Agricultural Economics Miscellaneous Report No. 67 August 1983

ECONOMIC ANALYSIS OF THE NORTH DAKOTA LIGNITE INDUSTRY

Randal C. Coon
John F. Mittleider
F. Larry Leistritz

Department of Agricultural Economics
North Dakota Agricultural Experiment Station
North Dakota State University
Fargo, North Dakota 58105

TABLE OF CONTENTS

List of Tables

List of Figures

Highlights

The North Dakota lignite industry is an important generator of business activity, tax revenues, and jobs for the state of North Dakota. Impacts accruing to the state of North Dakota are in the form of increased levels of business activity, personal income, tax collections, and employment. During the 1981 to 1983 biennium, more than $2.8 billion of total gross business volume was generated in-state from activities of lignite related companies. During that same period, tax revenues exceeded $79 million and the state realized an additional $3,150,000 from state and Federal royalties and Federal reclamation fees. In addition, direct employment was estimated at 6,458 jobs for fiscal year 1982 and nearly 8,000 jobs for fiscal year 1983. Secondary employment was estimated to remain at approximately 32,000 jobs through fiscal year 1983.

The North Dakota lignite industry continues to be in a growth stage, although production is expected to level off in 1985 unless new energy conversion facilities are constructed. However, even with only those facilities already operating or under construction, considerable potential exists for increased business activity, new employment opportunities, and additional state revenues. The development of North Dakota's lignite industry and its impact on the state's economy must be continuously monitored to provide the most up-to-date data available for decision makers in industry, government, and the public. Data contained in this study will provide benefits to governmental agencies and those directly and indirectly involved in the industry. This will allow for a continual estimation of the importance of the lignite industry to the total economy of North Dakota.

ECONOMIC ANALYSIS OF THE NORTH DAKOTA LIGNITE INDUSTRY

by

Randal C. Coon, John F. Mittleider, and F. Larry Leistritz*

Introduction

Lignite reserves in North Dakota account for 351 billion tons, or about two-thirds of the total lignite reserves of the United States.[1] Recoverable reserves have been estimated to be 16 to 35 billion tons (Figure 1).[2] North Dakota ranks 11th in demonstrated coal and lignite reserves among the 50 states.[3] At a mining rate of 20 million tons per year, which exceeds current production levels, the recoverable coal reserves of North Dakota would last between 800 and 1,700 years.

Currently, twelve mines produce about 18 million tons of lignite annually. Nine in-state power plants use most of North Dakota's lignite, while three additional out-of-state plants use North Dakota lignite. Presently, one electrical generating facility and one synthetic gas facility are under construction. Other facilities (sugarbeet, charcoal processing, and domestic heating) utilize the balance of North Dakota lignite for their own conversion or production processes. The demand for stable energy supplies has caused the lignite industry to continually expand, creating additional employment opportunities for residents and tax revenue for the state.

---

*Coon is Research Specialist, Mittleider is Research Associate, and Leistritz is Professor, Department of Agricultural Economics, North Dakota State University.

[1]George F. Nielson, Keystone Coal Industry Manual, Mining Informational Services, McGraw-Hill Mining Publications, 1982.

[2]Ibid.

[3]Ibid.

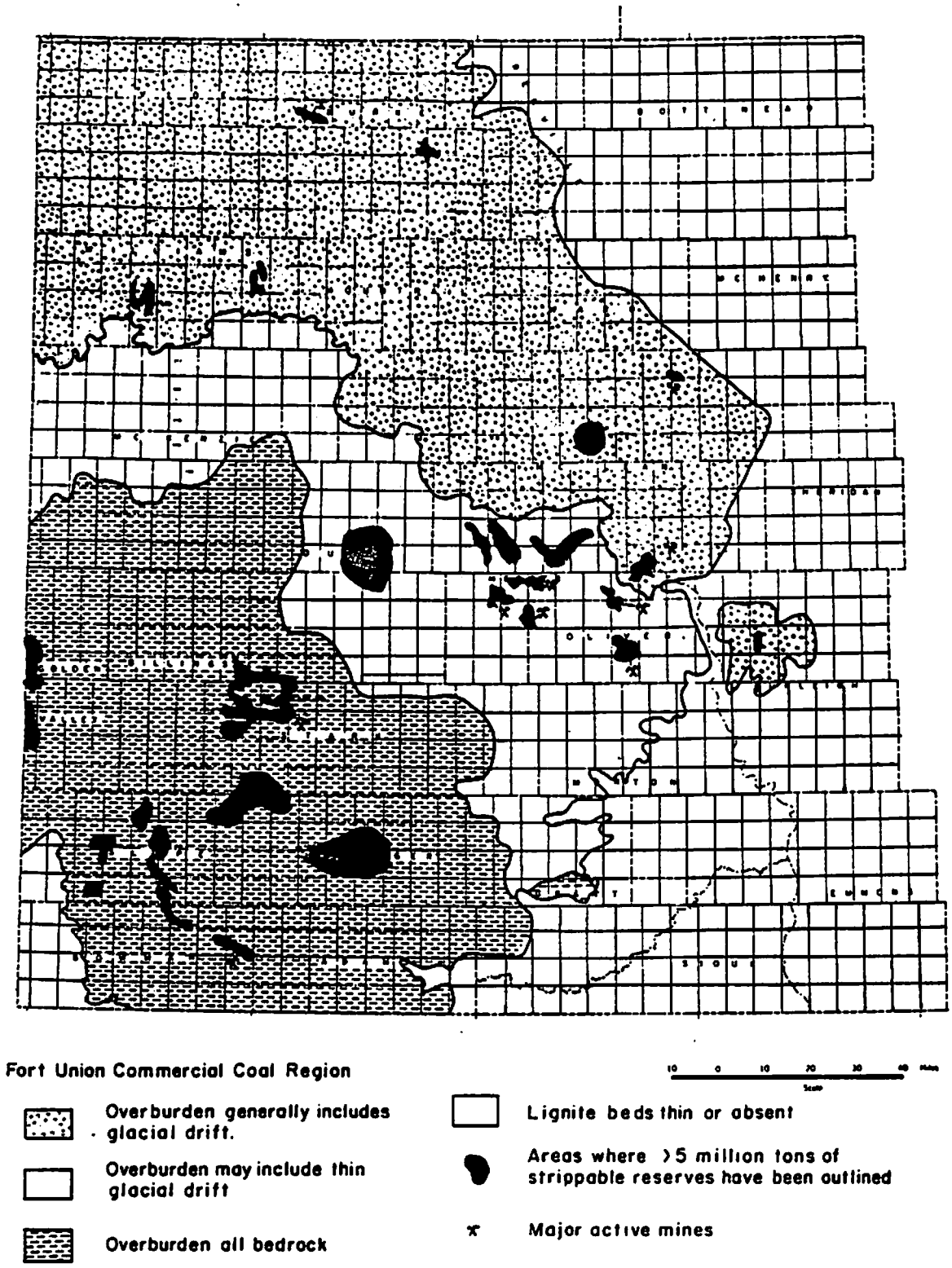

Figure 1. Location of Lignite Reserves in North Dakota

SOURCE: George F. Nielson, Keystone Coal Industry Manual, Mining Informational Services, McGraw-Hill Mining Publications, 1982.

