THE EXPLOITATION OF COAL AS AN ENGINE FOR GROWTH IN EASTERN KENTUCKY — AN INPUT-OUTPUT STUDY

Nasser Sherafat, Angelos Pagoulatos, and Kurt R. Anschel

Historically, the economic problems of Appalachia have been closely linked to the problems of the coal industry, which, with its boom and bust cycles, often has intensified the conditions of poverty, unemployment, outmigration, and capital flight from the area. For more than a decade it has been national economic policy "to develop in Appalachia a self-sustaining economy capable of supporting the people with rising incomes, improving standards of living and increasing employment opportunities" [1, p. 64]. It has been widely hypothesized that this societal goal will be achieved through exogenous increases in demand for coal as the result of its substitution for other energy sources. Therefore a study was made of the impacts of the increased demand for coal on the economies of the 18 coal-producing counties in Appalachian Kentucky.[1]

An input-output (I-O) model of West Virginia was adapted for the regional economy to study the output, income, and employment multiplier effects of the existing industries. The model also was used to derive an estimate of the occupational income distribution of the region. Through alternative assumptions about the growth of the coal industry in relation to the other industries of the region, the regional economy was projected to the year 1990 to obtain information about the effects of alternative growth patterns of the regional economy and the coal industry.

THE INPUT-OUTPUT MODEL

The construction of the I-O table was based on the West Virginia I-O table for 1975 which consists of 48 endogenous industries. The original West Virginia I-O table was constructed with primary data (1965) by Miernyck and then projected to 1975 with new direct input coefficients derived from "best practice" establishments in each sector[2] [6].

The I-O table for the coal counties of Eastern Kentucky was constructed for the base year 1974 because of the difficulties in obtaining 1975 data for the gross outlays of most industries in the region. The major adjustments were:

1. The 1975 West Virginia interindustry transaction table W_{48} (in 1965 prices) was adjusted to 1974 prices: $P_{48}W_4 = \bar{W}_{48}$ where P is a diagonal matrix (48 × 48) of price inflators.
2. Four sectors (chemicals, petroleum, primary metal products, and glass industires) which are not present in the region were deleted from the transaction table by transferring their sales and purchases to the import row and export column. A new matrix with 44 sectors was thus obtained, W_{44}.
3. The new interindustry transactions table, W_{44}, was aggregated to form a 13 × 13 matrix, G_{13}, because of the small size of some of the sectors and to emphasize leading ones.
4. From the transaction table G_{13}, the technical coefficients matrix, A_{13}, was obtained for the region where each $a_{ij} = g_{ij}/G_j$ (i, j = 1, ..., 13) and G_j represents West Virginia gross output of sector j.
5. The technical coefficients matrix A_{13} was then used to obtain the transactions table for the region, X_{13}, by premultiplying A_{13} with Q_{13} which represents the diagonalized matrix of the 1974 coal counties' sectorial gross output:

$$X_{13} = Q_{13}A_{13}.$$

Nasser Sherafat is a former Graduate Research Assistant, Angelos Pagoulatos is Assistant Professor, and Kurt R. Anschel is Professor, Agricultural Economics, University of Kentucky. The authors thank W. H. Miernyck of West Virginia University and James C. Hite of Clemson University for their valuable suggestions and encouragement during the early phases of this research effort, as well as Charles Renfro of the University of Kentucky for his assistance throughout and three anonymous reviewers.

[1]The coal counties are Bell, Breathitt, Clay, Floyd, Harlan, Johnson, Knott, Knox, Laurel, Lawrence, Leslie, Letcher, McCreary, Magoffin, Martin, Perry, Pike and Whitley. These counties produced 96 percent of the coal extracted in eastern Kentucky in 1974.

[2]For a discussion of reasons for using an existing regional model, rather than adopting national coefficients or using survey data, see [8]. The interindustry transactions tables, the I-O model, and detailed data sources and transformations can also be found in [8].

