections of input variables used in the regional forecasting model are the best currently available. In addition, SIMLAB II allows easy updating as new information becomes available (e.g. the national data base will be updated as soon as the 1972 U.S. input-output tables are published). Admittedly, however, we do not possess perfect knowledge or a crystal ball with which we could look into the future. No matter how good our initial data is, we can never be positively sure our projections are absolutely accurate. The farther into the future we forecast, the less confident we can be. This is so because we cannot foresee all the contingencies which will surely take place. However, if our baseline forecast can be validated by a process called "backcasting" we can feel confident that our estimates of the impacts resulting from hypothesized changes will be reasonable.

Validation of Baseline Forecasts

Backcasting is a technique employed to check or validate the coefficients used in SIMLAB to make the baseline forecast. It consists of comparing the forecast data (either forward or backward in time) to some independently derived data (usually employment or income). Major deviations in the estimates would suggest the model coefficients need to be calibrated, which is accomplished by adjusting the annual rate of change in area market share coefficients to force the baseline forecast to fit the existing data. This procedure assumes that the independently derived estimates are sufficiently accurate. In addition, the baseline forecasts will be compared with those published by the Bureau of Economic Analysis (BEA) for its multicounty economic areas. Such comparisons should lend credibility to subarea projections from SIMLAB II if the two are in substantial agreement. Once validated, the baseline is projected into the future and stored for comparison (impact analysis) with development forecasts.

Alternative Futures Forecasts

The principal value of simulation is that it allows the user to postulate certain changes and then assess the impacts caused by these changes. In the present case different assumptions about the type and magnitude of copper-nickel mining activities can be studied. For example, the staged development of one or more open pit mining operations can be simulated as well as compared to underground operations (or some combination of the two). In addition, the impacts of locating forward (or backward) linked industries in the study area can be assessed. For example, locating a smelting and refining facility in the region. Each development scenario will have different direct and indirect impacts on the region, and these impacts can be used for public policy purposes. Thus, the tradeoffs between the economic benefits of locating, for example, a smelter in the region, and the environmental effects of that location can be made by the Regional Copper-Nickel Study. The outputs of SIMLAB II can be used as inputs into the decision-making process of many public agencies. Forecasts of future population trends are crucial in determining the need for public infrastructure (roads, schools, hospitals, etc.). Increased economic activity will have a significant impact on the public budgets of many local communities, and these impacts can be assessed by simulating possible development.

SUMMARY AND CONCLUSIONS

The advent of high-speed digital computers has greatly enhanced the use of simulation in the area of socioeconomic forecasting. Once developed, a simulation program allows considerable operation on the simulated system at relatively low cost (a typical SIMLAB run costs less than $2). Because of its low cost and versatility, the Regional Copper-Nickel Study staff has adopted SIMLAB II, a socioeconomic forecasting simulation model, for use in assessing the potential impacts of copper-nickel mining and related activities in northeastern Minnesota. Impacts on Minnesota Economic Development Region III (plus Douglas County in Wisconsin) as well as the subcounty Copper-Nickel Study area will be addressed. Forecasts of selected socioeconomic indicators will be made and potential uses and users of such forecasts will be identified in their final reports.

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December 21, 1977

Enclosed is a draft copy of the Regional Copper-Nickel Study report on SIMLAB II. The purpose of this report is to provide the interested "informed layman" with a document explaining the use of simulation and SIMLAB II in the studies' socioeconomic impact analysis. I would appreciate your critical review and comments concerning its theoretical content and readability by January 9, 1978.

Sincerely,

Royden E Tull

Royden E. Tull
Planning Manager

RET/SM

Enc.

Please prepare a copy of the attached letter for each of these:

Distribution of SIMLAB II Report.

1. Wilbur Maki
2. Larry Leistritz
3. Richard Lichty
4. Donald Steinnes
5. ~~Paul Dorf~~
5. K. L. Wang
6. ~~AROC (Lutz)~~ Dave Martin
7. Dr. Fred Pool
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