A dynamic economic systems community impact model applied to coal development in the Northern Great Plains
by George Sterling Temple

A thesis submitted in partial fulfillment of the requirements for the degree of DOCTOR OF PHILOSOPHY in Applied Economics
Montana State University

Abstract:
ABSTRACT Large-scale coal mining and energy-related development may have substantial impacts on the predominantly rural Northern Great Plains. This dissertation investigates the impacts likely to occur in localities in this region, including both economic effects and fiscal consequences for governments.

The methodology employed is computer simulation. The simulation model is composed of an economic base submodel which determines labor requirements; a labor supply submodel which is used to predict employment/population ratios, migration and wages; a local government spending submodel; and a revenue submodel.

The model is used to predict economic and fiscal responses to forecasted coal mining in Montana. The dissertation concludes with an analysis of policy issues important in a rapid growth region.

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Applied Economics

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May, 1978

ACKNOWLEDGEMENTS

For their advice and help I would like to thank the members of my Graduate Committee: Oscar Burt, Jon Christianson, Maurice Taylor, Verne House, Doug YoungDay, Don Boyd and Robert Seibel. I am grateful to Rick Stroup and Dick McConnen for their comments on the policy chapter. The suggestions and advice of the ESCS Energy Team, composed of Stan Voelker, Tom Stinson, Andrea Lubov, Fred Hines, Jeff Conopask and Paul Myers, are gratefully acknowledged. Special thanks go to Tom Stinson for supplying me with his ENERGYTAX models, which form the revenue subroutines in the simulation model, and to Jeff Conopask, who supplied the coal mining forecasts for the model analyses.

I would also like to thank Bernard Ries and Gary Orser for their assistance with data handling and computer work. Special thanks go to Marjorie Powers for typing the various drafts, and to Peggy Humphrey who typed the appendix tables. I would like to express my great appreciation to Ed Ward for his interest and efforts on my behalf.

My greatest debt is to Lloyd Bender, Chairman of my Graduate Committee and Project Leader of the ESCS Energy Team. His constant interest, encouragement and help added immeasurably to this thesis.

Funding for the project was supplied by EPA and ESCS, USDA. Conclusions are the sole responsibility of the author.

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ABSTRACT

Large-scale coal mining and energy-related development may have substantial impacts on the predominantly rural Northern Great Plains. This dissertation investigates the impacts likely to occur in localities in this region, including both economic effects and fiscal consequences for governments.

The methodology employed is computer simulation. The simulation model is composed of an economic base submodel which determines labor requirements; a labor supply submodel which is used to predict employment/population ratios, migration and wages; a local government spending submodel; and a revenue submodel.

The model is used to predict economic and fiscal responses to forecasted coal mining in Montana. The dissertation concludes with an analysis of policy issues important in a rapid growth region.

Chapter 1

INTRODUCTION

A debate continues in the United States over the domestic dependence on foreign energy supplies. The creation of a Federal Department of Energy is symptomatic of the importance of the issue. Most analysts conclude that increased use of domestic coal as one substitute for oil is inevitable. This study concerns the impacts expected to result from major coal development. The study area is the Northern Great Plains (NGP), defined as North Dakota and parts of Montana and Wyoming.

Coal is likely to be more important in the future than it is now, although coal is currently the most important source of energy for generation of electricity. Electricity usage has grown steadily even in the face of rising prices. Uncertainty about foreign intervention in the delivery of oil and gas may lead to conversion to coal use even if such fears are unfounded. Canadian petroleum supplies are currently being phased out. Coal use is being urged by governmental authorities as an energy source not subject to foreign political interruption. Finally, present air quality standards and the possibility of more stringent standards would lead to greater use of low-sulfur coal.

The NGP, especially Montana and Wyoming, is likely to be a major supplier of low-sulfur coal to the nation (figure 1).

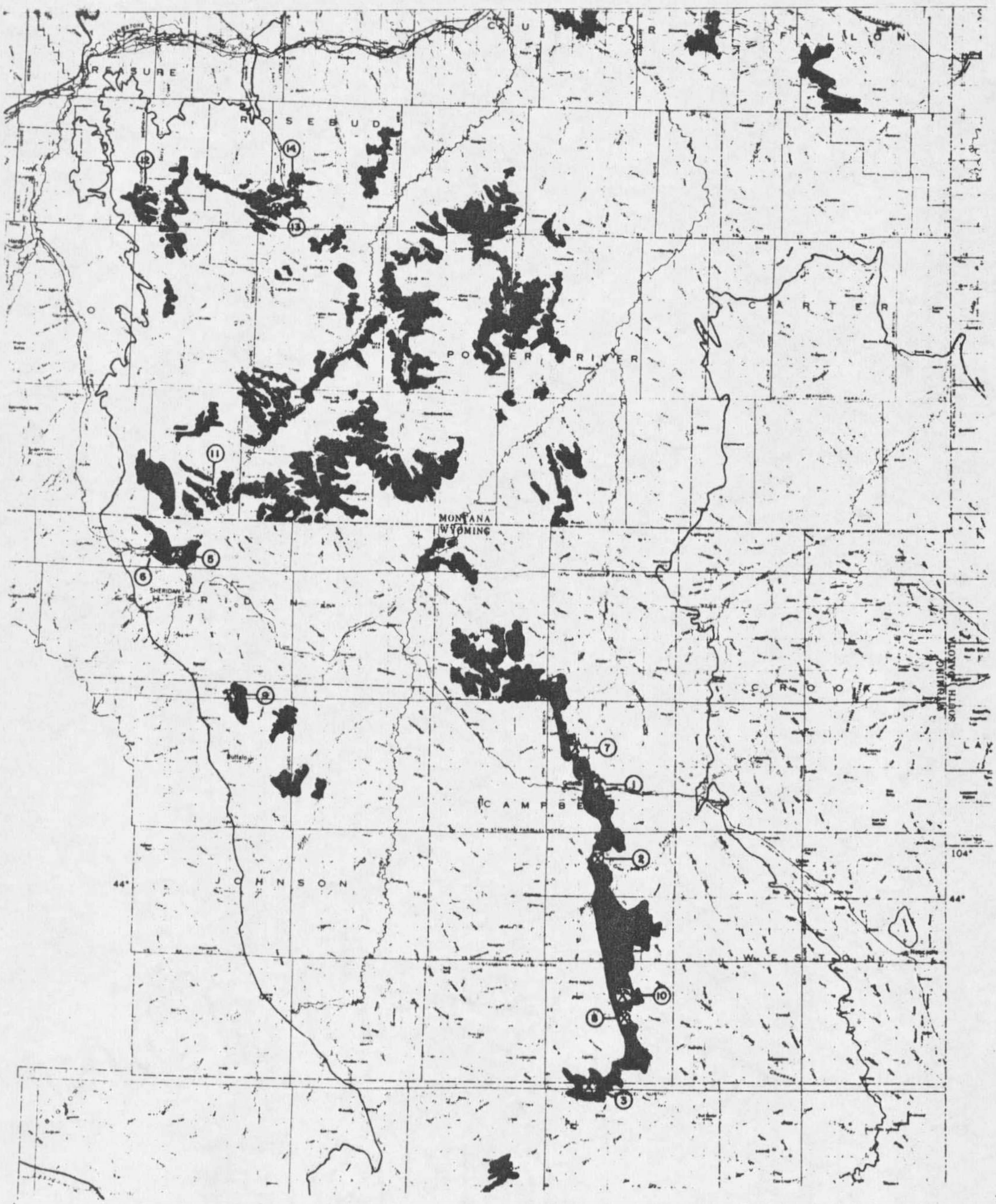

Figure 1. Surface Minable Coal Deposits, Montana/Wyoming Portion of the Northern Great Plains.
Source: U.S. Geological Survey.

Part of the demand will be the substitution of low-sulfur coal for high-sulfur coal and oil. But NGP coal also will satisfy the needs of new generators (figure 2). The NGP is expected to be the source of 45 percent of the coal demanded by new generating units in the U.S. through 1985 -- 159 million tons (table 1). More than 72 percent of this is already under contract, and is a much greater tonnage than any other region is expected to supply.

The NGP is capable of supplying the demand for low-sulfur coal due to the size of the deposits and low costs of mining. Favorable seam to overburden ratios of NGP deposits reduce mining costs. The five states of Montana, the Dakotas, Wyoming and Idaho contain almost one-third of the currently recoverable U.S. bituminous and subbituminous coal deposits containing less than one percent sulfur standardized for BTU content (Reiber, 1975). Most of this coal is concentrated in the study area. Forecasts of productive capacity of mines currently scheduled in Montana, North Dakota and Wyoming show a potential production of almost 450 million tons annually by 1985 (U.S. Federal Energy Administration, 1977).

Population growth primarily due to immigration will accompany coal development in the NGP. Population growth and new development will reverse trends in an historically stagnant region. Myers, Hines, and Conopask (1977) describe the region as a net exporter of

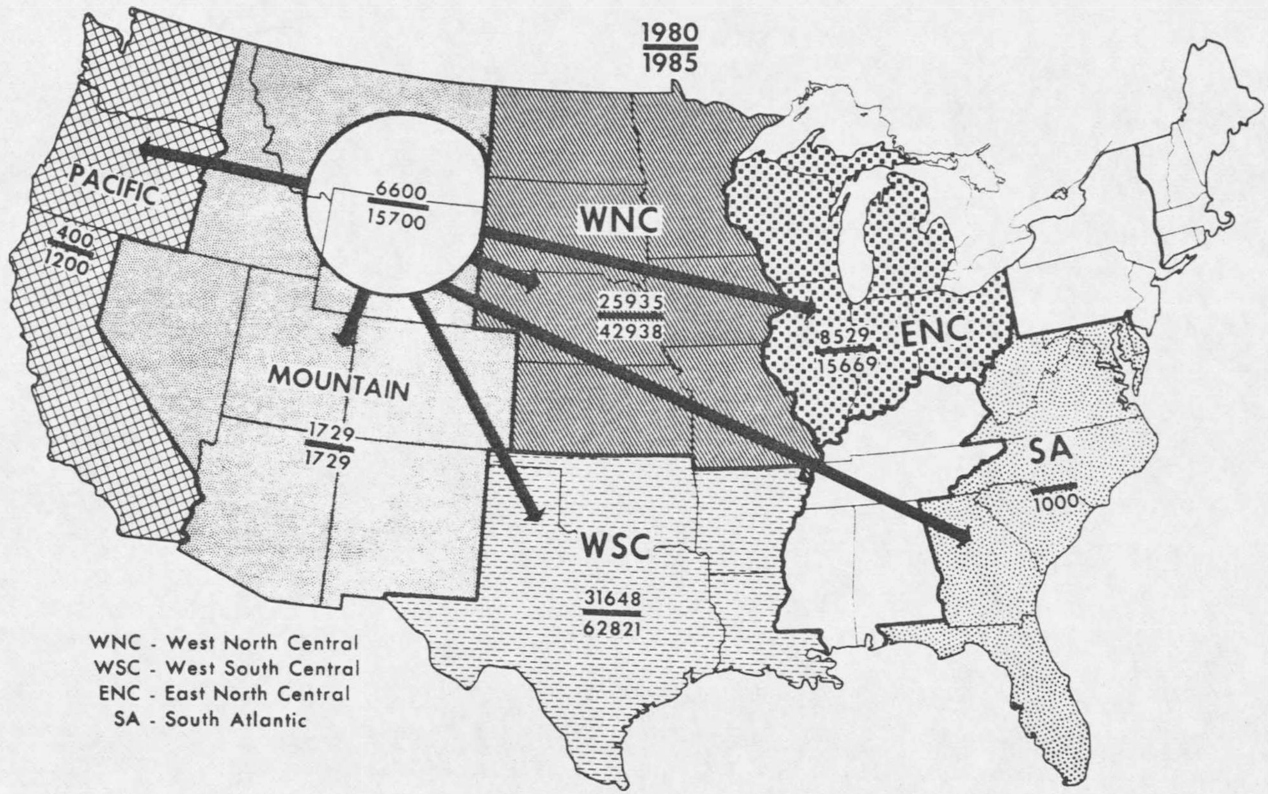

Figure 2--Flow of Coal to New Generating Units from the Western Regions of the Northern Great Plains, Thousands of Tons.
Source: U.S. Federal Power Commission (1977, p. 19).

Table 1--Sources of coal for new thermogenerating units, scheduled for service 1976-1985

Source	1975 Shipments to utilities (1000 tons)	1985 Total demand for new units (1000 tons)	1985 Quantities assured for new units (1000 tons)	1985 Percent assured
Appalachia	210,245	52,214	22,222	42.6
Interior basin	126,475	36,358	30,541	84.0
Bureau of mines district 15	16,923	53,655	39,590	73.8
Northern Great Plains	54,068 a/	159,157	115,638	72.7
Rockies	22,791	38,527	35,054	91.0
Unknown	---	17,860	---	---
Total	430,502	357,771	243,045	67.9

a/ Includes 4.2 million tons of coal produced in the State of Washington.
Source: U.S. Federal Power Commision (1977, p. 7).

people because of the overwhelming importance of agriculture at a time when agricultural employment was declining because of mechanization. Net rates of migration from the NGP were higher than the average of all U.S. nonmetropolitan counties. A sparse population distributed over a large geographic area forms few sizeable towns. Public and private services thus are performed on a very small scale and often are not capable of rapid adaptation to population growth. Williams (1975, p. 63) describes the Rosebud County fire department as having "...three spray trucks, one 6 x 6 army surplus truck with a 2000-gallon tank, and one 1935 LaFrance fire truck." Services such as fire protection are provided almost exclusively by volunteer forces.

What kinds of problems are expected from the change that coal development implies in such a setting? Most prominent are problems in adjusting to the new situation, and attempting to do so with institutions designed for a small and stable area. Adjustment problems include a number of factors which often are related. The scale of an energy development can swamp the capacity of existing institutions to maintain effectiveness. Law enforcement is an example. The rapidity of growth may leave little time for an orderly adjustment of the public service to desired levels.

The problem of spillovers is that jurisdictions may be impacted by rising population levels and increased demand for public services when the natural resource tax base is located elsewhere. In contrast to other sectors of the economy, natural resource-based industries are fixed in location. This means that the impacted residential location closest to a mine may not have the mine as part of its tax base. Manufacturing firms, in contrast, tend to locate within towns and become a part of the tax base. The seminal example of a spillover is the impact on Sheridan, Wyoming resulting from the coal mines near Decker, Montana.

Finally, problems are associated with the timing of resource development. A front-end load develops when a new installation begins to generate tax revenue only after the population causing the impact has lived in the area for some time. The demand for public services in this case may exceed the capacity of the tax base to finance them initially, even though the problem may be alleviated when the resource development comes onto the tax rolls. Another timing problem is the uncertainty about the duration of the project. Capital spending decisions by local public authorities especially are affected. Uncertainty whether a mine will continue to operate may prevent a school from being built because pupil levels would fall if the mine closes, and the bond repayment would be burdensome without the mine tax revenues. Problems such as these may lower the quality of life in a locality temporarily and also may lead to long-term social distress.[1]

Objectives and Statement of Purpose

This study quantifies the effects of energy development on local areas in the Northern Great Plains. A simulation model is designed to predict the time paths of employment, population, employment participation (defined as the ratio of employment to population), migration, wage levels, and local government revenues and expenditures. The study thus deals with the basic elements of the growth process because more complex issues cannot be investigated unless these are understood. Specific objectives of the study are:

(1) Estimate coefficients needed for the simulation model.

(2) Predict the time paths of impact variables given particular coal development scenarios.

(3) Examine issues raised by adjustment problems and evaluate impact policy measures.

Justification for the Study

The study is of analytical usefulness since it yields information about the responses of complicated economic and governmental

[1] An illustrative case study is Gilmore and Duff (1974).

systems to major perturbations. Such considerations are not treated well in standard economic theory and in existing econometric models. The study also has policy uses. The better idea that planners have of impact effects and the probability of their occurrence, the better they can plan to alleviate undesirable consequences. State and national politicians will be able to design more effective laws, tax systems and intergovernmental funds transfers.

The simulation model has features which make it of additional interest. Component parts of the model can stand alone. The tax algorithms, for example, can be applied independently to obtain evaluations of alternative tax systems. The model is based on secondary data so that the approach can be used in regions other than the NGP. The model can be expanded or contracted as needed for particular applications without destroying the overall structure. The model is also useful in assessing the magnitude of the economic damage that might be suffered by a community adjusting to rapid growth. This magnitude is important since the likelihood of local opposition and consequent delay or even abandonment of the project depends on the scale of economic loss. It also provides a measure of the economic incentive which would encourage rapid coal development.

Some other studies in this general area include those by Krutilla and Fisher (1976), Stenehjem (1975), Leistritz (1976) and

Ford (1976). Econometric modelling of regional systems often does not address adequately the types of problems associated with rapid development of natural resources in rural areas. Regional studies tend to be directed at urban rather than rural areas. The economic structures are quite different. This criticism is especially relevant to those studies which use input-output analysis. Rapid growth in simple rural economies almost guarantees that changes will occur in the input-output matrix, thus making earlier matrices invalid. Further, each community may have a different input-output structure, so that models will not be portable across communities. Another problem is that most studies focus on regions rather than localities due to data limitations, questions of methodology, and issues of interest. However, localities are the jurisdictions which must be analyzed when considering specific impacts.

Chapter 2

THEORETICAL ANALYSIS

Economic theory underlies the logical structure of the local impact model. The model is designed to predict the time path of secondary and induced effects on employment, population, employment participation, migration and wage levels, and local government revenues and expenditures. The model is driven by an exogenous demand for coal expressed in tons of coal mined per year and employment levels. An endogenously derived demand for service activities is generated. The geographic location of the derived demand for services is the main concern of economic base and central place theory. An increase in the demand for ancillary services raises the wages and incomes of proprietors. The model contains two responses to greater demands in the service sector. First, employment participation rates increase. Second, labor moves into the area; that is, net migration patterns change. These are the labor supply responses in the model. Labor supply and demand taken together form the labor market component of the simulation model.

Local government revenues and spending are the second component of the local impact model. Both revenues and expenditures change in response to population and income changes. The revenue side of the model is derived from the tax codes of each state and no statistical estimation is necessary. No theoretical justification for such equations is required and revenues are not discussed in this chapter.

Local government spending on the other hand is treated statistically, so the theoretical determinants of such spending are dealt with below.

Labor Demand

Time and space are two fundamental factors which affect the derived service demand for labor in a locality. Neither are treated well in standard economic theory. Received doctrine in economic theory is concerned almost solely with analysis of equilibrium. It would be desirable to explain the rate of adjustment of service sectors to exogenous changes; that is, the process of adjusting to equilibrium. Perhaps the only relevant theory in this regard has to do with stock adjustment models, in which costs of being out of the equilibrium position are balanced against adjustment costs. When attempts were made to apply this model by estimating a partial adjustment model for ancillary employment, the results were unsatisfactory. The time adjustment problem is treated on an ad hoc basis by using lagged variables. No theoretical discussion of time-related effects is carried out in this chapter.

The location of service activities in economic space has two aspects; identifying the levels of demand for services, and determining where those demands are satisfied. An integration of economic base theory and central place theory is the most useful for a regional simulation model.

Economic base theory relates induced activities in a region to exogenous activities.[2] The economic activity can be measured by either income or employment. The relationship usually is expressed as an economic base multiplier. This is similar to the Keynesian multiplier, and is derived using the same logic. In economic base terms, there is a propensity to spend locally. Sequential rounds of such spending, driven by exogenous basic activity, can be summarized in the multiplier. For a full treatment of this approach to economic base theory, see Tiebout (1962).

Economic base theory also can be expressed in terms of input-output analysis. The economic base model can be conceptualized as an input-output model with only two sectors. If the economic base multipliers are "pure" (that is, if they represent a relationship between ancillary employment and basic employment which includes no other variables), then the economic base multiplier is mathematically identical to the input-output multiplier (Billings, 1969).

It is just this "purity" which is compromised by considerations involving economic space. The fixed coefficients in input-output analysis best describe a complete system; that is, a functional economic region which is self-sufficient in ancillary services.

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[2]Induced, ancillary, and service activities are used interchangeably, and basic and export activities are the same.

Localities, especially rural regions of the Northern Great Plains, are never self-sufficient. Some goods and services are always supplied from outside the region. Central place theory attempts to explain the location of economic production; economic space is its major concern. The approach of central place theory is given in the articles by Parr and Denike (1970), and Parr, Denike, and Mulligan (1975).

Central place theory is concerned with the reasons for the development of central market areas (urban areas) which serve populations in the surrounding hinterlands. The point of departure is to recognize that for any good there is a unique production function which determines the optimal scale of output, firm size, and cost of production as well as transfer costs of the good to consumers. The transfer costs are borne by consumers who must purchase the good in a market at some distance from the point of use. Transportation costs differ among goods even if the market location is the same for both.

Least cost production locations depend upon both the production functions for each service activity and the density and distribution of consumers. Free entry will cause production location to be dispersed given the market size required by the production function and competition from distant rivals. Thus, firms are dispersed at evenly spaced intervals throughout the region if the production function allows profitable operation at low levels of output. Centralization will occur when large scale production is required for profitability.

Thus, goods can be ranked according to the size of the market area required for profitable production. This in turn defines a hierarchy of central places measured by the highest ranking good produced in each.