The final payments sector in the I-O model consists of value-added (household payments and remaining final payments) and imports. The household row consists of wages and salaries and was estimated from primary data available from the Kentucky Department of Human Resources. The import coefficients (m_j) of the j^{th} sector in the region are assumed to be equal to the coefficients of the corresponding sector in the West Virginia I-O table plus the import coefficients of those industries not present in the region. After estimation of the household income (H_j) and the imports (M_j), the remaining final payments sector (R_j) is given by the equation:

$$R_j = X_j - (\sum_{i=1}^{13} X_{ij} + H_j + M_j).$$

where

X_j = the output of the j^{th} industry
X_{ij} = the amount of output of industry i used by the j^{th} industry.

The final demand sectors of the region consist of household consumption, local and state government expenditures, federal government expenditures, gross private regional investment, and exports. Final demands were estimated by using Kentucky county data where available, and adopting the West Virginia coefficients by assuming the same proportion of sales for each industry to regional and final demand sectors. Exports (e_i) were calculated as the residual:

$$e_i = X_i - (\sum_{j=1}^{13} X_{ij} + \sum_{f=1}^{3} Y_{fi})$$

where Y_{fi} is the final demand for product (excluding exports) of industry i by sector f in the region and X_i is the output of the i^{th} industry.

The sectorial income distribution for the region was derived directly from the transaction table by calculating the ratio of the value-added of each sector to the gross regional product (GRP). The mapping between the sectorial and the occupational income distribution was obtained by disaggregating the employment of each sector into nine different occupations in the region. From U. S. data for the occupational earnings, the distribution of wages and salaries within each industry by different occupation and the distribution of wages and salaries between different occupations were derived. By use of the occupational income distribution, Gini cofficients were calculated for the employed labor force and the region as a whole.[3]

THE STRUCTURE OF THE REGIONAL ECONOMY

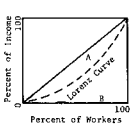
The 1974 coal counties transaction table shows that the GRP amounts to $1,699.39 million. On a percentage basis, 44 percent of this amount is derived from wages and salaries and 56 percent from other final payments (interest, rent, profits, and indirect business taxes). The transaction table also shows that eight sectors in the region—agriculture, underground coal mining, strip coal mining, all other mining, manufacturing, trade, transportation, and communications—together provide a net export value of $1,090.74 million. The coal industry alone furnishes 95 percent of the net exports of those eight industries. The other five sectors—construction, finance, all other services, education, and utilities—have a combined net import value of $95.49 million. The total value of net exports exceeds the value of net imports by $995.28 million. The total employment in the area of the 13 coal counties' sectors is estimated to be 94,057 in the private sectors, 25 percent of which is in the coal sector.

In 1974, underground and strip coal mining jointly comprised 56 percent of the GRP; 18 percent of GRP was in the form of wages and salaries paid by the coal industry and 38 percent of GRP was in the form of all other final payments of the coal industry. The coal industry generates 40 percent of all wages and salaries paid in the area and 68 percent of all other final payments.

Because the regional economy is heavily dependent on the coal sectors, it is logical that these sectors would influence the occupational employment distribution and the distribution of wages and salaries among the different occupations in the region. The region's occupational employment distribution in 1974 shows that operatives and craftsmen are the two largest occupational groups. They account for 40 percent of the total employment and receive 51 percent of the area's wages and salaries. Almost 21 percent of the labor force are workers employed by the coal sectors in these two occupational groups. The wages and salaries paid by the coal industry amount to 37 percent of the total earnings of these two

[3]The Gini coefficient provides a numerical measure of inequality utilizing the distribution given by the Lorenz curve. The Gini coefficient (L) is given by the ratio:

$$L = A/A + B$$



For a detailed formulation of the Lorenz curve and the Gini coefficient, see [7].

groups, reflecting the relatively high wage rates in the industry.

Despite the fact that in 1974 the value-added of the coal industries constituted 56 percent of the GRP, less than one third of this amount is in the form of wages and salaries because the coal industries are highly capital intensive. In fact, in 1974 strip coal mining had the lowest employment-output ratio, followed by utilities and underground coal mining. Because the coal industry is highly capital intensive and many coal entrepreneurs live outside the area, it can be concluded that the returns from the coal industry to the regional income are mostly in the form of wages and salaries.

