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An Introduction to the COALTOWN Impact Assessment Model

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AN INTRODUCTION TO THE COALTOWN IMPACT ASSESSMENT MODEL

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FOREWORD

Coal mining and conversion in the coal-rich Northern Plains create social and economic change in rural areas of the region. Coal development is expected to accelerate due to the low sulfur content of the reserves and their relative ease of mining as utilities throughout the Nation turn to coal for an alternative source of energy. Renewed Federal leasing of these vast reserves and the application of new coal conversion technologies could add greatly to the impacts in the few rural parts of the region with the easiest access and greatest reserves.

This report summarizes the first phase of a research plan designed to improve the accuracy of local economic impact estimates that are due to coal development in the Northern Plains. Very little attention has been directed to problems of estimating rapid employment and population changes in rural localities. Procedures designed for urban areas and large regions are inapplicable to small and isolated rural economies. The accuracy of impact analyses for rural areas has suffered.

Future research will be directed to estimating more precisely the timing of adjustments and their spatial distribution -- elements which are especially critical to impact assessments but which have received no research attention. That research will relate local economic changes in the past to changes in current periods, and will be directed to the general case of rapid rural change. It's successful application will be useful to evaluate numerous types of rapid change in many different rural places -- a generic application not confined to the Northern Great Plains.

This research has been conducted with the cooperation of Montana State University, North Dakota State University, and the University of Minnesota through special agreements with the Economics and Statistics Service of the U.S. Department of Agriculture. Numerous other technical and lay reports relating to coal development and community impacts are available from this research effort.

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EXECUTIVE SUMMARY

COALTOWN simulates future employment, population, wage levels, migration, State and local tax receipts, intergovernmental transfers, and local government expenditures for counties in Montana, Wyoming, and North Dakota. The model is designed to assess impacts by comparison of results when one or more energy projects are included with baseline results.

The model has three parts -- socioeconomic, State and local government revenues, and local government expenditures. The structure of COALTOWN is different from an economic base model although modified economic base concepts are used. Stochastic estimates of the major parameters of the model are used. A multiplier is not calculated by the model. Rather, predictions of 'ancillary' employment are made by use of equations. The model is dynamic in that it uses lagged variables, and because interrelationships among variables in the equations of the model produce reverberations in years following an initial change. Although the coefficients in the equations of the model are representative of Northern Plains counties, the application to a specific county yields results which will be different from that of counties with other background conditions.

The model is designed for near term prediction and assessment purposes. Principal uses are:

1. Predict absolute levels of socioeconomic aggregates for planning purposes.
2. Assess impacts on socioeconomic aggregates for purposes of evaluation of a facility.
3. Test the sensitivity of socioeconomic and fiscal aggregates to key policy measures.

The predictive accuracy of the stochastic estimating equations in the model is extremely good. The accuracy of results of the full model deteriorates for successive years included in the analysis, a characteristic common to all simulation models.

The model has limitations and shortcomings. First, it estimates only aggregate parameters because predictive accuracy declines with the level of disaggregation. Second, accurate results are very much dependent on the accuracy of data supplied by users as inputs. Third, no capability now exists to estimate the distribution of new people among counties, and local governments within a county. Finally, the level of aggregation to some extent prevents an analysis of the distribution of impacts among residents in the area.

The COALTOWN impact assessment model is a prototype research model in its current form. Each part of it can be used separately. The model requires maintenance each year in order to be up-to-date, and the model parameters should be re-estimated periodically. The general structure of the COALTOWN model appears to be a useful approach to impact assessments, and is a departure from other models used for that purpose.

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INTRODUCTION

Recent increases in coal mining and projections of future development and utilization of Northern Plains coal reserves have created concern that major social and economic changes will follow (2). 1/ Federal, State and local leaders need assessments of the effects of coal development on local economies and governments. Impact assessments aid in the evaluations of public and private policies and the impacts of specific projects, and can guide local and regional planning.

The COALTOWN model simulates future employment, population, wage levels, migration, State and local tax receipts, intergovernmental revenue transfers, and local expenditures for counties in the Northern Plains States of Montana, Wyoming, and North Dakota. COALTOWN enables an analyst to estimate and compare conditions "with" and "without" a project over a period of time. The project's impact is the difference between each of the forecasted indicators "with" and "without" the project.

COALTOWN is designed to reproduce conditions existing in the current economy and to modify those relationships as growth and change occur (11). Dynamics are built into the model's statistically estimated equations. The reverberations following initiation of a project and the continuing shocks within the system can be traced over a period of years.

GENERAL CHARACTERISTICS OF THE COALTOWN MODEL

COALTOWN estimates three sets of impacts -- aggregate socioeconomic indicators, governmental revenues, and governmental expenditures. Results from each can be used separately or in combination with the others for assessment purposes. Each has its own methodology, strengths, and weaknesses. The simulation begins with data supplied by the user for an initial year. Data for succeeding years are supplied by the model itself as well as the user. The number of years to be included is determined by the user, but the model is most appropriate for near-term analyses.

The Socioeconomic Component

Estimates of employment, jobs per resident, migration, population, and wages of ancillary employees are generated by the socioeconomic equations of COALTOWN. The definitions, methods of estimating and relationships among the elements of the model are quite different from that of an economic base model even though the rationale is similar.

1/ Underscored numbers in parentheses refer to references listed at the end of this report.

Primary employment, past economic events in the local economy, and the events in and the characteristics of the economies in adjacent areas all drive the socioeconomic part of the model (Figure 1). The model is dynamic in more than one respect due to this. A local economy may change even though primary employment may not change. In addition, a change in primary employment can alter local economic conditions in future years (10, 1).

