SIMULATING THE EMPLOYMENT IMPACT OF COAL DEVELOPMENT IN WYOMING*

Roger A. Matson and Jeannette B. Studer**

The current petroleum crisis has served to focus attention on the energy potential of the vast reserves of coal found in the Northern Great Plains states of Montana, North Dakota, South Dakota, and Wyoming. Renewed interest in this resource has led to the formulation of extensive plans for surface mining which portend substantial environmental change to this sparsely settled area.

Of the many environmental changes that extensive coal development may bring to the Northern Great Plains, none is more feared than "people pollution." Defined in local parlance as the massive and often unwanted influx of population into an area essentially lacking in urban infrastructure, "people pollution" is viewed by many local leaders as the principal environmental impact of coal development.

In response to this concern, the Northern Great Plains Resources Program (NGPRP), a joint federal-state planning effort, has commissioned a series of studies related to the socioeconomic and cultural impact of potential coal development. This paper is a result of a study which was undertaken to determine the extent of the economic and population impact on one portion of the area--the Powder River Basin of Wyoming.

The paper presents some preliminary results regarding the use of regional economic simulation in the evaluation of the impact of mineral activities in areas where a limited local labor supply may be an important consideration in the determination of future employment levels in both primary and secondary activities.

Nature of the Problem

The Powder River Basin of Wyoming contains an extension of the Fort Union

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**Economist, Office of Power, Tennessee Valley Authority, and Energy Economist, Old West Regional Commission, respectively.
Formation, a vast coal deposit covering the western half of North Dakota, the northwestern portion of South Dakota, the eastern third of Montana, and the northeastern portion of Wyoming. Coal in this region is lignite and sub-bituminous, with heat values ranging from 6,200 to 13,000 Btu./lb. [8].

An estimated 120 billion tons of recoverable reserves lie within the Fort Union Coal Region (Figure 1), including its Wyoming extension. Within the Powder River Basin alone, there are an estimated 21.2 billion tons of coal potentially recoverable through strip mining [10]. The Wyoming coal is generally sub-bituminous, varying from 8 feet to 70 feet in thickness, although in some areas it may reach 130 feet [8].

In 1972, 4.2 million tons of coal were mined from the Powder River Basin. By 1980, annual production should exceed 40 million tons—an increase of nearly ten times. For the most part, this production will consist of coal mined by strip or surface methods for export to thermal generating plants outside the area. By 1980, Wyoming coal will be shipped to points as distant as Indiana and Louisiana [10]. Extensive use of coal in power generation and coal gasification plants is also anticipated.

The current increase in coal production in this area has a number of proximate causes: (1) the relatively low sulphur content of the coal; (2) the availability of unit trains for shipment; (3) the delays experienced in the construction of nuclear power plants; and, more recently, (4) the rising prices of alternate energy commodities, particularly petroleum and natural gas.

The extent to which these factors will contribute to continued growth in production is uncertain. Accordingly, the NGPRP analysis for the area takes the form of alternative scenarios with ultimate (year 2000) production ranging up to 350 million tons per year. In addition to coal mining, substantial employment impacts are projected in the various scenarios in conjunction with coal gasification, power generation, and coal shipments.

For purposes of the NGPRP study, direct employment was estimated on the basis of the output hypothesized for each of the scenarios. Output estimates and coal requirements were developed for each of three scenarios by the NGPRP minerals work group. Other input requirements were then estimated by an economics work group. No consideration was given to labor availability in the preparation of the direct employment estimates for these scenarios. In some cases, alternative scenarios were developed for specific states which reflected such considerations.

The magnitude of the potential impact implied for the Powder River Basin area of Wyoming in each of the three NGPRP scenarios is indicated in Table 1. Scenario II-A was prepared by the authors to provide an additional mid-range alternative.

