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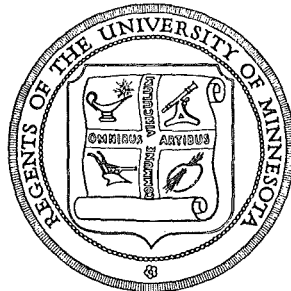P80-7   March 1980

ECONOMIC TRADE-OFF ANALYSIS OF STATE INDUSTRIAL

DEVELOPMENT POLICIES

W.R. Maki, P.D. Meagher and L.A. Laulainen, Jr.

Department of Agricultural and Applied Economics

University of Minnesota
Institute of Agriculture, Forestry and Home Economics
St. Paul, Minnesota 55108

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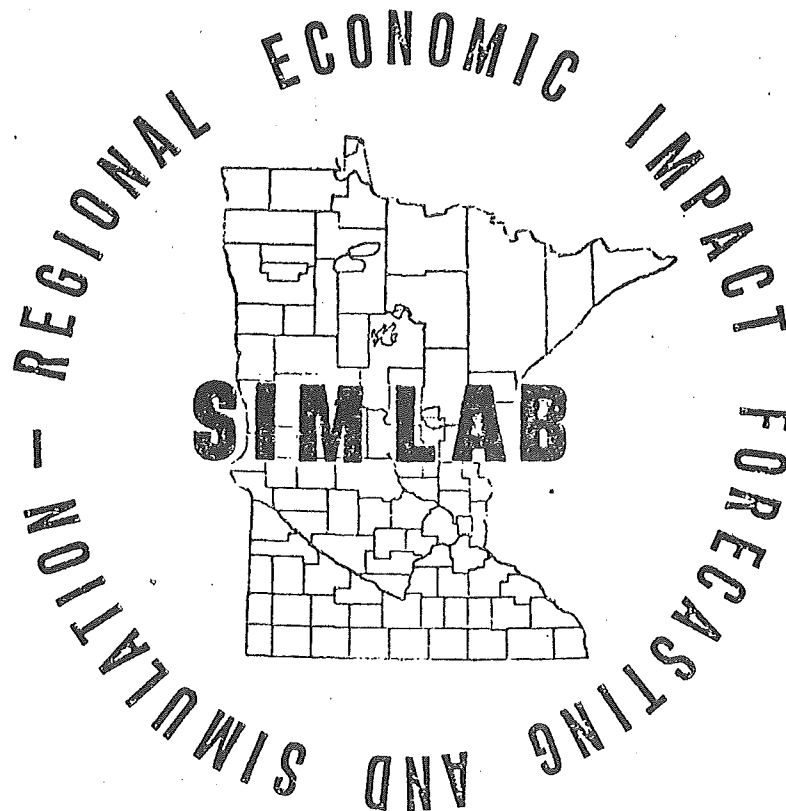

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ECONOMIC TRADE-OFF ANALYSIS OF STATE INDUSTRIAL DEVELOPMENT POLICIES [#]

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Recent shifts in the regional distribution of population and in the cost of doing business from state to state are affecting regional growth prospects. For some states, these shifts in economic activity are signaling the real possibility of corresponding shifts in their fiscal capabilities for adequately supporting essential public services.

A research program has been initiated by the Minnesota Department of Economic Development in cooperation with the University of Minnesota to build an economic framework for state industrial development policies which address changing industry patterns. Part of this framework is a trade-off model of the Minnesota economy.

This paper briefly describes the Minnesota trade-off model, including the series of modules representing segments of the Minnesota economy. The economic framework and the industry policy options are discussed, first, as background for the model applications. Results of a demonstration study in the use of the Minnesota trade-off model are examined, finally, with reference to the policy information needs.

ECONOMIC FRAMEWORK

The economic framework for state industrial development policy analysis addressed here starts with the supply side of economic activity, namely, the private investment decision and the factors which influence it (7,8,16). Closely linked to the invetment decision in this framework is the value added, or the gross state product, created by the related production activity. A shift in industry value added signals an earlier shift in industry investment. It may also signal future shifts in private capital formation.