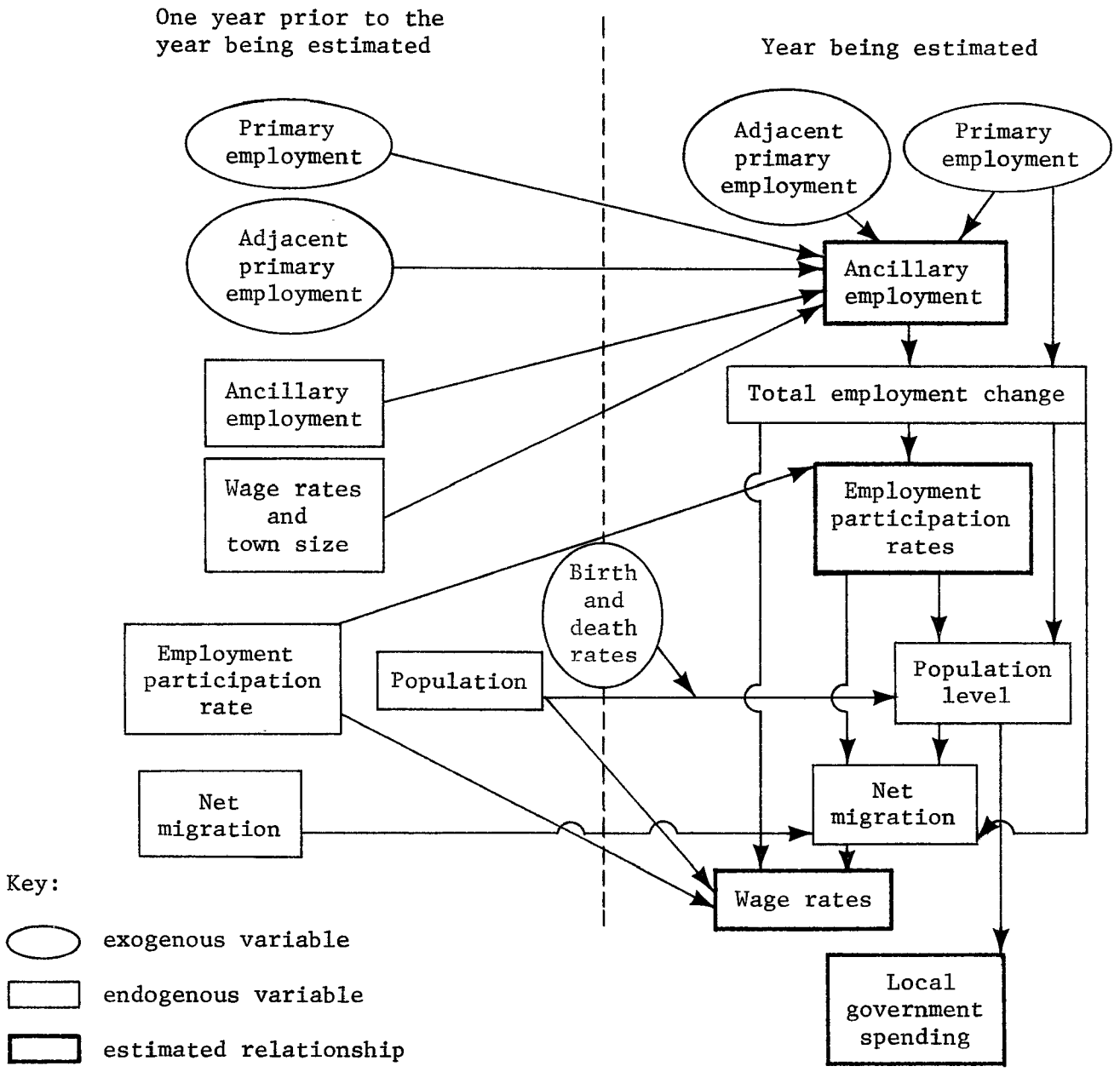

Figure 1--General structure of the socioeconomic segment of COALTOWN

Primary employment is composed of all energy-related construction and operation employment plus employment in agriculture, manufacturing, heavy construction and Federal establishments. These industries by assumption export their production to people outside the county. 2/ The user must supply, for use in the model, the number of workers in energy activities and in other primary industries for each year simulated. What has happened previously in a local economy establishes a foundation upon which future changes are built. The levels of primary employment, wages, employment participation and migration in prior years are a part of that economic foundation which influences current and future changes. The size of the largest town in a county, the distance to a regional trade center, the size of the dominant competing central place in an adjacent county, and the amount of primary employment in adjacent areas help to determine ancillary employment in a county. In turn, these also affect the future place of a county in the central place hierarchy.

The socioeconomic part of COALTOWN contains three essential equations which are used to estimate ancillary employment, the ratio of employment to population, and migration and wages. A brief description of what factors affect each of these impact elements followed by an illustration of some of the dynamic behavior will serve to introduce the COALTOWN model.

Ancillary Employment

The number of ancillary jobs in the aggregate is estimated by the COALTOWN equations for each simulation year (10). An employment multiplier is not estimated directly. 3/ Estimation of ancillary employment in a forecasting equation rather than calculating a multiplier each year requires less data, allows the introduction of dynamic features, and allows the implied marginal multiplier to be different from the average and to be non-linear. Ancillary employees include workers in wholesale and retail trade, finance, insurance, real estate, personal and business services, State and local government, and the portions of the transportation and construction sectors which serve local people. 4/

Ancillary employment is estimated as a function of the amount of primary employment in the current and prior year, ancillary employment in the prior year, the wage level of the prior year, the characteristics of the county economy, and the spatial setting of the county economy. 5/ It is noteworthy that ancillary employment in a county is described as responding to a host of variables and not just primary employment. Ancillary employment may increase due to secular change in service production technology in the Nation

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2/ 'Primary' employment does not encompass all basic employment in a county as economic base theory would dictate. For instance, service activities provided to people commuting from other counties is not included as 'primary' employment.

3/ The number of ancillary jobs in relation to the number of primary jobs is an implied multiplier, but its magnitude will not be the same as multipliers calculated with other definitions.

4/ Ancillary employment in the transportation and construction sectors are calculated using location quotients.

5/ The stochastic equation is in Appendix C, Appendix table 1.

or to increases in wages in a county (1). Furthermore, changes in prior years affect ancillary employment in succeeding years. The characteristics and spatial setting of a county which influence ancillary employment are the distance to a regional trade center, the size of the largest town in a county, and the activities in adjacent counties. For these reasons the number of ancillary workers in relation to primary workers varies from county to county, and through time.

