A SOCIAL ACCOUNTING SYSTEM AND SIMULATION MODEL FOR ANALYZING ALTERNATIVE ENERGY CHOICES FOR OKLAHOMA AND PROJECTING ECONOMIC VARIABLES FROM 1972 TO 2000

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CHAPTER I

INTRODUCTION

Need for the Study

Economic planning and policy analysis are essential at national and regional levels to evaluate changing economic and social problems. Public policy increasingly is concerned with problems of a regional nature. Area development, regional transport systems, metropolitan urban planning, and natural resources development and utilization are all examples of public concern for small areas and regions. There is a growing need for economic planning and policy analysis due to increasing urbanization and population movements, changing structural, social and economic conditions, advancing technologies, and increasing federal, state and local government budgets. Other pressures such as evaluating alternative energy sources and energy conservation are generating increased demand for improved planning and policy analysis by state and federal government bodies. Research is required to investigate the level and situation of economic and social events so as to evaluate alternatives and formulate appropriate social policies. This research information is vital for decision-making by planners involved in agriculture, industry, and government activities.

The current increasing worldwide demand for, and declining supply of, energy products has caused energy prices to rise sharply. The

Arab Oil Embargo of 1973 and the accompanying energy supply disruption altered many of the structural economic and social relationships that previously existed. The trend toward increased oil and gas consumption has been altered considerably. A significant permanent change in the world-wide energy system has occurred. This change involves new ownership rights and control over world crude oil produced outside the United States. Substantial uncertainty of recent occurrences of abrupt, temporary events such as nuclear accidents, political instability in oil producing nations, and extraordinary weather conditions may further affect economic planning and public policies. Such developments and changes have intensified the energy problems.

Oklahoma cannot be isolated from the world energy condition. The various developments and changing characteristics of the energy situation affects Oklahoma's economy. Like the economies of all other states, Oklahoma depends on the use of vast amounts of energy. The economic and social development of the state has been directly related to an unrestricted energy supply at relatively low prices. Its economic growth depends strongly on its ability to continue as a major energy producer. This ability, in turn, depends on the extent of Oklahoma's remaining energy resources, most of which are highly influenced by state and national policies regarding alternative choices of energy utilization. The demand for energy continues to rise sharply. Energy prices are accelerating from time to time, more truly reflecting their relative scarcity. The current energy situation leads to more efficient energy utilization and stimulates energy-saving innovation. The increasing need for energy, even at rising prices, and the short supply of energy resources, particularly oil and gas, require an analysis of alternative strategies in energy utilization.

Energy choices facing Oklahoma relate to choice of energy source for carrying out economic activities, rate of development of alternative energy sources, and rate of growth of high energy consuming industries. A large share of the energy resources is used for electricity generation. Electricity can be generated by utilization of natural gas, coal, fuel oil, nuclear and water. Most of the electricity used in Oklahoma is presently generated by burning natural gas. The state's known and potential natural gas reserves are its largest remaining energy source. However, much of this gas lies at great depths, hence drilling costs are high. Oklahoma is slowly substituting imported low-sulfur coal from Western states for natural gas in generation of electricity. More natural gas, therefore, may be available for agricultural uses, residential and commercial heating, industry use and export. Most of Oklahoma's coal has high sulfur content, and thus may cause some environmental problem in its use. Using Oklahoma produced coal in electric power generating plants would require either lowering air pollution standards, installing the technology for trapping sulfur, or blending high and low sulfur coals. Many factors affect the decisions of electric utilities in their choice of fuel mix and operating options.

It is necessary to identify the key alternative strategies and evaluate the effect of these energy choices on state development. Decisions in such matters cannot be achieved without an adequate energy information base. Due to lack of an adequate data base for analyzing energy choices, the Oklahoma social accounting system needs to be updated and an energy account constructed. An energy data base designed to fit into a comprehensive and logically consistent economic framework is needed by legislators, policy makers, researchers, and conservation strategists. In view of recent and continuing public interest in these problems and the absence of previous intensive investigation of energy choices for Oklahoma, the production of this study seems timely and important to evaluate the various alternative strategies in energy production and utilization for Oklahoma.

Objective of the Study

The overall objective of this study is to construct an energy data base for Oklahoma centered on the base year of 1972 and to use this information in the analysis of alternative energy choices for benefiting Oklahomans engaged in agriculture, industry and other sectors of the state economy. Most specifically, the objectives are to:

1. Develop a social accounting system for the state which includes:
   a. a transaction account;
   b. a capital account;
   c. a human resource account;
   d. a government account;
   e. an energy account.
2. Construct an energy balance sheet for the base period 1972 showing production and consumption of energy by energy source, and
3. Integrate the 1972 energy data base into a dynamic simulation model of the state economy. This model will:

a. project energy balance sheets (choices) to the year 2000, and

b. provide a tool which can be used for analyzing the impacts of alternative energy choices on state employment, income, and government revenues.

Organization of the Study

The components of a social accounting system (data base) for analyzing Oklahoma's energy choices are presented in Chapter II. Empirical components of the social accounting system are presented in four chapters. The transaction and capital accounts are presented in Chapters III and IV, respectively; the human resource and government accounts are presented in Chapter V; and the energy account is developed and presented in Chapter VI. The simulation model of Oklahoma energy is developed and presented in Chapter VII. Two analytical and empirical chapters follow. Simulation of economic variables which include baseline projections of employment, income, revenue, population, energy, etc., are presented and discussed in Chapter VIII. Economic impact analysis and policy implications from alternative energy choices are presented and evaluated in Chapter IX. The summary and conclusions are presented in Chapter X. Data sources and supplementary information are given in the appendices.

CHAPTER II

COMPONENTS OF A SOCIAL ACCOUNTING SYSTEM FOR ANALYZING ENERGY CHOICES

Increasing dependence upon energy for society's economic and social changes, rapidly declining supplies of conventional energy sources, accelerated population growth, increasing per capita incomes and changing political powers of oil producing countries, all have contributed to the worldwide current energy crisis. There is an imbalance between the demand for energy and the current capacity to produce energy from conventional sources in the United States. By comparing the reserves of energy and current energy consumption by source in the United States, the imbalance is immediately apparent. Tyner [70] indicates that about 50 percent of U.S. energy consumption is from oil, about 25 percent from natural gas, about 18 percent from coal, and the remaining 7 percent from nuclear, hydropower and other sources. In contract, about 90 percent of U. S. proven energy reserves are in coal and only 8 percent in oil and natural gas. So oil and natural gas constitute 75 percent of U.S. energy consumption and only 8 percent of U. S. energy reserves. It is this imbalance which is the main concern in the current energy situation [70].

Oklahoma, as one of the leading producers and consumers of energy products, cannot be isolated from the prevailing situation. The changing characteristics of the energy situation could dramatically affect

Oklahoma's economy directly or indirectly. To this effect, the present energy condition has, in turn, resulted in an awareness to evaluate the energy resources and future energy utilization at the state level. In this chapter, simulation, input-output, and other components of an Oklahoma social accounting system used to analyze energy choices are discussed in detail.

Application of Simulation and Input-Output Model

Oklahoma's economic expansion, social change and population growth have resulted in increased energy utilization. Oklahoma ranks as a major consumer of energy products in short supply--mostly natural gas and petroleum products [51]. A large portion of its fossil fuels, mainly natural gas, is used for generating electricity. Electricity consumption including hydropower has increased more rapidly than the increase in total energy requirements, and as a result the contribution of electricity to the total picture has increased sharply during the past decade [52].

Electricity is more efficient than other forms of energy in many end use applications. With the present energy situation, that is, rising energy prices and declining energy resources, the investigation of the best alternative energy choice becomes important. As industries and population continue to grow in Oklahoma there is a need to generate the necessary electric power through effective fuel mix and operating options. In other words, the general utilization of energy source needs to be evaluated whether to utilize Oklahoma coal or imported coal from Western states, or continue to use natural gas for electric power generation under the prevailing energy situation.

There also is the choice for further resource development and utilization or conservation of energy resources to minimize the energy problem created by uncertainties and to satisfy future energy needs.

A comprehensive economic model is required in building a social information system for evaluating the various alternative energy choices for Oklahoma. Simulation with an input-output approach is applied in the analysis of interrelationships of social accounts in this study.[1] Simulation and input-output models allow the introduction of many relationships which conventional models fail to do. Such models have the advantage of providing an organizational framework and a set of consistency checks that are difficult to achieve with less formal techniques. Simulation and input-output models contain a number of economic sectors and provide an opportunity to formulate an Oklahoma social accounting system in the detail needed to evaluate the alternative energy choices. The application of siumlation formulated around an input-output model offers a promising approach for improving the quality of information desired for analysis of public energy policies.

Concurrent with the rise in importance of regional and social analysis, has been the availability and usefulness of the digital computer. Despite the obvious complexities involved in regional and social analysis, the large-scale computer simulation models are able uniquely to deal with many of these complexities. Computer simulation models with input-output tables have currently become important techniques used in regional analysis. Considerable progress has been made in

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[1]Simulation is a sequential numerical technique representing the dynamic behavior of a system to solve a series of equations for the endogenous variables in a mathematical model.

applying simulation and input-output techniques to regions and states within a nation. The development of the model and review of previous simulation and input-output studies are presented in Chapter VII.

A dynamic input-output analysis can be employed by considering the intersectoral dependence involving lags and rates of change over time. Temporal differentiation of state energy production and utilization usually exists. Energy production changes through changes in productive capacity, technology, and changes in productivity of resource use. Energy utilization changes through changes in consumption patterns, substitutions among energy products, and change in relative energy prices due to higher costs of energy production and shortages of energy products.

Changes in economic activity affect energy use through changes in direct energy inputs, additional capital requirements and investments to attain a given level of energy production, and changes in incomes and the subsequent changes in energy consumption by the private and public sectors. The total number of energy consumers, as measured by the population level, and the existing energy consumption habits affect energy utilization as they change over time. Energy prices affect current energy use directly, but also affect future energy use through impacts on current investments in energy-using equipment and buildings. Government energy policy can play an important role on the rate of future energy consumption. Most energy policies enacted in recent years have been designed to reduce energy consumption or to encourage substitution of domestic fuel sources for imported energy products. The interaction of all these and other factors affect state energy production and utilization as they change over time.

The Oklahoma social accounting system and an extension of previous work of simulation models centered around an input-output analysis for Oklahoma by Doeksen [9] and Sarigedik [65]. Doeksen [9] developed a social accounting system for Oklahoma (1963) composed of a transaction account, capital account and human resources account. Sarigedik [65], extended Doeksen's study by updating the system to 1967, adding a government account and expanding the human resource account. This study updates the previous work to 1972 and incorporates a comprehensive energy account. The major contribution of this study is the sector disaggregation of energy utilization and production by basic energy source, thus recasting energy data into a form consistent with the input-output model composed of processing and final demand sectors.

Oklahoma is limited in its analysis of energy choices because of the lack of a consistent analytical framework and energy data base relating energy production and consumption to the various energy choices. This study specifically addresses the problem of developing an energy data base for use in analytical models dealing with Oklahoma's energy choices. The energy data base developed will serve other analytical models and other proposed analyses of energy related problems.

There are practical problems of data collection in regional input-output systems. Most regional and state accounts dealing with the transaction account and capital account are derived from national accounts instead of estimating from regional and state data. A central preoccupation of this study therefore has been the adaptations involved in building state control totals and applying these to national coefficients [77]. The use of national coefficients is also aimed at enhancing the empirical detail needed in regional and social analysis.

Collection of regional primary data requires much time and is very expensive.

Sector Specifications

The Oklahoma input-output structure is basically derived from the input-output structure of the United States for 1972 [79]. It consists of eighty-one processing (or purchasing) sectors, seven dummy and special industries, and eight final demand sectors. Production is grouped into eighty-eight industry groupings as the industrial categories, input-output numbers and standard industrial classification by SIC composition. Industry aggregation and classification by SIC are illustrated in detail in the methods and sources used for the construction of state total sector outputs of Appendix A. The base year of this study is 1972, primarily because the most recent and complete national input-output structure is available for that year.

According to the developed input-output structure for Oklahoma there are four sectors of agricultural activities, four sectors of mining except fuels, two sectors of construction, fifty-two sectors of manufacturing, thirteen sectors of service-type activities, two government sectors and four energy producing sectors. All these make up eighty-one sectors representing the endogenous processing sectors of the study. A complete listing of the sectors, which are referred to throughout this study, is presented in Table I along with the associated sector numbers.

The Oklahoma Model in Brief

The Oklahoma social accounting system is composed of five major

TABLE I

SECTORS OF THE OKLAHOMA MODEL

PROCESSING SECTORS

AGRICULTURE

1. Livestock and Livestock Products
2. Crops and Other Agricultural Products
3. Forestry and Fishery Products
4. Agricultural, Forestry and Fishery Services

MINING EXCEPT FUELS

5. Iron and Ferro Alloy Ores Mining
6. Nonferrous Metal Ores Mining
7. Stone and Clay Mining and Quarrying
8. Chemicals and Fertilizer Mineral Mining

CONSTRUCTION

9. New Construction
10. Maintenance and Repair Construction

MANUFACTURING

11. Ordnance Accessories
12. Food and Kindred Products
13. Tobacco Manufactures
14. Broad and Narrow Fabrics, Yarn and Thread Mills
15. Miscellaneous Textile Goods and Floor Coverings

MANUFACTURING (CONTINUED)

16. Apparel
17. Miscellaneous Fabricated Textile Products
18. Lumber and Wood Products, Except Containers
19. Wood Containers
20. Household Furniture
21. Other Furniture and Fixtures
22. Paper and Allied Products, Except Containers
23. Paper Board Containers and Boxes
24. Printing and Publishing
25. Chemicals and Selected Chemical Products
26. Plastics and Synthetic Materials
27. Drugs, Cleaning and Toilet Preparations
28. Paints and Allied Products
29. Paving and Roofing Material
30. Rubber and Miscellaneous Plastics Products
31. Leather Tanning and Finishing
32. Footwear and Other Leather Products
33. Glass and Glass Products
34. Stone and Clay Products
35. Primary Iron and Steel Manufacturing
36. Primary Nonferrous Metals Manufacturing
37. Metal Containers
38. Heating, Plumbing, and Struct. Metal Products
39. Screw Machine Products and Stampings
40. Other Fabricated Metal Products

TABLE I (Continued)

PROCESSING SECTORS

MANUFACTURING (CONTINUED)

41. Engines and Turbines
42. Farm and Garden Machinery
43. Construction and Mining Machinery
44. Materials Handling Machinery and Equipment
45. Metal Working Machinery and Equipment
46. Special Industry Machinery and Equipment
47. General Industrial Machinery and Equipment
48. Misc. Machinery, Except Electrical
49. Office, Computing, and Accounting Machines
50. Service Industry Machines
51. Electric Industrial Equipment and Apparatus
52. Household Appliances
53. Electric Lighting and Wiring Equipment
54. Radio, T.V., and Communication Equipment
55. Electronic Components and Accessories
56. Misc. Electrical Machinery and Supplies
57. Motor Vehicles and Equipment
58. Aircraft and Parts
59. Other Transportation Equipment
60. Scientific and Controlling Instruments
61. Optical, Ophthalmic, and Photographic Equipment
62. Miscellaneous Manufacturing

TRANSPORTATION, COMMUNICATION AND UTILITY

63. Transportation and Warehousing
64. Communications, Except Radio and T.V.
65. Radio and T.V. Broadcasting
66. Water Supply and Sanitary Services

WHOLESALE AND RETAIL TRADE

67. Wholesale and Retail Trade

FINANCE, INSURANCE AND REAL ESTATE

68. Finance and Insurance
69. Real Estate and Rental

SERVICES

70. Hotels, Personal and Repair Services Exc. Auto
71. Business Services
72. Eating and Drinking Places
73. Automobile Repair and Services
74. Amusements
75. Medical, Educational Services and Nonprofit Org.

GOVERNMENT ENTERPRISE

76. Federal Government Enterprises
77. State and Local Government Enterprises

ENERGY SECTORS

78. Petroleum Products Prod.
79. Natural Gas Prod.
80. Coal Mining
81. Electricity and Hydro-Power

TABLE I (Continued)

PROCESSING SECTORS
DUMMY AND SPECIAL INDUSTRIES
82. Noncomparable Imports
83. Direct Imports
84. Scrap, Used, and Secondhand Goods
85. Government Industry
86. Rest of the World Industry
87. Household Industry
88. Inventory Valuation Adjustment
V.A. Value Added
T.I. Total Input
FINAL DEMAND
89. Personal Consumption Expenditures
90. Gross Private Domestic Fixed Investment
91. Change in Business Inventories
92. Net Export
93. Federal Government Purchases, National Defense
94. Federal Government Purchases, Nondefense
95. State and Local Government Purchases, Education
96. State and Local Government Purchases, Other
T.O. Total Output

accounts as outlined in a flow chart in Figure 1. The accounts included in the system are a transaction account, a capital account, a human resource account, a government account and an energy account. The transaction account is the base of the Oklahoma social accounting system. Capital, human resource, government and energy accounts are directly related to the interindustry account. The five components of the information system and their characteristics are defined and discussed in detail in Chapters III through VI.

The Transaction Account

The interindustry account of the Oklahoma social accounting system consists of three major parts, namely a transaction flow table, a direct coefficients table, and a direct and indirect coefficients table. The transaction table is a double accounting system indicating dollar value of the goods and services traded by each sector of the economy. Each row and its corresponding column represents the transactions of an individual sector. The sales of the sectors are shown along the rows and the purchases of the sectors shown in the columns. The sum of a row is the total output of the sector represented by that row. The sum of a column is the total inputs of the sector represented.

The direct coefficients indicate input requirements per dollar of output for a given sector. The direct coefficients are relevant only for the processing sectors. The direct and indirect coefficients indicate the total change in input requirements as a result of a one dollar change in final demand. The total change includes the direct effect as well as all indirect effects resulting from the initial one

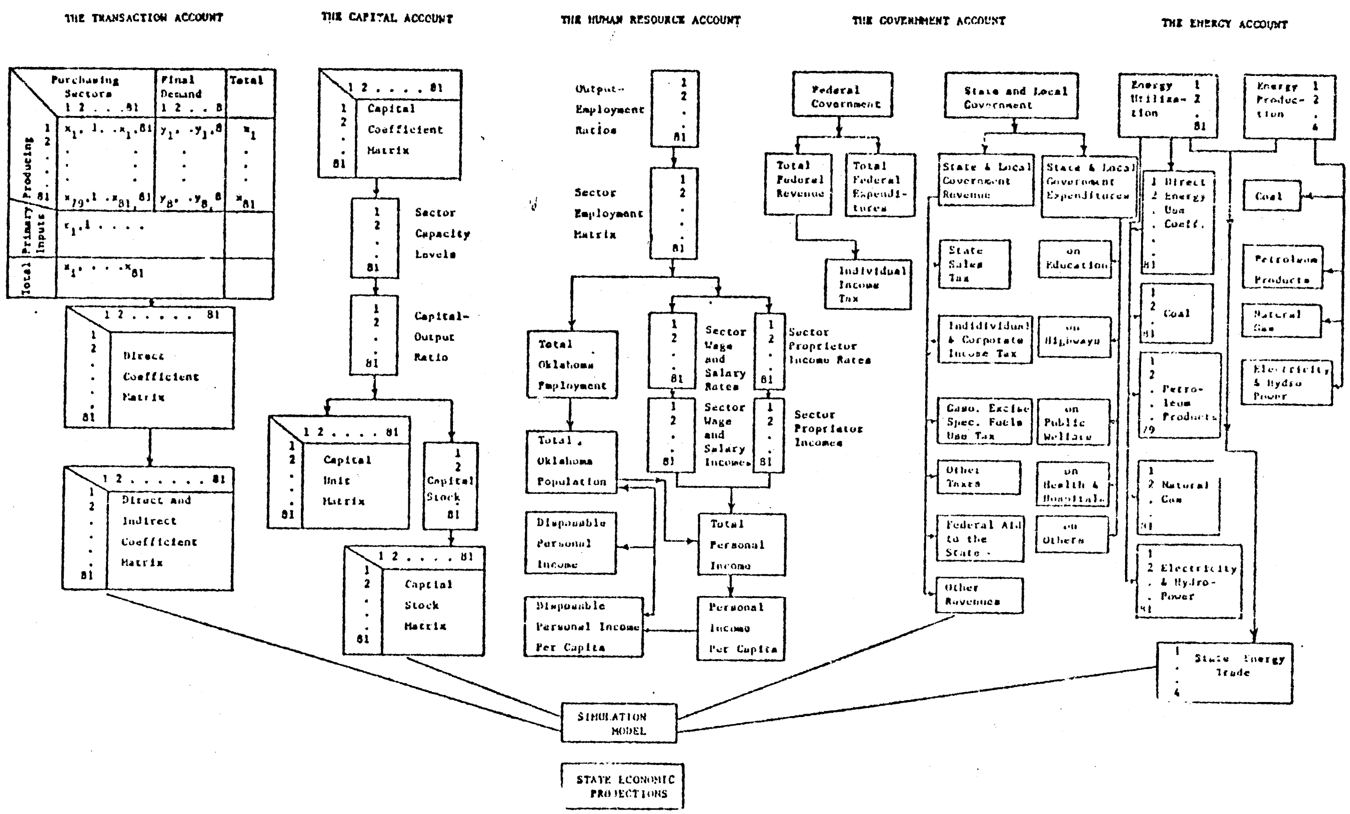

Figure 1. The Oklahoma Social Accounting System

dollar change. The transaction account is discussed in more detail in Chapter III.

The Capital Account

The capital account is composed of a capital coefficient matrix, capital-output ratios, sector output at capacity levels, a capital stock matrix, a capital unit matrix, an investment matrix and depreciation rates. The capital coefficient matrix forms the base of the capital analysis. The capital coefficient matrix and capital-output ratios at capacity output are mainly used in estimating the capital stock matrix and capital unit matrix.

The capital account is important for measuring impacts of dynamic change in Oklahoma's economy through the social accounting system. Changes in state energy production and utilization bring about other changes in the state's economic activity. These changes are related to investments, productive capacity and technology. It is necessary to evaluate changes in capacity due to economic growth and structural change as a result of different energy choices. The dynamics of the model help to investigate the impact of alternative energy choices on the capital economy. The definition and composition of the capital account are discussed in more detail in Chapter IV.

The Human Resource Account

The human resource account is of vital importance in a state social accounting system. Employment and income measures are used for analyzing effects of alternative energy choices. By including the human resource account the model provides measures of regional impacts for alternative energy choices on the levels of employment and income.

The human resource account provides data about the employment, income and population of the state. Estimates of wage and salary employment and proprietor employment by sector are included. With employment and ouput data, employment-output ratios are developed. The income portion includes wage and salary payments and proprietor income by sector. By using the employment and income data, income rates for wage and salary workers as well as proprietors by industry groupings are estimated. Personal income per capita and disposable income per capita are calculated from total personal income, disposable income, and population information. Data sources and computation procedures are discussed in more detail in Chapter V.

The Government Account

The government account is also important in the social accounting system because it provides the basis for estimating the cost of government and revenue of government from alternative energy choices. The analysis develops measures of regional impact for alternative energy choices on government revenues.

The government activities are analyzed in two sub-sections: federal government and state and local government in which discussion is centered around revenues and expenditures. State and local government revenues are discussed in six categories: (1) state sales tax; (2) individual and corporation income tax; (3) gasoline, fuel excise and special fuels-use tax; (4) all other state and local taxes; (5) federal aid to state and local government; and, (6) all other revenues. State and local government expenditures are analyzed in five categories:

(1) education, (2) highways, (3) public welfare, (4) health and hospitals, and (5) other. Complete data base and definitions for the account are discussed in more detail in Chapter V.

The Energy Account

The energy account is the unique component of the present Oklahoma social accounting system. The energy account provides the basis to investigate Oklahoma energy production and utilization and to evaluate alternative energy choices. Direct energy use coefficients (or energy use-to-output ratios) are estimated by using sector disaggregation of energy use and sector output. These and other coefficients of the social accounting system provide measures of regional impact for alternative energy choices on the level of state employment, income, and government revenues. The energy account presents sector disaggregation of energy production and utilization and interregional energy trade by basic energy source. The study has classified energy data into four sectors: petroleum products, natural gas, coal mining and electricity plus hydroelectric power. All energy is measured in physical terms and converted to BTU units which is convenient for analytical purposes in aggregation and comparison between the energy sources. Data base and computation procedures are presented in more detail in Chapter VI.

The five accounts mentioned above complete the regional social accounting system. These components comprise the information system and data basis for the simulation and input-output model developed in Chapter VII. The difference of this study from the previous simulation studies for Oklahoma is that a comprehensive energy account is developed. It is the basis for the study and evaluation of alternative energy choices on the economy of the state of Oklahoma.

CHAPTER III

THE INTERINDUSTRY TRANSACTION ACCOUNT

Implementation of an integrated social accounting system for a state economy necessitates a current transaction account. This section consists of three basic parts: a transaction matrix, a set of direct coefficients. Data sources, definitions, assumptions, and techniques used in estimating state control outputs by sector for the transaction account are presented in Appendix A. To illustrate the concept and definition of input-output economics, a brief review of methodology is presented in this section.

Input-Output Methodology[1]

Input-output or interindustry economics is both an accounting system that measures interdependence of industries and an analytical tool that evaluates the impact of autonomous changes on a closed economic system such as a state or nation. The central concept is a fundamental relationship between the volume of output and the volume of inputs for an industry. It represents a double entry accounting system. The transaction account is an empirical description that shows the sales and purchases of goods and services among the endogenous sectors of an

[1]For complete presentations of the historical development and formulation of input-output economics see Miernyk [35], Richardson [62] and Isard [30].

economic system. It also shows the interaction of the endogenous sectors with components of the exogenous sectors. Sectors of the transactions matrix are divided into two groups, the processing or intermediate sectors and the final demand sectors, making a distinction between production and final disposition of goods, and services. Each processing sector appears in the accounting system twice, as a producer of output and as a user of inputs. The transactions matrix is the basic account of the input-output model from which the other matrices are derived. Flows of inputs and outputs in the transactions matrix are expressed in dollar values to the producer (producer's prices) [16]. The transactions matrix can be divided into four quadrants as show in Figure 2. Quadrant I is the processing or interindustry section of the table that shows the flow of goods which are currently produced and sold but do not reach the ultimate users. The input-output model concentrates on this quadrant of the transactions matrix which shows the interrelationships of processing sectors.