State Economic Vulnerability to Industry Shifts

Both short-term and long-term shifts in gross state product are forecast and assessed in the economic trade-off analysis. In the short-term

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as in the year-to-year fluctuations in gross state product, the immediate
repercussions are most noticeable in the rates of unemployment. The peaks
and troughs in the business cycle are associated with widely varying em-
ployment effects. Because states differ in their industry composition,
they will differ, also, in their overall industry growth responses to
the upswings and downswings of the business cycle (4). Officials of some
states are inclined, therefore, to look favorably towards the enactment
of certain counter-cyclical employment stabilization policies (17).

In the long-term, for example, from one business cycle peak to the
next, real differences in gross state product occur because of differences
in rates of private capital formation. These differences occur, in part,
as a result of varying responses to the business cycle and, in part, be-
cause of secular shifts in markets and raw materials and in the costs of
doing businesses (5,11). The export-producing, or basic, industries of a
state are more susceptible to fundamentally changing industry location
factors than the residentiary, or service, industries.

In Minnesota, five export-producing industries are identified as
vulnerable to shifts in basic location factors. Four of the five in-
dustries -- agricultural products, forest products, mineral products and
tourism -- are natural resources-related, while high-technology manufactur-
ing is strongly oriented towards foreign export markets and, therefore,
its economic fluctuations are tempered by occasional counter-cyclical
market movements.

Computer Simulation and Industry Planning

The vulnerability of the Minnesota economy to both short-term and
long-term industry shifts in value added and employment is simulated by
the Minnesota economic trade-off model (MINTOM)** The individual modules
in the MINTOM computer program -- population, market, investment, demand,
production, labor force, value added, employment, household, government
and financial -- may be used independently in partial economic analysis,
but they are most effectively used as inter-connected elements in a re-
cursively-computed model of industry-specific activities (20). The
interfacing of several of the 11 modules with the computable models of
industry location and investment in the 12 North Central States and the
rest of the nation completes the MINTOM computer program. Thus, MINTOM
provides the economic data base and related procedures for assessing the
employment, income and population effects of given state expenditures for
industrial development purposes. Industry-specific measures of the bene-
fits and costs of these expenditures are obtained form the MINTOM program
output.

The causal ordering and linkages of modules in the MINTOM program are
represented, for the purposes of this paper, in Figure 1. Included among
the first-order variables, are those in the population, market and investment

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** SIMLAB is an earlier version of this model used in various state and
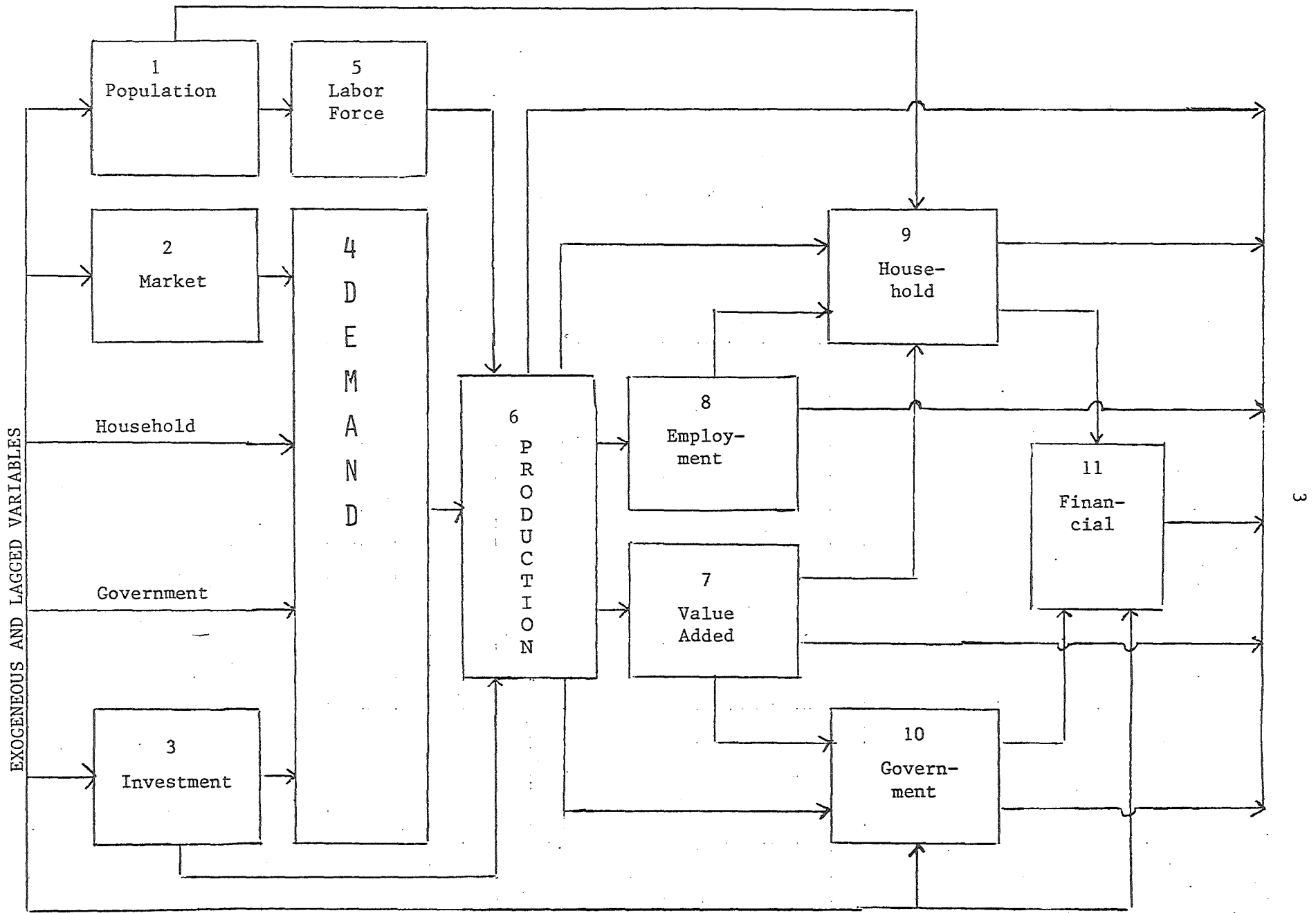substate studies (19, 20, 21).