Purpose of Study

The purpose of the study was to establish a lignite industry economic impact data base for use by decision makers in the industry and public sectors. Data and information for the study were supplied by members of the North Dakota Lignite Council and others involved in North Dakota's lignite industry. Collection of the data was initiated in August 1982, and completed in November 1982. Details of the methodology used in the study are provided in Appendix A.

Contributions of the lignite industry to the North Dakota economy have been examined to assess the total economic impact of the lignite industry. Economic contributions by the lignite industry to the state include employment, personal income, and numerous sources of tax revenues such as severance, coal conversion, and sales and use taxes.

The direct effects of the lignite industry include additional employment and income for North Dakota residents. Economic impacts also result from the industry's purchasing of goods and services from other segments of North Dakota's economy. Expenditures by the lignite mining and conversion industry are recirculated within the local economy in the form of purchases of goods and services, taxes to government agencies, and wages and salaries to households. These expenditures result in indirect and induced effects because of subsequent rounds of respending. Secondary impacts include increased employment and income for residents of the state. Finally, lignite mining and conversion industries pay several different types of taxes at the federal, state, and local level, and federal and state governments also receive royalties from coal production on public lands.

Lignite Characteristics

North Dakota coal is classified as lignite on the basis of its physical and chemical properties. It is high in moisture, but low in heat value.[4] Moisture content of North Dakota lignite averages 35 percent and average heat content is about 6700 BTU's per pound.[5] North Dakota lignite is found in seams six to thirty feet thick, with the average being ten feet.

History of North Dakota Lignite Mining

The first recorded use of lignite in North Dakota was near Mandan by the 1804 Lewis and Clark Expedition. Eighty years later, North Dakota's first lignite mine opened along the Mouse River in Ward County, producing a total of six tons of coal from an underground mine. By 1900, 73 underground mines were operating in North Dakota; but safety, economic, and technological problems led to the gradual elimination of underground mining.[6] In 1919, the state's first surface mine opened, using steam-powered shovels with 1.5 cubic yard buckets to remove the overburden.

However, it was not until the mid 60s that North Dakota's lignite industry began a course of steady growth. In 1963, North Dakota's lignite industry produced 2.5 million tons. Five years later, North Dakota's lignite production

---

[4]North Dakota Geological Survey, Mineral and Water Resources of North Dakota, North Dakota Geological Survey Bulletin 63, Grand Forks, North Dakota, 1973.

[5]Energy Resources Co., Inc., Low-Rank Coal Study-National Needs for Resource Development, report prepared for U.S. Department of Energy under Contract No. De-AC18-79FC10066, November 1980.

[6]North Dakota Lignite Council, Facts About North Dakota Lignite, 1977, North Dakota Lignite Council, Bismarck.

climbed to 6.8 million tons, had nearly doubled by 1978 to 12.9 million tons, and in 1983 it is anticipated that 18.5 million tons will be produced.[7]

About 94 percent of the North Dakota lignite mined is used for electrical power generation. In 1982, approximately 16.85 million tons were used for electrical power generation, 0.74 million tons for sugarbeet processing, 0.23 million tons for heating domestic and state buildings, 0.14 million tons for charcoal briquettes, and 0.05 million tons for the production of drilling mud additives.[8] Coal mine and conversion facility locations are shown in Figure 2.

It should be noted that productive capacities of existing mines in North Dakota are considerably greater than the 1982 production of 17.6 million tons. The U.S. Department of Energy (DOE) has estimated North Dakota's existing productive capacity to be approximately 21 million tons, 3.4 million tons above current production.[9] In other words, new mines would not have to be constructed in order to increase coal production in North Dakota.

Future Growth of North Dakota Lignite Industry

Future growth potential exists in North Dakota's lignite industry beyond current capacity. Basin Electric Power Cooperative has taken steps to obtain the necessary permits for a third electrical generating station at Antelope Valley near Beulah. In addition, energy conversion facilities are

---

[7]Bureau of Business & Economic Research, Statistical Abstract of North Dakota, 1979, University of North Dakota Press, University of North Dakota, Grand Forks, North Dakota, 1979; and Bill Cudworth, State Tax Department, October 11, 1982.

[8]North Dakota Lignite Council Estimates, December 1982.

[9]U.S. Department of Energy, Western Coal Survey--A Survey of Coal Mining Capacity in the West, DOE/RA-0045/1, Dist. Category UC-90J, U.S. Department of Energy, U.S. Government Printing Office, Washington, D.C., January 1981.