The conditions influencing the local supply of services are illustrated in figure 3. If a good is produced in a central place, the delivered price to a consumer at a remote site depends on distance. For any production function there is a critical distance beyond which the local demand at the remote site is sufficient to allow lower prices from local production. This critical distance is different for different goods. Thus, in the aggregate there should be a smooth relationship between distance and the amount of ancillary activity, given the level of basic activity.

The economic base multiplier must be adjusted for distance from a central place; however, specification of the precise nature of the adjustment is beyond the scope of theory. At sites adjacent to central places, ancillary activity would presumably be at a minimum. At the other extreme would be remote sites. These places would have the full level of service activity needed to complement the basic activity which exists. Thus, the value of the multiplier will vary between these extremes, but the nature of the variation is not known.

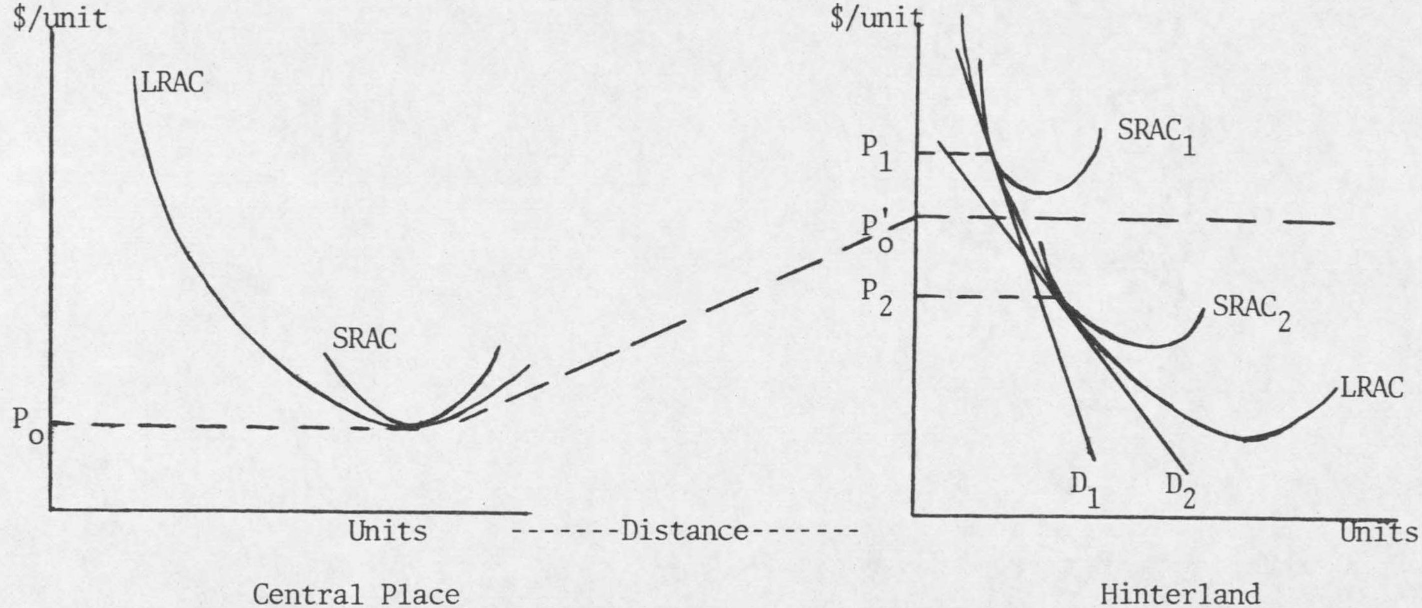

Figure 3--Conditions Influencing Local Supply of Ancillary Services.

Labor Supply

The expanding employment demands of a growing region can be met in several ways. Expansion of the population pool from which workers are drawn can come about due to either natural increase or net migration into the region. Also, a population pool of given size may supply more workers or existing workers may put in longer hours. The labor supply response includes all these; however, some are more susceptible to economic analysis than others. Natural increase especially may not be associated directly with economic factors in the short run. Therefore, no theoretical treatment of this subject will be given here, nor is it considered an empirical economic issue in the material to follow.

Economic theory treats each worker as an independent decision-maker and focuses attention on the response of hours worked to compensation. For present purposes this analysis must be broadened by recognizing that households, not individuals, constitute the decision making unit and by incorporating the effects of economic space on the labor supply response.

Analysis of the household labor supply decision can proceed along the lines given by Bowen and Finegan (1969, pp. 569-570). In their model, the household maximizes a utility function which has as arguments the quantities of goods consumed by the family, hours of labor supplied by each family member, and hours of leisure available to each family member. Market prices including wage rates are assumed given. Utility maximization implies that the rate at which the family is willing to substitute one good for another (including leisure) is the same as the rate at which it can do so. Hours supplied in the labor market by each family member are implied.

The institutional fact is that the hours of work for most jobs are "lumpy". The choice is to work or not to work. The result is an approximation to the labor supply decision implied by utility maximation. The approximation is not perfect because overtime and part-time jobs are not correctly taken into account. But the weight of the evidence is that a standard work week predominates. Although the number of hours worked by each family member cannot be considered the total number of all jobs held by the population, it is a close approximation.

Ideally the model also should be extended by considering life cycles of family members. The utility function in such a model includes arguments for each period in the lifetime of the household (a difficult concept in itself), with future variables discounted appropriately. The end result would yield an optimal temporal profile of the household with the number of jobs held by the family and its location in each time period determined. A model built along these lines would contain so many unobservable variables that it would not be operational.

Economic space could be taken into account by making all arguments in the utility function site-specific. The utility of leisure hours, for instance, would depend in part on location. Wage rates would be site-specific as well and include not only regional differences but also moving or commuting costs and uncertainty costs. Thus, the number of variables in the Bowen-Finegan model would be multiplied by the number of possible sites. In a national context this raises the number of variables to a level with which empirical analysis is incapable of dealing.

Dealing directly with the aggregate supply of labor instead of formally deriving it from utility maximization theories alleviates the estimation problem. Figure 4 illustrates the theoretical labor supply function. Most rural areas have average wage levels below those of the United States. The population in these areas presumably remains because of non-market site amenities.

What kind of response can be expected from increasing wages in a region of this sort? There are three possible sources of increased supply. First, the local labor supply may change due to interregional migration. This is likely to be the most important of the wage-mediated sources of labor supply. The shape of the graph in figure 4 represents the expected nature of the response. At wage rates below existing levels there will probably be substantial outmigration. Most of the regions in this study have been net losers of population over the past

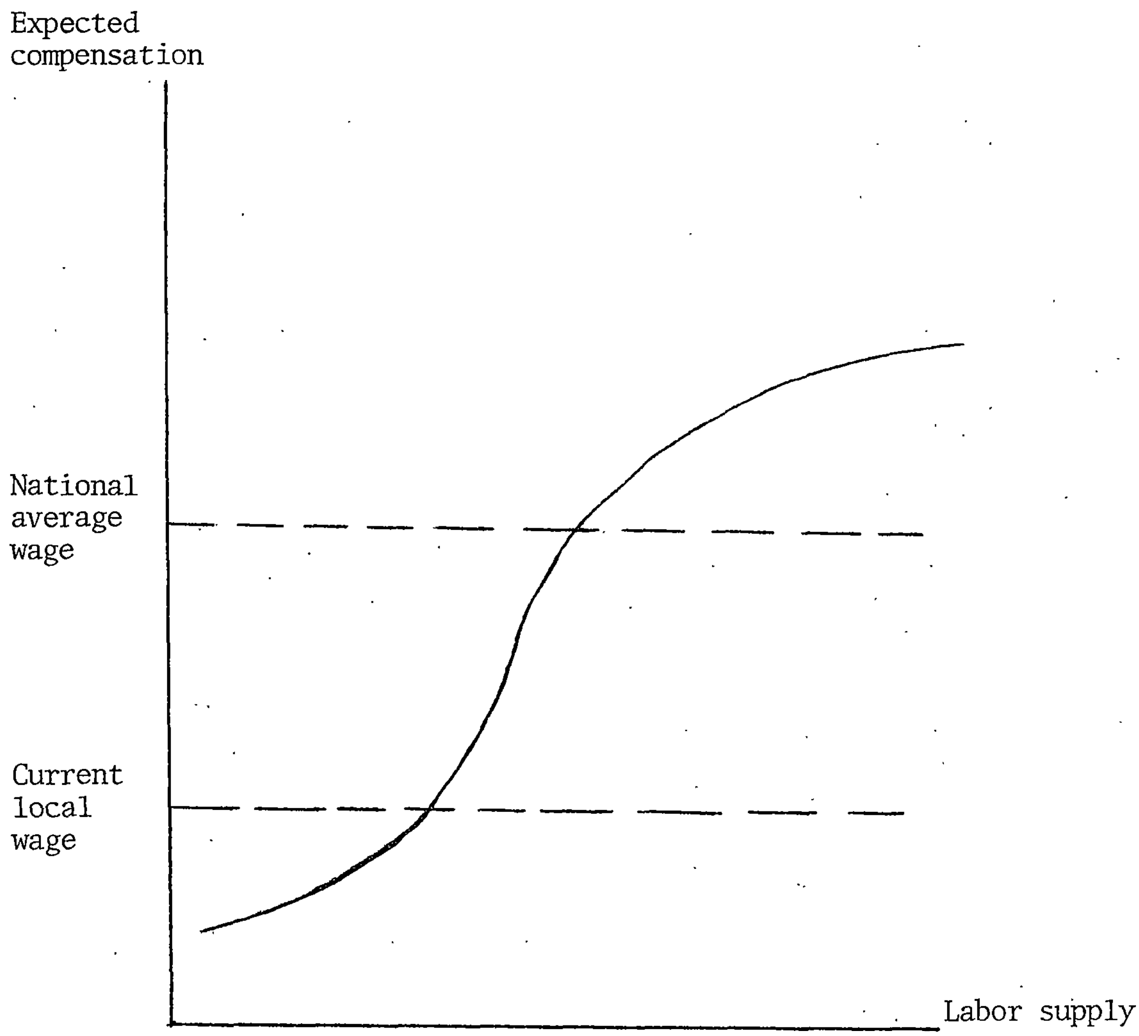

Figure 4--Expected Labor Supply Response in Low Income Areas.

decades. Predevelopment wage levels coupled with site amenities were associated with this rate of population loss. It is plausible to suppose that if wages were any lower the movement of people out would become substantial. On the other hand, wage levels between existing levels and the national average would cause marginal changes. Most people primarily attracted by the site amenities are already in the region; those primarily looking for high wages can do better elsewhere. But as wage levels approach and then exceed national levels, the region would be attractive to a wider field of potential inmigrants. In other words, when wages are below national levels the market supply area is limited to nearby regions with similar site amenities. Migrants from distant areas are few. But as wages approach and then exceed national levels, there is expansion in the labor market supply area; the whole nation becomes a potential source of migrants. Therefore, net migration would be very sensitive to wages at these levels.

Second, there may be internal shifts in labor use due to factor substition. This effect is minor in a sparsely settled rural area. Third, there might be an increase in employment participation rates. This effect, however, is unlikely to be large either. In rural areas it is more probable that employment opportunity rather than compensation is what draws workers from the existing population. This may be the case for several reasons. Rural areas are likely to be short on jobs. There may be people who would be willing to work at low wages if jobs were available. Traditionally in this category are those who are not heads of households. Shortage of local jobs means an inability to find work locally, and rural isolation makes commuting to distant jobs difficult. Therefore, wages are not included as an explanatory factor in the employment participation equation.

In summary, migration may be by far the most important source of new labor for boom areas. In order to induce appreciable numbers of migrants to move in, wages may have to rise considerably. Thus, boom areas may experience local inflation.

Local Government Spending

Analysis of this issue requires analysis of the demand for those goods which are supplied by governments locally.[3] The analysis outlined here closely follows that of Borcherding and Deacon (1972), and Bergstrom and Goodman (1973). The critical assumption is that the median quantity of public spending demanded is that demanded by the voter with the median income. If public authorities spend that quantity preferred by the greatest number of voters, then the median spending level will be adopted. This means that only the median voter's preferences need be analyzed.

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[3]Goods and services supplied by governments are assumed to be at least partly 'public goods'.

The analogue of sales price in the case of public goods is production cost. The cost of capital goods through time is determined in the national labor market and is not affected by one community's purchases. Wage costs are a function of local labor supply and demand. In the case of public goods, cost of production is divided among all taxpayers so that population size influences price. As long as the goods are public in some degree, this effect holds true.

Utility maximization yields a point on the demand curve of the median consumer. Constant elasticities of price and income are assumed in order to generate the complete demand curve. Income is, of course, median income. The constant elasticity assumptions determine the form of the demand function; that is, it is linear in logarithms.

In summary, then, the theoretical determinants of local public spending are median income, wages, and population levels. These variables are related in a log-linear fashion to the logarithm of public spending at local levels, and do not reflect conditions in the national capital goods markets.

Chapter 3

ECONOMETRIC ANALYSIS

Portions of the simulation model which depend on statistical estimation are ancillary employment, employment participation rates, migration, and local government spending. The discussion for each of these proceeds from the theoretical analysis developed earlier to a functional form suitable for estimation.

Data

The county is the primary unit of analysis. County-specific data are from Bureau of Economic Analysis (BEA), U.S. Department of Commerce, "Local Area Personal Income, 1969-74", and "Local Area Employment". The emphasis of the study is on rural areas, so the data base is restricted to 181 counties not adjacent to a Standard Metropolitan Statistical Area (SMSA). The counties include most of North and South Dakota, plus selected areas of Montana, Wyoming, and Colorado (Appendix A). The data base constitutes the years 1970 through 1974 for each of the 181 counties in the sample. Data for the years 1971-74 are used to estimate the dependent variables in the equations, and the 1970 data serve as the source for lagged variables.

A few variables are taken from other sources. The 1970 Census is the source for three variables; distance to the nearest trade center, largest town in the county, and largest adjacent town. All are used in the ancillary employment equation. All local government spending data are from the 1972 Census of Governments, the latest available figures. Fiscal data are used from Montana, North Dakota, and Wyoming. These are the only states in the region with expected major coal development. The government spending equations are estimated separately for each state, instead of pooling the observations, because variations in the provision of local services by type of local jurisdiction from state to state mean that a common spending response is an unwarranted assumption.

In summary, the equations for ancillary employment, employment participation rates, and migration are estimated with a data base composed of pooled time series, cross-section observations: 181 counties over four years. A simple cross-section of observations on the counties of each state are the data for the equations for local government spending.

Estimation Methods

The parameters to be estimated are part of a system and system estimation methods are necessary. The set of equations making up the system is given in Appendix B. This set constitutes a recursive system. The independent variables include some which are endogenous to the system for all stochastic equations except that for ancillary employment. These variables for the most part are transformations of dependent variables estimated in other equations. The system estimation method is two-stage least squares. Transformations on the endogenous variables are required after the first stage, so it is not feasible to use a standard package for two-stage estimation. Ordinary least squares is used for the first stage variables which are used as independent variables within the system (these are ancillary employment, wages, and indigenous population), and the necessary transformations are applied to obtain the instruments used in the second stage. The second stage estimations are carried out using ordinary least squares. Significance tests are calculated using formulae appropriate for two-stage least squares.

This procedure yields consistent estimators in the absence of violations of assumptions usually made in the classical least-squares model. However, it is not clear what effect such violations would have on the properties of the estimators. This is because the combination of lagged dependent variables, nonlinearities, and simultaneity in the model makes it difficult to determine the consequences of violating assumptions or to design appropriate tests for such conditions. Therefore, it is not possible to assert with complete confidence that the estimators are consistent.

Ancillary Employment

The theoretical relationship between economic base analysis and central place theory suggests that the basic employment multiplier should be related to the distance between the county of interest and a major trade center. The relationship chosen is quadratic. It is also possible for a given county to serve as a service center for nearby areas. For these reasons, the independent variables in the ancillary employment equation include the level of the economic base in a county in a product relationship with a quadratic function of the distance to the nearest trade center, as well as the level of basic activity in adjacent counties. It is not likely that ancillary employment adjusts completely to equilibrium within a single time period (one year), but theory gives no guide about the nature of the adjustment lag. A partial adjustment model was unsuccessful in explaining the adjustment mechanism. Allowance for lagged adjustment is made by including three lagged variables: (1) the dependent variable, (2) values of the base-distance relationship, and (3) the value for adjacent basic activity. The remaining independent variable is lagged ancillary wage rates scaled by the size of the largest town in the county, and it represents the effect of income on ancillary services demanded. The higher income levels are, the more services will be demanded.

Measuring the economic base is difficult since the data are from geographic entities which do not correspond to functional economic regions. Ideally, basic and ancillary activity are distinguished by the origin of the demand for the products sold by the industries concerned. But since it is impossible to identify demand sources precisely, the researcher is constrained to use standard industry classifications. The problem then is to allocate employment within an industry to the basic or ancillary sectors. The economic base is assumed to be agricultural employees and proprietors, employees in mining, manufacturing and the Federal government, plus any employees in transportation and construction over the regional averages.[4]

Results of the estimation of the ancillary employment parameters are summarized in table 2. The coefficients a_2, a_3, and a_4 as a group express the relationship between ancillary employment and the economic base-distance quadratic function. The negative sign on a_4 implies that the graph between the ancillary employment multiplier and distance is concave downward. This means that employment in the service sector increases at a decreasing rate with distance from competitive suppliers at major trade centers.

A Chow test shows that the lagged variables are significant as a group. This supports the hypothesis that adjustment to equilibrium is not immediate. Signs on other variables are as expected. The high

[4]The method of location quotients is used in the case of transportation. For a discussion of the virtues and drawbacks of these methods, plus the method of minimum requirements, see Lewis (1974). For a caveat on the indiscriminate use of methods such as location quotients, see Park (1970).

Table 2--Estimating equation for ancillary employment in Northern Great Plains counties, 1971-74 a/

Equation	Estimated coefficients	F statistics	Definition of variables
Dependent variable			
$ANCEMP_t$			Ancillary employment; total employment minus basic employment in year t.
Independent variables and coefficients b/			
a_0	-32.91643	-	Constant
$a_1\ ANCEMP_{t-1}$	1.04194	c/	ANCEMP in the prior year.
$a_2\ BASE_t$	0.42970	79.06	Base is defined on page 28 of the text.
$a_3\ BASE_t\ D$	-0.00305	7.58	Distance to a trade center multiplied by $BASE_t$.
$a_4\ BASE_t\ D^2$	-0.000005	0.83	Distance to a trade center squared multiplied by $BASE_t$.
$a_5\ ADJBASE_t$	0.12597	23.70	$BASE_t$ which is largest in any of the adj. counties multiplied by the ratio of the size of the largest local town to the largest town in any adjacent county.
$a_6\ BASE_{t-1}$	-0.42446	70.50	BASE in the prior year.
$a_7\ BASE_{t-1}\ D$	0.00338	8.87	Distance to a trade center multiplied by $BASE_{t-1}$.
$a_8\ BASE_{t-1}\ D^2$	0.000005	0.63	Distance to a trade center squared multiplied by $BASE_{t-1}$.
$a_9\ ADJBASE_{t-1}$	-0.13680	28.04	ADJBASE in prior year.
$a_{10}\ WAGE_{t-1}\ T$	0.00008	0.17	Mean salary & earnings, thou. per yr., of ancillary employees & proprietors multiplied by size of the largest local town.
e_{1t}			Error
Statistics			
R^2		0.99	
F		c/	
S.E.E.		126.07	
Mean of ANCEMP		2353.67	
d.f.		713.00	

a/ Coefficients estimated using ordinary least squares on a data base of 181 counties for 4 years.
b/ Coefficients are rounded to the fifth decimal place.
c/ Larger than 10,000.

coefficient of determination for this equation and the low ratio of the standard error of the estimate to the mean of the dependent variable imply that the equation should perform well in a simulation role.

Results obtained here are similar to those obtained by Bender (1975 and 1977). Those studies also show the importance of distance variables reflecting the importance of the central place in the economic base multiplier.

Employment Participation Rates

The determinant of the ratio of employment to population is assumed to be employment opportunities in the county. The percentage change in employment from the preceding year is used as a measure of this. The percentage change in employment is entered as a quadratic to account for the fact that employment participation can not be expected to maintain the same marginal response as employment opportunities grow. The sign on the linear term should be positive and on the quadratic term negative if there are demographic limits to the proportion of the population that can be employed.

The dependent variable is not the employment/population ratio for the county, but the ratio of this figure to that for the U.S. as a whole. This specification allows national trends to influence the fraction of the population employed. The lagged dependent variable is also included on the right hand side of the equation to control for local demographic variations or other unmeasurable variables.

This approach contrasts with other studies of labor force participation rates, notably that of Bowen and Finegan (1969). Bowen and Finegan use census data and primarily demographic variables such as age and sex. Their approach is not feasible because annual data of that sort are not available.

Estimation results are summarized in table 3. All variables have the expected signs, and the F statistics for each variable show significance at the 5% level. The coefficient of determination is high given that most of the data variation is cross-sectional rather than temporal. The low ratio of the standard error of the estimate to the mean of the dependent variable augurs well for simulation use of this equation.