Figure 1. Causal Ordering and Linkages of Modules in Minnesota Trade-Off Model Program.

modules, while the demand and labor force modules contain most of the
second-order variables. The first-order and second-order variables are
connected to exogenous and lagged variables. The value added and employ-
ment modules, which include the principal target, or outcome, variables
in this study, relate the production outcomes directly to the household
and government modules, or sectors. These linkages transform shifts in
value added and employment into corresponding shifts in household and
government income and expenditures. Finally, the financial module por-
trays the financial transactions of the business, household and government
sectors of the State's economy. This module contains the principal
policy variables available to Minnesota state government in its industrial
development efforts.

POLICY OPTIONS AND APPROACHES

State industrial development policy options and approaches repre-
sented here are limited to those which pertain to the key export-producing
sectors of the Minnesota economy cited earlier. They fall into the two
categories of employment stabilization and business investment. The impor-
tant target variables for each policy category are industry output, employ-
ment, and value added, Relationships over time among the three variables,
along with the balance of trade and balance of payments indicators, are
represented in Figure 2.

First, the two time periods -- the short-term and the long-term --
are differentiated by their policy outlook. The same target variables
are used, however, to monitor the statewide effects of the various
policies. The time paths of the target variables may be derived, by use
of MINTOM (19,21). Here, a generalized version of this output is presented
simply to emphasize the investment linkages in industry development.

Second, export-producing, or basic, industry is differentiated from
residentiary industry, which includes much or all of the following:
transportation, communication and public utilities; trade; finance, in-
surance and real estate; services; and government. A distinguishing
characteristic of export-producing industry is its high capital investment,
output per worker and growth in output per worker (which account, in part,
for the typically high ratios of residentiary to basic employment).

Third, the relationships between industry gross output and industry
employment are differentiated by stage of business cycle and industry
development. Output per worker increases rapidly during the initial
upswing of the business cycle and it increases, also, from one peak
level to the next (5,11,23).