Employment Participation by Residents

The demand for new workers in a county can be met by residents entering the labor force or by migration. The potential supply of local workers depends upon how much of the population is already employed, and how many would be attracted into the labor force if new jobs were available.

An estimate of the ratio of employment to population is used to calculate new entrants of local residents into the labor force as labor demand increases. 6/ The ratio of employment to population tends to increase and to remain high in tight labor markets characteristic of growing economies. To the extent that local people continue to enter the labor force, then the ratio of employment to population increases, migration is unnecessary, and population increases do not occur as employment expands. As the employment to population ratio reaches its upper limits, then migration occurs to satisfy demand for new labor. Once employment increases cease, the employment to population ratio slowly declines as migrants replace local residents in the labor force, and it continues to decline until the proportion of residents with jobs returns to a normal level. The number of jobs per person (the employment-population ratio) typically varies a great deal across counties and through time, but can be estimated quite accurately.

The model has a special programmed option for specifying an employment to population ratio for inmigrants different from that which is estimated within the model for the resident population. The feature is extremely important during construction periods when a temporary labor force is brought to the site of a facility. Temporary construction workers often leave their families elsewhere, and a high ratio of employment to population is observed for them. The result is a much less severe impact on population than might otherwise be expected.

Migration and Wages

Migrants fill those jobs not taken by local residents. Some construction and skilled operating employees are brought into a county through contracts and nationwide hiring. Other workers migrate to the area in response to job opportunities, higher wages, and local economic conditions.

COALTOWN explicitly assumes that wages will rise to the level required to induce net migration sufficient to cover the shortfall or surplus from employment demand not met by the local labor force. Net migration is a function of population of the county, migration in the prior year, wage level,

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6/ The stochastic equation is in Appendix C, Appendix table 2.

employment change, and relative employment participation. 7/. Net migration into a county is a flow of people. Some migration will come about as a result of the population size of an area without change in the economy. Other migration will occur as a result of prior changes including prior migration, employment changes in a prior period, and changes in employment participation. The equilibrating force is a change in wages -- increases hold residents and attract migrants, and decreases precipitate some outmigration of residents and tend to discourage inmigrants (3). The model calculates the ancillary wage necessary to attract or to discourage enough migrants to fill jobs not taken by local residents and the migrants who responded to economic signals in prior periods.

Dynamic Interactions

Interrelationships among the variables of the model are much more complicated than Figure 1 implies (10, 11). The estimating equations, for instance, include lagged variables which allow the model to capture some of the dynamics of the adjustment process from the old levels to the new levels of population and employment.

COALTOWN summarizes the dynamic features of the adjustment process. These features can be highlighted by an examination of the equations themselves and by an example. The equation for ancillary employment and its estimated coefficients imply (a) incremental employment multipliers which are larger for small communities than for large communities; (b) variations in employment multipliers depending upon the spatial setting of the county; (c) increases in employment multipliers through time; and (d) discrete changes in multipliers following a growth shock (10).

An evaluation of the equation estimating the ratio of employment to population shows that (a) the ratio will increase given rapid increases in labor demand, and (b) then will gradually trend toward a ratio that is slightly less than the U.S. level as labor demand stabilizes.

A brief example also can characterize some of the dynamic relationships accompanying adjustments. Assume an initial rapid increase in primary employment. Ancillary employment, the employment participation of residents, migration, wages, and population levels all change in that year. The effects of these changes will reverberate through the system the next year, and in succeeding years. Variables which affect the estimates in succeeding years are identified in Figure 1.

Most new employment at high growth rates is filled by migrants rather than increases in employment participation. Because migration accelerates, population grows more rapidly than when local residents supply the bulk of the labor.

The dynamics of the socioeconomic component of COALTOWN subsequently feeds into the local government expenditure and revenue parts of the model.

7/ A stochastic net migration equation is in Appendix C, Appendix table 3. It is used to estimate an ancillary wage index in the model.

State and Local Revenues

State and local government revenues and intergovernmental revenue flows are calculated through a series of accounting identities (Figure 2). Each State has a different tax and aid system, so separate models are required (12, 13, 14). The revenue accounting programs of COALTOWN are adopted from earlier modeling by Thomas Stinson at the University of Minnesota. 8/ The tax systems in each State also change as their respective Legislatures act. State, county, city, and school revenues are calculated for each year in the simulation as are all formula aids available to local governments. Intergovernmental revenues distributed by categorical grant or those which become part of a trust fund are totalled separately insofar as possible.

The revenue calculations are dependent upon mill levies supplied by the user. These conventionally are assumed to be at or near the levels existing in the base year. If revenues are deemed inadequate for a function, then the necessity of a mill levy increase is implied. If a revenue surplus is indicated, then a decrease in taxes at some time in the future is implied, depending upon the flexibility of the State and local tax system.

Figure 2--General structure of the revenue segment of COALTOWN

User inputs	Inputs from socioeconomic segment of model	Model outputs of revenues by source
Tax related characteristics of energy project		State revenues Severance Electricity production Property School Income Sales
Initial assessed values in county	Total employment	
State & local tax laws	Ancillary wages	County revenues Property School Sales
Mill levies	Population	School revenues
		City revenues Property Sales
		Intergovernmental transfers

8/ The revenue accounting programs are adapted from the ENGYTX Model developed by Thomas F. Stinson (7, 8). Tax information for each State was prepared by Stanley W. Voelker (14), Layton Thompson (12, 13) and Stinson (9). These subsequently have been updated for publication by Stanley W. Voelker.

Interrelationships among the tax and the socioeconomic components of the model are complex. Energy projects affect assessed values, employment, wages, and population which in turn influence government revenues as well as expenditures.

Local Government Expenditures

Expenditure estimates for counties and schools are estimated using each period's anticipated population (11). Expenditure estimates are a weak component of the model due to the data which are available, but the estimating equations are statistically significant. COALTOWN compares local revenues and expenditures but the user is cautioned against inappropriate interpretations from the estimates. In most instances, the revenue data should serve as a guide against which planned rather than estimated expenditures are compared.

