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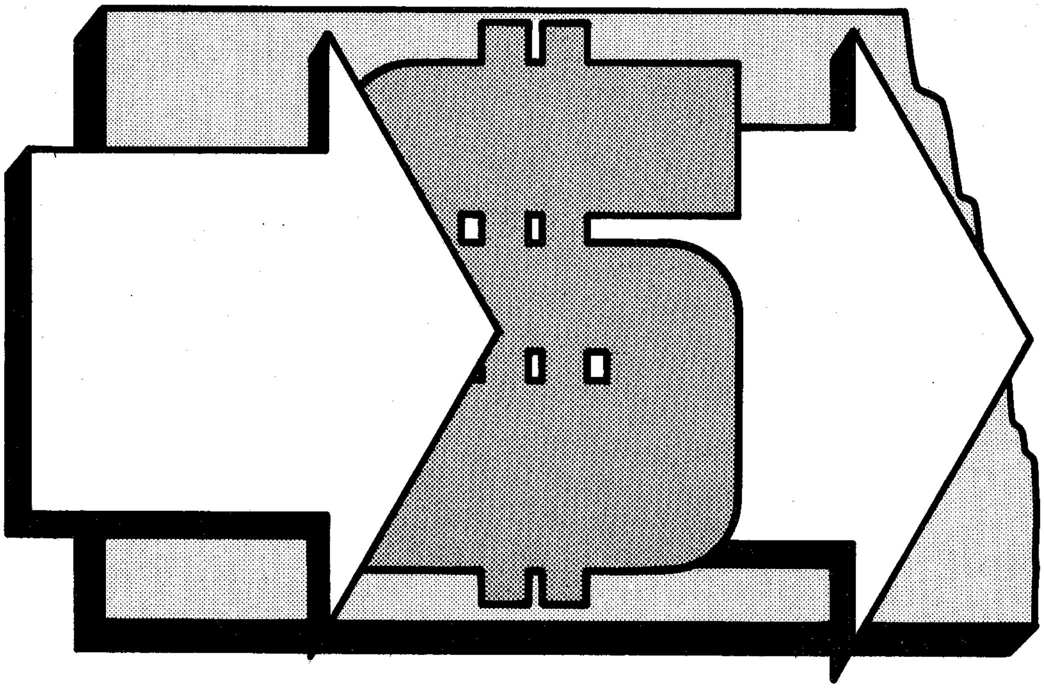

The North Dakota Input-Output Model:

A Tool for Analyzing Economic Linkages

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PREFACE

North Dakota's input-output model has become an integral part of many economic research activities involving state issues. Since its development to analyze the economic impacts associated with irrigation development in the 1960s, the model has been updated and used to analyze the effects of a wide variety of projects in North Dakota. Because the model is used and referenced frequently by economic researchers, the nontechnical audience often requests additional information to explain the input-output model and the theory behind it. The purpose of this report is to explain the principles of input-output analysis, to describe the structure of the North Dakota model, and to explain how to interpret the results that might be found in a feasibility or economic contribution study. This report was designed to be a companion document that can be used in conjunction with any report or presentation involving the North Dakota input-output model.

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Highlights

Input-output (I-O) analysis is a technique for describing the linkages or interdependencies among the various sectors within an economy. This technique has been employed to quantitatively describe the North Dakota economy. Development of the North Dakota I-O model followed a three-step approach. First, a transactions table was constructed showing the purchases and sales by each sector of the economy to each of the other industrial sectors. Next, the technical input-output coefficients table was derived from the transactions table. This technical coefficients table is the transactions table expressed as decimal fractions of the column totals in the transactions table. Finally, the input-output interdependence coefficients, or multipliers, table was derived from the technical input-output coefficents table.

Development of the North Dakota I-O model has taken place over a 20-year period. The first attempt to study the intersector relationships of a local community in the state was conducted in Ransom County in 1963. A survey of seven southwestern counties was initiated in 1966 for the purpose of developing an input-output model. This model was primarily used to analyze the economic impacts associated with development of the Garrison Diversion irrigation project. The model was tested and validated for use at the state and substate levels. As energy development became important in the state, the model was expanded to include coal mining, thermal-electric power generation, petroleum exploration/extraction, and petroleum refining.

North Dakota's economic base is comprised of those activities producing either a product paid for by nonresidents or products exported from the state. Included in these economic base activities are agriculture (livestock and crop production plus government payments for agricultural programs), mining, manufacturing, tourist expenditures for retail purchases and business and personal services, and federal government outlays for construction and to individuals. Application of the input-output interdependence coefficients to the estimated levels of basic economic activities, or sales for final demand, yields estimates of gross business volume. These values indicate the total dollar volume of business activity occurring after the multiplier process has been completed.

The North Dakota I-O model has been used to analyze the economic impacts associated with a wide range of issues in the state. Studies involved with irrigation, coal and other energy development, feasibility, contribution, recreation, government programs, and comprehensive socioeconomic model development have all relied heavily on the input-output model's economic estimates. The model has been used to determine the effects of a wide variety of industrial and agricultural developments in the state. Analyzing impacts associated with these developments using the input-output model has proven to be accurate and beneficial for those requiring this type of information.

THE NORTH DAKOTA INPUT-OUTPUT MODEL: A TOOL FOR ANALYZING ECONOMIC LINKAGES

by

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Introduction

North Dakota's economy is composed of basic activities that are primarily resource based, i.e., involving either energy or agricultural production (although manufacturing, tourist expenditures, and federal government outlays also are included). To better understand the basic components of the state's economy and the interdependencies among these components, input-output (I-O) analysis techniques have been used. Input-output analysis can be used to quantitatively describe and analyze the interrelationships (economic linkages) within a state or regional economy.

Basic economic activities are defined as those that bring dollars into a state or region in return for exported products. For example, suppose that a small regional economy such as a small farming community produces a product (e.g., crop production) which is shipped from the area. The producers receive money payments from outside the area and use part of those payments to pay for the inputs used in producing the product; these costs are, in turn, revenues to the secondary businesses that serve and support the crop production sector. The survival of an economic unit depends on its ability to produce products and sell them at a price that is high enough to pay all costs of production, including the market value of the use of the producer's own resources. The payments the firm makes to other firms for inputs purchased from them are revenues to trade and service industries. If the basic industry expands, there will be a demand for additional output from the trade and service businesses, and vice versa if the basic industry shrinks.

An I-O model has been developed for North Dakota to quantitatively describe the economy at the state and substate (i.e., state planning region) levels. This model has been used extensively for such economic analyses as studies of the economic contribution of specific sectors of the state's economy, evaluation of the impact of expansion or contraction of a given basic sector, secondary employment estimation, and state tax revenue estimation. In addition, the I-O model is one of the basic components of an integrated economic-demographic model that projects income, employment, population, and related variables based on relationships to its central feature, the I-O model.

Because the I-O model is used so often by economic researchers, it has been referenced extensively but has seldom, if ever, been fully explained to the nontechnical audience. The purpose of this report is to explain the

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principles of input-output analysis, to describe the structure of the North Dakota model, and to explain how to interpret the results that may appear in a feasibility or economic contribution study. This report was designed to be a companion document that can be used in conjunction with any report or presentation involving the North Dakota input-output model; it provides the reference material necessary to understand input-output analysis as it relates to the state's economy.

Remaining sections of this report cover I-O theory, history of the North Dakota I-O model, I-O data tables, applications of the model, and examples of the way in which the model has been used. A glossary of terminology relating to input-output analysis is presented in Appendix A.

Input-Output Theory

Input-output concepts had their roots in the early development of economic theory. In 1758 Francois Quesnay published *Tableau Economique*, which stressed the interdependence of economic activities (for a discussion of Quesnay's work, see Newman [1952]). Quesnay's original model depicted the operation of a single farm and showed successive "rounds" of wealth-producing activity that resulted from a given increase in agricultural output. Essentially, this was the forerunner of the modern multiplier concept. The next step in the development of input-output theory did not come until 1874 when Leon Walras published *Elements d'economic politique pure*. The model developed by Walras showed interdependence among producing sectors of the economy and the competing demands of each sector for the factors of production. His system also included equations representing consumer income and expenditure, and it allowed consumers to substitute the products of one sector for those produced by another.

Professor Wassily Leontief of Harvard University developed a general theory of production based on the notion of economic interdependence. He published the first input-output table for the American economy, showing how each sector of the economy was dependent upon each other sector. For a complete discussion of Leontief's work with input-output, see Leontief (1966). Since Leontief's first input-output table, interindustry analysis has become an important branch of economics. Input-output tables are used on a national level throughout the world, and in the United States many state and substate I-O models have been developed. Miernyk (1967) provides a detailed review of the history of input-output analysis and a discussion of its applications (Miernyk 1982).

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 analysis assumes that economic activity in a region is dependent upon the "basic" industries that exist in the area, referred to as its economic base. The North Dakota economy is largely export-based (i.e., it consists of those industries or "basic" sectors that earn income from outside the area). Remaining activities are the trade and service sectors (or industries) which exist to provide the inputs required by other sectors in the area.

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 the latter is true, 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. Development of these coefficients follows a three-step approach. First, a transactions table is constructed showing the purchases and sales by each of the sectors to each of the other industrial sectors. This table is arranged so columns show the purchases from (and payments to) each row sector, and the rows indicate the sales of that row sector to the column sectors.

Next, the technical input-output coefficients table is derived from the transactions table. The technical coefficients table is the transactions table expressed as decimal fractions of column totals in the transactions table. Thus, each coefficient in that table indicates the fraction of total inputs of the column sector that is obtained from the row sector. In other words, each coefficient indicates the direct requirements (per dollar of output) that the column sector obtains from the row sector.

Finally, the interdependence coefficients (multipliers) table is derived from the technical input-output coefficients table. The interdependence coefficients table shows the total input requirements (direct and indirect) that must be obtained from the row sector per dollar of output for final demand by the column sector. Each coefficient includes the direct input requirement from the transactions table, the indirect input requirements due to the multiplier effect, and, if appropriate, output for final demand by the column sector. The column totals of this table are the total output requirements of all row sectors in the economy per dollar of output for final demand by the column sector. These column totals are called gross receipts multipliers.

Mathematical Representation

An example of a hypothetical economy will be presented and discussed to further illustrate input-output theory. Assume the local economy in this example is the state (although it could be a substate region, a multistate region, or the nation.) An industry (or economic sector) can be defined as a grouping of business firms producing similar products. (Government and households are often defined as economic sectors; both are included in the North Dakota model. The household sector earns personal income in the form of rent, interest, wages and salaries, and profits.) For any industry, total value of output (sales) over a particular time period equals the sum of its sales to each local industry plus its sales in markets outside the state. That is, for n delineated sectors in the state,

$$(1) \quad Y_i = \sum_{j=1}^{n} T_{ij} + Z_i \qquad i,j = 1, 2, \ldots, n$$

where:

Y_i = total output for sector i
T_{ij} = in-state sales to sector j by sector i (endogenous transactions)
Z_i = out-of-state sales by sector i (exogenous transactions)

Equation 1 can be represented in tabular form as presented in Table 1. The T_{ij}'s denote endogenous transactions or in-state transactions occurring among industries of the model. Each T_{ij} indicates a sale by the i^{th} industry to the j^{th} industry. Conversely, T_{ij} can also show a purchase by the j^{th} industry from the i^{th} industry. Thus, columns represent purchases while rows show sales. In Table 1, the Z_i section shows exports (exogenous transactions), and the Y_i section indicates total output or total sales.

Table 1 represents a complete economic system. An import, or nonlocal input row has been added to the transactions table to show a complete picture of all transactions. By adding this row to the transactions table, total inputs equal total output, and the economy described becomes a complete economic system. In Table 1, ΣZ represents total exports by all industries,

TABLE 1. MATHEMATICAL REPRESENTATION OF A TRANSACTIONS TABLE FOR A HYPOTHETICAL THREE-SECTOR EXPORT-BASED ECONOMIC SYSTEM

Selling Sector	Purchasing Sector			Exports	Total Output
	Industry #1	Industry #2	Industry #3		
Industry #1	T_{11}	T_{12}	T_{13}	Z_1	Y_1
Industry #2	T_{21}	T_{22}	T_{23}	Z_2	Y_2
Industry #3	T_{31}	T_{32}	T_{33}	Z_3	Y_3
Imports	W_1	W_2	W_3		ΣW
Total Input	Y_1	Y_2	Y_3	ΣZ	$\Sigma\Sigma T + \Sigma W$ (or $\Sigma\Sigma T + \Sigma Z$)

summation of all elements in the row (including exports) equals total output by all industries, ΣW is the total imports, and column totals are total inputs of that sector. If households are not a sector that is included in the model, resource payments (in the form of rent, interest, salaries and wages, and profits) to households are included as a part of the import row. Thus, because resource payments to households are included in each column (either in the household row or as a part of the import row), total input of each sector must equal its total output. This is true because profit or loss of households is the balancing component of gross input that makes total input equal total output for each sector.