The output, employment, and income multipliers of the industries in the region are relatively low, reflecting weak linkages among these industries (Table 1).[5] Utilities and strip mining have the highest income and employment multipliers. Underground mining has low output (1.16) and income (1.33) multipliers. Obviously, underground mining provides a poor engine for growth in the region.

TABLE 1. OUTPUT, EMPLOYMENT AND INCOME MULTIPLIERS BY SECTOR, COAL COUNTIES, 1974

Sectors	Output Multipliers	Type I Employment Multipliers	Type II Employment Multipliers	Type I Income Multipliers	Type II Income Multipliers
Agriculture	1.27	1.16	1.22	1.32	1.53
Coal (underground)	1.16	1.26	1.61	1.15	1.33
Coal (strip)	1.46	1.71	2.15	1.58	1.83
All other mining	1.27	1.43	1.69	1.34	1.54
Construction	1.52	1.63	1.93	1.51	1.75
Manufacturing	1.26	1.37	1.56	1.30	1.50
Trade	1.27	1.14	1.30	1.15	1.33
Finance	1.17	1.33	1.47	1.46	1.69
All other services (except education)	1.28	1.16	1.33	1.18	1.36
Education	1.29	1.10	1.28	1.11	1.28
Transportation	1.22	1.27	1.51	1.21	1.40
Communication	1.14	1.13	1.36	1.10	1.27
Utilities	1.34	1.77	2.16	1.61	1.86

The Gini ratios for income of the employed labor force and for the region as a whole are .23 and .52, respectively. The 1974 Gini ratio for income in the United States as a whole is .35 [9, p. 69]. This disparity between the coefficients for the employed labor force in the region and for the U.S. reflects the large proportion of the labor force receiving income from the coal industry which is high and relatively uniform. The difference between the coefficients for the region as a whole and for the U.S. is caused by the relatively large numbers of families dependent on social security and public assistance.

PROJECTION OF OUTPUT, EMPLOYMENT, AND INCOME DISTRIBUTION

The gross output, employment, and sectorial and occupational distributions for selected years were projected on the basis of alternative assumptions about the differential growth of coal and the other industries.

Scenario I

The Scenario I projections are based on the historical rate of growth of final demand.[6] Total GRP rises by 48 percent over the period 1974 to 1990; underground coal mining's relative share decreases by 9 percent and strip mining's share increases by 3 percent.

The relative share of the coal industry from wages and salaries also diminishes by 6 percent, and its share of all other final payments drops 13 percent. The relative share of the coal industry in the total employment in the area falls 3 percent. The operatives and craftsmen

[4]Part of the money leaving the region is in the form of an indirect business tax which is the severance tax collected by the state and not the local government. Only about 20 percent of revenues from severance taxes return to the area in the form of state grants.

[5]The output multipliers are derived by summing the entries in the column under industry i in the matrix B_{13}, where:

$$B_{13} = (I_{13} - A_{13})^{-1}.$$

To obtain income and employment multipliers the transactions table X_{13} was closed with respect to households, thus X^*_{14}. The row household coefficients of X^*_{14} represent the direct income change. The direct and indirect income change is obtained by multiplying each row entry of matrix B_{13} by the corresponding household coefficient of matrix X^*_{14}. The ratio of the direct and indirect income change to the direct income change resulting from a unit increase in final demand is the type I income multiplier. The type II income multiplier is obtained from the ratio of the direct, indirect, and induced income change to the direct income change where the direct, indirect, and induced income change is represented by the household column of the matrix H^*_{14}:

$$H^*_{14} = (I_{14} - X^*_{14})^{-1}.$$

For the calculation of the employment multiplier the ratio of $E_j/X_j = \pi_i$, where E = employment and X = output, was first calculated. The direct employment change is given by π_i and the direct plus indirect employment change for j is given by:

$$\sum_{i=1}^{13} b_{ij} \cdot \pi_i.$$

The type I employment multiplier is the ratio of the direct plus indirect employment change and the direct employment change. The type II employment multiplier measures the ratio of the direct, indirect, and induced employment change to the direct employment change. The former is given for sector j by:

$$\sum_{i=1}^{13} h^*_{ij} \pi_i.$$

[6]Time series data from 1951 to 1974 were used to estimate through ordinary least squares the rate of growth in demand for the industries in the region. From 1974 to 1990 the output of underground mining increases by 2 percent, strip mining by 67 percent, communications 238 percent, and manufacturing 135 percent. The output of the construction sector decreases slightly and agricultural output remains constant.

occupational groups increase 1 percent in their relative share of total employment and decrease by less than 1 percent in their relative share of total wages and salaries.