Expenditures for capital items and the timing of capital expenditures and expected revenues are critical to assessments. COALTOWN provides guidance on the timing and extent of population change but makes no attempt to forecast the level or timing of capital expenditures by local governments.

PRINCIPAL USES OF THE COALTOWN MODEL

COALTOWN is designed to assess the impact of future energy development projects. Results from a baseline scenario without the proposed energy project are compared to the results from scenarios which include the energy projects in order to assess impacts on employment, population, migration, and revenues which result from a project.

A clear distinction should be made between an economic assessment and an economic forecast. An economic forecast is conditional on the accurate prediction of those factors which are used as data in the model. For example, one may not be able to accurately predict the future fiscal impact of an energy development project because future tax laws are unknown. However, one can assess the fiscal impacts taking the existing tax legislation as given. These results help assess the adequacy of the current tax structure for meeting future needs.

The user may test the sensitivity of the results to special background conditions by assuming alternative data inputs. This procedure helps to assess the importance of certain policy variables in addition to yielding a forecasted range for the economic indicators of interest. It should be emphasized that uncertainty about background conditions tends to cancel out in the comparison of the baseline results and the results which include the energy-related facility.

The three principal uses of the COALTOWN simulation then, are as follows:

1. It can be used to predict the absolute levels of population, employment, migration, and other impact variables for planning purposes.

2. It can be used to assess impacts due to a specific project for purposes of evaluation.

3. It can be used to assess the sensitivity of the results to various measures as an aid to policy analyses.

INFORMATION SUPPLIED BY THE USER

The user supplies two types of information: data regarding the energy project itself, and background information related to the region where the development will take place. These are labeled 'exogenous variables' in Figure 1. Information about the project itself includes the number of workers directly employed in operating and constructing the proposed facility in each year, the megawatts of electricity generated or the tons of coal mined each year, and optionally, the employment ratio of the migrant population.

Necessary background information regarding the region includes the initial population of the county, projected State and local mill rates, assessed value of property, the number of people currently in the ancillary and basic sectors, distance to a regional trade center, and the size of the largest town in any adjacent county. A detailed list of input variables is presented in Appendix A.

DATA GENERATED BY THE MODEL

The output generated by COALTOWN is, to a large extent, self-explanatory. An example of the printed output is illustrated in Figure 3. The user has an option of choosing a summary output which lists the major economic indicators and fiscal impacts for each year, or a complete output which includes detailed revenue statistics for each year.

The COALTOWN output generates the following information for each year of the simulation run: the number of workers employed by primary industries, the number of workers employed in ancillary jobs, the number of non-farm proprietors (owners of businesses and self-employed persons), total employment, relative real wages in the service sector as a percent of the base year, migration, population, the employment to population ratio, and the number of school children. Summary statistics for State, county, school and town revenues are also given along with estimates of school and county spending.

The detailed tax output (Figure 4) breaks revenues into the following categories: coal severance, gross proceeds, taxes on electricity generation, other taxes generated by mines and generators, taxes on people and businesses (for example, income, liquor, cigarette, and auto registration taxes), and intergovernmental flows. Information is also given regarding revenue sources peculiar to each State, such as the Wyoming sales tax, the school foundation program, or trust funds.

Figure 3--Example of summary output of COALTOWN, example county - Montana
Northern Great Plains scenarios - with new mines

Year	Tons mined	Energy project workers	All econ. base employment	Ancillary employment	Proprietors	Total employment
1975	8699999.	1541.	2680.	1827.	326.	4833.
1976	11699999.	675.	1806.	1965.	333.	4103.
1977	11699999.	552.	1675.	2051.	340.	4066.
1978	12699999.	880.	1995.	2176.	341.	4512.
1979	14199999.	1797.	2904.	2386.	331.	5621.
1980	17000000.	2476.	3576.	2667.	315.	6558.
1981	17500000.	2967.	4059.	2946.	303.	7308.
1982	18000000.	2432.	3516.	3157.	306.	6979.
1983	21500000.	1399.	2476.	3268.	323.	6066.
1984	23399984.	1289.	2358.	3424.	329.	6111.
1985	25000000.	1306.	2368.	3602.	332.	6302.

Year	Labor mkt. index	Migration	Emp/pop.	Town size	School kids	Population
1975	1.4764	2741.	.4624	3585.	2744.	10451.
1976	1.0701	-276.	.4009	3370.	2687.	10236.
1977	1.1054	-184.	.4022	3245.	2655.	10111.
1978	1.3286	509.	.4225	3813.	2804.	10679.
1979	1.4386	1961.	.4425	5836.	3335.	12702.
1980	.9047	1427.	.4617	7336.	3729.	14202.
1981	1.0701	1011.	.4778	8430.	4016.	15296.
1982	1.0701	-255.	.4613	8263.	3972.	15129.
1983	1.3316	-285.	.4063	8066.	3920.	14932.
1984	1.2257	-59.	.4085	8094.	3928.	14960.
1985	1.2007	101.	.4160	8282.	3977.	15148.

Year	State revenue	County revenue	School revenue	Town revenue	County spending	School spending	Per capita town revenue
1975	11756551.	872082.	2919474.	180484.	1167721.	2286656.	50.34
1976	15348542.	1220390.	3050717.	180882.	1152104.	2240318.	53.67
1977	15415457.	936882.	3240355.	177572.	1143006.	2213475.	54.72
1978	16840624.	779505.	3130495.	192040.	1184081.	2335542.	50.37
1979	19203488.	943750.	3642712.	248178.	1324652.	2769914.	42.53
1980	22782224.	712809.	4063318.	294704.	1423826.	3091306.	40.17
1981	23787392.	727580.	4330040.	331543.	1493764.	3325111.	39.33
1982	25299696.	865689.	4457834.	335793.	1483226.	3289508.	40.64
1983	29706400.	1059055.	4645040.	335459.	1470717.	3247422.	41.59
1984	31608928.	1081122.	4677916.	342211.	1472506.	3253427.	42.28
1985	33345296.	1099309.	4742510.	353620.	1484432.	3293576.	42.70

All values are in 1970 dollars (or that specified by a user).
All revenue is reported for the year in which the tax liability is generated. No allowance is made for lags in assessment or payment.