The higher scenarios suggest an impact of substantial magnitude. The Powder River basin is a sparsely settled area with agriculture and extractive industries providing the main economic base. The area as defined for purposes of this study (see map) consists of eight counties with a total 1970 population
<table>
<thead>
<tr>
<th>Scenario</th>
<th>Scenario II</th>
<th>Scenario II-A</th>
<th>Scenario III</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coal mining</td>
<td>558</td>
<td>1,475</td>
<td>2,695</td>
</tr>
<tr>
<td>Coal gasification</td>
<td>0</td>
<td>1,920</td>
<td>3,840</td>
</tr>
<tr>
<td>Power generation</td>
<td>128</td>
<td>128</td>
<td>128</td>
</tr>
<tr>
<td>Transportation</td>
<td>170</td>
<td>300</td>
<td>380</td>
</tr>
<tr>
<td>Total</td>
<td>856</td>
<td>3,823</td>
<td>7,043</td>
</tr>
</tbody>
</table>

of 107,364. The largest city in the area is Casper, which is located at some
distance from the major mining areas and had a population of 39,361 in 1970.
Gillette, the closest urban area to the bulk of the potential development,
had a 1970 population of 7,194.

In addition to coal development, the area is currently experiencing a
substantial boom in uranium mining and milling and petroleum and natural gas
exploration. These developments, which stem from the same basic causes as the
increase in coal production, virtually assure a highly competitive labor market
situation developing in the area within the next three to four years [9]. Given
the magnitude of development, it is apparent that the bulk of labor requirements
will be met from sources other than the natural growth of the local labor force.

The highly competitive labor market developing in the area strongly
suggested that the impact model adopted for use in the analysis have the
potential for evaluating labor supply considerations. Fortunately, a regional
economic simulation model was under development at the University of Wyoming
which appeared to have such a capability. Accordingly, an investigation was
launched to determine the feasibility of utilization of this model to evaluate
the prospective growth in the Powder River Basin Area economy.

The Simulation Model

The regional economic simulation model under development at the University
of Wyoming at the time this study began was a variant of the model originally
developed by Battelle Memorial Institute for a group of utilities operating
in the Susquehanna River Basin, an area which was then the subject of an
intensive water resources planning effort. The Battelle model was designed
to simulate regional economic growth under given economic and water resource
considerations [5].

The original Battelle model contained four interrelated sub-models. These
sub-models--employment, demographic, water supply and electric power--were
interrelated through forward linkages and feedbacks. The model was designed
to project employment, population, electric power consumption and dissolved
oxygen levels under the various development assumptions.

Export employment in each sub-region was projected on the basis of specific
locational considerations, such as wage rates, access to raw materials and
access to markets. Residential employment was classified as either business-
serving or household-serving. Business-serving employment was projected on
the basis of total employment and household-serving employment on the basis
of population, which served as a proxy for income [4].

Labor supply and demand were related through a migration variable on the
basis of relative unemployment rates. Wage rates were also related to
unemployment, so that unemployment could increase regional attractiveness to
labor-intensive industries as well as produce outmigration [4]. This adjustment
was endogenous--a unique feature of the model which makes it particularly
attractive for use in impact studies.

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Further development of the model was subsequently undertaken by the University of Alabama [1] and the Tennessee Valley Authority [2]. During this stage of development, a number of modifications were introduced into the basic Battelle model. Of particular interest is a generalized impact feature which permits the arbitrary increase or decrease of any variable or variables at any point in time. In addition, an endogenous labor force participation rate adjustment was introduced and migration rates were made functions of the relative wage rather than the unemployment rate [2].

These modifications greatly strengthened the demographic sub-model and the endogenous migration mechanism. However, a review of the method by which labor force supply considerations were incorporated into the employment sub-model indicated that substantial work would be required before the model could meet the objectives of the Powder River Basin study.

**Labor Supply Considerations in the Residential Industries**

Labor supply considerations enter into the employment sub-model in the Battelle-TVA approach in two ways: (1) the rate of growth of residential employment is in part a function of the unemployment rate; and (2) the rate of growth of certain export industries is influenced by the local wage rate which is in turn related to the unemployment rate. Before proceeding to a discussion of the way in which labor supply considerations influence the growth of export activities, it is well to first review the role that labor supply considerations play in the growth of residential activities.