A total of "n" processing sectors are listed in Quadrant I of Figure 2. The elements in each row indicate the sales of a sector to all other sectors in the economy during the given accounting period. The outputs of the sectors can be represented as $X_1, X_2, \ldots, X_n$. The flow of goods and services between two sectors can be designated as X_{ij} which denotes the amount of product moving from producing sector "i" to purchasing sector "j". Part of the output of the processing sectors is sold to final demand of Qudrant II. Dollar values of sales to final demand sectors are designated as Y_i. The row total for a given sector, X_i, represents the gross output for the sector, the sum of sales to processing sectors plus the sum of sales to final

		Intermediate or Processing Sectors 1, 2, - - - - - j - - - - - - - - n	Final Demand	Gross Output
Intermediate or Processing Sectors	1	X_{11}, - - - - - X_{ij} - - - - - - - X_{in}	Y	X_1
	2	- -	-	-
	-	- -	-	-
	-	- -	-	-
	i	- - - - - - - X_{ij} - - - - - - - X_{in}	Y_i	X_i
	-	- -	-	-
	-	Quadrant I - -	Quadrant - II	-
	-	- -	-	-
	n	- - - - - - - - X_{nj} - - - - - - - X_{nn}	Y_n	X_n
Final Payments		Quadrant III V_1 - - - - - V_j - - - - - - - - V_n	Quadrant IV	
Gross Outlay		X_1 - - - - - - X_j - - - - - - - - X_n		

Figure 2. Schematic Arrangement of Input-Output Transaction Table

demand sectors. It follows that:

$$X_i = \sum_{j=i}^{n} X_i + Y_i \qquad (i = 1, 2, \ldots, n)$$

Final payments by sector in the form of wages and salaries, proprietor income, rents, profits, and other factor payments are represented in Quadrant III. Quadrant IV, where final demand and final payments sectors intersect, includes inputs to final demand sectors not purchased from the processing sectors of Quadrant I and transfer payments.

The column total for a given sector, X_j, represents the gross outlay for a sector; the sum of purchases from the processing sectors X_{ij} plus the sum of payments to final payment sectors designated as V_j. This relationship can be stated as:

$$X_j = \sum_{i=1}^{n} X_{ij} + V_j \qquad (j = 1, 2, \ldots, n)$$

Gross output must equal gross outlay for each processing sector as the receipts from sales must equal receipts paid out for goods and services plus value of final payments.

The basic assumption of input-output analysis is that the relationship between the purchases of a sector and the level of output of that sector is linear. The relationship can be expressed in the following form:

$$X_{ij} = a_{ij}X_j + C_{ij} \qquad (i = j = 1, 2, \ldots, n)$$

where the a_{ij}'s and C_{ij}'s are constant parameters in the expression. In most empirical work the intercept C_{ij} is assumed zero and a_{ij}

represents the direct purchase of the jth purchasing sector from the ith producing sector per dollar of output (outlay) in the jth purchasing sector. The coefficient a_{ij} is obtained from the ratio between X_{ij} and X_j. Mathematically it is presented as:

$$a_{ij} = \frac{X_{ij}}{X_j} \qquad (i = j = 1, 2, \ldots, n)$$

Each a_{ij} indicates the direct dependence per dollar of output of each sector. A matrix of direct coefficients is computed from the processing portion (Quadrant I) of the transaction matrix.

The set of equations given above to show the disposition of output in the transactions matrix can be written as:

$$X_i = \sum_{j=1}^{n} a_{ij}X_j + Y_i \qquad (i = 1, 2, \ldots, n)$$

If "X" represents a column vector of output totals, "A" represents the matrix of input-output coefficients, and Y the column vector of final demand then:

$$X = AX + Y$$
$$X - AX + Y$$
$$(I - A)X + Y$$

Employing the use of the identity matrix and matrix algebra, under the condition that (I - A) is non-singular, both sides of the equation can be multiplied by the inverse of (I - A) yielding:

$$(I - A)^{-1} (I - A)X = (I - A)^{-1} Y$$
$$X = (I - A)^{-1} Y$$

which is the standard "solution" to the input-output system where total outputs (X) are a function of final demands (Y). Any size and composition of final demand can be represented in the sector Y and the level of gross output for each sector is determined. This provides a powerful tool for the analysis of the accumulated impact of exogenous forces on the economy. $(I - A)^{-1}$ is the total requirements or direct and indirect coefficients matrix. The coefficients in a given column "j" of this matrix reflect the total dollar production directly and indirectly required from each sector "i" to support a dollar of delivery to final demand by sector "j". The fundamental condition must be met that there are no negative entries in the total requirements matrix. In essence it would mean that each time the industry with a negative entry expanded its sales to final demand, its direct and indirect input requirements would decline [35].

Oklahoma Interindustry Transaction Account

Current Transaction Flow Table

The use of a regional input-output model for development planning and public policy often is prevented by the extensive data gathering process required in developing a model from primary data. The development of an input-output transaction table from primary sources is expensive and time consuming. Consequently the state transaction matrix is developed from national technical coefficients based on the location quotient technique as described and developed by Schaffer and Chu [66]. The location quotient (LQ) is a number comparing the relative importance in the nation. It is defined for industry i as:

$$LQ_i = \frac{X_i}{Z_i} \bigg| \frac{X}{Z}$$

where X_i represents the regional output of industry i, X the total regional output, Z_i the national output of industry i and Z the total national output, all for the same base year. The location quotient procedure provides the best estimates of production coefficients. Considering the cost differences and the applications, answers to policy questions based on secondary data models will not be significantly different from the results of primary data models [66].

The unique feature of the procedure is that information of a national technical coefficient matrix, state total output, and state total final demand without trade for each sector are required. The state flow of goods and services to final demand sectors is computed separately. The basic function of the procedure is to compute the state interindustry transactions matrix, technical coefficients matrix, and interdependence coefficient matrix. The disposition of output in the transactions matrix can be defined as follows:

$$A^N X^A + Y^0 = X^R$$

$$X^A - X^R = Y^T$$

where:

X^A = Column vector of state total actual output.

A^N = National direct coefficients matrix.

Y^0 = Column vector of state total final demand without trade.

X^R = Column vector of state total required output.

Y^T = Column vector of state trade.

If the state's actual sector output is equal to the state's required output ($X^A = X^R$), the state sector is assumed to be just self-sufficient, that is, it has its "proper share". If the state's actual sector output is greater than the state's required output ($X^A > X^R$), the state sector, in this case, produces more than its proportionate share, and exports its surplus production. In both situations, national technical coefficients ($A_{ij} = Z_{ij}/Z_j$) for that sector's row may be used directly to represent the state technical coefficients ($a_{ij} = X_{ij} | X_j$). In other words, if $LQ_i \geq 1$, $a_{ij} = A_{ij}$. As the result, the surplus production by sector is put in the export column vector of final demand.

However, if the state's actual sector output is less than the state's required output ($X^A < X^R$), that is, if $LQ_i < 1$, the state produces less than its proportionate share and imports the deficit requirements. In this situation the state technical coefficients (a_{ij}) are not equal to the national technical coefficients (A_{ij}), but equal to $a_{ij} = LQ_i \cdot A_{ij}$. The national coefficients of the sector's row are reduced proportionally to account for the state's deficit production and the difference placed as an import row vector in the final payments. The final state flow table is developed by including the inter-industry flows, final demand and imports and exports derived in the manner explained above. Once the state flow table is developed, the state technical and interdependence coefficients matrices are obtained by mathematical manipulation of the derived state flow table by assuming a linear relationship between the purchases of a sector and the level of output of that sector. The derived transactions matrix for the Oklahoma economy estimates the flow of goods and services for 1972.[2]

Column sectors of an interindustry flow matrix represent the consuming sectors, whereas row sectors represent the producing sectors. The interindustry flow of goods and services provides the base for analysis of the interindustry transaction account. By reading down a column of the Oklahoma transactions matrix the dollar value of inputs that a given sector purchased from the other sectors can be determined. At the same time by reading across a row of the transaction matrix the dollar value of output that a given sector sold to the other sectors can be estimated.

Direct Coefficients

These coefficients are sometimes referred to an input-output coefficients or technical coefficients in which the level of technology and trade patterns chiefly determine the characteristics of the coefficients over time [35]. These coefficients are relevant only for the processing sectors; therefore, direct coefficients are computed only for the columns of the purchasing sectors. The coefficients are obtained from the Oklahoma transactions matrix by dividing each column entry by the sector's total outlay. The result is a column of decimal fractions whose sum in one. No column sum can be greater than unity. This is because an industry cannot pay more for its input than it receives from the sales of its output [35]. The matrix of direct coefficients by itself is of limited usefulness because it shows only the "first-round" effects of a change in the output of one industry on the

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[2]The Oklahoma transactions matrix is not presented in the text due to its size.

industries from which it purchases inputs. However, the matrix provides the basis for a general solution of the input-output model.

The input coefficients indicate the direct purchases of each sector from every other sector per dollar of output. For each dollar of output by an industry listed at the top of a column, each column entry in the input coefficient matrix is an estimate of the direct requirement from the industry listed on a row.

The direct coefficients for the 77 non-energy producing sectors and the direct requirements of the output of the energy producing sectors are estimated from the transactions account. The energy outputs in BTU of the energy producing sectors are estimated separately. The direct energy coefficients for the four energy producing sectors and the direct energy requirements of the non-energy producing sectors are estimated in the energy account.[3]

Direct and Indirect Coefficients

Direct and indirect coefficients are also referred to as total requirements or interdependence coefficients. These coefficients indicate the total change in input requirements as a result of a one dollar change in sector final demand. The total change includes the direct effect, an estimate of the initial change, as well as all indirect effects or secondary changes resulting from the initial one dollar change. The combined direct and indirect effects on processing sectors, which result from a dollar increase in final demand for the output of each processing sector, is computed by inverting the (I-A)

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[3]This accounting is further explained in Chapter VI and Chapter VII.

matrix as illustrated in the input-output methodology section. The state direct and indirect coefficients for seventy-seven non-energy producing sectors are estimated from the final Oklahoma interindustry transactions matrix.

Each column entry in the total requirements matrix is the total direct plus indirect output requirement from the industry named at the row to support a dollar of sales to final demand by the industry named at the top of the column.

The direct coefficients, and direct and indirect coefficients are an integral part of the simulation model. It is through these accounts that the total impact of structural changes in the economy are measured.

CHAPTER IV

THE CAPITAL ACCOUNT

The capital account allows certain dynamic factors to be introduced into a social accounting system. Sector capacities can be increased by use of sector capital-output ratios and the capital coefficient matrix. Capital replacements can be estimated through use of sector depreciation rates. Inventory changes are estimated using inventory coefficients. When data are available, changes in capital-output ratios, capital coefficients, depreciation rates and inventory coefficients can be estimated given changes in technologies or changes in economic structure. For instance, a sharply rising demand for and declining supply of energy products effect a change in the economic structure and consequently the components of the capital accounts change. In this way dynamic models can be formulated using investment coefficients and the accelerator principle to evaluate the effects of new capital investment for alternative development strategies.

The capital account can be used in several ways. First, capital flow tables can be used to obtain information on the markets for capital goods. Conventional input-output tables provide marketing information only for current account transaction. Second, capital flow tables can be used to measure each industry's total output required for a specified level of investment in a given industry. Third, capital stocks by industry can be estimated using a series of capital flow tables [76].

The capital account in this section is presented in eight parts with each composed of the 81 sector input-output industry grouping: capital coefficient matrix[1], capacity estimates, capital-output ratios, capital stock matrix[2], capital unit matrix[3], inventory coefficients, investment coefficient matrix[4] and depreciation rates. A complete discussion of concepts and definitions used in deriving the Oklahoma capital account is obtained from Doeksen and Schreiner's extensive work about capital structure in Oklahoma [10].

Concepts and Definitions

The input-output transactions matrix of the proceeding section shows only the interindustry flows of current outputs and inputs while capital expenditures are aggregated into the capital formation component of the final demand. In a capital flow matrix this column is disaggregated with rows representing sales of capital-producing sectors and columns representing the purchases of capital-consuming sectors.

The capital coefficient matrix forms the base of the capital analysis. It can be derived from a capital flow matrix or by using direct survey techniques. Construction of capital coefficients using survey data is expensive and time consuming. The capital coefficient matrix is computed from a capital flow matrix by finding the percentage

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[1, 2, 3, and 4] Because of the size of the matrices the data of these components are not presented in the text.

distribution of each column. Thus a capital coefficient g_{ij} is defined as:

$$g_{ij} = \frac{b_{ij}}{b_j}$$

where b_{ij} is an element of the capital flow matrix measured as the dollar value of capital purchases of the jth sector from the ith sector, and b_j is the dollar value of total capital purchases of the jth sector from all sectors ($b_j = \Sigma b_{ij}$). Each capital coefficient (g_{ij}) indicates the amount of capital goods purchased from the ith sector per dollar's worth of capital expenditures by the jth sector per unit of time.

A capital stock matrix can be computed from the capital coefficient matrix and sector capital-output ratios. Capital-output ratios (K/X) for this analysis are defined as the ratio of total cost of plant and equipment to output at capacity. For this analysis, capacity is defined as that output equal to peak production. Once capacity output X_j^C is defined, the total amount of capital in each sector can be estimated. The procedure is as follows:

$$X_j^C \cdot (K/X)_j = K_j$$

where K_j is the dollar value of the capital stock of sector j, X_j^C is output at capacity for sector j, and $(K/X)_j$ is the capital-output ratio for sector j. The capital stock matrix can then be determined by multiplying total sector capital stock estimates (K_j) by the capital coefficient matrix, that is:

$$K_j \cdot g_{ij} = K_{ij}$$

where each K_{ij} represents the total amount of capital goods from sector i invested in sector j.

A capital unit matrix is defined as the amount of capital invested, and the composition of that capital, per unit of output capacity of the producing sectors. This matrix is computed from the capital coefficient matrix and the capital-output ratios at capacity output. It is estimated as follows:

$$(K/X)_j \cdot g_{ij} = O_{ij}$$

where $(K/X)_j$ is the capital-output ratio of sector j and g_{ij} is the capital coefficient. Each coefficient (O_{ij}) indicates the amount of capital needed from the ith sector to provide one unit of output capacity for the jth sector.

Another matrix of importance is the investment coefficient matrix [9]. By adding the capital unit coefficients (O_{ij}) and the diagonal matrix of inventory coefficients (S_{ij}), the total amount of capital required per unit of output expansion is estimated. The investment coefficient matrix is calculated as follows:

$$\frac{O_{ij} + S_{ij}}{\Sigma\ (O_{ij} + S_{ij})} = I_{ij}$$

where $(O_{ij} + S_{ij})$ are the combined capital unit and inventory coefficients. Each I_{ij} indicates the value of output of the ith sector required by the jth sector per unit of investment in j. The difference between the investment coefficient matrix and the capital coefficient matrix are the inventory estimates. Inventory coefficients are defined as the amount of inventory held per unit of output.

The capital analysis is completed by developing depreciation coefficients. The coefficients d_j indicate the depreciation rate per dollar of depreciable assets:

$$d_j = \frac{D_j}{K_j}$$

where D_j is the total annual depreciation of capital (K_j) in sector j.

Oklahoma Capital Account

Capital Coefficient Matrix

The capital coefficient matrix for Oklahoma was developed from the capital flow matrix for the United States in 1967 prepared by the office of Business Economics (OBE) of the Department of Commerce [76]. This represents the latest and most detailed data available for developing a capital coefficient matrix. The OBE capital flow matrix has 79 columns representing users of capital and 38 rows representing industries which produce capital. The Oklahoma capital coefficient matrix composed of an 81 by 81 matrix is derived from the national capital coefficient matrix. The location quotient approach is used to make the necessary adjustments for a row vector of Oklahoma relative to the national row vector. The estimates are based on the information of new structure and equipment components of gross private fixed capital purchases. Consumption of capital goods represents purchases made for replacement as well as for new plant construction.

Flows are recorded in producers' prices as is the convention for the national input-output transaction matrices.

The capital coefficients indicate the amount of capital goods required from each row sector for every dollar's worth of capital expenditures made by each column sector. One weakness of these data is that the coefficients refer to 1967 and thus market distribution patterns could change for other years. Another weakness is that technology is assumed to remain constant when 1967 capital coefficients are used for 1972 and technological efficiency in Oklahoma is the same as the national average. The sector capital expenditures for 1972 are updated from 1967 by assuming the growth rate of capital expenditures from 1963 to 1967 is equal to the growth rate from 1967 to 1972. In each case the annual average growth rate for each five-year period of capital expenditure is estimated.

The capital coefficients for the 81 input-output industry grouping for Oklahoma is part of the simulation model. By reading down a column, purchases of capital goods from producing sectors (row sectors) per dollar of capital outlay by the column sector are given.

Capacity Estimates

Capacity estimates are used to determine the output level that triggers new investment, primarily for additions to output. Bert Hickman [28] defines capacity as the "output at which average total costs is minimum for the given techniques factor prices and physical plants" (p. 96). Capacity estimates are difficult to measure and all studies on this subject have intrinsic weaknesses. The most recent capacity measure is that of the Wharton School of Econometrics Unit [31]. The method is extremely simple, however it is considered as good as any other estimate. In the Wharton procedure the Federal Reserve Board Indexes of industrial production are averaged into quarterly figures. The figures are charted and peaks determined by inspection. One hundred percent capacity is assumed for each peak period and a straight line connecting peaks describes capacity between peaks. For any period which the latest peak has not been reached, a straight line is extrapolated from the last peak period until production intersects that line. After such an intersection, capacity is assumed equal to the line connecting the last peak and the most recent production figure [9].

A similar method was used to measure capacity levels for the 81 input-output industry grouping in Oklahoma. However, employment figures are used as proxies for the production indexes of Oklahoma in 1972. Although employment data are not as good an indicator as the production index, it is the best statistic available at the state level. To derive the capacity estimates for Oklahoma the employment data from 1970 through 1974 are considered [44]. Employment of each industry category and year is averaged into quarterly figures. The employment peaks within the five year period are identified by inspection on a plotted graph. Each employment peak is assumed to represent one hundred percent capacity. Then quarterly employment of each industry category for 1972 is averaged into annual figures. Dividing the 1972 annual average sector employment data by the peak period sector employment data, the capacity estimates by industry classification are determined. Capacity estimates and output by sector for Oklahoma in 1972 are presented in Table II. The first column indicates capacity estimates by sector at the base year. For instance the coal mining industries (sector 80) is estimated to be operating at 83.8 percent of capacity and natural gas production (sector 79) at 92.7 percent of capacity. Similar analysis can be made for the other sectors.

The second column of Table II indicates output at capacity estimated by multiplying 1972 sector output by the reciprocal of the capacity estimate. For instance, output at capacity for wholesale and retail trade (sector 67) is estimated to be $2,815 million compared to $2,568 million of actual output in 1972. Livestock and livestock products (sector 1) can function at capacity output of $1,350 million compared to $1,197 million actual output and food and kindred products (sector 12) at $978 million of output at capacity compared to actual output of $941 million. Similar analysis can be made for the other sectors.

Capital-Output Ratios

The capital-output ratios are very important in the capital accounts of the Oklahoma social accounting system. There are many difficulties, however, in the measurement of the capital stock and its relationship to output flows. Capital is defined as the capital stock which is the value of depreciable assets. Output, to be consistent with the input-output model, is defined as the dollar value of receipts, except for the wholesale and retail trade sector where output is defined as the value of receipts less cost of goods purchased. Capital-output ratios, therefore, indicate the dollar value of capital required in order to obtain one dollar's worth of output.

To analyze the relationship between capital and output, either the marginal ratio or the average ratio is used. For this capital analysis,

TABLE II

CAPACITY LEVELS AND CAPACITY OUTPUT BY SECTOR, OKLAHOMA, 1972

I/O	Sector	Capacity Level,[5] Percent	Capacity Output[6] $1,000
1.	Livestock and Livestock Products	88.65	1,349,815
2.	Other Agricultural Products	88.65	628,925
3.	Forestry and Fishery Products	88.65	12,054
4.	Agricultural, Forestry and Fishery Services	82.97	56,930
5.	Iron and Ferroalley Ores Mining	100.00	0
6.	Nonferrous Metal Ores Mining	93.51	2,999
7.	Stone and Clay Mining and Quarrying	88.68	31,209
8.	Chemical and Fertilizer Mineral Mining	100.00	20
9.	New Construction	82.75	1,720,046
10.	Maintenance and Repair Construction	82.75	218,280
11.	Ordance Accessories	71.86	5,917
12.	Food and Kindred Products	96.24	977,625
13.	Tobacco Manufactures	80.00	128
14.	Broad and Narrow Fabrics, Yarn and Thread Mills	76.87	1,7318
15.	Miscellaneous Textile Goods and Floor Coverings	89.34	79,053
16.	Apparel	81.06	153,519
17.	Miscellaneous Fabricated Textile Products	93.99	31,038
18.	Lumber and Wood Products, Except Containers	81.12	160,312
19.	Wood Containers	81.20	4,155
20.	Household Furniture	75.40	38,422
21.	Other Furniture and Fixtures	72.56	21,010
22.	Paper and Allied Products, Except Containers	90.78.	90.474
23.	Paperboard Containers and Boxes	90.70	42,252
24.	Printing and Publishing	90.66	213,927
25.	Chemicals and Selected Chemical Products	84.40	58,710
26.	Plastics and Synthetic Materials	100.00	0
27.	Drugs, Cleaning and Toilet Preparations	84.40	7,807
28.	Paints and Allied Products	88.56	12,204
29.	Paving and Roofing Material	84.43	62,362
30.	Rubber and Miscellaneous Plastics Products	80.68	341,308
31.	Leather Tanning and Finishing	74.90	136
32.	Footwear and Other Leather Products	74.91	32,432
33.	Glass and Glass Products	94.52	138,304
34.	Stone and Clay Products	90.58	167,653
35.	Primary Iron and Steel Manufacturing	71.76	139,289
36.	Primary Nonferrous Metals Manufacturing	96.47	68,632
37.	Metal Containers	80.60	1,230
38.	Heating, Plumbing, and Struct. Metal Products	86.20	369,931
39.	Screw Machine Products and Stampings	84.94	11,316
40.	Other Fabricated Metal Products	80.60	122,431
41.	Engines and Turbines	71.56	8,160
42.	Farm and Garden Machinery	56.91	43,760
43.	Construction and Mining Machinery	76.50	399,554
44.	Materials Handling Machinery and Equipment	76.50	20.728
45.	Metal Working Machinery and Equipment	71.60	19,911
46.	Special Industry Machinery and Equipment	78.02	59,019
47.	General Industrial Machinery and Equipment	80.34	175,235

TABLE II (Continued)

I/O	Sector	Capacity Level, (Percent)	Capacity Output $1,000
48.	Misc. Machinery, Except Electrical	71.71	53,866
49.	Office, Computing, and Accounting Machines	90.13	218,297
50.	Service Industry Machines	74.02	128,181
51.	Electric Industrail Equipment and Apparatus	80.30	53,506
52.	Household Appliances	79.79	2,639
53.	Electric Lighting and Wiring Equipment	80.20	7,830
54.	Radio, T.V. and Communication Equipment	80.36	334,634
55.	Electronic Components and Accessories	80.10	29,528
56.	Misc. Electrical Machinery and Supplies	97.05	7,612
57.	Motor Vehicles and Equipment	75.38	132,692
58.	Aircraft and Parts	73.56	167,732
59.	Other Transportation Equipment	85.04	97,260
60.	Scientific and Controlling Instruments	75.81	26,073
61.	Optical, Ophthalmic, and Photo. Equipment	76.80	16,845
62.	Miscellaneous Manufacturing	88.23	72,380
63.	Transportation and Warehousing	93.54	97,448
64.	Communications, Except Radio and T.V.	84.13	372,155
65.	Radio and T.V. Broadcasting	92.82	57,805
66.	Water Supply and Sanitary Services	73.82	52,799
67.	Wholesale and Retail Trade	91.23	2,814,674
68.	Finance and Insurance	89.08	905,554
69.	Real Estate and Rental	77.94	2,642,017
70.	Hotels; Personal and Repair Services Exc. Auto	94.50	363,594
71.	Business Services	79.44	802,567
72.	Eating and Drinking Places	81.86	714,373
73.	Automobile Repair and Services	89.94	331,704
74.	Amusements	80.60	141,263
75.	Medical, Educ. Services, and Nonprofit Org.	88.12	1,102,490
76.	Federal Government Enterprise	95.56	232,984
77.	State and Local Government Enterprise	84.36	138,499
			Billion BTU
78.	Petroleum Products Production	89.37	1,390,151
79.	Natural Gas Production	92.66	2,088,137
80.	Coal Mining	83.83	75,280
81.	Electricity and Hydro-Power	97.60	116,758

Sources: [5]Estimated using employment figures from the Oklahoma Employment Security Commission [44].

[6]Estimated using capacity estimates and 1972 sector outputs.

capital-output ratios are used as averages and defined as the ratio of the total cost of plant and equipment to output at capacity. The marginal relationship is potentially much more unstable than the average since the average ratio compares a stock of capital accumulated over many years with the current output while the marginal ratio relates an addition to the capital stock over a short period to the change in output over the period [120]. The average ratios, defined for a time period of one year, 1972, are estimated as sector capital stock divided by sector output. Capital-output ratios for the U.S. estimated from U.S. Bureau of Labor Statistics [101] and [104] are used for the Oklahoma 1972 capital analysis.

