United States
Department of
Agriculture

Economic
Research
Service

Rural Development
Research Report
Number 63

Choosing Among Local Impact Models

Marlys Knutson Nelson
Lloyd D. Bender

Additional copies of this report ...

can be purchased from the Superintendent of Documents, U.S. Government Printing Office, Washington, DC 20402. Ask for Choosing Among Local Impact Models (RDRR-63). Write to the above address for price and ordering instructions. For faster service, call the GPO order desk at 202-783-3238 and charge your purchase to your Visa, MasterCard, Choice, or GPO Deposit Account. A 25-percent bulk discount is available on orders of 100 or more copies shipped to a single address. Please add 25 percent extra for postage for shipments to foreign addresses.

Microfiche copies ($6.50 for each report) can be purchased from the order desk, National Technical Information Service, 5285 Port Royal Road, Springfield, VA 22161. Enclose check or money order, payable to NTIS. For faster service, call NTIS at 703-487-4650 and charge your purchase to your Visa, MasterCard, American Express, or NTIS Deposit Account. NTIS will ship rush orders within 24 hours for an extra $10; charge your rush order by calling 800-336-4700.

The Economic Research Service has no copies for free mailing.

CHOOSING AMONG LOCAL IMPACT MODELS. By Marlys Knutson Nelson and Lloyd D. Bender, Agriculture and Rural Economics Division, Economic Research Service, U.S. Department of Agriculture. Rural Development Research Report No. 63.

ABSTRACT

Large-scale development projects attract many participants in education, assessment, negotiation, planning, and impact mitigation processes. However, each potential user of a model of a project's impacts has different goals and incentives to participate in the process. Impact model users must be familiar with the potentials and limitations of impact models in order to select one and interpret the results for their purposes. This report summarizes the features, capabilities, and limitations of large-scale impact models and assesses the kinds of information produced and the differences in the techniques used in the estimation process.

Keywords: Socieconomic impacts, rural growth models, local government planning, regional models, rural economic growth.

Washington, DC 20005-4788 November 1986

CONTENTS

PREFACE

Stringent environmental regulations of Federal and State Governments in the seventies spawned a long and often complex process of education, impact assessment and evaluation, negotiation for benefits, planning, and mitigation of undesirable effects of new industrial plants and projects. Impact models are tools for evaluating such new projects. Federal, State, and local government officials, project developers, and numerous citizens groups enter into the process, with different goals and incentives.

Impact models focus the attention of participants on the desirable and undesirable effects of new developments, establishing a basis for negotiation by each participant. To be most effective, impact models must provide information useful to a wide array of people with different goals and concerns.

Users of local impact models must be familiar with the potentials and limitations of impact models to select one and interpret the results for their purposes. Project developers strive for a cooperative and satisfied labor force, cutting down on labor turnover and inefficiencies. Housing and amenities are important to them. Local planning officials want to anticipate local government service requirements and identify revenues sufficient to cover budgets. State officials may desire projects to pay all the costs of development, including intergovernmental transfers to localities and costs faced by other communities. Environmentalists have similar concerns in addition to potential hazards specific to each project.

This report summarizes the features, capabilities, and limitations of impact models. The authors reviewed 16 such models to determine the uses, strengths, and weaknesses of these tools and assessed the kinds of information produced and the differences in the techniques used in the estimation process. They evaluated models according to the number of estimates made, the sequence in which estimates are made, interrelationships among estimates in the model, and the techniques used in the estimating process.

Current technology limits the usefulness of impact models for some purposes. First, the technology of impact modeling has not yielded dynamic models that can be applied to year-to-year planning. Second, the prediction of settlement patterns is very inexact, yet settlement patterns are necessary to anticipate expenditures and revenues of each local government. Third, impact models do not reflect the uncertainty of some events.

GLOSSARY: GENERAL TERMS

Assessment. Detailed estimates of economic and social changes attributable to a potential new facility, contingent upon the development proceeding as specified.

Contingency plan. Alternative course of action addressing potential problems that could arise from unpredictable future alterations in the authorized and planned construction, operation, or closure of a facility.

Demographic impact. Change in births, deaths, migration, and population.

Economic impact. Change in employment, income, labor force participation, resource productivity, demands for goods and services, or governmental revenues.

Evaluation. Interpretation of the impact assessment for changes that are most likely to bring problems, including overruns or shortfalls in local government revenues and temporary bulges in demands for housing or schools; a search for ways to make the project more beneficial, such as judicious use of revenue overruns.

Fiscal evaluation. The difference between local government revenues and expenditures.

Impact. Effect of a distinct and sudden economic change.

Impact analysis. All phases of impact assessment, planning, mitigation, evaluation, and monitoring.

Impact area. The geographic area included in an impact analysis; one county or a set of counties in most analyses.

Impact model. A logical step-by-step procedure for describing and analyzing sudden economic changes.

Impact policymaker. Any organized public or private group taking direct action concerning a new industrial facility that will affect an area, its governments, or its people.

Local government jurisdiction. The geographic boundaries of one of many local governments, including a county, town, school or irrigation district, or several types of special improvement districts.

Management. All phases of impact analysis.

Mitigation. Actions preventing unwanted effects from a new facility, including changes in plant design, operation, location, and construction and operation schedules, usually prior to the authorization of construction and operation.

Monitoring. Day-to-day oversight of a project to gauge the accuracy and adequacy of initial assessments, evaluations, and mitigation procedures, and to trigger the use of contingency plans when necessary.

Public service demand. Estimate of the levels of capital and operating expenditures of local government functions, including schools, streets, and sewage treatment.

Recovery value. The market value of an asset at some future time.

Scoping. Preliminary description of plans and effects of locating, building, operating, and closing a facility.

Sensitivity analysis. Variation in estimates produced by repeated applications of a model to a given situation in which a value of a model, such as a linking coefficient or project employment or scheduling, is varied.

Siting permit. A legal authorization to construct and operate a new facility at a particular site.

Choosing Among Local Impact Models

Marlys Knutson Nelson
Lloyd D. Bender*

INTRODUCTION

For years, planners have analyzed the economic and social effects of economic growth and decline to aid State and local government officials. Many econometric models were designed to analyze growth and decline for States, regions, and large cities. Within the last decade, large-scale models were designed to assess a broad range of social and economic effects of growth and decline in relatively small and isolated rural regions.

Impact models are simplified descriptions of an economic and social system. Such models provide a systematic way of thinking through the steps of a problem.

This report summarizes the uses, characteristics, and methods of alternative local impact and planning models and describes their features, capabilities, and limitations. A companion report annotates various models and approaches (21).1/

BACKGROUND

Models became complex as computer technology and additional data became available. Early regional planning models estimated changes for whole regions. They could not easily estimate changes in each small area of the region or the timing of those changes because of conceptual and computational difficulties. Some models also estimated only a few items such as population and income. They could not estimate important planning dimensions such as local government service demands or the revenues available to local governments until they could take account of the interplay of the various forces.

