A Model for Projecting Localized Economic, Demographic, and Fiscal Impacts of Large-Scale Projects

F. L. Leistritz, S. H. Murdock, N. E. Toman and T. A. Hertsgaard

For rural areas in which large scale industrial and resource development projects are located, the need for timely projections of the magnitude and location of economic, demographic, fiscal and other likely impacts is clearly apparent. The purpose of this paper is to describe a computerized model for projecting the effects of large scale developments on business activity, personal income, employment, population, requirements for selected public and quasi-public services, and public sector costs and revenues and to demonstrate the utility of the model for projecting local area impacts. The structure, data base, and interrelationships of each of the model's six major components are described. Its validity in simulating economic and demographic changes at regional, county and municipal levels is then evaluated.

Recent trends toward industrial decentralization have led an increasing number of firms to locate new facilities in rural areas [Summers *et al.*]. Similarly, changes in the nation's energy supply patterns point toward the development of large-scale energy resource extraction and conversion projects in sparsely populated rural areas, particularly in the West [Federal Energy Administration]. These developments present both an opportunity and a threat to nearby communities. While new industrial and resource development projects offer the benefits of new jobs and stimulus to the local economy, they also bring rapid population growth which few rural communities are prepared to handle [Gilmore *et al.*].

The socioeconomic patterns occurring during the construction and operation of large electric generating plants exemplify the paradoxical effects of many types of industrial facilities on rural areas. Such developments often lead to long desired increases in local employment and to general economic growth in the area. On the other hand, the total magnitude and speed of population growth associated with such projects, the fluctuations of such patterns during the project's life, the public service demands created by the growth and the uncertainty of the specific location of many of the impacts create severe planning problems for local areas.

Since public service needs fluctuate with population, local areas often must decide whether to build facilities to meet the requirements during a project's construction phase, and then face the possibility of having substantial excess capacity during the opera-

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tional phase, or to meet the requirements after the project is established [Cummings and Mehr; Cummings and Schulze]. In either case the demands for new services resulting from a new project likely will precede the revenues from it [Gilmore *et al.*; Toman *et al.*, 1977], and changes in the settlement patterns of new workers often negate the impacts some communities expect [Murdock *et al.*; Wieland *et al.*]. Hence, the need for timely projections of the magnitude and location of economic, demographic, fiscal and other impacts of new industrial developments is clearly apparent.

Unfortunately, however, information from environmental impact statements is often not specific enough for local planning and may be outdated by changes in project characteristics when it becomes available. In addition, despite the growing number of impact statements [Council on Environmental Quality] and the widespread preparation of manuals and books explaining impact assessment procedures [Abt Associates; Chalmers and Anderson], assessment reports often are difficult to understand and impossible to adapt to specific planning needs. It is not surprising, then, that local decision makers and planners increasingly demand impact assessment techniques that provide local area projections for a variety of economic and social factors in a timely and flexible manner.

The purpose of this paper is to describe the development of a computerized model for projecting the effects of large-scale developments on business activity, personal income, employment, population, requirements for selected public and quasi-public services, and public sector costs and revenues. Each major component of the model is briefly described and its usefulness is demonstrated with an assessment of the impacts of an electric generating-coal gasification facility in western North Dakota.

Model Characteristics

The economic-demographic projection model provides baseline and single- or multiple-project impact projections for all eight-state planning regions in North Dakota. The planning regions correspond to the trade areas of the state's major urban centers. Outputs are available as selected by the individual user at the regional, county, and municipal levels and include such variables as type of employment, population, population by age and sex, school enrollments by age, housing requirements by type, public sector costs and revenues by type, and net fiscal balance. Estimates of business activity, personal income, and requirements for medical and criminal justice services are available at the regional level.

A number of economic-demographic projection models have been developed in recent years [Ford; Hertsgaard *et al.*; Stenehjem]. The model described here, however, has a combination of unique characteristics.

First, the model provides projections for the (multi-county) region and for all municipalities in all the counties. Although other models provide outputs for regions [Olsen *et al.*] or county level projections [Cluett *et al.*; Stenehjem], and a few are community oriented [Ford], no other provides outputs at each of these levels.

Second, the model provides *annual* projections of a variety of economic and demographic indicators under both baseline and impact conditions over a 25-year planning horizon. This specificity through time and for both baseline and project construction and operational periods is a feature shared by very few other models.

Third, the model incorporates a wide range of specific inputs that help differentiate between development phases and types of impacts. For example, the model incorporates project-specific information on input purchasing patterns and includes functions which differentiate between project construction and operation and between permanent workers and indirect workers in such dimensions as local hiring rates, family sizes, settlement patterns, and types of housing.

Fourth, the model is user interactive; the user has the option of altering a number of the model's assumptions and parameters and of choosing the output reporting options desired. Key parameters in all components can be altered and reporting options allows the user to select specific types of output and to choose the specific areas for which outputs are desired.

Model Structure

The model consists of six basic components: 1) An Economic Input-Output Module; 2) A Cohort-Survival Demographic Module; 3) An Economic-Demographic Interface Module; 4) A Residential Allocation Module; 5) A Service Requirements Module; and 6) A Fiscal Impact Module. A generalized flow diagram is presented in Figure 1 with a general description of each component presented below. A detailed description of the model's initial structure and data base is provided in Hertsgaard *et al.* and an expanded version in Toman *et al.* These documents and other descriptive materials are available from the authors on request.