Capital-output ratios by industry grouping are presented in Table III. Type I capital-output ratios (column 1) reflect capital needs at average output, whereas Type II capital-output ratios (column 2) are defined as the ratio of the total cost of capital goods to the value of output at capacity, or the quantity of capital required per unit of capacity [62]. Considering the automobile repair and service industries (sector 73) as an example, capital stock needs of the automobile repair and service industries must be increased by $0.75283 to increase the sector's output by one dollar. Type II ratios represent the capital-output ratios at capacity levels of output. Type II capital-output ratios are obtained by multiplying the average capital-output ratio (Type I) by the estimated capacity levels in 1972. The ratios indicate the capital goods requirements by each sector to increase the sector's output by a dollar when the sector's output is at the capacity level. In this case the automobile repair services sector's need for capital

TABLE III

CAPITAL OUTPUT RATIOS AND CAPITAL STOCK BY SECTOR, OKLAHOMA, 1972

I/O	Sector	Capital-Output Ratios Type I	Type II
1.	Livestock and Livestock Products	0.43521	0.38581
2.	Other Agricultural Products	0.43520	0.38581
3.	Forestry and Fishery Products	0.28650	0.25398
4.	Agricultural, Forestry & Fishery Services	0.56197	0.46627
5.	Iron & Ferroalley Ores Mining	0.0	0.0
6.	Nonferrous Metal Ores Mining	1.54495	1.44468
7.	Stone & Clay Mining & Quarrying	0.82123	0.72827
8.	Chemical & Fertilizer Mineral Mining	1.48761	1.48761
9.	New Construction	0.17460	0.14448
10.	Maintenance & Repair Construction	0.17398	0.14398
11.	Ordance Accessories	0.35460	0.25482
12.	Food and Kindred Products	0.26585	0.25585
13.	Tobacco Manufactures	0.25234	0.15141
14.	Broad & Narrow Fabrics, Yarn & Thread Mills	0.35867	0.27571
15.	Miscellaneous Textile Goods & Floor Coverings	0.27979	0.24996
16.	Apparel	0.17303	0.14026
17.	Miscellaneous Fabricated Textile Products	0.17279	0.16241
18.	Lumber and Wood Products, Except Containers	0.33839	0.27450
19.	Wood Containers	0.44635	0.22076
20.	Household Furniture	0.20467	0.15432
21.	Other Furniture and Fixtures	0.21506	0.15607
22.	Paper & Allied Products, Except Containers	0.72085	0.65439
23.	Paperboard Containers & Boxes	0.39335	0.26512
24.	Printing and Publishing	0.36362	0.32965
25.	Chemicals & Selected Chemical Products	0.76926	0.53540
26.	Plastics & Synthetic Materials	0.70032	0.70032
27.	Drugs, Cleaning & Toilet Preparations	0.29580	0.19529
28.	Paints and Allied Products	0.25900	0.22937
29.	Paving and Roofing Material	0.55049	0.46478
30.	Rubber & Miscellaneous Plastics Products	0.40983	0.33065
31.	Leather Tanning & Finishing	0.18644	0.09525
32.	Footwear & Other Leather Products	0.17120	0.12825
33.	Glass and Glass Products	0.60254	0.56952
34.	Stone and Clay Products	0.58725	0.53193
35.	Primary Iron and Steel Manufacturing	0.75540	0.54208
36.	Primary Nonferrous Metals Manufacturing	0.40319	0.38896
37.	Metal Containers	0.32586	0.28089
38.	Heating, Plumbing, & Struct. Metal Products	0.31288	0.26576
39.	Screw Machine Products and Stampings	0.33035	0.26626
40.	Other Fabricated Metal Products	0.33035	0.26626
41.	Engines and Turbines	0.34473	0.21912
42.	Farm and Garden Machinery	0.29971	0.17056
43.	Construction & Mining Machinery	0.29375	0.22472

TABLE III (Continued)

I/O	Sector	Capital-Output Ratios Type I	Type II
44.	Materials Handling Machinery & Equipment	0.22610	0.17297
45.	Metal Working Machinery and Equipment	0.42668	0.26706
46.	Special Industry Machinery & Equipment	0.31430	0.24522
47.	General Industrial Machinery & Equipment	0.37011	0.29735
48.	Misc. Machinery, Except Electrical	0.38876	0.27878
49.	Office, Computing, and Accounting Machines	0.32485	0.29289
50.	Service Industry Machines	0.25628	0.18970
51.	Electric Industrial Equipment & Apparatus	0.34040	0.22323
52.	Household Appliances	0.24543	0.19583
53.	Electric Lighting & Wiring Equipment	0.28850	0.14789
54.	Radio, T.V. and Communication Equipment	0.27428	0.22041
55.	Electronic Components & Accessories	0.30633	0.12740
56.	Misc. Electrical Machinery & Supplies	0.29706	0.28830
57.	Motor Vehicles and Equipment	0.25815	0.19459
58.	Aircraft and Parts	0.38149	0.28062
59.	Other Transportation Equipment	0.25954	0.22071
60.	Scientific and Controlling Instruments	0.30596	0.23195
61.	Optical, Ophthalmic, & Photo. Equipment	0.35860	0.27540
62.	Miscellaneous Manufacturing	0.25044	0.22096
63.	Transportation and Warehousing	1.09911	1.02811
64.	Communications, Except Radio and T.V.	2.23877	1.88348
65.	Radio and T.V. Broadcasting	2.23877	2.07803
66.	Water Supply and Sanitary Services	2.23877	1.65266
67.	Wholesale and Retail Trade	0.45390	0.41409
68.	Finance and Insurance	0.50246	0.44759
69.	Real Estate and Rental	0.32646	0.25302
70.	Hotels; Personal & Repair Services exc. Auto	0.60690	0.57252
71.	Business Services	0.36209	0.28764
72.	Eating and Drinking Places	0.54696	0.44774
73.	Automobile Repair and Services	0.64088	0.57641
74.	Amusements	0.62592	0.34807
75.	Medical, Educ. Services & Nonprofit Org.	0.59692	0.52601
76.	Federal Government Enterprises	0.0	0.0
77.	State and Local Government Enterprises	0.0	0.0
78.	Petroleum Product Production	0.0000008088	0.0000007228
79.	Natural Gas Products	0.0000008329	0.0000007718
80.	Coal Mining	0.0000002645	0.0000002217
81.	Electricity and Hydro-Power	0.0000133597	0.0000130391

Sources: Estimated using the data available in the U.S. Bureau of Labor Statistics 101 and 104 .

goods when output is at capacity is $0.67710. Similar analysis could be made for the other sectors.

Capital Stock Matrix

Capital stock and new plant and equipment for the energy and non-energy sectors are presented in Table IV. The first column indicates sector capital stock in 1972. The amount of capital in each sector is derived by multiplying the capital-output ratio (Type II) defined at capacity level of output by the estimated output at capacity. The amount of capital in a sector times that sector's capital coefficients column (from the capital coefficient matrix) yields the composition of capital in each sector. Each entry represents the total value of capital goods produced by the row sector and purchased by the column sector. For instance, in the coal mining industries (sector 80) total capital investment for 1972 is $16,692,000 of which $3,836,000 is from new construction (sector 9), $8,522,000 from construction and mining machinery industries (sector 43), and $1,113,000 from wholesale and retail trade (sector 67).

The second column of Table IV indicates sector new plant and capital equipment in 1972. Investments on new plant and equipment by energy and non-energy sectors for the base period are estimated from the national data using the state sector output to national sector output ratio. For instance, automobile repair and services (sector 73) invested $36,729,000 and transportation and warehousing (sector 63) invested $208,801,000 on new plant and equipment, respectively, in 1972.

TABLE IV

CAPITAL STOCK AND INVESTMENT ON NEW PLANT AND EQUIPMENT BY SECTOR, OKLAHOMA, 1972

I/O	Sector	Capital Stock[7] $1,000	New Plant and Equipment[8] $1,000
		(1)	(2)
1.	Livestock and Livestock Products	208,667	56,579
2.	Other Agricultural Products	416,324	113,768
3.	Forestry and Fishery Products	3,061	831
4.	Agricultural, Forestry and Fishery Services	26,352	7,200
5.	Iron and Ferroalley Ores Mining	0	0
6.	Nonferrous Metal Ores Mining	4,625	641
7.	Stone and Clay Mining and Quarrying	22,572	3,244
8.	Chemical and Fertilizer Mineral Mining	30	0
9.	New Construction	245,243	64,653
10.	Maintenance and Repair Construction	37,477	9,947
11.	Ordance Accessories	730	115
12.	Food and Kindred Products	256,230	27,277
13.	Tabacco Manufactures	26	0
14.	Broad and Narrow Fabrics, Yarn and Thread Mills	5,818	754
15.	Miscellaneous Textile Goods and Floor Coverings	21,344	2,766
16.	Apparel	14,205	3,130
17.	Miscellaneous Fabricated Textile Products	2,286	464
18.	Lumber and Wood Products, Except Containers	57,271	6,444
19.	Wood Containers	486	54
20.	Household Furniture	5,907	1,327
21.	Other Furniture and Fixtures	3,262	732
22.	Paper and Allied Products, Except Containers	60,939	8,114
23.	Paperboard Containers and Boxes	18,303	2,441
24.	Printing and Publishing	68,039	10,521
25.	Chemicals and Selected Chemical Products	38,058	4,831
26.	Plastics and Synthetic Materials	0	0
27.	Drugs, Cleaning and Toilet Preparations	2,468	314
28.	Paints and Allied Products	4,199	535
29.	Paving and Roofing Material	36,234	2,861
30.	Rubber and Miscellaneous Plastics Products	126,588	20,777
31.	Leather Tanning and Finishing	9	0
32.	Footwear and Other Leather Products	4,116	799
33.	Glass and Glass Products	11,403	10,459
34.	Stone and Clay Products	95,776	8,795
35.	Primary Iron and Steel Manufacturing	106,347	7,867
36.	Primary Nonferrous Metals Manufacturing	48,038	3,555
37.	Metal Containers	236	37
38.	Heating, Plumbing, and Struct. Metal Products	125,305	17,460
39.	Screw Machine Products and Stampings	3,488	486
40.	Other Fabricated Metal Products	30,171	4,201
41.	Engines and Turbines	2,488	339
42.	Farm and Garden Machinery	7,187	1,011
43.	Construction and Mining Machinery	143,112	19,458

TABLE IV (Continued)

I/O	Sector	Capital Stock[7] $1,000	New Plant and Equipment[8] $1,000
		(1)	(2)
44.	Materials Handling Machinery	3,565	486
45.	Metal Working Machinery and Equipment	6,079	825
46.	Special Industry Machinery and Equipment	20,583	2,799
47.	General Industrial Machinery and Equipment	60,813	9,464
48.	Misc. Machinery, Except Electrical	20,066	2,724
49.	Office, Computing, and Accounting Machines	107,445	15,074
50.	Service Industry Machines	33,822	4,603
51.	Electric Industrial Equipment and Apparatus	17,096	3,247
52.	Household Appliances	425	81
53.	Electric Lighting and Wiring Equipment	1,906	416
54.	Radio, T.V. and Communication Equipment	79.478	15,127
55.	Electronic Components and Accessories	7,780	1,590
56.	Misc. Electrical Machinery and Supplies	2,808	534
57.	Motor Vehicles and Equipment	29,271	3,083
58.	Aircraft and Parts	36,423	8,054
59.	Other Transportation Equipment	26,872	4,218
60.	Scientific and Controlling Instruments	6,559	929
61.	Optical, Ophthalmic, and Photo. Equipment	7,055	999
62.	Miscellaneous Manufacturing	19,057	2,942
63.	Transportation and Warehousing	982,914	208,801
64.	Communications, Except Radio and T.V.	700,722	93,140
65.	Radio and T.V. Broadcasting	120,040	11,043
66.	Water Supply and Sanitary Services	52,272	12,570
67.	Wholesale and Retail Trade	258,476	171,190
68.	Finance and Insurance	126,079	45,142
69.	Real Estate and Rental	5,157,631	345,110
70.	Hotels; Personal and Repair Services Exc. Auto.	304,562	66,015
71.	Business Services	266,766	30,792
72.	Eating and Drinking Places	194,368	38,990
73.	Automobile Repair and Services	242,183	36,729
74.	Amusements	90,814	14,889
75.	Medical, Educ. Services and Nonprofit Org.	249,373	159,374
76.	Federal Government Enterprises	0	0
77.	State and Local Government Enterprises	0	0
78.	Petroleum Product Production	1,014,039	169,277
79.	Natural Gas Products	1,553,093	264,870
80.	Coal Mining	16,692	2,655
81.	Electricity and Hydro-Power	1,366,436	133,517

Sources: [7]Estimated using sector output at capacity (Table II), capital-output ratios (Table III) and capital coefficients.

[8]Estimated from U.S. 1972 investments on new plant and capital equipment [76].

Capital Unit Matrix

The capital coefficients and the capital-output ratios (Type II) are used to construct a capital unit matrix. The coefficients of this matrix are computed by multiplying the capital coefficients of a sector and the corresponding capital-output ratio at capacity level. Since unit of output is defined in dollars, each coefficient in the capital unit matrix indicates the dollar amount of capital goods needed from the producing sectors (row sector) per dollar increase in output of the purchasing sector (column sector).

The capital unit matrix is useful when considering the amount of capital needed to increase output in a particular sector. Output can be increased without additional capital if a sector is not operating at capacity. However, if a sector is operating at capacity and output needs to be expanded, capital per unit output will be required according to the capital-output ratio [9]. The composition of the required capital is determined from the capital unit matrix.

Inventory Coefficients

Inventory consists of raw materials, goods in process, and finished goods. The inventory coefficients indicate the amount of inventory needed per unit of output and are presented in Table V. Methods used to estimate the inventory coefficients and the data sources are discussed separately for the agricultural sectors, manufacturing sectors, and the remaining sectors.

The total inventories of the agricultural sector for the base year 1972 is available in Oklahoma Agriculture, 1974 [40]. It is 25.4 million dollars and is distributed among the four agricultural

TABLE V

INVENTORY COEFFICIENTS BY INDUSTRY GROUPINGS, OKLAHOMA, 1972

I/O	Sector	Inventory Coefficients
1.	Livestock and livestock products	0.008667
2.	Other agricultural products	0.026875
3.	Forestry and fishery products	0.004294
4.	Agricultural, forestry and fishery services	0.0
5.	Iron and ferroalley ores mining	0.0
6.	Nonferrous metal ores mining	0.012126
7.	Stone and clay mining and quarrying	0.008058
8.	Chemical and fertilizer mineral mining	0.0
9.	New construction	0.0
10.	Maintenance and repair construction	0.0
11.	Ordance accessories	0.022087
12.	Food and kindred products	0.006311
13.	Tobacco manufactures	0.029412
14.	Broad and narrow fabrics, yarn and thread mills	0.015775
15.	Miscellaneous textile goods and floor coverings	0.032566
16.	Apparel	0.024565
17.	Miscellaneous fabricated textile products	0.016491
18.	Lumber and wood products, except containers	0.007799
19.	Wood containers	0.007780
20.	Household furniture	0.035138
21.	Other furniture and fixtures	0.035138
22.	Paper and allied products, except containers	0.005989
23.	Paperboard containers and boxes	0.005987
24.	Printing and publishing	0.007725
25.	Chemicals and selected chemical products	0.019477
26.	Plastics and synthetic materials	0.0
27.	Drugs, cleaning and toilet preparations	0.019475
28.	Paints and allied products	0.019475
29.	Paving and roofing materials	0.013639
30.	Rubber and miscellaneous plastics products	0.011889
31.	Leather tanning and finishing	0.039216
32.	Footwear and other leather products	0.045483
33.	Glass and glass products	0.009130
34.	Stone and clay products	0.009131
35.	Primary iron and steel manufacturing	0.020872
36.	Primary nonferrous metals manufacturing	0.026093
37.	Metal containers	0.022117
38.	Heating, plumbing, and struct. metal products	0.022072
39.	Screw machine products and stampings	0.022052
40.	Other fabricated metal products	0.022071
41.	Engines and turbines	0.022097
42.	Farm and garden machinery	0.022092
43.	Construction and mining machinery	0.035682
44.	Materials handling machinery and equipment	0.035685

TABLE V (Continued)

I/O	Sector	Inventory Coefficients
45.	Metal working machinery and equipment	0.022097
46.	Special industry machinery and equipment	0.022092
47.	General industrial machinery and equipment	0.035276
48.	Misc. machinery, except electrical	0.022090
49.	Office, computing, and accounting machines	0.022093
50.	Service industry machines	0.022092
51.	Electric industrial equipment and apparatus	0.017465
52.	Household appliances	0.017456
53.	Electric lighting and wiring equipment	0.017473
54.	Radio, TV, and communication equipment	0.017464
55.	Electronic components and accessories	0.017465
56.	Misc. electrical machinery and supplies	0.017465
57.	Motor vehicles and equipment	0.023577
58.	Aircraft and parts	0.026992
59.	Other transportation equipment	0.026992
60.	Scientific and controlling instruments	0.036902
61.	Optical, ophthalmic, and photographic equip.	0.036908
62.	Miscellaneous manufacturing	0.017595
63.	Transportation and warehousing	0.007074
64.	Communications, except radio and TV	0.0
65.	Radio and TV broadcasting	0.0
66.	Water supply and sanitary services	0.0
67.	Wholesale and retail trade	0.004621
68.	Finance and insurance	0.0
69.	Real estate and rental	0.0
70.	Hotels; personal and repair services exc. auto.	0.0
71.	Business services	0.0
72.	Eating and drinking places	0.0
73.	Automobile repair and services	0.0
74.	Amusements	0.0
75.	Medical, educ. services and nonprofit org.	0.0
76.	Federal government enterprises	0.0
77.	State and local government enterprises	0.0
78.	Petroleum products prod. and dist.	0.015160
79.	Natural gas prod. and dist.	0.010910
80.	Coal mining	0.014876
81.	Electricity and hydro-power	0.0

Source: Estimated using the data available in Oklahoma Agriculture, 1974 [40], 1972 Census of Manufactures [86], and Internal Revenue Service [118].

sectors using the national inventory coefficients. Sector inventory is divided by sector output to estimate the inventory coefficients for the agricultural sectors.

The census of manufactures [86] estimates Oklahoma's change in inventories to be 88.2 million dollars for 1972. The amount of domestic production is the value of shipments plus the change in inventories. The total change of inventories is distributed to the 52 manufacturing sectors by the ratio of sector value of shipments to the total state value of shipments. Value of inventories is then divided by domestic production yielding the inventory coefficient.

The remaining sectors include: mining; construction; transportation and public utilities; finance, insurance, and real estate; wholesale and retail trade; and services. State data for these sectors are not directly available. Hence national inventory coefficients are adopted. Data to derive estimates are obtained for Internal Revenue Service [118] and the 1972 U.S. Input-Output table [80]. Internal Revenue Service presents data on the amount of inventory as used in this analysis. Inventory coefficients by sector are derived by dividing inventory by output estimates. Use of national coefficients assumes that the inventory level per unit of output in Oklahoma is the same as in the nation as a whole.

Investment Matrix

It is necessary to know the total amount of capital needed to expand output as well as its composition. The total amount of capital required per unit of output expansion is obtained by adding the capital unit coefficients and the inventory coefficients for a sector. By using the combined capital unit and inventory coefficient matrixes, an investment matrix is estimated. Each coefficient (I_{ij}) in the investment matrix is derived by dividing the column entry of the combined matrix by the total of all entries for that column. Investment Coefficients are defined as the value of output of the producing sector i needed by the purchasing sector j per unit of investment in j. The difference between the investment coefficients and the capital coefficients is that the investment coefficients include capital and inventory expenses per unit of investment, while the capital coefficients include only the capital requirements per dollar of capital investment in a sector.

Depreciation Coefficients

To complete the capital structure analysis, depreciation coefficients are estimated. These coefficients are estimated as the ratio of annual depreciation to total depreciable assets. The amount of annual depreciation and depreciable assets for 1972 are obtained from the Internal Revenue Service (IRS) [119], and U.S. Bureau of Labor Statistics [101]. Depreciation rates adopted for the Oklahoma capital analysis are presented in Table VI. The U.S. depreciation coefficients are used in the Oklahoma model of capital analysis. It is assumed that the depreciation rate of capital goods by sector at the national level is the same as that of the state.

The depreciation coefficients indicate that the annual depreciation rate varies from industry to industry. For instance, it is about 6.5 percent per year in the food and kindred products industries (sector 12), versus 11.2 percent in automobile repair and services (sector

TABLE VI

DEPRECIATION RATES BY SECTOR, OKLAHOMA, 1972

Sector	Depreciation Rates
1. Livestock and livestock products	0.09850
2. Other agricultural products	0.09898
3. Forestry and fishery products	0.09851
4. Agricultural, forestry, and fishery services	0.09498
5. Iron and ferroalley ores mining	0.0
6. Nonferrous metal ores mining	0.11399
7. Stone and clay mining and quarrying	0.08146
8. Chemical and fertilizer mineral mining	0.11398
9. New construction	0.02956
10. Maintenance and repair construction	0.02955
11. Ordance accessories	0.08587
12. Food and Kindred Products	0.06472
13. Tobacco manufactures	0.03257
14. Broad and narrow fabrics, yarn and thread mills	0.06814
15. Miscellaneous textile goods and floor coverings	0.06999
16. Apparel	0.03185
17. Miscellaneous fabricated textile products	0.04061
18. Lumber and wood products, except containers	0.10009
19. Wood containers	0.11588
20. Household furniture	0.05534
21. Other furniture and fixtures	0.06599
22. Paper and allied products, except containers	0.07418
23. Paper board containers and boxes	0.07361
24. Printing and Publishing	0.07772
25. Chemicals and selected chemical products	0.05431
26. Plastics and synthetic materials	0.0
27. Drugs, cleaning and toilet preparations	0.07505
28. Paints and allied products	0.07424
29. Paving and floor material	0.09663
30. Rubber and miscellaneous plastics products	0.09396
31. Leather tanning and finishing	0.06215
32. Footwear and other leather products	0.04836
33. Glass and glass products	0.11033
34. Stone and clay products	0.12918
35. Primary iron and steel manufacturing	0.15939
36. Primary nonferrous metals manufacturing	0.11265
37. Metal containers	0.08953
38. Heating, plumbing and struct. metal products	0.07285
39. Screw machine products and stampings	0.09929
40. Other fabricated metal products	0.09351
41. Engines and turbines	0.08350

TABLE VI (Continued)

42.	Farm and Garden Machinery	0.08001
43.	Construction and Mining Machinery	0.08002
44.	Materials Handling Machinery and Equipment	0.07039
45.	Metal Working Machinery and Equipment	0.09741
46.	Special Industry Machinery and Equipment	0.09238
47.	General Industrial Machinery and Equipment	0.07167
48.	Misc. Machinery, Except Electrical	0.09371
49.	Office, Computing, and Accounting Machines	0.07386
50.	Service Industry Machines	0.04966
51.	Electric Industrial Equipment and Apparatus	0.09203
52.	Household Appliances	0.07886
53.	Electric Lighting and Wiring Equipment	0.07448
54.	Radio, T.V. and Communication Equipment	0.06527
55.	Electronic Components and Accessories	0.09752
56.	Misc. Electrical Machinery and Supplies	0.05941
57.	Motor Vehicles and Equipment	0.05781
58.	Aircraft and Parts	0.07731
59.	Other Transportation Equipment	0.05630
60.	Scientific and Controlling Instruments	0.07724
61.	Optical, Ophthalmic, and Photographic Equipment	0.08060
62.	Miscellaneous Manufacturing	0.05112
63.	Transportation and Warehousing	0.14257
64.	Communications, Except Radio and T.V.	0.12586
65.	Radio and T.V. Broadcasting	0.12580
66.	Water Supply and Sanitary Services	0.12302
67.	Wholesale and Retail Trade	0.05420
68.	Finance and Insurance	0.06323
69.	Real Estate and Rental	0.03050
70.	Hotels; Personal and Repair Services exc. Auto.	0.12218
71.	Business Services	0.07591
72.	Eating and Drinking Places	0.05420
73.	Automobile Repair and Services	0.11196
74.	Amusements	0.16391
75.	Medical, Educ. Services & Nonprofit Org.	0.10999
76.	Federal Government Enterprises	0.0
77.	State and local government enterprises	0.0
78.	Petroleum products production	0.09095
79.	Natural gas production	0.10518
80.	Coal mining	0.06845
81.	Electricity and Hydro-power	0.09515

Source: Estimated using the data available in the U.S. Bureau of Labor Statistics [101].

73). The depreciation rate of capital goods in the coal mining industries (sector 80) is 6.8 percent while for petroleum products producing industries (sector 78) it is 9.1 percent.

CHAPTER V

THE HUMAN RESOURCE ACCOUNT AND GOVERNMENT ACCOUNT

The Human Resource Account

The human resource account is necessary in a comprehensive social accounting system. The account identifies quantity and quality changes of human resources over time. Such changes make human resources an important area for research study. Quantity of human resources is recorded by labor force, sector total employment, sector wage and salary and proprietor employment, while quality of human resources are recorded in terms of output-employment ratios, sector wage and salary and proprietor income levels, sector wage and salary and proprietor income rates, personal income, and per capita personal income. The human resource account is, therefore, discussed in terms of population, employment, income, and productivity rates.

Population

The population of Oklahoma shown in Table VII is based on the most recent Bureau of Census estimate. Oklahoma population has been increasing continuously since 1970. There were 2,559,463 people living in Oklahoma in 1970, 2,669,000 in 1973, compared to 2,770,000 in 1976 and reached 2,892,000 people in 1979. This represented an increase of 332,000, or 13.0 percent, in the total number of residents

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The state population is expected to continue to increase in and around the two major metropolitan areas. Between 1970 and 1979, the largest population changes in Oklahoma occurred in the state's Standard Metropolitan Statistical Areas (SMSA's). The Oklahoma City SMSA experienced the largest numerical increase in population for the period. Specifically, the number of inhabitants of the area grew by 95,100 or 13.6 percent, bringing the 1979 total to 794, 200 residents. The Tulsa SMSA expanded to 635,800 an increase of 86,700 or 15.8 percent from 1970 to 1979. The Lawton SMSA increased to 120,800 residents. This is a gain of 12,600 or 11.7 percent.

Employment

Employment data refer to persons on establishment payrolls who received pay for any part of the pay period. This shows that one person can have more than one job in the same period of time. The employment analysis tends to use crude but readily available employment data to measure labor inputs. The employment data series includes:

(1) Oklahoma labor force for 1970-77; and, (2) wage and salary, proprietor and total employment for 81 input-output industrial grouping for the year 1972.

Employment data were obtained from U.S. Department of Labor, Employment and Earning Statistics for States and Areas, 1939-74 [102]. Separate estimates of wage and salary employment are available only by relatively broad sector categories. The 1970-1974 covered employment data of Oklahoma Employment Security Commission [41] were used to allocate the broadly classified employment figures into the 81 input-output industrial grouping. Employment in agriculture was obtained from Oklahoma Department of Agriculture, 1974 [40]. Estimates of self-employed, unpaid family workers and domestic servants were available as total proprietor employment for the non-agricultural sectors from the Oklahoma Employment Security Commission [44], and from Oklahoma Department of Agriculture 1974 [40]. Proprietor employment among the input-output industry grouping, computed by Schreiner, et al [69], was used to disaggregate the 1972 proprietor employment of Oklahoma.

General characteristics of the Oklahoma labor force for 1970-1977 are presented in Table VIII. Wage and salary employment made a dramatic change through the years. Employment in industry and related services as reflected by wage and salary employment estimates was 787,500 in 1970, and 996,000 in 1977, a 26.5 percent increase. The population movement from the rural to urban areas, mainly metropolitan centers, was associated with a decline in employment in agriculture and an increase in employment in the non-agricultural industry and related services. The number of unemployed increased 48.2 percent from 41,500 in 1970 to 61,500 in 1977. Total labor force increased from 1,059,000 in 1970 to 1,282,300 in 1977, an increase of 21.0 percent and self-employed non-agriculture increased from 130,500 in 1970 to 149,800 in 1977, an increase of 14.8 percent. Total employment has increased continuously through the years. It increased from 1,017,500 in 1970 to 1,220,800 in 1977 or about 20.0 percent.