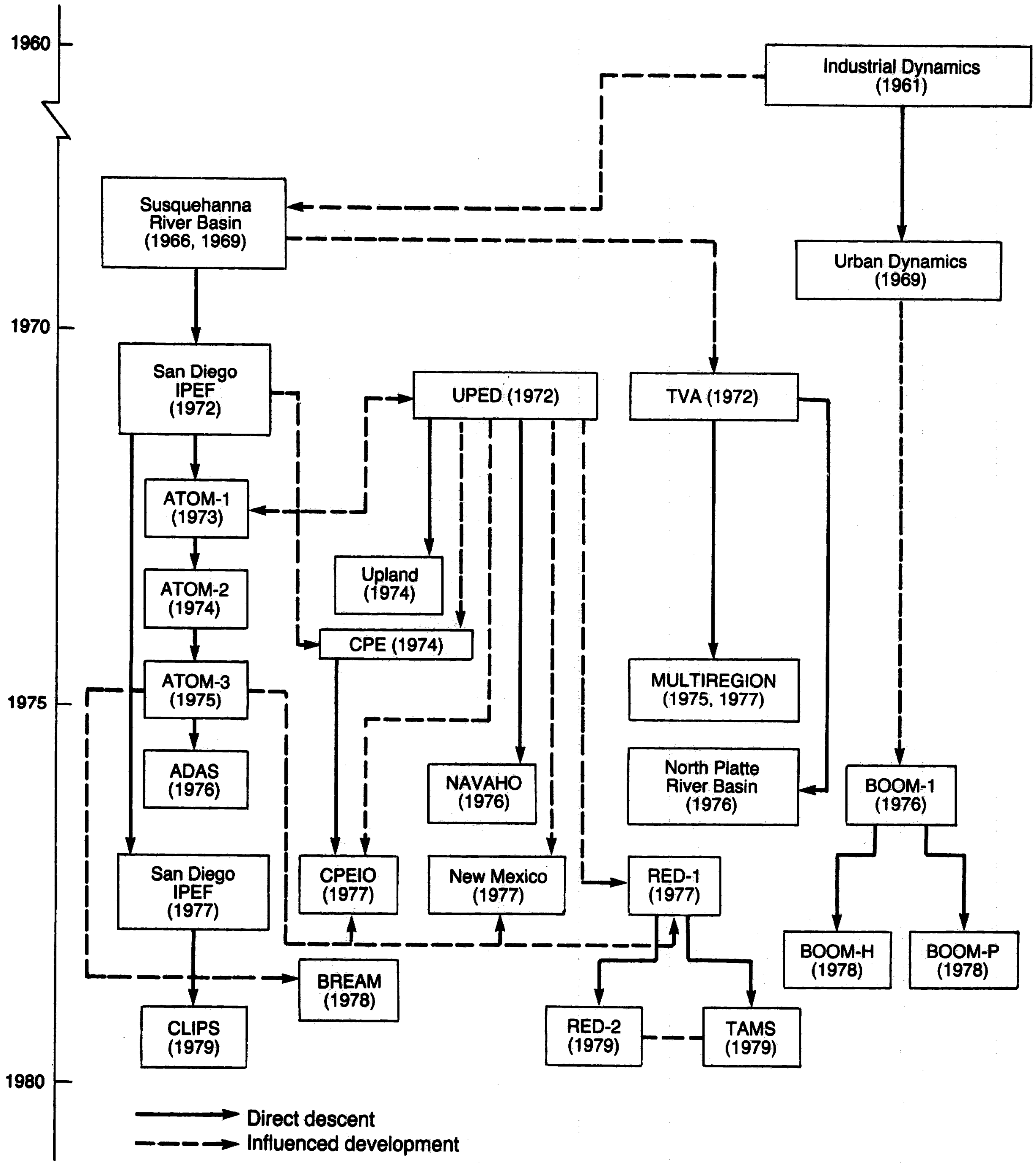
Models with those added capabilities proliferated by the midseventies. Families of models evolved, becoming more and more complex with each generation. One such family illustrates the influence of an initial set of models on subsequent ones (fig. 1). The Susquehanna River Basin model, which dates from 1966, linked together economic and demographic systems and emphasized nonmetropolitan areas rather than a single urban area (8,11). The most prolific part of this family sprang from the work on the ATOM series--the Arizona TradeOff Model (3). ATOM 3 eventially led to the Bureau of Reclamation Economic Assessment Model (BREAM) in 1977 (5) and several other models.

---

*The authors were economists with the Agriculture and Rural Economics Division, Economic Research Service, U.S. Department of Agriculture, when they conducted this research. Nelson was assigned to Oklahoma State University at Stillwater, and Bender was assigned to Montana State University at Bozeman.
1/ Underscored numbers in parentheses refer to items in the references at the end of the report.

Figure 1

The Development of Economic and Demographic Projection Models



Federal and State legislation fostered continued development of complex impact assessment models. The National Environmental Policy Act of 1969 (NEPA) requires analyses of the social, economic, and environmental impacts of major developmental projects (29). NEPA requires that an environmental impact statement (EIS) including effects on the quality of the human environment be prepared for each development.

Other Federal and State impact assessment requirements have since been imposed. The Nuclear Regulatory Commission's (NRC) Regulatory Guide and the Council on Environmental Quality's (CEQ) guidelines require a thorough assessment of the social and economic consequences of major developmental projects (29). State industrial siting legislation, such as the Wyoming Industrial Development and Siting Act of 1975 and similar laws in Montana, North Dakota, Minnesota, and California (8), frequently requires social and economic assessments and impact mitigation alternatives.

Developmental concerns are also represented in the many rural areas participating in the population turnaround of the seventies (2). The shift from Federal programs to State initiatives to promote enterprise growth and development has been dramatic (18). Growth of population and employment, especially in isolated rural areas, brings new problems. Local, county, and State officials as well as private groups use assessment models to help them anticipate and manage the impacts of many types of changes.

State and local officials frequently must decide which model to apply to a situation from among the proliferation of increasingly complex and detailed impact assessment models. In making such decisions, the officials must determine the purpose of the estimates, the importance of each estimate as ranked by the goals of the analysis, the methodologies behind the estimates, the interpretation of the estimates, and the accuracy of the model estimates. Despite the need to chose from among models, the advantages and disadvantages of alternative models are not well understood. The massive literature ranges from theoretical approaches to summaries of various impacts. Furthermore, many models are not well documented. Documentation is often either proprietary and not available, or it is complex and inappropriate.

IMPACT MODEL DESIGNS

Models may produce different estimates of the future because of differences in structural design and the accuracy of the linking coefficients. These two model features are equally important. They are the assumptions about the directions of effect and the exact amount one estimate in a model causes others to change.

The skeleton of any model is its structure, and the directions of effect form the structural design of a model. That structure is first based upon which estimates are assumed important enough to be included, and second upon which estimate affects others. The structure is typically a network of interactions in complex models, but the calculations may be relatively straightforward in simple models. For example, population change may be a result of births and deaths in one model. In others it may be a result of employment changes.

Each estimate a model produces is systematically calculated as the model progresses through its structural network along prescribed routes. The internal network is usually divided into distinct blocks, often called dimensions or submodels. Each submodel produces at least one estimate. Population, for example, may be estimated in one distinct block. That estimate is used later to make other estimates as each block in turn is related to others by the structural design. Thus, a population estimate will eventually affect the demand for local government functions as well as the tax revenues of local governments.

Tying together the structural design are linking coefficients giving the exact amounts that one estimate causes others to change. Errors in one of these linking coefficients early in a model would produce inaccurate estimates that are spread and magnified many times over as they are used in later calculations. An inaccurate population estimate used to calculate both local government service demands and local government tax revenues would yield erroneous estimates of the fiscal balances of local governments later in the model.

Glossary: Model Design

Driving force. The beginning point in a model's structure; the force that starts the analysis in a model; usually changes in an area's economic base.

Economic base. Any economic activity that brings income from outside the area into a local economy, including the export of goods to other areas, the sale of services and goods to outside shoppers, and net retirement, dividend and interest income, and subsidies, gifts, and other transfers of funds from outside sources.

Extrapolation. An estimate of future conditions based on limited current data that are known to be incomplete.

Forecast. A prediction with a known degree of accuracy.

Gross inmigration. The total number of people moving into an area over a specified time period.

Gross outmigration. The total number of people moving from an area over a specified time period.

Linking coefficient. Number within a model measuring the effect of one estimate on each of the other estimates.

Model dimensions. The impact estimates produced by a model, including employment, income, population, migration, local government service levels, local and State revenues, and school, hospital, and housing and transportation demands.

Model structure. A schematic outlining the way each estimate affects others, including impact estimates made, directions of causation, and exact sequences in which one estimate affects others.

Natural population increase. The excess of births over deaths in an area in a specified time period.

Complex model structures increase the chances that errors will build up (22, p. 361). The importance of a single linking coefficient's accuracy in a model may be judged by the number of other estimates that it indirectly affects in the structural network: would errors attributable to that coefficient spread throughout the system?

Changes in the economic base are the driving force that starts a model and makes it run. The economic base consists of any basic economic activities bringing income into the area from the outside. Productive activities create basic goods exported to other regions of the Nation or goods and services sold to people who commute into an area to shop. These basic productive activities use some locally produced goods and local labor, the foundation for all personal income. Income coming into an area from sources not related to employment and production, such as retirement income, is also basic to a local economy, increasing the derived demands for goods and services in a local

---

Net migration. The difference between gross in- and outmigration over a specified time period.

Projection. An estimate made by projecting past and present trends into the future.

Submodel. A subset of a model designed to produce at least one principal estimate; one dimension of a model.

Types of analyses. Different conceptual and procedural approaches to making estimates that affect the usefulness of model estimates for impact analyses.

Before-after analysis. An equilibrium planning analysis (simple or complex), in which the reason for change is known, but its effect is not stated separately.

Equilibrium. The point at which no additional changes are made; the point at which all forces are stable and balanced.

Equilibrium analysis. A picture of conditions at some future time at which a balance among forces has been established, disregarding intermediate time periods.

Interactive analysis. The user must interact with the model by supplying information at certain points in the estimation process.

Now-then analysis. An equilibrium planning analysis, extrapolating a trend to a point in the future, not explicitly taking into account any one cause behind the changes.

With analysis. Estimates assuming a sudden economic change in addition to continuous baseline changes over the period of the analysis.

Without (baseline) analysis. Benchmark estimates assuming no new and sudden change; only continuous increases or decreases in current economic activities in the area over the period of the analysis are considered.

With-without (impact) analysis. The difference between with and without analyses, yielding impact estimates for each model dimension.

economy and, therefore, the total number of jobs. Thus, translating changes in basic activities into changes in total economic activity is a fundamental part of any impact model.