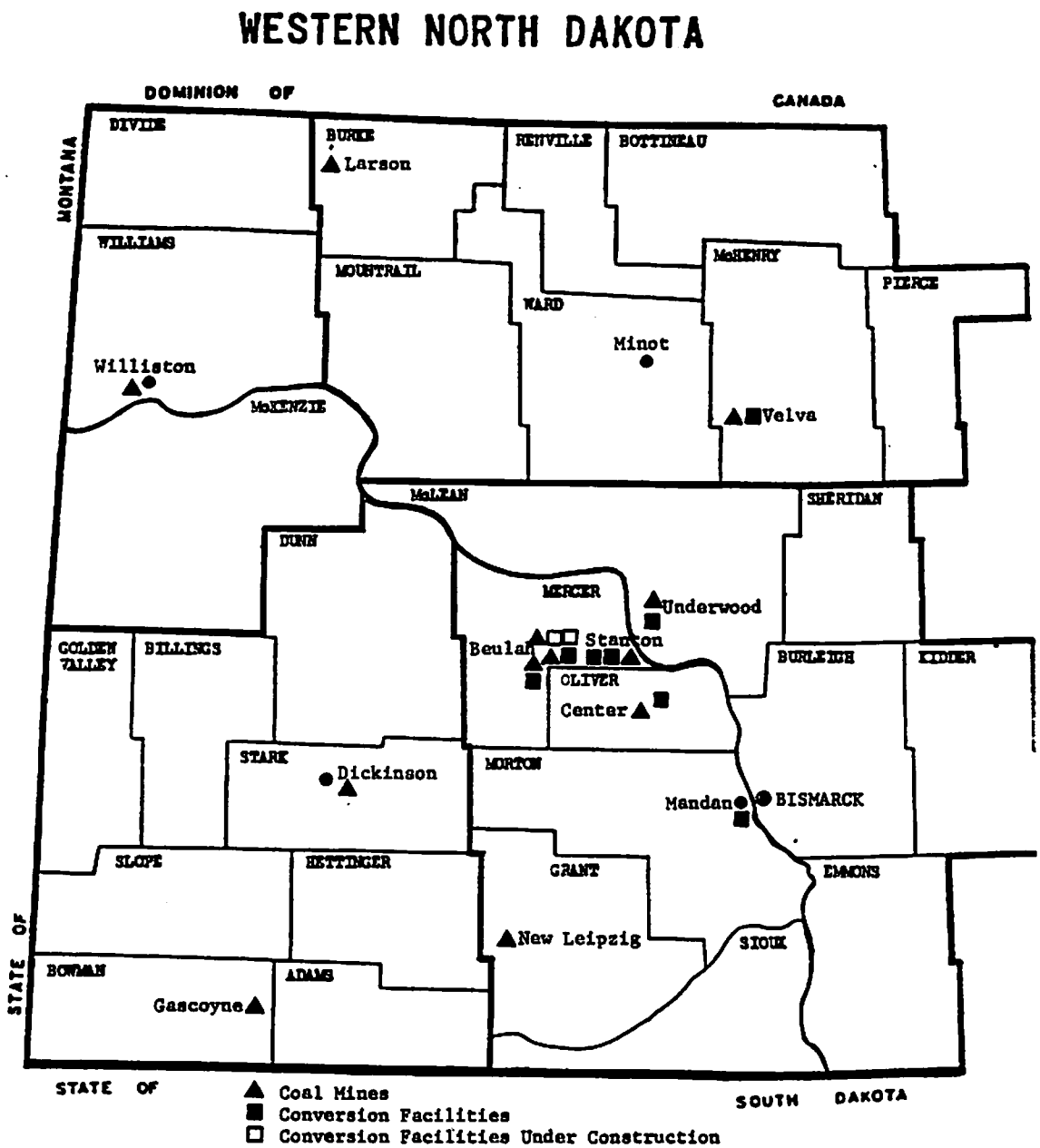

Figure 2. Major Mines and Energy Facilities in Western North Dakota, 1982

proposed for the Nokota Company's coal-to-methanol plant in Dunn County and Otter Tail Power Company's electrical generating Spiritwood Plant near Jamestown. Great Plains Gasification Associates announced in December 1982 that feasibility studies relating to a second phase of the Great Plains Project are being undertaken.

Methodology

Lignite industry economic impacts were analyzed for North Dakota for the 1981 to 1983 biennium (July 1, 1981 to June 30, 1983). The lignite industry was divided into two categories for purposes of this study: lignite mining companies and conversion facilities (companies converting lignite to electricity or other products).

Expenditures, gross business volumes, taxes, employment, and personal income were calculated to determine the economic contribution of the lignite industry to North Dakota. The analysis utilized a combination of primary and secondary data to address the various objectives.

First, a survey, developed in conjunction with the North Dakota Lignite Council, was disseminated to obtain current and anticipated employment, payroll, and expenditure data for those firms involved in the mining and utilization of lignite coal in North Dakota. The questionnaire was developed to provide each company's fiscal year 1982 expenditure data and estimated increases in levels of activities for fiscal year 1983. Expenditure data for specific sectors also were requested with an estimate of the percentage of each paid to North Dakota entities. Collection of the survey data in this manner allowed for estimation of those expenditures which occur in-state and hence lead to secondary (multiplier) effects in North Dakota.

Second, the North Dakota Input-Output Model utilized in-state lignite industry expenditure data to estimate direct and secondary economic impacts

in North Dakota. These impacts include increased levels of employment, personal income, and business activity.

Third, historic and anticipated coal severance and conversion tax revenue collections generated by the lignite industry were obtained from the North Dakota State Tax Department. Other tax revenues were estimated from the results of the North Dakota Input-Output Model. Sales and use, personal income, and corporate income tax collections associated with the estimated level of business activity were determined using tax revenue estimating equations (Appendix A).

Economic Impact

Expenditures and Gross Business Volumes

Total North Dakota expenditures by the lignite industry amounted to over $1.0 billion in the 1981-1983 biennium (Table 1). Expenditures made by

TABLE 1. ESTIMATED NORTH DAKOTA EXPENDITURES BY ECONOMIC SECTOR FOR COMPANIES INVOLVED IN LIGNITE RELATED ACTIVITIES, 1981-1983 BIENNIUM (THOUSAND DOLLARS)

Sector	Expenditures
Construction	665,090
Transportation	14,836
Communication & Public Utilities	6,051
Wholesale Trade & Ag Processing	47,318
Retail Trade	112,526
Finance, Insurance, Real Estate	4,486
Business & Personal Service	2,631
Professional & Social Service	2,686
Households	218,223
Total	1,073,883

the lignite industry were to many sectors of North Dakota's economy. Construction, retail trade, and households (wages, salaries, and lease

payments) were the sectors receiving the largest industry expenditures. Construction accounted for nearly $665 million in in-state expenditures for the 1981-1983 biennium, while expenditures to households totaled $218 million.[10] Construction expenditures are expected to decline dramatically in the next biennium unless additional plant development occurs. Expenditures to the household sector were the fastest growing category, projected to increase by over $33 million from fiscal year 1982 to fiscal year 1983. Also, nearly 97 percent of wages and lease payments were made in-state.

Personal income, retail trade sales, gross business volume for all business sectors, and total gross business volume attributable to lignite industry activity were determined for the biennium. The gross business volume generated by North Dakota's lignite industry increased from $1,370,625,000 in fiscal 1982 to $1,466,480,000 in fiscal 1983, for a total biennium expenditure of $2,837,105,000 (Table 2). Thus, it is estimated that for every dollar spent by the lignite industry, another $1.64 is generated in the North Dakota economy for a total of $2.64. Expenditures by the industry also resulted in personal income of nearly $853 million and retail sales over $624 million for the biennium.

Tax Collections

Gross business volumes provided the data necessary to estimate tax revenue generated as a result of the lignite industry. Categories of tax

---

[10]For purposes of this study, expenditures for coal by conversion facilities have been excluded from the analysis. Expenditures for coal by firms in the lignite conversion category are receipts to the lignite mining group. Industry total economic impacts would be overestimated if lignite purchases were included as expenditures and receipts within the same industry. If economic impacts were to be determined for the lignite conversion category alone, inclusion of these expenditures would be necessary. As it was the intent of this study to estimate the industry's total economic impacts, coal expenditures by the lignite conversion group were deleted from industry total expenditures.

TABLE 2. ESTIMATED PERSONAL INCOME, RETAIL SALES, GROSS BUSINESS VOLUME OF ALL BUSINESS (NONAGRICULTURAL) SECTORS, AND TOTAL GROSS BUSINESS VOLUME, TOTALS FOR COMPANIES INVOLVED IN LIGNITE RELATED ACTIVITIES, 1981-1983 BIENNIUM (THOUSAND DOLLARS)

Personal Income	Retail Sales	Gross Business Volume of All Business Sectors[a]	Total Gross Business Volume
852,913	624,224	1,804,934	2,837,105

[a]Includes all sectors except agriculture (crops and livestock), households, and government.

revenues consisted of sales and use, personal and corporate income, local jurisdiction, coal severance, and coal conversion taxes. Tax revenue as a result of the lignite industry was estimated at $79,607,000 for the 1981-1983 biennium with $36,168,000 (45 percent) being coal severance tax collections (Table 3). Sales and use tax collections were the next largest tax revenue source.

In addition to the taxes shown in Table 3, the lignite industry provided additional revenue to the state government in the form of coal royalties and Federal reclamation fees. State coal royalties amounted to $800,000 during the 1981-1983 biennium, while the state share of Federal coal royalties and Federal reclamation fees provided an additional $600,000 and $1,750,000, respectively. Thus, total royalties and reclamation fees realized to the state were approximately $3.2 million for the 1981-1983 biennium.