Total proprietor employment is composed of self-employed and unpaid family workers in agriculture and non-agricultural industry and related services. The self-employed and family workers in agriculture accounted for 44.3 percent of the total proprietor employment in 1972

TABLE VIII

OKLAHOMA LABOR FORCE, 1970-1977
(IN THOUSANDS)

Wage & Salary Employment	Proprietor Employment			Total Employed	Unemployed[b]	Total Labor Force
	Agriculture[a]	Non Agriculture	Total			
787.5	99.5	130.5	230.0	1,017.5	41.5	1,059.0
795.8	98.7	133.2	231.9	1,027.7	41.3	1,069.0
832.2	96.7	134.8	231.5	1,063.7	44.2	1,107.9
869.2	95.3	134.0	229.3	1,095.5	33.5	1,129.0
896.9	93.9	135.1	229.0	1,125.9	50.3	1,176.2
903.4	89.0	138.0	227.0	1,139.4	83.8	1,214.2
950.1	84.0	141.6	225.6	1,175.5	66.5	1,242.2
996.0	75.0	149.8	224.8	1,220.8	61.5	1,282.3

[a]Includes family workers in agriculture

[b]Includes those idled or unemployed as a result of labor dispute

Source: Oklahoma Department of Agriculture [40], Oklahoma Employment Security Commission [44], U.S. Department of Labor [102].

and 33.4 percent in 1977. Total proprietor employment indicated a continuous decline from 1972 to 1977. The decline in total proprietor employment is strictly associated with the continuous drop in the proprietor employment in agriculture. Proprietor employment in agriculture decreased 24.6 percent from 99,500 in 1972 to 75,000 in 1977.

Distribution of wage and salary employment, proprietor and total employment for the 79 input-output industrial grouping in 1972 and the percentage distribution of each industry sector to the total employment category is presented in Table IX. A sector's percent of total wage and salary employment indicates the relative importance of that sector as a source of employment. In 1972, in broad sector classification, government and service sectors employed 23.1 percent and 19.0 percent of all wage and salary workers, respectively. These sectors are followed by wholesale and retail trade, manufacturing, and transportation and public services with 18.6 percent, 16.8 percent and 6.4 percent, respectively. Agriculture accounted for 2.2 percent of the total wage and salary employment in 1972. Natural gas production employment and petroleum products production employment accounted each for 41.2 percent of total wage and salary employment in the energy sectors and 2.9 and 2.6 percent of total wage and salary employment, respectively. Food and kindred products employed 16,400 workers or 11.7 percent of total wage and salary employment in the manufacturing sector.

Total employment is composed of wage and salary employment and proprietor employment. The addition of proprietor employment changed the ranking of the broad sectors in the total employment. In order of magnitude the three leading sectors were service, government, and

TABLE IX

WAGE AND SALARY, PROPRIETOR AND TOTAL EMPLOYMENT BY INDUSTRY SECTOR, OKLAHOMA, 1972

	Wage and Salary Employment		Proprietor Employment		Total Employment	
Sector	Number	%	Number	%	Number	%
1. Livestock and Livestock Products	9,303	1.12	55,303	22.87	64,606	6.02
2. Other Agricultural Products	8,606	1.03	51,157	21.16	59,763	5.56
3. Forestry and Fishery Products	91	0.01	540	0.22	631	0.06
4. Agricultural, Forestry and Fishery Services	5,645	0.68	1,828	0.76	7,473	0.70
5. Iron and Ferroalley Ores Mining	0	0.0	0	0.0	0	0.0
6. Nonferrous Metal Ores Mining	137	0.02	0	0.0	137	0.01
7. Stone and Clay Mining and Quarrying	1,352	0.16	78	0.03	1,430	0.13
8. Chemical and Fertilizer Mineral Mining	1	0.0	0	0.0	1	0.0
9. New Construction	36,472	4.38	15,448	6.39	51,920	4.83
10. Maintenance and Repair Construction	4,628	0.56	2,705	1.12	6,333	0.68
11. Ordnance and Accessories	429	0.05	0	0.0	429	0.04
12. Food and Kindred Products	16,400	1.97	409	0.17	16,809	1.57
13. Tobacco Manufactures	3	0.0	0	0.0	3	0.0
14. Broad and Narrow Fabrics, Yarn and Thread Mills	685	0.08	0	0.0	685	0.06
15. Misc. Textile Goods and Floor Coverings	1,909	0.23	0	0.0	1,909	0.18
16. Apparel	9,933	1.19	246	0.10	10,179	0.95
17. Misc. Fabricated Textile Products	1,467	0.18	0	0.0	1,467	0.14
18. Lumber and Wood Products, Except Containers	2,709	0.33	702	0.29	3,411	0.32
19. Wood Containers	91	0.01	0	0.0	91	0.01
20. Household Furniture	1,466	0.18	122	0.05	1,588	0.15
21. Other Furniture and Fixtures	518	0.06	55	0.02	573	0.05
22. Paper and Allied Products, Except Containers	1,313	0.16	0	0.0	1,313	0.12
23. Paperboard Containers and Boxes	828	0.10	0	0.0	828	0.08
24. Printing and Publishing	8,700	1.05	955	0.40	9,655	0.90
25. Chemicals and Selected Chemical Products	1,444	0.17	29	0.01	1,473	0.14
26. Plastics and Synthetic Materials	0	0.0	10	0.0	10	0.0
27. Drugs, Cleaning and Toilet Preparations	192	0.02	4	0.0	196	0.02
28. Paints and Allied Products	315	0.04	7	0.0	322	0.03
29. Paving and Floor Material	447	0.05	8	0.00	455	0.04
30. Rubber and Miscellaneous Plastics Products	6,600	0.79	75	0.03	6,675	0.62

TABLE IX (Continued)

Sector	Wage and Salary Employment		Proprietor Employment		Total Employment	
	Number	%	Number	%	Number	%
31. Leather Tanning and Finishing	3	0.0	0	0.0	3	0.0
32. Footwear and Other Leather Products	708	0.09	12	0.0	710	0.07
33. Glass and Glass Products	4,441	0.53	150	0.06	4,591	0.43
34. Stone and Clay Products	5,159	0.62	122	0.05	5,281	0.49
35. Primary Iron and Steel Manufacturing	2,330	0.28	0	0.0	2,330	0.22
36. Primary Nonferrous Metals Manufacturing	2,070	0.25	0	0.0	2,070	0.19
37. Metal Containers	100	0.01	1	0.0	100	0.01
38. Heating, Plumbing, and Struct. Metal Products	11,712	1.41	188	0.08	11,900	1.11
39. Screw Machine Products and Stampings	721	0.09	13	0.01	734	0.07
40. Other Fabricated Metal Products	3,038	0.37	69	0.03	3,107	0.29
41. Engines and Turbines	75	0.01	0	0.0	75	0.01
42. Farm and Garden Machinery	747	0.09	19	0.1	766	0.07
43. Construction and Mining Machinery	8,447	1.02	91	0.04	8,538	0.79
44. Materials Handling Machinery and Equipment	438	0.05	0	0.0	438	0.04
45. Metal Working Machinery and Equipment	183	0.02	13	0.01	196	0.02
46. Special Industry Machinery and Equipment	701	0.08	52	0.02	753	0.07
47. General Industrial Machinery and Equipment	3,935	0.47	244	0.10	4,179	0.39
48. Miscellaneous Machinery Except Electrical	2,128	0.26	136	0.06	2,264	0.29
49. Office, Computing and Accounting Machines	2,522	0.30	15	0.01	2,537	0.24
50. Service Industry Machines	1,224	0.15	165	0.07	1,389	0.13
51. Electric Industrial Equipment and Apparatus	1,524	0.18	8	0.0	1,532	0.14
52. Household Appliances	75	0.01	1	0.0	76	0.01
53. Electric Lighting and Wiring Equipment	223	0.03	0	0.0	223	0.02
54. Radio, T.V. and Communication Equipment	9,574	1.15	116	0.05	9,690	0.90
55. Electronic Components and Accessories	841	0.10	7	0.0	848	0.08
56. Miscellaneous Electrical Machinery and Supplies	263	0.03	2	0.0	265	0.02
57. Motor Vehicles and Equipment	3,294	0.40	25	0.01	3,319	0.31
58. Aircraft and Parts	5,671	0.68	103	0.04	5,774	0.54
59. Other Transportation Equipment	2,435	0.29	10	0.0	2,445	0.23
60. Scientific and Controlling Instruments	576	0.07	6	0.0	582	0.05
61. Optical, Ophthalmic, and Photo. Equipment	377	0.05	0	0.0	377	0.04
62. Miscellaneous Manufacturing	1,863	0.22	314	0.13	2,177	0.20
63. Transportation and Warehousing	30,600	3.68	4,914	2.03	35,513	3.31
64. Communications, Except Radio and T.V.	10,144	1.22	0	0.0	10,144	0.94
65. Radio and T.V. Broadcasting	1,622	0.19	0	0.0	1,622	0.15

TABLE IX (Continued)

	Sector	Wage and Salary Employment		Proprietor Employment		Total Employment	
		Number	%	Number	%	Number	%
66.	Water Supply and Sanitary Services	568	0.07	136	0.06	704	0.07
67.	Wholesale and Retail Trade	151,995	18.26	39,182	16.20	191,177	17.80
68.	Finance and Insurance	31,571	3.79	5,538	2.29	37,109	3.46
69.	Real Estate and Rental	8,929	1.07	1,289	0.53	10,218	0.95
70.	Hotels; Personal and Repair Services Except Auto	16,825	2.02	17,468	7.22	34,293	3.19
71.	Business Services	27,952	3.36	13,995	5.79	41,947	3.91
72.	Eating and Drinking Places	33,791	4.06	8,711	3.60	42,502	3.96
73.	Automobile Repair and Services	4,591	0.56	2,298	0.95	6,889	0.64
74.	Amusements	5,917	0.71	2,964	1.23	8,881	0.83
75.	Medical, Educ. Services and Nonprofit Org.	63,482	7.63	11,507	4.76	74,989	6.98
76.	Federal Government Enterprises	56,000	6.73	0	0.0	56,000	5.21
77.	State and Local Government Enterprises	136.000	16.41	0	0.0	136.000	12.72
78.	Petroleum Products Production	21,786	2.62	1.025	0.42	22.811	2.11
79.	Natural Gas Production	24,198	2.91	1,211	0.50	25,409	2.37
80.	Goal Mining	510	0.06	0	0.0	510	0.05
81.	Electricity	6,035	0.79	0	0.0C	6,035	0.56
	TOTAL	832,200	100.00	231,500	100.0	1,063,700	100.0

Source: Oklahoma Employment Security Commission [42], and Oklahoma Department of Agriculture-1974 [40].

wholesale and retail trade sectors, containing 20.2 percent, 17.9 percent and 17.8 percent of total employment, respectively. These are followed by manufacturing with 13.5 percent and agriculture with 11.6 percent of total employment. For proprietor workers, 44.3 percent were employed in agriculture, 23.6 percent in the service sector, and 16.2 percent in wholesale and retail trade.

Income

This section of the human resource account analyzes personal income, personal income per capita, total labor income, wage and salary payments, proprietor income, and total civilian income by industrial classification. The income payments were obtained from the U.S. Department of Commerce [75] in broad sector categories. The 1970 payroll and proprietor income by sectors of Schreiner, et al [69] was used to allocate the wage and salary payments and proprietor income. Wage and salary payments measure earnings for the wage and salary employment in agriculture and non-agricultural industries and services. Proprietor income measures the net business earnings of owners of unincorporated enterprises which consist of sole proprietorships and partnerships. Farmers, independent professional practitioners, entrepreneurs in non-farm business, and others in a self-employment status are covered by the proprietors' income measure.

Personal Income Analysis. Total personal income is estimated by summing wage and salary payments, proprietor income, other labor income, property income and transfer payments, and subtracting the personal contribution to social insurance. Data which summarizes personal income are contained in Table X. Total personal income in Oklahoma

TABLE X

PERSONAL INCOME, OKLAHOMA, 1970-1975

	1970	1971	1972	1973*	1974	1975
			(Millions of Dollars)			
Wage and Salary Payments	5,323	5,646	6,171	6,805	7,663	8,370
Proprietor Income	926	857	1,033	1,598	1,494	1,485
Other Labor Income	314	350	389	443	524	598
Property Income	1,343	1,451	1,528	1,575	1,979	2,145
Transfer Payments	979	1,130	1,238	1,423	1,703	2,080
Personal Contribution to Social Insurance	-267	-325	-364	-448	-540	-591
Total Personal Income	8,693	9,232	9,995	11,558	12,933	14,237
Personal Income Per Capita	3,387	3,551	3,834	4,336	4,823	5,250

*Starting from 1973, the data are published differently. For every sector other than farms and government, under wage and salary heading, total payments are listed instead of wage and salary payments.

Sources: U.S. Department of Commerce, 1975-1976 [75].

increased about 16.0 percent from $8,693 million in 1970 to $9,995 million in 1972, and increased by 43.3 percent to $14,247 million from 1972 to 1975. Wage and salary payments increased significantly from 15.9 percent from 1970 to 1972 and 36.8 percent from 1972 to 1975. Income data indicate substantial increases in almost all categories over time. As shown in Table X, transfer payments, property income, other labor income, and personal contribution to social insurance made significant increases of 68.0 percent, 40.4 percent, 58.7 percent and 62.4 percent, respectively, from 1970 to 1975. However, proprietor income declined in 1972, 1974 and 1975. The main cause of the drop was identified as the decline of proprietor income in the farm sector.

Personal income per capita is defined as total personal income divided by population. Per capita personal income in Oklahoma has been increasing continuously as shown in Table X. Per capita personal income was $3,387 in 1970 and $5,250 in 1975. This was an increase of 55.0 percent in five years. Disposable income is obtained by subtracting personal taxes from total personal income.

Wage and Salary, Proprietor, and Total Civilian Income. Sources of wage and salary income, proprietor income and total civilian income are displayed in Table XI. Listed in Column (1) are wage and salary payments by industry classification and in Column (2) are the percentages by industry grouping of the total wage and salary payments. These percentages indicate the relative importance of each industry sector as a source of wage and salary income earned in Oklahoma in 1972.

The manufacturing sector has the largest share in the total wage and salary income with 18.5 percent, wholesale and retail trade is

TABLE XI

WAGE AND SALARY INCOME, PROPRIETOR INCOME, AND TOTAL CIVILIAN INCOME BY INDUSTRY SECTOR, OKLAHOMA, 1972

	Sector	Wage and Salary Income		Proprietor Income		Civilian Income	
		Thousand of Dollars	%	Thousand of Dollars	%	Thousand of Dollars	%
		(1)	(2)	(3)	(4)	(5)	(6)
1.	Livestock and Livestock Products	25,702	0.42	205,191	19.86	230,893	3.21
2.	Other Agricultural Products	23,771	0.39	189,803	18.37	213,574	2.97
3.	Forestry and Fishery Products	527	0.01	2,005	0.19	2,532	0.04
4.	Agricultural, Forestry and Fishery Services	18,076	0.29	5,461	0.53	23,537	0.33
5.	Iron and Ferro Alley Ores Mining	0	0.0	0	0.0	0	0.0
6.	Nonferrous Metal Ores Mining	1,127	0.02	0	0.0	1,127	0.02
7.	Store and Clay Mining and Quarrying	11,869	0.19	0	0.0	11,869	0.16
8.	Chemical and Fertilizer Mineral Mining	4	0.0	0	0.0	4	0.0
9.	New Construction	303,490	4.92	67,993	6.58	371,483	5.16
10.	Maintenance and Repair Construction	38,510	0.62	11,908	1.15	50,418	0.70
11.	Ordance Accessories	2,842	0.05	0	0.0	2,842	0.04
12.	Food and Kindred Products	123,323	2.00	752	0.07	124,075	1.72
13.	Tobacco Manufactures	10	0.0	0	0.0	10	0.0
14.	Broad and Narrow Fabrics, Yarn and Thread Mills	3,345	0.05	0	0.0	3,345	0.05
15.	Miscellaneous Textile Goods and Floor Coverings	12,248	0.20	0	0.0	12,248	0.17
16.	Apparel	43,235	0.70	677	0.07	43,912	0.61
17.	Miscellaneous Fabricated Textile Products	7,380	0.12	0	0.0	7,380	0.10
18.	Lumber and Wood Products, Except Containers	19,426	0.31	1,938	0.19	21,364	0.30
19.	Wood Containers	1,436	0.02	0	0.0	1,436	0.02
20.	Household Furniture	8,142	0.13	176	0.02	8,318	0.12
21.	Other Furniture and Fixtures	4,634	0.08	79	0.01	4,713	0.07
22.	Paper and Allied Products, Except Containers	11,001	0.18	0	0.0	11,001	0.15
23.	Paper Board Containers and Boxes	6,537	0.11	0	0.0	6,537	0.09
24.	Printing and Publishing	63,756	1.03	2,258	0.22	66,014	0.92
25.	Chemicals and Selected Chemical Products	12,957	0.21	79	0.01	13,036	0.18
26.	Plastics and Synthetic Materials	0	0.0	26	0.0	27	0.0
27.	Drugs, Cleaning and Toilet Preparations	1,215	0.02	11	0.0	1,226	0.02
28.	Paints and Allied Products	2,640	0.04	19	0.0	2,659	0.04
29.	Paving and Floor Material	5,204	.08	.22	0.0	5,226	0.07

TABLE XI (Continued)

	Sector	Wage and Salary Income		Proprietor Income		Civilian Income	
		Thousand of Dollars	%	Thousand of Dollars	%	Thousand of Dollars	%
		(1)	(2)	(3)	(4)	(5)	(6)
30.	Rubber and Miscellaneous Plastics Products	59,924	0.97	208	0.02	60,131	0.83
31.	Leather Tanning and Finishing	9	0.0	0	0.0	9	0.0
32.	Footwear and Other Leather Products	2,957	0.05	34	0.0	2,[illegible]92	0.04
33.	Glass and Glass Products	39,143	0.63	208	0.02	39,351	0.55
34.	Stone and Clay Products	40,840	0.66	170	0.02	41,009	0.57
35.	Primary Iron and Steel Manufacturing	21,028	0.34	0	0.0	21,028	0.29
36.	Primary Nonferrous Metals Manufacturing	16,880	0.27	0	0.0	16,880	0.23
37.	Metal Containers	640	0.01	3	0.0	644	0.01
38.	Heating, Plumbing, and Struct. Metal Products	96,563	1.56	519	0.05	97,083	1.35
39.	Screw Machine Products and Stampings	5,732	0.09	38	0.0	5,770	0.08
40.	Other Fabricated Metal Products	24,701	0.40	192	0.02	24,893	0.35
41.	Engines and Turbines	716	0.01	0	0.0	716	0.01
42.	Farm and Garden Machinery	5,207	0.08	52	0.01	5,259	0.07
43.	Construction and Mining Machinery	80,860	1.31	176	0.02	81,037	1.12
44.	Materials Handling Machinery and Equipment	4,190	0.07	0	0.0	4,190	0.06
45.	Metal Working Machinery and Equipment	1,556	0.03	38	0.0	1,594	0.02
46.	Special Industry Machinery and Equipment	5,924	0.10	128	0.01	6,052	0.08
47.	General Industrial Machinery and Equipment	32,685	0.53	628	0.06	33,313	0.46
48.	Misc. Machinery, Except Electrical	16;691	0.27	357	0.03	17,049	0.24
49.	Office, Computing, and Accounting Machines	28,016	0.45	41	0.0	28,057	0.39
50.	Service Industry Machines	10,473	0.17	455	0.04	10,928	0.15
51.	Electric Industrial Equipment and Apparatus	12,596	0.20	22	0.0	12,618	0.18
52.	Household Appliances	506	0.01	3	0.0	509	0.01
53.	Electric Lighting and Wiring Equipment	1,209	0.02	0	0.0	1,209	0.02
54.	Radio, T.V., and Communication Equipment	84,513	1.37	320	0.03	84.833	1.18
55.	Electronic Components and Accessories	4,970	0.08	19	0.0	4,989	0.07
56.	Misc. Electrical Machinery and Supplies	2,385	0.04	8	0.0	2,392	0.03
57.	Motor Vehicles and Equipment	27,301	0.44	68	0.01	27,368	0.38
58.	Aircraft and Parts	64,311	1.04	282	0.03	64,593	0.90
59.	Other Transportation Equipment	16,848	0.27	27	0.0	16,875	0.23
60.	Scientific and Controlling Instruments	4,755	0.08	16	0.0	4,771	0.07
61.	Optical, Ophthalmic, and Photographic Equipment	3,205	0.05	0	0.0	3,205	0.04

TABLE XI (Continued)

	Sector	Wage and Salary Income		Proprietor Income		Civilian Income	
		Thousand of Dollars	%	Thousand of Dollars	%	Thousand of Dollars	%
		(1)	(2)	(3)	(4)	(5)	(6)
62.	Miscellaneous Manufacturing	12,074	0.20	866	0.08	12,940	0.18
63.	Transportation and Warehousing	326,000	5.28	15,986	1.55	341,986	4.75
64.	Communications, Except Radio and T.V.	93,843	1.52	0	0.0	93,843	1.30
65.	Radio and T.V. Broadcasting	13,679	0.22	0	0.0	12,679	0.19
66.	Water Supply and Sanitary Services	5,174	0.08	5,607	0.54	10,781	0.15
67.	Wholesale and Retail Trade	953,333	15.45	152,987	14.81	1,106,320	15.36
68.	Finance and Insurance	240,066	3.89	34,106	3.30	274,172	3.81
69.	Real Estate Rental	47,934	0.78	25,929	2.51	73,863	1.03
70.	Hotels; Personal and Repair Services Exc. Auto	134,076	2.17	41,316	4.00	175,392	2.43
71.	Business Services	185,677	3.01	61,521	5.96	247,198	3.43
72.	Eating and Drinking Places	89,373	1.45	14,343	1.39	103,716	1.44
73.	Automobile Repair and Services	34,857	0.56	11,531	1.12	46,388	0.64
74.	Amusements	19,817	0.32	5,985	0.58	25,802	0.36
75.	Medical, Educ. Services and Nonprofit Org.	315,791	5.12	157,272	15.22	473,063	6.57
76.	Federal Government Enterprises	874,000	14.16	0	0.0	874,000	12.17
77.	State and Local Government Enterprises	789.000	12.79	0	0.0	789.000	10.95
78.	Petroleum Products Production	239,375	3.88	5,794	0.56	245.169	3.40
79.	Natural Gas Procution	251,235	4.07	7,348	0.71	258,583	3.59
80.	Coal Mining	6,000	0.10	0	0.0	6,000	0.08
81.	Electricity	54,953	0.89	0	0.0	54.953	0.76
	TOTAL	6,171,000	100.0	1,033,000	100.0	7,204,000	100.0

Source: U.S. Department of Commerce, 1973 [75] Oklahoma Employment Security Commission [41] and Dean F. Schreiner, Chang and Flood [69].

next with 15.5 percent. These sectors are followed by federal government, state and local government, and service sectors with 14.2 percent, 12.8 percent and 12.6 percent, respectively, of total wage and salary payments in 1972. Natural gas and petroleum products industries contained over 88.2 percent of the total wage and salary income of energy producing industries.

Proprietor income by industry is given in Column (3) of Table XI with percentages of each industry to total proprietor income given in Column (4). About 40 percent of proprietor income earned in Oklahoma was accounted for by agriculture. Services ranked second with 28.3 percent and wholesale and retail trade sector ranked third with 14.8 percent of total proprietor income.

The distribution of total civilian income and the percentage shares of total income by industry are given in Columns (5) and (6) of Table XI. The manufacturing sector accounted for 16.0 percent of total civilian income. This was followed by wholesale and retail trade, federal government and state and local government with 14.2 percent, 12.8 percent, and about 11 percent, respectively, of total civilian income earned in Oklahoma in 1972.

Productivity Rates

Productivity identifies labor's contribution to output by indicating efficiency and the associated cost considerations. This section illustrates the quality of human resources which are measured by output-employment ratios and wage and salary, and proprietor income rates.

Output-Employment Ratios. Output-employment ratios indicate the value of output produced by each employee. The ratios are obtained by dividing output by employment of each industry category. The employment-output ratio is the reciprocal of the output-employment ratio. The output-employment ratios in 1972 are presented in Table XII.

Comparing the output-employment ratios in Table XII, real estate and rental (sector 69) had the highest output-employment ratio at $201,522. This sector requires less labor per unit of output as compared to other sectors. Paving and roofing materials (sector 29) also had one of the highest output-employment ratios at $92,372. The high degree of capital intensity in some industry categories accounts for the large output-employment ratios. Following the paving and floor material industries (sector 29) are engines and turbines (sector 41) and office, computing, and accounting machines (sector 49) with $78,013, and $77,537, respectively.

Wage and Salary, and Proprietor Income Rates. Wage and salary, and proprietor income rates indicate the amount of income accounted for by each worker in each industry category as presented in Table XIII. The wage and salary, and proprietor income rate for each industry grouping is computed by using the income data from Table XI and the employment figures from Table IX. Income divided by employment gives the income rate.