A simplified description of the estimates summarized by an impact model might be as follows. An area's population changes because of more births than deaths (natural increase), special migration to and from an area (such as for family reasons or for retirement rather than for employment), and employment-related migration. Net inmigration is related to new jobs when the number of jobs exceeds the capacity of the local labor force to supply sufficient labor to fill them. The total number of jobs ultimately depends on the basic economic activities in the local economy and on the unique characteristics of that economy. New jobs in turn increase population, and the demands for services provided by local governments. Local government revenues depend not only on population but also on the industrial tax base of each local government.

Submodels describe a part of such activities. A submodel may be very complicated operationally even though it has a fairly straightforward task. Not only are the population and special subpopulations estimated, but labor force participation and migrant characteristics play a part in those estimates, for example. The number of inmigrants filling new jobs depends on the number of current residents taking new jobs--that is, on the rate of local labor force participation. The number of additional family members migrating with new jobseekers also depends on their labor force participation, in turn affecting demands for housing, schools, and other facilities. Each of these estimates must be linked together in impact models.

A model may produce several other kinds of estimates. The spread of population within the study area, determining which local governments are affected, is important to the estimation process. The number of jobs or net inmigration translates into housing demands. Estimates of various social characteristics that interest some groups have not received the same degree of attention, probably because of the priorities of policymakers using the models. Estimates of both local government expenditures and the flow of local government revenues are primary objectives of many impact models. These estimates in combination signal potential shortfalls or overruns and the need to plan alternative courses of action.

IMPACT MODEL USES

Models serve as aids to planners, policymakers, and the general public. Models may be used for planning for a future time period without regard for intermediate time periods--equilibrium planning; providing a learning environment for policymakers, the public, or researchers--an education process; preparing an environmental impact statement--an impact analysis; and estimating the timing of changes that signal alternative problem situations to which local government officials and citizens groups must respond--impact mitigation and contingency planning (table 1).

This variety of uses suggests that the complexity of impact models, the methodologies they use, and the kinds of estimates they produce will be important in selecting an impact model. Models designed for one purpose may be quite inappropriate for others, some model types can be used for planning but not for impact analyses. The selection of a model must be based on the user's objective--whether the model yields the kind of estimates desired and whether impact analysis or planning is the application. In addition, the source and magnitude of expected changes and each model's capabilities and limitations are important selection criteria. These characteristics provide a general basis for evaluating models.

Equilibrium Planning

Equilibrium planning analyses disregard intermediate time periods and the processes at work as the system moves toward a new equilibrium. The objective is to provide a picture of conditions at some future time. The user has little interest in the cause or timing of changes. Planning models are inappropriate for impact analyses.

Equilibrium planning models and their techniques may be simple or complex. The simple extrapolation of a trend is termed a "now-then" analysis. It might effectively extrapolate the age distributions of a stable population and its replacements. For example, plans for schools and medical services are closely related to age. A "now-then" planning model can estimate the adequacy of local government revenues to support those services. This type of planning model is appropriately applied to stable farming communities or to small towns and school districts with a stable economic base.

A simple "before-after" analysis is another type of equilibrium planning model. In this case the primary reason for the change is known. However, the model does not separate that part of the estimated results caused by any single change from the amount caused by other continuing changes. The objective is still a picture of the future without regard for intermediate periods or the results of a single change. Simple averages from secondary data could be used as the linking coefficients for such models when the anticipated changes are relatively small. That approach may be appropriate for expansions and contractions of small manufacturing plants in rural areas and for larger changes in many towns and cities.

Planning models used for analysis when changes are large require careful attention to the data and methods of estimation.2/ Planning estimates are very sensitive to employment and income changes, local labor force participation, and population settlement patterns. Employment and income changes in rapid-growth communities may not average the same as those in slow-growth places. Very small changes in labor force participation can also materially affect estimates of population change.3/ Working people who commute from outlying areas can affect population estimates in the same way as labor force participation. Thus, the values of the linking coefficients may be vastly different before and after such changes.

2/ Analysts evaluating large changes frequently adopt estimating coefficients from "similar" places that underwent "similar" changes. Econometric evaluations of such coefficients from cross-section data show that those coefficients are far from accurate, however, when applied to another area or region (4, p. 6).

3/ Some attention also should be given to the time period allowed for a return to equilibrium. Recent unpublished analyses from the Economic Research Service indicate that 5 to 8 years may be necessary for reestablishing an equilibrium.

Table 1--Characteristics of interest for impact model evaluation by user objectives

User objective	Type of analysis	General model products of interest to client	Appropriate situation for the analysis	Special capabilities desirable in model
Equilibrium planning		Estimating conditions at one future period		
Specific trends	"Now-then"	Community facilities affected by trend; revenues at future time	Stable local economic base and a minimum of change in external forces; for example, the age distribution affects demand for medical services	Method of trend analysis, relationships among population characteristics and local government service levels and relationships among local government revenue sources
Economic base changes	"Before-after"	Community facilities requirements after change; local government revenues after change		
Small changes			Small relative changes; for example, expansions or contractions of employment in an existing plant	Capacities in local government services sector to absorb changes and direct local government revenue changes
Large changes			Very large relative changes; for example, natural resources exploitation, resources-based processing, Federal and State construction projects	Change in average multipliers, labor force participation, population changes from net migration, population settlement patterns, local government service demands, revenues sources and flows
Education	Interactive with audience	Effects of one variable on others and amount	Any change	Components included in model, interactions among components, accessibility of model to participation, and understandability of model structure

Continued--

Table 1--Characteristics of interest for impact model evaluation by user objectives--Continued

User objective	Type of analysis	General model products of interest to client	Appropriate situation for the analysis	Special capabilities desirable in model
Impact analysis	"With-without"	One project's effects on local government expenditures and revenues, population, employment, and income in given political jurisdictions	Large relative changes in economic base, for example, most Federal and many State projects	
NEPA impacts		Estimating effects in one future period attributable to one project		
Baseline	Baseline "without" the project under consideration	Conditions with no new development project		Changes in the economic base that would have come about any way without a new project; includes all capabilities of small economic base changes in Equilibrium planning above
Changes	"With" analysis, including the project under consideration	Conditions after a project is added to the baseline		Accuracy of estimates and timing of external changes, includes all capabilities of Large economic base changes in Equilibrium planning above
Impacts	"With-without"	Results of one project	Large changes in economic base	Includes all capabilities of Baseline and Changes objectives above
Dynamic impacts	"Dynamic with-without"	Estimates timing of changes for each year or period	Extremely large relative changes; for example, irrigation projects, mines, power plants, hydroelectric projects, military bases	Timing of local government expenditures and revenues, population settlement patterns, stability and accuracy of economic base changes, interactions among model components, and accuracy of estimates

Education

Interactive models are used as educational tools. These models can be skeleton structures of cause-and-effect relationships and show where the linking coefficients logically belong. Model builders typically supply values for the linking coefficients of such models. Nevertheless users are encouraged to change the values of the linking coefficients. As each linking coefficient is altered, users can evaluate whether the changes are important to them.

Successive trials permit users to evaluate the sensitivity of the results to each coefficient. They can eventually concentrate on those estimates that are affected the most and that are important. The fundamental feature of such models is the series of cause-and-effect relationships.

Impact Analysis

The most common application of impact models is to fulfill NEPA requirements. NEPA impact analyses require a "with-without" approach but may use either a dynamic or equilibrium model. The objective is to find the changes due to one project alone. The changes that would have come about anyway are the baseline estimates. The difference between estimates "with" and "without" a project are the impacts attributable to the project.

Baseline estimates simulate the outcome with no new development project--the "without" case. The baseline estimates account for any national and regional trends. Of special importance are the projections of expected increases or decreases in the existing economic base, that is, the levels of manufacturing, agriculture, mining, Social Security, and other sources of income from outside the area. The baseline case is the benchmark for impact estimates and is extremely important.

A new project included with the baseline is the "with" part of the analysis. Accurate estimates of a new project's employment are essential to the model. Sources of large errors in impact analyses are underrepresentations of a project's employment and misspecifications of the timing of those employment changes. The NEPA impact estimates are the differences between estimates "with" and "without" a new project.

Impact Mitigation and Contingency Planning

Contingency planning goes beyond the assessment and evaluation phases of impact management. Evaluations of the results of impact assessment models anticipate problems at each phase of a project. Early in the project, planners may use mitigation measures to address problems that are almost certain to emerge. Planners may alter the project's design or construction and operation schedules or negotiate with the company and State and Federal officials for funds.4/ Other potential problems are less certain. In such cases, alternative courses of action--contingency plans--should be prepared.

The objective of contingency planning is to be flexible enough to maintain some balance between the demands of growth and the capacity and capability to meet those demands when the future is uncertain (8). Impact models can be used to

---

4/ Barrows and Charlier stress the use of impact analyses for purposes of negotiating for funds (1, p. 197).

narrow the array of possible problems to those that would be serious. By slightly changing construction and operation schedules or some of the important linking coefficients in the model, the potential magnitude of those problems can be gauged. Alternative plans addressing those problems could involve either mitigating the impacts early in the project or preparing alternative plans of action in case a problem appeared at some future time--that is, preparing contingency plans.