An input-output technical coefficients table can be derived from the transactions table based on the following relationship.

$$(2) \quad a_{ij} = \frac{T_{ij}}{Y_j}$$

An example technical coefficients table with mathematical representation (Table 2) shows the a_{ij}'s and the other ratios; although only the a_{ij}'s are

TABLE 2. MATHEMATICAL REPRESENTATION OF A TECHNICAL INPUT-OUTPUT COEFFICIENTS TABLE FOR A HYPOTHETICAL THREE-SECTOR EXPORT-BASED ECONOMIC SYSTEM

Selling Sector	Purchasing Sector		
	Industry #1	Industry #2	Industry #3
Industry #1	a_{11}	a_{12}	a_{13}
Industry #2	a_{21}	a_{22}	a_{23}
Industry #3	a_{31}	a_{32}	a_{33}
Imports	W_1/Y_1	W_2/Y_2	W_3/Y_3
Total	1.00	1.00	1.00

functional, the others are presented for descriptive purposes. The a_{ij} segment of Table 2 is used to calculate the interdependence coefficients or multipliers. Substituting equation 2 into equation 1 results in

$$(3) \quad Y_i = \sum_{j=1}^{n} a_{ij} Y_j + Z_i \qquad j = 1, 2, \ldots, n$$

Put in matrix notation, this relationship becomes

$$(4) \quad Y = AY + Z$$
$$(5) \quad Y - AY = Z$$
$$(6) \quad [I-A]Y = Z$$
$$(7) \quad [I-A]^{-1}[I-A]Y = [I-A]^{-1}Z$$
$$(8) \quad IY = [I-A]^{-1}Z$$
$$(9) \quad Y = [I-A]^{-1}Z$$

Each element of the $[I-A]^{-1}$ denotes the amount of output from the i^{th} industry that is required either directly or indirectly per unit of output by the j^{th} industry for export from the state. Table 3 shows a common format for

TABLE 3. MATHEMATICAL REPRESENTATION OF INPUT-OUTPUT INTERDEPENDENCE COEFFICIENTS TABLE FOR A HYPOTHETICAL THREE-SECTOR EXPORT-BASED ECONOMIC SYSTEM

Selling Sector	Purchasing Sector		
	Industry #1	Industry #2	Industry #3
Industry #1	m_{11}	m_{12}	m_{13}
Industry #2	m_{21}	m_{22}	m_{23}
Industry #3	m_{31}	m_{32}	m_{33}
Total Multipliers	M_1	M_2	M_3

presenting the inverse matrix. Each element (m_{ij}) is a multiplier indicating both the direct and indirect effect upon the "row industry" of basic income received by the "column industry." Summing the columns produces a multiplier (M_i) denoting the dollar value of output of all sectors that results per dollar of export by the "column industry." This multiplier is often referred to as the gross receipts multiplier. For a more detailed discussion of input-output theory, mathematics, and formula derivation, see Harmston and Lund (1967).

Hypothetical Economy

An example of how the multipliers would be derived for a hypothetical three-sector economy will further illustrate how input-output theory has been put to practical use. This economy consists of three sectors: Agriculture (Agr), Manufacturing (Mfg), and Trade and Service (T&S). Firms in each sector require inputs (the output of firms in other sectors) and also produce outputs (the inputs of firms in other sectors). As previously mentioned, three types of tables are involved in input-output analysis: (1) the transactions table, (2) the technical input-output coefficients table, and (3) the table of interdependence coefficients. Development of multipliers will be traced through the three-step process of constructing the above mentioned tables. An extensive discussion of mathematical procedures will not be repeated, but rather an explanation of the interpretation of the tables will be addressed.

Transactions Table

This table contains the basic data from which the other two tables are derived. This transactions table is simply a table showing the receipts (or payments) of each economic sector (group of similar economic units) to (or from) each other sector. The table is arranged so the columns show the expenditures of each sector to the row sectors and the rows indicate the receipts of each sector from the column sectors. Hypothetical data for the three-sector economy are presented in Table 4. The dollar volumes in the

TABLE 4. TRANSACTIONS TABLE FOR A HYPOTHETICAL THREE-SECTOR EXPORT-BASED ECONOMIC SYSTEM

Selling Sector	Purchasing Sector			Exports	Total Output
	(1) Agr	(2) Mfg	(3) T&S		
	- - - - - - - - - - - - -million dollars- - - - - - - - - - - -				
(1) Agr	6	7	16	71	100
(2) Mfg	4	13	8	25	50
(3) T&S	60	10	12	118	200
Imports	30	20	164		
Total Input	100	50	200		

column sectors refer to production inputs purchased from each row sector; these purchases are also sales of output to the column sector from the row sectors. For example, the 6 in the row 1, column 1, represents a purchase of $6 million of inputs by farmers from other farmers as well as a sale of $6 million of the agricultural sector's output to farmers. The 4 in row 2 of the agriculture column reflects $4 million of inputs purchased by farmers from the manufacturing sector. Additionally, the 60 in row 3 column 1, represents a sale of $60 million from the trade and service sector to the agriculture sector, the 10 in row 3 and the 12 in row 3 represent sales of $10 million and $12 million from the trade and service sector to the manufacturing and trade and service sectors, respectively.

All transactions among sectors 1, 2, and 3 are for intermediate products; that is, these transactions are for inputs to be used in additional stages of production. On the other hand, the exports (or sales for final demand) column in Table 4 represents sales of final products. These sales could be to households for personal consumption, to business firms for capital investment, or to the various governmental units, or they could be exports outside the local economy. The row entitled imports is the counterpart to the column exports. Imports include wages and salaries, profits or losses, rent, interest payments to people, depreciation allowances for capital investments, tax payments to government, and imports from outside the local economy. The profit or loss in row 4 is the residual which equates gross receipts and gross expenditures. Therefore, the column total is equal to the row total for a given sector.

Technical Input-Output Coefficients Table

The technical input-output table (also referred to as the direct requirements table or the A matrix) is simply the transactions matrix expressed as decimal fractions of column totals. Each coefficient in this table indicates the fraction of total inputs of the column sector obtained from the row sector. Alternatively stated, each coefficient indicates the direct requirements (per dollar of output) that the column sector obtains from the row sector.

The technical coefficients table (Table 5) is derived from the transactions table. Values in each column are expressed as percentages of the column total. For example, Table 5 illustrates that the manufacturing sector

TABLE 5. TECHNICAL INPUT-OUTPUT COEFFICIENTS FOR A HYPOTHETICAL THREE-SECTOR EXPORT-BASED ECONOMIC SYSTEM

Selling Sector	Purchasing Sector		
	(1) Agr	(2) Mfg	(3) T&S
(1) Agr	.06	.14	.08
(2) Mfg	.04	.26	.04
(3) T&S	.60	.20	.06
Imports	.30	.40	.82
Total	1.00	1.00	1.00

purchases 14 percent of its inputs from agriculture, 26 percent from itself, 20 percent from trade and services, and 40 percent as imports from outside the local economy and from the other sources comprising the imports sector. Input-output analysis assumes these column percentages are constant at all levels of output. For example, a 50 percent increase in the manufacturing sector's output (row 2) of $50 million would require $3.5 million additional input from agriculture ($25 million x .14), $6.5 million from manufacturing ($25 million x .26), $5 million from the trade and service sector ($25 million x .20), and $10 million from the imports sector. The 50 percent increase in the manufacturing sector's output requires an additional $15 million of inputs from sectors 1, 2, and 3 and $10 million in inputs from the import sector. However, associated with these direct requirements are the "second-round" or indirect and induced input requirements. The $3.5 million of additional input from agriculture implies that farm output must be increased by that amount, which in turn will require increased inputs in agriculture. The "second-round" or indirect and induced impacts can be found by applying the technical input-output coefficients from Table 5, column 1, to the required $3.5 million of expanded agricultural output. Second-round input requirements are $.21 million from other farms, $.14 million from the manufacturing sector, and $2.10 million from the trade and service sector. Increased output from these second-round effects will generate additional waves of input requirements (third, fourth, and subsequent rounds) resulting in the familiar multiplier effect. The second-, third-, fourth-, and all subsequent-round effects are included along with the direct effects measured by the technical coefficients in the interdependence coefficients (described in the next section).

Interdependence Coefficients Table

The interdependence coefficients (multiplier) table (Table 6) is derived from the technical input-output coefficients table. Computationally,

TABLE 6. INPUT-OUTPUT INTERDEPENDENCE COEFFICIENTS TABLE FOR A HYPOTHETICAL THREE-SECTOR EXPORT-BASED ECONOMIC SYSTEM

Selling Sector	Purchasing Sector		
	(1) Agr	(2) Mfg	(3) T&S
(1) Agr	1.1430	.2454	.1077
(2) Mfg	.1024	1.3891	.0678
(3) T&S	.7514	.4522	1.1470
Total Multipliers	1.9968	2.0867	1.3225

it is the inverse of the I-A matrix, or $[I-A]^{-1}$. It shows the total (direct and indirect) input requirements that must be obtained from the row sector per dollar of output for final demand by the column sector. Each coefficient includes the direct input requirement (from the technical coefficients or direct requirements table) and the indirect input requirement (resulting from the multiplier effect). Column totals of this table are the total output requirements of all the row sectors per dollar of output for export (or final demand) by the column sector. These column totals are called gross receipts multipliers.

The numbers in the columns of Table 6 are the total input requirements per unit of output produced for final demand. For example, for each dollar of output that agriculture produces for final demand, agriculture must supply a total input of $1.14, manufacturing must supply $.10 of input, and the trade and service sector must supply $.75 of input; this results in a total input requirement of $1.99 from all firms in the local economy. Additional purchases will also be made of imports, but these inputs will not result in an indirect multiplier effect within the local economy. The 1.9968 in column 1, Table 6, is the total final demand multiplier for the agriculture sector. The 1.14 multiplier in column 1, Table 6, consists of $1.00 (or the initial dollar) of output for final demand, $0.06 of direct inputs from other farmers (Table 5), and $0.08 is the remaining or indirect requirements purchased from other farmers. Similar interpretations hold for other columns of Table 6.

Each interdependence coefficient is the total input requirement from the row sector per unit of output produced for final demand by the column sector. Total dollar inputs required from all sectors for a given level of output for final demand by a sector may be found by multiplying that sector's output for final demand by its column of interdependence coefficients. For example, sector 1 or agriculture produces $71 million of output for final demand (Table 4). The total input requirement generated in other sectors by that $71 million is delineated below:

From	Total (Direct and Indirect) Requirements
1. Agr	1.1430 x $71 million = $ 81.15 million
2. Mfg	.1024 x $71 million = $ 7.27 million
3. T&S	.7514 x $71 million = $ 53.35 million
Total	1.9968 x $71 million = $141.77 million

The total production of all sectors that is generated, directly and indirectly, by the $71 million of agricultural production produced for final demand is $141.77 million (which includes the original $71 million of farm production).

Similarly, total dollar input requirements from a sector for given levels of output for final demand by all the sectors may be found by multiplying the interdependence coefficients for that row sector (Table 6) by the levels of final demand for the output of the respective sectors. From the hypothetical example in Table 4, these levels of final demand for the output of sectors 1, 2, and 3, respectively, are $71 million, $25 million, and $118 million. The total input requirements from sector 2 are as follows:

From	Total (Direct and Indirect) Requirements
1. Agr	.1024 x $ 71 million = $ 7.27 million
2. Mfg	1.3891 x $ 25 million = $34.73 million
3. T&S	.0678 x $118 million = $ 8.00 million
Total	$50.00 million

The total of $50.00 million of gross input from sector 2 is (and should be) identical to its gross receipts recorded in the transactions table (Table 4).

Assumptions and Limitations

The input-output model is based on two fundamental assumptions. The most restrictive assumption is that the direct coefficients are fixed. This implies constant technology, no external economies or diseconomies exist, and no substitution occurs due to changes in relative prices or availability of new materials. The fixed coefficients assumption restricts the use of input-output as a long-range forecasting technique.

The other assumption of the basic input-output model is that there are no errors of aggregation in combining firms into sectors. This implies that the coefficients for a sector are representative of all the firms within that sector. The more sectors within the model and the less complex the area's economy, the less chance errors of aggregation will arise.

History of the North Dakota Input-Output Model

Development of an input-output model for North Dakota has taken place during the past 20 years. Research and development of input-output analysis in North Dakota was initiated and has been conducted under the direction of Dr. Thor A. Hertsgaard, professor of Agricultural Economics at North Dakota State University. The first attempt to study intersector relationships of a local community in the state was undertaken by Stadig in 1963 (Stadig 1964). Expenditures data were collected from a sample of farmers (10 percent); nonfarm and nonbusiness households (8 percent); and business, social, and government organizations (100 percent) in the Lisbon area (i.e., the nine square block of townships in Ransom County in which Lisbon is centrally located). Expenditures were aggregated into 16 sectors, and the corresponding transactions, technical coefficients, and interdependence coefficients tables were constructed using input-output theory (as previously discussed). Interdependence coefficients were used to measure primary and secondary income for each sector and impacts of the respective sectors were analyzed for the local community. This research involved only a small geographic area with a rather simple economic structure, so it therefore was not deemed to be applicable to other state areas. However, the development of these multipliers was the first step toward development of the North Dakota I-O model.

Initially, the North Dakota I-O model was developed to analyze the economic impacts of irrigation development associated with the Garrison Diversion Project. A survey was undertaken to collect expenditures data from firms, households, and governmental units in the seven southwestern North Dakota counties of Adams, Bowman, Golden Valley, Hettinger, Billings, Slope, and Stark (Sand 1966; Bartch 1967). This area was chosen because (1) the area included a city (Dickinson) which serves as a trade center of a multicounty economic area, (2) the area had several towns (Beach, Bowman, Dickinson, Hettinger, and Mott) that served as centers of trade for their respective subareas, (3) each subarea trade center was at least 40 miles from the others and the major trade center was the only one within a 100-mile radius, and (4) the area was primarily agricultural with both small grain and livestock enterprises. The major problem encountered was the cost of undertaking such an extensive data-gathering effort. However, data were collected, and a 30-sector input-output model was developed. The resultant multipliers were used to evaluate the role of a region's trade center and to estimate the impact of the Garrison Diversion Unit.

The original 30-sector input-output model was later delineated into 21 economic sectors, and the interdependence coefficients were derived (Lutovsky 1968). Primary income of the basic sectors in the economy, or sales for final demand, were applied to the interdependence coefficients to estimate gross income of each sector. North Dakota was divided into 12 trade areas, and published estimates of state personal income were disaggregated to correspond with the trade areas. Estimates of personal income obtained from the two sources were compared for differences at the state and trade area levels. Results of the comparisons were favorable; all but two trade areas had percentage differences less than 11 percent, and the state difference was 5.41 percent for 1960. The conclusion was drawn that the interdependence coefficients could be used for economic analysis for other trade areas and at the state level with an acceptable degree of accuracy.