Wage and salary income rates are listed in Column (1) of Table XIII. These rates were obtained by dividing wage and salary payments by the number of wage and salary workers in each industry grouping. Federal government had the highest yearly wage and salary rate at $15,607. Coal mining, petroleum products, and natural gas producing

TABLE XII

OUTPUT-EMPLOYMENT RATIOS BY SECTOR, OKLAHOMA, 1972

Sector	Output-Employment Ratio[1/]
1. Livestock and Livestock Products	18,522
2. Other Agricultural Products	9,329
3. Forestry and Fishery Products	16,935
4. Agricultural, Forestry and Fishery Services	6,321
5. Iron and Ferroalley Ores Mining	0
6. Nonferrous Metal Ores Mining	20,467
7. Stone and Clay Mining and Quarrying	19,360
8. Chemcial and Fertilizer Mineral Mining	20,000
9. New Construction	27,414
10. Maintenance and Repair Construction	24,633
11. Ordance Accessories	9,911
12. Food and Kindred Products	55,974
13. Tobacco Manufactures	34,000
14. Broad and Narrow Fabrics, Yarn and Thread Mills	19,434
15. Miscellaneous Textile Goods and Floor Coverings	36,996
16. Apparel	12,226
17. Miscellaneous Fabricated Textile Products	19,886
18. Lumber and Wood Products, Except Containers	38,120
19. Wood Containers	37,003
20. Household Furniture	18,247
21. Other Furniture and Fixtures	26,616
22. Paper and Allied Products, Except Containers	62,554
23. Paper Board Containers and Boxes	46,283
24. Printing and Publishing	20,087
25. Chemicals and Selected Chemical Products	33,748
26. Plastics and Synthetic Materials	0
27. Drugs, Cleaning and Toilet Preparations	33,690
28. Paints and Allied Products	33,552
29. Paving and Roóf Material	92,372
30. Rubber and Miscellaneous Plastics Products	41,253
31. Leather Tanning and Finishing	34,000
32. Footwear and Other Leather Products	33,747
33. Glass and Glass Products	28,473
34. Stone and Clay Products	28,758
35. Primary Iron and Steel Manufacturing	42,899
36. Primary Nonferrous Metals Manufacturing	34,316
37. Metal Containers	9,793
38. Heating, Plumbing, and Struct. Metal Products	26,796
39. Screw Machine Products and Stampings	13,093
40. Other Fabricated Metal Products	31,759
41. Engines and Turbines	78,013
42. Farm and Garden Machinery	32,508
43. Construction and Mining Machinery	35,801
44. Materials Handling Machinery and Equipment	36,203
45. Metal Working Machinery and Equipment	72,793
46. Special Industry Machinery and Equipment	61,113
47. General Industrial Machinery and Equipment	33,685

TABLE XII (Continued)

	Sector	Output-Employment Ratio[1/]
48.	Misc. Machinery, Except Electrical	17,062
49.	Office, Computing, and Accounting Machines	77,537
50.	Service Industry Machines	68,328
51.	Electric Industrial Equipment and Apparatus	27,934
52.	Household Appliances	27,641
53.	Electric Lighting and Wiring Equipment	28,090
54.	Radio, T.V., and Communication Equipment	27,752
55.	Electronic Components and Accessories	27,851
56.	Misc. Electrical Machinery and Supplies	27,835
57.	Motor Vehicles and Equipment	30,136
58.	Aircraft and Parts	21,371
59.	Other Transportation Equipment	33,835
60.	Scientific and Controlling Instruments	33,964
61.	Optical, Ophthalmic, and Photographic Equipment	34,316
62.	Miscellaneous Manufacturing	29,339
63.	Transportation and Warehousing	25,666
64.	Communications, Except Radio and T.V.	30,865
65.	Radio and T.V. Broadcasting	33,080
66.	Water Supply and Sanitary Services	67,784
67.	Wholesale and Retail Trade	13,432
68.	Finance and Insurance	21,738
69.	Real Estate and Rental	201,522
70.	Hotels; Personal and Repair Services exc. Auto	10,019
71.	Business Services	15,199
72.	Eating and Drinking Places	13,759
73.	Automobile Repair and Services	43,306
74.	Amusements	12,725
75.	Medical, Educ. Services and Nonprofit Org.	12,955
76.	Federal Government Enterprises	3,976
77.	State and Local Government Enterprises	859
78.	Petroleum Products Production	60,822,374
79.	Natural Gas Production	73,706,762
80.	Coal Mining	123,739,608
81.	Electricity and Hydro-Power	15,461,876

[1/] Output- employment ratio for all sectors is indicated in dollars per unit of labor except for energy producing sectors (78 to 81) which are presented in millions of BTU per unit of labor.

industries also paid large wage and salary rates per employee at $11,765, $10,988 and $10,382 respectively. Agriculture (sectors 1 and 2) and agricultural forestry and fishery services (sector 4) paid very low wage and salary rates $2,763 and $3,202, respectively.

Proprietor income rates are presented in Column (2) of Table XIII. The rates are computed by dividing the number of proprietors into the proprietor income of each industry grouping. Water supply and sanitary services (sector 66) has the highest proprietor income rate at $41,428. This industry category is followed by real estate and rentals (sector 69), and medical, educational services and non-profit organizations (sector 75) for proprietor income rates of $20,113, and $13,667 per year, respectively.

The Government Account

The government account plays an important role in the simulation and input-output model. It provides the basis for estimating the government expenditures and revenues. The model develops measures of regional impact on government expenditures and revenues for alternative energy choices. The necessary equations for projecting the expenditures and revenues and relevant statistical information about the procedures of estimation are available in Chapter VII. The government account is analysed in two major activity groups: federal and state and local government.

Federal Government Activities

Federal government revenues in Oklahoma are generated from federal taxes collected in the state and include: individual income tax,

TABLE XIII

WAGE AND SALARY AND PROPRIETOR INCOME RATES, OKLAHOMA, 1972 (DOLLARS)

	Sector	Wage and Salary Rate	Proprietor Income Rate
		(1)	(2)
1.	Livestock and Livestock Products	2,763	3,710
2.	Other Agricultural Products	2,763	3,710
3.	Forestry and Fishery Products	5,791	3,713
4.	Agricultural, Forestry and Fishery Services	3,202	2,987
5.	Iron and Ferroalley Ores Mining	0	0
6.	Nonferrous Metal Ores Mining	8,226	0
7.	Stone and Clay Mining and Quarrying	8,779	0
8.	Chemical and Fertilizer Mineral Mining	4,000	0
9.	New Construction	8,321	4,402
10.	Maintenance and Repair Construction	8,321	4,403
11.	Ordance Accessories	6,626	0
12.	Food and Kindred Products	7,520	1,839
13.	Tobacco Manufactures	3,347	0
14.	Broad and Narrow Fabrics, Yarn and Thread Mills	4,883	0
15.	Miscellaneous Textile Goods and Floor Coverings	6,416	0
16.	Apparel	4,353	2,755
17.	Miscellaneous Fabricated Textile Products	5,031	0
18.	Lumber and Wood Products, Except Containers	7,171	2,758
19.	Wood Containers	7,776	0
20.	Household Furniture	5,554	1,451
21.	Other Furniture and Fixtures	8,946	1,436
22.	Paper and Allied Products, Except Containers	8,379	0
23.	Paper Board Containers	7,895	0
24.	Printing and Publishing	7,328	2,364
25.	Chemicals and Selected Chemical Products	8,973	2,753
26.	Plastics and Synthetic Materials	0	2,792
27.	Drugs, Cleaning and Toilet Preparations	6,328	3,102
28.	Paints and Allied Products	8,380	2,636
29.	Paving and Roof Material	11,642	2,750
30.	Rubber and Miscellaneous Plastics Products	9,079	2,762
31.	Leather Tanning and Finishing	3,166	0
32.	Footwear and Other Leather Products	4,177	2,885
33.	Glass and Glass Products	8,814	1,381
34.	Stone and Clay Products	7,916	1,396
35.	Primary Iron and Steel Manufacturing	9,025	0
36.	Primary Nonferrous Metals Manufacturing	8,155	0
37.	Metal Containers	6,404	2,792
38.	Heating, Plumbing, and Struct. Metal Products	8,245	2,756
39.	Screw Machine Products and Stampings	7,950	2,876
40.	Other Fabricated Metal Products	8,131	2,775
41.	Engines and Turbines	9,546	0

TABLE XIII (Continued)

Sector	Wage and Salary Rate	Proprietor Income Rate
	(1)	(2)
42. Farm and Garden Machinery	6,970	2,733
43. Construction and Mining Machinery	9,573	1,947
44. Materials Handling Machinery and Equipment	9,566	0
45. Metal Working Machinery and Equipment	8,504	2,876
46. Special Industry Machinery and Equipment	8,451	2,432
47. General Industrial Machinery and Equipment	8,306	2,569
48. Misc. Machinery, Except Electrical	7,844	2,628
49. Office, Computing, and Accounting Machines	11,109	2,648
50. Service Industry Machines	8,556	2,765
51. Electric Industrial Equipment and Apparatus	8,265	2,659
52. Household Appliances	6,746	2,792
53. Electric Lighting and Wiring Equipment	5,423	0
54. Radio, T.V. and Communication Equipment	8,827	2,763
55. Electronic Components and Accessories	5,910	2,636
56. Misc. Electrical Machinery and Supplies	9,069	3,257
57. Motor Vehicles and Equipment	8,288	2,703
58. Aircraft and Parts	11,340	2,748
59. Other Transportation Equipment	6,919	2,792
60. Scientific and Controlling Instruments	8,255	2,605
61. Optical, Ophthalmic, and Photographic Equipment	8,501	0
62. Miscellaneous Manufacturing	6,481	2,760
63. Transportation and Warehousing	10,654	3,254
64. Communications, Except Radio and T.V.	9,251	0
65. Radio and T.V. Broadcasting	8,433	0
66. Water Supply and Sanitary Services	9,109	41,428
67. Wholesale and Retail Trade	6,272	3,905
68. Finance and Insurance	7,604	6,158
69. Real Estate and Rental	5,368	20,113
70. Hotels; Personal and Repair Services exc. Auto	7,969	2,365
71. Business Services	6,643	4,396
72. Eating and Drinking Places	2,645	1,647
73. Automobile Repair and Services	7,592	5,018
74. Amusements	3,349	2,019
75. Medical, Educ. Services and NonprofitOrg.	4,975	13,667
76. Federal Government Enterprises	15,607	0
77. State and Local Government Enterprises	5,776	0
78. Petroleum Products Productions	10,988	5,653
79. Natural Gas Production	10,382	6,065
80. Coal Mining	11,765	0
81. Electricity and Hydro-Power	9,106	0

corporation income tax, and all other federal taxes such as employment, excise and miscellaneous (Table XIV). Among these three sources, individual income tax has the largest share. Individual income tax collections increased annually when the other sources showed ups and downs through the years. The highest rates of increase for the individual income tax collections were in 1974 and 1978, more than 25 percent above the previous year. In 1978, federal individual income tax collections increased by 145.4 percent over the collections in 1972.

Corporation income tax collections declined in 1976 by 15.5 percent from 1975 and by 7.4 percent in 1978 from 1977. Corporation income tax collections had the highest rates of increase in 1975 and 1977. The increase was 41.3 percent for 1975 and 44.5 percent for 1977 over the respective previous year. In 1978, corporation tax collections were 236.6 percent higher than the collections in 1972.

All other tax collections indicated a slight drop in 1975 and 1977. They declined 2.2 and 3.4 percent from the previous year, respectively. In 1978 all other tax collections increased by 23.6 percent and 31.1 percent above the collections in 1977 and 1972, respectively. Total federal tax collections declined by 0.8 percent in 1976 from 1975 but increased at an annual average rate of 15.6 percent through the seven-year period. In 1978 total federal tax collections were 134.7 percent higher compared to the total collections in 1972. Federal tax collections for each source and the total collections through the years are given in Table XIV.

Total federal government expenditures in Oklahoma indicated an increasing trend through the years. The expenditures increased at an annual average rate of 11.9 percent and this was less than the total federal tax collections. In 1977, the federal government expenditures were 74.9 percent higher than the total expenditures in 1972. Total federal government outlays in Oklahoma between 1972 and 1977 are shown in Table XV.

State and Local Government Activities

State and local government revenues in Oklahoma are obtained from three sources: tax collections, federal government aid, and all other state and local government revenues.

The main components of tax collections include state sales tax, gasoline and fuels excise taxes, individual and corporation income taxes, and all other state and local taxes. Among these sources, individual income taxes had the highest rate of increase of 190.7 percent followed by the state sales tax by 110.3 percent and all other state and local taxes with increases of 98.4 percent, respectively, from 1972 through 1978. Gasoline and fuels excise taxes increased the least by 19.3 percent through the years. Federal aid to state and local government increased by 53.4 percent between 1972 and 1976 while all other state and local government revenues increased by 55.6 percent from 1972 to 1976. Total tax collections of state and local governments increased by 109.2 percent from 1972 through 1978 (Table XVI).

In 1978, total state and local government revenues rose by 55.5 percent from 1972 to 1976 (Table XVII). Rates of increase from 1972 through 1976 are 53.4 percent and 55.6 percent for federal government aid and all other state and local revenues, respectively. Major state and local government expenditures are education, highway, public welfare, health and hospitals, and all other state and local government

TABLE XIV

FEDERAL GOVERNMENT TAX COLLECTIONS, OKLAHOMA, 1972-1978 (THOUSANDS OF DOLLARS)

Year	Individual Income Tax	Corporation Income Tax	All Other Federal Tax Collections	Total Federal Tax Collections
1972	1,272,227	273,952	400,056	1,946,235
1973	1,463,630	295,008	420,342	2,178,980
1974	1,829,477	416,912	431,893	2,678,282
1975	2,123,770	815,560	422,178	3,361,508
1976	2,207,017	689,186	439,188	3,335,391
1977	2,486,714	996,176	424,316	3,907,206
1978	3,121,914	922,154	524,300	4,568,368

Source: U.S. Department of the Treasury, Internal Revenue Service [117].

TOTAL XV

TOTAL FEDERAL GOVERNMENT OUTLAYS, OKLAHOMA, 1972-1977 (THOUSANDS OF DOLLARS)

Year	Federal Government Outlays
1972	2,947,633
1973	3,306,500
1974	3,587,200
1975	4,050,700
1976	4,456,855
1977	5,155,762

Source: U.S. Department of Commerce, Office of Economic Opportunity, 1973-77 [96].

TABLE XVI

STATE AND LOCAL GOVERNMENT TAX COLLECTIONS, OKLAHOMA, 1972-1978 (THOUSANDS OF DOLLARS)

Year	State Sales Tax	Gasoline & Fuels Excise Taxes	Income Tax	All Other State And Local Taxes
1972	106,623	93,631	140,731	288,809
1973	116,494	98,634	162,241	299,377
1974	134,286	99,687	187,631	343,798
1975	149,815	99,895	247,097	385,322
1976	168,981	104,871	287,942	426,965
1977	190,864	110,020	343,732	498,275
1978	224,178	111,725	409,073	572,978

Sources: State of Oklahoma Tax Commission, 1973-1978 [59].

TABLE XVII

STATE AND LOCAL GOVERNMENT REVENUES, OKLAHOMA, 1972-1977 (MILLIONS OF DOLLARS)

Year	Total Tax Collections	Federal Aid	All Other State And Local Revenues	Total Revenues
1972	629.8	444	383	1,456.8
1973	676.7	514	418	1,608.7
1974	765.4	559	473	1,797.4
1975	882.1	626	525	2,033.1
1976	988.8	681	596	2,265.8
1977	1,142.9	804	659	2,605.9

Source: Oklahoma Tax Commission, 1973-76 [56], U.S. Department of Commerce 1974-79 [94].

expenditures (Table XVIII). The rates of increase from 1972 to 1977 were 75.7 percent, 37.0 percent, 18.0 percent, 95.2 percent and 92.0 percent for education, highway, public welfare, health and hospitals, and all other state and local government expenditures, respectively. In 1977 total state and local government expenditures rose by 66.2 percent over the expenditures in 1972. Total expenditures increased at an annual average rate of 10.7 percent through the five-year period.

TABLE XVIII

STATE AND LOCAL GOVERNMENT EXPENDITURES,
OKLAHOMA, 1972-77
(THOUSANDS OF DOLLARS)

Year	Education Expenditures	Highway Expenditures	Public Welfare	Health & Hospitals	Allocation State & Local Expenditures	Total Expenditures
1972	667	227	306	125	442	1,767
1973	715	258	318	149	490	1,929
1974	778	276	286	161	592	2,094
1975	900	294	299	210	664	2,368
1976	1,054	296	337	226	717	2,631
1977	1,172	311	361	244	849	2,937

Source: U.S. Department of Commerce, [94], and U.S. Department of Commerce, Government Finances, [85].

CHAPTER VI

ENERGY ACCOUNT

In a relatively short time the economy has shifted from a position of abundant, low-cost energy to an outlook of possible energy shortages and rising energy prices. A combination of factors, culminated by the Arab Oil Embargo in 1973, has made apparent both short and long term energy problems. Events since the oil embargo have heightened the nation's awareness of its tenuous control over the security of the energy supplies which are so vital to the economy and way of life. The nation's demand for energy will continue to increase, even if a major energy conservation effort is instituted. A vast and complex set of issues and policy alternatives emerged, both at the national and state level, many of which affect both directly and indirectly the various sectors of the economy. Research and development studies need to be given much higher priorities in an effort to provide the level of information required for effective policy making in energy related matters.

The energy account is the basis of this study. It attempts to develop the necessary statistical information on energy required for critical analyses and evaluation of state energy choices. This becomes more important given the considerable impact of energy production on the state economy. The use of comprehensive economic models, such as input-output, containing a number of economic sectors, provides an opportunity to formulate the energy account in a detailed form for analysis. The application of such a model offers a promising approach for improving the quality of information available for analysis of public energy policies. The energy account appears in three major sections: (1) methodology and source of data, (2) consumption of energy by sector and source and (3) production and trade of energy by source.

Methodology and Source of Data

The major contribution of the data base reported here is its estimated distribution of energy utilization by input-output sector and basic energy source, thus recasting energy statistics into a form consistent with economic models composed of processing and final demand sectors. The energy sources are classified into natural gas, petroleum products[1] coal and electricity including hydropower. The input-output sector classification consists of 81 processing sectors and five final demand sectors in which the federal and state and local government purchases are each divided into two sub-categories. Four of the 81 processing sectors are energy producing sectors. For the purpose of the model used in the study, energy use and production are measured in British Thermal units (BTU's). All of the energy statistics are for the benchmark year of 1972, developed from secondary data. 1972 is a useful year since 1973 was the year in which OPEC carried out its massive price increases.

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[1] Components include gasoline, heating fuels, non-gasoline transportation fuels and products employed in industrial processing, energy production and miscellaneous uses.

Energy data by sector and energy source are limited at the state level. Data are available for energy consumption by region, energy source and major economic sector: namely agriculture, mining, construction, manufacture, service and government. Energy use for 1974 by the West South Central region is used as a base for allocation of energy to Oklahoma. Oklahoma's share of consumption of energy from the regional energy use for 1974 was estimated on the basis of the ratio of state employment total regional employment. Assuming the 1974 ratio of energy use by sector and energy source to total energy used is equal to the ratio in 1972, total energy used by energy source for the base period is distributed to the major economic sectors. Then, using the 1972 national ratio of energy use by source to total energy used in major economic sectors, the 1972 Oklahoma energy consumption is allocated among the input-output industry grouping of the state. This whole allocation procedure was used for the manufacturing and mining sectors. Sector allocation of energy used by source within the agriculture sector was made using depreciable assets. For industry groupings within services, construction and government, ratios of sector output to total output of the major economic sector were used as energy allocators.

The principal source of information on energy use by energy source for Oklahoma is from Irving Hoch [29]. Data from the U.S. Bureau of Census [81], [88] and [87]; the U.S. Department of Energy [99] and [100]; and the U.S. Department of Agriculture [72], were used to allocate total energy use by energy source to the input-output industry grouping for Oklahoma.

Energy production is generally reported in physical quantities such as tons of coal, barrels of crude oil, cubic feet of natural gas, kilowatt-hours of electricity, etc. All initial physical quantities of energy production for a particular energy source were converted to British Thermal Units (BTU's).[2] BTU is a convenient measure by which to compare energy sources. The Bureau of Mines is a primary source for converting original measures to BTU [7]. The scale factors for petroleum products, coal, electricity, and hydropower are obtained from that source. Natural gas data in cubic feet are converted to BTU value from data in the American Gas Association report [2]. Coal data appeared in BTU form in the National Coal Association report [37]. The conversion factors for all energy sources are also available in the Battelle Pacific Northwest Laboratories research report by Reardon [61]. The data on physical quantities for petroleum products, natural gas, and bituminous coal are obtained from the Bureau of Mines, 1973 [108] and quantities of electricity and hydropower are obtained from the Edison Electric Institute, 1973 [13].

The state energy use and production of 1972 and 1975 are used in this chapter as an example for a comparative analysis of state energy trade. State energy trade is defined as the difference between state energy use and production. The principal sources of information are Hoch [29], U.S. Bureau of Mines, [108] and U.S. Department of Energy,

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[2] British Thermal Unit (BTU) is the amount of heat necessary to raise the temperature of one pound of water by 1^{o}F at or near 39.02^{o}F. The conversion factors are 5.800 million BTU per barrel of crude oil, 4.011 million BTU per barrel of natural gasoline and cycle products, 0.0001032 million BTU per cu. ft. of natural gas, 24.050 million BTU per ton of coal, 0.003412 million BTU per kwh of electricity and 0.01379 million BTU per kwh of hydroelectric power [37].

[100]. The Oklahoma energy data base system is illustrated by reviewing the state's energy production, utilization and trade.

Energy Consumption

Oklahoma's economy and population growth has led to increased energy use. This increased utilization of energy is both a cause and a result of rising per capita income [51]. Total energy consumed by all sectors in Oklahoma for 1972 was estimated at 1,067.9 trillion BTUs, at a cost of 1,240 million dollars (Table XIX). The processing sectors accounted for 73.3 percent of the total energy consumed in the state and 45.6 percent of the total expenditures. The final demand sectors used 26.7 percent of the total energy and accounted for 54.4 percent of total energy expenditures. The household sector alone consumed 252.455 trillion BTUs of energy or about one quarter (23.6 percent) of the total energy at a cost of 610.8 million dollars or about half (49.3 percent) of the total cost. About 56.5 percent of household consumption of energy was for residential use, with the remaining 43.5 percent for transportation use. The federal and state and local government share of total energy use was 3.0 percent of BTUs and 5.2 percent of expenditures [29].

Total and per capita energy consumption and expenditures for Oklahoma by energy source are shown in Table XIX. Natural gas and petroleum products accounted for 92.4 percent of total energy consumption in Oklahoma for 1972. Natural gas was the largest single energy product consumed at 60.9 percent of the total energy use versus 31.6 percent for petroleum products. Electricity and hydropower's share of energy use was 7.4 percent and coal consisted of only 0.2 percent of total energy consumption. Petroleum products and natural gas accounted for 72.0 percent of total energy expenditures versus 28.0 percent for electricity and hydropower and 0.04 percent for coal.

TABLE XIX

CONSUMPTION OF ENERGY IN BTU AND EXPENDITURES BY ENERGY SOURCE, OKLAHOMA, 1972

	Consumption					
Energy Sources	BTU 10^9	%	Per Capita BTU 10^6	Millions of Dollars	%	Per Capita Dollars
1. Petroleum Products	337,016.4	31.56	128.00	676.3	54.55	256.87
2. Natural Gas	649,909.6	60.86	246.83	216.4	17.46	32.26
3. Electricity & Power	78,791.2	7.38	29.93	346.6	27.95	131.64
4. Coal	2,166.3	0.20	0.82	0	0.04	0.17
Total Energy	1,067,883.5	100.00	405.58	1,239.8	100.00	470.88

Source: Hoch, Irving, [29].

Oklahoma ranks 12th in the nation in terms of energy consumption for all purposes per capita which is 405,577,000 BTUs in 1972 compared to 351,500,000 BTUs per capita for the United States. The leading energy source for consumption in Oklahoma was natural gas at 246.8 million BTUs per capita followed by electricity and hydropower at $131.64 per capita. The total energy expenditure per capita was $470.88 in 1972 compared to $490.07 for the United States [29].

In general, the data on Oklahoma consumption of energy in physical BTU and dollar expenditure indicate a strong dependence on the conventional energy sources of natural gas and petroleum products. As of 1972, nuclear power and coal were not significant contributors to total Oklahoma energy consumption. However, the electric power generating industry has started to use increased amounts of imported low sulfur coal from Wyoming. Coal represents a potentially significant source of energy during a period of increasing concern for development of U.S. domestic energy supplies [51].

Energy Consumption By Sector and Source

Energy use by source and input-output sector in Oklahoma for 1972 is presented in Table XX. The manufacturing industries consumed about 24.6 percent of the total energy used and 33.6 percent of the total energy consumed by the processing sectors. Electricity generation consumed 20.3 percent of total energy use and 27.7 percent of energy consumed by the processing sectors. Petroleum products and natural gas producing industries consumed 13.3 percent of total energy used and 18.2 percent used by the processing sectors. Agriculture directly consumed 1.9 percent of total energy used in 1972.