Employment

Lignite industry direct employment was estimated to be 6,458 in fiscal year 1982 and projected to grow to 7,996 by fiscal year 1983 (Table 4). Of the 8,000 workers directly employed by North Dakota's lignite industry in fiscal year 1983, approximately 1,500 were employed in lignite mines, 2,500

TABLE 3. ESTIMATED TAX REVENUES ASSOCIATED WITH COMPANIES INVOLVED IN LIGNITE RELATED ACTIVITIES, 1981-1983 BIENNIUM (THOUSAND DOLLARS)

Sales and Use Tax	Personal & Corporate Income Tax	Local Jurisdiction Taxes[a]	Severance Tax	Energy Conversion Tax	Total
19,476	13,734	2,449	36,168[b]	7,780[c]	79,607

[a]Includes taxes such as property and transmission line.
[b]Tons of taxable coal severed times a rate of $1.00 per ton for fiscal year 1982 collections (July 1, 1981 to June 30, 1982). The tax is paid during the quarter following the quarter in which the severance takes place. SOURCE: Office of the State Tax Commissioner, Tons of Taxable Coal Severed, Quarterly Reports for Quarters Ending June 30, 1981, September 30, 1981, December 31, 1981, and March 31, 1982. Estimates for 1983 provided by Bill Cudworth, State Tax Department, October 11, 1982. Severance tax estimates are fiscal year tax collections.
[c]Kilowatt hours of electricity produced times a tax rate of 0.25 mills per KWH for fiscal year 1982 (July 1, 1981 to June 30, 1982). The tax is paid the quarter following that in which the production takes place. SOURCE: Office of the State Tax Commissioner, Coal Conversion Facilities Privilege Tax, 81-83 Biennium Report, including data for quarters ending September 30, 1981, December 31, 1981, March 31, 1982, and June 30, 1982. Estimates for 1983 provided by Bill Cudworth, State Tax Department, October 11, 1982. Coal conversion tax estimates are fiscal year tax collections.

TABLE 4. ESTIMATED DIRECT AND SECONDARY EMPLOYMENT TOTALS FOR COMPANIES INVOLVED IN LIGNITE RELATED ACTIVITIES, FISCAL YEARS 1982 AND 1983

Year	Direct Employment[a]	Secondary Employment
1982	6,458	31,981
1983	7,996[b]	32,211

[a]Includes construction workers, administrative personnel, and other company employees affiliated with the lignite industry. Construction employment estimates were obtained from Mercer County Socioeconomic Impact Mitigation Assessment, Volume XI, prepared by the Inter-Industry Technical Assistance Team, Basin Electric Power Cooperative, Great Plains Gasification Associates, and the Coteau Properties Company, Beulah, North Dakota, July 1982. (Note: construction workforce estimates are for Mercer County only.)
[b]Includes start-up personnel for Great Plains Gasification.

were employed by energy conversion facilities, and the remaining 4,000 workers were part of the construction work force in Mercer County. The total payroll during fiscal year 1983 for the mining and conversion employees was over $120 million. For every dollar of direct employee payroll in the North Dakota lignite industry, an additional $3.07 of personal income for North Dakota households is created. The payroll for the construction workers was included in the construction sector expenditures.

Lignite industry expenditures also are responsible for creating secondary (indirect and induced) employment. Secondary employment for fiscal year 1982 was estimated at 31,981 and 32,211 for fiscal year 1983. Thus, for every permanent job created within the North Dakota lignite industry, another 4 to 5 jobs are created to provide goods and services within the economy. Similarly, for every $1 million of expenditures by the lignite industry, there are approximately 13 direct and 60 secondary jobs created.

The indirect and induced employment is the result of large expenditures injected into the state's economy by the lignite industry. Secondary employment is determined by productivity ratios, the dollars of gross business volume needed to create one new job in each respective sector.

Income for employees in the lignite industry is quite favorable as compared to that of the average North Dakota worker. Fourty-five percent of lignite industry employees earned an income between $25,000 and $35,000 annually (Figure 3). Only one percent of the lignite industry workers earned less than $10,000 annually. This compares with average earnings per North Dakota worker of $9,930.[11] The lignite industry offers North Dakotans an opportunity to seek well paying jobs in the state.

---

[11]Derived from United States Bureau of the Census, Summary Tape File 3A: North Dakota, 1980.