Figure 4--Example of detailed revenue of COALTOWN, example county - Wyoming Northern Great Plains scenarios - without new mine

1975 revenue amounts by type and jurisdiction

	Wyoming	County	School district	Town
Sev. or GP taxes	437759.69	109439.88	191337.38	.00
Other mine taxes	256678.44	23707.44	41448.56	.00
People taxes	4058922.00	580528.19	3446778.00	608013.06
Total taxes	4755359.00	831624.44	3679563.00	864776.94
Intergov. flows	-3003154.00	165703.75	2245920.00	591531.69
Net revenue	1752205.00	997328.19	5925483.00	1456308.00

The county share of local sales tax revenue is: 117949.13

The town share of local sales tax revenue is: 256763.88

State aid available for local impacts, but not automatically rebated, amounts to 437759.69 of State taxes generated locally.

Note: All taxes are reported for the year in which the tax liability is incurred.

THE PREDICTIVE ACCURACY OF ESTIMATING PROCEDURES

Differences in employment and population due to spatial patterns and temporal variations in economic activity appear to be summarized well by COALTOWN equations. These equations account for a very large proportion of the variations in reported values of employment, employment participation, migration and population of the 181 sample nonmetropolitan counties for the period 1971-74.

Seven counties in the Northern Plains are destined to be major coal producers in the next decade. Population values estimated by COALTOWN equations are compared with observed values for these counties in Table 1 for the 1970-77 period. Other estimated values are reported in Appendix tables 4-5. The spatial and temporal influences of mining and conversion are accounted for in the counties.

The accuracy of the estimates appears to be especially noteworthy because these major coal counties exhibited different growth patterns. These patterns range from stability to rapid change as indicated by observed employment over the period. McLean, North Dakota had stable employment, and estimated population tracks well. Both Big Horn, Montana and Converse, Wyoming

Table 1--Equation estimates 1/ and observed values, population 2/ 1970-77, seven Northern Plains counties with coal mining and/or conversion

Year	Big Horn		Rosebud		McLean		Mercer		Campbell		Converse		Sheridan	
	est.	obs.	est.	obs.	est.	obs.	est.	obs.	est.	obs.	est.	obs.	est.	obs.
1970	10,213	10,063	6,196	6,044	11,799	11,322	6,370	6,170	13,587	13,049	5,943	6,072	18,106	17,865
1971	10,203	10,109	6,233	6,106	11,538	11,671	6,253	6,184	12,978	12,820	6,903	6,630	18,260	17,984
1972	9,967	10,330	6,195	6,419	11,472	11,563	6,136	6,180	13,226	12,489	6,528	6,672	17,810	18,123
1973	9,998	10,352	6,427	6,857	11,331	11,443	6,192	6,169	12,233	12,295	6,416	6,866	17,856	18,832
1974	10,240	10,498	7,013	7,826	11,316	11,472	6,550	6,279	12,794	12,035	7,177	7,162	19,517	19,177
1975	10,681	10,934	11,899	9,652	11,810	11,600	6,762	6,404	14,231	13,103	8,117	8,029	20,175	19,924
1976	10,663	10,590	9,239	9,886	11,903	11,851	6,147	6,720	14,542	14,540	8,596	9,363	20,380	21,012
1977	10,199	10,675	9,480	10,503	12,630	12,272	6,713	7,039	17,521	16,759	10,072	10,687	21,951	21,619

1/ Coefficients from Temple (1978) applied to revised BEA 1969-77 data. Coefficients were estimated from unrevised data for 181 nonmetropolitan counties 1970-74 (11).

2/ All current year values are estimated and any lagged values in estimating equations are observed values of revised BEA data 1969-77.

exhibit a relatively stable employment until 1974. Estimated population is very close in each case despite the change in later years. The Decker mine, at that time one of the largest in the Nation, was just starting operations in Big Horn County. No new energy projects were initiated in Converse County in this period. Rosebud, Montana and Mercer, North Dakota were the sites of power plant and mine construction, and coal mining was being initiated in Campbell County, Wyoming in this period. Population in Rosebud County was overestimated in 1975, the year of completion of construction of power generators. Despite those causes of rapid change, the population estimates are extremely close. Finally, Sheridan County, Wyoming is the site of a city and the recipient of impacts from Campbell and Big Horn Counties. Although the economic conditions in these counties were different and certainly uncharacteristic of the region, the COALTOWN equations performed extremely well in estimating population.

Total population is found by dividing estimated total employment by the estimated employment to population ratio. Total employment is the sum of primary employment and the estimated values for ancillary and non-farm proprietors. An inaccuracy in any one of the estimates in the population calculation will produce errors. That is illustrated by the 1974-75 population estimates in Campbell County when unusual conditions prevailed there but for which no adjustment was made. Workers commuting into Campbell County distorted the employment participation rate. For most accurate results when unusual conditions are known to exist, COALTOWN users should incorporate that information beforehand into the model.

LIMITATIONS OF THE MODEL

Any simulation model has inherent limitations. The model's structure and the validity of its coefficients are basic considerations. COALTOWN'S structure is purposely simple and uses aggregate variables which can be predicted most accurately. Even though it is simple, dynamic interrelationships among variables often make it difficult to follow through the logic of a change in one part of the model. Thus, the aggregate level of prediction and the simplicity of structure allow more accurate forecasting but at a loss of some detail.

A common limitation of all simulation models is that their accuracy declines for each year into the future for which predictions are made. Inaccurate estimates in early years tend to accumulate and to reduce the accuracy of later estimates. In addition, structural changes in the economy which are not anticipated by the model are likely to occur in the long run. An example is the trend upward of the service to base ratio and the employment ratio. These trends probably will not continue at the same pace in the long run. Thus, the model should be viewed as a near term assessment model.