Manufacturing and transportation industries dominated the consumption of petroleum products at 21.8 percent and 22.6 percent, respectively, of total petroleum products used. Processing sectors used 53.7 percent and the final demand sectors consumed 46.3 percent of the total consumption of petroleum products. The leading natural gas consumer was electricity generation at 29.3 percent followed by manufacturing at 27.1 percent and petroleum, natural gas, and coal produc-

TABLE XX

CONSUMPTION OF ENERGY BY SECTOR AND ENERGY SOURCE
IN BILLION BTU, OKLAHOMA, 1972

I/O	Sectors	Petroleum Products	Natural Gas	Electricity	Coal	Total Energy
1.	Livestock and livestock products	1723.639	2002.631	168.609	0.0	3894.879
2.	Other agricultural products	4920.564	5517.016	481.336	0.0	10918.916
3.	Forestry and fishery products	442.384	550.888	43.275	0.0	1036.547
4.	Agricultural, forestry & fishery services	1955.454	2435.068	191.284	0.0	4581.806
5.	Iron & ferroalley ores mining	0.0	0.0	0.0	0.0	0.0
6.	Nonferrous metal ores mining	295.892	98.459	320.180	0.0	714.531
7.	Stone & clay mining & quarrying	925.657	2756.859	374.635	0.0	4057.152
8.	Chemical & fertilizer mineral mining	0.883	0.0	0.504	0.0	1.387
9.	New construction	5591.199	0.0	78.759	0.0	5669.958
10.	Maintenance & repair construction	709.546	0.0	59.982	0.0	769.528
	Agriculture, mining and construction	16565.218	13360.921	1668.564	0.0	31594.703
11.	Ordance accessories	254.207	379.892	91.616	0.0	725.715
12.	Food and kindred products	6908.199	17489.841	953.518	0.0	25351.557
13.	Tabacco manufactures	0.270	0.987	10.052	0.0	1.309
14.	Broad & narrow fabrics, yarn & thread mills	1430.588	2313.889	409.247	0.0	4153.724
15.	Miscellaneous textile goods & floor coverings	516.526	1045.937	77.634	0.0	1640.097
16.	Apparel	824.819	1080.473	275.683	0.0	2180.975
17.	Miscellaneous fabricated textile products	140.625	241.750	38.817	0.0	421.191
18.	Lumber and wood products, except containers	2247.294	2516.169	316.796	0.0	5080.259
19.	Wood containers	62.199	164.138	12.939	0.0	139.276
20.	Household furniture	325.871	46.310	73.699	0.0	1045.850
21.	Other furniture and fixtures	208.233	340.423	42.156	0.0	590.812
22.	Paper & allied products, except containers	7943.955	12640.048	629.079	0.0	21210.083
23.	Paperboard containers & boxes	459.735	888.060	99.338	0.0	1447.133
24.	Printing and publishing	673.377	1282.753	285.492	0.0	2241.622
25.	Chemicals & selected chemical products	10000.595	39237.434	1415.982	0.0	50654.010
26.	Plastics & synthetic materials	0.0	0.0	0.0	0.0	0.0
27.	Drugs, cleaning & toilet preparations	816.706	1721.849	136.068	0.0	2647.623
28.	Paints and allied products	148.738	291.086	32.557	0.0	472.380

TABLE XX (Continued)

I/O	Sectors	Petroleum Products	Natural Gas	Electricity	Coal	Total Energy
29.	Paving & floor materials	464.693	2355.357	32.447	0.0	2852.492
30.	Rubber & miscellaneous plastics products	1667.216	3241.418	466.429	0.0	5375.063
31.	Leather tanning & finishing	0.271	0.987	10.052	0.0	1.309
32.	Footwear & other leather products	85.186	83.872	39.026	0.0	208.084
33.	Glass and glass products	1961.988	7903.731	138.363	0.0	10004.082
34.	Stone and clay products	6963.637	16207.088	500.446	0.0	23671.171
35.	Primary iron and steel manufacturing	14900.832	28279.764	1407.634	1221.361	45809.592
36.	Primary nonferrous metals manufacturing	3293.868	10834.327	807.433	867.967	15803.595
37.	Metal containers	4.666	11.446	1.044	0.0	17.156
38.	Heating, plumbing & struct. metal products	2185.851	5362.343	488.966	0.0	8037.160
39.	Screw machine products and stampings	60.907	149.418	13.625	0.0	323.950
40.	Other fabricated metal products	525.907	1290.184	117.645	0.0	1933.746
41.	Engines and turbines	227.163	508.167	47.791	0.0	783.121
42.	Farm and garden machinery	316.406	705.514	41.947	0.0	1063.867
43.	Construction & mining machinery	332.632	1075.539	81.182	0.0	1489.352
44.	Materials handling machinery & equipment	106.821	231.882	25.461	0.0	364.164
45.	Metal working machinery and equipment	336.688	823.922	108.103	0.0	1268.713
46.	Special industry machinery & equipment	227.163	473.632	66.156	0.0	766.951
47.	General industrial machinery & equipment	424.579	1238.350	107.686	0.0	1770.614
48.	Misc. machinery, except electrical	232.572	651.244	76.699	0.0	960.615
49.	Office, computing, and accounting machines	151.442	296.020	68.451	0.0	515.913
50.	Service industry machines	310.997	749.917	73.043	0.0	1133.957
51.	Electric industrial equipment & aparatus	278.505	653.044	97.490	0.0	1029.039
52.	Household appliances	6.923	16.234	22.423	0.0	25.580
53.	Electric lighting & wiring equipment	35.712	83.738	2.501	0.0	131.951
54.	Radio, TV, and Communication equipment	1297.287	3041.910	454.111	0.0	4793.308
55.	Electronic components & accessories	136.891	320.985	47.918	0.0	505.794
56.	Misc. electrical machinery & supplies	45.762	252.204	26.019	0.0	229.085
57.	Motor vehicles and equipment	1907.901	4371.227	439.299	0.0	6718.427
58.	Aircraft and parts	421.875	966.998	174.259	0.0	1563.132
59.	Other transportation equipment	459.735	596.973	119.998	0.0	1176.707
60.	Scientific and controlling instruments	192.007	419.361	72.834	0.0	684.202
61.	Optical, ophthalmic & photographic equipment	362.380	276.285	45.495	0.0	684.160

TABLE XX (Continued)

I/O	Sectors	Petroleum Products	Natural Gas	Electricity	Coal	Total Energy
62.	Miscellaneous manufacturing	482.722	828.856	130.642	0.0	1442.219
	Manufacturing	79212.930	205947.930	11718.250	2089.328	31794.703
63.	Transportation and warehousing	76044.811	16380.698	0.0	0.0	92425.509
64.	Communications, except radio & TV	4.672	33.724	233.253	0.0	271.649
65.	Radio & TV broadcasting	0.801	22.916	139.973	0.0	163.590
66.	Water supply & sanitary services	0.520	83.706	112.178	0.0	195.884
67.	Wholesale & retail trade	398.963	2956.475	3778.117	0.0	7133.555
68.	Finance and insurance	12.906	215.114	116.613	0.0	344.633
69.	Real estate and rental	33.186	554.149	299.860	0.0	887.195
70.	Hotels: personal & repair services exc. auto	39.988	766.520	361.319	0.0	1167.827
71.	Business services	95.894	1598.377	866.476	0.0	2560.747
72.	Eating & drinking places	124.479	779.889	1069.003	0.0	1973.371
73.	Automobile repair and services	35.268	587.844	318.669	0.0	941.781
74.	Amusements	13.217	228.311	219.429	0.0	460.957
75.	Medical, educ. services & nonprofit org.	51.328	7857.298	1616.959	0.0	9525.585
76.	Federal government enterprises	67.484	5595.470	1001.735	0.0	6664.689
77.	State & local government enterprises	35.414	2936.395	665.691	0.0	3637.500
	Transportation, commun., trade & service	76968.537	42135.406	10998.410	0.0	130101.353
78.	Petroleum Productions Production	6769.831	72816.769	865.659	0.0	80552.259
79.	Natural Gas Production	1263.221	60047.482	808.410	0.0	62119.113
80.	Coal Mining	411.599	393.837	614.304	10.672	1430.413
81.	Electricity and Hydro-power	5747.161	190243.529	19663.336	66.300	215720.326
	Energy processing	14191.812	323610.617	21951.709	76.972	360522.108
	TOTAL PROCESSING SECTORS	181087.100	553888.500	45889.800	2166.300	783031.700
82.	Household industry	146836.000	81660.000	23959.000	0.0	252455.00
83.	Federal government - defense	1330.342	882.060	758.550	0.0	2970.952
84.	Federal government - non-defense	3118.158	2067.440	1777.950	0.0	6963.548
85.	State & local government - education	1755.799	4313.745	2421.482	0.0	8491.026
86.	State and local government - other	2889.001	7097.855	3984.317	0.0	13971.173
	TOTAL FINAL DEMAND	155929.300	96021.100	32901.400	0.0	284851.800
	GRAND TOTAL	337016.400	649909.600	78791.200	216.300	1067883.500

ing industries at 20.5 percent. The processing sectors used 85.2 percent of total natural gas consumed while the remaining 14.8 percent was used by the final demand sectors.

Manufacturing sectors consumed 17.3 percent of total electricity while 10.5 percent was used within the electricity generating sector itself. Final demand consumed slightly more than half of all electricity (50.7 percent) with the remaining 49.3 percent used by the processing sectors. The household sector consumed 36.9 percent of total electricity. The manufacturing industries used most (96.5 percent) of the coal consumed with insignificant amounts used for electricity generation (3.1 percent). Nuclear power was not produced or consumed in Oklahoma in 1972.

Direct Energy Use Requirements by Sector and Energy Source

The direct energy use requirement by sector is computed as the ratio of energy used to the index of output for 1972. For the non-energy producing sectors, direct energy requirements show the energy consumed by energy source per unit of value of output. For the energy producing sectors, direct energy requirements show the energy consumed by energy source per unit of energy output. The coefficients indicate the amount of energy, measured in BTU, required to produce one dollar's worth of output of each sector in the non-energy producing sectors. For the energy producing sectors the data measure the amount of energy in BTU required to produce one unit of BTU output. These data summarize all the factors that go into determining how much energy was used to produce a given amount of output in a sector. This obviously includes the type of technology and production process used and its efficiency, as well as the scale of individual operations, the degree of integration in the industry, the mix of products, and a host of other factors which effect the amount of energy used per unit of output. However, it is not possible to separate the rates of energy consumed among the complex factors entering into the determination of the coefficients [61].

Energy use requirements by basic energy source and input-output industry grouping are presented in Table XXI. Transportation and warehousing is a major user of energy per unit of output at 101,401 BTU with manufacturing at about 50,000 BTU per unit of output. The finance, insurance and real estate sector used the least energy per unit of output (430 BTU).

Coal is consumed by the primary iron, steel and non-ferrous metals manufacturing sectors at an average of 12,219 BTU of coal per unit of output. Electricity generation used 0.00065 BTU of coal per unit of output and coal mining used 0.00017 BTU of coal per unit of output. Manufacturing industries used 14,519 BTU of petroleum products and 37.749 BTU of natural gas per unit of output. Transportation and warehousing consumed 83,430 BTU of petroleum products and 17.922 BTU of natural gas per unit of output. Electricity generating and petroleum production used 1.86002 BTU and 0.05869 of BTU of natural gas per unit of output, respectively. Electricity generation used 0.20203 BTU of electricity per unit of output. Federal government and state and local government enterprises consumed an average of 19.935 BTU of total energy per unit of output.

TABLE XXI

DIRECT ENERGY REQUIREMENT PER UNIT OF OUTPUT IN THOUSAND BTU, BY SECTOR, OKLAHOMA, 1972

I/O	Sectors	Petroleum Products	Natural Gas	Electricity	Coal	Energy
1.	Livestock and livestock products	1.44043	1.67358	0.14091	0.0	3.25492
2.	Other agricultural products	8.82544	9.89523	0.86332	0.0	19.58399
3.	Forestry and fishery products	41.39847	51.55131	4.04969	0.0	97.00047
4.	Agricultural, forestry and fishery services	41.39841	51.55220	4.04962	0.0	97.00023
5.	Iron and ferroalley ores mines	0.0	0.0	0.0	0.0	0.0
6.	Nonferrous metal ores mining	105.52505	35.11386	114.18673	0.0	254.82584
7.	Stone and clay mining and quarrying	33.44620	99.61191	13.53647	0.0	146.59458
8.	Chemical and fertilizer mineral mining	44.16302	0.0	25.21099	0.0	69.37401
9.	New construction	3.92823	0.0	0.05533	0.0	3.98357
10.	Maintenance and repair construction	3.92824	0.0	0.05526	0.0	3.98350
11.	Ordance accessories	59.78518	89.34435	21.54662	0.0	170.67614
12.	Food and kindred products	7.34239	18.58911	1.01345	0.0	26.94495
13.	Tobacco manufactures	2.65130	9.67385	0.51150	0.0	12.83665
14.	Broad and narrow fabrics, yarn and thread mills	107.46605	173.81976	30.74271	0.0	312.02851
15.	Miscellaneous textile goods and floor coverings	7.31354	14.80952	1.09922	0.0	23.22228
16.	Apparel	6.62809	8.68247	2.21534	0.0	17.52590
17.	Miscellaneous fabricated textile products	4.82038	8.28676	1.33058	0.0	14.43771
18.	Lumber and wood products, except containers	17.28090	19.34845	2.43605	0.0	39.06539
19.	Wood containers	18.45682	19.03194	3.83946	0.0	41.32821
20.	Household furniture	11.24857	22.30963	2.54293	0.0	36.10113
21.	Other furniture and fixtures	13.65731	22.32720	2.76487	0.0	38.74938
22.	Paper and allied products, except containers	96.72063	153.89732	7.62274	0.0	258.24069
23.	Paperboard containers and boxes	11.99664	23.17362	2.59219	0.0	37.76245
24.	Printing and publishing	3.47196	6.61393	1.47201	0.0	11.55791
25.	Chemicals and selected chemical products	201.82427	791.85957	28.57625	0.0	1022.26009
26.	Plastics and synthetic materials	0.0	0.0	0.0	0.0	0.0
27.	Drugs, cleaning and toilet preparations	123.94990	261.32173	20.65075	0.0	405.92243

TABLE XXI (Continued)

I/O	Sectors	Petroleum Products	Natural Gas	Electricity	Coal	Total Energy
28.	Paints and allied products	13.76056	26.92998	3.10194	0.0	43.70249
29.	Paving mix. and block, asphalt felts and coatings	8.82574	44.73443	0.61625	0.0	54.17642
30.	Rubber and miscellaneous plastics products	6.05450	11.77122		0.0	19.51956
31.	Leather tanning and finishing	2.65130	9.67385	0.51150	0.0	12.83665
32.	Footwear and other leather products	3.50633	3.54225	1.60632	0.0	8.56489
33.	Glass and glass products	15.00851	60.46074	1.05843	0.0	76.52769
34.	Stone and clay products	45.85564	106.72338	3.29544	0.0	155.87496
35.	Primary iron and steel manufacturing	149.07689	282.92779	14.08282	12.21923	458.30674
36.	Primary nonferrous metals manufacturing	46.37096	152.52527	11.36701	12.21921	222.48244
37.	Metal containers	4.70838	11.54995	1.05348	0.0	17.31181
38.	Heating, plumbing, and struct. metal products	6.85475	16.81613	1.53338	0.0	25.20426
39.	Screw machine products and stampings	6.33656	15.54494	1.41750	0.0	23.29900
40.	Other fabricated metal products	5.32952	13.07442	1.19219	0.0	19.59613
41.	Engines and turbines	38.82470	86.85138	8.16795	0.0	133.84403
42.	Farm and garden machinery	12.70503	28.32935	1.168436	0.0	42.71873
43.	Construction and mining machinery	1.08825	3.51875	0.26560	0.0	4.87259
44.	Materials handling machinery and equipment	6.73651	14.62334	1.60563	0.0	22.96548
45.	Metal working machinery and equipment	23.58423	57.71378	7.57236	0.0	88.87037
46.	Special industry machinery and equipment	4.93329	10.28583	1.43670	0.0	16.65583
47.	General industrial machinery	3.01582	8.79610	0.76490	0.0	12.57683
48.	Misc. machinery, except electrical	6.02097	16.85981	1.98822	0.0	24.86900
49.	Office, computing, and accounting machines	0.76972	1.50454	0.34791	0.0	2.62216
50.	Service industry machines	3.27783	7.90393	0.76985	0.0	11.95161
51.	Electric industrial equipment and apparatus	6.50632	15.25626	2.27754	0.0	24.04015
52.	Household appliances	3.28727	7.70845	1.15052	0.0	12.14625
53.	Electric lighting and wiring equipment	5.70115	13.36814	1.99569	0.0	21.06497
54.	Radio, TV, and communication equipment	4.82421	11.31195	1.68870	0.0	17.82482
55.	Electronic componets and accessories	5.79506	13.58839	2.02853	0.0	21.41199
56.	Misc. electrical machinery and supplies	6.19494	14.52606	2.16854	0.0	22.88954
57.	Motor vehicles and equipment	19.07463	43.70222	4.39198	0.0	67.16882
58.	Aircraft and parts	3.41920	7.83731	1.41233	0.0	12.66884
59.	Other transportation equipment	5.55840	7.21767	1.45083	0.0	14.22690
60.	Scientific and controlling instruments	9.71401	21.21630	3.68480	0.0	34.61512
61.	Optical, ophthalmic, and photographic equipment	28.01110	21.35620	3.51666	0.0	52.88396

TABLE XXI (Continued)

I/O	Sectors	Petroleum Products	Natural Gas	Electricity	Coal	Total Energy
62.	Miscellaneous manufacturing	7.55895	12.97906	2.04572	0.0	22.58373
63.	Transportation and warehousing	83.42995	17.97152	0.0	0.0	101.40147
64.	Communications, except radio and TV	0.01484	0.42462	0.74066	0.0	1.18011
65.	Radio and TV broadcasting	0.01543	0.44164	0.77033	0.0	1.22740
66.	Water supply and sanitary services	0.01334	2.14763	0.31245	0.0	2.47342
67.	Wholesale and retail trade	0.15537	1.15135	1.47133	0.0	2.77805
68.	Finance and insurance	0.01600	0.26667	0.14456	0.0	0.42723
69.	Real estate and rental	0.01612	0.26863	0.14562	0.0	0.43036
70.	Hotels; personal and repair services exc. auto	0.11638	1.93983	1.05158	0.0	3.10799
71.	Business services	0.15401	2.50702	1.35905	0.0	4.01648
72.	Eating and drinking places	0.21286	1.33363	1.82803	0.0	3.37452
73.	Automobile repair and services	0.11822	1.97042	1.06816	0.0	3.15679
74.	Amusements	0.11695	1.94948	1.05680	0.0	3.12324
75.	Medical, educ. services and nonprofit org.	0.05283	8.08771	1.66438	0.0	9.80492
76.	Federal government enterprises	0.30311	25.13237	4.49935	0.0	29.93482
77.	State and local government enterprises	0.30311	25.13241	4.49935	0.0	29.93487
78.	Petroleum Products Production	0.00545	0.05869	0.00062	0.0	0.06476
79.	Natural Gas Production	0.00068	0.03220	0.00038	0.0	0.03326
80.	Coal Mining	0.00652	0.00624	0.00815	0.00017	0.02108
81.	Electricity and Hydro-Power	0.05619	7.86002	0.20203	0.00065	2.11889

[a]Unit of output for secotrs 1-77 defined in terms of thousands of 1972 dollars and for sectors 78-81 in terms of BTU.

Energy Production and Trade

Energy Production By Source

Oklahoma is a major energy producing state. Energy production by basic energy source in trillion BTUs from 1971 to 1976 is illustrated in Table XXII. In 1972, total energy produced in Oklahoma was estimated at 3,272.5 trillion BTUs. Over half (57.0 percent) of the total energy produced was from natural gas followed by petroleum products[3] at 38.0 percent and the remaining 5.0 percent of total energy produced consisted of electricity and hydropower (at 3.1 percent) and bituminous coal (at 1.9 percent). About ten percent of total BTU's of petroleum products is used for raw materials and non-energy products such as petro chemical inputs.[4]

Petroleum products and natural gas accounted for over 90 percent of total energy production in Oklahoma for the years 1971-1976. Petroleum products showed a continuous annual decline in production from 1971 to 1976. The total petroleum products declined at an average annual rate of 4.8 percent over the period. Natural gas production increased marginally by 1.6 percent over the entire period. Coal production and electricity including hydropower increased at an average annual rate of 9.5 percent and 6.5 percent, respectively, from 1971 to 1976.

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[3]The components of petroleum products include crude petroleum (87.2 percent), natural gasoline and cycle products (4.9 percent), and liquified petroleum gas (7.9 percent).

[4]This estimate is reduced from the total energy production for adjustment on the basis of input-output relationships.

Energy production is an important element of Oklahoma's economic base. About 55,000 workers are employed in the production of the state's energy resources, and thousands of others are engaged in the distribution and marketing services of those energy supplies. A large portion of Oklahoma's jobs, business income and tax revenues are generated from energy production [52].

Energy Trade Analysis

Oklahoma as a major producer of crude oil and natural gas is also a net exporter of energy to the rest of the country (Table XXIII). In 1972, the net fossil energy export was 2,181.114 trillion BTU's which is 68.8 percent of the total fossil energy production in Oklahoma. Net fossil energy trade in 1975 dropped to 1,693.433 trillion BTU's and amounted to about 62.0 percent of production. Oklahoma ranks third among all oil producing states as an exporter of energy. Oklahoma exports large amounts of natural gas, crude oil, and natural gas liquids, and a small amount of coal to neighboring states and abroad. Very little of the coal produced in Oklahoma is used in the state. Oklahoma coal generally exceeds the sulfur content permitted in present state antipollution standards. As a result, most Oklahoma steam coal is now shipped to other states for use in cement production and for electricity generation. Metallurgical coal produced in Oklahoma is used in making coke for steel production in other states and is exported to Japan, Mexico and West Germany.

Higher energy prices have been an incentive for energy production and the resulting shift in related prices has created a positive effect upon the state economy by transferring income from energy using to energy producing regions [52]. Most of the energy price increase came after the oil embargo in 1973. For instance, a comparison of export level and values can be made from Table XXIII. Natural gas export value has increased substantially from 1972 to 1975 due to the higher prices despite a lower production level. The value of coal exports increased by 249 percent from 1972 to 1975. The export of petroleum products from Oklahoma decreased due to a decline of production and a slight increase in Oklahoma consumption in 1975 compared to 1972. In general, the value of energy exports has increased dramatically due to higher energy prices. As energy production decreases, energy exports will continue to decline in quantity, but the value may not.

TABLE XXII

ENERGY PRODUCTION BY ENERGY SOURCE IN TRILLION BTU
OKLAHOMA, 1971-1976

Year	Petroleum Products	Natural Gas	Bituminous Coal	Electricity & Hydropower	Total Energy
1971	1,271.941	1,738.156	53.728	93.826	3,157.651
1972	1,242.382	1,864.707	63.107	102.280	3,272.476
1973	1,163.945	1,827.651	52.782	130.258	3,174.355
1974	1,093.091	1.691.388	56.662	138.048	2.979.189
1975	1,003.547	1,656.783	69.072	134.019	2,863.421
1976	999.118	1,765.325	87.422	130.552	2,982.417

Source: Estimated from the physical quantities reported by the Bureau of Mines, 1971-76 [110] and Edison Electric Institute, 1971-76 [15].

TABLE XXIII

PRODUCTION, CONSUMPTION AND EXPORT OF FOSSIL FUELS OKLAHOMA, 1972 AND 1975

		Petroleum Products	Natural Gas	Coal	Total
Production					
1972	BTU 10^9	1,242.382	1,864.707	63.107	3,170.196
	$1,000,000	2,493.228	620.956	12.878	3,127.062
1975	BTU 10^9	1,003.547	1,656.783	69.072	2,729.402
	$1,000,000	2,342.202	1,208.259	32.320	3,582.781
Consumption					
1972	BTU 10^9	337.016	649.910	2.156	989.082
	$1,000,000	676.328	216.423	442	893.193
1975	BTU 10^9	359.193	673.836	2.940	1,035.969
	$1,000,000	838.688	491.415	1.376	1,331.479
Export					
1972	BTU 10^9	905.366	1,214.797	60.951	2,181.114
	$1,000,000	1,816.900	404.533	12.436	2,233,869
1975	BTU 10^9	644.354	982.947	66.132	1,693.433
	$1,000,000	1,503.514	716.844	30.944	2,251.302

Source: Estimated from Hoch [29] and U.S. Bureau of Mines [100].

CHAPTER VII

THE SIMULATION MODEL FOR OKLAHOMA

Simulation, as applied in economic systems, is a numerical technique for conducting experiments, usually on a digital computer. It involves setting up of mathematical models describing the behavior of systems over extended periods of time. Simulation models presently and prospectively are the most feasible, the most workable, and probably the most potentially useful types of models in dynamic systems analysis. The introduction and availability of digital computers has increased the application of this type of empirical tool and has made it possible to manage large, complex economic models [3]. In this chapter recent simulation studies based on input-output techniques are reviewed. This is followed by a description of the input-output based simulation model used to evaluate alternative energy choices for Oklahoma.

Previous Simulation Studies

Input-output and simulation models have been employed as the major approach in the analysis of interrelationships in regional economic studies. Since the model presented in this study is a simulation model formulated around an input-output model, it is appropriate to review similar models of regional economies developed in recent years. Of special interest are those models which are impact oriented and relevant to state economies such as Oklahoma.

The Iowa State study by Maki, Suttor, and Barnard [33] was one of the first regional simulation studies based on the input-output model. Twenty-three major equations described the economic conditions of Iowa. These included derivation of final demand, sector output, sector employment, value added, total personal income, and disposable income. Simulation runs were performed over the 1954-74 period.

W. H. Miernyk [34] developed a simulation model of the West Virginia economy. The study focused on the use of an input-output model to simulate certain aspects of economic development. The process of structural change in the economy was viewed in a dynamic setting. Data were obtained by personal interviews from a sample of establishments.

One of the most cited regional simulation studies is the Susquehanna River Basin model developed by H. R. Hamilton, et al. at the Battelle Memorial Institute [27]. It is a dynamic simulation model representing important categories of variables in a regional economy: demographic, employment, and water. The demographic and employment sectors are tied together by an important feedback loop including variables of population, labor force, wage rate, unemployment, and migration. Data from the two sectors are fed into a water resource sector, viewed as a "technical sector", to determine water quality and quantity variables. However, the water sector's feedback on the demographic and employment sectors was not considered critical and hence not included in the model. The model might be called an "employment determining model" since economic activity is specified in terms of employment rather than variables such as income, value added, or output. The model incorporates export base theory for determining employment in which the principal "driving force" of the model is market area demand operating through export industry employment.

Arthur Ekholm [16] developed a model for determining regional economic adjustments to declining groundwater and petroleum supplies in the High Plains of Oklahoma and Texas. The model deals with the development of an information system and a dynamic simulation model which estimates the impact of declining groundwater and petroleum resources in a regional economy. The region includes a combination of 28 counties of the High Plains of Oklahoma and Texas. The information system is estimated from secondary sources and consists of a 42 sector interindustry transactions matrix, a capital account and a human resource account. The regional economy from 1967 to 2010 is simulated by means of a system of difference equations arranged in a recursive sequence that determines sector and regional population subject to groundwater and petroleum supply projections. Output determination in each year involves the use of an independent resource projection system, the Leontief inverse matrix, and a feedback loop.

Beside the above mentioned models, a lineage of other simulation studies can be added to the list. Several simulation studies on the state of Oklahoma have been formulated around the input-output system of analysis. Doeksen [9] developed a model for the Oklahoma economy for the base period 1963. His input-output formulation consisted of twelve endogenous and five exogenous sectors. The major contribution of the study was the addition of the capital account in which capital coefficients for Oklahoma were developed. Sector output at capacity levels, capital-output ratios, a capital unit matrix, a capital stock matrix, and an investment matrix were included. The model was used to simulate various major state economic variables over the 1963-1980 period. The main objective of the study was to develop a social accounting system for Oklahoma and to utilize the system in evaluating development strategies by projecting output, employment, income, revenue, and other state economic variables.

Sarigedik updated the Oklahoma model to 1967 and extended the model by adding a government account and expanding the human resource account [65]. The government account incorporated revenues and expenditures of federal and state and local governments. The model is composed of seventeen endogenous and five exogenous sectors used to simulate the state economy over the 1967 to 1985 period. The major purpose of the study was to update the social accounting system for Oklahoma to 1967 and to utilize the information in evaluating growth of the state economy on the government and human resource accounts.