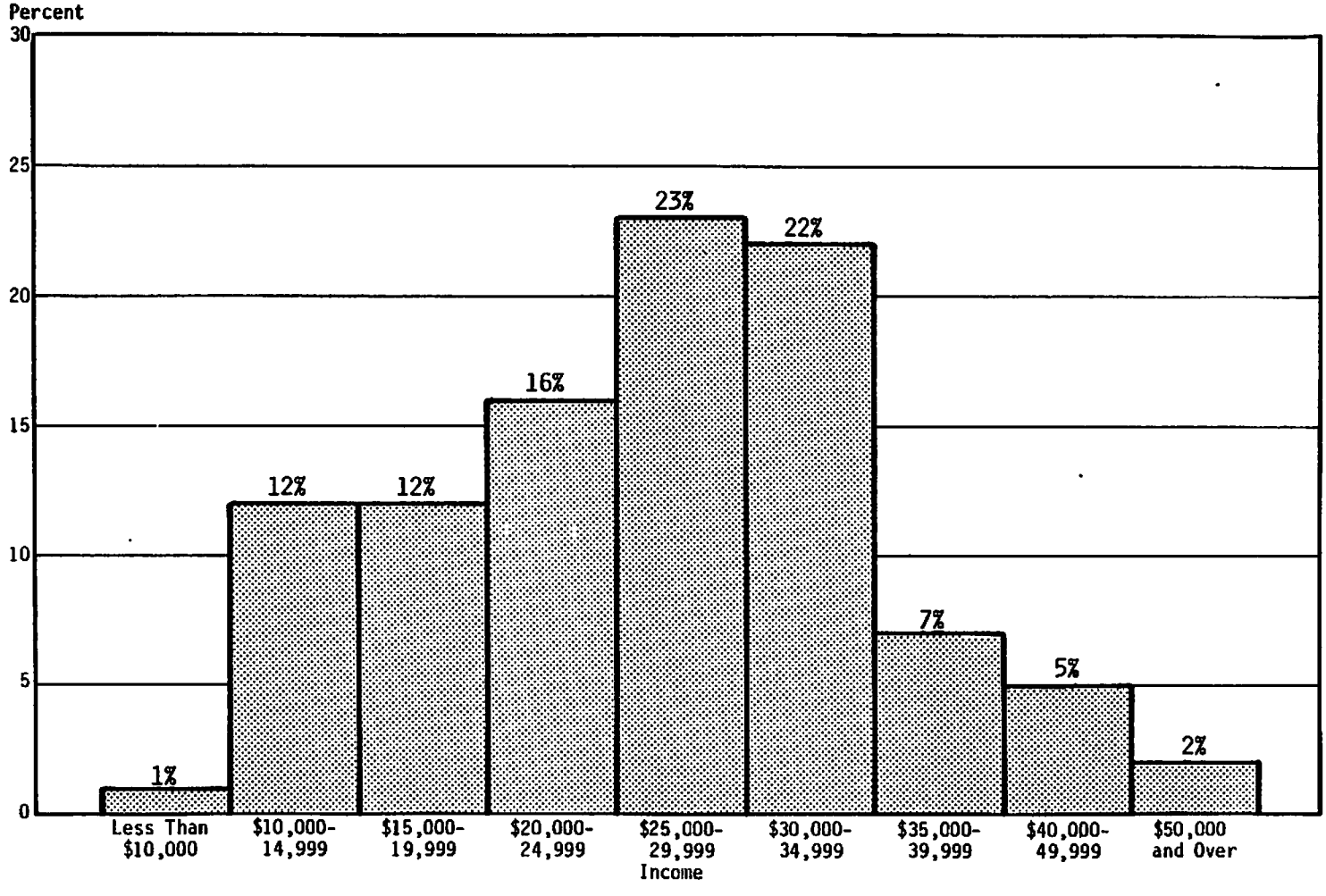

Figure 3. Employment by Income Category for the North Dakota Lignite Industry, Direct Operations Personnel, Fiscal Year 1982

Appendix A

METHODOLOGY

The Input-Output Model

Economic impact analysis requires choosing a technique for estimating the indirect and induced effects of an industry or a new project on economic activity, employment, and income. The alternatives considered included the economic base approach, econometric estimation based on time-series or cross-sectional data, and input-output analysis. Input-output (I-O) analysis was selected as the economic impact assessment framework for the North Dakota Lignite Council Study. The primary reasons for this were that, compared to the economic base approach, I-O provides considerably more detailed impact estimates (i.e., business volume and employment by sector) and that I-O allows the analyst to take explicit account of differences in wage rates and local input purchasing patterns in evaluating the impacts of various development proposals.[1] Econometric techniques were thought to be inappropriate for this application because data were of insufficient detail for such analyses.[2]

Input-output analysis is a technique for tabulating and describing the linkages or interdependencies between various industrial groups within an economy. The economy considered may be the national economy or an economy as small as that of a multicounty area served by one of the state's major retail trade centers. The North Dakota economy is divided into 17 industrial groups referred to as sectors of the economy. The sector delineation and corresponding SIC codes are presented in Appendix Table 1.

---

[1]For additional discussion of the comparative capabilities of the input-output and economic base approaches, see Lewis, W. C., "Export Base Theory and Multiplier Estimation: A Critique," The Annals of Regional Science, Vol. 10, No. 2, 1976, pp. 68-70. Richardson, H. W., Input-Output and Regional Economics, Halstead Press, New York, 1972.

[2]For a detailed discussion of the application of econometric techniques to regional analysis, see Glickman, N. J., Econometric Analysis of Regional Systems: Exploration of Model-Building and Policy Analysis, Academic Press, New York, 1977.

TABLE 1. ECONOMIC SECTORS OF THE NORTH DAKOTA INPUT-OUTPUT MODEL AND STANDARD INDUSTRIAL CLASSIFICATION CODE OF EACH

	Economic Sector	SIC Code[a]
1.	Ag., Livestock	Group 013 - Livestock
2.	Ag., Crops	All of major group 01 - agricultural production, except group 013 - livestock
3.	Sand & Gravel Mining	Major group 14 - mining and quarrying of nonmetallic minerals, except fuels
4.	Construction	Division C - contract construction (major groups 15, 16, and 17)
5.	Transportation	All division E - transportation, communications, electric, gas, and sanitary services, except major groups 48 and 49
6.	Communications & Public Utilities	Major group 48 - communications and major group 49 - electric, gas, and sanitary services, except industry no. 4911
7.	Wholesale Trade & Ag. Processing	Major group 50 - wholesale trade, and major group 20 - food and kindred products manufacturing
8.	Retail Trade	All of division F - wholesale and retail trade, except major group 50 - wholesale trade
9.	Finance, Insurance, and Real Estate	Division G - finance, insurance, and real estate
10.	Business and Personal Service	All of division H - services, except major groups 80, 81, 82, 86, and 89
11.	Professional and Social Services	Major group 80 - medical and other health services, major group 8, legal services, major group 82 - educational services, major group 86 - nonprofit membership organizations, and major group 89 - miscellaneous services
12.	Households	Not applicable
13.	Government	Division I - government
14.	Coal Mining	Major group 12 - bituminous coal and lignite mining
15.	Electric Generating	Industry number 4911 - electric companies and systems
16.	Petroleum and Natural Gas Exploration and Extraction	Major group 13 - crude petroleum and natural gas
17.	Petroleum Refining	Major group 29 - petroleum refining and related industries

[a]Executive Office of the President/Bureau of the Budget, Standard Industrial Classification Manual, 1967, U.S. Government Printing Office, Washington, D.C., 1967.

The input-output analysis used in this model assumes that economic activity in a region is dependent upon the basic industries that exist in an area, referred to as its economic base. The economic base is largely a region's export base, i.e., those industries (or "basic" sectors) that earn income from outside the area. These activities in North Dakota consist of livestock and crop production, manufacturing, mining, tourism in the area, and federal government outlays in the area. The remaining economic activities are the trade and service sectors, which exist to provide the inputs required by other sectors in the area.

The North Dakota input-output model has three features which merit special comment. First, the model is closed with respect to households. In other words, households are included in the model as a producing and a consuming sector. Second, the total gross business volume of trade sectors was used (both for expenditures and receipts in the transactions table) rather than value added by those sectors. This procedure results in larger activity levels for those sectors than would be obtained by conventional techniques, but this is offset by correspondingly larger levels of expenditures outside the region by those sectors for goods purchased for resale. The advantage of this procedure is that the results of the analysis are expressed in terms of gross business volumes of the respective sectors, which is usually more meaningful to most users. The third feature is all elements in the column of interdependence coefficients for the local government sector were assigned values of zero, except for a one (1.00) in the main diagonal. This was intended to reflect the fact that expenditures of local units of government are determined by the budgeting process of those units, rather than endogenously within the economic system.

Production by any sector requires the use of production inputs, such as materials, equipment, fuel, services, labor, etc., by that sector. These inputs are referred to as the direct requirements of that sector. Some of these inputs will be obtained from outside the region (imported), but many will be produced by and purchased from other sectors in the area economy. If so, these other sectors will require their own inputs from still other sectors, which in turn will require inputs from yet other sectors, and so on. These additional rounds of input requirements that are generated by production of the direct input requirements (of the initial sector) are known as the indirect requirements.