Net Migration

The determinant of migration into a county is expected income which includes both wages and employment opportunities. Employment change is entered as a quadratic to allow for the possibility of a non-linear response. Initial population of the county in the current year (prior to migration) is included because large populations may attract mobile persons. But, whether a large population is associated with either a large net influx or a large net outflow or an approximate balance between the two is uncertain. The lagged dependent variable implies lagged adjustments to economic conditions. The lagged value of the ratio of employment participation rates should adjust for tight

Table 3--Estimating equation for relative employment participation rates in the Northern Great Plains counties, 1971-74 a/

Equation b/	Estimated coefficients	F statistics	Definition of variables
Dependent variable			
$RELLFPR_t$			Fraction of county population employed relative to U.S. fraction, in year t.
Independent variables and coefficients			
b_0	0.037	-	Constant
b_1 $RELLFPR_{t-1}$	0.961	6493.58	RELLFPR in prior year.
b_2 $PCEMP_t$	0.602	122.98	Percent change in total employment from prior year to year t.
b_3 $PCEMP_t^2$	-2.314	44.48	Square of $PCEMP_t$.
e_{2t}			Error
Statistics			
R^2		0.90	
F		2173.24	
S.E.E.		0.05	
Mean of RELLFPR		1.008	
d.f.		720.000	

a/ Coefficients estimated using two-stage least squares on a data base of 181 counties for 4 years.
b/ All estimated values rounded to the third decimal place.

local labor markets. Wages are entered using an exponential functional form with an arbitrary base. The expected response of migration to wages is curvilinear; that is, at very low wage rates outmigration should be substantial, at average wage rates net migration should not be very responsive to marginal changes, and at high wage rates inmigration should be heavy and very responsive to wage changes. Attempts to incorporate this hypothesis using functional forms such as third-order polynomials yielded negative slopes over the middle range of the data.

The particular function chosen forces positive slopes everywhere. The exponential operates only for wage rates greater than $5,000 per year. Levels of outmigration which would be associated with lower wage rates produce an arbitrary wage rate of $4875 in the simulation model.

Results for the migration estimation procedure are given in table 4. This regression is less successful than the preceding two when one considers the equation as a whole. The primary reason for this probably involves deficiencies in the data for the dependent variable. Net migration data are taken partly from the <u>Current Population Reports</u> of the Census Bureau, which regards migration as a residual after determining population change and natural increase.

Table 4--Estimating equation for net migration in Northern Great Plains counties, 1971-74 a/

Equation b/	Estimated coefficients	F statistics	Definition of variables
Dependent variable			
MIG_t			Net migration in year t.
Independent variables and coefficients			
c_0	81.8002	-	Constant
c_1 $POPIN_t$	-0.0080	25.17	Population in year t, prior to migration.
c_2 MIG_{t-1}	0.5961	266.13	MIG in prior year.
c_3 $EXPONENT_t$	60.3945	198.35	Base e carried to the power $\{2(wage_t\ 5.0)\}$ c/
c_4 $EMPCH_t$	0.4719	24.90	Total employment change from prior year.
c_5 $EMPCH_t^2$	-0.0001	14.79	Square of $EMPCH_t$
c_6 $RELLPR_{t-1}$	-72.0162	0.89	RELLFPR in prior year d/
e_{3t}			Error
Statistics			
R^2		0.625	
F		55.906	
S.E.E.		520.833	
Mean of MIG		50.315	
d.f.		716.000	

a/ Coefficients estimated using two-stage least squares on a data base of 181 counties for 4 years.
b/ All estimated values rounded to the fourth decimal place.
c/ $WAGE_t$ defined in table 2.
d/ RELLFPR defined in table 3.

The figures are reported in units of 100, so for small counties there is likely to be a large percentage rounding error. This fact probably accounts for the coefficient of determination being lower for this equation than for others in the system, and for the high ratio of the standard error of the estimate to the mean of the dependent variable. However, the individual variables in the equation perform as expected for the most part. The only case of a sign being incorrect is that on the employment fraction variable, but the coefficient is not significant in any case. The estimated equation succeeds in explaining five-eighths of the variance in net migration even with limits of this kind.

The approach taken contrasts with that in the literature as summarized by Greenwood (1975). Greenwood's concern is point-to-point flows, that is, gross migration. His analysis concentrates on such factors as the distance between the origin and the destination and the information available to individuals concerning remote areas, as well as more obvious economic comparisons of the two regions. A similar approach discusses the determinants of gross migrations in the Northern Great Plains (O'Meara, 1977). But the issue of the places of origin of the immigrants or the destinations of the out-migrants is unimportant when one is concerned with a particular region. And, only local economic conditions are feasible to consider since there are so many possible origins and destinations.

Local Government Spending

The determinants of spending by local governments should include median income, costs of providing services, and population levels. Median income figures are available only from the 1970 census of population and not for 1972 which is the date for which government spending data are available. Wages are the only source of variation in production costs since cross section data are used. Since wages would represent both demand and supply effects, they are eliminated from the estimating equations.

Spending aggregates are used. The explanatory power of the equations is thought to decline as the spending category becomes more specific due to inherent variability among jurisdictions. The equations are estimated in log-linear form in order to allow for possible scale effects. Results are given in table 5. Economies or diseconomies of scale appear to exist for a number of jurisdictions, especially in Montana and North Dakota. The explanatory power of the equations is good on the whole, especially for school expenditures. The low ratios of the standard errors of estimates to the means of the dependent variables leads one to expect that the equations would perform well in a simulation context.

The evaluation of the individual equations has been in a prediction context with each equation taken separately. The prediction performance of the system is treated below.

Table 5--Estimated coefficients of annual expenditures for counties and schools, Northern Great Plains, 1971-74 1/

Equation	Estimated coefficients by government b/					
	Counties			Schools		
	Montana	N.Dakota	Wyoming	Montana	N.Dakota	Wyoming
Dependent variable						
$\ln GOV_{it}$ c/						
Independent variables & coefficients d/						
d_{i0}	0.929	0.423	-1.750	-1.280	-1.729	-1.213
$d_{i1} \ln POP_t$	0.647	0.675	0.938	0.983	1.011	0.994
e_4						
Statistics						
R^2	0.736	0.865	0.749	0.937	0.928	0.955
F	92.065	319.059	35.799	492.879	644.965	256.164
S.E.E.	0.333	0.222	0.447	0.219	0.234	0.177
Mean of lnGov	6.342	6.423	6.824	6.951	7.255	7.879
d.f.	33.000	50.000	12.000	33.000	50.000	12.000

a/ Estimated using two-stage least squares on a data base of 181 counties.
b/ All estimated values rounded to the third decimal place.
c/ Log base e of total government expenditures in 1972
d/ The coefficient d_{i0} is a constant, and e_4 is the error term. $\ln POP_t$ is the natural logarithm of population in year t.

Chapter 4

TAX SYSTEMS OF MONTANA, NORTH DAKOTA, AND WYOMING

This chapter describes briefly the tax systems of Montana, North Dakota, and Wyoming, and compares them with respect to revenue generated by coal mining and related development. The material is taken for the three states respectively from Thompson (1977), Voelker et. al. (1976), and Thompson and Schutz (1977). For a full description of the tax systems of the three states the reader is referred to these publications. A summary of the tax system of each state will be given here.

In Montana, property taxes generate more than half the total State and local tax revenue, with the personal income tax a distant second. There is no general retail sales tax in Montana. Taxes on natural resources in 1976 were the fourth largest source of State and local revenue, after the property tax, personal income taxes, and highway user taxes. This revenue source is the fastest growing, however, accounting for 2.7 percent of revenues in 1974 and 6.3 percent in 1976. Moreover, the contribution of this sector is understated because the local ad valorem minerals gross proceeds taxes are included in property taxes. Of intergovernmental transfers within the State, the most important is the school foundation program.

North Dakota has three primary sources of State and local revenue: property taxes, retail sales and use taxes, and net income taxes. These account for over 70 percent of total revenue. Mineral taxes in North Dakota account for less than 5 percent of total tax collections. As coal mining has proceeded in the State, collections from the coal severance tax have risen from nothing in fiscal 1972 to over $5 million in fiscal 1976. No gross proceeds tax exists in North Dakota. The most important intergovernmental transfers are the school foundation program and the personal property tax replacement grants. North Dakota no longer taxes personal property and the State compensates localities for this lost source of revenue.

In Wyoming, property taxes including minerals gross proceeds taxes account for almost half of total State and local revenues. Also important are sales taxes and mineral severance taxes. These three amount to over 75 percent of all collections in fiscal 1977. This is in part due to the fact that there is no personal or corporate income tax in Wyoming and in part due to the high valuation of minerals which form a large part of the property tax base of the State. In fact, mining gross proceeds amount to almost half the assessed property value. Of this the most important is crude oil, which accounts for almost 80 percent of assessed mineral valuation. This reflects the historical importance of petroleum in Wyoming. The importance of coal is much lower but is increasing rapidly. As in the other states the school foundation program is the most important intergovernmental transfer program.

Coal Taxation Comparison

There are broad similarities in the way coal mining is taxed from state to state. In general terms, coal can be regarded as property and taxed in that way; the act of mining can be viewed as income-producing activity and taxed on that basis; or coal can be thought of as a non-renewable capital asset, the mining of which justifies a special tax such as a severance tax. All of the states use taxation schemes which fall into these categories. But there are important differences as well which influence both the magnitude and the timing of the fiscal return that a jurisdiction can expect from a given mine.

Consider first the taxes that local jurisdictions can impose upon a mine. In all three states the only relevant local form of taxation is the property tax (except for an optional county sales tax in Wyoming). There are significant differences though, in the way the property tax impinges on the mine. The coal itself is taxed only in two of the three states, Montana and Wyoming, where gross proceeds of mining are defined as part of the property tax base (table 6). The other general component of property taxation includes the usual sources of property tax revenues such as land, structures, equipment, etc, except that North Dakota has no personal property tax so that mine and generating equipment are not a part of the tax base. The revenue magnitudes from gross proceeds taxes dwarf those collected from other sources.

Table 6--Comparison of local jurisdiction property tax mine revenue sources over three states: tax base

Tax component	Montana	North Dakota	Wyoming
Coal	45% of contract sales price X tonnage	None	Gross proceeds
Other	Land, equipment	Land, structure	Equipment, structure

North Dakota localities have a very small tax base for a given mine compared to Montana and Wyoming. This is exacerbated because North Dakota excludes personal property from the tax base, so that the value of equipment, enormous in the case of a large dragline operation, is not a source of local revenue in that state. The other major point to be made involves the difference between the definition of the taxable value of gross proceeds in Montana and Wyoming. Montana uses a lower valuation than does Wyoming for coal selling at comparable prices.[6] That, coupled with the fact that in Montana taxable value is defined as 45 percent of price times tonnage, means that the yield from a given mill levy is lower in Montana than in Wyoming. Alternatively, one can say that for a given amount of revenue, the share paid by the

[6]Telephone conversation with Warren Bower, Wyoming State Supervisor of Assessments, March 13, 1978.

mine is lower and the share paid by the residents higher in Montana than in Wyoming.

Let us now consider state taxes on the mining of coal. Table 7 contains, for each state, the distribution of taxes on coal. The table is restricted to taxes levied directly on coal production, and does not include income or license taxes paid by the mine, taxes on coal held in inventory, or property taxes on equipment used by the mine.

Most of the levies are earmarked and a comparatively small percentage of the revenue is available directly to the state general fund. The amounts available to the legislature for discretionary appropriations can be augumented with some of the funds from the "trusts" category. But the bulk of these trust funds have restrictions on spending the principal.

Wyoming allocates a greater percentage of its coal revenues to capital expenditures than does Montana or North Dakota. Montana has the largest share going to trust funds. Since both Montana and Wyoming tax the value of coal mined it is possible to compare them directly. Montana has a higher tax rate and this is only partially offset by the fact that the rate in Montana is applied to the "contract sales price" instead of the actual sales price. The contract sales price is defined as the actual sales price minus all taxes per ton. Given Montana's tax

Table 7--Direct state levies on coal mining and distribution of revenues, 1980, Montana, Wyoming, and North Dakota a/

Distribution b/	State: Montana % of contract sales price x tonnage	Wyoming % of gross proceeds	N. Dakota dollars per ton
General fund	5.850	2.0	0.243
Impact aid			
Earmarked	.150		0.162
Categorical grants	2.625	2.0	0.405
Resources, trusts & other			
Water		1.5 e/	
Buildings		1.5 e/	
Highways		1.0	
Energy	1.125		
Education	4.770 d/	0.6 f/	
Trusts, general c/	16.250	2.5	
Total	30.770	11.1	0.81

a/ Includes revenue from taxes levied directly on coal mining. Does not include income, sales, use, inventory, or property taxes other than gross proceeds.
b/ Based on final distribution of revenues.
c/ Includes trust funds which can be appropriated for general purposes.
d/ Assumes no school deficiency levy.
e/ There are maximum limits on these funds.
f/ Assumes full 6-mill foundation levy.

structure this implies that the contract sales price is roughly three-fourths of the actual sales price. Since Montana's tax rate is almost three times higher than Wyoming's, Montana's tax yield per ton mined is about twice Wyoming's.

The tax yield can be expressed in a way that allows comparison with North Dakota by making assumptions about coal prices and inflation rates. North Dakota taxes coal on a per ton basis, but the tax rate depends on the inflation rate. Specifically, the tax is 65 cents per ton plus an additional cent per ton for every one point increase in the BLS wholesale price index.[7] If the rate of inflation until 1980 is assumed to be 5 percent per year, the tax rate is 81 cents per ton. If the price of coal in 1977 on the average is $6 per ton and is adjusted upward by the inflation rate, the 1980 coal price would be $6.95 per ton. Assuming $6.95 coal it is possible to express Wyoming and Montana coal taxes in dollars per ton.

Montana's tax yield per ton mined is about twice that of either of the other two states (table 8). The tax yield for North Dakota is about the same as that for Wyoming. The second major conclusion to be drawn is that local impact aid in North Dakota is about four times as great as it is for either Montana or Wyoming. This tends to compensate for the low level of local taxation in North Dakota. It also

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[7] The law allows an increase but not a decrease. It is a ratchet effect.

Table 8--Direct state taxes per $6.95-ton on coal, 1980, Montana, Wyoming, North Dakota

Distribution	State		
	Montana	Wyoming	N. Dakota a/
	--dollars per $6.95-ton mine price--		
General fund	0.300	0.14	0.243
Impact aid	0.143	0.14	0.567
Earmarked	0.008		0.162
Categorical	0.135	0.14	0.405
Resources, trusts & other	0.304	0.31	---
Water		0.10	
Buildings		0.10	
Highways		0.07	
Energy	0.058		
Education	0.246	0.04	
Trust, general	0.838	0.17	---
Total	1.588	0.77	0.81

a/ Assumes 5% per year increase in wholesale price index.

implies that North Dakota has more flexibility in compensating areas adjacent to mines, which bear much of the impact but have little of the tax base, than would be the case in the other two states. (However, this conclusion must be modified because most of the impact aid in Montana and Wyoming is discretionary, and therefore could be used for adjacent areas. Nevertheless, the amounts per ton are much less.) A third conclusion is that education, most of which is higher education, is a major beneficiary of coal mining in Montana, but receives little or nothing in the other two states. Finally, since many of the trust funds have restrictions on spending the principal, it is relevant to compare the per ton yields of the three states for all except this category. Calculations show that the figures are: Montana, 75 cents; North Dakota, 81 cents; Wyoming, 60 cents. On this measure of currently available funds, North Dakota leads.

Other taxes paid by the mine or its employees or ancillary service workers are numerous, but they do not make as large a contribution to state revenues as do direct state coal taxes. On the state level, the major revenue sources would include; for Montana, the income tax, (including the corporate license tax), the unemployment insurance tax, the motor fuels tax, and the property tax on mine equipment; for North Dakota, the personal and corporate income taxes, the sales tax (applicable both to retail sales and mine equipment), the unemployment insurance tax, the business privilege tax, and motor vehicle and fuel taxes; for Wyoming, sales taxes, unemployment insurance taxes, the property tax on mine equipment, and motor vehicle taxes. Rather than discuss each of these revenue sources separately, the reader is referred to Stinson and Voelker (1978). In this publication are summarized all taxes paid by sample mines and their employees for the three states considered here. Taxes are broken down by jurisdiction as well as type. The numbers reflect 1976 tax laws, so they do not include 1977 changes. But the effect of the 1977 changes was to enhance the relative importance of the direct coal taxes discussed above.

School Foundation Programs

Foundation programs merit separate discussion because they are the most important intergovernmental transfer programs on the state level, approached only by coal impact disbursements, and because they are often complex. The purpose of a foundation program is to equalize the school operating expenditures over the state and to assure that all students receive a minimum funding level. In all three states the foundation program works by defining an expenditure level per pupil (which varies with school size) and then allowing school districts the product of the per pupil level times number of pupils, minus some specified local taxation support. The state systems differ in how closely the schools are bound to the foundation spending levels by the tax formulas used and the degree of control by local voters over tax levies.

Montana has the most complicated and the most rigid foundation program because it is impossible for local unvoted levies to yield amounts greater than the state-specified permissive budget. The foundation program in Montana is split into two parts (figure 5). Counties are required to levy 40 mills on all property. Not more than 80 percent of the state-specified permissive budget may be generated by the 40-mill levy. Any deficiency is made up by the State; any excess is transferred to the State. Therefore, the county revenue plus the State transfers yield exactly 80 percent of the permissive budget. Using the permissive levy, school districts may levy 15 mills, or a levy sufficient to yield the other 20 percent of permissive budget, whichever is less. If 15 mills are levied and are insufficient to yield 20 percent, the State makes up the balance. Thus, the school district cannot use this levy to exceed the permissive budget. Any additional funds must come from voted levies.

Both North Dakota and Wyoming give foundation monies to schools on the basis of per pupil expenditure levels times pupil numbers (again with school size relevant), and subtract off some local tax money. In North Dakota, this is done by subtracting 20 mills times the tax base for each district from the foundation levels (figure 6). Thus, the district is practically forced to levy at least 20 mills. In Wyoming there is a mandatory 22-mill levy which remains in the locality, and this amount is subtracted from the foundation levels

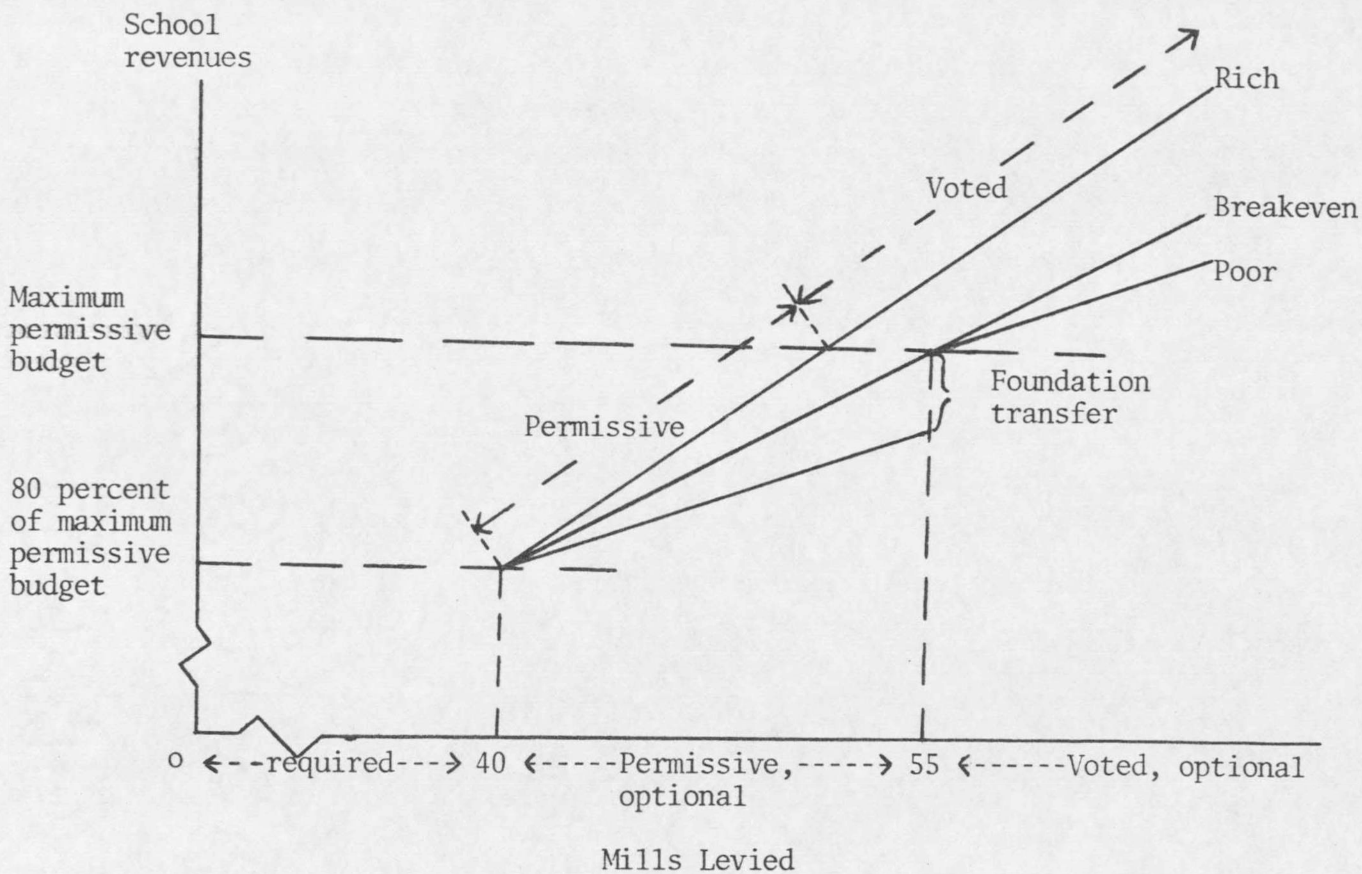

Figure 5--Montana School Revenue and Foundation Program, Three Hypothetical School Districts.