Two groups have a high stake in impact mitigation and contingency planning--local governments and project owners. Project owners can minimize costs if a stable and productive labor force is available and if the project remains on schedule. Their incentive is to ensure adequate housing and transportation and living conditions that are conducive to productivity (6). Local governments have the responsibility for balancing tax revenues and the additional demands for local government services, most notably schools, sewers, health services, water systems, streets, and police protection. Impact management must involve anticipating problems and negotiating funds to address those problems. Specifying mitigation measures and preparing contingency plans are initial steps in that process (20, pp. 97-113).

Planning for contingencies places stringent standards on models. The requirements for data and accurate linking coefficients are formidable. Contingency planning requires a dynamic model, that is, one that accurately forecasts year-to-year changes and also takes into account the interplay of estimates within the model.

Two examples illustrate model uses. In the first, an unexpected delay in a development project's first phase might cause it to overlap the beginning of construction of a second project. Pressures are put on an already tight labor market, driving wages and housing values up and increasing labor inmigration further than initially planned.

Planners and officials can develop alternative plans for addressing this situation. The potential problem might be averted by direct mitigation actions before the project started. A complete rescheduling of the construction and operation phases of both projects could have preceded State and local approval of the project.

A contingency plan--held in reserve in case the problem appeared--might call for the developer to construct housing for temporary workers. Families of some workers would be discouraged from living in the immediate community by that action. The temporary demand for school facilities would also be lessened.

A second example is very common for large projects. Local government revenues typically begin to flow after a project's construction, sometimes several years after operation has begun.5/ In cases where revenues or the magnitude of the changes are uncertain, contingency planning can be valuable. A local government should not contruct a new school before there are students to use it or funds to support it. The uncertain timing of such facilities may require a set of conditional plans, put into action only when the needs become certain.

5/ The lag in tax revenues from a new project will vary greatly from State to State.

Contingency planning requires a dynamic model to anticipate many of the problems that might arise because of the timing of changes and potential sudden alterations in the magnitude of impacts. Plans that are conditional on uncertain events in the future can be developed by using impact models.

IMPACT MODEL CHARACTERISTICS

Each impact assessment model has its own structural design and set of linking coefficients. Similarities among models usually result from the use of similar data or techniques or from similar perceptions of users' desires. The analysis in this report characterizes models according to impact area, kinds of estimates produced by a model, and the techniques used to arrive at the values of linking coefficients (table 2).

Of the 16 models we describe, 15 handle estimates for cases "with" and "without" a project. Only these types are appropriate for impact analyses.

Impact Area

The geographic area of interest--the impact area--for most impact models is the community in which new projects are to be located and its immediate commuting area. While the distribution of benefits and costs is important to policymakers in State and local industrial development programs, the geographic areas involved often are small, limiting the fundamental objectives to the anticipation and amelioration of only major problems. Impact models are not designed as benefit-cost models; they assess only major benefits and costs in a limited geographic area.

The choice of geographic boundaries and units of analysis is severely constrained by data availability. County-level income, employment, and population estimates are available from the Bureau of Economic Analysis, U.S. Department of Commerce (28) and are the most commonly used secondary data. Only one model explicitly addressed the issue of the appropriate boundaries of an impact area (30). A gravity technique defined points of equal influence for a given city or town. Those points defined the impact area under consideration. Others used gravity techniques to allocate aggregate population, income, and other estimates among small geographic areas within a region or State, however.6/

Impact Submodels

Impact models typically are divided into submodels, each of which produces one or a set of estimates. Submodels include employment and income; population and its characteristics; interactions among employment, income, and population; and other effects such as demands for housing and local government services, local government revenue flows, and various social and demographic characteristics that may signal potential problems.

Each submodel is usually built around one of several different techniques. Those techniques invariably influence the structure and overall design of the

---

6/ Reluctance to use past geographic patterns of population distribution as predictors of future patterns may reflect modelers' suspicions that large projects may completely change settlement patterns in a region.

model. The submodels and the techniques most commonly used are identified and explained briefly below (table 3).

The Employment and Income Submodel

The primary purpose of this submodel is to estimate either employment or income. When income is the choice, some average wage coefficient translates income into an employment equivalent. Other practitioners favor employment as the primary objective. They hypothesize that wages may vary greatly, depending upon the growth rate of the local economy, its industrial mix, and the skill mix of the labor force; income is of secondary interest. These practitioners want to factor employment into population by using a varying labor force participation rate that reflects the demand for labor. Several regional economic estimating approaches commonly are used--economic base, input-output (I/O), econometric, or a blend of these (23).

A simple economic base approach measures economic activity in terms of either employment or income. This approach is inexpensive and requires minimal data and calculation. Economic base models usually deal in aggregate changes in the whole system and rarely in individual industry sectors. The economic base model is a very special case of an input-output model with only two sectors. One sector is composed of all of the industries that are "basic" to the local economy, generating a flow of income from outside the region into the local economy. The other sector is "nonbasic," composed of the remaining activities whose demand and sales depend on the basic sectors' activity. The coefficient linking the nonbasic and the basic sectors is a multiplier.

The economic base multiplier, calculated beforehand and incorporated into the model, translates a new level of basic activity into an estimate of total economic activity (13, pp. 11-22). The difference between basic and total activity is nonbasic activity, consisting of a variety of services and goods produced for local use. The multiplier is the ratio of total economic activity to the basic activity, in terms of either income or employment. A multiplier of 1.5 would mean that each unit (dollar or employee) of basic activity on average translates into 1.5 units of total activity--that is, the unit of basic activity plus another 0.5 unit of nonbasic activity.7/

The multiplier is applied to expected basic activities without a new project to estimate baseline totals. Applying the multiplier to basic activities plus a new project results in estimates of total economic activity including the new project under evaluation.

The simple economic base multiplier is an average relationship that assumes equilibrium. Such a multiplier does not estimate the time needed to arrive at equilibrium nor does it identify which nonbasic sectors increase. Furthermore, the average relationship may change as the regional economy changes, making

7/ An important consideration, but one that is abused, is that the same measures be used throughout each complete analysis. The method chosen to calculate multipliers used in the model must be the method used to define baseline activities, for instance. If employment or income is reported in standardized full employment terms, the multipliers in the model must be calibrated to those units. Models are misused when coefficients in the model are built using one method and applied to data that are constructed using another method.

Table 2--Socioeconomic impact models reviewed by characteristics and techniques employed

Characteristic/technique	Models 1/
Type of analysis:	
Impacts from project--no baseline	SIA
Project impacts ("with-without")	ATOM, BATTELLE II, BREAM, CLIPS, COALTOWN, DEISM, DRI, MRMI, NED, NEDAM, OCDSM, PURDUE, REAP, SEAM II, TAMS
Impact area:	
Community	BREAM, CLIPS, DRI, NEDAM, OCDSM, REAP, SEAM II, TAMS
County	ATOM, BATTELLE, COALTOWN, DEISM, MRMI, SIA
State or regions	NED
Nation	PURDUE
Dimensions of models and techniques:	
Employment and income:	
Economic base	BATTELLE II, BREAM, CLIPS, DEISM, DRI, SEAM II, SIA
Input-output	ATOM, NEDAM, OCDSM, REAP, TAMS
Input-output and econometric	MRMI
Economic base and econometric	COALTOWN, NED
Linear programming	PURDUE
Population:	
Cohort-survival	ATOM, BATTELLE, BREAM, CLIPS, DEISM, MRMI, NED, NEDAM, OCDSM, PURDUE, REAP, SEAM II, TAMS
Employment-population ratio	COALTOWN, DRI, SIA

See footnote at end of table.

Continued--

Table 2--Socioeconomic impact models reviewed by characteristics and techniques employed--Continued

Characteristic/technique	Models 1/
Interface of dimension:	
Employment and population	ATOM, BATTELLE II, CLIPS, DRI, NED, SEAM, SIA
Employment, income, and population	BREAM, COALTOWN, DEISM, MRMI, NEDAM, OCDSM, PURDUE, REAPS, TAMS
Spatial disaggregation of impacts:	
None	COALTOWN, DEISM, MRMI, PURDUE, SIA
Subjective	DRI
Existing or adjusted proportions	ATOM, BREAM, CLIPS, REAP, TAMS
Simple or adjusted gravity model	BATTELLE, BREAM, CLIPS, NED, NEDAM, OCDSM, REAP, TAMS
Linear programming model	SEAM
Other dimensions:	
None	ATOM, DEISM, MRMI, NED
Fiscal	BREAM, CLIPS, COALTOWN, DRI NEDAM, OCDSM, PURDUE, REAP, SEAM, SIA, TAMS
Public services	BATTELLE, BREAM, CLIPS, DRI, OCDSM, PURDUE, REAP, SEAM, SIA, TAMS
Housing	BREAM, CLIPS, DRI REAP, SEAM, SIA, TAMS

1/ See the appendix to this report for a glossary of models and their references. Additional references and discussion may be found in (8, 21).