The Input-Output Module

The input-output module estimates gross business volume by economic sector for a specified level of final demands for the area's products. Employment requirements by sector and development phase then are derived from the estimates of gross business volume. The input-output model employed was derived from primary data collected by personal interviews from firms and households in southwestern North Dakota. The model was developed by Sand and Bartch, and the coefficients were subsequently tested for validity by Senechal. For detailed discussions of the theory and procedures of input-output analysis, see Leontief and Richardson.

A region's baseline employment is estimated by first using econometric techniques to develop projections to 1999 of sales to final demand (essentially exports) for each of the region's basic sectors. (Baseline employment refers to the level of employment necessary to support the level and types of economic activity likely to be present in the region in the absence of major new development projects.) These projections were developed using historical data for the period 1958 through 1975. Regressions of time on the sales to final demand of each sector were undertaken using linear, logarithmic, exponential, and quadratic functional forms. The quadratic form gave the best fit in most cases. These projections were then reviewed by industry experts who indicated that they were consistent with current trends and emerging forces affecting the various sectors.

Application of the input-output interdependence coefficients to the projected final demand vectors results in the estimates of gross business volume for each sector. The procedure for translating gross business volume in the respective sectors to employment involves dividing gross business volume in each sector by gross business volume per worker in that sector. Gross business volume per worker was computed from historic employment data for the years 1958 through 1975 for each of the sectors and projected to 1999 using procedures similar to those used in projecting sales to final demand.

Assessment of the impact of a new energy project is based on a set of project-specific data assembled for each project. Key elements of the project data file include: a) Project location, b) Annual estimates of construction and permanent employment, c) Annual estimates of local purchases by sector, and d) Estimates of total plant investment and taxable value. Other data in the project data file are the initial construction date, the date when commercial production begins, land requirements for permanent facilities, average acreage to be mined annu-

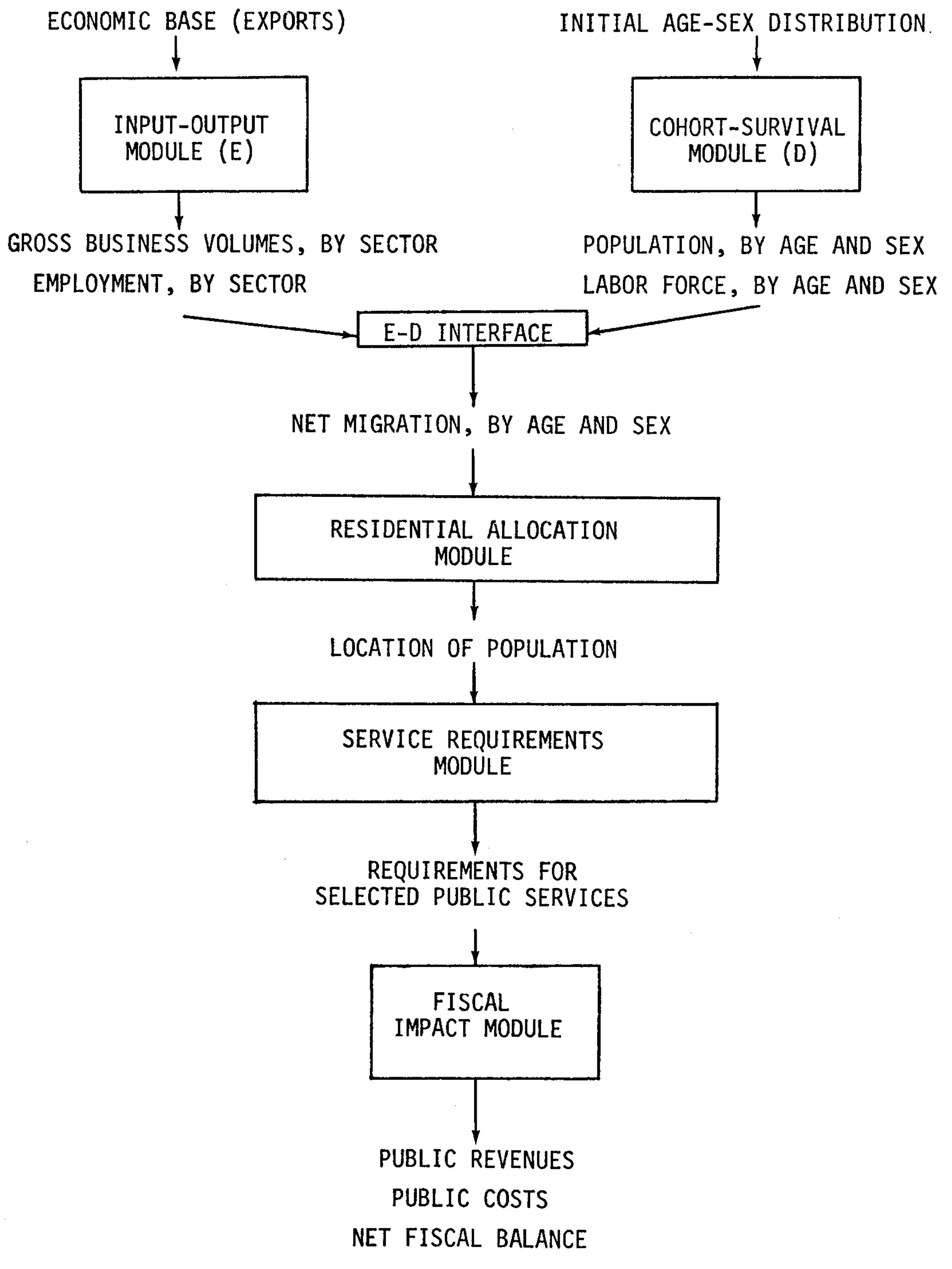

Figure 1. Data and output flows of economic-demographic model.

ally (if any), and average annual production of electricity, coal and synthetic gas (whichever apply). The estimated local purchases provide the basis for estimating the amount of indirect and induced employment resulting from each project. The end result of the economic module calculations is an estimate of total required employment for the economic baseline and for any set of development projects. This estimate of total required employment is later used in the economic-demographic interface component.