The amount and accuracy of input data supplied by the user is important for the same reason. Inaccurate input data produce inaccurate estimates in early years, and these become inputs in each successive year so that errors build up over time. Some examples may illustrate this problem. Data for the

employment directly associated with a project and with future projects are critical for an accurate evaluation, but they are seldom known with certainty. The labor force participation rates of new migrants coming into the region are even more difficult to anticipate in the future. They depend on the duration of the project, the characteristics of the local housing stock, the possibility of building temporary housing for construction workers, the size of families, and many other factors. As mentioned previously, this type of uncertainty can be evaluated by testing a range of alternative values for input variables. Uncertainty associated with particular input variables which may affect the outcome of a baseline run (for example, the projected growth rate of other basic sectors) will not be as important when doing an impact assessment comparing a "with" and "without" simulation as when forecasting the absolute levels of the impact variables for use in planning.

Another important shortcoming of COALTOWN is its inability to allocate new population to locations within the county and region. This information would prove useful in assessing fiscal impacts on school districts and towns. The problem is compounded when energy impacts spill over to surrounding counties, because the magnitude of the spillover cannot be estimated and allocated by the model. The user must make a judgement about the distribution of workers within the county.

COALTOWN does not predict the industries which may move into a region as a result of energy development. This type of secondary development could prove to be significant in some areas. For example, energy intensive industry might be drawn to a region to take advantage of low power rates. Manufacturing industries which serve the needs of the energy sector might also be drawn to a region undergoing intensive coal development. The model will underestimate future growth to the extent that secondary industries are attracted to a location.

COALTOWN uses employment as a key variable although income is conceptually preferable. Employment is used because county agricultural income data are not reliable, and COALTOWN applies to rural counties where agriculture is important. Each job is implicitly assumed to have the same impact on the region. For instance, when the effects of income associated with coal royalty payments to individuals are investigated, the user must translate these payments into equivalent employment units.

The distribution of impacts among people and the social strains which emerge because of this is not addressed by COALTOWN. Definitive statements about different impacts of coal development among people cannot be made. The importance of such considerations should not be minimized. Residents of a region would be very interested in knowing how the benefits of future development might be distributed between current residents and newcomers. The impact of new development also may be quite different for each socioeconomic class. This information is relevant in assessing the benefits and costs, and the political implications of development.

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APPENDIX A

DATA SUPPLIED TO COALTOWN

The following is a comprehensive list of all exogenous data variables which the user inputs into the COALTOWN model. Each variable is described briefly.

Identification

The title of the scenario.

County name.

The number of scenarios to be analyzed for a particular county.

The number of counties to be analyzed.

The one digit code associated with Montana (1), North Dakota (2), or Wyoming (3).

The last year of the scenario (the first year of the scenario is assumed to be 1975 as the program now stands).

Definition of Scenario and Setting of the County

The tons of coal mined in the county in each year of the scenario.

The number of jobs in the energy sector during each year of the scenario. This includes miners, power plant operators, and energy project construction workers.

Other primary workers in agriculture, manufacturing, mining other than coal mining, Federal government, and the basic portions of the transportation and construction industries.

All wage and salary employees not in the primary sectors. 1/

Number of nonfarm proprietors. 1/

The ratio of total employment (including proprietors) to total population. 1/

Net migration. 1/

The ratio of total ancillary income (in thousands of dollars) to the number of ancillary employees plus nonfarm proprietors. 1/

County population. 1/

1/ Provided for the initialized year of the model only.

The number of workers employed in the primary industries in adjacent county with the largest primary employment.

Distance (in miles) from the largest town in a county to the Rand McNally Regional Trade Center.

Population of the largest town in the county. 1/

Population of the largest town in any adjacent county.

Revenues and Expenditures

The actual sales price of a ton of coal measured in 1970 dollars.

County sales tax applicable only to Wyoming counties.

Projected mill rates in each year for the State, county, school district, and town respectively.

Average assessed values for: (1) detached homes, (2) mobil homes, (3) apartments, (4) cars, and (5) trucks respectively.

The ratio of actual to estimated county spending (this correction factor makes estimated expenditure figures more realistic for the particular county being investigated).

The ratio of actual to estimated school spending (this correction factor makes estimated expenditure figures more realistic for the particular county being investigated).

The ratio of commercial property value (in dollars) to ancillary employment.

A vector with two values tells the number of cars per capita and the number of trucks per capita respectively.

Total taxable value of all property in the county.

The amount (measured in megawatts) of electric power generating capacity in the county in 1974.

The projected amount (measured in megawatts) of electric power generating capacity in the county for each year of the scenario.

Data for Special Options

Whether the user desires a detailed tax printout.

The employment/population ratio if migrants are assumed to have a different one than the existing population in the county.

1/ Provided for the initialized year of the model only.

Whether new basic energy workers will not live within the county's largest town.

Whether energy development will include the construction of thermogenerating plants.

Whether the user will input rates of growth for the basic sectors in the object county as well as the basic sectors in the adjacent counties.

Whether the user will input a vector of coal royalty payments (this may be the case if coal development will occur on Indian land - the royalty payment will be converted into employment equivalents by dividing total yearly payments by the average basic yearly wage).

Coal royalty payments applicable to coal development on Indian land.

Projected values for the employment/population ratio of migrants. In cases where there is a large influx of temporary workers and a shortage of family housing units, this value will tend to be much higher than the employment/ population ratio of current county residents.

The fraction of migrant workers not living in the major town in the county in each year of the scenario.

The annual rate of growth of the basic sectors in the adjacent county with the largest number of basic employees.

The annual rate of growth (or decline) of the basic sectors (other than energy related sectors) in the county being studied.

The projected growth rate of the largest town in any adjacent county.

APPENDIX B

CHARACTERISTICS OF DATA USED IN ESTIMATING COALTOWN

Data used for estimating the principal parameters of the model have certain advantages, but also imply limitations. Employment, income, and population estimates, 1970-74 are from the Bureau of Economic Analysis, Department of Commerce. They are estimates which are revised successively as information becomes available, and the coefficients of the model are subject to error from that source. A combined cross section and time series analysis is dictated for this reason (4, 5).

The observations are 181 Northern Great Plains counties which are nonmetropolitan in character -- rural counties. The economies of these counties are relatively uncomplicated (6) yet provide a range of conditions for application of the modified economic base approach.