Fourth, the growth in gross state product in the various stages of
the business cycle and of long-term industry development are accompanied
by shifts in money flows into and out of the state. For example, during
a period of expanded construction and growth in gross state product, a
negative balance of trade (exports minus imports) is accompanied by a
positive balance of payments (exports, plus investments and profits,
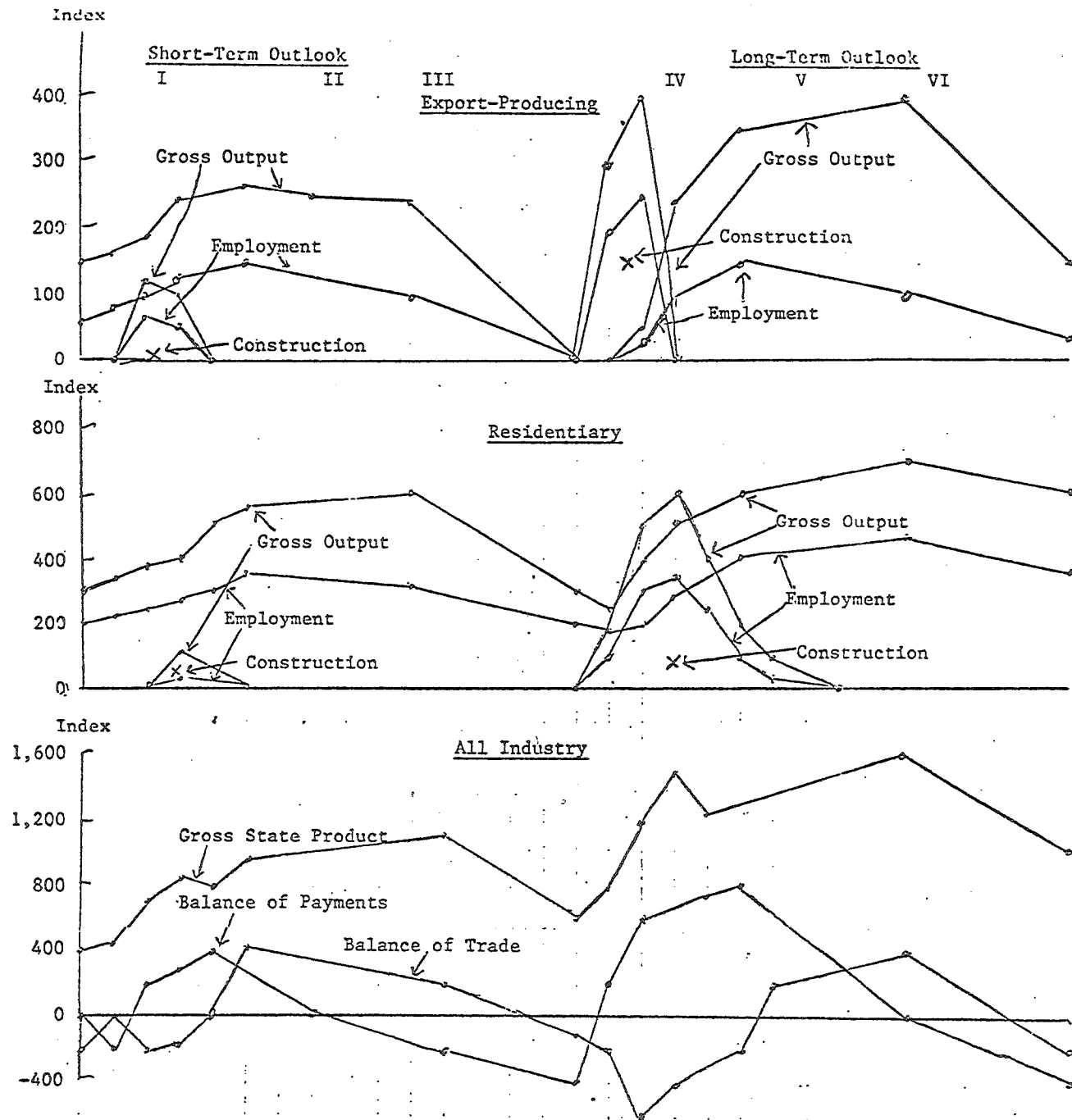minus imports). During the declining stage of industry development,

Figure 2. Relation of Short-Term Economic Fluctuations and Long-Term Development Trends to Gross Private Capital Formation in Export-Producing and Residentiary Activities.

negative balances of trade and of payments accompany a declining gross state product.

Employment Stabilization

State employment stabilization policies address the problem of state economic vulnerability to the business cycle. They focus on year-to-year fluctuations in industry value added and employment.