Generally speaking, business-serving and consumer-serving residential activities are projected in the same way. In both cases, a target level is derived as a function of some previously determined variable, such as population or employment. The approach towards target employment is then governed by several factors calculated to simulate a lagged response under different conditions of labor availability. The routine is as follows:

1. \[ DWRI = f(POPN \text{ or } WIIS) \]
2. \[ DAR1 = DWRI - WIRI_{t-1} \]
3. \[ DBRI = f(DAR1) \]
4. \[ LAMI = f(LURL) \]
5. \[ WARI = (DBRI) \times (LAMI) \]
6. \[ WIRI_t = WIRI_{t-1} + WARI \]

where

- \( DWRI \) is defined as the desired (target) number of workers in any given residential industry;
- \( POPN \) is total population;
- \( WIIS \) is the number of workers in industries served by the given residential industry;
DARI is the additional workers desired;
WIRI is the existing number of workers in the residentiary industry;
DBRI is some fraction of DARI;
LAMI is defined as a labor availability multiplier;
LURL is the local absolute or relative unemployment rate; and
WARI is the incremented number of workers in the given residentiary industry.

Under this formulation, equation (1) serves to establish a target number of residentiary workers. The extent to which the actual number of workers approaches the desired number depends upon the fractional share of the desired increment that is permitted to be filled in any one year (equation 3) and the extent to which this increment is adjusted by the labor availability multiplier (equations 4 and 5).

Although it is suggested that the target level may be readily established from cross-sectional analysis of census or other employment data [5], it is not apparent that a relationship specified on this basis would be consistent with the elaborate delay mechanism described in the remainder of the routine. Specification is complicated by the inability to deal with the fractional growth factor introduced in equation (3).

These reservations notwithstanding, a test of the residentiary employment projection routine for the Powder River Basin area indicated a reasonable ability to replicate historical growth. The test utilized target levels previously developed for a study of the North Platte River area of Wyoming [6].

The North Platte River target levels were established through cross-sectional analysis of employment data from the 1970 Census. Consumer services were regressed against total population. Business services were regressed against total employment less employment in business services. Several regressions were run to establish the best fit for small areas; the regressions eventually selected considered only states with populations under 1,000,000. Hawaii and Nevada were excluded because of the high ratio of consumer services to total population that results from their tourist industries [6].

The resulting regressions for consumer services and business services are presented below as estimated for equation (1):

**Consumer Service Employment (as a function of population)**

\[ Y = 361.13 + 0.11523X \]

\[ r = .9885 \]

\[ F = 386.2588 \]

**Business Services Employment (as a function of other employment)**

\[ Y = 3422.51 + 0.14997X \]

\[ r = .9584 \]

\[ F = 101.5219 \]
These regressions provide the basis for the computation of the number of desired workers in each of the residentiary sectors.* The actual number of workers may not lie on the regression line, but each model cycle will push the number of workers in each category toward the desired level, according to either population or employment. The rate at which the desired number and actual number of workers converges is governed by the fractional growth rate function (equation 3).

For purposes of the test, the fractional growth rate was arbitrarily established at 0.4. Thus, 40 percent of the gap established in equation (2) was closed in any one time period. The labor availability multiplier was also established arbitrarily with a range such that the multiplier was equal to 1 at six percent unemployment, 1.2 at 10 percent, and .25 at two percent.

Since the effect of the delay mechanism is to leave the projected level always somewhat below the target level in periods of positive increase in population and employment, it was found necessary to increase the target levels from those established by the regressions. This was accomplished by increasing the value of the intercept. In the case of business services, an increase of 300 was necessary to approximately replicate the 1970 Census value. However, an increase of 2300 was required in the case of consumer services.

Given these adjustments, the model replicates history and projects with the desired delay as may be observed from Table 2, which compares projected, target and actual employment in the two residentiary sectors. It should be noted that the target levels presented in Table 2 assume the population and total employment generated with the residentiary adjustment mechanism operative.