Subsequently the interdependence coefficients were evaluated for reliability over a longer time period (1958-1968) by determining sales for final demand for each year during the period and applying these values to the coefficients to obtain estimates of personal income (Senechal 1971). For this analysis the state was divided into eight regions and personal income was disaggregated to correspond to these regions. Methodology for estimating income from basic economic sectors (or sales for final demand) was developed, and final demand vectors were calculated for each basic sector and state region for 1958 to 1968. These final demand vectors were applied to the interdependence coefficients to estimate gross business volume and personal income at the state and regional levels. Personal income estimates at the state level were very accurate, and substate estimates were reliable within certain limitations. Conclusions from this study were that the interdependence coefficients developed in southwestern North Dakota were valid for other parts of the state and that the model should be aggregated into fewer sectors.

Accordingly, the I-O model was aggregated into a 13-sector model and remained unchanged for many years. As previously mentioned, the principal intended use for which input-output coefficients initially were assembled in North Dakota was for projecting the economic impacts of irrigation development in the state. However, since the data were collected, a wide variety of applications has been made. The major use of the model during the 1970s was for estimating the economic impacts of coal resource development.

The model developed from the original expenditures data had only one sector to describe the various mining activities within the state. This sector reflected the characteristics of firms in southwestern North Dakota that were engaged in sand and gravel mining but did not include such activities as coal and petroleum mining. The omission of coal and petroleum mining was not a serious deficiency in the model as long as the major component of the state's economic base was agriculture and as long as there were no important interdependencies of other economic sectors with coal and petroleum mining. However, the increasing importance of mining as a component of the state's economic base and the prospects for accelerated development of coal conversion facilities in the state resulted in a need for more detailed input-output data for the energy sectors.

Collection of expenditures data in North Dakota from firms in four additional sectors related to energy production was undertaken in 1975 (Hertsgaard et al. 1976). These sectors were coal mining, thermal-electric power generation, petroleum and natural gas extraction, and petroleum refining. Expenditures data for the energy-related industries were used to obtain technical coefficients for the four additional economic sectors. These coefficients were appended to the technical coefficients for the 13-sector model to obtain a 17 by 17 matrix of technical coefficients for the 17-sector model. The interdependence coefficients for the 17-sector model were then computed by inverting the [I-A] matrix of that model.

The 17-sector I-O model has been used extensively since its development and has been especially useful for analyzing impacts resulting from energy development. Energy development in the state has declined considerably since 1983, but the I-O model has been used for other purposes, such as economic contribution studies and analysis of impacts associated with industrial development in the state. Although the model has not been changed in recent years, it is possible to adjust the I-O model to reflect changes in the state's economic base. This process involves collecting expenditures data and augmenting the current I-O matrix as previously discussed. Changing and refining the North Dakota I-O model over time has made it more accurate and useable and gives a good indication of its importance to researchers for economic analyses, such as forecasting, contribution studies, and impact analysis.

North Dakota Input-Output Model

The current version of the North Dakota I-O model groups the state's economy into 17 industrial classifications, or sectors. Sector delineations and corresponding Standard Industrial Classifications (SIC) are presented in Table 7. These groupings were used to identify expenditures (i.e., transactions table) and basic economic sectors. Thus, input-output interdependence coefficients and sales for final demand were determined according to these categories.

Expenditures data previously gathered (Sand 1966; Bartch 1967; Hertsgaard et al. 1976) were the basis for the current I-O model's transactions table. Using methodology previously discussed, the transactions table was converted into an input-output technical coefficients table for the North Dakota economy (Table 8). Input-output interdependence coefficients (multipliers) were derived from the technical coefficients by inverting the I-A matrix, or computationally $[I-A]^{-1}$. The resultant 17-sector North Dakota input-output interdependence coefficients are presented in Table 9.

Although the input-output interdependence coefficients have been discussed in great detail in an earlier section of this report, a brief explanation of the North Dakota multipliers will be presented to facilitate

TABLE 7. ECONOMIC SECTORS AND ASSOCIATED STANDARD INDUSTRIAL CLASSIFICATION CODES FOR THE NORTH DAKOTA INPUT-OUTPUT MODEL

Economic Sector	SIC Code
1. Agriculture, Livestock	Major Group 02 - Agricultural Production, Livestock
2. Agriculture, Crops	Major Group 01 - Agricultural Production, Crops
3. Nonmetallic Mining	Major Group 14 - Mining and Quarrying of Nonmetallic Minerals, Except Fuels
4. Contract Construction	Major Groups 15, 16, 17 - Contract Construction
5. Transportation	Major Groups 40, 41, 42, 43, 44, 45, 46, and 47 - Transportation
6. Communications and Utilities	Major Group 48 - Communication, and Major Group 49 - Electric, Gas, and Sanitary Services, Except Industry No. 4911
7. Agricultural Processing and Miscellaneous Manufacturing	Major Group 50 and 51 - Wholesale Trade, Major Group 20 - Food and Kindred Products Manufacturing
8. Retail Trade	Major Groups 52, 53, 54, 55, 56, 57, 58, and 59 - Retail Trade
9. Finance, Insurance, and Real Estate	Major Groups 60, 61, 62, 63, 64, 65, 66, and 67 - Finance, Insurance, and Real Estate
10. Business and Personal Services	Major Groups 70, 72, 73, 75, 76, 78, and 79 - Business and Personal Services
11. Professional and Social Services	Major Groups 80, 81, 82, 83, 84, 86, 88, and 89 - Professional and Social Services
12. Households	Not Applicable
13. Government	Major Groups 91, 92, 93, 94, 95, 96, and 97 - Government
14. Coal Mining	Major Group 12 - Bituminous Coal and Lignite Mining
15. Thermal-Electric Generation	Major Group 491 - 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

SOURCE: Office of Management and Budget 1972.

TABLE 8. INPUT-OUTPUT TECHNICAL COEFFICIENTS FOR 17-SECTOR MODEL, NORTH DAKOTA

Sector	(1) Ag, Lvstk	(2) Ag, Crops	(3) Nonmetallic Mining	(4) Const	(5) Trans	(6) Comm & Pub Util	(7) Ag Proc & Misc Mfg	(8) Retail Trade	(9) FIRE
(1) Ag, Livestock	0.0937	0.0019	0.0000	0.0000	0.0000	0.0000	0.0742	0.0575	0.0000
(2) Ag, Crops	0.1535	0.0210	0.0000	0.0000	0.0000	0.0000	0.3476	0.0013	0.0011
(3) Nonmetallic Mining	0.0024	0.0020	0.0348	0.0265	0.0059	0.0007	0.0006	0.0003	0.0002
(4) Construction	0.0014	0.0175	0.0000	0.0129	0.0013	0.0174	0.0010	0.0093	0.0016
(5) Transportation	0.0042	0.0018	0.0208	0.0051	0.0014	0.0077	0.0024	0.0067	0.0033
(6) Comm & Public Util	0.0068	0.0035	0.0864	0.0118	0.0224	0.0414	0.0059	0.0207	0.0434
(7) Ag Proc & Misc Mfg	0.2737	0.0693	0.0000	0.0000	0.0000	0.0000	0.3671	0.0002	0.0201
(8) Retail Trade	0.0601	0.2920	0.0965	0.1016	0.1560	0.0384	0.0090	0.0582	0.0808
(9) Fin, Ins, Real Estate	0.0115	0.0525	0.0170	0.0147	0.0314	0.0240	0.0044	0.0097	0.0077
(10) Bus & Pers Services	0.0028	0.0253	0.0079	0.0036	0.0134	0.0050	0.0010	0.0019	0.0278
(11) Prof & Soc Services	0.0026	0.0019	0.0019	0.0012	0.0014	0.0019	0.0005	0.0015	0.0049
(12) Households	0.3416	0.4316	0.4258	0.3239	0.4209	0.4477	0.0430	0.1779	0.6956
(13) Government	0.0100	0.0202	0.0159	0.0055	0.1992	0.0398	0.0029	0.0064	0.0184
(14) Coal Mining	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
(15) Thermal-Elec Generation	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

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TABLE 8. INPUT-OUTPUT TECHNICAL COEFFICIENTS FOR 17-SECTOR MODEL, NORTH DAKOTA (CONTINUED)

Sector	(10) Bus & Pers Service	(11) Prof & Soc Service	(12) Households	(13) Govt	(14) Coal Mining	(15) Thermal-Elec Generation	(16) Pet Exp/Ext	(17) Pet Refining
(1) Ag, Livestock	0.0000	0.0005	0.0097	0.0000	0.0000	0.0000	0.0000	0.0000
(2) Ag, Crops	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
(3) Nonmetallic Mining	0.0011	0.0005	0.0015	0.0000	0.0002	0.0000	0.0005	0.0000
(4) Construction	0.0103	0.0147	0.0498	0.0000	0.0108	0.0059	0.0857	0.0035
(5) Transportation	0.0059	0.0019	0.0009	0.0000	0.0031	0.0009	0.0137	0.0033
(6) Comm & Public Util	0.0536	0.0394	0.0443	0.0000	0.0215	0.0024	0.0230	0.0021
(7) Ag Proc & Misc Mfg	0.0000	0.0010	0.0016	0.0000	0.0241	0.0339	0.0000	0.0000
(8) Retail Trade	0.0911	0.1420	0.4129	0.0000	0.0642	0.0078	0.0125	0.0021
(9) Fin, Ins, Real Estate	0.0267	0.0223	0.0961	0.0000	0.0017	0.0512	0.0009	0.0005
(10) Bus & Pers Services	0.0209	0.0030	0.0328	0.0000	0.0018	0.0018	0.0004	0.0000
(11) Prof & Soc Services	0.0037	0.0347	0.0593	0.0000	0.0066	0.0033	0.0004	0.0002
(12) Households	1.3697	0.5654	0.0683	0.0000	0.3738	0.1207	0.1309	0.0302
(13) Government	0.0216	0.0104	0.0579	0.0000	0.0014	0.0134	0.0004	0.0028
(14) Coal Mining	0.0000	0.0000	0.0000	0.0000	0.0000	0.1582	0.0003	0.0000
(15) Thermal-Elec Generation	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	0.0893	0.7492
(17) Pet Refining	0.0000	0.0000	0.0000	0.0000	0.0168	0.0075	0.0000	0.0000

TABLE 9. INPUT-OUTPUT INTERDEPENDENCE COEFFICIENTS, BASED ON TECHNICAL COEFFICIENTS FOR 17-SECTOR MODEL, NORTH DAKOTA

Sector	(1) Ag, Lvstk	(2) Ag, Crops	(3) Nonmetallic Mining	(4) Const	(5) Trans	(6) Comm & Pub Util	(7) Ag Proc & Misc Mfg	(8) Retail Trade	(9) FIRE
(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) Nonmetallic Mining	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 & Public Util	0.0921	0.0836	0.1556	0.0604	0.0839	1.1006	0.0766	0.0529	0.1321
(7) Ag Proc & Misc Mfg	0.5730	0.1612	0.0272	0.0207	0.0277	0.0239	1.7401	0.0452	0.0704
(8) Retail Trade	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) Thermal-Elec Generation	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

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TABLE 9. INPUT-OUTPUT INTERDEPENDENCE COEFFICIENTS, BASED ON TECHNICAL COEFFICIENTS FOR 17-SECTOR MODEL, NORTH DAKOTA (CONTINUED)

Sector	(10) Bus & Pers Service	(11) Prof & Soc Service	(12) Households	(13) Govt	(14) Coal Mining	(15) Thermal-Elec Generation	(16) Pet Exp/Ext	(17) Pet Refining
(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) Nonmetallic Mining	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 & Public Util	0.1104	0.1192	0.1055	0.0000	0.0712	0.0378	0.0510	0.0444
(7) Ag Proc & Misc Mfg	0.0237	0.0362	0.0417	0.0000	0.0618	0.0782	0.0097	0.0089
(8) Retail Trade	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) Thermal-Elec Generation	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

their interpretation. In this discussion, coefficients from Table 9 will be rounded to two decimal places (or cents) to make the interpretation more easily understood. Each number in the interdependence coefficients table indicates the total output that is required by the row sector per dollar of output for export from North Dakota by the column sector. For example, Table 9 indicates that each dollar of livestock production for export from the state will generate a gross income in the livestock sector of $1.21 (the $1.00 of livestock production for export from the state plus $0.21 of output by the livestock sector for replacement of breeding stock as well as for the livestock products that are produced within the state and consumed by anyone in the state who is involved, directly or indirectly, in the production of livestock for export from the state). Similarly, each dollar of livestock production will generate a gross income of $0.39 to the crops producing sector, $0.57 to the agricultural processing and miscellaneous manufacturing sector, $0.71 to the retail trade sector, $1.05 to the household sector (including any profits of the livestock producer but consisting mostly of personal income in the form of wages and salaries, rents, and profits of others in the state who are involved, directly or indirectly, in the production of livestock), and a total gross income of all sectors in the state of $4.49. Thus, each dollar of income received from the export of livestock from the state "turns over" about four and one-half times within the state. Likewise, it can be said that each dollar of income from the export of crops from North Dakota "turns over" about 3.7 times in the state or that the crops "multiplier" is 3.7.