Anti-cyclical policy instruments to reduce business fluctuatins may include, as suggested by L'Esperance, state intergovernmental revenues, state government expenditures, and gross state product originating in state and local government (17,18). An intentional increase in gross state product during a business recession is expected to counter a decline in manufacturing and other cyclically-sensitive industry employment.

Short-term counter-cyclical policies must link target and policy control variables. In the Ohio model, the gross state product and its individual industry components are linked directly to the control variables. However, the Ohio model omits some of the supply side of gross state product formation, especially the linkages between private investment and government expenditures and revenues.

Business Investment

Business investment policies of state government shift the impact assessment from a primarily short-term to a long-term outlook. The purpose of public intervention in industrial development is to trigger sustained industry expansion by limited public expenditures in selected industries and geographic areas (14,24,25). According to Daniels and Kreschink, this intervention is confined to small, newly-organized businesses engaged in export-producing activities(6).

Small, newly-organized businesses are expected to account for 50 percent of the new jobs created in the 1980's. Yet, these are the ubsinesses most in need of additional access to private financing sources. However, only a fraction of these businesses -- those which are "basic" to a state's economy -- would be eligible candidates for state financial or technical assistance programs on the basis of the restricted elibibility criteria proposed by Daniels and Kreschink.

Earlier findings of a study of U.S. industry investment support the contention that business liquidity is an important determinant of business investment (8). Related studies of the effects of regional economic policies in Great Britain also support these findings (25).

COMPUTER SIMULATION OF ALTERNATIVE FUTURES

This short review of state industrial development policies has focused on the possible role of public intervention in private investment decisions

and the importance of differentiating between export-producing and residentiary production activities and between a short-term and a long-term policy outlook. The MINTOM computer porgram and related database were developed specifically for the purpose of simulating the statewide and regional effects of alternative industry-specific development policies which focus on investment and employment changes in the key export-producing industries of a state.

Model Variables and Parameters

Each of the MINTOM modules is now presented with emphasis on the specific industry policy target and control variables cited in the preceding section. Each module is described briefly, starting with the first-order modules (see, Figure 1).

The population module is based on an age-cohort survival model. It represents the regional demographic characteristics. It also provides for in-migration and out-migration by age and sex classes and for in-migration employee dependent ratios. While population levels are derived as a final step each year, they are shown as first-order, rather than lagged, variables. Thus, the population module yields forecasts for use in the labor force module as well as summary statistics for evaluating the computational results of the preceding year program. State investment strategies may be motivated, in part, by a desire to affect the rates of population out-migration (1). Such efforts may be directed towards particular age groups in the total population, which would be monitored in an assessment of the success of these efforts (3). Also, the population module lends itself to the development of an allocation-type input-output model in which the output, rather than input,coefficients are fixed. Such a model would be used in the study of period-to-period demographic flows from one population group to another (26).

The market module capsules the market intelligence of each industry into two variables and two parameters, namely, the U.S. gross output, the annual rate of growth in U.S. gross output, the state's industry market share, and the annual rate of change in the market share. Thus, each industry is linked to the rest of the world through its exports, if any. Changes in output-increasing investment result in corresponding changes in exports and usually in the export market share for the state's industry. Similarly, changes in the costs of doing business in the state are translated into corresponding changes in export market shares.

The investment module differentiates between output-increasing and pollution-abatement investment in plant and equipment. It also differentiates between replacement and expansion investment. Capital consumption allowances are derived from depreciation rates and capital stock levels, which are maintained through replacement investment. The latter is limited by the capital consumption allowance, which is a component of industry value added. Expansion investment is limited by business profits before taxes (i.e., value added, less earnings, indirect taxes and depreciation).

The demand module yields forecasts of the export and investment demands, which were derived by the two first-order modules, and the final purchases of the household and government sectors. The demand module thus "drives" the regional model. Personal consumption expenditures are derived from expenditure elasticity coefficients and forecast levels of total disposible income and total population while federal, state and local government expenditures are linked to population.

The production module makes use of the annual input-output multipliers (derived by the Minnesota two-region input-output model program) in the forecasting of annual industry-specific gross output levels (12). Industry gross outputs meet the forecast demand levels, subject to the constraints imposed by industry capacity levels, including both capital stock and occupation-specific labor supply.