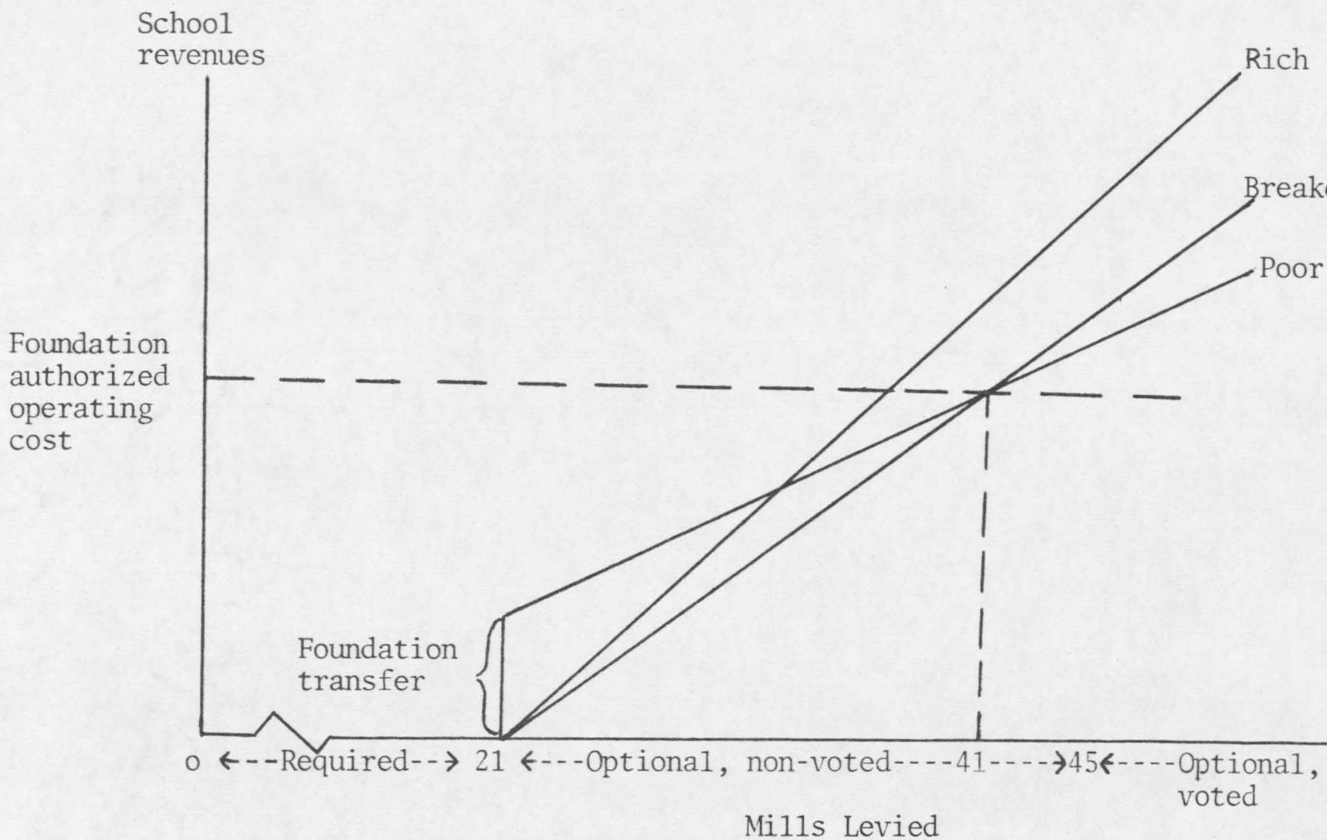

Figure 6--North Dakota School Revenue and Foundation Program, Three Hypothetical School Districts.

(figure 7). These two procedures amount to nearly the same thing, of course. The difference between them is that in the case of rich districts which generate a lot of revenue, the required 22 mills in Wyoming can generate an amount in excess of the foundation level, which, unlike the case of Montana, remains in the local district. In North Dakota, the rich district has the option of levying less than 20 mills and still reaching the foundation levels.

The other difference between North Dakota and Wyoming has to do with local voter control. North Dakota districts can levy up to 24 mills without a vote. Wyoming districts can levy an additional 15 mills on top of the required levies without a vote; voted levies can add up to 3 mills over that. Thus, rich districts aside, there is much greater voter control in North Dakota than in Wyoming.

Finally, North Dakota partially finances its foundation program with a 21-mill levy on all local property. This money goes to the State. Since it does not remain locally, it has no effect on local school levy decisions. To discourage competitive under-assessment, the 21-mill levy is adjusted so that the locality generates the same amount of revenue that would be generated by a 21-mill levy on property assessed at the State average rate.

It should be re-emphasized that foundation programs apply to operating funds only. Capital expenditures are the sole responsibility of localities, and require voter approval for bond issues.

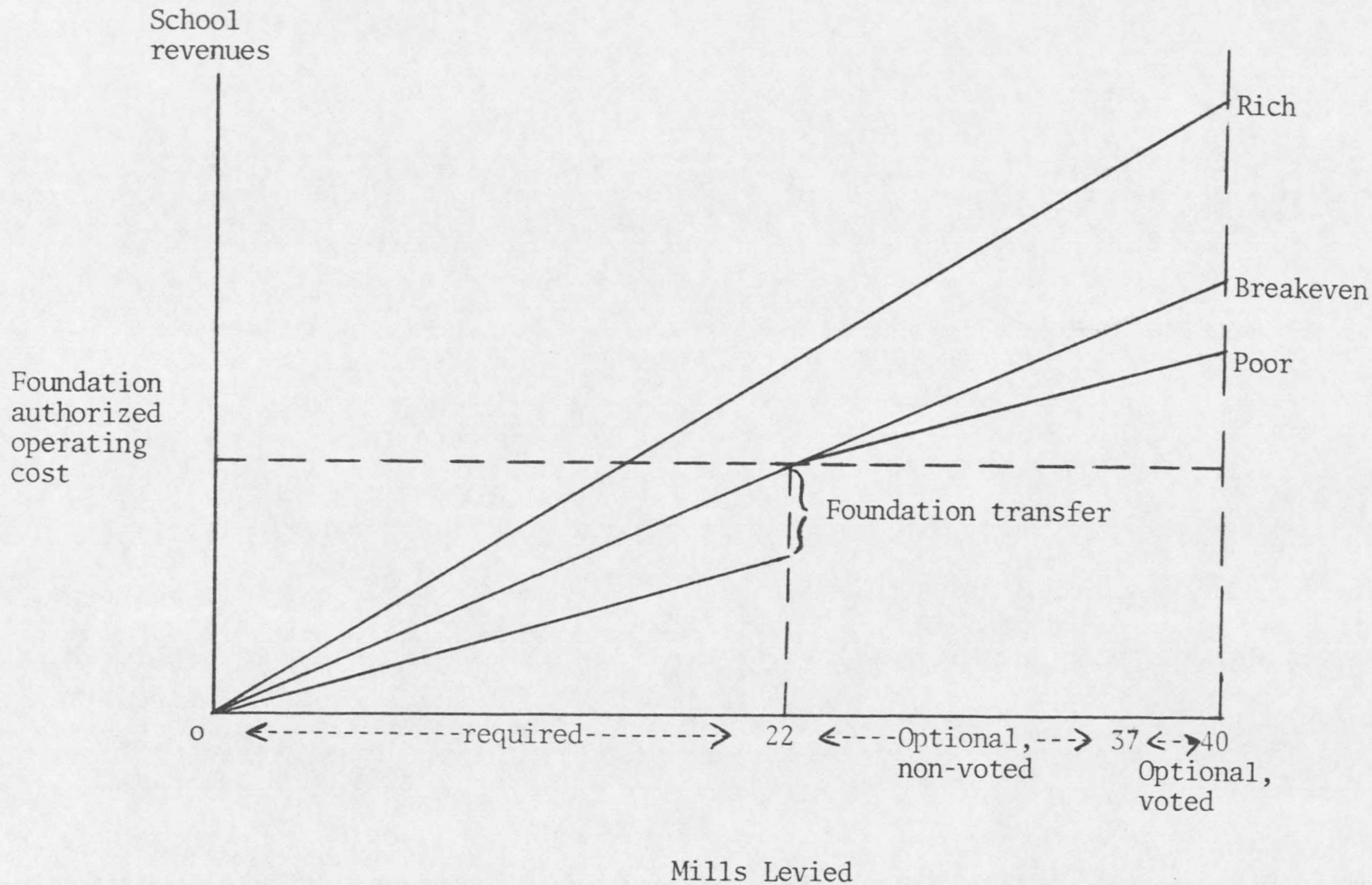

Figure 7--Wyoming School Revenue and Foundation Program, Three Hypothetical School Districts

The Model Tax Base

The tax codes of the three states have been computerized to form the revenue portions of the model. I am indebted to Tom Stinson, ESCS, for supplying me with his ENERGYTAX models. These required only minor alterations for use as revenue subroutines in the simulation model.

The model generates various components of the tax base. Coal taxes are a consequence of exogenous coal mining activity. Residential and personal property (automobiles) depends on population. Commercial property is a function of ancillary employment. The model also generates total income and sales tax bases where these apply, as well as various minor sources of revenue such as gasoline, liquor and cigarette taxes. These are functions of population. This is meant to be indicative rather than exhaustive, for the different kinds of tax are too numerous to be listed in detail.

Chapter 5

THE SIMULATION MODEL

Previous chapters have discussed components of the simulation model and statistical analysis of those components where this is appropriate. In this chapter the complete model is discussed, with emphasis on the interaction among the components. Next, statistical tests appropriate to a complete system are considered. These include simulation tests on the historical data base used to estimate the model and Monte Carlo procedures which generate forecast variances for the model.

The Complete Model

Exogenous basic employment changes lead to changes in ancillary employment requirements (figure 8). The total of these represents labor demand. The corresponding labor supply response comes through three channels: natural increase, changes in employment participation rates, and migration. The results from the labor market submodel are values for, among other things, wage rates for ancillary employees and population levels. These enter into the determination of local government expenditures. Finally, State and local revenues are determined.

Interactions among components which occur during the same time period are distinguished from those which occur over time, and give dynamic richness to the model. Both of these sets of interactions

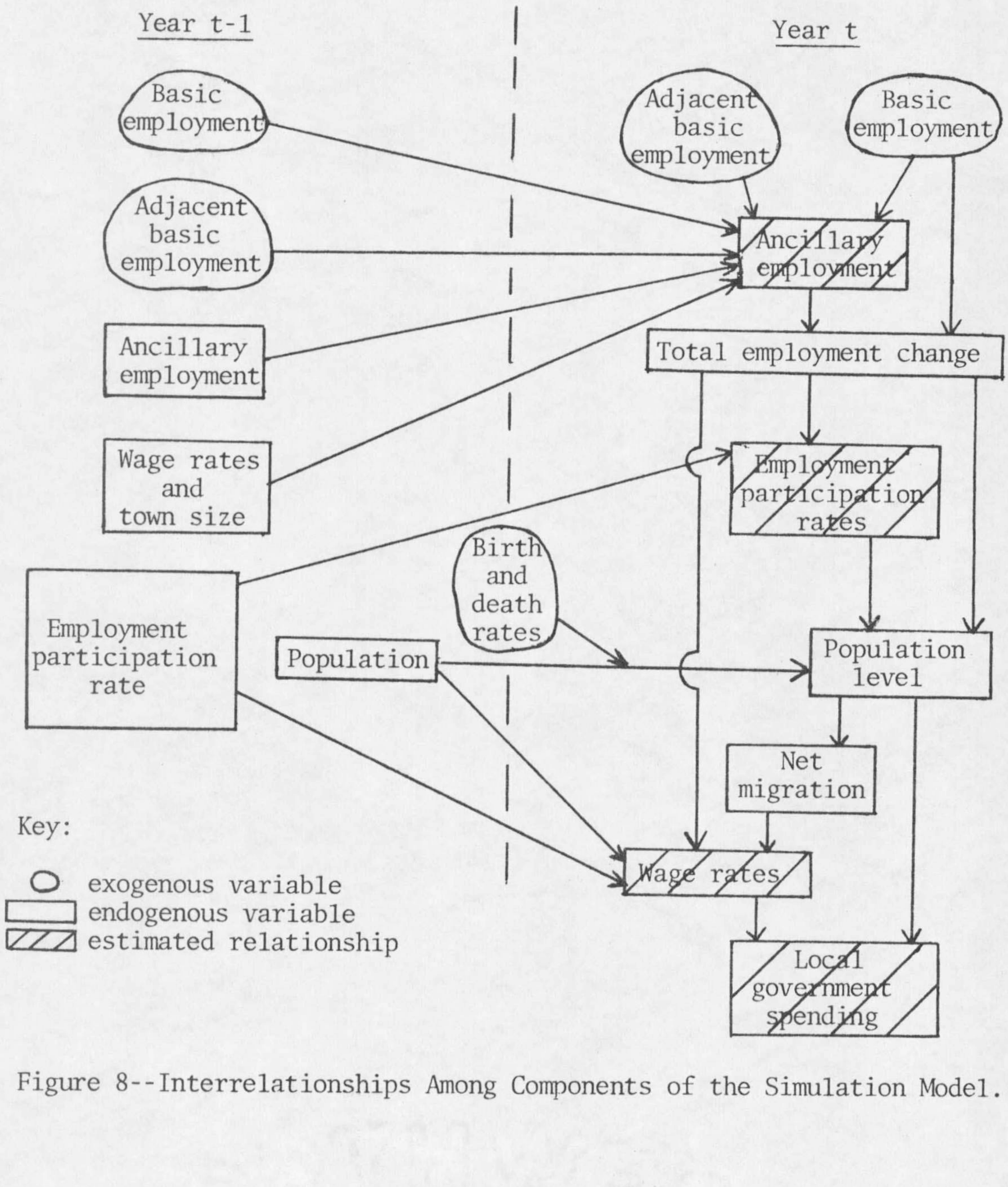

Figure 8--Interrelationships Among Components of the Simulation Model.

can be deduced from the set of equations in Appendix B, which defines all of the model except the revenue portions.

The non-revenue interactions are illustrated in figure 8. Exogenous basic employment determines ancillary employment requirements. The employment participation rate is in part determined by the percentage change in total employment. Natural increase depends on the size of the population at the beginning of the time period. The change in employment requirements is the change in labor demand; natural increase and the employment participation rate determine to what extent the change in demand is met by the supply of local labor. Any difference is made up through migration. The determinants of migration include among other things wage rates. Therefore, wages are set at the level which induces the required quantity of net migration.

Local government expenditures depend on population levels and on local inflation. Spending levels derived from the population figures are adjusted by the local inflation rate to reflect the increased cost of local labor. Population change comes about via natural increase and migration. Therefore the new level of population is known once migration and natural increase are determined.

The model also contains dynamic interactions. In some cases, lagged values of dependent variables help determine current values. This is true for ancillary employment, employment participation rates, and migration. There are also equations which contain as independent variables lagged values produced by other equations. The ancillary employment equation contains lagged values for the economic base and for the economic base in adjacent counties, which are exogenous, and for ancillary wage rates, which are produced by the program in the previous time period. The latter relationship is positive, so that there is a positive feedback loop operating. Increased levels of ancillary employment increase employment requirements, tending to increase the migration required and hence wages, which in turn further raises ancillary employment.

The migration equation also contains the lagged value of the employment participation rate as well as current values of employment change and wages as explanatory variables. These interact in a complicated way. For example, suppose the lagged value of the employment participation rate and current employment change are both large. This tends to produce a large value for the current employment participation rate which tends to reduce the need for migration. Large employment changes, however, act directly to increase required migration. Within the migration equation itself, large employment changes tend to induce net inmigration, while high values for the lagged employment participation rate tends to discourage it. For a given required migration level, these respectively lower and raise the wage required.

Finally, there are feedback effects involving population. Population changes are derived from the requirement for more labor, both basic and ancillary, in a growth situation. Large, immediate population change requirements are met through migration. But the increased population in one year feeds back into population requirements in succeeding years. Higher population levels mean a large growth via natural increase, so that the indigenous labor force can supply more of the required labor force. Population also enters into the migration equation so that a higher level of population (along with large values for lagged migration) implies that a given current migration requirement can be met with a lower wage than otherwise would be needed. Finally, the population growth occurs in the town, which enters into the ancillary employment equation, so that a larger population implies more ancillary employment. Thus, the population level has both negative and positive feedbacks.

Three adjustments to the estimated equations are used in the simulation process. First, the calculated values for the employment participation rate are not allowed to vary from the national value by more than 8 percent. The reason is that boom conditions, with associated large changes in employment, produce unrealistically large values for this variable in the absence of the constraint.

Second, the predicted values for government spending are adjusted. For each county in the sample the ratio of actual to estimated government spending (in each category) was calculated, using the values from the estimating equation. For a particular county in the simulation process, the appropriate ratios are used to multiply the calculated values for each category of government spending. The justification for this procedure is that the simulation process does not involve a random choice of county; the county is predetermined. Therefore, it is permissible to use information on the expected deviation of spending in a particular county from that in the sample as a whole.

Third, wage rates are not allowed to fall below $4,875 per year. Essentially this means that outmigration becomes infinitely elastic at this wage rate. This is done to prevent the model from producing unrealistically low wage rates.

Historical Simulation

Previously the statistical tests on individual equations within the model were described. But statistical tests on single equations do not describe adequately the performance of those equations in a system. It is possible that even if all equations in a model perform well in isolation the system as a whole may not. The reason for this is that the dynamic structure of the system is much richer than that of any equation of which the system is comprised, so that inter-equation feedbacks can affect the system's performance.

Statistical tests for systems are less well developed than are such tests for individual equations. In particular, there seem to be no methods of evaluating the statistical significance of the performance of the system in the way that hypotheses about coefficients can be tested. Acceptance and rejection regions are not defined. So the statistical tests discussed below must be regarded as indicative rather than definitive.

The statistical test discussed in this section is a way of determining goodness of fit for the model as a whole over the period for which historical data are available - the estimation period. The procedure is to start the simulation process with initial (1970) values for variables in the system and then run the simulation for the four years 1971 to 1974. This is done for each of the 181 counties in the data base. Thus, for each variable of interest there are 724 (4 x 181) predicted values. These can be compared with the actual values for an idea of the goodness of fit of the whole model with respect to the particular variable. Following Pindyck and Rubinfeld (1976, pp. 314-320) the quantitative measure of goodness of fit used here is the root-mean-square simulation error, or more exactly the ratio of the RMS simulation error to the mean of the variable of interest. The RMS simulation error is defined as the sum of the squared differences between simulated and actual values divided by the number of observations, i.e.

$$\text{RMS error} = \sqrt{\frac{1}{N} \sum_{i=1}^{N} (Y_i^s - Y_i^a)^2}$$

where Y_i^s = simulated value of Y_i

Y_i^a = actual value of Y_i

N = number of observations

Thus, the RMS error measures the deviation of the simulated variable from its actual pattern. This is then expressed as a ratio to the mean to provide a standard of comparison.

The revenue parts of the model are not included in this test because they are nonstochastic. The expenditure portion was also dropped, since the only data base was for fiscal 1972 and this precludes generating a four year series. The remaining parts of the model yield five variables of interest: ancillary employment, ancillary earnings, employment participation rate, migration and population. The RMS simulation error tests on these variables are summarized in table 9.

The results indicate that for the most part the model generates values for variables which track actual values quite closely. The major exception is migration. The probable reason for the high ratio of the RMS error to the mean in this case is not a defective model but a defective data series. As was pointed out in chapter 3, reported migration is given in units of one hundred. This involves a considerable amount of rounding error. The model, of course, produces a figure for migration which is distributed continuously. There is likely to be a large difference between simulated and actual values

Table 9--Historical simulation test for goodness of fit a/

Variable	Calculated values b/ Mean value	Root-mean square simulation error c/	Ratio of RMS simulation error to mean
Ancillary employment	2353.668	1246.757	0.530
Employment participation rate	0.437	0.048	0.111
Net migration	50.315	1559.988	31.004
Population	10139.871	3486.023	0.344
Ancillary wage rates d/	5.734	1.483	0.259

a/ Simulated on a data base of 181 counties for 4 years.
b/ All values rounded to the third decimal place.
c/ Defined on p. 59 of the text.
d/ Thousands of dollars.

a great deal of the time, which will necessarily translate into a high RMS simulation error. Further evidence for this interpretation is given by the low ratio for ancillary earnings. Since ancillary earnings are determined after migration in the model, and depend on the value of migration, if the model were producing erroneous migration figures these should also adversely affect the ancillary earnings numbers. Yet this does not appear to happen.