The Cohort-Survival Demographic Module

The cohort-survival form of demographic model was selected because it is accepted as among the most accurate projection techniques and provides more detailed output than other methods.[1] The cohort-survival method of population projection applies a set of birthrates, migration rates, and survival rates to a set of baseline population data for a projected period in order to determine end-of-period population. Rather than utilizing total population figures, this method employs a set of age-sex cohorts showing persons of the same sex born during the same period of time. Sets of mortality, migration, and fertility rates are specified for each of these cohorts. Cohort rates for the projected period are applied to the population in each cohort to estimate an area's future population. Thus the cohort-survival module projects population in each age and sex cohort through the basic population equation:

$$P_{t_2} = P_{t_1} + B - D + M$$

Where: P_{t_2} = Population at a given future year, t_2; P_{t_1} = Population at a preceding base year, t_1; B = Births between t_1 and t_2; D= Deaths between t_1 and t_2; and M = Net migration between t_1 and t_2.

Seventy-five single-year age cohorts were used for each sex. The initial population values were taken from the 1970 Census of Population. Rates for the processes of migration (for those older than 65), mortality, and fertility were based on historic data.[2] Future migration rates for persons less than 65 years old were determined through the interface procedure described in the next section. Future patterns for survival rates and fertility rates are assumed to follow national trends over time with a fertility level of 2.1 births per adult female being used as a default value.[3] This fertility level results in a replacement level of births and reflects current levels of fertility.

The Economic-Demographic Module Interface

The interface component links the projections of required employment from the input-output module with the projections of available labor force from the demographic module to determine the level of employment needs that can be met by the indigenous population and those that must be met by the in-migration of new workers. The interface module is applied at the county level, is fully employed in both baseline and impact projections and operates with the following order of structural components and procedures (see Figure 2).

(1) Projected employment requirements are grouped into four broad employ-

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[1]For a discussion of alternative population projection techniques and their relative capabilities, see Barclay and Shryock and Siegal.

[2]Age-sex specific migration rates for North Dakota counties for 1960-1970 were taken from Bowles *et al.* Survival rates were computed from life tables from Ludtke and Blair. Age-specific fertility rates were computed from births by age of mother for 1972, 1973, and 1974. These data were obtained from the Division of Health Statistics, North Dakota State Department of Health.

[3]The fertility rates are computed for each female cohort from 10-45+ years of age. The sum of these age-specific rates for all cohorts is the total fertility rate. In the present model, the user is allowed to choose a total fertility rate ranging from 1.8 to 2.5 for the projection period. These rates are used in the computation of age-specific rates that would result in the user selected average number of births (during her lifetime) per female in a population. The rates resulting in a 2.1 level of completed fertility are utilized in the model if the user does not specify some other permissible value.