Under Scenario I, the regional economy diversifies and the dependency on coal decreases gradually. The manufacturing sector's share of GRP increases from 7.5 percent in 1974 to 11.9 percent in 1990. However, this diversification leaves the distribution of wages and salaries unchanged, causing at the same time a decrease of 3 percent of the average wages of the region. Total employment increases 51 percent, an annual increase of 2.6 percent.

Scenario II

This scenario takes into consideration the current and prospective substitutions of coal for crude oil and natural gas [5]. The projections are based on the assumption that, in addition to the historical rate of growth, there would be an annual 5 percent increase in the export demand for coal. The direct, indirect, and induced effects of the expansion of the coal industry on other industries were derived. Gross regional product increases by 133 percent over the period 1974 to 1990 with an increasing dependence of the regional economy on the coal industry. The coal industry's share of GRP increases by 4 percent in 1990, its share of total wages and salaries increases by 5 percent, and its relative share of all other final payments increases by 3 percent (Table 2).

Total employment in the region increases by 111 percent during the period 1974 to 1990, or 4.8 percent per annum. The coal industry's share of total employment of the two leading occupational groups, operatives and craftsmen, increases by 5 percent, as does those groups' share of total wages and salaries; thus most of the increases realized by operatives and craftsmen result from the expansion of the coal industry. The distribution of wages and salaries in the region in 1990 remains relatively unchanged. This pattern is expected because most of the increase in employment is attributable to the coal industry's expansion, which causes the share of each occupational group to increase by the same proportion. The average real wage and salary in 1990, however, increases by 3.3 percent over the 1974 amount. This increase also is related to the increase in employment in the coal industries, which hire mostly skilled workers with wages and salaries above the average (Table 3).

CONCLUSIONS

This study measures the degree of dependency of the regional economy of the coal-producing counties in eastern Kentucky on

TABLE 2. PROJECTED SECTORAL SHARE OF GROSS REGIONAL PRODUCT (GRP), FROM SCENARIO II IN FORM OF LABOR INCOME AND OTHER FINAL PAYMENTS FOR THE COAL COUNTIES, 1990

	Value Added		Wage & Salary		All Other Final Payments	
Sector	Thousands of dollars	% of GRP	Thousands of dollars	% of GRP	Thousands of dollars	% of GRP
Agriculture	17,552	0.44	7,904	0.20	9,649	0.24
Coal (underground)	1,087,775	27.44	432,282	10.90	655,493	16.53
Coal (strip)	1,301,906	32.84	306,989	7.74	994,917	25.10
All other mining	40,922	1.03	19,389	0.49	21,533	0.54
Construction	64,186	1.62	35,373	0.89	28,813	0.73
Manufacturing	335,425	8.46	183,209	4.62	152,216	3.84
Trade	372,626	9.40	236,245	5.96	136,381	3.44
Finances	117,799	2.97	23,619	0.60	94,180	2.38
All other services	297,651	7.51	211,481	5.33	86,170	2.17
Education	74,604	1.88	72,880	1.84	1,723	0.04
Transportation	100,889	2.54	53,159	1.34	47,731	1.20
Communications	94,122	2.37	47,080	1.19	47,042	1.19
Utilities	58,827	1.48	21,784	0.55	37,043	0.93
Gross Regional Product	3,964,277	100.00	1,651,388	41.66	2,312,889	58.34

the coal industry. The coal industry directly produces more than half of the gross regional product and one fourth of private sector employment. As a result, fluctuations in the demand for coal based either on energy policy shifts or changes in the relative scarcity of other energy sources produce marked impacts on the coal counties. If the export demand for coal increases by 5 percent annually over the historical rate of growth, employment will increase 4.8 percent per annum through 1990. As a result of the relatively high wages paid by the coal industry, its expansion will also increase average wages and salaries of employed workers in the region. During the same period, it is anticipated that population will grow an average of 1.7 percent; hence, unemployment and resulting poverty will be substantially reduced although greater inmigration could be induced [3, pp. 48-49]. As a result, a significant decline in the Gini ratio for the region, and thus a reduction in the disparity between the regional and U.S. coefficients, also can be anticipated.