The operational effect of the delay mechanism and the labor availability multiplier is apparent in the projected residentiary employment in Scenario III for 1985, the year of maximum direct impact under the scenarios. In that year, consumer services is only 83 percent of target level and business services only 73 percent. By 2000, both are within five percent of the target levels. While this may be a desired effect, it is apparent that many relationships in the residentiary projection routine must be determined arbitrarily.

**Labor Supply Considerations in the Endogenous Export Sectors**

Labor supply considerations enter the determination of the rate of employment growth in the endogenous export sectors** of the Battelle-TVA model

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*Two additional residentiary sectors--government and construction--were also considered in this analysis. However, a discussion of those sectors is omitted from this paper because handling these sectors presents peculiar problems not intrinsic in the generalized formulation for residentiary industries. The problem of how to handle construction is of course a significant consideration in a study such as that discussed in this paper.

**Some export sectors are projected exogenously. Agriculture falls into this category, as does export mining in the Battelle formulation.
TABLE 2: Target, Projected and Actual Residentiary Employment, Powder River Basin Area (Selected Years)

<table>
<thead>
<tr>
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<tbody>
<tr>
<td><strong>Consumer Services</strong></td>
<td>15,005</td>
<td>16,015</td>
<td>17,693</td>
<td>20,206</td>
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<tr>
<td>Target Level</td>
<td>14,674</td>
<td>15,284</td>
<td>16,730</td>
<td>19,764</td>
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<tr>
<td>Projected Level</td>
<td>14,519</td>
<td>---</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>Actual Census</td>
<td>0.98</td>
<td>0.95</td>
<td>0.95</td>
<td>0.98</td>
</tr>
<tr>
<td>Projected/Target</td>
<td>0.98</td>
<td>0.86</td>
<td>0.92</td>
<td>0.95</td>
</tr>
</tbody>
</table>

**Business Services**

<table>
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<tr>
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<tbody>
<tr>
<td>Target Level</td>
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<td>11,239</td>
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<td>15,628</td>
</tr>
<tr>
<td>Projected Level</td>
<td>7,603</td>
<td>9,711</td>
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</tr>
<tr>
<td>Actual Census</td>
<td>7,574</td>
<td>---</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>Projected/Target</td>
<td>0.83</td>
<td>0.86</td>
<td>0.92</td>
<td>0.95</td>
</tr>
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</table>

**Scenario II**

**Consumer Services**

<table>
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<tbody>
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<td>Target Level</td>
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<td>Projected Level</td>
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<td>Actual Census</td>
<td>14,519</td>
<td>---</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>Projected/Target</td>
<td>0.98</td>
<td>0.92</td>
<td>0.83</td>
<td>0.95</td>
</tr>
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</table>

**Business Services**

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<th></th>
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</tr>
</thead>
<tbody>
<tr>
<td>Target Level</td>
<td>9,106</td>
<td>11,868</td>
<td>14,493</td>
<td>21,015</td>
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<td>Projected Level</td>
<td>7,603</td>
<td>9,414</td>
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<td>20,092</td>
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<tr>
<td>Actual Census</td>
<td>7,574</td>
<td>---</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>Projected/Target</td>
<td>0.83</td>
<td>0.79</td>
<td>0.73</td>
<td>0.96</td>
</tr>
</tbody>
</table>

Source: Water Resources Research Institute, University of Wyoming.
through a relative wage index. An increasing relative wage increases regional production costs and decreases relative regional attractiveness to industries. Conversely, a falling relative wage increases relative regional attractiveness [5].

The endogenous export sector projection routine in the model emphasizes the use of relative production costs. A relative cost per dollar of shipments is computed for each endogenous export activity as follows:

\[ (7) \quad TCI = (WCC) \times (1) + (WTC) \times (RTC) + (WMC) \times (RMC) \\
+ (WPC) \times (RPC) + (WLC) \times (RWI) \]

where

TCI = total cost index  
WCC = weight on constant costs  
WTC = weight on transportation of product costs  
RTC = relative cost of transporting product  
WMC = weight on cost of transporting materials  
RMC = relative cost of transporting materials  
WPC = weight on power costs  
RPC = relative power costs  
WLC = weight on labor costs  
RWI = relative wage index