The labor force module yields forecasts of the supply of labor based on forecast age- and sex-specific labor force participation rates and forecast population levels. The labor supply pool is then distributed among nine occupation classes. This supply is affected by occupation-specific, in-commuting and out-commuting members of the labor force.

The value added module provides for the remuneration of the primary inputs of the production system, namely, labor and capital, in the form of earnings, depreciation, indirect taxes, and business profits before taxes. This module includes also the import rate which is derived from the Minnesota two-region input-output model program.

The employment module represents the occupation-specific industry work force. It contains the parameters for changing the output per worker, the earnings per worker, and the occupational composition of the industry work force. This module capsules, for example, the employment and earnings effects of investment in education.

The household module contains the household-related parameters of total, and, also, employed and unemployed, persons per household. It also provides for the distribution of total earnings and property income among income classes and the distribution of households among housing units.

The government module represents the public sector activities and the flows of public income and expenditures. It relates each federal, state and local tax to its appropriate source and it provides for the disbursement of all government expenditures. It includes the data base for deriving the annual tax receipts of state and local governments from each industry and sector (15).

The financial module represents, finally, the financial transactions of the private and public sectors in the state's economy. These transactions determine the distribution of business profits to household, government and business sectors and the availability of financing for private and public investment (2).

The MINTOM program operates recursively, largely on its own endogenously-determined data once the computer run begins or the program is perturbed with a policy control variable. During the run, the principal exogenous inputs are the rate of growth of U.S. gross output in each of the basic industries, the rate of change in male and female labor force participation rates, the rate of change in earnings per worker, the output per worker in each industry, and the rate of change in the fertility rates for females of childbearing age.

A complete set of input data for the initial or base year of the model run of about 10,000 elements is estimated, or obtained from published sources. Regional employment by industry, earnings, household expenditures, and population are obtained from state and federal agencies. Although the existing model base year is 1970, the availability of U.S. Census data is no great advantage since any base year may be chosen. About 3,000 of the 10,000 base-year data elements are in the core input-output table. This information is generated from secondary sources using auxilary computer programs. Input data consists of regional gross output by industry and regional final demand for the base year. These are estimated largely from regional data published by the U.S. Department of Agriculture, the U.S. Census of Manufacturers, and the Regional Economic Information System in the U.S. Department of Commerce. State sales tax data and published studies of consumer behavior are used to estimate regional household spending. All government spending data is from published federal and state sources. A final input to the program which estimates the state input-output table is the U.S. input-output data from the U.S. Department of Commerce and the U.S. Department of Labor (12). Use of this data assumes that existing regional industry will have the same technical (but not trade) structure as its national counterpart. The resulting input-output table is inspected and revised as necessary to include unique features of the regional industry input structure.

Once variables and parameters are estimated, the model is fitted to most recent regional population, employment, and earnings series. Fitting is accomplished by adjustment of model variables and parameters from their previously estimated values.

Two tests of validity are applied to candidate models. Both depend on judgement exercised by the model builder. One test involves comparing fitting model variables and parameters with their previously estimated values. If the candidate model is accepted, the model builder must be prepared to conclude that his original estimates are in error or at least that the fitted model values are within certain acceptable confidence limits. A second test involves examination of model forecasts. Because of the recursive nature of the model, the regional population forecasts are calculated last as a function of forecast employment and other demographic variables. A series of plausible population forecasts suggests that forcasts of other socio-economic indicators are also plausible. Experience has shown that the population forecasts are extremely sensitive to changes in labor force participation rates, output per worker, and length of work week.

Model Interpretation and Use

Model interpretation and use is illustrated, finally, by the results of recent study of alternative resource development options in Northeast Minnesota (19,21). These development options demonstrate a range of applications of the multi-modular computer model.

Mining industry employment, payroll, investment and output of single-mine and multiple mine operations are examined, first. The data were prepared by mining industry specialists. Next, the indirect effects are presented as the aggregate economic consequences of the projected mining operation for the Study Region. These findings were prepared from the MINTOM data output for the Study Region.

Direct Economic Effects

Direct economic effects start with the new jobs created by construction activity. This is followed by additional new jobs created by the mining activity itself (see, Figure 2).