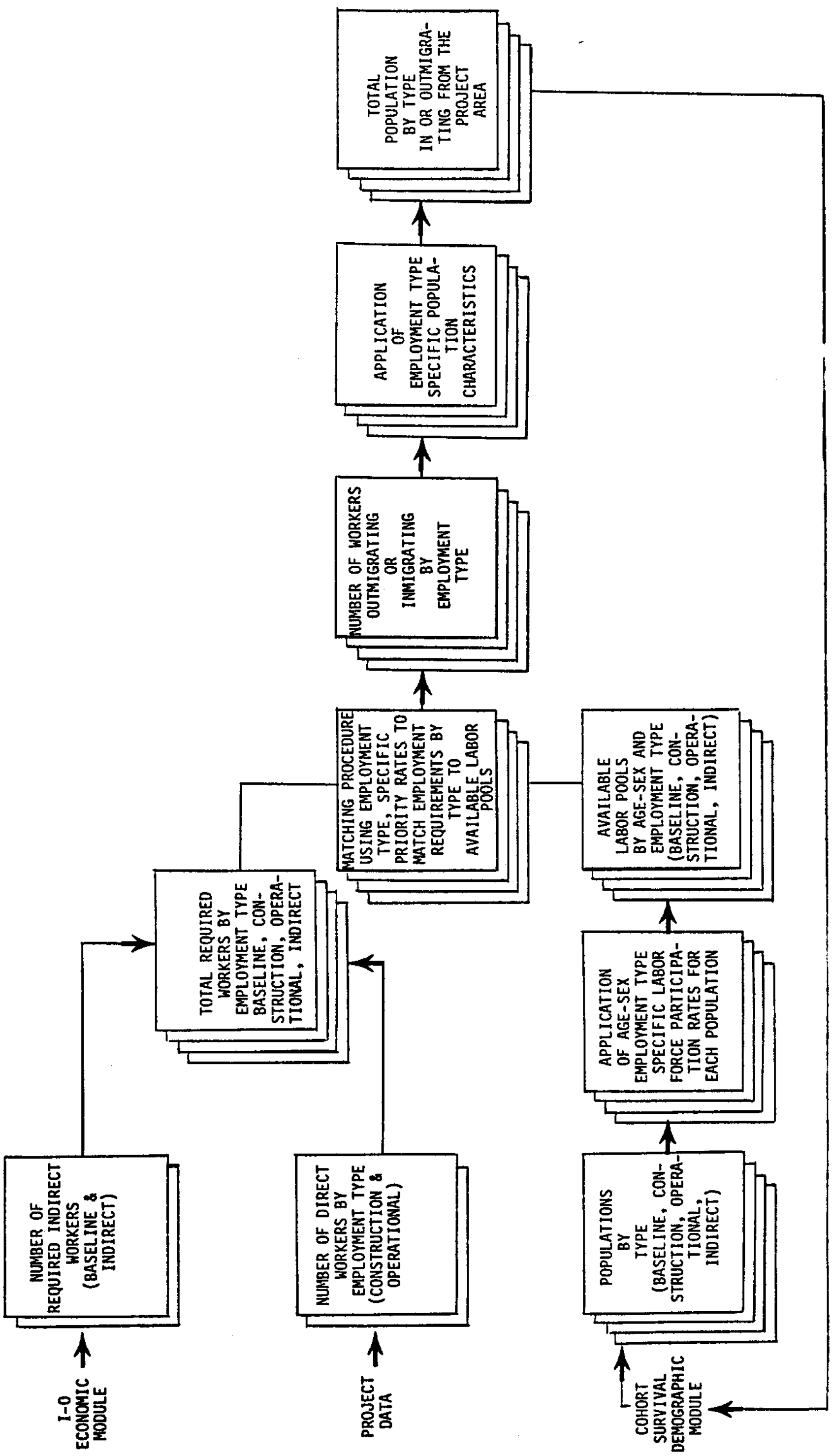

Figure 2. Flowchart of interface module of economic-demographic model.

ment types: baseline (i.e., all employment resulting from baseline economic activity), project-related construction, project-related permanent, and project-related indirect. Employment estimates for these four types of employment are maintained as separate outputs from the economic (I-O) module and from data on project characteristics. Under the baseline conditions, of course, only projections of baseline employment are produced.

(2) During baseline projection periods and in the year preceding project construction, estimates of the number of available workers are obtained by the application of county-level age-sex specific labor force participation rates to age-sex cohorts derived from the demographic model. This produces the number of total workers available in each age-sex group at that time. A similar procedure is followed under impact conditions. However, age-sex specific estimates of available labor pools are obtained for each of the baseline, construction, operational and indirect types of employment related populations for each period by the application of labor force participation rates that are specific to each age-sex group and each type of employment to their age-sex cohorts. Throughout all impact analyses, these employment and population types are retained as separate computational units.

(3) Given the labor requirements by employment type as derived from (1) and the estimates of available labor by age and sex for each employment type from (2), a matching procedure is utilized which takes required employment from available employment pools in accordance with a predetermined employment-type priority schedule. This schedule, shown in Figure 3, incorporates estimates of the differential abilities of various kinds of workers to fill various kinds of employment. For example, it is assumed that baseline indigenous jobs are filled only from the available baseline labor pool. For operating jobs a specified proportion is assumed to in-migrate due to special skill requirements. Then, other jobs are filled first from the available indigenous population, then from construction-related populations, and finally from operational and indirect worker populations. Employment requirements are filled from each age-sex group within each population type according to the proportion that each age-sex group is of the total available labor within the population type.

(4) From step 3, all labor force requirements that can be filled from the available pool are determined. If the labor pool available exceeds that required, out-migration is assumed to occur while an excess of labor requirements over available labor is assumed to trigger in-migration.

(5) The results of steps 3 and 4 provide estimates of the number of workers by age-sex employment type that must out-migrate or in-migrate.

(6) The number of migrating workers by age-sex employment type are converted to estimates of population change by applying a set of employment-type specific population characteristics to the number of workers of each type. Thus, for each of the baseline, construction, operational and indirect worker types, there is an associated set of data used to estimate the characteristics of sex, marital status, presence or absence of family in the impact area, age distribution of other workers in the household, age distribution of workers and age distribution of dependents.[4] The end result is the total

[4]The characteristics (marital status, age of spouse, number of children, age of children, and labor force participation rates of dependents) of in-migrating and out-migrating workers were assumed to be similar to

SEQUENCE AND PRIORITIES FOR JOBFILLING
BY POTENTIAL JOBHOLDERS

Job Sector	Potential Jobholder from Population Group
Baseline Jobs	1. Indigenous Population*
Construction Jobs	1. Construction workers population in specified fraction of jobs
	2. Indigenous population
	3. Construction workers (in or out-migration to balance)
Operating Jobs	1. Operating worker population in specified fraction of jobs
	2. Indigenous population
	3. Construction worker's associated population
	4. Operating worker population (in or out-migration to balance)
Indirect Jobs	1. Indirect workers population in specified fraction of jobs.
	2. Indigenous population
	3. Operating worker population
	4. Construction worker population
	5. Indirect population (in or out-migration to balance)

*Out-migrate indigenous population after the employment for all job sectors including indirect jobs are satisfied.

Figure 3. Sequence and priorities for jobfilling by potential jobholders.

number of persons by age and sex that will either leave or in-migrate into an area for each project period.

(7) The population figures determined in (6) then become the inputs for the next iteration of the demographic module.

The in-migrating workers and their dependents are allocated to the respective municipalities in the proportion determined by the residential allocation module.