The multiplier effect results when each producing sector buys some fraction of its inputs from other sectors of the state's economy and these sectors, in turn, use some fraction of that income to buy some of their inputs from still other sectors, and so on. In other words, the multiplier effect is due to the spending and respending within the state's economy of part of each dollar that enters the state through payment for products that are exported from the state. The multipliers for livestock products (4.49) and crops (3.69) do not imply that these products cost that amount to produce. (Each dollar of output costs $1.00 to produce, where any profit is part of the cost.) It simply means that the dollar that was received from the export of livestock was spent an additional 3.49 times (making a total of $4.49 of income to all sectors in the state) before the dollar leaves the state, and the dollar received from the export of crops is spent another 2.69 times by others (for a total income of all sectors of $3.69).

Examination of the gross receipts multipliers in Table 9 reveals substantial differences in these values among the different sectors. These differences in multiplier values arise in large measure from variation in the extent to which the respective sectors purchase their inputs from in-state suppliers (versus buying them from entities located outside the state). The substantial differences in multiplier values also suggest that one of the major strengths of input-output in analyzing economic change in an increasingly diversified economy is the capability of input-output to account for such differences. That is, an analysis using input-output methods will reflect differences in the magnitude of multiplier effects among sectors whereas the economic base technique assumes that an initial increase in basic employment has the same effect regardless of the basic industry (e.g., agriculture versus mineral extraction) in which it occurs.

The input-output model used to describe the North Dakota economy 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 that 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.

North Dakota Sales for Final Demand

The input-output analysis used in this model assumes that economic activity in a region is dependent upon the basic industries that exist in the 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). North Dakota's economic base is comprised of those activities producing a product paid for by nonresidents, or products exported from the state. Included in these economic base activities are agriculture (livestock and crop production plus government payments for agricultural programs), mining, manufacturing, tourist expenditures for retail purchases and business and personal services, and federal government outlays for construction and to individuals (Coon, Vocke, and Leistritz 1984b). These basic economic activities are classified into economic sectors in accordance with the delineations in Table 7 as follows: (1) Agriculture, Livestock; (2) Agriculture, Crops; (4) Contract Construction; (7) Agricultural Processing and Miscellaneous Manufacturing; (8) Retail Trade; (10) Business and Personal Services; (12) Households; (14) Coal Mining; (15) Thermal-Electric Generation; (16) Petroleum and Natural Gas Exploration/Extraction; and (17) Petroleum Refining.

Data used in estimating the sales for final demand were obtained from a wide variety of secondary sources. For a complete discussion of data sources and methodology used to estimate the final demand vectors, see Hertsgaard et al. (1977). Table 10 presents the North Dakota sales for final demand. Final demand vectors are expressed here in terms of the prices that existed in that year (current year dollars). However, for some purposes it is desirable to adjust the values for each year by an index of year-to-year price changes so as to remove the effects of price changes. One index frequently used for this adjustment is the Gross National Product Implicit Price Deflator (Table 11).

Adjustment by such an index results in measures that are intended to indicate the real value of sales to final demand (by removing economy-wide price effects). The measures computed by such a procedure represent their purchasing power in terms of the prices that existed in a given year (referred

TABLE 10. SALES FOR FINAL DEMAND, BY ECONOMIC SECTOR, NORTH DAKOTA, (CURRENT DOLLARS), MILLION DOLLARS, 1958-1984

Year	(1) Ag, Lvstk	(2) Ag, Crops	(4) Constr	(7) Ag Proc & Misc Mfg	(8) Retail Trade	(10) Bus & Pers Serv	(12) Households[a]	(14) Coal Mining	(15) Thermal-Elec Gen	(16) Pet Exp/Ext	(17) Pet Refining	Total
1958	220.3	440.3	18.3	62.5	16.5	5.5	187.0	1.1	0.0	5.4	13.1	970.0
1959	217.3	394.9	27.2	57.0	18.0	6.0	186.5	1.0	0.0	10.9	12.9	931.7
1960	175.4	390.9	32.7	66.1	14.9	5.0	187.9	1.0	0.0	14.5	12.5	900.9
1961	213.9	341.7	24.0	67.5	17.2	5.8	237.2	1.3	0.0	21.0	12.6	942.2
1962	199.3	476.8	16.5	62.6	18.7	6.3	344.2	1.5	0.0	22.8	12.5	1,161.2
1963	207.7	543.1	17.1	73.0	21.7	7.2	334.5	1.3	0.0	23.3	12.5	1,241.4
1964	213.3	451.2	30.2	78.4	26.2	8.7	485.2	1.5	0.0	25.9	12.7	1,333.3
1965	247.5	554.5	31.0	78.4	33.0	11.0	361.4	1.5	0.0	28.0	13.4	1,359.7
1966	271.5	609.4	23.3	84.2	45.0	15.0	428.6	1.3	4.4	29.7	14.0	1,526.4
1967	280.9	568.4	24.4	91.7	54.7	18.2	380.8	2.1	8.4	28.0	14.6	1,472.2
1968	264.2	570.5	27.0	101.5	69.7	23.2	447.9	2.4	12.3	34.3	14.7	1,567.7
1969	265.0	641.8	35.2	162.0	75.8	25.3	501.5	2.4	11.7	26.2	14.9	1,761.8
1970	272.5	671.0	182.1	148.1	85.7	28.5	567.7	3.2	13.8	30.3	15.2	2,018.1
1971	304.7	673.7	60.7	162.0	93.8	31.3	605.1	3.5	17.5	32.9	15.9	2,001.1
1972	376.4	975.0	72.9	170.0	86.3	28.8	649.0	3.3	21.4	34.6	16.8	2,434.5
1973	475.9	1,795.7	61.6	243.0	94.5	31.5	726.7	4.1	19.3	38.4	19.1	3,509.8
1974	448.5	2,072.1	72.4	304.8	92.6	31.1	806.0	4.9	22.4	76.1	22.6	3,953.5
1975	452.8	1,555.8	82.9	306.6	112.5	37.5	1,046.9	7.1	20.6	84.3	25.9	3,732.0
1976	484.3	1,194.3	44.9	467.2	134.2	44.8	1,066.7	16.0	38.6	100.8	27.0	3,618.8
1977	483.3	1,178.6	51.7	408.1	143.6	47.8	1,076.7	18.2	46.3	102.0	29.2	3,585.5
1978	529.4	1,615.2	65.8	435.8	165.0	54.9	1,157.8	22.0	65.4	108.5	30.8	4,250.6
1979	694.1	1,692.6	78.0	523.8	147.5	49.2	1,381.9	32.2	91.6	182.5	46.9	4,920.3
1980	781.4	1,721.6	108.1	562.2	144.5	48.2	1,687.4	48.3	120.1	410.4	74.3	5,706.5
1981	594.0	2,339.5	78.8	616.3	160.4	53.5	1,896.5	54.5	140.8	973.1	131.8	7,039.2
1982	604.5	2,306.0	56.0	526.5	167.2	55.7	1,598.2	57.8	162.0	857.3	121.3	6,512.5
1983	662.7	2,607.2	79.7	537.0	196.4	65.5	1,936.5	76.7	196.4	782.8	112.8	7,253.7
1984	660.1	2,361.3	111.6	572.5	176.8	58.9	2,131.7	96.3	226.3	719.9	109.4	7,224.8

[a]Household sector sales for final demand include oil lease bonus payments as estimated by Coon, Anderson, and Leistritz (1986).

TABLE 11. GROSS NATIONAL PRODUCT IMPLICIT PRICE DEFLATORS FOR 1980 BASE

Year	GNP Implicit Price Deflators
1958	37.23
1959	38.12
1960	38.74
1961	39.10
1962	39.81
1963	40.44
1964	41.02
1965	41.95
1966	43.29
1967	44.58
1968	46.54
1969	48.95
1970	51.58
1971	54.12
1972	56.40
1973	59.61
1974	64.82
1975	70.80
1976	74.50
1977	78.87
1978	84.62
1979	91.80
1980	100.00
1981	110.23
1982	116.80
1983	121.41
1984	125.96

SOURCE: U.S. Department of Commerce 1972-1985.

to as the base year, which in Table 11 is 1980) and are frequently referred to as constant dollar prices. The Gross National Product Implicit Price Deflator reflects the composite of all individual prices in the economy, some prices increased by more than the deflator suggests and others increased less (or even decreased). Thus, a sector whose product prices rise more rapidly than the general rate of inflation (as occurred in the oil extraction sector during the late 1970s and early 1980s) will realize an increase in purchasing power beyond that due to the increase in physical output.

Use of the Implicit Price Index assumes that a single index was applicable for all sectors of the economy for a given year. The methodology was rather simple--current year dollar final demand vectors were divided by their respective Implicit Price Index to determine 1980 base dollar sales for final demand. Current year dollar input-output tables for North Dakota will be presented in the text, and Appendix B contains tables that provide data for constant dollar (1980 prices) final demand vectors, gross business volumes, and productivity ratios.

North Dakota 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 either baseline or project/industry and either historic or projected. Multipliers applied to the historic North Dakota final demand vectors yield estimates of the state's historic gross business volumes (Table 12). If the multipliers are applied to sales for final demand in current dollars, the resultant gross business volumes also are in terms of current year dollars (and constant dollar final demand vectors applied to the multipliers yield constant dollar gross business volumes). Gross business volumes are the total dollars of business activity that take place when the state's exported products bring money into the state and these dollars "turn over" via the multiplier process.

When using input-output analysis to measure the economic impact of a given development, the in-state expenditures to each respective sector are applied to the multipliers. Resultant values are more properly called levels of business activity. The methodology remains the same, but terminology is slightly different because sales for final demand for the state (in-state expenditures for a development) are applied to the multipliers yielding gross business volume (total level of business activity). Contribution studies use terminology similar to impact assessments.

Gross business volume of the household sector (Sector 12) is, by definition, personal income. 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. One point to remember is that Department of Commerce personal income estimates are reported in current year dollars so final demand vectors used to make these comparisons also must be in similar terms. For the time period 1958 to 1984, estimates of North Dakota personal income from the input-output model had an average deviation of 5.47 percent from Department of Commerce estimates (Table 13). The Theil's coefficient of .066 also indicates the model is quite accurate for predictive purposes. 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 [1981] and Pindyck and Rubinfeld [1981].)

North Dakota 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 were available from information published annually (North Dakota Employment Security Bureau 1958-1984) and disaggregated to correspond with the sectors of the input-output model (Table 14). Gross business volume for each sector was

TABLE 12. GROSS BUSINESS VOLUMES OF ECONOMIC SECTORS ESTIMATED BY THE INPUT-OUTPUT MODEL, NORTH DAKOTA, MILLION DOLLARS, 1958-1984

Year	(1) Ag, Lvstk	(2) Ag, Crops	(3) Nonmetallic Mining	(4) Const	(5) Trans	(6) Comm & Pub Util	(7) Ag Proc & Misc Mfg	(8) Retail Trade	(9) FIRE	(10) Bus & Pers Service	(11) Prof & Soc Service	(12) House-holds	(13) Govt	(14) Coal Mining	(15) Thermal-Elec Generation	(16) Pet Exp/Ext	(17) Pet Refining
1958	327.2	614.1	7.0	93.6	11.6	85.1	315.3	725.8	151.0	63.9	67.5	1,022.4	91.7	1.1	--	16.8	13.1
1959	319.5	560.0	6.9	99.4	11.2	81.5	296.9	689.8	143.2	61.2	64.6	978.4	87.2	1.0	--	22.7	12.9
1960	270.4	545.0	6.8	102.7	10.7	78.4	288.2	662.0	137.9	58.2	62.1	942.5	83.8	1.0	--	26.3	12.5
1961	316.7	508.7	6.8	97.9	11.3	83.2	306.8	687.8	143.7	60.8	66.5	1,011.5	88.2	1.3	--	33.5	12.6
1962	315.7	650.1	8.0	109.3	13.5	103.8	316.1	863.5	181.1	75.8	84.2	1,285.8	110.6	1.5	--	35.4	12.5
1963	332.7	732.5	8.5	115.8	14.4	110.2	349.5	926.9	193.6	81.8	88.8	1,353.9	117.8	1.3	--	36.0	12.5
1964	344.5	642.2	9.3	137.2	15.2	120.7	354.1	984.1	206.7	87.3	99.2	1,521.2	127.3	1.5	--	39.0	12.7
1965	386.2	765.4	9.6	138.2	15.9	120.2	385.6	1,010.6	209.2	91.4	96.5	1,470.1	127.8	1.5	--	41.9	13.4
1966	426.1	840.9	10.4	143.6	17.7	135.5	421.9	1,141.0	235.2	105.2	109.0	1,662.4	143.7	2.0	4.4	44.3	14.1
1967	433.6	803.9	10.1	138.9	17.2	129.5	432.6	1,098.6	224.1	104.1	103.4	1,573.0	137.1	3.4	8.4	42.9	14.7
1968	421.9	808.5	10.6	148.9	18.1	138.0	444.5	1,169.1	236.7	113.7	110.5	1,684.5	145.1	4.4	12.3	50.0	14.9
1969	444.3	927.7	12.0	171.2	20.3	154.9	564.3	1,315.0	266.7	127.4	124.0	1,891.0	163.2	4.3	11.7	41.2	15.1
1970	463.6	957.7	17.1	334.6	22.9	174.1	555.7	1,460.7	295.7	141.0	138.7	2,117.3	181.3	5.4	13.8	46.0	15.4
1971	504.7	982.2	14.0	214.8	22.9	176.0	598.6	1,485.4	300.3	145.7	141.2	2,156.6	184.4	6.3	17.5	49.5	16.1
1972	618.8	1,345.8	17.3	261.2	28.0	213.4	704.2	1,814.2	371.0	171.1	170.8	2,601.4	226.1	6.7	21.4	52.1	17.1
1973	822.2	2,330.9	24.4	334.2	40.5	305.3	1,023.9	2,662.2	546.4	244.0	242.1	3,674.7	328.7	7.2	19.3	58.2	19.4
1974	828.6	2,664.6	27.4	381.2	45.6	341.7	1,164.4	2,974.8	612.8	269.9	270.3	4,104.7	367.7	8.5	22.4	102.5	22.9
1975	813.0	2,110.9	25.7	375.7	42.7	327.5	1,098.2	2,773.5	570.7	257.0	262.8	4,009.8	347.0	10.4	20.6	113.5	25.3
1976	857.0	1,834.5	23.7	325.3	41.7	316.5	1,340.8	2,641.1	541.5	251.4	253.0	3,861.0	331.7	22.1	38.6	133.6	27.7
1977	845.5	1,779.7	23.6	329.6	41.2	313.4	1,236.6	2,618.3	535.1	251.6	250.9	3,829.5	328.0	25.6	46.3	136.8	30.0
1978	949.1	2,296.5	28.1	394.3	48.6	369.0	1,388.3	3,126.8	638.3	299.3	294.1	4,481.3	388.7	32.4	65.4	145.5	31.8
1979	1,186.9	2,510.2	32.6	461.2	56.9	426.4	1,660.4	3,533.3	731.9	328.0	340.3	5,187.2	447.3	46.8	91.6	240.4	48.4
1980	1,328.7	2,612.5	37.7	561.7	67.0	488.7	1,800.8	3,937.0	822.6	359.7	388.5	5,930.5	505.3	67.4	120.1	513.8	76.3
1981	1,185.7	3,259.0	43.8	660.5	85.0	581.4	1,904.1	4,626.5	965.3	421.0	451.7	6,899.5	591.0	77.1	140.8	1,179.6	134.2
1982	1,157.1	3,160.3	40.3	589.1	78.6	535.1	1,736.6	4,313.0	895.5	397.2	413.8	6,305.3	546.3	83.7	162.0	1,044.0	123.9
1983	1,279.6	3,530.5	45.4	667.6	85.6	604.7	1,856.0	4,909.0	1,109.5	453.7	473.5	7,223.2	621.5	108.0	196.4	955.7	116.1
1984	1,276.9	3,290.0	45.7	694.6	84.2	606.5	1,887.3	4,861.9	1,018.1	444.3	479.5	7,324.8	622.5	132.3	226.3	884.3	113.3