Monte Carlo Methods

One of the problems with multiple equation systems is that it is not generally possible to obtain forecast variances for particular variables by analytic means. This is because forecast errors can be affected by the feedback structure of the model. Monte Carlo techniques, as discussed in Pindyck and Rubinfeld (1976, pp. 360-363), provide a way out of this difficulty. The approach is to perform a large number of stochastic simulations. A stochastic simulation is one in which the values of coefficients and error terms for stochastic equations are drawn at random from specified probability distributions. A large number of such simulations generates probability distributions for variables of interest. These can be used to calculate standard deviations or confidence intervals. Forecast variances can therefore be produced experimentally.

If estimated coefficients have desirable properties, the probability distributions from which coefficients and error terms are drawn are known. For each equation the error term is assumed normally distributed with zero mean and standard deviation given by the standard error of estimate. The coefficients of a given equation follow a joint normal distribution in which each coefficient has a mean equal to its estimated value, a standard deviation equal to its estimated standard error, and the covariances between coefficients are given by the estimated covariance matrix. In practice it is not feasible to generate random numbers from joint normal distributions, so the off-diagonal elements in the covariance matrices were assumed to be zero. This means that each coefficient was assumed to be independently normally distributed.

The mechanics of the Monte Carlo process can now be described. For each stochastic simulation a particular random value is used for each coefficient. This value is constant during the simulation since coefficients were estimated under the assumption that they were constant over time. A different random error term is used for each year in each stochastic simulation since the error terms are not constant over time. Given these values the simulation proceeds as usual and the values of variables of interest are recorded. Fifty stochastic simulations were performed and these fifty data points were used to calculate standard deviations. The same (arbitrary) values for exogenous variables were used for each simulation. Results are given in table 10.

Three points need to be made about these results. First, stochastic simulation results are compared to the deterministic forecast rather than to the mean of the stochastic forecasts. The reason for this is that with nonlinear equations in the model there is no guarantee that the mean of the stochastic simulations will converge to the deterministic forecast as the number of simulations grows.[8] Second, the expenditure variables can be included with the economic variables considered in the historical simulation tests. Revenue projections were not included for the same reason as before; the relevant equations are not stochastic. Third, the variation tends to cumulate over time so that calculated standard deviations are much greater for later years than for earlier years. The recursive structure of the model is reflected in the fact that variances for variables at the end of the logical chain, such as expenditure levels, are usually larger than those such as ancillary employment which are at the beginning of the recursive sequence.

Taken together these two tests of the system warrant confidence being placed in the model. The historical data are reproduced well. Some of the variances calculated from the Monte Carlo approach are

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[8]Pindyck and Rubinfeld (1976, p. 363).

Table 10--Monte Carlo simulation results, selected years a/

Variable	1975	1980	1985	1990
Ancillary employment	1858 (367)	3755 (4297)	4543 (8580)	5998 (14403)
Employment participation	0.44986 (0.022)	0.48654 (0.027)	0.47994 (0.030)	0.45932 (0.029)
Net migration	41 (707)	1266 (4083)	761 (7532)	1552 (17740)
Population	7751 (707)	16296 (7990)	17403 (15850)	22855 (26451)
Town size	2453 (707)	10998 (9335)	12105 (24892)	17557 (77127)
Wage rates	5.1625 (298)	3.9999 (326)	6.9245 (302)	7.4640 (289)
County expenditures	1051 (115952)	1693 (152123)	3162 (192761)	4725 (235084)
School expenditures	2359 (161954)	4924 (430471)	9406 (716257)	15457 (842465)

a/ The first figure in each cell is the deterministic value for that variable in that year. The figure in parentheses just below is the standard error.

large in the later years, but that is an unavoidable consequence of the cumulation of forecast errors over time. It simply reflects the fact that forecasting is more difficult in the far future than the near future. Low variances in early years mean that confidence can be placed in simulation results for those years and in the structure of the model. The model as a whole does not exhibit wide swings in its predictions.

Chapter 6

COAL DEVELOPMENT IMPACTS IN MONTANA

Coal mines in Montana, as in other areas of the Northern Great Plains, are very large. Tonnages range from 400,000 tons per year from the Knife River Savage mine in Richland County to an anticipated 20,000,000 tons at the Western Energy Colstrip mine when it is in full production in the future. Coal is stripped and either sent by unit train to utility customers in other states or, as in the case of Western Energy, used to supply mine-mouth generators. The coal to be produced in Montana by 1985 is located in southeastern Montana (Federal Energy Administration, 1977). Projected mines are in Big Horn County (including two mines on the Crow Reservation), and McCone, Musselshell, Richland, and Rosebud Counties. By 1985 when all projected mines are in full production, 101.1 million tons per year are due to be mined in Montana. About 94.5 million tons is expected from mines in Big Horn and Rosebud Counties alone. Therefore, this analysis considers the impacts on these two counties only.

Big Horn County has most of its area taken up by the Crow Reservation, yet only two mines are projected on reservation lands: AMAX E. Sarpy Creek, with an expected annual tonnage by 1985 of five million, and the Shell Young's Creek mine, which is expected to be producing ten million tons per year by 1985. Most of the eight mines in the county are to be located near Sheridan, Wyoming, and are not on Indian lands.

These, as a group, are expected to yield almost 55 million tons by 1985. The AMAX and Young's Creek mines have not been included in this analysis of Big Horn County because of uncertainty concerning leases on American Indian lands.

Both Big Horn and Rosebud Counties are rural and isolated. The coal mining centers in both are located away from the populated towns of the counties. Until the development of mining, the main component of the economic base was agriculture, which was fairly stable over a period of decades. Coal mining on the scale envisaged thus could produce strains on the service sector and the local public sector, neither of which is equipped historically to handle the relative growth that the mining activity implies.

Mining Projections to 1985

Forecasted mining activity in Rosebud involves no mines in addition to the ones already in operation, just increases in the annual tonnages produced. The two mines listed by the Federal Energy Administration (1977) are the Peabody Big Sky mine, which produced 2.4 million tons in 1977 and is expected to yield five million tons per year by 1985; and the Western Energy complex at Colstrip. In 1977, Western Energy mines produced 9.3 million tons. By 1985 with the addition of Colstrip 3 and 4, the annual tonnage is expected to be 20 million. On an assumed productivity of 40,000 tons per employee per year by 1985, there will be 500 miners at the Colstrip Western Energy mines and 125 at Peabody Big Sky. It is assumed that workers and their families live at Colstrip, and that Forsyth is the adjacent town which also will receive demands for ancillary services.

Eight mines are scheduled to be on stream in Big Horn County but only two are currently in operation. These are the Westmoreland Sarpy Creek Tract III mine which produced 5.5 million tons in 1977, and Decker West which produced 10.1 million (table 11). Labor productivity depends on the size of the mine. A total of 1,382 mine workers are expected to be associated with the Big Horn County mines in 1985.

Table 11--Anticipated Big Horn County Mines, 1985

Name	Million tons	Number of employees
Consolidated CX Ranch	5.0	111
Decker East	8.0	178
Decker North	4.0	133
Decker West	11.5	288
NERCO Spring Creek	10.0	222
Shell Pearl	2.0	67
Westmoreland Sarpy Creek Tract II	4.0	133
Westmoreland Sarpy Creek Tract III	10.0	250
Total	54.5	1382

Most of the Big Horn County mines are located in the southeastern corner of the county, almost in Wyoming, so that special implications exist for impacts on Montana. There are no towns currently in that part of the county, and few roads leading to Hardin which do not go through Wyoming. Most of the miners now working on the Decker mine live in Sheridan, Wyoming. This means that Montana jurisdictions receive the tax benefits of the coal mining but have few of the growth impacts. Sheridan, on the other hand, has impacts but no extra coal-related revenue source for needed public services. This is the extreme case of adverse boomtown effects which are exacerbated because of jurisdictional lines. In the absence of residence possibilities on the Montana side of the border, Sheridan can expect to be impacted even more as the projected mines in Big Horn County come on stream.

It is possible that in the future some miners may live in Montana. Plans have been announced for the construction of a new town in the Decker area. Press reports indicate that a construction firm intends to begin preliminary road work in 1978 if permits can be obtained, and to have 10,000 people there within a decade. The new town is not considered in the analyses because of the uncertainties surrounding the project plus the fact that, even if it proceeded on schedule, an exponential growth rate in population means only two or three thousand people living there by 1985, and that it in effect would be merely a suburb of Sheridan.

Impact Analyses to 1985

Of interest in Rosebud County is the net effect of the additional forecasted coal development. Analyses were made with and without the expected coal mining to isolate this effect (table 12).[9] For the most part variables have higher values in the case involving additional coal development than is true for the static case. Although expected, some of the dynamic richness of the model also is apparent in the time series. Wage rates are lower in some years for the additional case than for the other case which reflects the dynamic response of the model. Increasing employment requirements generate high migration inflows for several years, such as 1983, in the development case. High values of past migration tend to induce high levels of current migration. If employment requirements do not rise much in these years, the tendency toward high migration rates is discouraged by low wages. In other words, there is a tendency for people to overrespond to employment opportunities.

The wage variable reacts to an overresponse of migration. This is why wages fluctuate in the years immediately following the initiation of a mining project. Further, wage rates partially determine local government spending because the effects of local inflation are considered. Therefore, wage fluctuations lead to fluctuations in local

[9] Data for these analyses as well as others discussed below are presented in Appendix C.

Table 12--Differences due to additional mining in Rosebud county, selected variables

Year	Total employment	Percent employment participation	Population	Net migration	Dollars ancillary wages
1975	0	0	0	0	0
1976	87	0.30	138	137	175
1977	94	0.31	150	11	-726
1978	130	0.40	209	58	222
1979	189	0.56	302	91	134
1980	288	0.83	460	155	243
1981	324	0.87	523	61	-776
1982	343	0.85	562	36	-154
1983	471	1.15	766	201	486
1984	568	1.32	930	158	-491
1985	643	1.42	1063	127	-289

government expenditures. The reason for the fluctuation is that the model requires that full adjustment to changes take place in one year. In reality this may not be true. Adjustment may take place over several years, in which case there would be less sharp changes in required migration and less fluctuation in wages and in government spending.[10] So the numbers given here may be taken as indicators of the tightness or looseness of the labor market, which possibly would be worked out over time.

About half of the extra total employment is accounted for by miners, with the rest being ancillary workers.[11] The town of Colstrip grows by an extra 1,000 people by 1985 in the development case compared to what it would have done had no additional mining employment come about.

The fiscal consequences of coal development for jurisdictions in Rosebud County depend on the mill rates adopted as well as the tax base.

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[10]The data contain little information on adjustment speeds. An unsuccessful attempt was made to apply a partial adjustment model to employment requirements, as described in chapter 2. If this had worked, a given basic employment change would have induced a response in ancillary employment over time. In turn, this would bring about immigration spread through the years at lower annual rates, and wage rates would not fluctuate so much. Finally, the time path of government spending would be more stable.

[11]In all runs the non-mining component of the economic base is held constant. Also, the national inflation rate is assumed to average 5 percent in the 1970's and 3 percent in the 1980's.

Per capita revenues for county and school districts are presented in table 13. Values are given for each of three millages: the actual 1975 rates, a rate ten mills higher, and one ten mills lower.

The reason that the school district revenues vary so little with mill levies is that most of the required expenditures are carried by the State foundation program. The use of the school levy is for new capital construction and for enrichment. Capital and operating requirements are aggregated in the model, so foundation-supplied operating revenues tend to dominate overall. However, the ability of the school district to derive so much revenue results from the assumption that mines are located within the district. For adjacent impacted districts the capital spending burden especially may be severe. Also if a mine shuts down within the district it may be faced with the loss of the major part of its tax base while still in debt for earlier construction. So the favorable results for the school district are conditioned by the distribution of population and continued mine operation.

Revenues for Colstrip, on the other hand, are not much greater than for the whole county, even at 79 mills. This is a consequence of the absence of mining gross proceeds and the thermogenerators from the

Table 13--Calculated revenue per capita by jurisdiction and by selected mill levies, Rosebud county

Year	Local government and assumed mill levies								
	County			School district a/			Town		
	High 34.05 mills	1975 24.05 mills	Low 14.05 mills	High 27.91 mills	1975 17.91 mills	Low 7.91 mills	High 79 mills	1975 69 mills	Low 59 mills
1975	237.22	178.04	118.67	1230.37	1117.52	1004.65	331.40	293.78	256.16
1976	273.48	206.94	140.04	1268.00	1142.41	1016.12	324.68	286.92	249.16
1977	272.18	204.49	136.44	1270.25	1143.84	1016.74	333.72	294.57	255.42
1978	280.88	209.81	138.36	1283.95	1152.68	1020.69	340.43	300.13	259.84
1979	298.32	222.99	147.23	1301.79	1164.14	1025.71	346.03	304.76	263.48
1980	289.34	206.95	124.06	1332.04	1183.73	1034.52	350.14	308.09	266.04
1981	276.33	197.75	118.66	1311.90	1170.76	1028.73	314.78	277.07	239.35
1982	278.77	199.46	119.64	1315.42	1173.06	1029.78	316.79	278.72	240.65
1983	300.31	214.73	128.57	1344.34	1191.73	1038.08	313.81	275.97	238.13
1984	309.35	221.13	132.29	1356.14	1199.34	1041.46	312.78	274.98	237.17
1985	316.48	226.17	135.22	1365.98	1205.70	1044.28	313.16	275.24	237.32

a/ Data reported as dollars per student where 1.17 students per employee are assumed. Millages shown are permissive plus voted levies, but revenues shown include the dollar foundation level also.

tax base, and also of the small size of the town.[12]

Finally, the marginal yield of an extra mill is very high for the county. This is a clear indication of the effect on the tax base that coal mining can have.

The impacts on Big Horn County are much more easily described since it is assumed that all miners live in Wyoming. The economic impacts on the county are likely to be minor; employment, wages (of residents), migration and population of Big Horn County are probably unaffected by coal mining. Sheridan will be the impacted area. Under the assumption that other components of the economic base are unchanged, table 14 gives values for population and county government expenditures over the period until 1985.

Population growth is modest. The total increase over the 11-year period is less than 1,000 and is due to service growth in Hardin not related to coal mining. Rosebud County shows an increase of more than 2,000 starting from a smaller base. The increase in county government spending is likewise small. Aside from some sharp fluctuations in early years caused by changes in migration and hence wage rates, there is a slow and fairly steady growth pattern in county government spending.

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[12] It is assumed here that Colstrip is an independent, incorporated town through the whole time period. This assumption corresponds to the announced intention of Montana Power to seek incorporated status for Colstrip.

The increase during the 1976-1985 decade is only $142,000, and is to be expected without coal development.

Table 14--Big Horn county population and expenditures with anticipated levels of coal development, 1975-1985 a/

Year	Population number of people	Expentitures dollars
1975	9,955	704,613
1976	9,991	1,073,753
1977	10,024	842,567
1978	10,074	968,740
1979	10,136	1,024,284
1980	10,209	1,083,669
1981	10,338	1,078,633
1982	10,476	1,073,904
1983	10,623	1,120,531
1984	10,778	1,169,382
1985	10,941	1,216,122

a/ Miners are assumed to live in Sheridan, Wyoming.

The analyses for Big Horn County assume no towns currently in the Decker area of the county. Those rural school districts which contain the mine tax base will have a much higher yield on each mill levied; that is, mill levies could be much lower in order to support their present operations. The only meaningful comparison of revenues and expenditures must be done on the county level. As one would expect, and as can be seen from the data in the appendix, the county is in a surplus position for all assumed mill levies in all years except for a couple of years in the low millage case due mainly to higher wages in a tight labor market.

The contribution to county funds made by taxes on the mines is perhaps of most interest. This is presented in table 15 below for each of three assumed mill levy rates.[13] By way of comparison, the 1975 Big Horn County levy was about 27 mills. This had dropped to 16 mills the next year.

Table 15--Big Horn county direct tax revenues from coal mines, selected millage rates with anticipated coal development 1975-1985

Year	10 mill levy	20 mill levy	30 mill levy
		---------- dollars----------	
1975	294224	586925	887949
1976	295304	587111	875508
1977	351672	699173	1042587
1978	360817	717355	1069697
1979	405948	807080	1203491
1980	584249	1161566	1732087
1981	936750	1862377	2777103
1982	1061584	2110552	3147159
1983	1219897	2425297	3616488
1984	1231413	2448189	3650618
1985	1231405	2448173	3650595

[13]The data are obtained from detailed tax printouts too voluminous to be included in the appendix.

One of the important issues in impact analysis is the possibility of spillovers from one jurisdiction to another. This means that one jurisdiction may have the revenue sources (mines) and another may have the impact effects because growth may occur there if it is adjacent to the mining area. If this happens, it may be desirable to try to match the revenue with the required expenditures. This issue is discussed in greater detail elsewhere.

The impacts on Sheridan, Wyoming due to the mines in Big Horn County, Montana constitute a seminal case of the spillover effect. Therefore it is of interest to determine the net effect on Sheridan County of the coal development in Big Horn County. This information is given in table 16. It is apparent that the Montana mining has a significant impact on Sheridan. Revenue figures are not given since they are only slightly different in the two cases. By way of comparison, the 1974 population of Sheridan County was 19,253, total employment was 8,889 and the area attracted 550 net migrants. Sheridan is a regional trading center, and the 1974 town population was 12,500. The county also has coal mining of its own. It was assumed that by 1985, 464 miners would be producing 6.5 million tons of coal annually.

Summary

The analyses considered imply that most impacts of coal development in Montana with the exception of tax revenues are concentrated in Rosebud County. Total population in Montana will be 1,000 people

Table 16--The differences in impacts on Sheridan county due to coal mines in Big Horn county, selected variables, 1975-85

Year	Total employment	Percent employment participation	Population	Net migration	Dollars ancillary wages	Dollars county spending	Dollars school spending
1975	533	0.73	860	859	266	516,970	689,775
1976	644	0.82	1049	184	0	222,470	305,420
1977	703	0.83	1157	101	-112	141,651	203,801
1978	745	0.83	1239	75	-37	254,522	353,040
1979	876	0.92	1459	212	456	1,003,291	1,337,944
1980	1248	1.28	2043	575	420	1,284,136	1,727,572
1981	1901	1.91	3067	1013	1835	3,138,344	4,159,353
1982	2228	2.12	3627	543	-175	667,749	940,814
1983	2551	2.29	4192	543	-80	1,150,468	1,601,069
1984	2655	2.21	4437	221	-1262	-502,825	-557,703
1985	2712	2.11	4613	150	-418	853,354	1,231,454

greater than it would have been in the absence of development, and 643 more persons will be employed. This is a moderate impact.

What of the fiscal and noneconomic effects? The two major areas of controversy surrounding coal mining are the environmental consequences, which are important but beyond the scope of this study, and State tax revenues which include questions concerning the best use of coal-generated tax funds and whether State impact grants are needed. State taxes as a result of coal mining include direct taxes on the coal, taxes such as the state income tax paid by miners, and similar taxes paid by the ancillary businesses and population. The magnitudes of direct State coal tax revenues are much greater than the others, and are currently subject to a possible legal challenge, so they are considered alone. The amount of the calculated State tax to be paid directly by all the mines in Big Horn and Rosebud Counties, Montana is given in table 17. The taxes which generate these funds are the severance tax, the State property tax applied to mines, the RIT tax, the unemployment insurance tax paid by mines, the corporate income tax and miscellaneous fees.[14] It is also assumed that 1975 millage rates were in effect for both counties. This matters because local taxes are deducted as part of finding net income on which the corporate income

[14]This does not include the levy for the State school foundation program.

tax is based, and are a part of the calculation of contract sales price on which severance, RIT and property taxes are based.

Table 17--Direct state mine tax revenues

Year	Dollars
1975	30,415,041
1976	34,622,168
1977	38,116,830
1978	40,085,920
1979	44,988,224
1980	59,966,624
1981	82,517,824
1982	90,951,008
1983	105,673,216
1984	109,061,232
1985	111,308,256

The magnitudes are impressive, as the State should be receiving more than $100 million per year within five years.

On the assumption that coal development takes place as forecast, both State and county revenues seem adequate to meet needs, unless low mill levies are adopted in the counties. Schools with mining in the tax base are primarily taken care of through the foundation program and should not suffer except perhaps from capital spending needs in advance of coal mines coming on the tax rolls. Other school districts could be impacted if new facilities are required. Towns are in much worse condition by not having mines as part of the tax base.

What could cause these generally favorable conclusions to change? There are three main sources of problems. First, public expenditures may be required before an adequate tax base exists. This is the front end problem. It was mentioned above in connection with school capital construction, but in principle could apply to any level of local government. Second is the spillover problem. Impacted areas may not have a correspondingly higher tax base. This has been discussed in terms of school districts and also in the case of Sheridan, Wyoming. Third is the issue of uncertainty. All analyses in this chapter have proceeded assuming a particular coal development timetable. But there is nothing to prevent a mine from shutting down suddenly. If it does so, the locality may suffer a drastic cut in its tax base and yet be saddled with large future spending obligations, such as bond repayment for capital construction. This could mean sharp increases in local mill levies and unused capital facilities. These issues are discussed more fully in the next chapter.