The Residential Allocation Module

The residential allocation component of the model estimates the probable location patterns of in-migrating workers and their dependents. The allocations are made at the municipal level using a gravity model. Use of the gravity model involves the basic assumptions that the number of in-migrants moving to a city will be inversely related to the distance between that city and the employment site. Finally, the model assumes that qualitative differences between possible settlement locations will affect settlement choices. In symbolic form, these assumptions may be stated as follows for each site:

$$M_i = \frac{\left(\frac{P_i}{D_i^a}\right) W_i}{\sum_{i=1}^{n} \left(\frac{P_i}{D_i^a} W_i\right)}$$

Where: M_1 = Fraction of total in-migrants locating in city i; P_i = Population of city i; D_i^a = Distance between city i and the work site, raised to the power a; and W_i = The relative qualitative attraction of city i.

those indicated by available data for such workers. Data have been collected for in-migrating construction and operating workers through surveys conducted at power plants and coal mines in four Northern Great Plains States [Leholm *et al.* 1975; Mountain West Research]. Census data profiles of previous out-migrants provide the basis for estimating characteristics of future out-migrants from the area (i.e., an out-migrating primary worker is assumed to have an associated average family unit with characteristics based on Census profiles).

The user may specify values for the distance exponent (a) and the value of the community attraction index (W_i) for any city. In the module, $\Sigma M_i = 1$. The W_i conceptually could assume any positive value consistent with the user's evaluation of the relative qualitative attraction of various cities. User specification of W_i values other than 1.0 generally has been based on specific local information regarding relative availability of housing and key public services. The major role of the W_i variable is to allow users to test the sensitivity of community level impact projections to settlement pattern assumptions.

Separate gravity model allocations occur for each type of worker. Standard values for the exponent parameters were estimated using data on settlement-commuting patterns of construction workers at electric generating plant construction sites in North Dakota, Montana and Wyoming and similar data for permanent (operating) workers at coal mines and power plants in North Dakota, South Dakota, Montana and Wyoming.[5] The value of the exponent parameter for indirect workers was estimated through analysis of changes in employment patterns in western North Dakota communities that have experienced coal development previously.

The Service Requirements Modules

The service requirements modules project total service requirements on the basis of population-based rates for four types of service needs: 1) Educational Services, 2) Housing, 3) Medical Services, and 4) Criminal Justice Services.

In each case, these modules consist of procedures which apply rates of occurrence per unit of population to total, age specific or age-sex specific population groups to obtain estimates of service needs for in-migrating populations. Among the outputs produced by

[5] Data collection procedures are described in Leholm *et al.* (1976) for construction workers and Leholm *et al.* (1975) for operating workers. Statistical procedures for estimating the exponent parameters are described in Wieland *et al.*

these modules are: 1) School enrollments by age; 2) Housing demands by type of housing (single or multiple family, mobile homes, etc.; 3) Number of physicians needed; 4) Number of hospital beds needed; 5) Number of police officers needed; and 6) Number of police vehicles needed. School and housing information are available at regional, county and municipal levels. Medical and criminal justice projections are made available only at the regional level.

The Fiscal Impact Module

The fiscal impact component utilizes the expected settlement patterns from the residential allocation module and subsequent population changes determined for each area by the economic and demographic modules to determine the expected public sector costs and revenues associated with such changes. The module estimates both state and local costs and revenues.

In each case the module works through a three-step procedure which involves: 1) Computation of expected increased public revenues; 2) Computation of expected increased public costs; and 3) Computation of net difference between increased costs and increased revenues referred to as the net fiscal balance.

Changes in state and local tax collections are estimated by applying appropriate tax rates to the estimated change in the relevant tax base. Thus, changes in state sales and use tax revenues are estimated on the basis of historic relationships between sales tax collections and the gross receipts of the retail sector. Similar procedures are used to estimate changes in state personal income tax, corporate income tax, and corporate privilege tax collections. Coal severance tax and coal conversion tax collections by the state and subsequent disbursements to local jurisdictions are based on prevailing statutory formulas. Increases in collections of the various state highway taxes and liquor and tobacco taxes are estimated on a per capita basis.

For local units of government, the estimate of added property tax revenue is obtained by applying the prevailing statewide average property tax rate to the estimated taxable value of project facilities, other business structures, and residences resulting from the industrial developments and associated population growth.[6] Federal revenue sharing payments and public utility user fees are estimated on a per capita basis while state school foundation program payments associated with increased enrollments are estimated on a per pupil basis.

The module also accounts for reductions in tax revenues resulting from decreased agricultural production. The potential reduction in agricultural production is estimated on the basis of the acreage to be used for the plant site; the acreage to be mined; and the acreage expected to be used for residential, transportation, and related uses. The reduction in acreage is translated into a reduction in sales to final demand by the agricultural sectors. Hence, the estimated changes in employment, income, and state and local tax revenues are *net* changes (i.e., increases resulting from industrial expansion less decreases resulting from reduced agricultural production).

Estimates of capital costs for new public facilities are based primarily on recent engineering data, while operation and maintenance cost estimates are based primarily on cross-sectional regression analysis of a sample of county and city budget data from counties and cities in western North Dakota. The

[6]The estimated value of additional business structures was based on the finding by Prestgard that the North Dakota average investment in taxable real property is $0.22 per dollar of annual gross business volume. Taxable value of project facilities was based on information obtained from company officials. Taxable value of new residential units was based on average values of single family homes, multi-family permanent housing, and mobile homes. The statewide average property tax rate was employed primarily because the State of North Dakota was engaged in a program to equalize assessment levels and effective tax rates among jurisdictions. For impact projections covering a period of up to 25 years, then, the statewide average rate appeared to be a more appropriate estimator than the current rates specific to each jurisdiction. For many states, however, use of local tax rates may be preferred.

counties and cities included in the sample covered the range of potential populations of the communities likely to be affected by the new industrial developments. Results of the regression analysis are reported in Hertsgaard *et al.*

All cost and revenue components are computed on the basis of the most current data available and adjusted to the 1975 price level. Then, those components that are subject to price level changes are inflated at an annual rate of 7 percent (or any rate selected by the user) through the life of the development. Increased costs are subtracted from increased revenues to estimate the annual net fiscal balance for the state and local units of government.[7]

Model Validation

Two approaches were employed in appraising the model's validity. First, a historical simulation process was used to evaluate the accuracy of the model in estimating key economic and demographic variables. In addition, the model's dynamic response to stimuli was tested by simulating the impacts of a large electric generating-coal gasification complex and comparing the time paths of key endogenous variables with results obtained from case studies of similar facilities.