The total of the direct and indirect input requirements of each sector in an economy is measured by a set of coefficients that is known as the input-output interdependence coefficients. Each coefficient indicates the total (direct and indirect) input requirement that must be produced by the row sector per dollar of output for final demand by the column sector. Final demand is defined as output by a basic sector that is sold outside the region. Final demand consists of receipts from sales of livestock (receipts of Sector 1), receipts by Sector 2 for sale of crops, receipts by Sector 4 for federal government outlays for construction, processed agricultural products and other manufacturing receipts (Sector 7), receipts by Sectors 8 and 10 for tourist expenditures, receipts by Sector 14 for exports of mine product, Sector 15 receipts for electricity exported, receipts for crude oil exported (Sector 16), and receipts by Sector 17 for exported refined petroleum products. For any of these basic sectors which produce for final demand, the sum of the values for that column indicates the multiplier effect in the region's economy resulting from a dollar's worth of sales outside the region by that sector. For example, if the column total of interdependence coefficients for the livestock producing sector is 4.49, $4.49 worth of output is required by all

sectors in the economy in order that $1.00 worth of livestock be produced for final demand. Thus, it can be said that the output multiplier for the livestock producing sector is 4.49 or that the original dollar "turns over" about 4.5 times in the region.

If the level of output of any of the basic sectors were to increase, the level of output of other sectors also would be expected to increase. The amount of the increase in other sectors would be equal to the dollar amount of the increase in the basic sector's output times the respective interdependence coefficients in the column for the basic sector. For example, the effect of a $1 million increase in federal government outlays for construction in the region could be estimated from Column 4, Appendix Table 2. Livestock production in the region could be expected to increase by $30,000 (0.03 times $1 million); crop production by $10,000 (0.01 times $1 million); retail trade volume by $410,000 (0.41 times $1 million); personal income (the income of households, Sector 12) by $610,000 (0.61 times $1 million); and the total for all sectors in the economy by $2,440,000 (2.44 times $1 million). These increases in the respective sectors represent both the direct and the indirect effects of expanded final demand that is injected into the region via the contract construction sector because of increased federal expenditures to it.

Given these basic procedures, the gross business volumes of each sector in the area economy can be estimated by multiplying the output of the "basic" sectors (payments received from outside the area) by the interdependence coefficients for those sectors.

The multiplier effect for a sector (which is measured by the sum of the sector's column of interdependence coefficients) results from the spending and respending within the region's economy of income that is received from sale of its exports. For example, the establishment of a new manufacturing plant in a

TABLE 2. INPUT-OUTPUT INTERDEPENDENCE COEFFICIENTS, BASED ON TECHNICAL COEFFICIENTS FOR 17-SECTOR MODEL FOR NORTH DAKOTA

Sector	Lvstk. (1)	Crops (2)	S&G (3)	Const. (4)	Tran. (5)	C&U (6)	W&AP (7)	Ret. (8)	FIRE (9)
1. Ag. Livestock	1.2072	0.0774	0.0445	0.0343	0.0455	0.0379	0.1911	0.0889	0.0617
2. Ag. Crops	0.3938	1.0921	0.0174	0.0134	0.0178	0.0151	0.6488	0.0317	0.0368
3. Sand & Gravel	0.0083	0.0068	1.0395	0.0302	0.0092	0.0043	0.0063	0.0024	0.0049
4. Construction	0.0722	0.0794	0.0521	1.0501	0.0496	0.0653	0.0618	0.0347	0.0740
5. Transportation	0.0151	0.0113	0.0284	0.0105	1.0079	0.0135	0.0128	0.0104	0.0120
6. Comm. & Util.	0.0921	0.0836	0.1556	0.0604	0.0839	1.1006	0.0766	0.0529	0.1321
7. Wholesale & Ag. Proc.	0.5730	0.1612	0.0272	0.0207	0.0277	0.0239	1.7401	0.0452	0.0704
8. Retail	0.7071	0.8130	0.5232	0.4100	0.5475	0.4317	0.6113	1.2734	0.6764
9. Fin., Ins., Real Estate	0.1526	0.1677	0.1139	0.0837	0.1204	0.1128	0.1322	0.0577	1.1424
10. Bus. & Pers. Services	0.0562	0.0684	0.0430	0.0287	0.0461	0.0374	0.0514	0.0194	0.0766
11. Prof. & Soc. Services	0.0710	0.0643	0.0559	0.0402	0.0519	0.0526	0.0530	0.0276	0.0816
12. Households	1.0458	0.9642	0.8424	0.6089	0.7876	0.7951	0.7859	0.4034	1.2018
13. Government	0.0987	0.0957	0.0853	0.0519	0.2583	0.0999	0.0796	0.0394	0.1071
14. Coal Mining	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
15. Electric Generating	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
16. Pet. Exp./Ext.	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
17. Pet. Refining	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Gross Receipts Multiplier	4.4931	3.6851	3.0284	2.4430	3.0534	2.7901	4.4509	2.0871	3.6778

- continued -

TABLE 2. INPUT-OUTPUT INTERDEPENDENCE COEFFICIENTS, BASED ON TECHNICAL COEFFICIENTS FOR 17-SECTOR MODEL FOR NORTH DAKOTA (CONTINUED)

Sector	B&PS (10)	P&SS (11)	HH (12)	Govt. (13)	Coal (14)	E. Gen. (15)	Pet. Exp./Ext. (16)	Pet. Ref. (17)
1. Ag. Livestock	0.0384	0.0571	0.0674	0.0000	0.0376	0.0251	0.0159	0.0145
2. Ag. Crops	0.0152	0.0229	0.0266	0.0000	0.0285	0.0321	0.0062	0.0057
3. Sand & Gravel	0.0043	0.0050	0.0057	0.0000	0.0032	0.0019	0.0045	0.0037
4. Construction	0.0546	0.0787	0.0902	0.0000	0.0526	0.0328	0.1148	0.0929
5. Transportation	0.0118	0.0100	0.0093	0.0000	0.0084	0.0048	0.0180	0.0172
6. Comm. & Util.	0.1104	0.1192	0.1055	0.0000	0.0712	0.0378	0.0510	0.0444
7. Wholesale & Ag. Proc.	0.0237	0.0362	0.0417	0.0000	0.0618	0.0782	0.0097	0.0089
8. Retail	0.4525	0.6668	0.7447	0.0000	0.3995	0.2266	0.1838	0.1675
9. Fin., Ins., Real Estate	0.1084	0.1401	0.1681	0.0000	0.0771	0.0977	0.0388	0.0358
10. Bus. & Pers. Services	1.0509	0.0455	0.0605	0.0000	0.0289	0.0201	0.0139	0.0127
11. Prof. & Soc. Services	0.0497	1.1026	0.0982	0.0000	0.0493	0.0301	0.0210	0.0195
12. Households	0.7160	1.0437	1.5524	0.0000	0.6666	0.3973	0.3205	0.2951
13. Government	0.0774	0.0881	0.1080	1.0000	0.0511	0.0444	0.0280	0.0285
14. Coal Mining	0.0000	0.0000	0.0000	0.0000	1.0000	0.1582	0.0003	0.0002
15. Electric Generating	0.0000	0.0000	0.0000	0.0000	0.0000	1.0000	0.0000	0.0000
16. Pet. Exp./Ext.	0.0000	0.0000	0.0000	0.0000	0.0138	0.0084	1.0981	0.8227
17. Pet. Refining	0.0000	0.0000	0.0000	0.0000	0.0168	0.0102	0.0000	1.0000
Gross Receipts Multiplier	2.7133	3.4159	3.0783	1.0000	2.5664	2.2057	1.9245	2.5693

region would result in expenditures by the plant for some locally supplied inputs, such as materials, labor, etc. These expenditures will generate additional rounds of spending in the region because the firms providing materials to the plant will now purchase some additional inputs in the region and employees of the plant will spend a part of their income in the region. These expenditures, in turn, will generate another round of spending and so on.