TABLE 13. ESTIMATES OF PERSONAL INCOME AND DIFFERENCES IN ESTIMATES, NORTH DAKOTA, 1958-1984 (THOUSAND DOLLARS)

Year	Department of Commerce Estimate	I-O Analysis Estimate	Percent Difference
1958	--	1,022,412	--
1959	1,008,057	978,420	- 2.94
1960	--	942,488	--
1961	--	1,011,462	--
1962	1,460,980	1,285,790	-11.99
1963	--	1,353,864	--
1964	--	1,521,191	--
1965	1,497,762	1,470,129	- 1.84
1966	1,555,539	1,662,394	6.87
1967	1,595,042	1,573,010	- 1.38
1968	1,643,964	1,684,451	2.46
1969	1,850,417	1,890,973	2.19
1970	1,913,283	2,117,319	10.66
1971	2,158,416	2,156,642	- .08
1972	2,676,385	2,601,416	- 2.80
1973	3,841,862	3,674,738	- 4.35
1974	3,739,859	4,104,667	9.75
1975	3,755,431	4,009,827	6.77
1976	3,828,880	3,860,970	.84
1977	3,982,404	3,829,503	- 3.84
1978	4,798,839	4,481,331	- 6.62
1979	5,228,461	5,187,221	- 0.79
1980	5,657,789	5,930,502	4.72
1981	7,123,641	6,899,460	- 3.15
1982	7,306,383	6,305,332	-13.70
1983	7,936,951	7,223,150	- 8.99
1984	8,479,079	7,324,837	-13.61
Average Absolute Difference			5.47

Mean = -1.875 (S.D. = 6.626)

Theil's U_1 Coefficient = .066

divided by the corresponding employment for each respective sector and year to calculate the productivity ratios. Using gross business volumes generated by current year sales for final demand yielded productivity ratios also in terms of current dollars. Productivity ratios for North Dakota were calculated for the 1958 to 1984 period (Table 15).

Productivity ratios are particularly useful when conducting economic impact analysis or contribution studies. When in-state expenditures for a specific development are applied to the multipliers, the resultant gross business volumes can be divided by the productivity ratios to estimate

TABLE 14. EMPLOYMENT BY ECONOMIC SECTOR, NORTH DAKOTA, 1958-1984[a]

Year	(1) & (2) Ag	(3) Nonmetallic Mining	(4) Const	(5) Trans	(6) Comm & Pub Util	(7) Ag Proc & Misc Mfg	(8) Retail Trade	(9) FIRE	(10) Bus & Pers Service	(11) Prof & Soc Service	(12) House-holds	(13) Govt	(14) Coal Mining	(15) Thermal-Elec Generation	(16) Pet Exp/Ext	(17) Pet Refining	TOTAL
1958	99,670	130	14,430	6,558	7,995	16,448	36,400	5,070	12,474	14,067	--	30,260	380	60	1,903	335	246,180
1959	94,670	127	15,879	6,637	8,121	16,812	37,385	5,380	13,312	15,009	--	31,280	383	60	1,800	325	247,180
1960	91,750	123	13,860	6,585	8,032	16,608	37,627	5,580	13,613	15,350	--	31,500	383	60	1,344	315	242,730
1961	87,670	130	13,619	6,351	7,686	16,279	37,277	5,710	14,177	15,986	--	32,310	382	60	1,438	305	239,380
1962	87,670	115	15,644	6,225	7,629	16,789	36,352	5,940	14,634	16,501	--	33,920	381	60	1,274	296	243,430
1963	82,750	109	14,476	6,143	7,573	18,154	37,952	6,070	15,257	17,204	--	36,370	365	75	1,206	286	243,990
1964	78,000	113	15,291	6,071	7,503	19,055	39,226	6,230	15,804	17,821	--	38,740	349	83	1,278	276	245,840
1965	74,750	135	15,128	5,986	7,484	19,711	39,755	6,360	15,737	17,746	--	40,320	289	127	1,506	266	245,300
1966	70,660	135	12,071	6,033	7,667	20,085	40,235	6,450	16,076	18,129	--	42,080	354	188	1,441	266	241,870
1967	65,170	128	11,242	6,027	7,724	19,894	39,819	6,710	16,818	18,966	--	44,420	345	194	1,357	266	239,080
1968	63,500	125	10,565	5,941	7,680	20,335	40,119	6,740	17,329	19,542	--	47,240	337	193	1,328	256	241,230
1969	60,750	136	10,467	5,921	7,686	20,617	40,544	6,800	17,392	19,611	--	48,330	325	196	1,399	247	240,420
1970	51,920	132	12,407	5,721	7,012	19,796	40,049	6,422	17,598	19,851	--	44,920	334	239	1,003	216	227,620
1971	51,410	132	13,135	5,736	7,050	20,282	40,805	6,568	18,579	20,950	--	45,019	357	249	981	207	231,460
1972	51,580	129	14,884	5,677	7,089	21,713	42,945	6,809	19,406	21,884	--	45,927	374	269	934	200	239,820
1973	51,080	128	14,064	5,751	7,279	23,979	44,936	7,074	20,359	22,957	--	46,481	384	281	908	209	245,870
1974	52,670	137	14,869	5,874	7,486	26,022	46,639	7,479	21,387	24,118	--	47,527	356	312	1,033	201	256,110
1975	48,750	150	17,095	5,804	7,357	29,945	48,809	7,850	22,651	25,543	--	50,053	426	334	1,352	201	266,320
1976	51,250	156	19,363	5,941	7,611	30,772	52,205	8,397	23,658	26,679	--	51,633	514	354	1,645	202	280,380
1977	56,750	161	20,125	6,228	7,962	30,713	53,279	9,075	24,616	27,758	--	52,841	599	358	2,051	204	292,720
1978	54,270	165	22,555	6,690	8,583	32,326	54,437	9,627	26,090	29,421	--	55,079	742	363	2,996	206	303,550
1979	52,450	170	22,325	7,199	9,276	34,448	56,146	10,089	27,292	30,775	--	55,817	809	368	3,969	207	311,340
1980	52,680	175	19,996	7,525	9,724	32,701	55,928	10,532	28,114	31,704	--	56,057	970	386	6,066	212	312,770
1981	52,270	180	18,161	7,741	9,995	32,962	55,175	10,814	29,806	33,610	--	55,784	1,134	498	8,753	217	317,100
1982	51,870	184	19,240	7,620	9,722	32,469	55,960	10,845	31,299	35,295	--	55,596	1,302	553	7,202	193	319,350
1983	51,370	189	21,292	7,342	9,371	31,579	56,303	11,013	32,367	36,500	--	56,467	1,395	599	4,885	198	320,870
1984	50,870	194	17,528	7,530	9,546	32,380	58,358	11,242	33,453	37,725	--	57,123	1,557	646	5,065	203	323,420

[a]Includes nonagricultural self-employed, unpaid family and domestics (proprietors), and adjusted wage and salary employment (employees, not jobs).

TABLE 15. GROSS BUSINESS VOLUME TO EMPLOYMENT (PRODUCTIVITY) RATIOS, BY ECONOMIC SECTOR, NORTH DAKOTA, 1958-1984

Year	(1) & (2) Ag	(3) Nonmetallic Mining	(4) Const	(5) Trans	(6) Comm & Pub Util	(7) Ag Proc & Misc Mfg	(8) Retail Trade	(9) FIRE	(10) Bus & Pers Service	(11) Prof & Soc Service	(12) Households	(13) Govt	(14) Coal Mining	(15) Thermal-Elec Generation	(16) Pet Exp/Ext	(17) Pet Refining
1958	9,444	53,846	6,486	1,768	10,644	19,169	19,939	29,783	5,122	4,798	--	3,030	2,894	--	8,828	39,104
1959	9,290	54,330	6,259	1,687	10,035	17,659	18,451	26,617	4,597	4,304	--	2,787	2,610	--	12,611	39,692
1960	8,887	55,284	7,409	1,624	9,760	17,353	17,593	24,713	4,275	4,045	--	2,660	2,610	--	19,568	39,682
1961	9,414	52,307	7,188	1,779	10,824	18,846	18,451	25,166	4,288	4,159	--	2,729	3,403	--	23,296	41,311
1962	11,016	69,565	6,986	2,168	13,605	18,827	23,753	30,488	5,179	5,102	--	3,260	3,937	--	27,786	42,229
1963	12,872	77,981	7,999	2,344	14,551	19,251	24,422	31,894	5,361	5,161	--	3,238	3,561	--	29,850	43,706
1964	12,649	82,300	8,972	2,503	16,086	18,583	25,087	33,178	5,523	5,566	--	3,286	4,297	--	30,516	46,014
1965	15,406	71,111	9,135	2,656	16,060	19,562	25,420	32,893	5,807	5,437	--	3,169	5,190	--	27,822	50,375
1966	17,930	77,037	11,896	2,933	17,673	21,005	28,358	36,465	6,543	6,012	--	3,414	5,649	23,404	30,742	53,007
1967	18,988	78,906	12,355	2,853	16,765	21,745	27,589	33,397	6,189	5,451	--	3,086	9,855	43,298	31,613	55,263
1968	19,376	84,800	14,093	3,046	17,968	21,858	29,140	35,118	6,561	5,654	--	3,071	13,056	63,730	37,650	58,203
1969	22,584	88,235	16,356	3,428	20,153	27,370	32,433	39,220	7,325	6,322	--	3,376	13,230	59,693	29,449	61,133
1970	27,374	129,545	26,968	4,002	24,828	28,071	36,472	46,044	8,012	6,987	--	4,036	16,167	57,740	45,862	71,296
1971	28,922	106,060	16,353	3,992	24,964	29,513	36,402	45,721	7,842	6,739	--	4,096	17,647	70,281	50,458	77,777
1972	38,088	134,108	17,549	4,932	30,102	32,432	42,244	54,486	8,816	7,804	--	4,923	17,914	79,553	55,781	85,500
1973	61,728	190,625	23,762	7,042	41,942	42,699	59,244	77,240	11,984	10,545	--	7,071	18,750	68,683	64,096	92,822
1974	66,322	200,000	25,637	7,763	45,645	44,746	63,783	81,936	12,619	11,207	--	7,736	23,876	71,794	99,225	113,930
1975	59,977	171,333	21,977	7,356	44,515	36,673	56,823	72,700	11,346	10,288	--	6,932	24,413	61,676	83,949	125,870
1976	52,517	151,923	16,800	7,019	41,584	43,572	50,590	64,487	10,626	9,483	--	6,424	42,996	109,039	81,215	137,128
1977	46,259	146,583	16,377	6,615	39,361	40,263	49,143	58,964	10,220	9,038	--	6,207	42,737	129,329	66,699	147,058
1978	59,804	170,303	17,481	7,264	42,991	42,946	57,438	66,303	11,471	9,996	--	7,057	43,665	180,165	48,564	154,368
1979	70,488	192,012	20,660	7,904	45,971	48,201	62,930	72,542	12,019	11,058	--	8,013	57,794	248,913	60,578	233,696
1980	74,811	215,297	28,091	8,903	50,255	55,070	70,394	78,103	12,793	12,253	--	9,014	69,524	311,139	84,707	360,075
1981	85,034	243,533	36,367	10,977	58;170	57,768	83,851	89,267	14,125	13,439	--	10,594	67,983	282,730	134,764	618,212
1982	84,080	218,788	30,620	10,309	55,042	53,484	77,073	82,571	12,691	11,723	--	9,826	64,293	292,948	144,954	642,088
1983	93,635	240,042	31,356	11,662	64,527	58,772	87,188	92,571	14,018	12,973		11,007	77,439	327,880	195,633	586,323
1984	89,744	235,691	39,630	11,188	63,537	58,285	83,311	90,558	13,280	12,710		10,987	84,996	350,310	174,591	558,256

secondary (or indirect and induced) employment. Secondary employment is that which will arise as a result of the expenditures from the development as they are spent and respent throughout the economy by the multiplier process. This employment is in addition to the workers directly employed by the new project, and essentially comes into existence to serve and supply the new development. Impact analyses typically list direct and secondary employment resulting from a development. Estimating secondary employment by using productivity ratios provides sector-specific secondary employment estimates, contrasting to the aggregate ratio method (which assumes the ratio to be applicable to all sectors) characteristic of export base models. It should be noted that this method of estimating secondary employment will not conform to classic secondary/direct employment ratios. Because the dollar is considered the force that is necessary to create a job, industries that are more capital intensive (typically with greater levels of expenditure per direct job) will often have higher secondary/direct employment ratios.