The input-output and simulation model of this study is related to the Ekholm [16], Doeksen [9] and Sarigedik [65] studies. The present model is different from these studies in base year model formulation and purpose of analysis. All previous accounts in the system have been updated to base year 1972. The difference in model formulation from the previous studies is development of an energy account which is a unique component of the social accounting system. The major contribution, therefore, lies in the energy account which develops Oklahoma energy use and production by economic sector and energy source. Direct energy requirements (energy use-output ratios) by sector and energy source are estimated. The processing sectors are separated into two groups--the non-energy demand determined output sectors (77) and energy supply determined output sectors (4). Outputs of the non-energy sectors are determined by final demand and by direct requirements of the energy sectors. Output of the energy sectors are independently determined outside the model and then fed into the simulation and input-output model as exogenous data. Projected output of the non-energy sectors, direct energy requirements of the processing sectors, direct energy requirements of households and government, and projected production of state energy are used to determine state energy trade by energy source.

The purpose of the model is to evaluate alternative energy choices for Oklahoma. The model is designed to simulate over the period 1972-2000 using a system of difference equations arranged in recursive sequence. It is used to evaluate alternative energy choices for Oklahoma on such state economic variables as employment, income, government revenue and expenditure energy trade.

The Oklahoma Simulation Model

The operation of the simulation model is recursive involving 119 major equations for a given year. There are four main parts in the model which include: (1) estimating final demand, (2) determining sector output, (3) projecting state economic variables, and (4) projecting state energy requirements and trade. All these are discussed in detail in this chapter. The specification of the Oklahoma simulation model starts first in sequence with the various components of final demand. Final demand sectors include personal consumption expenditures, private capital formation, change in business inventories, net exports, federal government purchases for national defense and non-defense, and state and local government purchases for education and other services (i.e. highways, public welfare, health and hospitals). Secondly, after final demand is estimated, output requirements by endogenous sectors are determined. Thirdly, sector output estimates are utilized to derive state economic projections. State economic variables projected by the model include income, employment, government revenues and expenditures and gross state product. Fourth, the data generated on final demand are used in the process of projecting the state energy requirements and energy trade.

The complete listing of economic variables, matrices, and scalers are presented in Tables XXIV, XXV, and XXVI, respectively. The economic variables are presented by capital letters, matrices by the subscripted capital letter "A", and scalers by the subscripted small letter "a." All annual growth rates defined either as "A" or "a" are estimated by least squares with logarithmic exponential functions. Figure 3 depicts the flow chart of the economic variables. The flow chart helps in explaining how final demand is used to estimate output and how output is used to project various state economic variables. State economic variables are measured in thousands of constant 1972 dollars and energy estimates are expressed in thousands of BTU.

Estimating Final Demand

There are eight final demand sectors. First, each final demand component needs to be estimated. Then, total final demand is estimated by summing all components.

Private Capital Formation. The accelerator principle reflects

TABLE XXIV

VARIABLES IN OKLAHOMA SIMULATION MODEL

Variable	Description
$(XDC)_t$	Column vector of non-energy sector capacity output in year t.
$(XEC)_t$	Column vector of energy sector capacity output in year t.
$(IN)_t$	Column vector of new plant and equipment investment for $(IND)_t$ non-energy sectors and (INE) for energy sectors in year $_t$t.
$(XD)_t$	Column vector of output of non-energy demand determined sectors in year t.
$(XE)_t$	Column vector of output of supply energy supply determined sectors in year t.
$(K)_t$	Column vector of capital stock $(KD)_t$ for non-energy sector and $(KE)_t$ for energy sector at the beginning of year t.
$(IR)_t$	Column vector of replacement investment $(IRD)_t$ for non-energy sectors and (IRE) for energy sectors in year $_t$t.
$(I)_t$	Column vector of total investment for energy and non-energy sectors in year t.
$(PCF)_t$	Column vector of composition of new investment for energy and non-energy sectors in year t.
$(C)_t$	Total purchases od durable goods in year t.
$(PCY)_t$	Per capita disposable income in year t.
$(PCD)_t$	Column vector of consumption of durable goods in year t.
$(CN)_t$	Total non-energy non-durable purchases in year t.
$(PCN)_t$	Column vector of consumption of non-energy non-durable goods in year t.
$(P)_t$	Oklahoma population in year t.
$(CS)_t$	Total consumption of services in year t.
$(PCS)_t$	Column vector of consumption of services in year t.
$(PCE)_t$	Column of total personal consumption expenditures for non-energy sectors in year t.
$(EX)_t$	Total net export demand for non-energy sectors in year t.
$(CBI)_t$	Column vector of sector inventory in year t.

TABLE XXIV (Continued)

Variable	Description
$(FDP)_t$	Column vector of federal government purchases for national defense in year t.
$(FPO)_t$	Column vector of federal government purchases for non-defense in year t.
(TFP)	Column vector of total federal government purchases in year t.
$(TSE)_t$	Total state and local government expenditures on education in year t.
$(SLE)_t$	Column vector of state and local government expenditures on education in year t.
$(SLW)_t$	State and local government expenditures on highways in year t.
$(SLP)_t$	State and local government expenditures on public welfare in year t.
$(SLH)_t$	State and local government expenditures on health and hospitals in year t.
$(SLO)_t$	Other state and local government expenditures in year t.
$(TSO)_t$	Total state and local government expenditures other than education in year t.
$(TSL)_t$	Column vector of total state and local expenditures in year t.
$(SLR)_t$	Column vector of state and local government expenditures on all items except education in year t.
$(Z)_t$	Column vector of total final demand in year t.
$(TPI)_t$	Total personal income in Oklahoma in year t.
$(PIP)_t$	Personal income per capita in Oklahoma in year t.
$(TP)_t$	Total Oklahoma population in year t.
$(P_{ij})_t$	Column vector of population in year t in cohort i for sex j.

TABLE XXIV (Continued)

Variables	Description
$(AP_{ij})_t$	Column vector of advancement from cohort i to cohort i + 1 between year t and year t + 1.
$(M_{ij})_t$	Column vector of net immigration into cohort i between year t and year t + 1 of sex j.
$(D_{ij})_t$	Column vector of deaths by members of cohort i of sex j in year t to year t + 1.
$(B_j)t$	Column vector of births of sex j in year t.
$(WNN)_t$	Column vector of wage and salary employment for non-energy sectors in year t.
$(PNN)_t$	Column vector of proprietor employment for non-energy sectors in year t.
$(SNN)_t$	Column vector of sector total employment for non-energy sectors in year t.
(TNN)	Sum total of sector employment for non-energy sectors in year t.
$(WEN)_t$	Column vector of wage and salary employment for energy sectors in year t.
$(PEN)_t$	Column vector of proprietor employment for energy sectors in year t.
$(SEN)_t$	Column vector of sector total employment for energy sectors in year t.
$(TEN)_t$	Sum total of sector employment for energy sectors in year t.
$(TSN)_t$	Sum total of non-energy and energy sector employment in year t.
$(WNP)_t$	Column vector of wage and salary payments for non-energy sectors in year t.
$(PNY)_t$	Column vector of proprietor income for non-energy sector in year t.
$(TNP)_t$	Sum total of wage and salary payments for non-energy sectors in year t.
$(TNY)_t$	Sum total of proprietor income for non-energy sectors in year t.

TABLE XXIV (Continued)

Variables	Description
$(WEP)_t$	Column vector of wage and salary payments for energy sectors in year t.
$(TEP)_t$	Sum total of wage and salary payments for energy sectors in year t.
$(TWP)_t$	Sum total of non-energy and energy sector wage and salary payments in year t.
$(PEY)_t$	Column vector of proprietor income for energy sectors in year t.
$(TEY)_t$	Sum total of proprietor income for energy sectors in year t.
$(PYT)_t$	Sum total of non-energy and energy sector proprietor income in year t.
$(TTP)_t$	Total transfer payments in Oklahoma in year t.
$(TPY)_t$	Total property income in Oklahoma in year t.
$(OLY)_t$	Total other labor income in Oklahoma in year t.
$(VD)_t$	Column vector of value added for non-energy sectors in Oklahoma in year t.
$(VE)_t$	Column vector of value added for energy sectors in Oklahoma in year t.
$(XG)_t$	Gross state product in Oklahoma in year t.
$(TFT)_t$	Total federal government tax collection in Oklahoma in year t.
$(IIT)_t$	Federal government individual income tax collections in Oklahoma in year t.
$(SST)_t$	Total value of state sales tax collections in Oklahoma in year t.
$(GFT)_t$	Gasoline and fuels excise and special fuels use tax collections in Oklahoma in year t.
$(ICT)_t$	Individual and corporation income tax withheld by the state in Oklahoma in year t.

TABLE XXIV (Continued)

Variables	Description
$(OGT)_t$	All other taxes collected by state and local government in Oklahoma in year t.
$(FAG)_t$	Federal aid to state and local government in Oklahoma in year t.
$(AOR)_t$	Other revenues to state and local government in Oklahoma in year t.
$(SLC)_t$	Total state and local government revenue collections in Oklahoma in year t.
$(TDI)_t$	Total disposable income in Oklahoma in year t.
$(DIP)_t$	Disposable income per capita in Oklahoma in year t.
$(ET)_t$	Column vector of state energy trade by energy sources in year t.
$(FE)_t$	Column vector of final energy consumption by energy sources in year t.
$(FET)_t$	Total sum of energy demand in year t.
$(FEH)_t$	Total final energy demand by household sources in year t.
$(FEF)_t$	Total final energy consumption by federal government by sources in year t.
$(FES)_t$	Total final energy consumption by state and local government by sources in year t.
$(FCH)_t$	Total final coal consumption by household in year t.
$(FPH)_t$	Total final petroleum products consumption by household in year t.
$(FNH)_t$	Total final electricity and hydro-power consumption by household in year t.
$(TFE)_t$	Sum total of federal government pruchases for energy and non-energy sectors in year t.
$(FCF)_t$	Total final coal consumption by federal government in year t.

TABLE XXIV (Continued)

Variables	Description
$(FPF)_t$	Total final petroleum products consumption by federal government in year t.
(FNF)	Total final natural gas consumption by federal government in year t.
$(FTF)_t$	Total final electricity and hydro-power consumption by federal government in year t.
$(FCS)_t$	Total final coal consumption by state and local government in year t.
$(FPS)_t$	Total final petroleum products consumption by state and local government in year t.
$(FNS)_t$	Total final natural gas consumption by state and local government in year t.
$(FTS)_t$	Total final electricity and hydro-power consumption by state and locat government in year t.
$(FC)_t$	Total final coal consumption in year t.
$(FP)_t$	Total final petroleum products consumption in year t.
$(FN)_t$	Total final natural gas consumption in year t.
$(FT)_t$	Total final electricity and hydro-power consumption in year t.
$(EC)_t$	Column vector of state energy consumption by energy source in year t.

TABLE XXV

MATRICES IN OKLAHOMA SIMULATION MODEL

Matrix	Description
A_0	Diagonal matrix of average output-capital ratios for non-energy and energy sectors.
A_1	Diagonal matrix of average capital-output ratios A_1 for non-energy and A_{01} for energy sectors.
A_2	Diagonal matrix of one plus annual change in capital-output ratios A_2 for non-energy and A_{02} for energy sectors.
A_3	Diangonal matrix of depreciation rates for non-energy and energy sectors.
A_4	Capital coefficient matrix.
A_5	Column vector of sector purchases of durable goods to total purchases of durable goods.
A_6	Column vector of sector purchases of non-energy non-durable goods to total expenditures of non-energy non-durable goods.
A_7	Column vector of sector purchases of services to total expenditures of services.
A_8	Diagonal matrix of one plus annual growth rate of durable and non-energy non-durable exports.
A_9	Diagonal matrix of sector inventory to sector output lagged one year.
A_{10}	Column vector of total state and local government purchases by sector for education to total education expenditure.
A_{11}	Column vector of total state and local government purchases by sector for other services to total expenditure for other services.
A_{12}	Diagonal matrix of one plus annual growth rate in energy production.
A_{13}	Direct and indirect coefficient matrix of non-energy sectors.
A_{14}	Direct requirements from the non-energy sectors per unit of output of the energy sectors ($/BTU).
A_{15}	Diagonal matrix of labor-output coefficients for non-energy sectors.

TABLE XXV (Continued)

Matrix	Description
A_{16}	Diagonal matrix of one plus annual growth rate in (A_{15}).
A_{17}	Diagonal matrix of labor-output coefficients for energy sectors.
A_{18}	Diagonal matrix of one plus annual growth rate in (A_{17}).
A_{19}	Diagonal matrix of wage and salary employment to total employment for non-energy sectors.
A_{20}	Diagonal matrix of one plus annual growth rate in (A_{19}).
A_{21}	Diagonal matrix of ratio of wage and salary employment to total employment for energy sectors.
A_{22}	Diagonal matrix of one plus annual growth rate in (A_{21}).
A_{23}	Diagonal matrix of wage and salary income rates for non-energy sectors.
A_{24}	Diagonal matrix of one plus annual growth rate in (A_{23}).
A_{25}	Diagonal matrix of wage and salary income rates for energy sectors.
A_{26}	Diagonal matrix of one plus annual growth rate in (A_{25}).
A_{27}	Diagonal matrix of proprietor income rates for non-energy sectors.
A_{28}	Diagonal matrix of one plus annual growth rate in (A_{27}).
A_{29}	Diagonal matrix of proprietor income rates for energy sectors.
A_{30}	Diagonal matrix of one plus annual growth rate in (A_{29}).
A_{31}	Diagonal matrix of ratio of value added to sector output for non-energy sectors.
A_{32}	Diagonal matrix of ratio of value added to sector output for energy sectors.
A_{33}	Direct energy requirements per unit of output of the energy sectors (Btu/Btu).
A_{34}	Direct energy requirements per unit of output of the non-energy sectors (Btu/$).

TABLE XXVI

SCALARS IN OKLAHOMA SIMULATION MODEL

Scalar	Description
a_0	Upper limit to capacity output for capital formation.
a_1	Ratio of durable expenditures to disposable income lagged one year.
a_2	One plus annual growth rate in (a_1).
a_3	Ratio of non-durable expenditures to disposable income lagged one year.
a_4	One plus annual growth rate in (a_4).
a_5	Ratio of service expenditures to disposable income lagged one year.
a_6	One plus annual growth rate in (a_5).
a_7	One plus annual growth rate in federal government expenditures for national defense.
a_8	One plus annual growth rate in federal government expenditures for non-defense.
a_9	Distributive coefficient of births by sex.
a_{10}	Average immigration rate for Oklahoma.
a_{11}	One plus annual growth rate in transfer payment.
a_{12}	One plus annual growth rate in property income.
a_{13}	One plus annual growth rate in other labor income.
a_{14}	Ratio of social security payments to wage and salary income.
a_{15}	One plus annual growth rate in (a_{14}).
a_{16}	Ratio of total energy final demand by household to total disposable income.
a_{17}	One plus annual growth rate in (a_{16}).
a_{18}	Ratio of petroleum products final demand by household to total energy demand by household.

TABLE XXVI (Continued)

Scalar	Description
a_{19}	Ratio of natural gas final demand by household to total energy demand by household.
a_{20}	Ratio of coal final demand by household to energy demand by household.
a_{21}	Ratio of electricity and hydropower final demand by household to total energy demand by household.
a_{22}	Ratio of total energy final demand by federal government to total federal government expenditures.
a_{23}	One plus annual growth rate in (a_{22}).
a_{24}	Ratio of petroleum products final demand to total energy demand by federal government.
a_{25}	Ratio of natural gas final demand to total energy demand by federal government.
a_{26}	Ratio of coal final demand to total energy demand by federal government.
a_{27}	Ratio of electricity and hydropower final demand to total energy demand by federal government.
a_{28}	Ratio of total energy final demand by state and local government to total personal income.
a_{29}	One plus annual growth rate in (a_{28}).
a_{30}	Ratio of petroleum products final demand to total energy demand by state and local government.
a_{31}	Ratio of natural gas final demand to total energy demand by state and local government.
a_{32}	Ratio of coal final demand to total energy demand by state and local government.
a_{33}	Ratio of electricity and hydropower final demand to total energy demand by state and local government.

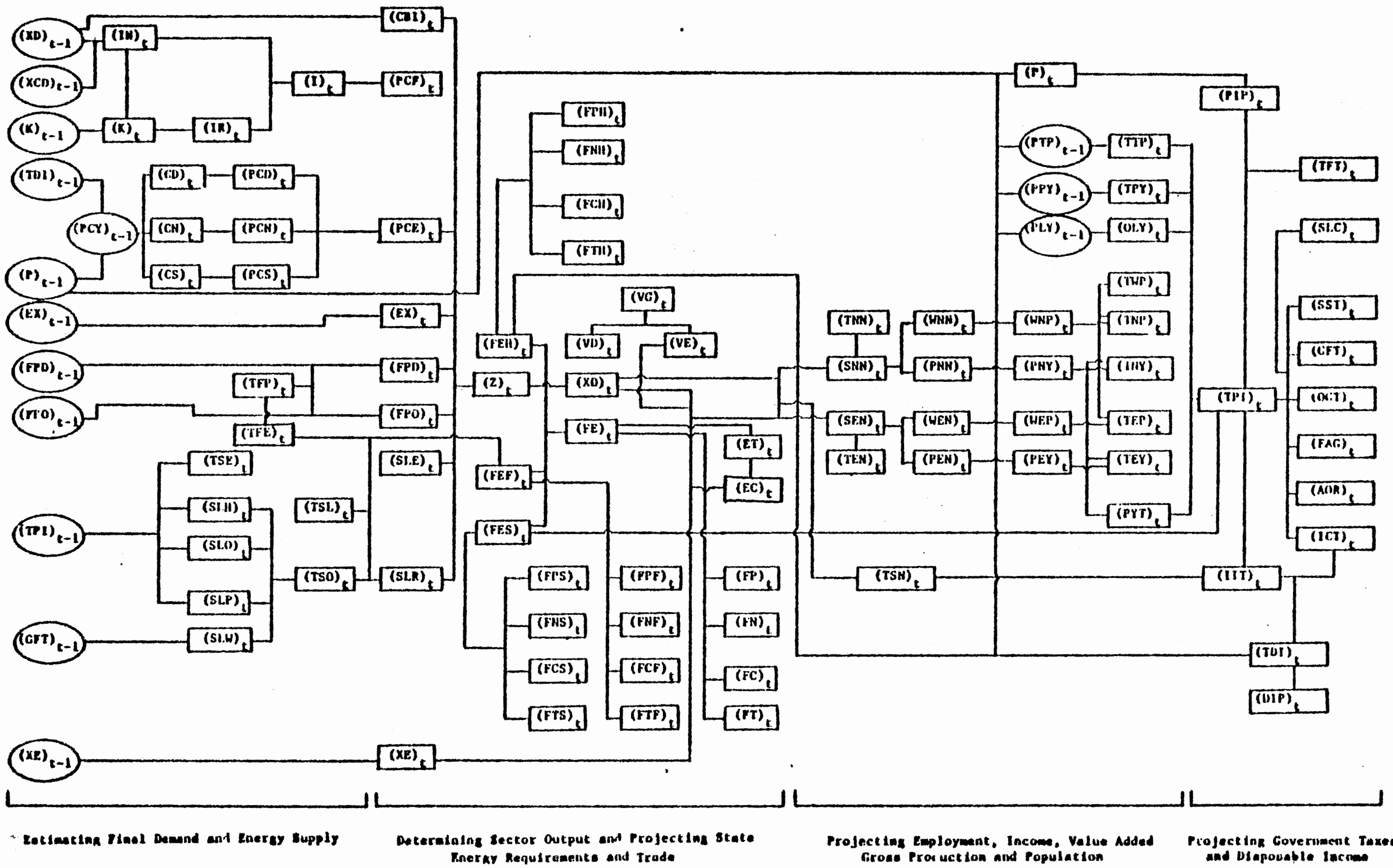

Figure 3. Flow Chart of the Oklahoma Simulation Model

the fact that a change in output over time influences net investment through changes in capital stock. The investment due to changes in output is known as "induced investment" as opposed to "autonomous investment" which is not influenced directly by changes in output. Thus, total investment in a period of time is the summation of (1) replacement or antonomous investment and (2) new plant and equipment or induced investment. Composition of new investment is obtained by multiplying the capital coefficient matrix by the column vector of total investment.

To initiate the system sector capacity output and new plant and equipment for the base year 1972 for both energy and non-energy sectors are computed. Sector capacity output is determined as follows:

$$(XDC)_t = (XDC)_{t-1} + A_{od}\,(IND)_{t-1} \tag{7.1}$$

$$(XEC)_t = (XEC)_{t-1} + A_{oe}\,(INE)_{t-1} \tag{7.2}$$

$$(IN)_{t-1} = \begin{bmatrix} (IND)_{(t-1)} \\ \hdashline (INE)_{t-1} \end{bmatrix}, \quad A_o = \begin{bmatrix} A_{od} \\ \hdashline A_{oe} \end{bmatrix}$$

where,

$(XDC)_t$ and $(XEC)_t$ = Column vector of sector capacity output for non-energy and energy sectors in year t, respectively.

$(XDC)_{t-1}$ and $(XEC)_{t-1}$ = Column vector of sector capacity output for non-energy and energy sectors in year t-1, respectively.

$(IND)_{t-1}$ and $(INE)_{t-1}$ = Column vector $(IN)_{t-1}$ of new plant and equipment for non-energy and energy sectors in year t-1, respectively.

A_{od} and A_{oe} = Diagonal matrix (A_o) of average output-capital ratios for non-energy and energy sectors, respectively.

New plant and equipment, the first component of total investment is estimated by using the acceleration principle. It is estimated by multiplying capital-output ratios, annual change in capital-output ratios, and the difference of sector output in base period 1972 and sector capacity output in time period t multiplied by an upper limit capacity coefficient.

$$(IND)_t = (A_{1d})_t \, [(XD)_{t-1} - a_o(XDC)_t] \qquad (7.3)$$

$$(A_{1d})_t = (A_{1d})t\text{-}1 \cdot A_{2d} \qquad (7.4)$$

and

$$(INE)_t = (A_{1e})_t \, [(XE)_{t-1} - a_o(XEC)_t] \qquad (7.5)$$

$$(A_{1e})_t = (A_{1e})_{t-1} \cdot A_{2e} \qquad (7.6)$$

$$(A_1)_t = \begin{bmatrix} (A_{1d})_t \\ \text{- - - -} \\ (A_{ie})_t \end{bmatrix} \quad , \quad A_2 = \begin{bmatrix} A_{2d} \\ \text{- - - -} \\ A_{2e} \end{bmatrix} \quad , \quad (IN)_t = \begin{bmatrix} (IND)_t \\ \text{- - - -} \\ (INE)_t \end{bmatrix}$$

where

$(IND)_t$ and $(INE)_t$ = column vector $(IN)_t$ of new plant and equipment investment for non-energy and energy sectors in year t, respectively.

a_o = upper limit (90%) to capacity output for capital formation.

$(A_{1d})_t$ and $(A_{1e})_t$ = diagonal matrix of average capital-output ratios $(A_1)_t$ for non-energy and energy sectors in year t, respectively.

A_{2d} and A_{2e} = diagonal matrix of one plus annual change in capital-output ratios (A_2) for non-energy and energy sectors, respectively.

Investment on new plant and capital equipment by each sector is based upon the following conditions for both non-energy and energy sectors:

If $(XD)_{t-1} > a_o (XDC)_t$ and $(XE)_{t-1} > a_o (XEC)_t$, sectors invest on new plant and capital equipment. But, if $(XD)_{t-1} \leq a_o (XDC)_t$ and $(XE)_{t-1} \leq a_o (XEC)_t$, sectors do not invest on new plant and capital equipment.

The diagonal matrix of A_2 reflects the technological change and incorporates this change into future estimates of capital as trends in the capital-output ratios.

Capital stock at the beginning of each period is equal to capital stock at the beginning of the preceding period plus new plant and equipment investment made during the following period.

$$(KD)_t = (KD)_{t-1} + (IND)_t \tag{7.7}$$

and

$$(KE)_t = (KE)_{t-1} + (INE)_t \tag{7.8}$$

$$(K)_{t-1} = \begin{bmatrix} (KD)_{t-1} \\ \hdashline (KE)_{t-1} \end{bmatrix}, \quad (K)_t = \begin{bmatrix} (KD)_t \\ \hdashline (KE)_t \end{bmatrix}$$

where

$(KD)_{t-1}$ and $(KE)_{t-1}$ = column vector of capital stock $(K)_{t-1}$ for non-energy and energy sectors in year t-1, respectively.

$(KD)_t$ and $(KE)_t$ = column vector of capital stock $(K)_t$ for non-energy and energy sectors in year t, respectively.

Replacement investment is the second component of total investment. It is a function of sector capital stocks in base period 1972 times the respective depreciation rates.

$$(IRD)_t = A_{3d}(KD)_{t-1} \tag{7.9}$$

and

$$(IRE)_t = A_{3e}\,(KE)_{t-1} \tag{7.10}$$

$$(IR)_t = \begin{bmatrix} (IRD)_t \\ \hline (IRE)_t \end{bmatrix}, \quad A_3 = \begin{bmatrix} A_{3d} \\ \hline A_{3e} \end{bmatrix}$$

where:

$(IRD)_t$ and $(IRE)_t$ = column vector of replacement investment $(IR)_t$ for non-energy and energy sectors in year t, respectively.

A_{3d} and A_{3e} = diagonal matrix of depreciation rates (A_3) for non-energy and energy sectors, respectively.

Total investment is determined by adding the new plant and equipment and the replacement investment made by the non-energy and energy sectors.

$$(I)_t = (IN)_t + (IR)_t \tag{7.11}$$

where:

$(I)_t$ = column vector of total investment for energy and non-energy sectors in year t.

$(IN)_t$ = column vector of new plant and equipment for non-energy sectors $(IND)_t$ and energy sectors $(INE)_t$ in year t

$(IR)_t$ = column vector of replacement investment for non-energy sectors $(IRD)_t$ and energy sectors $(IRE)_t$ in year t.

The sector composition of new investment is determined by multiplying the capital coefficient matrix by total investment.

$$(PCF)_t = A_4 \, (I)_t \qquad (7.12)$$

where:

$(PCF)_t$ = column vector of sector composition of new investment for both energy and non-energy sectors in year t.

A_4 = capital coefficient matrix

Personal Consumption Expenditures. The model considers durable goods, non-energy non-durable goods, and services in estimating the personal consumption expenditures. Durable goods include such things as lumber and wood products, appliances, electrical and transport equipment, and mining products. Non-durable goods include food, clothing, drugs, household supplies, and other similar items. Service outlays include telephone, cleaning, transportation, recreation, medical care, education, and religious activities. Total purchases of durable goods, non-energy non-durable goods, and services are estimated as a function of per capital disposable income and population.

$$(PCY)_t = (TDI)_t/(P)_t \qquad (7.13)$$

where:

$(TDI)_t$ = total disposable income in year t.

$(PCY)_t$ = per capita disposable income in year t.