Historical Simulation

In order to evaluate the historical accuracy of the input-output module, final demand vectors were computed for the coal producing area of western North Dakota (State Regions 7 and 8) and then were multiplied by the interdependence coefficients to obtain the level of personal income generated by that level of sales to final demand.[8] These estimates of personal income were compared with those reported by the U.S. Department of Commerce for the years 1959, 1962, 1965-76. The difference was less than 5 percent for eight of the 14 years and only two years had differences of more than 10 percent. The mean absolute error was 5.0 percent for the entire 14 year period, and the mean error was 3.9 percent. The value of Thiel's U_2 coefficient was 0.08. This value indicated a very close correspondence between predicted and actual values as the statistic U_2 has a minimum value of 0 in the case of a perfect forecast and takes on a value of 1 when the prediction method is a naive no-change extrapolation (Leuthold).

The model's population projection capabilities were evaluated by comparing model projections with census population estimates for 1975 for 15 counties in western North Dakota. Differences between the total projected population and total estimated population were 0.8 percent for counties and 3.1 percent for cities. The differences were less than 10 percent for 12 of the 15 individual counties, and the average absolute difference was 8.5 percent for counties and 8.6 percent for cities with populations exceeding 500. Similar evaluations are presently underway for several other key economic and demographic variables.

Impact Projection

In a model that is designed to simulate the effects of large changes in exogenous variables or policy parameters, an important evaluation criterion is whether the nature of the responses of the endogenous variables are consistent with relevant theory and empirical observations of the phenomena in other locations [Pindyck and Rubinfeld]. Thus, as a second means of examining the validity of the model, we analyzed the model's response in several case studies, one of which is presented below, and assessed the consistency of output from the modeling effort with general patterns encountered in other energy impacted areas. A review of literature on such areas [Gilmore *et al.*; Wieland *et al.*; Leholm *et al.*; Mountain West

[7]For a more detailed description of the fiscal impact module, see Toman *et al.* (1979); Toman *et al.* (1977).

[8]The gross business volume (gross receipts) of the household sector provided an estimate of personal income which, except for very minor definitional differences, is comparable to personal income as reported by the U.S. Department of Commerce.

Research] revealed several basic patterns of events for an impact situation which should be reflected in the model's output.

1. An expected increase in indirect employment and in the indirect to direct employment ratio during the construction period with the ratio reaching its peak during the operation phase [Gilmore *et al.*].
2. An expected peak in total population during the construction period followed by reduced and relatively stable population levels during the operating period [Gilmore *et al.*; Mountain West Research].
3. An expected shift in the mix of service demands between construction and operation phases. For example, housing shifts from mobile home to single family housing were anticipated [Wieland *et al.*; Gilmore *et al.*; Leholm *et al.*].
4. An expected trend of fiscal deficits during the initial project construction period followed by decreasing deficits or surpluses during later periods.[9] Patterns of fiscal resource distribution also typically indicate more severe problems for municipalities and school districts than for counties [Gilmore *et al.*].[10]

The case study presented below reports an analysis of the effects of a proposed electric generation and coal gasification complex in western North Dakota. The complex consists of two 450-megawatt (MW) electric generating units and two 125 million cubic foot per day Lurgi-process gasification units with a combined fuel requirement of 14.6 million tons of lignite coal per year. The total permanent operating work force will be 1,314 workers while the peak construction work force will be 3,240. Construction began in 1978 and will take 11 years. The plant site is located in a sparsely populated, agricultural area typical of many in the Plains. Projected effects of the project on employment, population, housing and net fiscal balance of selected jurisdictions are summarized in Table 1.

As anticipated by our knowledge of other impact areas, increased economic activity arising from the project is projected to substantially increase indirect (or secondary) employment in the site county (Table 1). In addition, the ratio of indirect employment to direct project employment generally is lower during the project construction period than during the period of plant operation.[11]

Also similar to other impact areas, increased direct and indirect employment is projected to substantially increase population for communities near the plant site. The region's population increase is expected to peak at 9,300 in 1985 and stabilize at about 7,400 after construction is completed in 1988. Most of this population growth is expected to occur in Mercer County and especially in the town of Beulah (Table 1). Beulah's population is projected to increase more than four-fold between 1976 and 1980. However, population tends to stabilize both for Mercer County and for Beulah after project construction is completed in 1987.

The changing mix of service demands is also shown. Population growth substantially increased demand for housing and community services. The model projects that

[9] A fiscal deficit indicates that a jurisdiction's additional project-related revenues are less than its additional project-related costs while a fiscal surplus has the opposite interpretation. A projected deficit for a given jurisdiction can be interpreted as an indication that the jurisdiction cannot maintain both current service levels and current tax rates.

[10] Municipalities are particularly likely to experience fiscal problems because they are generally unable to tax the project facilities. School districts experience difficulties when the project facilities are located outside their district and also because increases in property tax revenues may lag the growth in enrollment by several years.