Tax Revenue Estimation

Several state tax revenues can be estimated using the input-output model. These include state personal income tax, state corporate income tax, and sales and use tax collections. Tax revenue estimates are based on historic relationships between tax collections and input-output model estimates of gross business volumes for selected sectors. Tax rates calculated were based on state tax rates in existence in 1983 (Coon et al. 1984). Estimates of state personal income tax collections were based on the following relationship:

State personal income tax collections = 2.1 percent X personal income.

Personal income from the input-output model is the gross business volume of the household sector (Sector 12). The equation to estimate state corporate income tax collections is

State corporate income tax collections = .31 percent X gross business volume of all business sectors.

All business sectors consist of all sectors of the economy except for the agriculture (Sector 1 and Sector 2), households (Sector 12), and government (Sector 13) sectors. State sales and use tax collections were estimated based on the following formula:

State sales and excise tax collections = 4.06 percent X retail trade.

Retail trade is the gross business volume of the retail trade sector (Sector 8) of the input-output model. Caution should be used when applying the tax estimator rates as they were based on tax laws as they existed in 1983. If tax rates change, these estimators may not accurately predict tax revenues. Also, after a change in state tax rates a lag of a minimum of one year will occur before data are available to produce new estimators. More than one year's tax collection data should be available before new estimators are calculated if they are to be used with a high level of confidence.

Tax revenue estimators currently being used have been used in conjunction with impact analysis and contribution studies. Ratios developed at the state level are assumed to apply to single projects or industries. This means that the in-state expenditures for a particular development can be applied to the multipliers to yield levels of business activity. Applying the tax rate estimators to the business activity of the proper sectors will produce estimates of personal income, state income, and sales and excise tax revenues for North Dakota.

Regional Input-Output Model

The North Dakota input-output model has been used for analysis of substate regions with relative accuracy (Lutovsky 1968; Senechal 1971). Eight state planning regions have been defined with each having a major retail trade center (Figure 1). Each of these regions in effect is an economic system and, therefore, the multipliers can be applied to the economic base to provide estimates of business volumes. One set of interdependence coefficients was used for economic analysis of both state and substate regions when the I-O model consisted of 13 sectors. Expansion of the model to 17 sectors (Hertsgaard et al. 1977) resulted in an unusual occurrence; the petroleum refining sector had a large volume of exports from the producing region to other regions within North Dakota. Thus, separate technical coefficients tables were developed for the state and the state's regions. The resultant multipliers were slightly different for the state and the regions (Coon et al. 1984).

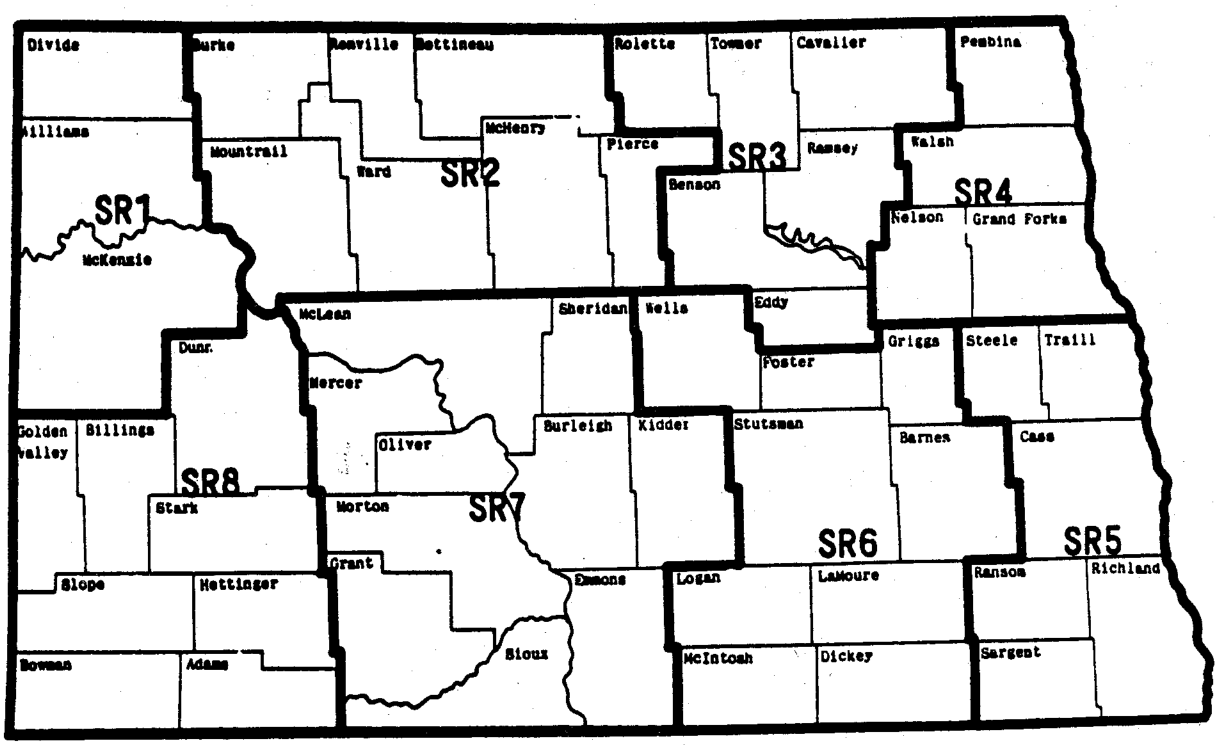

Figure 1. North Dakota State Planning Regions

Sales for final demand, gross business volumes, employment, productivity ratios, and model validation tables were developed for each of North Dakota's eight State Planning Regions (Coon et al. 1984). These tables will not be duplicated in this report, but it should be noted that all input-output analysis undertaken at the state level also has been completed at the regional level. Economic analysis using input-output at a regional level is handled in a similar manner; regional multipliers are applied to in-region expenditures to estimate regional business activity. This business activity can be divided by the region's respective productivity ratios to estimate secondary employment at this level. Also, state tax ratios can be applied to the proper business activity to determine estimated tax revenue collections. In essence, the methodology for input-output analysis is the same at the state or substate level, but the corresponding input-ouput tables used to perform the analysis may differ.

A brief comparison of regional personal income estimates from the Department of Commerce and the I-O model will be used to validate the model at the substate level. Table 16 presents a comparison of each region and the state for selected statistical tests. Income estimates vary more over time at the region level than for North Dakota, but the Theil coefficient indicates this variability does not preclude use of the model at this level and in fact the closeness of the values to 0.0 would indicate the model performs quite well and can be used with confidence.

Uses of Input-Output Analysis In North Dakota

Input-output analysis is a technique that is quite easy to use to estimate the economic impacts of new income injections into the economy. A common use of input-output analysis is to assess the effect of a new manufacturing or processing plant in the state. In such a case there will be a one-time impact on the state's economy that results from the construction of the facility. There also will be annually recurring impacts associated with the operation of the plant after the plant is completed and production begins.

Information needed to estimate the economic impacts of a new plant in the state is the set of expenditures that will be injected into the respective sectors of the state's economy during the construction and the operation phases of the plant. These expenditures are multiplied by the appropriate interdependence coefficients of the input-output model to provide estimates of gross income changes for the respective sectors in the state that are attributable to the construction and operation of the new plant. Typically, new income is injected into the state during the construction phase through three sectors: the contract construction sector (expenditures to firms in the construction industry), the retail trade sector (expenditures for materials purchased within the state), and the household sector (payrolls of employees not already included as part of the expenditures to the contract construction sector). New income is injected into the state's economy during the operating phase of the new plant via two sectors: the retail trade sector (for materials purchased from other firms in the state each year) and the household sector (the new plant's payroll after operation begins).

TABLE 16. COMPARISON OF STATISTICAL TESTS FOR THE INPUT-OUTPUT MODEL PERSONAL INCOME ESTIMATION, NORTH DAKOTA REGIONS 1-8 AND STATE, 1958-1984

Region	Average Absolute Difference[a]	Mean Average Difference[b]	Standard Deviation[c]	Theil Coefficient[d]
1	12.64	- 5.26	15.43	0.14
2	8.91	3.86	10.90	0.08
3	20.55	19.91	11.81	0.16
4	9.77	7.45	11.15	0.08
5	18.64	-18.28	11.14	0.22
6	8.57	7.58	6.62	0.07
7	5.80	- 5.56	6.19	0.10
8	14.68	13.56	11.22	0.13
STATE	5.47	- 1.88	6.27	0.07

[a]Average absolute difference is the sum of the absolute values of the percent difference of I-O estimates and historic data divided by the number of observations.
[b]Mean average difference is the sum of the percent difference of the I-O estimate and historic data divided by the number of observations.
[c]Standard deviation is for the difference of the I-O estimate and historic data.
[d]Theil's coefficient is calculated using the formula:

$$U_1 = \frac{\sqrt{\frac{1}{T} \Sigma(Ys - Ya)^2}}{\sqrt{\frac{1}{T} \Sigma(Ys)^2} + \sqrt{\frac{1}{T} \Sigma(Ya)^2}}$$

where: T = time period
Ys = simulated value of Y
Ya = actual value of Y

Input-output anlaysis also has been used to measure the impact of an existing industry or plant in a fully operational stage. This type of input-output analysis is termed a contribution study (i.e., I-O methodology is used to measure the business activity, employment, personal income, and tax revenues an industry contributes to the current economy of the state). This type of study provides estimates of the absolute size of an individual firm or industry and their relative importance to the state economy. Also, input-output analysis can be used for analyses, such as revenue forecasting and analyzing the state's economic base and its composition.

The input-output model also has been incorporated as one module of a large economic-demographic assesment model for simulating the North Dakota economy. In this model, the input-output interdependence coefficients are applied to forecasts of future sales to final demand (exports) for each relevant sector to develop estimates of gross business volume for all sectors of a given substate region. The projected levels of gross business volume then are used to estimate employment in each sector. These employment levels then provide a basis for estimating the extent of net in- or out-migration and hence the likely extent of population growth or decline in the region. Input-output analysis serves as the driving mechanism of this comprehensive socioeconomic assessment model.

Examples of Input-Output Analysis

A number of studies in North Dakota have employed input-output analysis to estimate the economic impacts of various types of developments. The topics addressed in these studies have covered a wide range of issues involving North Dakota. Studies involved with irrigation, coal or other energy development, feasibility, contribution, recreation, government programs, and comprehensive socioeconomic model development have relied heavily on the North Dakota I-O model's economic estimates. Not all studies completed in each of these areas will be referenced, but rather a few selected reports associated with each topic will be noted.

The North Dakota I-O model was developed principally to analyze the economic impacts associated with irrigation development in the state (Schaffner and Carkner 1975; Leitch and Anderson 1978); this probably was the largest proposed single resource development project in the state up to that time. The model was used for analyzing other agricultural impacts such as those occurring from added growing-season rainfall (Schaffner et al. 1983).

Feasibility studies almost always include an analysis of the economic impact associated with the particular project development. This analysis is important because it indicates how the development will help the state's economy in terms of personal income and employment. Often, when state funding is being sought, the economic impact has a bearing on securing state loans, etc. Feasibility studies have primarily focused on processing of the state's agricultural products and have included projects such as malt plants (Anderson and Frasse 1970), wheat gluten plants (Mittleider et al. 1978), pasta processing (Fraase, Walsh, and Anderson 1974; Mittleider and Anderson 1978), and sunflower processing plants (Cobia et al. 1977). For a complete listing of economic impacts associated with feasibility studies done in North Dakota, see Mittleider et al. (1983b). Input-output analysis also has been used to analyze the economic impacts associated with rural industrialization (Helgeson and Zink 1973).

Large-scale energy development in western North Dakota brought with it an increased need for analyzing economic impacts. The North Dakota I-O model was used extensively for estimating impacts with coal development projects in the 1970s. Impact assessments were provided for such projects as a coal gasification plant (Dalsted et al. 1976) and coal mine development (Toman et al. 1977). The North Dakota input-output model provided the basis for a very comprehensive socioeconomic impact assessment model with the acronym NEDAM. This computer model was developed in the 1970s and became fully operational with documentation a short time later (Leistritz et al. 1982). NEDAM became so popular and well-reviewed throughout the United States that it subsequently was adopted for usuage in Wyoming (Coon et al. 1983), Montana (Chase et al. 1982), and Minnesota (Coon, Vocke, and Leistritz 1984a). These models can be used to analyze the socioeconomic impacts associated with a development of any type in the respective states. NEDAM continues to be used extensively and constantly is being updated and enhanced as data become available (Coon et al. 1984).

Economic impacts associated with North Dakota recreation have been analyzed using the I-O model. Studies involving recreation development (Helgeson and Holte 1978; Mittleider and Leitch 1984a), nonresident sportsmen expenditures (Anderson and Leitch 1984), and the contribution of state parks to the North Dakota economy (Mittleider and Leitch 1984b) have been analyzed.