The derivation of the cost index is such that it may be viewed as a ratio which reflects differences in regional and national costs of production:

\[ (8) \quad TCI = \frac{X}{VSN} = \frac{CCN}{VSN} \times (1) + \frac{TCN}{VSN} \times (RTC) + \frac{MCN}{VSN} \times (RMC) \\
+ \frac{PCN}{VSN} \times (RPC) + \frac{LCN}{VSN} \times (RWI) \]

where

VSN = national value of shipments  
CCN = national constant costs  
TCN = national costs for transportation of product  
MCN = national costs for transportation of materials  
PCN = national power costs  
LCN = national labor costs  
X = hypothetical cost of regional production
and
\[
\frac{CCN}{VSN} + \frac{TCN}{VSN} + \frac{MCN}{VSN} + \frac{PCN}{VSN} + \frac{LCN}{VSN} = \frac{VSN}{VSN} = 1
\]

Once the total cost index (TCI) is determined in the model, it is used to establish a reciprocal cost index:

(9) \( RCI = TCI - 1 \)

where

\( RCI = \) reciprocal cost index

The reciprocal cost index is then used to adjust an exogenously determined market growth rate of employment to arrive at an estimate of the regional employment growth rate:

(10) \( PCER = GLM - (CEE) \times (RCI) \)

where

\( PCER = \) percent change in regional employment
\( GLM = \) market growth rate of employment
\( CEE = \) a cost elasticity coefficient

The Battelle-TVA formulation is curious in that it suggests that the "price" of the product varies on the basis of the location of production. Alternatively, price may be taken as given and the profitability of production permitted to vary as a function of costs at various locations. Such an approach would emphasize regional differences in gross profits, i.e., the difference between value added and labor costs.

Gross profits may be defined as either the difference between value added and labor costs or as the difference between value of shipments and labor costs plus costs of purchased materials. Given any set of prices, gross profits per dollar of shipments can be readily calculated using essentially the same variables as already existent in the model:

At the national level,

(11) \[
\frac{AGPN}{AVSN} = \frac{AVSN}{AVSN} - \frac{AICN}{AVSN} - \frac{ATCN}{AVSN} - \frac{AMCN}{AVSN} - \frac{APCN}{AVSN} - \frac{ALCN}{AVSN}
\]

at the regional level,

(12) \[
\frac{AGPR}{AVSR} = \frac{AVSN}{AVSN} - \frac{AICN}{AVSN} \times (1) - \frac{ATCN}{AVSN} \times (RTC) - \frac{AMCN}{AVSN} \times (RMC)
\]
\[ \frac{APCN}{AVSN} \times (RPC) - \frac{ALCN}{AVSN} \times (RWI) \]

where

AGPN = national gross profits at given prices
AGPR = regional gross profits at given prices
AVSN = national value of shipments at given prices
AVSR = regional value of shipments at given prices
AICN = national cost of other purchased materials at given prices

Given gross profits per dollar of shipments at both the national and regional levels, relative gross profits can be determined:

\[(13) \quad ARG\widehat{P} = \frac{AGPR}{AVSR} - \frac{AGPN}{AVSN}\]

where

ARG\widehat{P} = relative gross profits per dollar of shipments

As can readily be seen, ARG\widehat{P} can be substituted for the reciprocal cost index in the existing equation (10). Such a substitution would involve mainly a conceptual change in the model.

There is no need to stop at this point, however. According to Borts and Stein [3], the regional relative change in employment (i.e., \( PCER - GLM \)) in the period between time \( t \) and time \( t+n \) may be viewed as a function of the difference between the regional ratio of change in gross profit to expenditures for plant and equipment and the comparable national ratio in the same period:

\[(14) \quad (PCER - GLM)_{t, t+n} = f \left( \frac{\Delta AGR\widehat{P}}{AEP\widehat{R}} - \frac{\Delta AGPN}{AEPN} \right)_{t, t+n}\]

where

AEP\widehat{R} = regional expenditures for plant and equipment at given prices
AEPN = national expenditures for plant and equipment at given prices