Chapter 7

BOOMTOWN POLICY

The results of the model are of a positive rather than a normative nature, because the objective was to describe the likely consequences of any given development scenario. The normative aspects of energy development also should be considered. The normative principle underlying the discussion is that the beneficiaries of an energy project should pay the costs associated with the development in so far as possible. If costs are internalized, production is efficient in the classical sense, in the absence of other disturbances. If some costs are externalized, too much is produced. Therefore the problem is to identify the benefits and costs. Furthermore, problems of property rights in the broadest sence of the concept and their implications for efficiency and equity emerge.

Benefits are discussed next. Costs are considered in the following section. This is somewhat difficult since some costs, notably impact costs, are not easily defined. Following the discussion of costs are sections on theoretical methods of conceptualizing impact problems, and the applied uses of the model to predict the consequences of policy measures.

Benefits

Since we are considering specifically energy-related developments, the benefits are also specific. Most Northern Great Plains coal is used for electricity generation, so the obvious beneficiaries of a project are the consumers of the power. In this case costs should properly be included in the price of electricity. There may be other national interests which are public goods. An example is Project Independence which is designed to reduce oil imports. Part of the benefit in these cases is nationwide, and the associated cost responsibility is governmental. Also, people in an energy-project locality may benefit. Economic development may bring about additional services such as more restaurants or more convenient air travel. Costs of access to some services may be reduced. An example might be increased availability of governmental services. Finally, prices of locally supplied factors such as labor or land may rise, which makes owners of these factors better off. These last are pecuniary economies which need no special welfare attention.

Costs

Costs which are easy to define include the value of resources used in mining which normally appear on the mine's income statement, such as labor and capital. Also included is the value of resources which may be costs to the firm only because of government action. An example is resources used for reclamation. Other costs arise from externalities. We can distinguish between pecuniary and technological externalities. Factor price changes due to energy development have already been mentioned as a source of benefits. To those who hire those factors the rises in prices are pecuniary diseconomies. Pecuniary externalities require no normative discussion because they are not external to the market system. Technological externalities such as air pollution are outside the market system and must be adjusted for if efficiency is to be achieved. One category of costs deserves special treatment. This is impact costs, which may be internal or external. If external, they can be pecuniary or technological.

The literature contains little theoretical discussion of impact costs, where cost is understood to have its formal meaning of resources expended which could have been used alternatively. Crocker (1975) categorizes boomtown impacts in terms of the costs of adjustment. The disequilibrium transition from one equilibrium to another is especially marked in the case of boomtowns because the two equilibrium positions are so far apart in relative terms. In comparative statics being out of equilibrium involves a social cost since resources are not being allocated in the best manner. But in a dynamic context the question is the nature of the optimal path between the two equilibria. It is possible but unlikely that the optimal path is the one that would be taken in the absence of any policy measures. If policies are to be adjusted, two general kinds of programs are possible. One attempts to use resources to speed the adjustment process. This is difficult to accomplish. The alternative is to invest resources in programs which mitigate the effects of being out of equilibrium. The policies discussed later in this chapter are designed to do this.

The point to be noted is that presumably some optimal resource quantities should be diverted into programs such as these. This defines the optimal adjustment path. It is not likely that the optimal quantity of resources devoted to impact mitigation programs is the amount needed to completely offset the disequilibrium costs. This means that from an efficiency point of view probably not all impact costs should be corrected by policy measures. Equity considerations may lead to additional compensation, but that is a different issue.

More common than theoretical analysis has been research into actual impact costs suffered by boomtowns. For example, Gilmore (1976) lists a number of boomtown problems typical of energy development in the Rocky Mountain region. Three categories include most problems.

First, the response of entrepreneurs in the ancillary service sector often lags behind the demand derived from the population increase during the boom. This may be due to an adaptive expectations effect or it might be because of uncertainty about the duration of the boom and consequent unwillingness to invest capital in the area. The slow response means that less than equilibrium amounts of the good or service are supplied. Two industries stand out especially: medical care and housing. A shortage in medical personnel may be due to the same degradation in the quality of life that makes labor recruitment in other fields difficult (as is discussed below); the housing shortage is due to a number of factors. The supply of permanent housing does not expand to meet the demand. On the supply side, local contractors often see their workforces shrink rather than expand as workers join the energy project. On the demand side, local inflation of both wages and land prices causes the price of new housing to rise above what most of the immigrants can pay. Also, local financial institutions are often not equipped to finance extensive house construction because they lack ties to the secondary mortgage market and local saving does not generate enough funds. Temporary housing such as trailer court pads may not be constructed because the anticipated construction period may not be long enough to cover the usual five to seven year payback period for these installations.

Second, there may be at least a temporary reduction in the provision of public services due to the inability of the tax base to grow at the same rate as the population demanding services. We can distinquish between temporary and permanent declines and between capital and operating expenditures. If the location of the project is such that it falls within the jurisdiction of the locality of interest, and if state laws define the tax base properly, eventually the locality will receive at least sufficient tax revenue from the project to maintain public service spending at desirable levels. For purposes of both capital and operating spending, though, there may be a lag between the time expenditures should rise and the time the project comes on the tax rolls. This is the "front end" problem. Also, if project-related population growth occurs in areas which do not have the project in the tax base there will be budget squeezes on local governments. This is quite common for municipalities and school districts, but it is not limited to these jurisdictions. The extreme case involves the Decker area mines in Montana where the population impact is almost entirely in Wyoming. Finally, even if the project-related tax base is adequate, localities may have problems with capital spending because of uncertainty about the duration of the project. Local governments may be unwilling to assume debt for capital construction even if the tax base including the project is easily sufficient to repay the bonds, because of the possibility that the project may shut down unexpectedly and leave the community with a severe debt burden. This may mean that there will be insufficient capital equipment in the region even if the project lasts for the expected length of time.

Third, there is a disruption in the social fabric of the community in many cases. There is discord often between original residents and immigrants, and a degraded quality of life, both social and environmental. This may lead to rapid turnover in the local labor force.

All three of these are disequilibrium problems. There may be other inefficiencies associated with boomtowns as well which are not strictly impact or transition costs. There are externalities such as air pollution from coal dust, or traffic congestion caused by unit trains traveling through ground level railway crossings. These things presumably would not disappear as the boomtown adjusted to equilibrium. Charging the energy firm for the use of the resources involved, or perhaps even direct action by government, might increase efficiency.

Impact Policies: Theory

There are two general categories of policy: compensation to those who bear the burden of impacts, and correction measures designed to mitigate the impact costs directly. The measures evaluated using the simulation model are of the latter type, while this section is primarily devoted to the former.

Discussion of compensation implies that those who might be compensated are known. Ideally each person should be treated individually: in practice it is impossible to identify everyone who suffers harm, and to determine the magnitude of the cost. Instead the focus must be on groups, many of whose members (though perhaps not all) will have been injured by the energy development.

To determine those injured, begin by assuming that only people living close to the project can be impacted. This may exclude those living at some distance who have particular concern on aesthetic grounds, for example, but to include them would be impractical.

Nearby residents can be classified as indigenous residents who remain through the duration of the project, those who migrate out, and people who move in. Previous residents who remain in the area or who move out, possibly because of the boom conditions, are clear candidates for inclusion among those impacted.

Inmigrants are less clearly classified. Given the assumption of perfect knowledge about boom conditions, inmigrants reveal that they are better off than they would have been by staying where they were. This view holds that they have obtained a net welfare gain and deserve no compensation; that is, they were aware of impacts at the time a decision was made. But the assumption of perfect knowledge is demonstrably untrue. It is contradicted by the fact that employment turnover rates, reflecting dissatisfaction with boomtown life, are very high. According to Gilmore (1976, p. A-7) turnover in Sweetwater County, Wyoming ranged between 35 percent and 100 percent during boom years. This would not happen if people were better off after moving in unless they were planned short-term residents or unless greener pastures seemed available elsewhere.

What is the proper way to view these inmigrants from a welfare economics perspective? One possibility is just to argue that they made a bad investment decision, the consequences of which ought to be borne by those who made the decision. On this view the migration decision is basically an example of decision-making under uncertainty where the unsuccessful migrants did not invest enough in obtaining prior information or else simply obtained an unfortunate outcome from a stochastic process. Since information is expensive, we can argue that the optimal amount of resources devoted to obtaining it is what people actually buy through the market.

If this view is adopted can the reasoning also apply to indigenous residents of the area? They might be thought of as having made a bad decision as well, to remain in the area or to have moved in originally, perhaps years before the boom project began. This line of thought leads to the conclusion that no compensation should be paid to anyone.

This argument does not seem to give very useful results. It is predicated on the assumption that people can predict the future adequately and that the element of surprise is handled well enough by optimal response to uncertainty. This conflicts with equity and compensation analysis. These theories would seem to be based on the assumption that it is not always possible to anticipate events. Development of generally recognized rights must spring from a generally accepted view of the future. If some "surprising" event occurs that makes that view obsolete, then equity claims may exist.

Therefore if an energy project impacts indigenous residents of an area they may be entitled to compensation.[15]

O'Hare and Sanderson (1978) argue that it is efficient for the governing system to accept some uncertainties; that is, a social insurance scheme should exist.

There is an analogy with natural catastrophes such as earthquakes, tornadoes and floods. Victims of these events are compensated by transfer payments, and the existence of the transfer is not eliminated by the fact that people live in seismic zones, tornado belts or flood plains which increase the probability of disaster. Boomtown development also can be thought of as a random event with differing probabilities depending on location; that is, previous residents should be compensated for developments which destroy their investments in the social and physical infrastructure.

O'Hare and Sanderson think that immigrants should not be eligible for such aid. Without the assumption of perfect knowledge, however, it is impossible to deny that some immigrants could be worse off and therefore should also rate compensation on the same terms as existing residents.

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[15]People who move from the community because of impacts are at least as well off as if they were living in the impacted community. The difference between their welfare before development and welfare at the level of impact at which they decide to move is an estimate of the (continued on next page)

To sum up, the common inclination is to assume that immigrants are less deserving of impact compensation than either longtime residents or those who moved away because of the boom. Yet this is very difficult to establish. It seems that everyone adversely impacted is deserving of compensation if anyone is.

The other technique, mentioned earlier, of dealing with impact costs is a policy designed to mitigate the impacts directly. Since most impacts are adjustment costs, policies can be designed to ease the adjustment process. Most attention has been paid to problems of local government. States in the Northern Great Plains coal area have devised plans to aid impacted localities through grants. Adjustment costs which do not affect local governments have received less attention.

Impact Policies: Applications

The state has considerable power to affect the location and timing of energy development projects through mechanisms such as issuing permits and requiring environmental impact statements. This power could be used in an impact mitigation strategy by controlling

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15 cont'd.
impact on them. However, that amount of welfare change need not be equivalent to the change they would experience from the predevelopment to the fully developed impact stage.

the location and start-up time of a particular project.[16] But analysis is required to determine an optimal strategy. Would social policy be better served by lumping all mines together in a single area or requiring that they be dispersed? Would it be better to start all mines at the same time and thereby restrict the development impacts to that time, or spread the beginning of mining out over time and also diffuse the development impact? Analyses for several scenarios reflect the above options. Comparison of the results sheds light on the policy questions.

A standard county, meant to be typical of the counties in southeastern Montana, was assumed. The county is assumed already to have one 10 million ton per year operation. Three different scenarios are considered. In the first, a single, 9.2 million ton mine was added, beginning in the first year of the simulation in each of four counties. The second scenario considered the effects of four such mines all starting operations in the same place and at the beginning of the simulation period. In the third scenario the four mines were phased in one by one, in 1975, 1979, 1983 and 1987 in one place. By comparing the results of the second and the third scenarios it is possible to describe the effects of requiring delays in mine starts.

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[16]Analysis of conditional and modified permits is a required part of the environmental impact statement.

The second scenario compared to the first shows the differences which result from mines dispersed in space as opposed to being concentrated in one place.

If all four mines begin operations in the same year, there is a much greater impact on the county in the initial years than if the mines are phased in, as one would expect (tables 23, 24, and 25, Appendix D). Initial migration is 1,779 in the first case and 213 in the second. Then migration drops off in the first case, never getting above 300 until the final year. When mines are phased in over time, high levels of migration occur at four year intervals, with the highest value being 866. It is clear that a community would be much better able to handle the impacts if mines are phased in over time. Services such as expanded housing could be provided much more easily over time than all at once.

Corresponding to the very large initial migration stream if all mines begin at one time is a very high wage rate. Wage levels drop dramatically in the second year. In general, though, wage fluctuations are smaller in this case after the first year or two, because most of the migration changes have taken place by then. When mines are spread through time there is a typical pattern of high wages only as mines come on stream (when migration requirements are high), followed by very low wages. The explanation of this in terms of the model is that high values of lagged migration stimulate high values for current migration, which must be discouraged by low wage rates. The economic explanation is that too many people respond to the high wage signal and information flows are slow to adapt so that changes in responses are delayed or lagged; consequently current variables such as wage rates must change a great deal to induce a reversal of migration flows.

Employment participation rates are high in the early years, as would be expected if all mines start in the same year. By the early 1980's, however, the series are virtually identical for each case. Population and town sizes are consistently smaller if mines are phased in because natural increase is working on a smaller initial population. Although higher population levels imply greater public spending needs, local fiscal surpluses are consistently large if mines are all brought on stream at the same time. This is due to the large mined tonnages which form most of the property tax base. However any spillover effects would undoubtedly be more severe if all mines began operations at the same time.

Turning to the question of spatial dispersion, the most general conclusion is that there appear to be economies of scale in concentrating mines in one area. Relevant variables are not four times as large when all mines are concentrated locally. For example, the initial value of the population of the town is 1,750. Although this increases by 250 in the single mine case compared to an increase of about 1,800 in the four mine case in the first year of simulation, by 1985 the increase in town size is 3,000 in the single mine case and 4,400 in the four mine case. This of course is much less than a fourfold multiplication. Results are similar for county population and total employment. Increases over initial levels in the four mine case, while larger, are not proportionately larger than the increase in the single mine case. The intuitive explanation of this seems to be that, although initial impacts (within the first year or two) are higher if mine development is concentrated, over time these impacts are not sustained in a proportionate fashion. This suggests that optimal policy from an impact management viewpoint may be to encourage the development of a central town in the coal mining area.[17] If this were accompanied by a policy of phasing mines in, the total impact on the community fisc might be made much smaller than if uncontrolled development were allowed.

Finally, mention should be made of the effect on ancillary activity in adjacent counties of increased mining in a particular county. Growing mining activity will stimulate ancillary employment in adjacent counties. Thus it is not practical to expect that policy

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[17]Part of the cost of development would then be travel to the work location. This policy thus might not minimize total net social cost. Regardless, the incidence of the cost depends on whether workers (and presumably the mine) bear the cost of travel to work.

measures can completely restrict impacts to one county; some spillover is inevitable if all secondary impacts are considered.

Other Policy Issues

A number of other questions important to policymakers remain. One with a great deal of current interest is state taxation of mineral deposits. The State of Montana has been notified that utilities which buy Montana coal will challenge the legality of the State severance tax. The challenge is to be based on the argument that the tax is an unconstitutional hindrance to interstate commerce. Assuming that State power to tax mining is not completely overthrown, there may well be a policy interest in alternative taxation measures which could be directed at impacts. It is possible that taxes such as these could more easily pass judicial scrutiny. The following are several possibilities. (1) If coal is to be taxed on an ad valorem basis, change the definition of taxable gross proceeds from contract sales price to actual mine mouth value.[18] A lower tax rate would generate the same revenue, but the incidence of development costs would fall more heavily on the mine. (2) Allow or require a nonrefundable prepayment of taxes (or monies of some sort), based on a five to ten year horizon, or the life of the mine, to be used to meet the front end problem.

[18] This could be determined by current coal spot prices, regardless of existing contracts.

Such payments could be deducted from later taxes. In much the same way social costs could be recovered in part by increased siting fees and permits. (3) Taxes like the Resource Indemnity Trust tax could be increased and defended on grounds of compensation for resources or unintended destruction of resources such as aquifers. Presumably this would have more validity than a severance tax which is not called a compensating tax. (4) Sales and use taxes on mining equipment could be imposed, and property tax rates on this category of equipment could be raised.

The severance tax is a special case. A general issue of policy interest is the incidence of taxation. There is presumably an interest in having the mine pay as large a share of taxes as possible and residents as small a share as possible; at least this would be in the interest of local people. The question is how this can be done. At the State level there is little difficulty. The State can define special taxes such as the severance tax in such a way that they apply only to coal mining. Local governments, on the other hand, have little scope for creative taxation. Typically they rely on the property tax alone. So the question is how the State can define the tax base in coal mining counties so that the mines pay a larger fraction of the total local tax bill.

Part of the tax base consists of mining equipment. The State can put equipment in a category where the ratio of taxable to assessed value is very high, and put residential and commercial property in a category where the ratio is very low. The main component of the tax base for a mine is the value of coal produced. Two methods the State can use to raise this value are to make the taxable value of gross proceeds equal to the assessed value (rather than 45 percent) and to define the mine value higher. The advantage is lowered tax bills for local residents and less need for State impact grants since the overall local tax base is higher.

One of the main problems in boomtown impacts is spillovers, where a locality suffers the impact but does not share in the project revenue. An effective way of meeting this problem is to have sharing across jurisdictions -- either shared revenue or shared expenditure. A good way of accomplishing this is to consolidate jurisdictions, either formally or by having them share functions. An example of the former is consolidation of school districts. If the old district lines are drawn so that only one district has an enhanced tax base, the redistricting will allow all to share in the source of funds. Another way of widening the base for the source of funds is to rely on the State, through the foundation program, to make up any operating deficit. Capital expenditures can be shifted to operating expenditures by contracting with the county to build needed schools which are then leased. Counties can also take over some functions usually delegated to municipalities, such as street maintenance, snow removal and police protection. At the local level, incentives bring these shared functions about. The historical trends toward elimination of rural school districts are driven by political pressures by urban areas for access to the rural tax base for their own educational needs. But working out this process can take time, so there may be a need for State action to encourage this functional sharing.

State impact grants are another version of interjurisdictional sharing, this time between State and locality rather than two localities. Impact grants (or loans) take advantage of the superior ability of the State to design revenue instruments which can be focused on the source of the impact. But if the impacts are not widely spread within the State, political pressures for a grant program may not be as effective as those for inter-locality cooperation. Furthermore, categorical grants often are piecemeal and frustrate a comprehensive approach.

Finally, several other techniques can be used at the local level to alleviate impacts. Special Improvement Districts can be used for such things as road development in the neighborhood of a new project. Zoning powers can be used to control development patterns. An early program of land acquisition and development by local authorities or in cooperation with them can prevent undesirable housing growth patterns and excessive land cost spirals. To be effective both this and zoning must be done enough in advance so that the situation does not get out of control. This means foresight by local planners and cooperation from energy developers. However, it must be recognized that speculative talents like these often are not forthcoming from elected officials. By definition, a speculative action is one not taken by a majority of the population and therefore might not be politically popular. The feasibility of the programs just mentioned is therefore in doubt.

Chapter 8

CONCLUSION

Model Summary

Previous chapters have considered the problem of economic impacts in boom areas and have discussed a methodology for analyzing these impacts. The approach stems from the concept of the economic base. The exogenous basic activity in a region generates ancillary employment. The amount of ancillary employment depends on the degree of economic activity in neighboring counties and the location of the county in economic space as well as basic employment in the county. Ancillary employment is affected by spillovers of demand for services caused by basic activity in adjacent counties. The value also varies with the distance to a trade center. Statistical results demonstrate the importance of dynamic effects; lagged values of basic and ancillary employment partially determine current ancillary activity. Finally, incomes of residents in part determine the level of ancillary activity that can be supported.

The direct and induced employment requirements in energy boom areas may cause tightness in the local labor market. One manifestation of this is increased employment of the local population. Statistical results indicate that employment participation rates in a county, relative to those in the United States as a whole, are partially determined by percentage changes in employment, which is an index of job opportunities.

Even with enhanced participation by the indigenous population the local labor supply may be insufficient to meet requirements. Substantial immigration may be needed, and indeed is characteristic of boomtowns. It is likely that economic inducements are needed to alter migration streams. Empirical analysis shows that wage and employment changes are both important in bringing about migration.

Public sector effects are important too, especially the impacts which may fall on local governments in the area. Tax revenues are derived from the basic and ancillary activity associated with energy development, and spending requirements of local governments change with development. What governments spend depends primarily on the number of people who have access to their services. Also important are the prices that must be paid for the factors that produce government services. Estimated national inflation rates and local wages as a measure of local inflation help determine government spending. Finally, since legal differences require different responsibilities of similar jurisdictions in different states, equations determining local government spending are state-specific.

Actual tax codes and intergovernmental revenue transfer requirements are contained in nonstochastic revenue equations. Given appropriate tax rates and tax bases, these produce revenue figures for State and local governments.

Once the time path of basic (coal mining) employment is specified, values for the endogenous variables of the system are generated. First ancillary employment is calculated. That along with basic employment defines employment requirements. The employment participation rate response of the indigenous population to total employment changes is determined. The amount of net migration required to balance employment requirements and labor supply, after allowing for the indigenous response, is then computed. The wage rate needed to induce that level of migration, given past migration streams and the effect of known employment changes, is then found. Given the resultant population levels and wage rates, local government expenditures are calculated. Finally the model determines tax revenues and intergovernmental transfers.