Table 3--Techniques used in socioeconomic impact assessment by assessment objective

Technique	Assessment objective/ assumption or uses
Static approach	To project employment, population, and so forth; assumes status quo will continue.
Economic base	To project basic (export-oriented) employment; estimates, future total employment using an average multiplier.
Location quotient	To estimate the ratio of local service (or induced) employment to basic employment.
Minimum requirements	To estimate the minimum percentage of employment across regions for each industry required to satisfy local needs; assumed any excess is export employment.
Input-output analysis	To estimate how impacts originating in one sector are transmitted throughout other sectors in the economy.
Gravity model	To estimate the geographic distribution of population; uses the initial distribution to distribute the expected population at a future time.
Linear programming	To estimate the geographic distribution of population by minimizing the cost of housing and commuting of workers in the area.
Cohort-survival	To estimate population changes based upon birth and death rates by age and sex.
Targeted service requirements	To estimate changes in public service requirements (for example, water, sewer, and fire protection) that may result from the change in population in the study area.
Fiscal projects	To project public sector revenues and expenditures, baseline and incremental, resulting from a development project.

estimation at some future date unreliable. When used in dynamic situations, the average multiplier probably overstates estimates.

The critical operation in calculating a multiplier coefficient from secondary data is to determine which economic activities are basic and which are nonbasic (14). Mistakes in that operation result in an economic base multiplier that is biased (7).8/ In the simplest case, all activity in each industrial sector is merely assumed to be either basic or nonbasic. For example, manufacturing is assumed to be basic and business services nonbasic.

We can use other techniques to calculate the basic and nonbasic components of economic activity of each industry sector and to find their totals (table 3). The location quotient technique assumes that the basic part of each sector is the amount each sector's activity is above the average proportion for the region. The minimum requirement technique assumes that the basic part of each sector is the amount each sector's activity is above some minimum proportion, typically a lower proportion than that of the region.

The economic base method describes the overall economy at one point in time. This method assumes that the pattern of purchases, productivity, and all other relationships among industry sectors remain the same over the period of analysis, whether economic activity is going up or down. For these reasons, the economic base method is best applied to small changes in an economy with a relatively stable economic base mix.

Input-output models have a high level of industrial disaggregation with linking coefficients which are averages. These coefficients specify the amounts one industrial sector buys from and sells to each other sector at some given point in time. Because data actually gathered in the field are very expensive, many input-output submodels now use readily available secondary data (24).

The advantage of an input-output model is its ability to trace changes in each sector's activity that are caused by some initial change in any one of the others. A change in one sector will affect all other sectors from which it buys supplies or to which it markets its output. Economies with highly interdependent sectors will produce large changes in total regional output as the economic base increases.

Input-output models can produce several different types of multipliers. These multipliers are not equal to economic base multipliers. Multipliers from different input-output models also may have different values and applications (25, pp. 55-66). Input-output multipliers are averages and are used for equilibrium analyses (15).

Input-output relationships also may change over time as the economy of a region changes, although the coefficients of the model usually are not altered during the analysis. Thus, input-output multipliers have some of the same limitations as economic base multipliers.

8/ The degree of sector disaggregation, the level of geographic coverage, and the exact method used to calculate relationships all affect the values of the multipliers and the accuracy of the estimates, whether the technique is economic base, input-output, or econometric.

Econometric models usually estimate aggregate changes in the whole system, even though some estimate changes in each industry. Their comparative advantage is in evaluating the accuracy of the model's linking coefficients. In some cases, they produce dynamic estimates tracing the timing of changes toward a final equilibrium. Secondary data are used to generate the linking coefficients, although the statistical procedures are time consuming and expensive. Econometric techniques typically include regression analyses of time-series and cross-section data. Models applicable to different geographic settings for equilibrium planning usually use cross-section data. Dynamic models allow the linking coefficients within the model to change as the economy changes. Time-series data permit the dynamic to be described and included, although the applicability of such models to different regions may be questioned.

Pooled time-series data from across several different regions through time can account for both geographic differences and the dynamics of change. Econometric techniques can allow modelers to build dynamics into models, but the characteristics of each model will be different, and the accuracy of each model must be evaluated. Econometric models can be very complex. The logic of changes in the estimates can be so complex and obscure that practitioners cannot interpret them; hence, they label the model a "black box."

Approaches to modeling employment and income are often a mixture of different methods sometimes combining elements of economic base, input-output, and

---

Glossary: Techniques

Cohort-survival technique. A procedure for calculating the natural population increase from an intial population over a specified period of time; used in calculating net migration as the difference between natural population increases and a population level consistent with employment and labor force participation.

Cross-section data. Observations of an event at one time across several geographic locations.

Dynamic. Characteristic of a model, procedure, or technique in which year-to-year changes toward a final equilibrium are estimated, taking into account changes in linking coefficients of the model during growth or decline.

Econometric technique. Statistical procedures used to derive a mathematical description of an area's economic system; technique used to derive the linking coefficients and interrelationships of an economic model and to test the accuracy of the linking coefficients and the complete model's forecast accuracy.

Economic base submodel. An employment- and income-estimating procedure that is driven by an aggregate of all basic economic activities, disregarding changes in the composition of the economic base.

Gravity technique. A procedure for distributing population, income, or other model estimates among the local government jurisdictions within an area, usually in proportion to past settlement patterns but with adjustments for other influences such as the cost or time of commuting to and from work.

econometric techniques. Three models we reviewed--COALTOWN, MRMI, and NED--used at least two of these techniques (table 2). Finally, modelers often arbitrarily tailor the coefficients of a model to a particular situation even though data are not available, especially when a model applies to very large developments for which comparable historical observations are not available.

The Population Submodel

Population estimates typically use either cohort-survival or employment-population ratio techniques. The cohort-survival technique starts by applying birth and death rates to an initial population in order to estimate the potential population from indigenous sources at some future period as though migration had not taken place.9/ That process yields estimates of the maximum amount of labor that could possibly come from the initial population, assuming various rates of labor force participation. The difference between that potential labor supply and the estimated future employment is an estimate of net worker migration. Inmigration would occur if demand exceeds supply, or net outmigration if the potential supply exceeds the employment estimate. This

9/ In (26) see page 778 for a brief review of the cohort-component method, and pages 735-42 and 746-50 for technical discussions of age, sex, and geographic estimates.

Input-output submodel. An employment or income submodel driven by changes in each economic sector's demand from outside the area; a detailed description of goods and services bought from and sold to each other sector within the area; traces the effects on each sector in an area of changes in purchases and sales by each sector.

Interface. Interactions among estimates in a model.

Linear programming. A mathematical procedure for estimating the geographic distribution of new residents (as it is applied to impact modeling), yielding the expected distribution of new residents, minimizing the combined cost of housing and commuting, and explicitly taking into account the location of new plants, the availability and cost of new and vacant housing, and the cost of commuting to work.

Location quotient. A procedure for estimating the economic base, yielding the amount of activity in each industry, above its average regional or national proportion of total activity, that is available to handle demands from other regions.

Minimum requirements. A procedure for estimating the economic base, yielding the amount of activity in each industry, above the proportion of total activity a county or area of some assumed minimum critical size, that is available to handle demands from other regions.

Static. Characteristic of a model, procedure, or technique in which time is disregarded and the model's linking coefficients are constant and unchanging, regardless of the rate of economic growth or decline.

Time-series data. Observations of an event in one location through time.

procedure can be amended to include recent migrants as part of the indigenous population in each successive period.

Refinements of the cohort-survival technique have been introduced since its early use in modeling (11). For example, subpopulations with different demographic characteristics, such as university students, military personnel, or racial or ethnic subpopulations, can be analyzed separately. The advantages are that birth and death rates and rates of labor force participation and migration specific to each group can be used to estimate potential future labor force levels. Some models even calculate migration that is unrelated to labor demand.

The cohort-survival approach estimates migration as potential population (with rates of labor force participation applied to it) less the estimates of employment. The rate of labor force participation in this approach frequently takes the form of an assumed average number of family members and an assumed average number of working persons per family. These data are available only from the decennial census. Changes in those averages must be assumed in an attempt to calibrate them to very large economic developments. Because the cohort-survival method estimates the potential age and gender mixtures of the population at some future time period in a "now-then" equilibrium analysis, the method is most appropriately applied to areas with stable economies.

The method using a ratio of employment to population (E/P) recognizes that labor force participation depends upon the demand for labor which may vary substantially during growth. The ratio of employment to population is a rate of labor force participation. This ratio may be based on historical regional data, national ratios adjusted by the user to reflect rapid or slow growth, or an econometric forecast of the ratio based upon prior employment changes (labor demand) and certain regional characteristics.

Population is obtained by dividing estimated future employment by an estimated ratio of employment to population. An estimated population increase has to come from net immigration or an excess of births over deaths. The excess of births over deaths can be estimated by using the cohort survival method from the preceding year's population. This natural increase is a minor part of population increase in periods of rapidly changing economic activity; migration is the major source. Furthermore, population estimated by this method can be disaggregated into school-age or other groups by the same relative weights used in the traditional cohort-survival system in order to gauge the demands for schools and medical services.