Going further, Borts and Stein suggest that equation (14) may be used to forecast regional employment growth relative to the national growth in
employment in that industry:

The growth position of an industry is determined by its relative rate of return in the prior period. The predicted relation between $\lambda_t$ and $\mu_{t-1}$ is given by the regression line for the previous period [3, p. 179].

where

$\lambda_t$ is defined as $PCER - GLM$; and

$\mu_{t-1}$ is defined as $\frac{\Delta AGPR}{AEPR} - \frac{\Delta AGPN}{AEPN}$

The validity of this projection technique has been defended by Borts and Stein using data for machinery industries in New England during the period 1939-1954.

Incorporation of the Borts and Stein formulation into the existing Battelle-TVA model would require projection of regional and national capital expenditures and a mechanism for converting gross profits per dollar of shipments into total gross profits. While meeting these requirements would not be easy, it seems likely that the Borts and Stein approach is preferable to the existing relative cost formulation. Accordingly, an effort was made to determine whether or not the Borts and Stein approach was applicable to a region where economic activity consisted largely of extractive activities. Because of data limitations, the smallest relevant region that could be used was the Rocky Mountain Region as defined by the Bureau of the Census.

Data were obtained for 62 industries in the Rocky Mountain Region from the 1963 and 1967 Census of Manufactures and Census of Mineral Industries. On this basis, the following estimate was obtained for equation (14):

\[
(14) \quad (PCER - GLM)_{t, t+n} = f \left( \frac{\Delta AGPR}{AEPR} - \frac{\Delta AGPN}{AEPN} \right)_{t, t+n}
\]

\[
Y = .25621 + .04372X \quad r = .46311 \quad F = 16.382
\]

The correlation is clearly significant at the .01 level, although substantially below that achieved by Borts and Stein in New England. It is possible that this simply reflects a lower degree of potential interchange of labor among industries in the Rocky Mountain Region due to the existence of several distinct labor markets. If this is the case, more geographically detailed data might provide a better correlation.

While the coefficient of correlation derived in the Borts and Stein approach is somewhat disappointing, the formulation appears to offer an opportunity for empirical verification. It is doubtful if the same can be said for the original relative cost approach embodied in the model.
Relative Rates of Return Among Regions

The previous section raises the possibility that the model could be reformulated so that changes in relative rates of return could influence the rates of employment growth among industries in a region. Under such an approach, the aggregate supply of labor might still continue to be determined by the aggregate relative wage through the migration mechanism as reformulated by TVA.

Borts and Stein argued that those industries in a region with the highest rates of return grew relatively faster because of their ability to bid labor away from industries with lower rates of return. It has been shown that the predicted relationship between relative rate of return and employment growth held in the Rocky Mountain Region during the period 1963-1967.

We turn now to an examination of whether or not industries grew fastest in those regions with the highest relative rates of return in that industry. Attention is focused on coal mining and petroleum and natural gas extraction, two industries where natural resource considerations are extremely significant as locational determinants.

Regression were run on the 13 states for which adequate data on coal mining were available in both 1963 and 1967 and on the 22 states for which similar data were available for petroleum and natural gas.* The relationship tested was the same as used by Borts and Stein (equation 14 above) except that the data consisted of several state observations for each specific industry.

The following results were obtained for the two industries:

Coal Mining (SIC 12)

\[ Y = 0.0565 + 0.0389X \]

\[ r = 0.5018 \]

\[ F = 3.703 \]

Petroleum and Natural Gas (SIC 13)

\[ Y = 0.1194 + 0.1230X \]

\[ r = 0.3942 \]

\[ F = 3.680 \]

The correlation for coal mining is significant at the .10 level as is the correlation for petroleum and natural gas. The signs are in the right direction, but the results are inconclusive.

*Because of data limitations, it was necessary to use two digit SIC data for states. The authors recognize that more specifically defined data would be desirable.
These rather poor results notwithstanding, a direct attack was made on Borts and Stein's second contention—that the relative rate of return in one period was a predictor of the relative rate of employment growth in the next. Because 1972 data were available for employment (although not gross profits), it was possible to regress the 1967-1972 relative rate of employment growth against the 1963-1967 relative rate of return.