Multiplication of the interdependence coefficients by the sales of the basic sectors (income received from outside the region or sales for final demand) yields estimates of the gross business volumes of each of the sectors in the region. Sales of the basic sectors can be baseline or project/industry specific which are used in the case of impact analysis. The resulting product for the household sector (Sector 12) is personal income received from the respective business sectors in the form of wages and salaries, profits, rents, and interest income of individuals.

Interdependence Coefficients

The input-output technical and interdependence coefficients for the North Dakota economy were derived from actual expenditure data collected in 1965 for business firms, households, and units of government in southwestern North Dakota.[3] The North Dakota input-output interdependence coefficients were calculated originally for a 13 sector model.

---

[3]Sand, L. D., "Analysis of Effects of Income Changes in Intersectional and Intercommunity Economic Structure," unpublished M.S. Thesis, Department of Agricultural Economics, North Dakota State University, Fargo, 1968; Bartch, B. L., "Analysis of Intersectional and Intercommunity Structure in Southwestern North Dakota," unpublished M.S. Thesis, Department of Agricultural Economics, North Dakota State University, Fargo, 1968; Senechal, D. M., "Analysis of Validity of North Dakota Input-Output Models," unpublished M.S. Thesis, Department of Agricultural Economics, North Dakota State University, Fargo, 1971.

The original coefficients were derived when energy production (coal, electricity, crude petroleum, and refined petroleum products) was not a very large component of the North Dakota economic base. Increasing importance of North Dakota energy exports made expansion of the model necessary. Survey expenditure data of the energy-related industries were collected in 1975.[4] These expenditures data yielded technical coefficients (direct requirements) for four additional economic sectors. These coefficients were simply appended to the 13 sector direct requirements matrix to form an augmented 17 sector direct requirements matrix. The technical coefficients for the four energy sectors were included as columns 14-17. Rows 14 to 17 for columns 1-13 were assigned a value of zero. This was appropriate because the original 13 sectors have insignificant amounts of expenditures to the energy sectors, but the energy sectors had a considerable amount of expenditures to the original 13 sectors. Inverting the 17 X 17 technical coefficients matrix yielded the 17 sector interdependence coefficients. Interdependence coefficients for the 17 sector model are presented in Appendix Table 2.

Gross Business Volumes

Application of the input-output multipliers to the final demand vectors yields estimates of gross business volume of all sectors of the economy. Final demand vectors can be baseline or project/industry and historic or projected. Multipliers applied to the historic final demand vectors yield estimates of historic gross business volumes. Gross business volume of the

---

[4]Hertsgaard, T. A., Randal C. Coon, F. Larry Leistritz, and Norman L. Dalsted, Developing Economic Impact Projection Models for the Fort Union Coal Region, EPA-908/4-77-009, Environmental Protection Agency. Denver, Colorado, June 1977.

household sector (Sector 12) is personal income. Applying multipliers for the lignite industry to its final demand vectors for 1982 and projected final demand vectors for 1983 will give estimates of the gross business volumes and personal incomes that are directly or indirectly attributable to the lignite industry for that time period.

The accuracy of the input-output model has been tested by comparing personal income from the model with personal income reported by the Bureau of Economic Analysis, U.S. Department of Commerce. For the time period 1958 to 1980, estimates of North Dakota personal income from the input-output model had an average deviation of 5.13 percent from Department of Commerce estimates (Appendix Table 3). The Theil's coefficient of .031 also indicates the model is quite accurate for predictive purposes.[5]

Productivity Ratios

The ratio of gross business volume to employment is called the productivity ratio. This ratio indicates the gross business volume required in each sector to generate one more worker in that sector. Employment data are available from information published annually by the North Dakota Employment Security Bureau, Bismarck, North Dakota. Labor force data were reorganized into classifications similar to the sectors of the input-output model. Productivity ratios for North Dakota were calculated for the 1958 to 1979 time period (Appendix Table 4). Regression equations were determined and used to project productivity ratios for the years 1982 and 1983.

---

[5]The Theil U_1 coefficient is a summary measure, bounded to the interval 0 and 1. A value of 0 for U_1 indicates perfect prediction, while a value of 1 corresponds to perfect inequality (i.e., between the actual and predicted values). For further discussion on the Theil coefficient, see Leuthold, Raymond M., "On the Use of Theil's Inequality Coefficients," American Journal of Agricultural Economics, Vol. 57, No. 2, 1975, pp. 344-346; Pindyck, Robert S. and Daniel L. Rubinfeld, Econometric Models and Economic Forecasts, Second Edition, McGraw-Hill, New York, 1981.

TABLE 3. ESTIMATES OF PERSONAL INCOME AND DIFFERENCES IN ESTIMATES, 1958-1980

Year	Estimates by Input-Output Techniques ($000)	Estimate by U.S. Department of Commerce ($000)[a]	Percent Difference
1958	$1,022,412	$1,027,000	- 0.5
1959	978,420	956,000	2.3
1960	942,488	1,066,000	-11.6
1961	1,011,460	995,000	1.7
1962	1,285,790	1,353,000	- 5.0
1963	1,353,864	1,280,000	5.8
1964	1,521,191	1,277,000	19.1
1965	1,470,128	1,508,000	- 2.5
1966	1,662,393	1,553,000	7.0
1967	1,573,010	1,592,000	- 1.2
1968	1,684,451	1,645,000	2.4
1969	1,890,973	1,830,000	3.3
1970	2,117,318	1,904,000	11.2
1971	2,156,642	2,158,000	- 0.1
1972	2,601,416	2,676,000	- 2.8
1973	3,674,738	3,875,000	- 5.2
1974	4,104,667	3,740,000	9.8
1975	4,009,826	3,755,000	6.8
1976	3,860,970	3,728,000	3.6
1977	3,829,503	3,833,000	- 0.1
1978	4,481,330	4,984,000	-10.1
1979	4,763,620	5,047,000	- 5.6
1980	5,430,915	5,415,000	0.3
Average Error =			5.13
Theil's Coefficient = .031429843			

[a]Survey of Current Business, August 1979, pp. 28-31 (1958-1976), Survey of Current Busines, April 1980, p. 25 (1977) and Survey of Current Business, April 1981, p. 38 (1978-1979).