Differences between the cohort-survival and the ratio of employment to population methods can be more apparent than real. However, the starting points and the methods of getting the linking coefficients are different and important. In the cohort-survival method, very small changes in assumptions of either the average number of members in each family or in the number employed in each family will affect population and migration estimates greatly.

The similarity between the two approaches is that family size and the number working in each family (used in the cohort-survival approach) translate into an implied ratio of employment to population.10/ A difference of 0.05 in the rate of labor force participation applied to a county population of only 10,000 would result in a 500-person difference in the estimated local labor force response. That, in turn, implies differences in net worker migration, population, housing demand, and local government expenditures.

The population submodel is an extremely vital component of any impact assessment model. Because numerous other estimates are dependent directly on it, one should closely evaluate this submodel.

The Interface Dimension

Estimates produced by impact models interact with each other in the model design. These interactions are the interface dimension. Because a model is a network of relationships, every estimate is probably related at least indirectly with every other estimate. Indeed, under some methods of solving models, each estimate can directly influence the values of all others.

The interrelationships between the employment and population estimates are examples of an interface. The interaction may be a simple balancing of the two with no prior interaction--that is, potential population may be estimated independently of employment. Estimated employment and the population supporting it would be balanced through migration; employment growth which is more rapid than potential indigenous population growth would bring inmigration, but population growth which is more rapid than employment growth would bring outmigration.

A more complex interaction involves employment estimates in calculating population estimates. Employment changes affect labor force participation (the ratio of employment to population) in a succeeding year. Labor force participation then translates into a population level consistent with it.

The most complex interface is the use of one estimate to calculate two other estimates that later are balanced. For example, population affects both government expenditures and revenues. Then the difference between revenues and expenditures is the estimated fiscal balance at a given tax rate.

Interactions among model estimates are required for dynamic or equilibrium analyses. Yet, the complexity of the interrelationships implies that erroneous estimates early in the calculating network magnify other errors introduced at later points in the system (22, p. 361).

The Geographic Distribution of Effects

Expenditures in each local government depend on its population. One can estimate population for a region and then apportion that estimate among

10/ The following example illustrates how the two methodologies might be identical and points out potential sources of errors in population and other impact estimates. Assume an average of 3.5 members per family and an average of 1.5 of the family members working. The implied ratio of employment to population is 0.428--that is, 1.5 workers divided by 3.5 people. In this cohort-survival example, an increase of 100 workers would require 66 new families if 1.5 people in each family of 3.5 members worked, and a population increase of 233 people, the same value produced by dividing new employment of 100 by 0.428.

localities, or one can calculate total local government expenditures associated with population and then allocate the expenditures among local governments.

Population may be distributed on the basis of a gravity technique, a method based on linear programming, or the best judgment of community leaders and planners. In all cases, one must consider commuting time, vacancy rates, availability of private land for housing, and housing costs.

The simplest gravity technique distributes the future population in proportion to the current population.11/ More complex techniques take into account the distance from a specific developmental project as a proxy for the cost of commuting to work. But even with refinements, the gravity technique is less accurate in predicting settlement patterns in rural areas than in urban areas (19, p. 470). Large developmental projects in relation to the local economy can change commuting and settlement patterns from what they were.

Another approach, based on linear programming, attempts to minimize the cost of housing and commuting for workers (27). The linear programming technique constrains the availability and cost of suitable private land for housing, temporary quarters, and rental properties. This technique also considers the cost of commuting.

A special problem with the linear programming approach highlights a fundamental difficulty hidden in all other approaches--the "recovery value" of housing. The initial cost of housing minus its recovery value at some future time is the realized market depreciation cost. Housing used during a temporary boom period would become very expensive if its market value depreciates rapidly afterwards. The recovery value of housing is the most important cost of housing for temporary workers. Linear programming estimates of population distribution and type of housing are particularly sensitive to recovery value.

Many practitioners use their best judgment to estimate population settlement patterns. They maintain that communities have some degree of control over settlement patterns--that is, the outcome depends on decisions made by a community. The attitudes of community leaders and the incentives and disincentives that they impose on housing developers can alter and direct the type and location of new housing. For example, growth patterns can be controlled by restricting or expanding services (9, p. 78).

The location of new housing and public facilities may even be fixed prior to construction and operation of projects. Authorities in some States authorize projects on condition that developers provide new housing and other public facilities beforehand. Community leaders may use contingency planning as a part of the authorization process to anticipate the expected amount and timing of population changes. By altering the scheduling of construction, one can use assessment models to yield upper and lower bounds for housing estimates. Authorities may also preselect the most advantageous taxing jurisdictions in which to locate new projects, housing, and other facilities. These uses of impact assessment models go beyond that necessary for NEPA.

11/ See (12) for applications of the gravity technique.

Other Dimensions

Population estimates are extremely important because they provide the basis for many additional impact estimates. These estimates include housing and public services, such as water and wastewater treatment and disposal, solid waste management, education, health services, law enforcement, fire protection, and libraries.

Planning coefficients imbedded in the model translate population estimates into other estimates. For example, an average number of persons per family or the number of workers per family may be used to estimate new households. An average expenditure per person or household for each local government function yields an estimate of total expenditures.

Practitioners also can use linking coefficients derived from regression analyses to estimate local government expenditures. However, data limitations force the use of a two-step process. The Census reports only expenditures by function for county-level aggregates. Thus, county population is associated only with county expenditures. The county totals are allocated to local government jurisdictions using methods parallel to those for allocating population.

Capital expenditure budgets are derived by using engineering and planning coefficients in relation to the population. The square feet of school buildings per pupil multiplied by the number of pupils and the cost per square foot yields school-building costs, for example. The largest capital outlays are for roads and streets, schools, water and sewage systems, and hospitals. Communities are especially interested in the timing of capital outlays, because local planners need reasonable certainty that new facilities will not go unused and that revenues will be available.

Although one of the more important dimensions of impact assessment models is local government revenues, revenue estimation is difficult. Tax codes change frequently, and local government revenues vary greatly from State to State, among local governments, and from industry to industry. The expense of updating and maintaining a revenue estimating system frequently prevents its use in models. Furthermore, the complexity of State and local revenue systems results in errors when simplified calculations are made.

The most accurate method of revenue estimation involves tracing through every source of potential revenue change. First, one must identify every potential source of change in the tax base. Then, one can trace the exact distribution of revenue from those sources through the system to the government that spends the revenue.

Local governments in some States depend heavily upon property taxes as a source of revenue. Other States share their revenues among local governments based upon population in some cases and complex formulas in others. Many States fund local governments in relation to local effort and other criteria. School revenues often are a combination of local revenues plus revenues from the State's school foundation program. Finally, some local revenues are from users fees and local collections, such as hospitals and water and sewer fees.

The interrelationships among all of those sources can become very complex, with spending from State sources decreasing as spending from local sources increases, for example. Although some models use equations based upon assessed values, population, income, and business receipts, the most accurate revenue estimation system takes account of the exact detail of every tax code and revenue distribution formula, tracing all changes from source to final disposition--a revenue and expenditure algorithm.

IMPACT MODEL LINKING COEFFICIENTS

Prior to using a model, one must derive the values of linking coefficients in one of several ways, the best judgment of the analyst or knowledgeable community leaders, linear extrapolations of current trends, national, regional, or county averages, averages from other counties that are similar in regard to the conditions being addressed, averages that are assumed to change as development occurs, or econometric forecasts from a broad data base.

Linking coefficients describe the amount that one estimate affects others. Linking coefficients are averages--that is, they describe what happens on average. In deriving the value of linking coefficients, one must answer several critical questions: Does the average represent the data from which it is calculated? What is the chance that the impact area is well described? Does economic growth or decline change the coefficients?

Too often shortcut methods are used to derive linking coefficients. Relying on "best judgment" is to rely on the artistry of the analyst. Extrapolations of current trends assume the same forces will be working in the future. Simple averages of national, regional, or county data not only assume that relationships will be the same, but also that the average describes the impact area under study. Model designers must be sure that linking coefficients are accurate and that users know the statistical properties and accuracy of the coefficients.

Certain statistical methods can help. First, the linking coefficients can be tailored to the unique conditions in an impact area. Second, the accuracy of the coefficients can be gauged. Large banks of data are used for those purposes. The data are observations of each measure through time (a time series) or across a number of places (a cross section). From those data, one then computes an average coefficient. In the best of cases, a very large proportion of observations lies close to the overall arithmetic average rather than being widely scattered. Chances are good that such an average effectively describes a large proportion of the population from which it is computed.12/ When observations are widely scattered, the average would not be a good description of a large portion of the whole population.

Other simple statistical methods produce a more effective descriptor from a set of observations. One method separates observations into different groups on some preconceived basis. For illustration here, some observations may be metropolitan areas and others nonmetropolitan. Each group has an average that more effectively describes the observations in it than does the overall

---

12/ Arithmetic averages should always be computed from normally distributed observations.

average.13/ Chances are good that averages of population density, labor force participation, age, and other measures would be significantly different.