Employment

Employment data for counties are compiled by the Department of Commerce from several sources. Wage and salary statistics are the most thorough and accurate of these because they are derived from unemployment compensation records filed by firms. Estimates of the number of proprietors are from these and other sources such as the Internal Revenue Service. Farm labor and especially farm proprietors and their incomes are the least accurate due to the coverage and nature of the reports available.

Employment is the number of jobs reported by an establishment. Second and part-time jobs are included. Double counting of unknown magnitude is inherent in the data.

The county location of the reporting establishment rather than residence of the worker is reported. Although commuting across county boundaries is not common in the rural portions of the Northern Great Plains, it can be characteristic of rapid growth areas, especially during construction of major facilities. For these reasons, the exact distribution of the population in and among counties is not known.

The industry detail of employment data in this study is the one-digit SIC level. Disaggregation below that at the county level is probably unreliable.

Income

Income of wage and salary workers by industry, and farm and non-farm proprietors also is reported by the Department of Commerce. Income data are prepreferred for economic analysis in most economic base studies. Income data appear to be inappropriate in counties dominated by agriculture. First, coverage of the agricultural wage and salary employment is incomplete. Second, farm income is allocated to the county level from estimates of state totals

each year, hence, is an inaccurate measure. Finally, farm income is a poor measure of economic activity in agriculture because it varies greatly even when farm production and household expenditures do not.

Population

Population estimates reported by the Department of Commerce are those generated to allocate Federal revenue sharing funds. The estimates are an average of several estimates and are adjusted to agree with state totals. Regression estimates are based upon variables such as school enrollments and vehicle registrations. Other estimates are based on vital statistics, medical records and tax data. The estimation method may vary from state to state and estimates are revised periodically.

Changes in size of family, presence of school children and age composition of families in rapid growth areas can result in inaccurate population estimates. The model allows user specification of different employment to population ratios for inmigrants in order to reflect rapid growth conditions.

APPENDIX C

STOCHASTIC ESTIMATION OF COALTOWN PARAMETERS

Appendix table 1--Estimating equation for ancillary employment in Northern Great Plains counties, 1/ 2/

Equation	Estimated coefficients	F statistics	Definition of variables
Dependent variable			
$ANCEMP_t$			Ancillary empl.; total empl. minus basic empl. in year t
Independent variables & coefficients			
a_0	-32.91643		Constant
a_1 $ANCEMP_{t-1}$	1.04194	3/	ANCEMP in prior year
a_2 $BASE_t$	0.42970	79.06	BASE is defined as no. of agricultural employees & farm proprietors, empl. in mining, forestry & fishing, manuf., & Federal govt. plus any employees in trans. & const. over the regional avgs.
a_3 $BASE_t$ D	-0.00305	7.58	The distance to a Rand McNally Regional trade center multiplied by $BASE_t$
a_4 $BASE_t$ D^2	- .000005	0.83	Distance to 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 adj. 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} $Wage_{t-1}$	0.00008	0.17	Mean salary & earnings, thou. per yr. of ancillary employees & proprietors multiplied by size of largest local town
e_{1t}			Error
Statistics			
R^2		0.99	
F		3/	
S.E.E.		126.07	
Mean of ANCEMP		2353.67	
d.f.		713.00	

1/ Two parallel ancillary employment equations were subsequently estimated for use in the COALTOWN model. One equation has wage & salary ancillary workers as its dependent variable & the other uses non-farm proprietors as a dependent variable.

2/ Coefficients were estimated using two-stage least squares on a data base of 181 rural Northern Great Plains counties for 4 years, 1971-1974.

3/ Larger than 10,000.

Appendix table 2--Estimating equation for employment ratio in the Northern Great Plains counties, 1/

Equation 2/	Estimated coefficients	F statistics	Definition of variables
Dependent variable			
$RELLFPR_t$			The county employment population ratio relative to the U.S. ratio, in year t
Independent variables & 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	

1/ Coefficients estimated using two-stage least squares on a data base of 181 counties for 4 years, 1971-1974.
2/ All estimated values rounded.

Appendix table 3--Estimating equation for net migration in Northern Great Plains counties, 1/

Equation	Estimated coefficients	F statistics	Definition of variables
Dependent variable			
MIG_t			Net migration in year t
Independent variables & 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 $\{2(wage_t-5.0)\}$ 2/
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 $RELLFPR_{t-1}$	-72.0162	0.89	RELLFPR in prior year 3/
e_{3t}			Error
Statistics			
R^2		0.68	
F		259.49	
S.E.E.		293.94	
Mean of MIG		50.32	
d.f.		717.00	

1/ Coefficients estimated using two-stage least squares on a data base of 181 rural Northern Great Plains counties for 4 years, 1971-1974.
2/ Wages defined as mean salary and earnings, thou. per year, of ancillary employees and proprietors.
3/ RELLFPR is defined as the county employment ratio relative to the U.S. ratio in year t.

Note: In the actual COALTOWN Simulation Model this equation was used to estimate the wage level. Migration was used as an independent variable (see appendix E).

APPENDIX D

PREDICTIVE ACCURACY OF ESTIMATES FOR SELECTED COUNTIES

Appendix table 4--Equation estimates 1/ and observed values, ancillary employment, non-farm proprietors and employment per 100 population, 2/ 1970-77, seven Northern Plains counties with coal mining and/or conversion