[11] The only apparent exceptions to this relationship are in the years 1982 and 1987. However, these are years in which project construction employment is expected to be at very low levels.

TABLE 1. Changes in Employment, Population, Housing and Fiscal Balance for Mercer County and City of Beulah Resulting from Electric Generating-Coal Gasification Project, 1978-1999

Year	Additional Employment in Mercer County			Additional Population		Additional Housing Units for Beulah		Net Fiscal Balance		
	Direct Employment	Indirect Employment	Ratio (Indirect/Direct)	Mercer County	Beulah	Number	Percent Mobile Homes	Mercer County	City of Beulah	Beulah School District
								($000)	($000)	($000)
1978	542	378	0.70	2,120	1,340	150	0	−200	−808	−331
1979	1,279	981	0.77	5,519	3,309	452	9.1	−466	−1,573	−716
1980	1,611	1,038	0.64	7,188	4,322	958	47.5	−544	−1,496	−738
1981	1,701	1,038	0.61	7,725	4,878	1,252	50.1	−552	−1,406	−757
1982	1,066	1,038	0.97	5,553	3,641	1,378	48.3	−240	−656	−183
1983	1,301	1,038	0.80	6,410	4,173	986	21.8	−325	−1,275	−725
1984	1,601	1,038	0.65	7,845	5,144	1,110	26.6	632	−1,275	−378
1985	1,557	1,038	0.67	8,138	5,430	1,353	36.9	627	−986	−136
1986	1,426	1,038	0.73	7,765	5,317	1,421	38.6	661	−745	109
1987	1,146	1,038	0.91	6,751	4,837	1,378	36.2	744	−499	547
1988	996	1,038	1.04	6,350	4,532	1,184	25.5	748	−436	571
1989	996	908	0.91	6,240	4,550	1,097	19.2	1,802	490	1,568
1990	996	895	0.90	6,189	4,571	1,107	19.6	1,811	564	1,811
1995	996	835	0.84	6,239	4,925	1,131	19.8	1,772	686	2,880
1999	996	792	0.80	6,294	5,232	1,140	20.0	1,747	1,457	4,331

additional housing requirements in Beulah will exceed 1,400 units at the peak of plant construction activity and stabilize at about 1,100 units after the construction period (Table 1). The composition of additional housing is projected to change substantially during the course of the project. During the early years of plant construction, mobile homes and other types of temporary housing are expected to constitute more than one-half of the total additional housing units. However, as the project proceeds toward full-scale operation, single- and multiple- family permanent housing is expected to account for a growing share of the total units. By 1990, permanent units will make up 80 percent of the additional housing.

Finally, the fiscal balances projected for Mercer County jurisdictions also follow the general patterns observed in other impact areas. The additional costs and additional revenues of Mercer County, surrounding counties, and all incorporated municipalities and school districts in each county were projected for each year from 1978 to 1999. Additional costs were subtracted from additional revenues to obtain the net fiscal balance for each unit of government for each year. The net fiscal balance for Mercer County and for the city of Beulah and its school districts are shown in Table 1.

Mercer County is projected to have a negative fiscal impact during the first six years of the project. However, when the first units of the plants begin operation in 1982, the additional severance and conversion taxes received by the county quickly create a surplus of added revenues over added costs.

Both the city of Beulah and the Beulah school district have negative fiscal impacts during the early years of project construction. However, increased state educational transfer payments coupled with coal severance tax and coal conversion tax payments are sufficient to outweigh the increased school costs by 1986 (Table 1). The net fiscal balance for the city of Beulah does not become positive until 1989, after all units of the project have gone into production.

Overall, then, each of the expected patterns is, in fact, found in the model's projections. Although such findings do not, of course, certify either the validity of the projections nor their likelihood of accurately projecting the project effects, the similarities to those actually encountered in other impact areas together with the results of the historical simulation clearly lend support to the validity of the model's structure.

Conclusion and Implications

The model presented here can have wide application in projecting the likely effects of new industrial projects and providing public decision makers with useful planning information. In its present and earlier versions, it has been used by over 50 different groups in North Dakota including the State Senate Finance and Taxation Committee, the state highway, education and social services departments, the U.S. Bureau of Land Management, several local cities and regional planning organizations and by private industry. It is also being adapted to assess impacts of energy development projects in Texas.

The approach embodied in the economic-demographic model is widely applicable to site and project-specific projections of the impacts of a variety of energy and other resource and industrial developments. While the model was designed specifically to simulate the dynamics of rapid growth associated with projects involving large construction forces, it also should be applicable to smaller projects and those with short construction periods. The model's basic design also lends itself to adaptation to other geographic settings. Adaptation of the model to a given area would consist primarily of substituting appropriate economic and demographic data and coefficients (for example, I-O coefficients, demographic rates, gravity model powers) for those reflecting North Dakota conditions. Of the model's six components only the fiscal impact module would be likely to require basic changes in computational procedures. Some changes in this module's revenue functions would be required to reflect unique features of a state's tax structure.

The model employs an integrated set of functional elements that allow for a wide range of user inputs and that provide a wide range of planning-oriented outputs. Its wide use and its initial validation suggest a generally acceptable model structure. Overall, then, the model represents a promising beginning toward the creation of more effective and useful models for projecting socioeconomic impacts in rural areas.

References

Abt Associates, Inc. *Social Assessment Manual: A Guide to the Preparation of the Social Well-Being Account*, U.S. Bureau of Reclamation, Washington, D.C., 1975.

Barclay, G. W. *Techniques of Population Analysis*, John Wiley and Sons, New York, 1959.