The results of this regression effort are rather interesting:

Coal Mining (SIC 12)

\[ Y = -.0164 + .0923X \]

\[ r = .4042 \]

\[ F = 2.149 \]

Petroleum and Natural Gas (SIC 13)

\[ Y = .0286 + .0504X \]

\[ r = .4564 \]

\[ F = 5.262 \]

In both cases, the sign of the regression coefficient is in the correct direction. While the correlation coefficients are of the same approximate magnitude, only the correlation for petroleum and natural gas is significant at the .05 level. It should be recalled that only 13 observations were available for coal mining.

The evidence suggests that the use of gross profits as a predictor of employment growth in the mineral industries has promise. To the extent that a gross profits approach is consistent with the rest of the logic, the utility of the model is greatly enhanced by this finding.

**Gross Profits and Capital Expenditures**

It has also been suggested that gross profits might be useful as a predictor of capital expenditures [4]. Since projections of capital expenditures are necessary for the determination of relative rates of return in any sequential simulation model, regressions were run to test this suggestion. Once again, we focus on coal mining and petroleum and natural gas extraction.

Capital expenditures data were obtained from the 1967 Census of Mineral Industries for the same 13 coal producing and 22 oil producing states used in the regressions in the previous section. The hypothesis tested was whether or not 1963 gross profits were useful predictors of 1967 capital expenditures. Data were entered in thousands of constant dollars.

The regression results indicate that such projection of capital expenditures is indeed feasible:

Coal Mining (SIC 12)

\[ Y = 4231.09 + .30340X \]

\[ r = .9029 \]

\[ F = 48.512 \]
Petroleum and Natural Gas (SIC 13)

\[ Y = 12254.36 + 0.31072X \]

\[ r = 0.9303 \]

\[ F = 128.614 \]

In both cases, the correlations are significant at the .01 level. Similar results were found for narrowly defined manufacturing categories. The evidence again suggests that a gross profits approach might be feasible in the Battelle-TVA model. Continued efforts at model development along this line seem indicated.

**Summary Observations**

Our evaluation of the Battelle-TVA regional economic simulation approach as an impact evaluation tool has led to two quite different conclusions. First, the utility of the model is limited by the need to arbitrarily specify relationships essential to the employment sector. Second, the model seems adaptable to a Borts and Stein type approach to employment projection.

A regression analysis utilizing data from 62 manufacturing and mining industries in the Rocky Mountain Region indicated a significant relationship between relative rates of return and relative rates of employment growth. A similar analysis utilizing state observations for coal mining and oil and gas extraction indicated the possibility of a similar correlation among states. A relationship was also established between relative gross profits in the petroleum industry and the rate of employment growth in the following period among states.

The imperative need for regional impact models which incorporate labor supply considerations suggests that additional research should be done with respect to the utility of gross profits as a predictor of labor movements. It is possible that such an approach might lead to important new findings in the areas of interindustry mobility and the industrial determinants of migration.

For example, some recent research by one of the authors has established a significant correlation between industrial hiring of migrants and the wage paid to migrants by that industry [7]. It is possible that gross profits might hold the key to the determination of the wage rates paid migrants and thus lead to additional understanding of migrant behavior.

Unfortunately, it is not clear how to relate gross profits to the behavior of employment in the residenitory industries, where the bulk of labor is supplied by new entrants to the labor market. It is possible that a fully specified labor market model is the only ultimate solution to the residenitory labor force problem. Fortunately, data are available from the Continuous Work History Sample of the Social Security Administraion that make possible specification of far more elaborate labor supply models than have typically been contemplated in regional economic impact analysis.

In the meantime, the Battelle-TVA type of regional economic impact
simulation model appears to be a flexible research tool that has unfortunately received far too little attention in regional impact studies. While we have been harsh with respect to its shortcomings, we remain convinced that regional simulation is a most useful vehicle for addressing many of the difficult problems of regional economic analysis.
REFERENCES