The results are values of variables for each particular year. The system is recursive, and the stochastic equations in it were estimated using appropriate econometric methods (two-stage least squares). But the model as a whole is dynamic. Some equations contain as independent variables lagged values of variables produced by the same or other equations, so that feedback loops exist. This makes the time path of the system much richer than would be true if no dynamic interactions were a part of the model. Lagged independent variables in the ancillary employment equation include last year's ancillary employment, basic employment, basic employment in adjacent counties, wages and size of the largest town in the county. Lagged employment participation rates influence current rates and current migration. Migration streams also tend to persist; lagged migration feeds back into current migration in a positive loop. Complicated interactions among these various feedback loops are possible.

Impact Summary

Boom conditions create disruptions in the patterns of what often have been stable rural economies. Population and employment levels often change rapidly, as do migration patterns and wage rates. Much attention has been paid to potential fiscal problems of local governments in boom regions. These arise if expenditure requirements and an increased tax base do not coincide in time or in space. Often these problems can be remedied by state action. Requiring mines to begin operations sequentially rather than all at once can reduce the magnitude of the impact on communities in any one year and can provide valuable time for local adjustment to boom conditions. State policies can help provide funds to those local jurisdictions where they are most needed. This can be done through categorical state grants, loan programs using state funds, or by state encouragement of revenue sharing among local jurisdictions.

Gilmore (1976) attributes the high turnover of labor in boom towns to impacted services -- conditions which reduce real income. The model demonstrates that at least part of that turnover may be attributed to an overreaction in migration. As wages increase, individuals decide to move to the area. The larger the wage increase the greater the number attracted. But in small labor markets too many respond. Wages subsequently are driven down and people migrate out again. This sequence of events seems to be characteristic of the ancillary sector which includes small retail businesses and their employees.

Analysis of hypothetical mine development illustrates this. In a case in which a 9 million ton mine comes on stream every four years, migration and wages in a standardized county show strong cyclical patterns. For example, migration goes from 261 to 866 to 299 over three years where the mine begins operations in the second year.

The model has been applied specifically to Montana coal development. There are some special factors in the case of Montana. Most of the forecasted coal development is restricted to two counties, Rosebud and Big Horn. Additional mining in Rosebud County involves no new mines, just expansion of mines. Twenty million tons per year are scheduled to be produced by 1985 from Western Energy Colstrip mines 1 through 4. The extra employment and population expected to result from this and from a slight expansion of the Peabody mine is not large; population rises by an extra 1,063 over what it otherwise would have been, and employment by 643. In other words, most of the impact on Rosebud County has already taken place. In Big Horn County most of the eight proposed new mines are located in the Decker area. The impacts due to these mines will probably fall on Sheridan, Wyoming. Aside from taxes, the economic impacts on Montana will not be large.

This conclusion depends on the assumption that mining proceeds as forecast. If there are departures from the forecast, the ability of localities to cope with the situation could be seriously impaired. Problems could arise for three reasons. If new mines come on stream local governments might have to supply public services for mine workers and the associated ancillary population before the mines came on the tax rolls. This is the front end problem. Another problem involves impact spillovers, where one government has the expenditure responsibility and another has the tax revenue. At present Montana is benefitting from this effect in the case of mines near Sheridan, but it could conceivably cause problems also. The most likely example is where there are spillovers from one local government to another, such as when the extra population impacts a school district which does not have the mines in its tax base. This same problem can exist for towns where most of the people live but which do not have mining within their limits. The final problem, and one that could be important in Montana, results from uncertainty about the duration of mining activity. Sudden shutdowns can leave localities with most of their tax base gone but with much of their spending obligations intact, especially if they have taken on debt for capital expenditures.

Alternatively, uncertainty can prevent local governments from undertaking needed spending programs when faced with imminent rapid growth.

If it is probable that impacts on the private sector in Montana will not be large, the same cannot be said of impacts on the public treasury. If current tonnage forecasts are met, if the price of coal does not decline, and if the State severance tax is not successfully challenged, dollar flows to the State should exceed $100 million annually within a very few years. This includes both trust and discretionary funds. Local governments with coal mining gross proceeds in their tax bases should be able to generate large budget surpluses at their historical mill levy rates. Big Horn County will receive $2,448,173 in direct coal tax revenue in 1985, assuming a 20-mill levy. Rosebud County will get $1,350,019 in 1985 under a 24.05-mill levy. Thus coal mining represents a major effect on State and local revenue flows.

Suggestions for Additional Research

Some of the functional forms which components of the model take were determined by data limitations. It is relevant here to point out extensions of the model that could be undertaken if appropriate data become available. This can also serve as a guide to additional research.

One very desirable feature would be to group populations into age and sex brackets. This would have at least four benefits: (1) It would allow a more realistic modeling of population natural increase, since age-and-sex-specific birth and death rates could be used; (2) employment participation rates could be made age-and-sex-specific as well, so that differential responses to job opportunities could be built into the model; (3) if migrants could be identified by age and sex it would be possible to determine different employment participation rates for migrants and nonmigrants from the data, instead of imposing these differences from outside; and (4) this would allow greater precision in determining government spending. For example, numbers of school-age children could be identified more precisely. The problem is that annual BEA data are not available for (1) county population breakdowns of this sort, and (2) migrants are not identified by category. Without these data it is not possible to disaggregate populations in the model. A possible data source is the Continuous Work History Sample based on Social Security records. If this data source could be integrated with the existing data base it would be a considerable advance.

Another improvement would be to determine the dynamic adjustment process of employment requirements more exactly. This would obviate having the entire response to basic employment occur in a single time period. The consequences for having such rapid adjustment in the model are that wage rates and hence government expenditures fluctuate markedly in response to an initial change in basic employment of any size. If the process of adjustment could be spread out over several years the figures produced by the model would possibly be more accurate and the disequilibrium adjustment process characteristic of boomtowns would be shown. This could not be done in the present study because the data did not yield evidence of such adjustment. It may be necessary to develop a data base composed solely of boom areas to obtain information on the adjustment process, rather than to rely on data involving fairly static conditions as is typical of the Northern Great Plains.

A third improvement would be to have more detail in the government spending equations. It would be useful to know something about categories of government spending and the way in which they respond to growth. Some public services may be legally mandated while others may be discretionary. If so, a growth area with tight budget constraints may have a distinctive time pattern of expenditures, which may suggest some appropriate policy actions. But at present the data source for spending is not a reliable source for fugures on disaggregated spending, as it contains much imputed data and has other problems including the absence of consistency of category over observations.

If good spending figures were available, the model could be reprogrammed to calculate breakeven mill levies for local governments.

At present the mill levies are supplied to the model as exogenous data. It is more realistic to assume that local governments strive to keep taxes down as much as possible. Given spending requirements and the tax base, breakeven mill levies could be calculated. To be of use specifically in boom growth situations, however, the spending figures should be based on the kind of information mentioned in the previous paragraph.

One possibility currently under investigation[19] is the notion of transition zones in public spending. The idea is that there are ranges of population size in which the functional relationship between population and spending is constant. These ranges are separated by regions of transition between the functional relationships. The transition zones might correspond to different capital requirements for producing public goods. If this research is successful it might allow a good definition of boom area expenditure time paths.

An alternative to this is to calculate per capita revenues for each jurisdiction. Given mill levy rates, such numbers come directly from the model and can be compared to existing per capita numbers as measures of revenue adequacy.

Another area which could be improved involves migration. It was very difficult to find a functional form to apply to the migration

[19] Work on this is being carried out by Tom Stinson and Andrea Lubov, ESCS, University of Minnesota.

equation in which the statistical results agreed with the theoretical requirement that higher wages should always be positively associated with higher values of net migration. In part this is due to data problems: migration figures subject to rounding errors and the use of average regional wage rates rather than those relevant to migrants. Possibly the Continuous Work History Sample would be useful here. Another improvement would be to examine the effect that public spending has on migration flows. Public as well as private goods should affect the location decision. But no time series data on public spending are available.

Taxation of coal on Indian lands is another area of interest. Much western coal is on reservation land. The question of whether State and local governments can tax coal production on Indian lands is not settled law. Until this issue is resolved (probably in the courts) the fiscal consequences of such mining cannot be determined.

It is important to know whether the coefficients in this model, which were derived from a data base composed of all rural counties in the Northern Great Plains, are the same as those which apply to coal areas specifically. Current research by Jeff V. Conopask[20] is designed to answer this question by using econometric analysis of Northern Great Plains coal-producing counties. Finally, it would be useful to have

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[20] ESCS, USDA, Washington, D.C.

data on town sizes in the same year for which government spending numbers exist.

Conclusion

In the course of the research which this study presents, a simulation model capable of analyzing the effects of coal development in the Northern Great Plains was constructed. Although data limitations constrained the development of the model in several ways, the result is nevertheless a model which is useful in predicting impacts of energy development. The model has been used to predict the outcomes of various coal mining development possibilities. It has also been used to analyze the impacts associated with rapid energy-related growth, and to suggest and evaluate policy measures. Results show that the model is a valuable tool for analyzing these kinds of questions.

APPENDICES

Appendix A

NORTHERN GREAT PLAINS COUNTIES

Northern Great Plains Counties

Colorado

Cheyenne
Douglas
Elbert
Kiowa
Kit Carson
Larimer
Lincoln
Logan
Morgan
Phillips
Sedgwick
Washington
Weld
Yuma

Montana

Big Horn
Blaine
Carbon
Carter
Chouteau
Custer
Daniels
Dawson
Fallon
Fergus
Garfield
Glacier
Golden Valley
Hill
Judith Basin
Liberty
McCone
Musselshell
Petroleum
Phillips
Pondera
Powder River
Prairie

Montana-cont.

Richland
Roosevelt
Rosebud
Sheridan
Stillwater
Sweet Grass
Teton
Toole
Treasure
Valley
Wheatland
Wibeaux

North Dakota

Adams
Barnes
Benson
Billings
Bottineau
Bowman
Burke
Burleigh
Cavalier
Dickey
Divide
Dunn
Eddy
Emmons
Foster
Golden Valley
Grand Forks
Grant
Griggs
Hettinger
Kidder
La Moure
Logan
McHenry
McIntosh

North Dakota cont.

McKenzie
McLean
Mercer
Morton
Mountrail
Nelson
Oliver
Pembina
Pierce
Ramsey
Ransom
Renville
Richland
Rolette
Sargent
Sheridan
Sioux
Slope
Stark
Steele
Stutsman
Towner
Traill
Walsh
Ward
Wells
Williams

South Dakota

Aurora
Beadle
Bennett
Bon Homme
Brookings
Brown
Brule
Buffalo
Butte
Campbell
Charles Mix
Clark

South Dakota-cont.

Clay
Codington
Corson
Custer
Davison
Day
Deuel
Dewey
Douglas
Edmunds
Fall River
Faulk
Grant
Gregory
Haakon
Hamlin
Hand
Hanson
Harding
Hughes
Hutchinson
Hyde
Jackson
Jerauld
Jones
Kingsbury
Lake
Lawrence
Lincoln
Lyman
McCook
McPherson
Marshall
Meade
Mellette
Miner
Moody
Pennington
Perkins
Potter
Roberts
Sanborn

South Dakota-cont.

Shannon
Spink
Stanley
Sully
Todd
Tripp
Turner
Union
Walworth
Washbaugh
Yankton
Ziebach

Wyoming

Big Horn
Campbell
Converse
Crook
Fremont
Goshen
Hot Springs
Johnson
Laramie
Niobrara
Platte
Sheridan
Washakie
Weston

Appendix B

THE SYSTEM OF EQUATIONS

$$(1)\quad ANCEMP_t = a_0 + a_1\ ANCEMP_{t-1} + a_2\ BASE_t + a_3\ BASE_t.DIST + a_4\ BASE_t.DIST^2 + a_5\ ADJBASE_t + a_6\ BASE_{t-1} + a_7\ BASE_{t-1}.DIST + a_8\ BASE_{t-1}.DIST^2 + a_9\ ADJBASE_{t-1} + a_{10}\ WAGE_{t-1}.TOWN + e_{1t}$$

$$(2)\quad RELLFPR_t = b_0 + b_1\ RELLFPR_{t-1} + b_2\ PCEMP_t + b_3\ PCEMP_t^2 + e_{2t}$$

$$(3)\quad MIG_t = c_0 + c_1\ MIG_{t-1} + c_2\ POPI_t + c_3\ e^{2(WAGE_t - 5.175)} + c_4\ CEMP_t + c_5\ CEMP_t^2 + c_6\ RELLFPR_{t-1} + c_7\ DUM_t + e_{3t}$$

where $DUM_t = WAGE_t - 5.175$ if $WAGE_t \leq 5.175$

$DUM_t = 0$ if $WAGE_t > 5.175$

$$(4)\quad \ln GOV_{it} = d_{io} + d_{i1}\ \ln POPN_t + e_{4it},\quad i = 1,2,3$$

$$(5)\quad Q_{dt} = ANCEMP_t + BASE_t$$

$$(6)\quad Q_{st} = Q_{dt}$$

$$(7)\quad Q_{st} = MW_t + LOCW_t$$

$$(8)\quad LOCW_t = POPI_t \cdot RELLFPR_t \cdot USLFPR_t$$

$$(9)\quad MW_t = MIG_t \cdot RELLFPT_t \cdot USLFPR_t$$

$$(10)\quad POPN_t = POPI_t + MIG_t$$

$$(11)\quad CEMP_t = Q_{dt} - Q_{dt-1}$$

$$(12)\quad PCEMP_t = CEMP_t/Q_{dt-1}$$

where:

ANCEMP = ancillary employment

BASE = economic base

DIST = distance to trade center

ADJBASE = adjacent economic base

WAGE = ancillary earnings

TOWN = town size

RELLFPR = employment participation rate relative to the U.S. rate

PCEMP = percentage change in employment

MIG = net migration

POPI = indigenous population

CEMP = change in employment

GOV = government spending

POPN = total population

Qd = labor demand

Qs = labor supply

MW = migrating workers

LOCW = local workers

USLFPR = U.S. employment participation rate

Complete definitions of variables are given in the tables in chapter 3.

Equations (1) - (4) are stochastic, (5) - (12) are identities. This gives 12 equations in 12 unknowns: $ANCEMP_t$, $LFPR_t$, $PCEMP_t$, MIG_t, $WAGE_t$, $CEMP_t$, GOV_{it}, $POPN_t$, Q_{dt}, Q_{st}, MW_t, $LOCW_t$.

The model is a partially recursive simultaneous set of equations. Thus, equations (2), (3), and (4) were estimated using 2SLS.

Appendix C

IMPACTS OF ANTICIPATED COAL DEVELOPMENT IN MONTANA

Table 18-Constant level of coal mining and labor market and fiscal responses, 1975-85, Rosebud county

Item	Units	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985
Coal mined, total	Mil. tons	8.7	8.7	8.7	8.7	8.7	8.7	8.7	8.7	8.7	8.7	8.7
Peabody	" "	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3
Western Energy	" "	6.4	6.4	6.4	6.4	6.4	6.4	6.4	6.4	6.4	6.4	6.4
Employment, total	Number	3,582	3,661	3,734	3,808	3,882	3,957	4,032	4,108	4,185	4,263	4,341
Basic employment a/	"	1,736	1,736	1,736	1,736	1,736	1,736	1,736	1,736	1,736	1,736	1,736
Peabody mine	"	66	66	66	66	66	66	66	66	66	66	66
Western Energy mine	"	182	182	182	182	182	182	182	182	182	182	182
Ancillary employment b/	"	1,846	1,925	1,998	2,072	2,146	2,221	2,296	2,372	2,449	2,527	2,605
Labor market conditions												
Participation rate c/	Percent	44.78	45.23	45.68	46.08	46.43	46.75	46.81	46.86	46.88	46.88	46.85
Net migration	Number	288	50	33	42	50	55	99	105	110	115	118
Wages of ancillary employees	Dollars	4,875	4,887	5,751	6,003	6,011	6,009	6,279	6,106	6,106	6,116	6,110
Population in county	Number	7,998	8,094	8,174	8,263	8,361	8,464	8,612	8,767	8,928	9,094	9,264
Colstrip	"	532	628	708	797	895	998	1,146	1,301	1,462	1,628	1,798
Expenditures of governments												
County	Thous. dol.	1,177	1,249	1,553	1,714	1,816	1,922	1,864	1,889	1,969	2,057	2,142
School district d/	" "	2,114	2,252	2,810	3,114	3,313	3,521	3,435	3,503	3,675	3,862	4,049
Revenues of governments												
State	" "	13,508	13,664	14,268	14,632	14,720	15,255	14,789	14,843	15,183	15,248	15,316
County	" "	1,420	1,459	1,468	1,478	1,519	1,389	1,321	1,347	1,375	1,403	1,433
School district d/	" "	4,681	4,794	4,900	5,008	5,118	5,230	5,259	5,361	5,463	5,567	5,672
Town	" "	156	187	216	249	287	329	341	389	440	493	549

a/ Total of agricultural, manufacturing, mining, federal government, and the basic part of transporation employment.
b/ Difference between total and basic employment.
c/ Ratio of employment to population.
d/ Includes all school districts in the county. Revenues and expenditures cannot be compared directly since the coal mining is part of the tax base of only one school district.

Table 19--Anticipated mining and labor market and fiscal responses, 1975-85, Rosebud county

Item	Units	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985
Coal mined, total	Mil. tons	8.7	11.7	11.7	12.7	14.2	17.0	17.5	18.0	21.5	23.4	25.0
Peabody	" "	2.3	2.4	2.4	2.5	3.0	3.0	3.5	4.0	4.5	4.5	5.0
Western Energy	" "	6.4	9.3	9.3	10.2	11.2	14.0	14.0	14.0	17.0	18.9	20.0
Employment, total	Number	3,582	3,748	3,828	3,938	4,071	4,245	4,356	4,451	4,656	4,831	4,984
Basic employment a/	"	1,736	1,796	1,796	1,819	1,855	1,918	1,933	1,938	2,018	2,071	2,108
Peabody mine	"	66	68	68	71	85	85	100	105	110	115	125
Western Energy mine	"	182	245	245	265	287	350	350	350	425	473	500
Ancillary employment b/	"	1,846	1,952	2,032	2,119	2,216	2,327	2,423	2,513	2,638	2,760	2,876
Labor market conditions												
Participation rate c/	Percent	44.78	45.53	45.99	46.48	46.99	47.58	47.68	47.71	48.03	48.20	48.27
Net migration	Number	288	187	44	100	141	211	160	141	311	273	245
Wages of ancillary employees	Dollars	4,875	5,062	5,025	6,225	6,145	6,252	5,503	5,952	6,592	5,625	5,821
Population in county	Number	7,998	8,232	8,324	8,472	8,663	8,924	9,135	9,329	9,694	10,024	10,327
Colstrip	"	532	766	858	1,006	1,197	1,458	1,669	1,863	2,228	2,558	2,861
Expenditures of governments												
County	Thous. dol.	1,177	1,308	1,373	1,807	1,901	2,071	1,699	1,918	2,244	2,016	2,192
School district d/	" "	2,114	2,373	2,501	3,311	3,509	3,863	3,195	3,635	4,310	3,917	4,302
Revenues of governments												
State												
High mill levies	" "	13,571	18,249	18,364	20,461	22,757	27,588	27,647	28,723	34,313	36,935	39,711
1975 mill levies	" "	13,583	18,386	18,502	20,611	22,925	27,791	27,856	28,938	34,570	37,215	40,011
Low mill levies	" "	13,546	18,525	18,641	20,763	23,095	27,997	28,069	29,156	34,831	37,499	40,314
County												
34.05 mill levy	" "	1,897	2,251	2,266	2,380	2,584	2,582	2,524	2,601	2,911	3,101	3,268
24.05 mill levy	" "	1,424	1,704	1,702	1,778	1,932	1,847	1,806	1,861	2,082	2,217	2,336
14.05 mill levy	" "	949	1,153	1,136	1,172	1,275	1,107	1,084	1,116	1,246	1,326	1,396
School district d/												
27.91 mill levy	" "	5,156	5,560	5,689	5,916	6,201	6,616	6,686	6,850	7,323	7,665	7,965
17.91 mill levy	" "	4,683	5,010	5,123	5,311	5,545	5,879	5,967	6,109	6,492	6,779	7,031
7.91 mill levy	" "	4,210	4,456	4,554	4,703	4,886	5,138	5,243	5,363	5,655	5,887	6,090
Town												
79.00 mill levy	" "	176	249	286	342	414	511	525	590	699	800	896
69.00 mill levy	" "	156	220	253	302	365	449	462	519	615	703	787
59.00 mill levy	" "	136	191	219	261	315	388	399	448	531	607	679

a/ Total of agricultural, manufacturing, mining, federal government, and the basic part of transportation employment.
b/ Difference between total and basic employment.
c/ Ratio of employment to population.
d/ Includes all school districts in the county. Revenues and expenditures cannot be compared directly since the coal mining is part of the tax base of only one school district.