Year	Big Horn		Rosebud		McLean		Mercer		Campbell		Converse		Sheridan	
	est.	obs.	est.	obs.	est.	obs.	est.	obs.	est.	obs.	est.	obs.	est.	obs.
						- Ancillary employment -								
1970	1,389	1,684	1,138	1,110	2,015	1,998	1,081	1,051	2,533	2,619	1,376	1,349	4,475	4,545
1971	1,760	1,757	1,160	1,301	2,083	1,997	1,083	1,090	2,691	2,642	1,467	1,468	4,597	4,688
1972	1,828	1,678	1,361	1,423	2,052	1,966	1,126	1,211	2,784	2,721	1,501	1,611	4,818	4,998
1973	1,744	1,724	1,490	1,587	2,059	1,989	1,274	1,353	2,844	2,826	1,627	1,649	5,141	5,094
1974	1,818	1,821	1,670	1,803	2,056	2,159	1,450	1,549	3,007	3,068	1,752	1,781	5,435	5,200
1975	1,908	1,916	1,973	2,320	2,244	2,304	1,641	1,558	3,326	3,688	1,936	2,042	5,543	5,497
1976	2,015	1,954	2,408	2,324	2,460	2,388	1,558	1,659	4,002	4,244	2,210	2,264	5,897	5,862
1977	2,066	2,136	2,410	2,256	2,617	2,549	1,732	1,931	4,704	4,982	2,479	2,487	6,508	6,164
						- Non-farm proprietors -								
1970	290	300	237	228	482	441	251	232	479	472	297	292	833	827
1971	305	249	231	233	448	405	236	209	488	446	295	281	857	830
1972	253	267	236	215	412	384	212	204	453	460	287	299	841	848
1973	272	264	218	227	389	379	206	204	470	443	306	302	868	863
1974	266	279	229	269	385	400	204	218	447	448	306	324	875	906
1975	281	287	258	328	406	403	219	222	445	470	326	350	905	907
1976	288	276	342	334	408	411	229	230	465	502	353	397	907	928
1977	273	291	345	352	413	432	233	242	486	528	398	418	908	977
						- Employment per 100 population -								
1970	36.10	38.63	40.86	41.64	40.22	41.70	39.50	40.50	41.26	43.29	44.06	42.93	44.03	44.79
1971	38.20	38.35	42.68	45.21	40.89	39.99	39.99	40.31	39.46	39.93	43.94	45.52	44.66	45.52
1972	37.96	36.29	46.79	45.58	39.46	38.90	41.77	42.10	41.80	43.94	46.45	46.29	46.39	46.08
1973	37.32	35.97	48.20	46.28	40.27	39.58	44.78	45.85	45.14	44.75	46.27	43.31	47.50	44.90
1974	37.00	37.76	48.23	44.94	40.67	40.53	47.83	51.66	46.66	50.02	45.34	45.99	46.32	45.52
1975	35.36	34.58	33.29	53.83	40.18	41.12	50.98	52.95	48.85	57.16	46.11	48.49	45.93	46.38
1976	34.72	34.98	49.39	46.05	43.12	42.89	51.24	47.21	58.89	61.10	50.72	47.63	48.21	46.65
1977	35.47	37.23	42.68	38.50	45.69	46.62	49.87	49.73	61.61	67.27	50.34	47.72	49.16	47.25

1/ Coefficients from Temple (1978) applied to revised BEA 1969-77 data. Coefficients were estimated from unrevised data for 181 nonmetropolitan counties 1970-74 (11).

2/ All current year values are estimated and any lagged values in estimating equations are observed values of revised BEA data 1969-77.

Appendix table 5--Simulated predictions of employment-population ratio and population, and percent deviation from observed 1971-74, seven Northern Plains counties with coal mining and/or conversion 1/

Year	Big Horn		Rosebud		McLean		Mercer		Campbell		Converse		Sheridan	
	pre.	% dev.	pre.	% dev.	pre.	% dev.	pre.	% dev.	pre.	% dev.	pre.	% dev.	pre.	% dev.
	- Employment-population ratio -													
1971	.3839	-1.01	.4243	-7.21	.4367	2.93	.4150	-2.06	.4026	4.12	.4375	-1.97	.4347	-2.20
1972	.3910	7.39	.4391	-5.82	.4393	6.39	.4255	-4.24	.4230	-8.10	.4413	-2.10	.4379	-1.36
1973	.4051	10.24	.4615	-1.39	.4590	7.54	.4491	-7.49	.4395	-7.47	.4385	1.33	.4545	1.03
1974	.4228	9.53	.4752	3.76	.4646	6.08	.4693	-12.71	.4576	-14.43	.4582	0.37	.4669	1.05
	- Population -													
1971	10,269	1.57	6,276	2.78	11,554	-1.39	6,372	2.63	12,934	-3.76	6,723	1.57	18,295	1.02
1972	10,150	-1.46	6,369	-0.48	11,422	-1.53	6,372	2.77	13,465	15.09	6,659	-0.61	18,096	-0.57
1973	9,869	-4.56	6,364	-7.70	11,314	-1.81	6,380	2.52	13,206	7.66	6,392	-7.43	17,791	-5.75
1974	10,097	-3.69	6,501	-15.20	11,307	-1.66	6,822	6.53	13,701	15.55	6,721	-5.83	18,061	-6.19

1/ Simulated predictions using system-generated values of estimating equations.

APPENDIX E

THE SYSTEM OF EQUATIONS

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

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

3. $MIG_t = c_0 + c_1\ MIG_{t-1} + c_2\ POPI_t + c_3\ e^{2\ (WAGE_t - 5)} + c_4\ CEMP_t + c_5\ CEMP_t^2 + c_6\ RELLFPR_{t-1} + e_{3t}$ */

4. $\ln GOV_{it} = d_{i0} + d_{i1} \ln POPN_t + e_{4it},\ i = 1,2,3$

5. $Q_{dt} = ANCEMP_t + BASE_t$

6. $Q_{st} = Q_{dt}$

7. $Q_{st} = MW_t + LOCW_t$

8. $LOCW_t = POPI_t \times RELLFPR_t \times USLFPR_t$

9. $MW_t = MIG_t \times RELLFPR_t \times USLFPR_t$

10. $POPN_t = POPI_t + MIG_t$

11. $CEMP_t = Q_{dt} - Q_{dt-1}$

12. $PCEMP_t = CEMP_t / Q_{dt-1}$

where:

ANCEMP	= ancillary employment
BASE	= economic base
DIST	= distance to trade center
ADJBASE	= adjacent economic base
WAGE	= ancillary earnings divided by ancillary employment
TOWN	= town size
RELLFPR	= employment participation rate relative to the U.S. rate
PCEMP	= percentage change in employment

---

*/ Equation 3 was used in the COALTOWN Simulation Model to predict the wage level. Net migration was computed using identities 5 through 9 and the predicted values for $ANCEMP_t$ and $RELLFPR_t$.

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

Equations 1 through 4 are stochastic, 5 through 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, $LOCW_t$. Equations 1, 2, and 3 were estimated using 2SLS.

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