Simple statistical tests measure the effectiveness of these averages compared with the overall average--that is, whether the descriptive power of the averages has been improved by separating the population into groups. This methodology can be misleading, however, because it attributes all of the differences in the averages to their metropolitan status in this example. We know that much of the difference could be attributed to industry mix, transportation systems, or communications, for instance.14/ Additional refinements would involve several different classifications and cross classifications of data into distinct subgroups.

Another step is similar to using simple averages but takes more influences into account. Multiple regression techniques automatically separate observations into groups on the basis of those influences thought to be important. These analyses tell the amount and direction that the average changes when each characteristic of an area is different. This technique tailors the linking coefficient to important characteristics of the area under study, increasing the chances that a particular linking coefficient describes the impact area.

Multiple regression analyses may also indicate changes in linking coefficients with growth or decline. Dynamic changes are reflected in a model as an area grows or declines. For example, labor force participation increases as the demand for labor increases; that is, rates of labor force participation in 1 year will be higher as a result of employment increases in the prior year. A higher labor force participation in turn translates into fewer new people to fill jobs. Instead, the residents supply additional labor. Thus, one model using a fixed average rate of labor force participation would predict a larger population change than a model with rates of labor force participation that increased as a result of economic growth in the area.

Despite the accuracy of individual linking coefficients, a model may predict inaccurately because of the way model coefficients interact with one another. Thus, estimates produced by the complete model should be compared with the historical record.

UNRESOLVED ISSUES

Certain issues remain unresolved in many large scale impact models. Because there is a distinct pattern of one model evolving from predecessors, the same issues and problems posed in early models tend to be passed along from one generation of models to others.

Model Structures

The complexity of model structures is closely associated with the possibility of forecast errors. Forecast errors begin when one linking coefficient early

13/ This simple method is reflected in attempts to use coefficients computed from a group of observations from areas that are "similar" to the impact area. However, that approach has proven to be untrustworthy.

14/ This situation is called a misspecification of the problem and is also a serious concern with advanced methods.

in a model is ineffective in describing future outcomes.15/ It produces an unreliable estimate. That estimate produces yet another estimate in the calculation chain. The second estimate is often more unreliable than the first--that is, the error is compounded, not simply carried forward or cancelled. The longer the chain of estimates made from each prior one, the greater is the chance that errors will be magnified (22, p. 361). Thus, several linking coefficients that are erroneous will multiply forecast errors unless each neatly counterbalances the preceding errors.

This difficulty leads to some general guidelines about model structures. First, the number of estimates in a model should be kept at a minimum, minimizing the number of links in the chain where errors can be introduced.16/ Second, estimates made in a model should be aggregates when appropriate in order to minimize unnecessary linkages. If each subclass of population, for example, is estimated separately and then summed to the total population that is to be used later, then needless links are used to arrive at a total. Third, forecasts for early years are probably more accurate than for later years. In this case, the forecasts for 1 year are used in making the next year's estimates. Each additional time period perpetuates and magnifies forecast errors.

Impact models are designed for many different uses, and they necessarily must be complex to provide forecasts for a variety of purposes. In the final analysis, users should know the accuracy of models in estimating events of the past or for other regions. With notable exceptions, few models are evaluated in this way.

Nature of Existing Data

Certain data characteristics cause difficulty in judging the accuracy of linking coefficients, whether the coefficients are derived from simple averages or by using other statistical techniques.17/ Special econometric procedures address such problems.

Three common difficulties--serial correlation, multicollinearity, and spatial interdependence--relate to a series of data through time, the interrelatedness of an area's characteristics, and the linkage of an area to the economies of its neighbors. In the first case, a linking coefficient's effectiveness can be overstated by the statistical analysis when using time series data.18/ In the second case, identifying a specific characteristic

---

15/ Errors also can be introduced at the start when incorrect information about the local area is given to the model as a starting point.

16/ This statement does not mean that the model should be simplistic or naive. Rather, we recognize that the sources of forecast errors within the model must be minimized.

17/ In addition, the accuracy of data used in models is open to question. Miernyk (17) concludes that "...our capacity to develop highly sophisticated regional models has far outrun our ability to implement them, given the primitive nature of available data...."

18/ Serial correlation occurs when an observation at one time period is not independent of others at later time periods: the accuracy at one time is not independent of the accuracy at later time periods. This situation biases the calculated variances of the estimates and contributes to overconfidence in the accuracy of a coefficient (16, p. 275).

causing differences in a linking coefficient's value becomes difficult when the characteristics within the impact area are closely related.19/ Finally, when the impact area is adjacent to a large town or city, some events in the impact area are directly associated with events in the adjacent area. Yet, that association is difficult to separate out and take into account in the model's linking coefficients.

Those who wish to evaluate impact models should, at the very least, receive a description of the models' linking coefficients, the purpose of each coefficient, and an explanation of how they fit together. The statistical properties of the models' coefficients, procedures for deriving the coefficients, and each coefficient's accuracy should be available to users for evaluation by independent authorities. The best evaluation of a model is to compare its forecast with actual historical events in some prior use of the model.

Issues Beyond Current Technology

Current technology does not adequately address specific issues that would be helpful for purposes of using models for impact management and contingency planning.20/ These issues are dynamics, prediction of settlement patterns, and uncertainty. These topics pose challenges for future research.

Dynamics

Most of the impact models we reviewed are of the equilibrium type. Except for pure planning models, equilibrium models are appropriate for preparing NEPA environmental impact statements. These models are not appropriate for estimating annual changes because a new equilibrium is not probable in the same period as the initial change. Dynamic models do estimate year-to-year changes by allowing only a partial movement each year toward the final equilibrium.

A year-by-year path of an economy is required for contingency planning as a part of impact management. Population estimates that translate into expenditures for community services, for example, have to be related to the year-to-year flows of revenues that support those services. Thus, accurate representations of the dynamics of change are important. At this point, the technology of impact modeling has not yielded many dynamic models that can be applied to contingency planning.

Settlement Patterns

Revenue flows will not match expenditures for local government services when workers in a new industrial development choose to live in a nearby area whose government does not benefit from the new industrial tax base. Impact models cannot anticipate this common problem accurately. Such a model requires accurate forecasts of setlement patterns to gauge the year-to-year adequacy of

---

19/ Multicollinearity is the correlation among two or more of the independent variables. It produces larger variances of the estimators than is true, leading to a possible lower reported level of confidence in coefficients than is valid (22, p. 66).

20/ Halstead and others (10) recommend close monitoring of the progress of construction and operation of new facilities as a method of circumventing these difficulties.

the revenues of local governments in advance of potential impacts and as a prelude to contingency planning.

Current impact models are quite inexact in predicting settlement patterns. That fact signals that careful planning and zoning and possibly the use of preconditions for authorizing permits must be used in impact mitigation, planning, and management.

Uncertainty

Impact models do not directly address questions relating to uncertainty, such as: What is the chance that planned construction and operation schedules will be changed? Will the price of the product change and affect the plant's operations? Will the operation slow down significantly during recessions? Will the industrial facility close early?

Sensitivity analysis can provide partial answers. One can vary scenarios of the project in repeated runs of a model as an experiment to see the impact estimates most sensitive to each change. Even more fundamental to this issue is the probability that one of these problems will appear.

The problem of uncertainty as it relates to impact management and contingency planning can be stated as "... the essence of the planning problem.... The public is not well served by a strategy that simply plans for the most likely future..." (5). Perhaps the best advice to prospective model users is to treat impact models as "sophisticated calculating mechanisms" and not modern-day crystal balls.

REFERENCES

1. Barrows, Richard, and Marj Charlier. "Local Government Options for Managing Rapid Growth," Chap. 8, Coping with Rapid Growth in Rural Communities. Ed. Bruce A. Weber and Robert E. Howell. Boulder, CO: Westview Press, 1982, pp. 193-220.

2. Beale, Calvin L. "The Recent Shift of United States Population to Nonmetropolitan Areas 1970-75," International Regional Science Review, Vol. 2, No. 2, Winter 1977, p. 113.

3. Beckhelm, Terrance L., James A. Chalmers, and William M. Hannigan. ATOM 3: A Description of ATOM 3 and of the Research Related to Its Development. Arizona Off. Econ. Plan. and Dev., Bur. of Bus. and Econ. Res.; and Arizona State Univ., Dept. of Economics, July 1975.

4. Bender, Lloyd D. Differences in the Timepaths of Service Employment Responses: Rapid Growth and Local Planning. ERS Staff Report AGES 841201. U.S. Dept. Agr., Econ. Res. Serv., Dec. 1984.

5. Chalmers, J. A., and E. J. Anderson. Economic/Demographic Assessment Manual. U.S. Dept. Int., Bur. Rec., Nov. 1977.

6. Cummings, Ronald G., and William D. Schulze. "Optimal Investment Strategy for Boom Towns," American Economic Review, Vol. 68, No. 3, 1978, pp. 374-85.