Although in the next few years intensified exploitation of coal resources will reduce the economic problems of the region, the coal industry cannot serve as a long-term source of economic growth for the area. In the immediate future, increased surface mining provides substantial impacts on employment and income through its linkages to the rest of the economy. However, at 1971 rates of exploitation, only 20 years remain before surface mining reserves will be severely depleted and substantially higher costs will be incurred even with new methods of production. Obviously, before depletion occurs, a change in the output mix between surface and underground coal mining would be expected to take place[7] [4, p. 95]. Thus, after approximately 1990, little surface mining will remain the region and regional economic growth will be largely dependent on underground mining with its weak linkages to the rest of the economy and low multipliers. To speed growth, diversification of the economy must be encouraged through intervention by the public sector. In 1974, only 5.7 percent of all payments other than wages and salaries were retained in the region. Perhaps taxation of profits, rents, and interest that would otherwise leave the region could provide the resources for encouraging diversification. The present severance tax and property taxes on known coal reserves are means of capturing the resources.

Because of the rather inelastic demand for products of industries serving the local market, diversification must be in export-based industries, largely manufacturing. Appalachia, however, has few qualities with which to attract manufacturing except the availability of coal. Hence, the best opportunity for diversifying the economy is the establishment of a coal-based petrochemical industry. Public subsidy in some form may

TABLE 3. OCCUPATIONAL EMPLOYMENT PROJECTION FROM SCENARIO II FOR THE EASTERN KENTUCKY COAL COUNTIES BY SECTOR, 1990

Occupational Categories	Professional, Technical & Kindred	Managers, Officials Proprietors	Sales Workers	Clerical Workers	Craftsmen & Kindred Workers	Operatives	Service Workers	Laborers Except Farm	Farmers & Farm Workers	Total
Sectors										
Agriculture	72	4	4	25	20	19	5	103	3,596	3,848
Coal (undergournd)	419	717	49	894	8,927	18,529	367	2,857	-----	32,760
Coal (strip)	308	526	36	656	6,548	13,591	269	2,095	-----	24,030
All other mining	174	228	9	197	555	1,119	28	91	-----	2,401
Construction	174	412	24	301	2,194	349	32	630	-----	4,116
Manufacturing	1,976	1,389	521	2,898	4,495	14,327	528	1,631	-----	27,836
Trade	876	6,855	8,159	6,479	3,276	4,436	5,308	2,521	-----	37,913
Finance	184	1,095	1,137	2,584	86	24	207	99	-----	5,406
All other services	12,300	2,252	194	6,040	1,946	1,630	10,936	676	-----	35,974
Education	6,219	704	14	1,657	221	144	1,683	73	-----	10,715
Transportation	115	621	43	1,009	972	2,813	112	513	-----	6,196
Communications	748	431	94	2,303	1,654	43	36	23	-----	5,332
Utilities	207	143	11	369	707	226	53	393	-----	2,109
Total	23,770	15,378	10,296	25,413	31,601	57,249	19,635	11,706	3,596	198,638

The sum of rows or columns may not equal the totals due to rounding error.

[7]These estimates of surface mining are based on the assumption that 80 percent of known reserves of 14-inch and thicker seams are recoverable. However, the depletion date remains unknown because changing economic conditions affect the rate of extraction and determination of recoverable reserves.

be required to attract the investment to the region.

The results of this research illustrate the problems of a region or country whose growth is based on exploitation of a single extractive industry. Although employment and wages and salaries increase as a result of the growth of the industry, little secondary growth occurs. Rather, capital in the form of profits, interest, and rents leaves the region to be used for investment elsewhere. The product of the extractive industry is shipped to processing plants already built elsewhere closer to markets, and drawing their inputs from a variety of locations. The result is a low-level equilibrium in the region which is difficult to break without public intervention.

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