First, a construction work force of 1,800 to more than 2,500 is required in the peak year to build the mining-related facilities. The underground mine requires a smaller construction work force than the open pit mine.

A single, fully-integrated copper-nickel operation, mine, mill and smelter/refinery provides from nearly 2,100 to over 2,500 jobs. These are filled almost entirely by residents in the immediate commuting area. Total employment reaches its peak very early in the commuting area because of the overlap of construction and mine operation work forces. Even the employment level of peak production never attains the high employment levels of the construction period.

The capital investment required to product copper and nickel metal is approximately $600 million (in 1977 dollars). In each development option, the investment for the smelter/refinery is about $324 million. Differences in total required investment are due to the method of mining and the concentrating process necessary to handle various ore grades.

Each of the three scenarios is designed to generate about $285 million in gross annual output. (These are now represented in 1970, rather than 1977, dollars in the computer program.) Operating expenditures, other than payroll, total about $60 million each year.

The direct requirements of more than one single fully integrated copper-nickel operation are multiplies of the single operation impacts. Four open pit operations of the same size would, for example, employ four times the number of workers as the single open pit scenario and produce four times the gross output.

The timing of development is an important consideration in assessing any multiple mine impacts. If the total period of construction were prolonged, the drop in employment immediately following the construction employment peak would be eliminated, or at least minimized, between development.

Indirect Economic Effects

Expansion of mining operations requires the supporting economic sectors of the area to adjust to the new levels of activity. Thus, the total economic impact of a copper-nickel operation is greater than the direct impacts of the mining operation itself. Most local businesses indirectly benefit from the basic industry expansion.

The indirect impacts start with increases in personal income. Business receipts increase as the payroll of the copper-nickel work force begins to circulate in the local area. As the copper-nickel businesses expand their sales of goods and services, additional employment and capital facilities are required. These in turn foster additional economic demands and the "multiplier" effects of the initial copper-nickel operation thus ripple throughout the economy.

Some sectors show the effects of copper-nickel development to a greater degree than others. The service, trade and government sectors experience the greatest amount of indirect economic activity. However, these effects lag behind the direct effects because of the lag in sales-realted investment expansion (as illustrated, also, in Figure 2).

Model Extensions

Since further discussion of the Northeast Minnesota study findings can be found in the companion paper presented here, we prefer to conclude with an assessment of potential uses of computer simulations in state industrial policy analysis and implementation. We start with mining as a candidate industry.

The market outlook for the Minnesota iron mining industry specifically is affected by the rapidly increasing value of its production. The steel industry price index increased 7.1 percent per year in the 1976-1980 period. Post-1980 price increases are projected at a 5-percent annual rate in the assessment of the tax impact of the taconite industry. Almost all of the iron ore production is now in the form of taconite pellets. This shift in production has been accompanied by a shift,also, in the total energy requirements of the combined iron mining and manufacturing industries towards the mining areas.

Because of cyclical fluctuations in U.S. consumption, the Minnesota iron mining industry is expected to produce above and below the long-run trend levels. Between 1970 and 1971, for example, production declined from 56.1 million tons to 51.3 million tons, or 8.6 percent. By the end of 1972, annual production had declined another 4.5 percent. Then, in 1973, production increased by 22.5 percent. Thus, during the 1970's, the fluctuations averaged at 10.1 percent, exclusive of the effects of the strike in 1977. If future cyclic fluctuations in Minnesota taconite production were to average 10.1 percent above and below the long-run trend, then in 1987, for example, production could be as much as 80.7 million tons, or as little as 65.9 million tons.

The MINTOM program has been calibrated to the annual data for 1977 and to the high taconite production option for the period from 1980 to 2000. In this option, the Minnesota taconite industry expands production from about 57 million long tons in 1980 to about 100 million long tons in 2000. Employment in the taconite industry does not increase over this period because of increases in worker productivity. Output per worker in taconite and all other industries is assumed to increase at the long-term historical rate during the 1980's and at 80 percent of the long-term rate after 1990.

The high taconite option provides for no copper-nickel development. Computer runs under different assumptions concerning taconite industry growth and copper-nickel development yield the projections of employment and population which differ from the high taconite option. Since all other assumptions are held to be the same, deviations from the high taconite option are measures of the impacts of taconite industry and copper-nickel development.