Bartch, B. L. "Analysis of Intersectoral and Intercommunity Structure in Southwestern North Dakota," Masters Thesis, North Dakota State University, Fargo, 1968.

Bowles, G., C. L. Beale, and E. S. Lee. *Net Migration of the Population, 1960-1970, by Age, Sex, and Color.*, U.S. Department of Agriculture and Institute for Behavioral Research and Research Applied to National Needs, University of Georgia, Athens, 1975.

Chalmers, J. A., and E. J. Anderson. *Economic-Demographic Assessment Manual: Current Practices, Procedural Recommendations and a Test Case*, U.S. Bureau of Reclamation, Denver, 1977.

Cluett, C., M. T. Mertaugh, and M. Micklin. "A Demographic Model for Assessing the Socio-Economic Impacts of Large-Scale Industrial Development Projects," Presented at the 1977 Annual Meeting of the Southern Regional Demographic Group, Virginia Beach, Virginia, 1977.

Council on Environmental Quality. *102 Monitor*. Council on Environmental Quality, Washington, D.C., 1977.

Cummings, R. G., and A. F. Mehr. "Investments for Urban Infrastructure in Boomtowns," *Natural Resources Journal*, 17 (1977): 223-240.

Cummings, R. G., and W. D. Schulze. "Optimal Investment Strategy for Boomtowns: A Theoretical Analysis", *American Economic Review*. 68 (1978): 374-385.

Federal Energy Administration. *National Energy Outlook*, U.S. Government Printing Office, Washington, D.C., 1976.

Ford, A. *Summary Description of the BOOM I Model*, Los Alamos Scientific Laboratory, 1976.

Gilmore, J. S., K. D. Moore, D. M. Hammond, and D. C. Coddington. *Analysis of Financing Problems of Coal and Oil Shale Boom Towns*. Federal Energy Administration, Washington, D.C., 1976.

Hertsgaard, T. A., S. H. Murdock, N. E. Toman, M. Henry, and R. Ludtke, *REAP Economic-Demographic Model: Technical Description*, North Dakota Regional Environmental Assessment Program, Bismarck, 1978.

Leholm, A. G., F. L. Leistritz, and J. S. Wieland. *Profile of North Dakota's Coal Mine and Electric Power Plant Operating Work Force*, Ag. Econ. Rpt. No. 100, North Dakota Agricultural Experiment Station, Fargo, 1975.

Leholm, A. G., F. L. Leistritz, and J. S. Wieland, *Profile of North Dakota's Electric Power Plant Construction Work Force*, Ag. Econ. Stat. Series No. 22, North Dakota Agricultural Experiment Station, Fargo, 1976.

Leontief, W. W. *Input-Output Economics*. Oxford University Press, New York, 1966.

Ludtke, R., and R. Blair. *North Dakota Abridged Life Tables, 1960-1970*, North Dakota Department of Health, Bismarck, 1974.

Leuthold, R. M. "On the Use of Thiel's Inequality Coefficients", *American Journal of Agricultural Economics*, 57(1975): 344-346.

Mountain West Research, Inc. *Construction Worker Profile*, Old West Regional Commission, Washington, D.C., 1975.

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 in the West", *Land Economics*, 54(1978): 461-71.

Olsen, R. J., *et al. Multiregion: A Simulation-Forecasting Model of BEA Economic Area Population and Employment*, Oak Ridge National Laboratory, Oak Ridge, Tennessee, 1977.

Pindyck, R. S., and D. L. Rubinfeld. *Econometric Models and Economic Forecasts*, McGraw-Hill Book Company, New York, 1976.

Prestgard, P. G. "Effects of Coal Development on Public Costs and Revenues in North Dakota", Masters Thesis, North Dakota State University, Fargo, 1974.

Richardson, H. W. *Input-Output and Regional Economics*. Halsted Press, New York, 1972.

Sand, L. D. "Analysis of Effects of Income Change on Intersectoral and Intercommunity Structure", Masters Thesis, North Dakota State University, Fargo, 1966.

Senechal, D. M. "Analysis of Validity of North Dakota Input-Output Models", Masters Thesis, North Dakota State University, Fargo, 1971.

Shryock, H. S., and J. S. Siegel. *The Methods and Materials of Demography*, U.S. Government Printing Office, Washington, D.C., 1973.

Stenehjem, E. J. *Summary Description of SEAM: The Social and Economic Assessment Model*, Argonne National Laboratory, Argonne, Illinois, 1978.

Summers, G. F., S. D. Evans, F. Clement, E. M. Beck and J. Minkoff, *Industrial Invasion of Nonmetropolitan America*, Praeger Publishers, New York, 1976.

Toman, N., S. H. Murdock and T. Hertsgaard, *REAP Economic-Demographic Model, Version II: Technical Description*, North Dakota Regional Environmental Assessment Program, Bismarck, 1979.

Toman, N. E., A. G. Leholm, N. L. Dalsted, and F. L. Leistritz. "A Fiscal Impact Model for Rural Industrialization", *Western Journal of Agricultural Economics*, 1 (1977): 242-47.

U.S. Department of Commerce, Bureau of Economic Analysis. "Regional Economic Information System", Washington, D.C. 1976.

U.S. Department of Commerce, Bureau of the Census. *Current Population Reports: Population Estimates and Projections*, Series P-25, No. 682 U.S. Government Printing Office, Washington, D.C., 1977.

Wieland, J. S., F. L. Leistritz, and S. H. Murdock. "Characteristics and Residential Patterns of Energy Related Work Forces in the Northern Great Plains", *Western Journal of Agricultural Economics*. 4(1979): 57-68.