Table 20--Anticipated mining, constant basic employment and labor market and fiscal responses, 1975-85, Big Horn county

Item	Units	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985
Coal mined, total	Mil. tons	13.1	13.1	15.6	16.0	18.0	25.9	41.5	47.0	54.0	54.5	54.5
CX Ranch	" "							1.5	3.0	5.0	5.0	5.0
Decker East	" "						4.9	6.0	6.0	8.0	8.0	8.0
Decker North	" "					2.0	2.0	3.0	3.0	4.0	4.0	4.0
Decker West	" "	9.1	9.1	10.1	10.5	10.5	10.5	11.0	11.0	11.0	11.5	11.5
Nerco Spring Creek	" "						3.0	7.0	10.0	10.0	10.0	10.0
Shell Pearl	" "							1.0	2.0	2.0	2.0	2.0
Westmoreland Sarpy Creek												
Tract II	" "							2.0	2.0	4.0	4.0	4.0
Westmoreland Sarpy Creek												
Tract III	" "	4.0	4.1	5.5	5.5	5.5	5.5	10.0	10.0	10.0	10.0	10.0
Employment, total	Number	3,979	4,063	4,148	4,233	4,318	4,404	4,490	4,577	4,665	4,753	4,842
Basic employment a/	"	2,078	2,078	2,078	2,078	2,078	2,078	2,078	2,078	2,078	2,078	2,078
Ancillary employment b/	"	1,901	1,985	2,070	2,155	2,240	2,326	2,412	2,499	2,587	2,675	2,764
Labor market conditions												
Participation rate c/	Percent	39.97	40.67	41.38	42.02	42.60	43.14	43.44	43.69	43.92	44.10	44.26
Net migration	Number	-590	-21	-25	-9	4	14	70	78	86	94	100
Wages of ancillary employees	Dollars	4,875	7,058	5,263	5,745	5,762	5,778	6,215	5,956	5,978	6,000	5,999
Population in county	Number	9,955	9,991	10,024	10,074	10,136	10,209	10,338	10,476	10,623	10,778	10,941
Expenditures of governments												
County	Thous. dol.	705	1,074	843	969	1,024	1,084	1,079	1,074	1,121	1,169	1,216
School district d/	" "	2,177	3,321	2,609	3,005	3,184	3,377	3,376	3,377	3,541	3,714	3,883
Revenues of governments												
State												
High mill levies	" "	20,220	20,875	24,020	25,033	28,335	40,445	63,340	71,566	81,896	83,146	83,219
Medium mill levies	" "	20,093	21,028	24,203	25,222	28,547	40,754	63,836	72,129	82,633	83,799	83,872
Low mill levies	" "	20,183	21,184	24,389	25,413	28,763	41,068	64,339	72,699	83,288	84,461	84,534
County												
30 mill levy	" "	2,275	2,307	2,542	2,582	2,814	3,049	3,997	4,405	4,914	4,989	5,032
20 mill levy	" "	1,653	1,686	1,849	1,860	2,030	2,067	2,703	2,977	3,319	3,369	3,398
10 mill levy	" "	1,043	1,062	1,151	1,135	1,240	1,078	1,399	1,537	1,709	1,735	1,749
School district d/												
36.31 mill levy	" "	6,492	6,628	6,985	7,176	7,501	8,488	10,916	11,972	13,284	13,493	13,619
26.31 mill levy	" "	5,871	6,006	6,290	6,455	6,716	7,522	9,648	10,573	11,722	11,906	12,018
16.31 mill levy	" "	5,261	5,381	5,592	5,728	5,926	6,550	8,369	9,162	10,146	10,305	10,403

a/ Total of agricultural, manufacturing, mining, federal government, and the basic part of transportation employment. Assumed constant since miners are assumed to live in Sheridan, Wyoming.
b/ Difference between total and basic employment.
c/ Ratio of employment to population.
d/ Includes all school districts in the county. Revenues and expenditures cannot be compared directly since the coal mining is part of the tax base of a school district with almost no students.

Table 21--Anticipated mining and labor market and fiscal responses, 1975-85, Sheridan county, not including miners from Big Horn county mines

Item	Units	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985
Coal mined, total	Mil. tons	0.8	1.0	1.9	1.4	2.8	5.5	6.5	6.5	6.5	6.5	6.5
Ash Creek	" "				0.1	0.5	0.5	0.5	0.5	0.5	0.5	0.5
P. K. Big Horn	" "	0.8	1.0	1.9	1.3	2.0	2.0	2.0	2.0	2.0	2.0	2.0
P. K. Whitney	" "						1.0	1.0	1.0	1.0	1.0	1.0
Sheridan Welch	" "					0.3	2.0	3.0	3.0	3.0	3.0	3.0
Employment, total	Number	8,992	9,258	9,471	9,597	9,754	10,094	10,317	10,444	10,554	10,666	10,780
Basic employment a/	"	3,665	3,682	3,757	3,777	3,827	3,994	4,049	4,049	4,049	4,049	4,049
Ash Creek mine	"				20	40	40	40	40	40	40	40
P. K. Big Horn mine	"	80	97	172	172	172	172	172	172	172	172	172
P. K. Whitney mine	"						67	67	67	67	67	67
Sheridan Welch mine	"					30	130	185	185	185	185	185
Ancillary employment b/	"	5,327	5,576	5,714	5,820	5,927	6,100	6,268	6,395	6,505	6,617	6,731
Labor market conditions												
Participation rate c/	Percent	43.51	44.11	44.67	45.04	45.41	45.98	46.13	46.13	46.09	46.04	45.97
Net migration	Number	1,305	199	95	-18	50	348	281	144	127	140	147
Wages of ancillary employees	Dollars	7,416	4,875	4,987	5,012	6,090	6,718	5,125	5,050	5,921	6,137	6,108
Population in county	Number	20,669	20,988	21,204	21,309	21,482	21,955	22,364	22,638	22,896	23,169	23,450
Sheridan city	"	13,916	14,235	14,451	14,556	14,729	15,202	15,611	15,885	16,143	16,416	16,697
Expenditures of governments												
County	Thous.dol.	6,756	4,731	5,132	5,440	6,994	8,268	5,890	6,047	7,381	7,969	8,262
School district d/	" "	8,732	6,120	6,642	7,044	9,059	10,723	7,647	7,856	9,595	10,366	10,754
Revenues of governments												
State	" "	-1,699	-1,491	-850	-1,186	116	2,447	2,930	2,947	3,060	3,119	3,158
County	" "	1,017	1,046	1,168	1,165	1,345	1,648	1,668	1,697	1,741	1,777	1,810
School district d/	" "	10,014	10,370	10,904	11,013	11,437	12,257	12,563	12,738	12,895	13,057	13,222
Town	" "	1,223	1,212	1,271	1,312	1,405	1,527	1,456	1,496	1,572	1,626	1,673

a/ Total of agricultural, manufacturing, mining, federal government, and the basic part of transportation employment.
b/ Difference between total and basic employment.
c/ Ratio of employment to population.
d/ Includes all school districts in the county. Revenues and expenditures cannot be compared directly since the coal mining is part of the tax base of only one school district.

Table 22--Anticipated mining and labor market and fiscal responses, 1975-85, Sheridan county, with miners from Big Horn county included

Item	Units	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985
Coal mined, total	Mil. tons	0.8	1.0	1.9	1.4	2.8	5.5	6.5	6.5	6.5	6.5	6.5
Ash Creek	" "				0.1	0.5	0.5	0.5	0.5	0.5	0.5	0.5
P. K. Big Horn	" "	0.8	1.0	1.9	1.3	2.0	2.0	2.0	2.0	2.0	2.0	2.0
P. K. Whitney	" "						1.0	1.0	1.0	1.0	1.0	1.0
Sheridan Welch	" "					0.3	2.0	3.0	3.0	3.0	3.0	3.0
Employment, total	Number	9,525	9,902	10,174	10,342	10,630	11,342	12,218	12,672	13,105	13,321	13,492
Basic employment a/	"	4,038	4,056	4,150	4,183	4,310	4,708	5,157	5,273	5,431	5,431	5,431
Ash Creek mine	"				20	40	40	40	40	40	40	40
CX Ranch mine b/	"							50	85	111	111	111
Decker East mine b/	"						140	150	150	178	178	178
Decker North mine b/	"					67	67	100	100	133	133	133
Decker West mine b/	"	259	259	273	276	276	276	283	283	288	288	288
Nerco Spring Creek mine b/	"						86	175	222	222	222	222
P. K. Big Horn mine	"	80	97	172	172	172	172	172	172	172	172	172
P. K. Whitney mine	"						67	67	67	67	67	67
Shell Pearl mine b/	"							33	67	67	67	67
Sheridan Welch mine	"					30	130	185	185	185	185	185
Westmoreland Sarpy Creek--												
Tract II mine b/	"							67	67	133	133	133
Tract III mine b/	"	114	115	120	130	140	145	250	250	250	250	250
Ancillary employment c/	"	5,487	5,846	6,024	6,159	6,320	6,634	7,061	7,399	7,674	7,890	8,061
Labor market conditions												
Participation rate d/	Percent	44.24	44.93	45.50	45.87	46.33	47.26	48.04	48.25	48.38	48.25	48.08
Net migration	Number	2,164	383	196	57	262	923	1,294	687	670	361	297
Wages of ancillary employees	Dollars	7,682	4,875	4,875	4,975	6,546	7,138	6,960	4,875	5,841	4,875	5,690
Population in county	Number	21,529	22,037	22,361	22,548	22,941	23,998	25,431	26,265	27,088	27,606	28,063
Sheridan city	"	14,776	15,284	15,608	15,795	16,188	17,245	18,678	19,512	20,335	20,853	21,310
Expenditures of governments												
County	Thous. dol.	7,273	4,954	5,273	5,695	7,997	9,553	9,029	6,715	8,532	7,466	9,115
School district e/	" "	9,421	6,425	6,846	7,397	10,397	12,451	11,806	8,797	11,196	9,808	11,986
Revenues of governments												
State	" "	-1,795	-1,636	-1,022	-1,357	-31	2,232	2,674	2,435	2,505	2,428	2,561
County	" "	1,063	1,100	1,226	1,229	1,429	1,765	1,854	1,883	1,958	1,987	2,042
School district e/	" "	10,583	11,063	11,675	11,833	12,404	13,638	14,652	15,195	15,716	16,004	16,243
Town	" "	1,325	1,324	1,393	1,446	1,587	1,788	1,882	1,904	2,058	2,084	2,191

a/ Total of agricultural, manufacturing, mining, federal government, and the basic part of transportation employment.
b/ Big Horn County mine.
c/ Difference between total and basic employment.
d/ Ratio of employment to population.
e/ Includes all school districts in the county. Revenues and expenditures cannot be compared directly since the coal mining is part of the tax base of only one school district.

Appendix D

EFFECTS OF ALTERNATIVE MINING DEVELOPMENT IN A HYPOTHETICAL MONTANA COUNTY

Table 23--One mine starting in 1975 in a standard coal county, Montana, and labor market and fiscal responses, 1975-90

Item	Units	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
Coal mined	Mil. tons	0.0	9.2	9.2	9.2	9.2	9.2	9.2	9.2	9.2	9.2	9.2	9.2	9.2	9.2	9.2	9.2
Employment, total	Number	4,190	4,291	4,391	4,492	4,594	4,697	4,800	4,905	5,010	5,116	5,223	5,331	5,441	5,551	5,662	5,774
Basic employment a/	"	2,211	2,211	2,211	2,211	2,211	2,211	2,211	2,211	2,211	2,211	2,211	2,211	2,211	2,211	2,211	2,211
Mine	"	466	466	466	466	466	466	466	466	466	466	466	466	466	466	466	466
Ancillary employment b/	"	1,979	2,080	2,180	2,281	2,383	2,486	2,589	2,694	2,799	2,905	3,012	3,120	3,230	3,340	3,451	3,563
Labor market conditions																	
Participation rate c/	Percent	44.86	45.32	45.82	46.25	46.63	46.97	47.07	47.13	47.17	47.18	47.18	47.02	46.87	46.71	46.56	44.68
Net migration	Number	213	73	62	74	83	90	142	149	155	161	165	203	204	207	208	691
Wages of ancillary employees	Dollars	6,026	5,025	5,718	5,967	5,969	5,966	6,294	6,088	6,093	6,107	6,101	6,307	6,150	6,161	6,149	7,166
Population in county	Number	9,341	9,467	9,584	9,713	9,852	9,999	10,199	10,406	10,621	10,844	11,072	11,339	11,609	11,884	12,161	12,923
Town	"	2,016	2,142	2,259	2,388	2,527	2,674	2,874	3,081	3,296	3,519	3,747	4,014	4,284	4,559	4,836	5,598
Expenditures of governments																	
County	Thous.dol.	1,205	1,065	1,282	1,418	1,503	1,593	1,562	1,577	1,648	1,724	1,789	1,846	1,984	2,079	2,170	2,711
School district	" "	2,913	2,585	3,127	3,473	3,700	3,942	3,893	3,957	4,164	4,390	4,613	5,031	5,173	5,465	5,750	7,336
Revenues of governments																	
State	" "	1,174	14,732	15,133	15,534	15,625	16,211	15,691	15,747	1,6133	16,203	16,276	16,707	16,798	16,893	17,366	18,302
County	" "	654	1,343	1,346	1,352	1,389	1,246	1,186	1,211	1,237	1,264	1,291	1,320	1,350	1,381	1,413	1,451
School district	" "	5,265	5,957	6,108	6,262	6,421	6,582	6,614	6,757	6,903	7,051	7,200	7,352	7,507	7,664	7,824	7,988
Town	" "	466	513	560	613	671	734	715	774	836	902	970	1,047	1,126	1,208	1,293	1,454

a/ Total of agricultural, manufacturing, mining, federal government, and the basic part of transportation employment.
b/ Difference between total and basic employment.
c/ Ratio of employment to population.

Table 24--Four mines starting in 1975 in a standard coal county, Montana, and labor market and fiscal responses, 1975-90

Item	Units	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
Coal mined, total	Mil. tons	0.0	36.8	36.8	36.8	36.8	36.8	36.8	36.8	36.8	36.8	36.8	36.8	36.8	36.8	36.8	36.8
Mine 1	" "	0.0	9.2	9.2	9.2	9.2	9.2	9.2	9.2	9.2	9.2	9.2	9.2	9.2	9.2	9.2	9.2
Mine 2	" "	0.0	9.2	9.2	9.2	9.2	9.2	9.2	9.2	9.2	9.2	9.2	9.2	9.2	9.2	9.2	9.2
Mine 3	" "	0.0	9.2	9.2	9.2	9.2	9.2	9.2	9.2	9.2	9.2	9.2	9.2	9.2	9.2	9.2	9.2
Mine 4	" "	0.0	9.2	9.2	9.2	9.2	9.2	9.2	9.2	9.2	9.2	9.2	9.2	9.2	9.2	9.2	9.2
Employment, total	Number	5,118	5,265	5,402	5,539	5,678	5,819	5,960	6,104	6,248	6,393	6,540	6,688	6,838	6,989	7,141	7,294
Basic employment a/	"	2,850	2,850	2,850	2,850	2,850	2,850	2,850	2,850	2,850	2,850	2,850	2,850	2,850	2,850	2,850	2,850
Mine 1	"	213	213	213	213	213	213	213	213	213	213	213	213	213	213	213	213
Mine 2	"	213	213	213	213	213	213	213	213	213	213	213	213	213	213	213	213
Mine 3	"	213	213	213	213	213	213	213	213	213	213	213	213	213	213	213	213
Mine 4	"	213	213	213	213	213	213	213	213	213	213	213	213	213	213	213	213
Ancillary employment b/	"	2,268	2,415	2,552	2,689	2,828	2,969	3,110	3,254	3,398	3,543	3,690	3,838	3,988	4,139	4,291	4,444
Labor market conditions																	
Participation rate c/	Percent	46.93	47.29	47.70	48.06	48.37	48.65	48.67	48.67	48.64	48.58	48.52	48.30	48.08	47.87	47.67	45.70
Net migration	Number	1,779	164	125	136	147	154	216	225	231	239	244	290	292	296	297	894
Wages of ancillary employees	Dollars	7,659	4,875	5,239	5,979	5,993	5,982	6,346	6,121	6,122	6,138	6,130	6,361	6,187	6,197	6,183	7,263
Population in county	Number	10,907	11,134	11,323	11,525	11,739	11,961	12,246	12,542	12,846	13,159	13,480	13,848	14,221	14,599	14,981	15,962
Town	"	3,582	3,809	3,998	4,200	4,414	4,636	4,921	5,217	5,521	5,834	6,155	6,523	6,896	7,274	7,656	8,637
Expenditures of governments																	
County	Thous. dol.	1,696	1,149	1,311	1,589	1,693	1,796	1,776	1,792	1,876	1,968	2,057	2,237	2,281	2,394	2,502	3,156
School district	" "	4,327	2,952	3,388	4,133	4,431	4,732	4,718	4,800	5,066	5,360	5,649	6,202	6,382	6,760	7,130	9,194
Revenues of governments																	
State	" "	1,963	55,278	55,900	56,735	56,825	57,994	57,500	57,558	57,995	58,075	58,159	58,653	58,758	58,867	59,415	60,508
County	" "	678	3,340	3,257	3,173	3,213	2,521	2,461	2,488	2,516	2,545	2,575	2,607	2,640	2,673	2,709	2,750
School district	" "	6,283	8,720	8,875	9,045	9,246	9,451	9,522	9,709	9,899	10,092	10,287	10,484	10,686	10,890	11,097	11,309
Town	" "	715	783	850	923	1,002	1,087	1,044	1,117	1,193	1,272	1,354	1,445	1,538	1,635	1,734	1,903

a/ Total of agricultural, manufacturing, mining, federal government, and the basic part of transportation employment.
b/ Difference between total and basic employment.
c/ Ratio of employment to population.

Table 25--Four mines starting sequentially in a standard coal county, Montana, and labor market and fiscal responses, 1975-90

Item	Units	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
Coal mined, total	Mil. tons	0.0	9.2	9.2	9.2	9.2	18.4	18.4	18.4	18.4	27.6	27.6	27.6	27.6	36.8	36.8	36.8
Mine 1	" "		9.2	9.2	9.2	9.2	9.2	9.2	9.2	9.2	9.2	9.2	9.2	9.2	9.2	9.2	9.2
Mine 2	" "						9.2	9.2	9.2	9.2	9.2	9.2	9.2	9.2	9.2	9.2	9.2
Mine 3	" "										9.2	9.2	9.2	9.2	9.2	9.2	9.2
Mine 4	" "														9.2	9.2	9.2
Employment, total	Number	4,190	4,291	4,391	4,492	4,903	5,022	5,136	5,253	5,680	5,815	5,944	6,077	6,522	6,675	6,821	6,972
Basic employment a/	"	2,211	2,211	2,211	2,211	2,424	2,424	2,424	2,424	2,637	2,637	2,637	2,637	2,850	2,850	2,850	2,850
Mine 1	"	213	213	213	213	213	213	213	213	213	213	213	213	213	213	213	213
Mine 2	"					213	213	213	213	213	213	213	213	213	213	213	213
Mine 3	"									213	213	213	213	213	213	213	213
Mine 4	"													213	213	213	213
Ancillary employment b/	"	1,979	2,080	2,180	2,281	2,479	2,598	2,712	2,829	3,043	3,178	3,307	3,440	3,672	3,825	3,971	4,122
Labor market conditions																	
Participation rate c/	Percent	44.86	45.32	45.82	46.25	47.50	47.82	47.87	47.90	48.65	48.60	48.53	48.30	48.23	48.03	47.82	45.84
Net migration	Number	213	73	62	74	553	119	166	176	645	221	217	261	866	299	287	861
Wages of ancillary employees	Dollars	6,026	5,025	5,718	5,967	6,974	4,875	6,288	6,118	6,989	4,875	6,086	6,358	7,155	4,875	6,117	7,244
Population in county	Number	9,341	9,467	9,584	9,713	10,323	10,502	10,729	10,967	11,675	11,964	12,250	12,582	13,521	13,899	14,266	15,209
Town	"	2,016	2,142	2,259	2,388	2,998	3,177	3,404	3,642	4,350	4,639	4,925	5,257	6,196	6,574	6,941	7,884
Expenditures of governments																	
County	Thous.dol.	1,205	1,065	1,282	1,418	1,811	1,344	1,613	1,640	2,011	1,468	1,917	2,100	2,552	1,823	2,397	3,050
School district	" "	2,913	2,585	3,127	3,473	4,531	3,383	4,092	4,192	5,253	3,868	5,093	5,630	7,016	5,062	6,715	8,736
Revenues of governments																	
State	" "	1,174	14,732	15,133	15,534	16,344	29,549	29,724	29,779	30,681	43,390	44,216	44,678	45,761	57,957	59,317	60,358
County	" "	654	1,343	1,346	1,352	1,398	1,668	1,609	1,634	1,669	2,110	2,140	2,171	2,213	2,659	2,695	2,736
School district	" "	5,265	5,957	6,108	6,262	6,761	7,483	7,526	7,683	8,184	8,906	9,083	9,264	9,790	10,539	10,740	10,949
Town	" "	466	513	560	613	762	834	809	873	1,017	1,094	1,171	1,258	1,437	1,534	1,632	1,802

a/ Total of agricultural, manufacturing, mining, federal government, and the basic part of transportation employment.
b/ Difference between total and basic employment.
c/ Ratio of employment to population.

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