Composition of the North Dakota economy and how it is changing have been analyzed using input-output analysis (Coon, Vocke, and Leistritz 1984b). The model also has been used in such diverse projects as economic contribution studies (Coon, Mittleider, and Leistritz 1983), transportation models (Mittleider, Tolliver, and Vreugdenhil 1983), and for analyzing impacts of the Payment in Kind (Federal Government Agricultural Program) on the North Dakota economy (Mittleider et al. 1983a).

As can be discerned from its extensive applications, the North Dakota input-output model is a useful and accurate tool for describing the economic linkages and interrelationships of North Dakota's economy. This model has been used to determine the effects of a wide variety of industrial and agricultural developments in North Dakota. Analyzing the impacts from these developments using input-output analysis has proven to be accurate and beneficial to both private industry and government personnel. The value of having economic information, such as that provided by input-output analysis, has become more apparent in recent years with the much larger developments (e.g., the coal gasification plant in western North Dakota). The better the economic impact assessment information available to policymakers, the more effectively the impacts associated with a development can be managed.

Interpreting the Results of An Economic Impact Assessment

An example of an actual economic impact assessment will be presented in order to further explain the results of such an analysis. Excerpts from an analysis of the contribution of state parks (Mittleider and Leitch 1984b, p. 7ff.) will show the type of information required and the interpretation of the results. (The tables associated with the excerpts are numbered as they were in the original publication and are presented following the excerpts.)

> State park operation-and-maintenance expenditures occurred in several sectors of the economy (Table 5). Households (wages and salaries), construction, and retail trade were the sectors with the largest state park expenditures, accounting for over 90 percent of the total. State park operation-and-maintenance expenditures totaled $2,753,448 in fiscal 1984, compared to the previous five-year average of $2,102,529. Headquarter operations accounted for over 38 percent of total park expenditures.

Applying state park operation-and-maintenance expenditures to the interdependence coefficients yielded total business activity for all sectors. Personal income, retail sales, business activity for all business sectors, and total business activity were estimated for each state park for fiscal 1984 (Table 6). These values include both the first-round effect (Table 5) and the secondary impact. Operation-and-maintenance expenditures by the state park system resulted in personal income of over $2.6 million and retail sales over $2 million. Over $7 million in total business activity occurred as a result of the original $2,753,448 in state park operation-and-maintenance expenditures. The multiplier effect for these expenditures was 2.65, meaning that each dollar spent for state park operation and maintenance generated $2.65--the original dollar plus $1.65 in additional business activity.

Personal income, retail sales, and business activity of all business sectors were used to estimate income tax collections resulting from state park operation-and-maintenance expenditures (Table 7). Personal income tax estimates included both direct and secondary effects; that is, income taxes attributable to wages and salaries for state park employees plus income taxes resulting from the multiplier effect. Total tax collections accruing to the state were $86,978 as a result of state park operation-and-maintenance expenditures. Sales and use tax collections of over $50,000 (58 percent of the total) were the largest tax collection category, followed by personal income taxes of $23,700 (27 percent) and corporate income taxes of $13,000 (15 percent).

In addition to tax revenues, operation-and-maintenance expenditures create direct and secondary employment opportunities. Direct employment figures were obtained from the North Dakota Parks and Recreation Department, and secondary employment was estimated by using productivity ratios, the number of dollars of business activity needed to support one worker for each respective sector. Direct employment in state parks, in full-time equivalents, was 68.5 for fiscal 1984 (Table 8). Secondary employment, resulting from additional rounds of spending, was estimated to be 106 people for the same period.

TABLE 5. ESTIMATED NORTH DAKOTA STATE PARK OPERATION-AND-MAINTENANCE EXPENDITURES, BY ECONOMIC SECTOR AND PARK, FISCAL YEAR 1984

	Expenditures by Sector							
State Park	Construction	Transportation	Communication & Public Utilities	Retail Trade	Finance, Insurance, Real Estate	Business & Personal Service	Household	Total
	-dollars-							
Beaver Lake, Doyle, & Streeter	---	540	2,926	11,394	1,260	664	36,368	53,152
Fort Lincoln, Butte View, & Sully Creek	147,000	945	14,715	28,120	2,498	1,745	102,983	298,006
Fort Stevenson	215,000	900	9,237	19,405	1,620	1,166	83,101	330,429
Fort Ransom	---	540	3,263	10,891	1,215	754	28,246	44,909
Icelandic	35,000	990	8,798	19,283	2,295	1,166	83,968	151,500
Lake Metigoshe	30,000	990	13,388	27,647	1,845	1,919	101,460	177,249
Lake Sakakawea & Little Missouri Bay	45,000	990	12,634	26,832	3,060	1,745	103,533	193,794
Lewis & Clark	152,417	990	7,729	17,283	1,575	1,166	77,221	258,381
Turtle River & Devils Lake	36,200	1,035	11,475	27,317	3,060	1,919	113,070	194,076
Headquarters	116,500	20,460	18,926	447,337	1,755	101,718	345,256	1,051,952
Total	777,117	28,380	103,041	635,509	20,183	113,962	1,075,206	2,753,448

TABLE 6. ESTIMATED PERSONAL INCOME, RETAIL SALES, BUSINESS ACTIVITY OF ALL BUSINESS (NONAGRICULTURAL) SECTORS, AND TOTAL BUSINESS ACTIVITY, RESULTING FROM STATE PARK SYSTEM OPERATION-AND-MAINTENANCE EXPENDITURES, BY PARK, FISCAL YEAR 1984

State Park	Personal Income	Retail Sales	Business Activity of All Business Sectors[a]	Total Business Activity
	- - - - - -	- - - - - -	-dollars-	- - - - - -
Beaver Lake, Doyle, & Streeter	65,794	44,303	76,052	151,981
Fort Lincoln, Butte View, & Sully Creek	277,418	182,118	472,027	792,684
Fort Stevenson	278,583	180,850	537,121	859,196
Fort Ransom	53,261	37,772	65,219	126,949
Icelandic	170,811	107,856	226,771	423,403
Lake Metigoshe	201,942	131,501	262,841	495,686
Lake Sakakawea & Little Missouri Bay	214,702	138,575	291,403	538,903
Lewis & Clark	229,310	147,477	414,847	679,679
Turtle River & Devils Lake	223,583	142,289	287,781	545,149
Headquarters	893,469	941,102	1,609,220	2,678,768
Total	2,608,873	2,053,843	4,243,282	7,292,398

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

TABLE 7. ESTIMATED TAX REVENUES RESULTING FROM NORTH DAKOTA STATE PARK OPERATION-AND-MAINTENANCE EXPENDITURES, FISCAL YEAR 1984

State Park	Sales and Use Tax[a]	Personal Income Tax	Corporate Income Tax	Total
Beaver Lake, Doyle, & Streeter	1,165	599	233	1,997
Fort Lincoln, Butte View, & Sully Creek	5,452	2,525	1,449	9,426
Fort Stevenson	5,715	2,535	1,649	9,899
Fort Ransom	952	485	200	1,637
Icelandic	3,135	1,554	696	5,385
Lake Metigoshe	3,676	1,838	807	6,321
Lake Sakakawea & Little Missouri Bay	3,956	1,954	895	6,805
Lewis & Clark	4,609	2,087	1,274	7,970
Turtle River & Devils Lake	4,070	2,035	883	6,988
Headquarters	17,479	8,131	4,940	30,550
Total	50,209	23,743	13,026	86,978

[a]Includes only tax assessments on nonpark expenditures to the retail trade sector as parks do not pay sales and use tax. Taxable retail sales are total retail sales (Table 6) less park operation-and-maintenance expenditures to the retail trade sector (Table 5).

TABLE 8. ESTIMATED DIRECT AND SECONDARY EMPLOYMENT ATTRIBUTABLE TO NORTH DAKOTA STATE PARK OPERATION-AND-MAINTENANCE EXPENDITURES, FISCAL YEAR 1984

State Park	Direct Employment[a]	Secondary Employment
Beaver Lake, Doyle, & Streeter	3.75	--
Fort Lincoln, Butte View, & Sully Creek	7.00	12
Fort Stevenson	6.25	14
Fort Ransom	2.75	--
Icelandic	6.25	4
Lake Metigoshe	6.50	4
Lake Sakakawea & Little Missouri Bay	6.50	6
Lewis & Clark	4.50	11
Turtle River & Devils Lake	7.50	5
Headquarters	17.50	50
Total	68.50	106

[a]Includes part-time employees. Part-time personnel are reported in full-time equivalents. Obtained from the North Dakota Parks and Recreation Department.

Summary

The purpose of this report was to provide a reference and companion document to accompany input-output related presentations and reports. Input-output theory, the history of the North Dakota I-O model, North Dakota I-O data tables, applications of the model, and an actual impact assessment were included to cover the subject completely. This document will primarily be used as a reference for persons interested in input-output analysis and how it relates to the North Dakota economy.

As can be seen from the section on examples of the model's useage, the North Dakota input-output model has become an integral part of state-oriented economic research. Primary benefits from I-O analysis have been to help plan for the socioeconomic impacts associated with a particular development. However, planners and decision makers of all kinds have benefited from the estimates provided by the model. Development of the NEDAM model further highlights the usage of the input-output model for forecasting purposes of not only economic but also socioeconomic variables.

The North Dakota input-output model has evolved in scope from the interdependency of a local community to a state and substate economic tool in a period of approximately 20 years. During this period the model has gone through several revisions to arrive at the current version. Importance and flexibility of the I-O model are further exemplified by the fact that it has undergone upgrades and enhancements and can easily be expanded to better describe additional state industrial sectors. Economic researchers have used the North Dakota input-output model extensively and will continue to rely on it in the future because of its ability to provide an accurate and detailed economic analysis.

Appendix A

Definition of Terminology

Terms

Basic Economic Activity: an economic activity that produces output for final demand (which, in North Dakota, is principally for export from the area).

Business Activity: computationally, the resultant of the application of the multipliers to the expenditures within an area by a firm or industry. This term is used when analyzing a firm or industry's expenditures for an impact or contribution study.

Constant (Base Year) Dollars: dollars expressed in terms of purchasing power for a base year's prices.

Contribution Study: an economic study in which the expenditures of an individual firm or industry in an area are used to measure its relative magnitude to the economic unit.

Current (Year) Dollars: dollars reflecting their purchasing power in terms of that given year's prices.

Direct Employment: workers employed by a firm or industry being analyzed by an impact or contribution study.

Economic Base: those economic activities within an area which produce products exported from that area in return for dollars.

Economic Impacts: resultant increase or decrease in economic activity resulting from the expansion or shrinkage of a particular firm, industry, or sector in the area economy.

Economic Sector: a grouping of firms engaged in similar types of economic activities.

Gross Business Volume: computationally, the resultant of the application of the multipliers to the sales for final demand. These values indicate the total dollar volume of business activity occurring after the multiplier process has been completed.

Gross Receipts Multiplier: total output requirements of all row sectors in the economy per dollar of output for final demand by the column sector.

Identity Matrix: a matrix consisting of all zeros except for one's in the main (upper left to lower right) diagonal.

Input-Output Analysis: a technique for tabulating and describing the linkages or interdependencies between various industrial groups within an economy.

Interdependence Coefficients (Multipliers): computationally, they are the inverse of the [I-A] matrix, or $[I-A]^{-1}$. Each element of the matrix shows the total (direct and indirect) input requirements that must be obtained from the row sector per dollar of output for final demand by the column sector.

Personal Income: gross business volume of the household sector of the input-output model.

Productivity Ratio: the ratio of gross business volume to employment. These values indicate the amount of business activity necessary to maintain or create one job in each sector of the economy.

Retail Trade Center: a city with retail trade activities serving itself and the surrounding trade area.

Sales for Final Demand (Final Demand Vector): the value (measured in terms of dollars) of exports from the economic unit by a basic economic sector.

Secondary (Indirect and Induced) Employment: workers not employed directly by the firm or industry being analyzed by a contribution or impact study, but whose jobs were created as the result of expenditures by the particular firm or industry.

Technical Coefficients: the transactions table expressed as decimal fractions of column totals in the transactions table. This table is usually referred to as the A matrix.

Transactions Table: a table showing the purchases and sales by each of the economic sectors to each of the sectors. Columns show purchases from (and payments to) each row sector, and the rows indicate the sales of that row sector to the column sectors.