7. Gerking, Shelby D., and Andrew M. Isserman. "Bifurcation and the Time Pattern of Impacts in the Economic Base Model," Journal of Regional Science, Vol. 21, No. 4, 1981, pp. 451-67.

8. Gilmore, J. S., and others. Socioeconomic Impacts of Power Plants. EPRI EA-2228. Palo Alto, CA: Electric Power Research Inst., Feb. 1982.

9. Goodwin, H. L., Jr., Gerald A. Doeksen, and Robert L. Oehrtman. "Determination of Settlement Patterns in Rapidly Growing Rural Areas," The Annals of Regional Science, Vol. 18, No. 3, Nov. 1984, pp. 67-80.

10. Halstead, John M., and others. Socioeconomic Impact Management. Boulder, CO: Westview Press, 1984.

11. Hamilton, H. R., and others. System Simulation for Regional Analysis: An Application to River-Basin Planning. Cambridge, MA: Massachusetts Inst. of Technology Press, 1969.

12. Haynes, Kingsley E., and A. Stewart Fotheringham. Gravity and Spatial Interaction Models. Sage Scientific Geography Series, Vol. 2. Beverly Hills, CA: Sage Publications Inc., 1982.

13. Hustedde, Ron, Ron Shaffer, and Glenn Pulver. "Community Economic Analysis: A How To Manual," North Central Regional Center for Rural Development, Iowa State Univ., 1984.

14. Isserman, Andrew M. "Estimating Export Activity in a Regional Economy: A Theoretical and Empirical Analysis of Alternative Methods," International Regional Science Review, Vol. 5, No. 2, Winter 1980, pp. 155-84.

15. Jensen, R. C. "The Concept of Accuracy in Regional Input-Output Models," International Regional Science Review, Vol. 5, No. 2, Winter, 1980, pp. 139-54.

16. Kmenta, Jan. Elements of Econometrics, New York, NY: Macmillan Publishing Co., 1971.

17. Miernyk, W. H. "Comments on Recent Developments in Regional Input-Output Analysis," International Regional Science Review, Vol. 1, No. 2, 1976, pp. 47-55.

18. Miller, James P. Interstate Competition for Business: Changing Roles of Federal and State Initiatives. ERS Staff Report AGES 831012. U.S. Dept. Agr., Econ. Res. Serv., Dec. 1983.

19. Murdock, S. H., J. S. Wieland, and F. L. Leistritz. "An Assessment of the Validity of the Gravity Model for Predicting Community Settlement Patterns in Rural Energy-Impacted Areas of the West," Land Economics, Vol. 54, No. 4, Nov. 1978, pp. 461-71.

20. Murray, James A., and Bruce A. Weber. "The Impacts of Rapid Growth on the Provision and Financing of Local Public Services," Chap. 4, Coping with Rapid Growth in Rural Communities. Ed. Bruce A. Weber and Robert E. Howell. Boulder, CO: Westview Press, 1982, pp. 97-113.

21. Nelson, Marlys Knutson. Socioeconomic Impact Models: An Annotated Bibliography. ERS Staff Report AGES 850228. U.S. Dept. Agr., Econ. Res. Serv., Feb. 1985.

22. Pindyck, Robert S., and Daniel L. Rubinfeld. Econometric Models and Economic Forecasts. New York: McGraw-Hill Book Co., 1976.

23. Pleeter, Saul. Economic Impact Analysis: Methodology and Applications. Boston, MA: Martinus Nijhoff Publishing Co., 1980.

24. Round, Jeffery I. "Nonsurvey Techniques: A Critical Review of the Theory and the Evidence," International Regional Science Review, Vol. 8, No. 3, 1983, pp. 189-212.

25. Shaffer, Ron. "Estimating Local Income Multipliers: A Review and Evaluation of the Techniques for Ex Ante Use," Proceedings of the Ex Ante Growth Impact Models Conference. Ed. Leroy J. Husak and George Morse. North Central Regional Center for Rural Development, Iowa State Univ., 1979, pp. 43-73

26. Shryock, Henry S., and Jacob S. Siegel and Associates. The Methods and Materials of Demography, Volume 2. U.S. Dept. Comm., Bur. of the Census, June 1980.

27. Stenehjem, Erik. Summary Description of SEAM: The Social and Economic Assessment Model. U.S. Dept. Energy, Argonne Natl. Lab., Apr. 1978.

28. U.S. Department of Commerce, Bureau of the Census. "Regional Economic Information System." Annual computer files.

29. U.S. General Services Administration. Code of Federal Regulations. Title 40, Parts 1500-08.

30. Woods, Michael Denton. "A Simulation Model for Rural Communities in Oklahoma." Ph. D. dissertation. Oklahoma State Univ., 1981.

APPENDIX: MODELS REVIEWED

Acronym	Documentation
ATOM	Battelle Columbus Laboratories. Final Report on Development of the Arizona Trade-Off Model. Arizona Dept. of Econ. Plan. and Dev., Mar. 1973.
	Beckhelm, Terrance L., James A. Chalmers, and William M. Hannigan. ATOM 3: A Description of ATOM 3 and the Research Related to Its Development. Arizona Off. Econ. Plan. and Dev., Bur. of Bus. and Econ. Res.; and Arizona State Univ., Dept. of Economics, July 1975.
BATTELLE II	Cluett, Christopher, and Jeffrey Jacobsen. Socioeconomic and Demographic Forecasting Model. Battelle Human Affairs Research Center and U.S. Dept. Energy, May 1978.
BREAM	Chalmers, J., and E. Anderson. Economic/Demographic Assessment Manual. U.S. Dept. Int., Bur. Rec., Nov. 1977.
CLIPS	Monts, J. Kenneth, and E. Ray Bareiss. Community-Level Impacts Projection System. Texas Energy Advisory Council and Center for Energy Studies, Univ. of Texas at Austin, Feb. 1979.
COALTOWN	Bender, Lloyd D., George S. Temple, and Larry C. Parcels. An Introduction to the COALTOWN Impact Assessment Model. EPA-600/7-80-146, U.S. Env. Protection Agcy. and U.S. Dept. Agr., Econ. Res. Serv., Aug. 1980
DEISM	Governor's Office of Planning Coordination. Nevada's Demographic and Economic Impact Simulation Model. Dec. 1978.
DRI	Denver Research Institute, Resource Planning Associates. Socioeconomic Impacts of Western Energy Resource Development. U.S. Dept. Energy, June 1979.
MRMI	Harris, Curtis, Jr. "New Developments and Extensions of the Multiregional, Multi-Industry Forecasting Model," Journal of Regional Science, Vol. 20, No. 2, May 1980.
NED	Reeve, Ross, Rodger Weaver, and Eric Natwig. The Navajo Economic-Demographic Model: A Method of Forecasting and Evaluating Alternative Navajo Economic Futures, Vol. 1. Navajo Tribe and Utah Off. of State Planning Coordinator, Off. of Prog. Dev.

Acronym	Documentation
NEDAM	Chase, R. A., and others. Expansion and Adaptation of the North Dakota Economic-Demographic Assessment Model for Montana: Technical Description. Misc. Rpt. No. 61. North Dakota State Univ., Dept. of Agr. Econ.
OCDSM	Woods, Michael Denton. "A Simulation Model for Rural Communities in Oklahoma." Ph. D. dissertation. Oklahoma State Univ., 1981.
PURDUE	White, T. Kelley, and others. The Purdue Development Model: A Systems Approach to Modeling Demographic-Economic Interaction in Agricultural Development. Agr. Exp. Sta. Res. Bul. No. 925. Purdue Univ., Oct. 1975.
REAP	Johnson, A. William, and F. Larry Leistritz. The REAP Economic-Demographic Model 1: User Manual. North Dakota State Univ. and North Dakota Reg. Env. Assess. Prog., Dec. 1976.
	Hertsgaard, Thor, and others. REAP Economic-Demographic Model: Technical Description. North Dakota State Univ. and North Dakota Reg. Env. Assess. Prog., Aug. 1978.
SEAM	Stenehjem, Erik, and James Metzger. A Framework for Projecting Employment and Population Changes Accompanying Energy Development. Phase I and Phase II. U.S. Dept. Energy, Argonne Natl. Lab., Aug. and Oct. 1976.
	Stenehjem, Erik. Summary Description of SEAM: The Social and Economic Assessment Model. U.S. Dept. Energy, Argonne Natl. Lab., Apr. 1978.
SIA	Murphy/Williams Urban Planning and Housing Consultants. Socioeconomic Impact Assessment: A Methodology Applied to Synthetic Fuels. U.S. Dept. Energy, Apr. 1978.
TAMS	Murdock, S., and others. The Texas Assessment Modeling System: User Manual. Texas Center for Energy and Min. Res., Texas Rural Dev. Prog., and Texas Agr. Exp. Sta., Texas A&M Univ., Sept. 1979.

☆U.S. Government Printing Office : 1986 -180-917/40694