Taconite industry and potential copper-nickel development impacts are presented as differences between the baseline and the high taconite output, and then between the high taconite option and the copper-nickel development. Impact estimates are generated in two separate simulation runs, one in which a special assumption is made concerning the taconite industry and another in which copper-nickel development is assumed.

Lingering effects from the massive construction project required for copper-nickel development are responsible for anomalies in the impact forecasts. For example, rapid expansion of facilities to meet demand during the construction period results in a slump in construction, once copper-nickel operations commence. Thus, copper-nickel development has negative forecast impacts on employment in construction. These negative impacts gradually diminish but do not entirely disappear by the year 2000. Similarly, a boom-bust cycle is induced in the durable goods industries like logging, wood products, paper products, primary iron, and machinery.

Community economic effects of mineral industry development are viewed, finally, from local and regional perspectives, namely, employee commuting, industry suppliers and tax revenue disbursements. Employee commuting from place of residence to place of work establishes the primary industry economic impact area while the location of industry suppliers establishes the secondary area.

Most taconite industry workers live within 10 to 15 miles of the mining operation. Very few -- less tahn 10 percent of the total -- commute more than 20 miles.

Within the commuting areas of Northeast Minnesota taconite plants total employment is projected to decline in the late 1980's. If copper-nickel development were to start in 1983, the increase in jobs in this industry would delay the regional employment decline until the late 1990's. If neither taconite industry expansion (beyond the baseline level of 78 million tons) nor copper-nickel development were to occur by 1990, the projected employment decline would mean an even sharper population decline within the primary taconite industry commuting areas.

Of the 2,431 individual taconite industry suppliers who were located in Minnesota in 1977, 60 percent were in Northeast Minnesota while 33 percent were in the Minneapolis-St. Paul Metropolitan Area. The Northeast Minnesota suppliers represented 44 of the 54 Minnesota industry groups listed earlier. Thus, the taconite industry here is linked, in varying degree, with almost every segment of the Minnesota, and especially the Northeast Minnesota, economy. Much of this infrastructure is available for copper-nickel development.

Expansion of mining into manufacturing operations would introduce additional forward (i.e., product market) and backward (i.e., input supplier) linkages. Such expansion would increase substantially the secondary impact area of potential future Northeast Minnesota mineral industries. Unlike the taconite producers, which are large firms, the industry suppliers generally are small firms, many of which face the typical problems of liquidity and access to expansion capital. Candidate firms for state financial and technical assistance would be found in this segment of the industry. By targeting state efforts towards these firms, access to both financing and information could be nearly equalized between the small and large firms (10,16).

Community economic effects of mineral industry development are demonstrated, also, by the sharply increasing levels of industry tax revenues. The 1977 legislature revisions in the taconite production tax marked a sharp upward shift form $58 million to $98 million in total taxes collected, specifically from the Northeast Minnesota mining industry. Total occupation, production and royalty taxes collected exceeded $500 million for the 10-year period starting in 1970.

In summarizing current Minnesota research on the building and use of computer simulation models for state industrial policy analysis, we refer, first, to state policy options. These options may focus on short-term outcomes, namely, the stabilization of employment and income from one business cycle to the next, or they may focus on long-term outcomes. In the long-term outlook, private investment in the export-producing, or basic, industries is the policy focus. Five export-producing industries-- agricultural products, mineral products, wood products, high-technology manufacturing and tourism -- have been identified as candidate industries for a new state policy on industrial development.

The Minnesota trade-off model (MINTOM) has been built for the purpose of simulating alternative economic and demographic futures for the state and its substate regions. An early application of this model was undertaken in a series of studies of the mineral industry in Northeast Minnesota. Model variables and parameters, interpretation and use, and future extensions were discussed in the context of the Minnesota economic framework for state industrial policy analysis.

The long-term, rather than short-term, outlook is emphasized in the Northeast Minnesota studies. This is less a deliberate effort to avoid addressing the potentials for short-term employment and income stabilization than a result of the structure of the mining industry, its geographic location, and the policy options available to state government. Mineral producers in Northeast Minnesota are large firms with access to national

financial markets and with a stable and skilled work force. With a long-term outlook, however, additional policy options emerge which focus on small, growing and potentially profitable firms among those supplying the mining industry with special products and services.

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