Appendix B

North Dakota Input-Output Tables in Constant Dollars

APPENDIX TABLE 1. SALES FOR FINAL DEMAND, BY ECONOMIC SECTOR, NORTH DAKOTA, MILLION DOLLARS, (1980=BASE DOLLARS), 1958-1984

Year	(1) Ag, Lvstk	(2) Ag, Crops	(4) Constr	(7) Ag Proc & Misc Mfg	(8) Retail Trade	(10) Bus & Pers Serv	(12) Households[a]	(14) Coal Mining	(15) Thermal-Elec Gen	(16) Pet Exp/Ext	(17) Pet Refining	Total
1958	591.7	1,182.6	49.2	167.9	44.3	14.8	502.3	3.0	--	14.5	35.2	2,605.5
1959	570.0	1,035.9	71.4	149.5	47.2	15.7	489.2	2.6	--	28.6	33.8	2,443.9
1960	452.8	1,009.0	84.4	170.6	38.5	12.9	485.0	2.6	--	37.4	32.3	2,325.5
1961	547.1	873.9	61.4	172.6	44.0	14.8	606.6	3.3	--	53.7	32.2	2,409.6
1962	500.6	1,197.7	41.4	157.2	47.0	15.8	864.6	3.8	--	57.3	31.4	2,916.8
1963	513.6	1,343.0	42.3	180.5	53.7	17.8	827.2	3.2	--	57.6	30.9	3,069.8
1964	520.0	1,100.0	73.6	191.1	63.9	21.2	1,182.8	3.7	--	63.1	31.0	3,250.4
1965	590.0	1,321.8	73.9	186.9	78.7	26.2	861.5	3.6	--	66.7	31.9	3,241.2
1966	627.2	1,407.7	53.8	194.5	104.0	34.7	990.1	3.0	10.2	68.6	32.3	3,526.1
1967	630.1	1,275.0	54.7	205.7	122.7	40.8	854.2	4.7	18.8	62.8	32.8	3,302.3
1968	567.7	1,225.8	58.0	218.1	149.8	49.8	962.4	5.2	26.4	73.7	31.6	3,368.5
1969	541.4	1,311.1	71.9	330.9	154.9	51.7	1,024.5	4.9	23.9	53.5	30.4	3,599.1
1970	528.3	1,300.9	353.0	287.1	166.1	55.3	1,100.6	6.2	26.8	58.7	29.5	3,912.5
1971	563.0	1,244.8	112.2	299.3	173.3	57.8	1,118.1	6.5	32.3	60.8	29.4	3,697.5
1972	667.4	1,728.7	129.3	301.4	153.0	51.1	1,150.7	5.9	37.9	61.3	29.8	4,316.5
1973	798.4	3,012.4	103.3	407.6	158.5	52.8	1,219.1	6.9	32.4	64.4	32.0	5,887.8
1974	691.9	3,196.7	111.7	470.2	142.9	48.0	1,243.4	7.6	34.6	117.4	34.9	6,099.3
1975	639.5	2,197.5	117.1	433.1	158.9	53.0	1,478.7	10.0	29.1	119.1	35.3	5,271.3
1976	650.1	1,603.1	60.3	627.1	180.1	60.1	1,431.8	21.5	51.8	135.3	36.2	4,857.4
1977	612.8	1,494.4	65.6	517.4	182.1	60.6	1,365.2	23.1	58.7	129.3	37.0	4,546.2
1978	625.6	1,908.8	77.8	515.0	195.0	64.9	1,368.2	26.0	77.3	128.2	36.4	5,023.2
1979	756.1	1,843.8	85.0	570.6	160.7	53.6	1,505.3	35.1	99.8	198.8	51.1	5,359.9
1980	781.4	1,721.6	108.1	562.2	144.5	48.2	1,687.4	48.3	120.1	410.4	74.3	5,706.5
1981	538.9	2,122.4	71.5	559.1	145.5	48.5	1,720.5	49.4	127.7	882.8	119.6	6,385.9
1982	517.6	1,974.3	48.0	450.8	143.2	47.7	1,368.3	49.5	138.7	734.0	103.9	5,576.0
1983	545.8	2,147.4	65.6	442.3	161.8	54.0	1,595.0	63.2	161.8	644.8	92.9	5,974.6
1984	524.1	1,874.6	88.6	454.5	140.4	46.8	1,692.4	76.5	179.7	571.5	86.9	5,736.0

[a]Household sector sales for final demand include oil lease bonus payments as estimated by Coon, Anderson, and Leistritz (1986).

APPENDIX TABLE 2. GROSS BUSINESS VOLUMES OF ECONOMIC SECTORS ESTIMATED BY THE INPUT-OUTPUT MODEL, NORTH DAKOTA, MILLION DOLLARS, (1980=BASE DOLLARS), 1958-1984

Year	(1) Ag, Lvstk	(2) Ag, Crops	(3) Nonmetallic Mining	(4) Const	(5) Trans	(6) Comm & Pub Util	(7) Ag Proc & Misc Mfg	(8) Retail Trade	(9) FIRE	(10) Bus & Pers Service	(11) Prof & Soc Service	(12) House-holds	(13) Govt	(14) Coal Mining	(15) Thermal-Elec Generation	(16) Pet Exp/Ext	(17) Pet Refining
1958	878.8	1,649.5	18.7	251.4	31.2	228.7	846.8	1,949.6	405.6	171.7	181.4	2,746.3	246.2	3.0	--	45.2	35.3
1959	838.1	1,468.9	18.1	260.8	29.3	213.8	778.9	1,809.4	375.6	160.5	169.4	2,566.5	228.8	2.6	--	59.4	33.8
1960	698.0	1,406.9	17.5	265.2	27.6	202.4	743.8	1,708.8	355.9	150.3	160.3	2,432.8	216.2	2.6	--	67.8	32.3
1961	810.0	1,301.0	17.4	250.4	28.8	212.7	784.6	1,759.1	367.6	155.5	170.1	2,586.7	225.5	3.3	--	85.7	32.3
1962	793.1	1,633.1	20.0	274.6	33.9	260.8	793.9	2,169.0	454.9	190.5	211.5	3,229.7	277.8	3.8	--	89.0	31.5
1963	822.6	1,811.2	21.1	286.4	35.7	272.6	864.1	2,292.2	478.7	202.3	219.7	3,347.9	291.3	3.2	--	88.9	31.0
1964	839.7	1,565.5	22.6	334.4	37.1	294.3	863.2	2,399.1	503.9	212.9	241.8	3,708.4	310.4	3.7	--	95.0	31.1
1965	920.5	1,824.6	22.9	329.4	37.9	286.6	919.2	2,409.0	498.8	217.9	230.0	3,504.5	304.6	3.6	--	99.7	32.0
1966	984.4	1,942.4	24.1	331.8	41.0	312.9	974.6	2,635.9	543.2	243.1	251.9	3,840.2	332.1	4.6	10.2	102.2	32.5
1967	972.7	1,803.3	22.6	311.5	38.7	290.5	970.4	2,464.3	502.6	233.5	231.9	3,528.5	307.4	7.7	18.8	96.3	33.1
1968	906.5	1,737.3	22.7	320.0	39.0	296.5	955.1	2,512.0	508.7	244.2	237.3	3,619.4	311.8	9.4	26.4	107.4	32.0
1969	907.6	1,895.1	24.5	349.8	41.4	316.5	1,152.8	2,686.4	544.9	260.2	253.3	3,863.0	333.4	8.7	23.9	84.2	30.7
1970	898.9	1,856.7	33.1	648.6	44.4	337.5	1,077.3	2,831.9	573.3	273.4	268.9	4,104.9	351.5	10.5	26.8	89.2	29.9
1971	932.5	1,814.7	25.9	396.9	42.3	325.2	1,106.0	2,744.6	554.9	269.2	261.0	3,984.9	340.7	11.6	32.3	91.5	29.8
1972	1,097.2	2,386.2	30.7	463.1	49.6	378.3	1,248.5	3,216.7	657.8	303.4	302.8	4,612.5	400.8	11.9	37.9	92.4	30.3
1973	1,379.3	3,910.2	40.8	560.6	67.9	512.1	1,717.6	4,466.0	916.7	409.3	406.1	6,164.6	551.4	12.1	32.4	97.6	32.4
1974	1,278.3	4,110.7	42.2	588.1	70.3	527.2	1,796.3	4,589.3	945.4	416.3	417.1	6,332.4	567.3	13.1	34.6	158.2	35.4
1975	1,148.2	2,981.6	36.3	530.6	60.3	462.6	1,551.2	3,917.4	806.1	363.1	371.2	5,663.7	490.2	14.6	29.1	160.4	35.8
1976	1,150.4	2,462.5	31.8	436.7	56.0	424.8	1,799.7	3,545.1	726.9	337.4	339.6	5,182.5	445.2	29.7	51.8	179.3	37.1
1977	1,072.0	2,256.5	29.9	418.0	52.2	397.4	1,567.9	3,319.9	678.4	319.1	318.1	4,855.6	415.9	32.4	58.7	173.4	38.0
1978	1,121.6	2,713.9	33.3	466.0	57.5	436.1	1,640.6	3,695.1	754.3	353.7	347.6	5,295.8	459.3	38.3	77.3	171.9	37.6
1979	1,293.0	2,734.4	35.6	502.5	62.0	464.5	1,808.8	3,848.9	797.3	357.3	370.7	5,650.6	487.2	51.0	99.8	261.9	52.7
1980	1,328,6	2,612.5	37.7	561.7	67.0	488.7	1,800.8	3,937.0	822.6	359.7	388.5	5,930.5	505.3	67.4	120.1	513.8	76.3
1981	1,075.6	2,956.6	39.8	599.2	77.1	527.5	1,727.4	4,197.1	875.7	381.9	409.8	6,259.2	536.1	69.9	127.7	1,070.2	121.7
1982	990.8	2,705.8	34.5	504.5	67.3	458.2	1,486.9	3,692.8	766.7	340.1	354.3	5,398.5	467.7	71.7	138.7	893.9	106.1
1983	1,053.9	2,907.9	37.4	549.8	70.5	498.1	1,528.7	4,043.3	839.7	373.8	390.0	5,949.4	511.9	89.0	161.8	787.2	95.6
1984	1,013.8	2,611.9	36.3	551.5	66.9	481.5	1,498.3	3,860.0	808.3	352.7	380.7	5,815.4	494.2	105.1	179.7	702.1	90.0

APPENDIX TABLE 3. GROSS BUSINESS VOLUME TO EMPLOYMENT (PRODUCTIVITY) RATIOS, BY ECONOMIC SECTOR, NORTH DAKOTA, (1980=BASE DOLLARS), 1958-1984

Year	(1) & (2) Ag	(3) Nonmetallic Mining	(4) Const	(5) Trans	(6) Comm & Pub Util	(7) Ag Proc & Misc Mfg	(8) Retail Trade	(9) FIRE	(10) Bus & Pers Service	(11) Prof & Soc Service	(12) House-holds	(13) Govt	(14) Coal Mining	(15) Thermal-Elec Generation	(16) Pet Exp/Ext	(17) Pet Refining
1958	25,366	143,846	17,422	4,757	28,605	51,483	53,560	80,000	13,764	12,895	--	8,136	7,894	--	23,751	105,373
1959	24,368	142,519	16,424	4,414	26,326	46,330	48,399	69,814	12,056	11,286	--	7,314	6,788	--	33,000	104,000
1960	22,941	142,276	19,134	4,191	25,199	44,785	45,414	63,781	11,040	10,442	--	6,863	6,788	--	50,446	102,539
1961	24,078	133,846	18,386	4,534	27,673	48,197	47,189	64,378	10,968	10,640	--	6,979	8,638	--	59,596	105,901
1962	27,674	173,913	17,553	5,445	34,185	47,286	59,666	76,582	13,017	12,817	--	8,189	9,973	--	69,858	106,418
1963	31,828	193,577	19,784	5,811	35,996	47,598	60,397	78,863	13,259	12,770	--	8,009	8,767	--	73,714	108,391
1964	30,835	200,000	21,869	6,111	39,224	45,300	61,160	80,882	13,471	13,568	--	8,012	10,601	--	74,334	112,681
1965	36,723	169,629	21,774	6,331	38,295	46,633	60,596	78,427	13,846	12,960	--	7,554	12,456	--	66,201	120,300
1966	41,420	178,518	27,487	6,795	40,811	48,523	65,512	84,217	15,121	13,894	--	7,892	12,994	54,255	70,922	122,180
1967	42,596	176,562	27,708	6,421	37,610	48,778	61,887	74,903	13,883	12,227	--	6,920	22,318	96,907	70,965	124,436
1968	41,634	181,600	30,288	6,564	38,606	46,968	62,613	75,474	14,091	12,143	--	6,600	27,893	136,787	80,873	125,000
1969	46,134	180,147	33,419	6,992	41,178	55,915	66,258	80,132	14,960	12,916	--	6,898	26,769	121,938	60,185	124,291
1970	53,072	250,758	52,277	7,761	48,132	54,420	70,711	89,271	15,536	13,546	--	7,825	31,437	112,134	88,933	138,426
1971	53,437	196,212	30,216	7,374	46,127	54,531	67,261	84,485	14,489	12,458	--	7,567	32,492	129,718	93,272	143,961
1972	67,533	237,984	31,113	8,737	53,364	57,500	74,902	96,607	15,634	13,836	--	8,726	31,818	140,892	98,929	151,500
1973	103,553	318,750	39,860	11,806	70,353	71,629	99,385	129,587	20,104	17,689	--	11,862	31,510	115,302	107,488	155,023
1974	102,316	308,029	39,552	11,967	70,424	69,030	98,400	126,407	19,465	17,294	--	11,936	36,797	110,897	153,146	176,119
1975	84,713	242,000	31,038	10,389	62,878	51,801	80,259	102,687	16,030	14,532	--	9,793	34,272	87,125	118,639	178,109
1976	70,495	203,846	22,553	9,426	55,813	58,484	67,907	86,566	14,261	12,729	--	8,622	57,782	146,327	108,996	183,663
1977	58,651	185,714	20,770	8,381	49,912	51,050	62,311	74,754	12,963	11,459	--	7,870	54,090	163,966	84,544	186,274
1978	70,674	201,818	20,660	8,594	50,809	50,751	67,878	78,352	13,556	11,814	--	8,338	51,617	212,947	57,376	182,524
1979	76,785	209,165	22,508	8,610	50,078	52,508	68,552	79,022	13,093	12,046	--	8,729	62,989	271,195	65,991	254,628
1980	74,811	215,297	28,091	8,903	50,255	55,070	70,394	78,103	12,793	12,253	--	9,014	69,570	311,139	84,707	360,075
1981	77,144	220,933	32,993	9,958	52,772	52,407	76,069	80,983	12,813	12,192	--	9,611	61,632	256,425	122,261	560,982
1982	71,265	187,326	26,219	8,827	47,126	45,794	65,990	70,696	10,866	10,037	--	8,413	55,056	250,814	124,111	549,985
1983	77,121	197,698	25,824	9,606	53,148	48,407	71,813	76,247	11,548	10,686	--	9,066	63,806	270,117	161,142	482,889
1984	71,273	187,119	31,463	8,882	50,444	46,273	66,143	71,896	10,545	10,091	--	8,652	67,513	278,173	138,609	443,438

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