TABLE 4. PRODUCTIVITY RATIOS FOR NORTH DAKOTA, BY ECONOMIC SECTOR, HISTORIC 1958-1979, AND PROJECTED 1982-1983[a]

Year	(1) Ag. Lvstk.	(2) Ag. Crops	(3) Sand & Gravel	(4) Const.	(5) Trans.	(6) C&PU	(7) Whls. & AP	(8) Retail
1958	9,444	9,444	53,654	6,485	1,769	10,648	19,167	19,940
1959	9,290	9,290	54,339	6,260	1,684	10,039	17,662	18,451
1960	8,887	8,887	52,959	7,413	1,625	9,761	17,350	17,593
1961	9,415	9,415	52,400	7,189	1,774	10,823	18,847	18,451
1962	11,017	11,017	69,357	6,989	2,165	13,610	18,828	23,753
1963	12,871	12,871	78,330	8,000	2,353	14,555	19,250	24,424
1964	12,649	12,649	82,115	8,970	2,508	16,090	18,582	25,087
1965	15,406	15,406	71,274	9,134	2,658	16,067	19,561	25,420
1966	17,931	17,931	77,363	11,898	2,942	17,668	21,006	28,359
1967	18,990	18,990	78,859	12,355	2,859	16,767	21,747	27,590
1968	19,376	19,376	84,680	14,096	3,052	17,965	21,858	29,140
1969	22,583	22,583	88,235	16,358	3,420	20,156	27,371	32,434
1970	27,375	27,375	129,167	26,967	4,005	24,826	28,072	36,473
1971	28,921	28,921	106,242	16,353	3,988	24,966	29,514	36,402
1972	38,089	38,089	134,318	17,547	4,925	30,099	32,431	42,245
1973	61,727	61,727	190,234	23,764	7,041	41,937	42,700	59,245
1974	66,322	66,322	199,664	25,638	7,760	45,645	44,748	63,783
1975	59,978	59,978	171,360	21,974	7,351	44,515	36,674	56,823
1976	52,518	52,518	152,006	16,801	7,019	41,580	43,571	50,592
1977	46,258	46,258	146,323	16,377	6,610	39,366	40,265	49,144
1978	59,805	59,805	170,481	17,481	7,269	42,994	42,945	57,438
1979	67,097	67,097	180,200	19,479	7,425	42,627	46,485	58,861
1982	71,588	71,588	203,911	25,349	8,619	51,038	49,164	66,434
1983	74,615	74,615	210,848	26,157	8,947	52,954	50,690	68,655

- CONTINUED -

TABLE 4. PRODUCTIVITY RATIOS FOR NORTH DAKOTA, BY ECONOMIC SECTOR, HISTORIC 1958-1979, AND PROJECTED 1982-1983[a] (CONTINUED)

Year	(9) F.I.R.E.	(10) B&PS	(11) P&SS	(12) HH	(13) Govt.	(14) Coal	(15) Elec. Gen.	(16) Pet.	(17) Pet. Ref.
1958	29,782	5,124	4,799	--	3,029	2,907	--	8,822	39,158
1959	26,617	4,599	4,302	--	2,789	2,627	--	12,589	39,745
1960	24,708	4,278	4,047	--	2,659	2,627	--	19,555	39,737
1961	25,173	4,290	4,160	--	2,730	3,427	--	23,301	41,384
1962	30,488	5,182	5,104	--	3,261	3,961	--	27,790	42,314
1963	31,889	5,362	5,163	--	3,239	3,586	--	29,809	43,783
1964	33,178	5,525	5,566	--	3,286	4,330	--	30,496	46,105
1965	32,900	58,10	5,438	--	3,169	5,228	--	27,795	50,470
1966	36,459	6,545	6,014	--	3,416	5,672	23,404	30,713	52,884
1967	33,396	6,190	5,450	--	3,086	9,971	43,299	31,637	55,342
1968	35,125	6,560	5,653	--	3,072	12,935	63,731	37,627	58,066
1969	39,225	7,324	6,323	--	3,377	13,114	59,694	29,474	60,968
1970	46,046	8,012	6,987	--	4,036	16,153	57,741	45,875	71,273
1971	45,725	7,843	6,742	--	3,096	17,594	70,281	50,440	77,957
1972	54,488	8,817	17,803	--	4,922	17,909	79,554	55,808	85,365
1973	77,247	11,986	10,546	--	7,072	18,669	68,683	64,091	92,660
1974	81,939	12,618	11,209	--	7,737	23,798	71,795	99,252	113,980
1975	72,706	11,348	0,287	--	6,933	24,387	61,677	83,974	126,015
1976	64,488	10,627	9,484	--	6,424	43,078	109,040	81,204	136,946
1977	58,961	10,223	9,038	--	6,207	42,674	129,330	66,707	146,951
1978	66,300	11,472	9,996	--	7,057	43,646	180,165	48,561	154,549
1979	67,526	11,341	10,172	--	7,434	57,794	248,913	59,827	216,304
1982	80,061	13,182	11,505	--	7,851	47,519	202,983	86,190	171,830
1983	82,576	13,582	11,838	--	8,098	49,772	214,821	89,324	178,525

[a]Projected using linear regression techniques.

Productivity ratios are all in current year dollars as lignite industry expenditures are current year dollar values. Gross business volumes resulting from lignite industry expenditures divided by the corresponding productivity ratios yield indirect and induced employment. Expenditures by the lignite industry to sectors of the economy create indirect and induced, or secondary, employment necessary to support the industry.

Tax Revenue Estimation

Estimation of tax revenues resulting from the lignite industry is also an important part of the impact analysis. Gross business volumes generated by the input-output model provide business activity upon which taxes can be calculated. Equations were developed that estimate tax revenues based on gross business volumes. The tax rates were determined by dividing the taxes collected[6] for sales and use, personal income, and corporate income tax by their gross business volumes that were estimated for the respective sectors in each year by use of the input-output model. An average tax rate, calculated for each tax based on 1980 and 1981 tax rates, was used to estimate tax collections for 1982 and 1983.

Actual coal severance and conversion tax rates were available for 1982. Equations for revenues from other minor taxes were available but were not considered for the lignite industry impact analysis.[7] Local jurisdiction tax estimates were obtained from the questionnaire.

---

[6]Tax collections were provided by Mr. Bill Cudworth, State Tax Department, Bismarck, North Dakota, October 15, 1982.

[7]Tax revenue estimators were available for highway taxes; cigarette and tobacco taxes; liquor and beer taxes; and local ad valorem property taxes.

State sales and use tax collections were estimated using the following equation:

State sales and use tax collections = 3.12% X gross business volume of the retail trade sector.[8]

State personal income tax collections were determined using the following relationship:

State personal income tax collections = 0.99% X personal income.[9]

The equation to estimate state corporate income tax collections is:

State corporate income tax collections = 0.293% X gross business volumes of all business sectors.[10]

Estimated coal severance and conversion tax collections for 1982 to 1985 were obtained from the North Dakota Tax Department, Bismarck, North Dakota. A coal severance tax rate of $1.00 per ton (the rate as of June 30, 1982) was used for calculating the 1982 collections. The coal conversion tax rate for 1982 was 0.25 mills per kilowatt hour produced for sale by electric generating plants and $0.10 per thousand cubic feet of gas produced by gasification plants.

---

[8]Retail trade sector of the input-output model is Sector 8.

[9]Personal income from the input-output model is the gross business volume in the household sector (Sector 12).

[10]All business sectors consist of all nonfarm business sectors. This includes all sectors of the North Dakota input-output model except Sectors 1, 2, 12, and 13.

ECONOMIC ANALYSIS OF THE NORTH DAKOTA LIGNITE INDUSTRY