(P) = population in year t.

Total durable purchases and distribution by sector are computed as:

$$(CD)_t = (a_1)_t \ (PCY)_{t-1} \ (P)_t \quad (7.14)$$

and

$$(a_1)_t = (a_1)_{t-1} \ a_2 \quad (7.15)$$

$$(PCD)_t = A_5 \ (CD)_t \quad (7.16)$$

where

$(CD)_t$ = total purchases of durable goods in year t.

$(a_1)_t$ = ratio of durable expenditures to disposable income in year t.

a_2 = one plus annual growth rate in (a_1).

$(PCD)_t$ = column vector of purchases of durable goods in year t

A_5 = column vector of sector purchases of durable goods to total purchases of durable goods.

$(P)_t$ = population in year t.

The composition of total and sector purchases of non-energy non-durable goods are computed as follows:

$$(CN)_t = (a_3)_t \ (PCY)_{t-1} \ (P)_t \quad (7.17)$$

$$(a_3)_t = (a_3)_{t-1}\ a_4 \qquad (7.18)$$

and

$$(PCN)_t = A_6\ (CN)_t \qquad (7.19)$$

where:

$(CN)_t$ = total purchases of non-energy non-durable goods in year t.

$(a_3)_t$ = ratio of non-energy non-durable expenditures to disposable income in year t.

a_4 = one plus annual growth rate in (a_3).

$(PCN)_t$ = column vector of purchases of non-energy non-durable goods in year t

A_6 = column vector of sector purchases of non-energy non-durable goods to total expenditures of non-energy non-durable goods.

The composition of total and sector purchases of services are estimated as follows:

$$(CS)_t = (a_5)_t\ (PCY)_{t-1}\ (P)_t \qquad (7.20)$$

$$(a_5)_t = (a_5)_{t-1}\ a_6 \qquad (7.21)$$

and

$$(PCS)_t = A_7\ (CS)_t \qquad (7.22)$$

where:

$(CS)_t$ = total purchases of services in year t.

$(a_5)_t$ = ratio of service expenditures to disposable income in year t

(a_6) = one plus annual growth rate in (a_5).

$(PCS)_t$ = column vector of purchases of services in year t.

A_7 = column vector of sector purchases of services to total expenditures for services.

Total personal consumption expenditures is the sum of sector purchases of durable goods, non-energy non-durable goods and services.

$$(PCE)_t = (PCD)_t + (PCN)_t + (PCS)_t \quad (7.23)$$

where:

$(PCE)_t$ = column vector of total personal consumption expenditures in year t.

Non-energy Export Demand. State export demand is influenced mainly by the United States' demand. Therefore, it is assumed that Oklahoma's non-energy exports are a given share of U.S. demand and estimated from growth in the U.S. economy. Demand for services are determined by state economic activity and not related to the United States' demand. State exports of services are assumed to be zero.

Total export demand for both durables and non-energy non-durables at the beginning of each period are a function of export demand in the previous period and growth in U. S. demand.

$$(EX)_t = A_8 \ (EX)_{t-1} \qquad (7.24)$$

where:

$(EX)_t$ = column vector of export demand for durables and non-energy non-durables in year t.

A_8 = diagonal matrix of one plus annual growth rate of durable and non-energy non-durable exports.

Business Inventories. Sector inventory changes are estimated as a function of sector output lagged one year.

$$(CBI)_t = A_8 \ (XD)_{t-1} \qquad (7.25)$$

where:

A_9 = diagonal matrix of sector inventory to sector output lagged one year.

$(CBI)_t$= column vector of sector inventory in year t.

Federal Government Purchases. Federal government purchases are divided into two categories: (1) purchases for national defense which includes Department of Defense (DOD), Atomic Energy Commission (AEC), and defense related; and (2) purchases for non-defense which includes National Aeronautics and Space Administration (NASA), Environment Protection Activities, Economic and Financial Assistance, and all other non-defense federal purchases. Both categories are estimated as a function of the previous year's purchases. The column vector of each category in year t-1 is multiplied by one plus the growth rate in expenditures.

$$(FPD)_t = a_7\ (FPD)_{t-1} \tag{7.26}$$

$$(FPO)_t = a_8\ (FPO)_{t-1} \tag{7.27}$$

$$(TFP)_t = (FPD)_t + (FPO)_t \tag{7.28}$$

where:

$(FPD)_t$ = column vector of federal government purchases for national defense in year t.

$(FPO)_t$ = column vector of federal government purchases for non-defense in year t.

$(TFP)_t$ = column vector of total federal government purchases in year t.

(a_7 = one plus annual growth rate in federal government expenditures for national defense.

a_8 = one plus annual growth rate in federal government expenditures for non-defense.

State and Local Government Purchases. State and local government purchases are divided into two categories: (1) state and local government purchases on education, and (2) state and local government purchases on "other" which includes highways, public welfare, and health and hospitals. Following a previous study, purchases are estimated as functions of total state personal income and gasoline taxes [1]. For each of these estimates, the lagged value of the independent variable is used. It is implicitly assumed that changes in independent variables show their effect on dependent variables during the following year. Total personal income is the independent variable most frequently used for state and local government expenditure estimates. Highway expenditures are projected as a function of gasoline tax collections of the preceding year [8]. Ordinary least square regression was used to estimate state and local government expenditures in the following five equations (the t statistic, R^2 and Durbin-Watson statistics below in the following equations):

$$(TSE)_t = 30028.02376 + 0.064390\ (TPI)_{t-1} \qquad (7.29)$$
$$t = 15.24,\ R^2 = 0.9831,\ d = 2.0532$$

$$(SLW)_t = -123185.76749 + 3.885700\ (GFT)_{t-1} \qquad (7.30)$$
$$t = 4.61,\ R^2 = 0.7524,\ d = 1.2915$$

$$(SLP)_t = 23211.32637 + 0.027368\ (TPI)_{t-1} \qquad (7.31)$$
$$t = 7.10,\ R^2 = 0.9264,\ d = 1.6938$$

$$(SLH)_t = -33078.00000 + 0.015880\ (TPI)_{t-1} \qquad (7.32)$$
$$t = 9.20,\ R^2 = 0.8943,\ d = 1.0470$$

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[1] For estimating equations (7-29) through (7-33) it is assumed that the dependent variables do not influence the independent variables.

$$(SLO)_t = -10669.00000 + 0.054890\ (TPI)_{t-1} \quad (7.33)$$

$$t = 8.53,\ R^2 = 0.8793,\ d = 1.3530$$

where:

$(TSE)_t$ = state and local government expenditures on education in Oklahoma in year t.

$(TPI)_{t-1}$ = total personal income in Oklahoma in year t-1.

$(SLW)_t$ = state and local government expenditures on highways in Oklahoma in year t.

$(GFT)_{t-1}$ = gasoline and fuels excise and special fuels use tax in Oklahoma in year t-1.

$(SLP)_t$ = state and local government expenditures on public welfare in year t.

$(SLH)_t$ = state and local government expenditures on health and hospitals in Oklahoma in year t.

$(SLO)_t$ = other state and local government expenditures in Oklahoma in year t.

The two categories of state and local government purchases are education, $(TSE)_t$ and "other" $(TSO)_t$. The latter category is the sum of the following:

$$(TSO)_t = (SLW)_t + (SLP)_t + (SLH)_t + (SLO)_t. \quad (7.34)$$

where:

$(TSO)_t$ = total state and local government expenditures other than education in year t.

Sector proportions of total state and local government purchases in Oklahoma are estimated as the following:

$$(SLE)_t = A_{10}\ (TSE)_t \tag{7.35}$$

$$(SLR)_t = A_{11}\ (TSO)_t \tag{7.36}$$

$$(TSL)_t = (SLE)_t + (SLR)_t \tag{7.37}$$

where:

$(TSL)_t$ = column vector of total state and local government purchases in Oklahoma in year t.

$(SLE)_t$ = column vector of state and local government expenditures on education in Oklahoma in year t.

$(SLR)_t$ = column vector of state and local government expenditures in the remaining items beside education in year t.

A_{10} = column vector of total state and local government purchases by sector for education to total education expenditures.

A_{11} = column vector of total state and local government purchases by sector for other services to total expenditures for other services.

Total Final Demand. Total final demand is the sum of final demands for private capital formation (PCF), personal consumption expenditures (PCE), non-energy net exports (EX), business inventories (CBI), federal government purchases (TFP), and state and local government purchases (TSL). After estimating each individual final demand and summing the individual final demands, total final demand for year t is as follows:

$$(Z)_t = (PCF)_t + (PCE)_t + (EX)_t + (CBI)_t + (TFP)_t + (TSL)_t \qquad (7.38)$$

where:

$(Z)_t$ = column vector of total final demand in Oklahoma in year t.

Determining Sector Output

Sector output estimates are used for determining state energy requirements and net energy trade. Projections on employment, income, government revenues and population are directly or indirectly estimated from sector outputs. Sector outputs are estimated for the supply determining energy sectors and the demand determined non-energy sectors.

Supply Determined Energy Sectors. Annual projections of energy production to the year 2000 are estimated independently of the simulation model. The energy production estimates measured in BTU are fed into the model as exogenous data. One assumption to be tested with the simulation model is the impact of energy produced based on historical trends. The following relationship expresses this assumption:

$$(XE)_t = A_{12} (XE)_{t-1} \qquad (7.39)$$

where:

$(XE)_t$ = column vector of output of energy supply determined sectors in year t.

$(XE)_{t-1}$ = column vector of output of energy supply determined sectors in year t-1.

A_{12} = diagonal matrix of one plus annual growth rate in energy production.

Other energy choices will be evaluated as discussed in the following chapter.

Demand Determined Non-Energy Sectors. In Chapter III the standard solution of the disposition of output in the input-output framework was $X = (I-A)^{-1} Y$. In this analysis of the Oklahoma economy the processing sectors have been separated into two groups, the demand determined non-energy sectors and the supply determined energy sectors. To identify the structure of this system, the disposition of output equation is partitioned into submatrices representing the demand determined non-energy sectors and the supply determined energy sectors.

Using the subscript "1" for output of the non-energy sectors and the subscript "2" for output of the energy sectors, the matrix equations for the disposition of output can be written as follows:

$$\begin{bmatrix} X_1 \\ \hline X_2 \end{bmatrix} = \left[\begin{array}{c|c} A_{11} & A_{12} \\ \hline A_{21} & A_{22} \end{array}\right] \cdot \begin{bmatrix} X_1 \\ \hline X_2 \end{bmatrix} + \begin{bmatrix} D_1 + T_1 \\ \hline D_2 + T_2 \end{bmatrix}$$

where A_{ij}'s are the partitions of the direct coefficients matrix, X's are the sector outputs, D's are final demands without trade, and T's are net trade. The matrix equation can be rewritten as two equations, the first representing the disposition of output for the demand determined non-energy sectors measured in dollars, the second representing the disposition of output for the supply determined energy sectors in BTU:

$$X_1 = A_{11} X_1 + A_{12} X_2 + D_1 + T_1$$

$$X_2 = A_{21} X_1 + A_{22} X_2 + D_2 + T_2$$

The output of the supply determined energy sectors, X_2, is exogenous. It has been predetermined and is not affected by the level of output of the demand determined non-energy sectors, X_1. The two equations are solved independently on the basis of final demands $(D_1 + T_1)$ and D_2 and the predetermined energy sector output X_2. Solution of net energy trade for Oklahoma, T_2 is discussed in a following section. Given X_2 as exogenous data, A_{11} and A_{12} as parameters of the model from the direct coefficient matrix, and $(D_1 + T_1)$ as the final demand for the demand determined sectors, the solution for X_1 can be derived from the equation for the disposition of X_1. Rewriting the equation:

$$X_1 = (I-A_{11})^{-1} A_{12}X_2 + (I-A_{11})^{-1} (D_1 + T_1)$$

This differs from the "standard input-output solution." Final demand for the demand determined non-energy sectors is "adjusted" to include the direct requirements of the supply determined energy sectors. The equation is presented in the simulation model as follows:

$$(XD)_t = A_{13}\, A_{14}\, (XE)_t + A_{13}\, (Z)_t \qquad (7.40)$$

where:

$(XD)_t$ = column vector of output (X_1) for the non-energy secotrs in year t.

$(XE)_t$ = column vector of output (X_2) for the energy sectors in year t.

A_{13} = direct and indirect coefficient matrix $(I-A_{11})^{-1}$ of the non-energy sectors.

A_{14} = direct requirements (A_{12}) of output from the non-energy sectors per unit of output of the energy sectors.

$(Z)_t$ = column vector of total final demand ($D_1 + T_1$) of the non-energy sectors in year t.

After estimating sector output, the simulation model projects variables such as employment (wage and salary, and proprietor), income (wage and salary, proprietor, property, other labor, and transfer payments), value added, federal government revenues, state and local government revenues, personal income, per capita personal income, disposable income and per capita disposable income. Equations (7.47) through (7.92) represent the relationships used to project these economic variables. Population is projected as a separate component and included in the simulation model. Equations (7.41) to (7.46) are used to project Oklahoma total population.

Projecting State Economic Variables

Population. There are alternative ways of including population in a simulation model. However, it is incorporated into the Oklahoma simulation model as a separate component. The absolute size of total Oklahoma population is utilized to determine future personal consumption expenditures and state and local government purchases. A traditional population projection model as found in Hamilton, et al. [27] is used. Oklahoma data consistent with the model are not available so national population coefficients are used. The main variables used in projecting population are: death rates, birth rates, trend in death rates, migration rates, and population at the base period, 1972. A cohort approach is utilized. The population cohorts in years are: less than 15, 16-19, 20-29, 30-39, 40-44, 50-59, 60-64, 65-69, 70-79, and greater than 80 years of age, for both sexes, hence 22 cohorts in all. The total population is projected as follows:

$$(TP)_t = \sum_{j=1}^{2} \sum_{i=1}^{11} (P_{ij})_t \tag{7.41}$$

where:

$(TP)_t$ = Total Oklahoma population in year t.

$(P_{ij})_t$ = column vector of population in year t in cohort i for sex j.

$$(P_{ij})_t = (P_{ij})_{t-1} + (AP_{i-1j})_{t-1} + (M_{ij})_{t-1} - (AP_{ij})_{t-1} - (D_{ij})_{t-1} \tag{7.42}$$

where:

$(P_{ij})_{t-1}$ = column vector of initial population in cohort i of sex j.

$(AP_{ij})_t$ = column vector of advancement from cohort i to cohort i + 1 between year t and year t + 1.

Birth is estimated as:

$$(B_j)_t = \sum_{i=1}^{11} (BR_i)\,(P_{ij})_t \tag{7.43}$$

and $(AP_{ij})_t = (B_j)_t/a_9$ (7,44)

where:

$(B_j)_t$ = column vector of births of sex j in year t.

(BR_i) = diagonal matrix of birth rates for women in cohort i.

a_9 = distributive coefficient of births by sex.

Deaths $(D_{ij})_t$ by members of cohort i of sex j are projected as:

$$(D_{ij})_t = (DR_{ij})_{t-1} \, (T_{ij}) \, (P_{ij})_t \tag{7.45}$$

where:

$(DR_{ij})_{t-1}$ = diagonal matrix of death rates for cohort i of sex j in year t-1.

(T_{ij}) = diagonal matrix of trends in death rate for cohort i of sex j.

Net immigration is estimated as follows:

$$(M_{ij})_t = a_{10}(P_{ij})_t(MR_{ij}). \tag{7.46}$$

where:

(MR_{ij}) = diagonal matrix of migration rates for cohort i of sex j.

a_{10} = average immigration rate for Oklahoma.

The population coefficients used in projecting total Oklahoma population are available in Table XLVI of Appendix C.

Employment. State employment consists of two components: (1) wage and salary, and (2) proprietor. Total sector employment projections are the result of three data sources: (1) sector output, (2) labor-output coefficients, and (3) annual rate of change in labor-output coefficients.

Total sector employment includes all entries of the column vectors of sector wage and salary employment, and sector proprietor employment.

$$(SNN)_t = (A_{15})_t \, (XD)_t \tag{7.47}$$

$$(A_{15})_t = (A_{15})_{t-1} \, A_{16} \tag{7.48}$$

$$(SEN)_t = (A_{17})_t \, (XE)_t \tag{7.49}$$

$$(A_{17})_t = (A_{17})_{t-1} \, A_{18} \tag{7.50}$$

$$(TNN)_t = \sum_i (SNN)_t \tag{7.51}$$

$$(TEN)_t = \sum_i (SEN)_t \tag{7.52}$$

$$(TSN)_t = (TNN)_t + (TEN)_t \tag{7.53}$$

where:

$(SNN)_t$ and $(SEN)_t$ = column vectors of total employment for non-energy and energy sectors in year t, respectively.

$(TNN)_t$ and $(TEN)_t$ = sum total of sector employment for non-energy and energy sectors in year t, respectively.

$(TSN)_t$ = sum total of all sector employment in year t.

$(A_{15})_t$ and $(A_{17})_t$ = diagonal matrices of labor-output coefficients for non-energy and energy sectors in year t, respectively.

A_{16} and A_{18} = diagonal matrices of one plus annual growth rate in (A_{15}) and (A_{17}), respectively.

Sector wage and salary employment is projected as follows:

$$(WNN)_t = (A_{19})_t \, (SNN)_t \tag{7.54}$$

$$(A_{19})_t = (A_{19})_{t-1} \, A_{20} \tag{7.55}$$

$$(WEN)_t = (A_{21})_t \, (SEN)_t \tag{7.56}$$

$$(A_{21})_t = (A_{21})_{t-1} \, A_{22} \tag{7.57}$$

where:

$(WNN)_t$ and $(WEN)_t$ = column vectors of wage and salary employment for non-energy and energy sectors in year t, respectively.

$(A_{19})_t$ and $(A_{21})_t$ = diagonal matrices of wage and salary employment to total employment for the non-energy and energy sectors in year t, respectively.

A_{20} and A_{22} = diagonal matrices of one plus the annual growth rate of the corresponding elements of (A_{19}) and (A_{21}), respectively.

Proprietor employment is the difference between total sector employment and wage and salary sector employment.

$$(PNN)_t = (SNN)_t - (WNN)_t \tag{7.58}$$

$$(PEN)_t = (SEN)_t - (WEN)_t \tag{7.59}$$

where:

$(PNN)_t$ and $(PEN)_t$ = column vectors of proprietor employment for non-energy and energy sectors in year t, respectively.

Income. In this section, wage and salary payments and proprietor income are projected by sector. Total value of all government wages and salaries, transfer payments, property income, and other labor income are also estimated. Using these estimates, total personal income and personal income per capita are computed.

Sector wage and salary payments are estimated as a function of wage and salary employment.

$$(WNP)_t = (A_{23})_t \ (WNN)_t \tag{7.60}$$

$$(A_{23})_t = (A_{23})_{t-1} \ A_{24} \tag{7.61}$$

$$(WEP)_t = (A_{25})_t \ (WEN)_t \tag{7.62}$$

$$(A_{25})_t = (A_{25})_{t-1} \cdot A_{26} \tag{7.63}$$

$$(TNP)_t = \sum_i (WNP)_t \tag{7.64}$$

$$(TEP)_t = \sum_i (WEP)_t \tag{7.65}$$

$$(TWP)_t = (TNP)_t + (TEP)_t \tag{7.66}$$

where:

$(WNP)_t$ and $(WEP)_t$ = column vectors of wage and salary payments for non-energy and energy sectors in year t, respectively.

$(TNP)_t$ and $(TEP)_t$ = sum total of wage and salary payments for non-energy and energy sectors in year t, respectively.

$(TWP)_t$ = sum total of all wage and salary payments in year t.

$(A_{23})_t$ and $(A_{25})_t$ = diagonal matrices of wage and salary income rates for non-energy adn energy sectors in year t, respectively.

A_{24} and A_{26} = diagonal matrices of one plus annual growth rates of (A_{23}) and (A_{25}), respectively.

Similarly, proprietor income by sector is estimated as a function of proprietor employment.

$$(PNY)_t = (A_{27})_t \ (PNN)_t \qquad (7.67)$$

$$(A_{27})_t = (A_{27})_{t-1} \ A_{28} \qquad (7.68)$$

$$(PEY)_t = (A_{29})_t \ (PEN)_t \qquad (7.69)$$

$$(A_{29})_t = (A_{29})_{t-1} \ A_{30} \qquad (7.70)$$

$$(TNY)_t = \sum_i (PNY)_t \qquad (7.71)$$

$$(TEY)_t = \sum_i (PEY)_t \qquad (7.72)$$

$$(PYT)_t = (TNY)_t + (TEY)_t \qquad (7.73)$$

where:

$(PNY)_t$ and $(PEY)_t$ = column vectors of proprietor income for non-energy and energy sectors in year t, respectively.

$(TNY)_t$ and $(TEY)_t$ = sum total of proprietor income for non-energy and energy sectors in year t, respectively.

$(PYT)_t$ = sum total of non-energy and energy sectors proprietor income in year t.

$(A_{27})_t$ and $(A_{29})_t$ = diagonal matrices of proprietor income rates for non-energy and energy sectors in year t, respectively.

A_{28} and a_{30} = diagonal matrices of one plus annual growth rates of (A_{27}) and (A_{29}), respectively.

Transfer payments, property income, and other labor income are all projected as a function of population and the previous year's per capita level adjusted for growth. These computations are given in the following equations:

$$(TTP)_t = a_{11}\ (PTP)_{t-1}\ (P)_t \tag{7.74}$$

$$(TPY)_t = a_{12}\ (PPY)_{t-1}\ (P)_t \tag{7.75}$$

$$(OLY)_t = a_{13}\ (PLY)_{t-1}\ (P)_t \tag{7.76}$$

where:

$(TTP)_t$ = total transfer payments in Oklahoma in year t.

$(PTP)_{t-1}$ = per capita transfer payment in year t-1.

$(TPY)_t$ = total property income in Oklahoma in year t.

$(PPY)_{t-1}$ = per capita property income in year t-1.

$(OLY)_t$ = total other labor income in Oklahoma in year t.

$(PLY)_{t-1}$ = per capita other labor income in year t-1.

a_{11} = one plus annual growth rate in transfer payments.

a_{12} = one plus annual growth rate in property income.

a_{13} = one plus annual growth rate in other labor income.

Total personal income in Oklahoma can be computed by summing individual components and subtracting social security payments from overall total.

$$(TPI)_t = (TWP)_t + (PYT)_t + (TTP)_t + (TPY)_t + (OLY)_t - a_{14}\, a_{15}\, (TWP)_t \qquad (7.77)$$

where:

$(TPI)_t$ = total personal income in Oklahoma in year t.

a_{14} = ratio of social security payments to wage and salary income.

a_{15} = one plus annual rate of growth in (a_{14}).

Personal income per capita is estimated by dividing total personal income by population in year t.

$$(PIP)_t = (TPI)_t/(P)_t \qquad (7.78)$$

where:

$(PIP)_t$ = personal income per capita in Oklahoma in year t.

Value Added and Gross State Product. Value added by sector is estimated as follows:

$$(VD)_t = A_{31}\ (XD)_t \qquad (7.79)$$

$$(VE)_t = A_{32}\ (XE)_t \qquad (7.80)$$

where:

$(VD)_t$ and $(VE)_t$ = value added for non-energy and energy sectors in Oklahoma in year t, respectively.

A_{31} and A_{32} = diagonal matrices of the ratio of value added to sector output for non-energy sectors, respectively.

Gross state product $(XG)_t$ is the sum of sector value added:

$$(XG)_t = \sum_i (VD)_t + \sum_i (VE)_t \qquad (7.81)$$

Federal Government Revenue. Federal government revenues consist of federal government tax collections in Oklahoma. These revenues are estimated in a simple regression equation as a function of total personal income:

$$(TFT)_t = -174145.55657 + 0.22382\ (TPI)_t \qquad (7.82)$$

$$t = 11.34,\ R^2 = 0.9698,\ d = 1.0373$$

where:

$(TFT)_t$ = federal government tax collections in Oklahoma in year t.

Individual personal income tax which is included in total federal government tax revenue is estimated separately so that estimation of personal disposable income is possible. Individual personal income tax is projected in a simple regression analysis whose independent variables is total federal government tax revenue.

$$(IIT)_t = 87985.54320 + 0.620040\ (TFT)_t \qquad (7.83)$$

$$t = 16.41\ R^2 = 0.9854,\ d = 2.0928$$

where:

$(ITT)_t$ = federal government individual income tax collections in year t.

State and Local Government Revenues. State and local government revenue has six components: (1) state sales tax; (2) gasoline and fuels excise and special fuels use tax; (3) state collections of individual and corporation income tax; (4) other state and local government taxes; (5) federal aid to state and local governments; and (6) all other revenues of state and local governments. Census data were used in a regression analysis to estimate the recursive system of total personal income determining values of each component. The estimations are as follows:

$$(SST)_t = 2314.53069 + 0.01065\ (TPI)_t \qquad (7.84)$$

$$t = 18.30,\ R^2 = 0.9904,\ d = 1.7275$$

$$(GFT)_t = 42094.39470 + 0.00540\ (TPI)_t \qquad (7.85)$$

$$t = 7.40,\ R^2 = 0.9012,\ d = 1.9854$$

$$(ICT)_t = -239860.95177 + 0.03714\ (TPI)_t \qquad (7.86)$$

$$t = 23.90,\ R^2 = o.9896,\ d = 1.6968$$

$$(OGT)_t = -12.66022 + 0.02775\ (TPI)_t \qquad (7.87)$$

$$t = 21.97,\ R^2 = 0.9877,\ d = 1.8482$$

$$(FAG)_t = 25985.85190 + 0.04648\ (TPI)_t \qquad (7.88)$$

$$t = 20.53,\ R^2 = 0.9906,\ d = 1.8613$$

$$(AOR)_t = -24.00523 + 0.03930\ (TPI)_t \quad (7.89)$$

$$t = 25.46,\ R^2 = 0.9982,\ d = 1.7610$$

where:

$(SST)_t$ = total value of state sales tax collections in Oklahoma in year t.

$(GFT)_t$ = gasoline and fuels excise and special fuels use tax collections in Oklahoma in year t.

$(ICT)_t$ = individual and corporation income tax withheld by the state in Oklahoma in year t.

(OGT) = all other taxes collected by state and local government in Oklahoma in year t.

$(FAG)_t$ = federal aid to state and local government in Oklahoma in year t.

$(AOR)_t$ = other revenues to state and local government in Oklahoma in year t.

Total state and local government revenues projected are obtained by adding the six components.

$$(SLC)_t = (SST)_t + (GFT)_t + (ICT)_t + (OGT)_t + (FAG)_t + (AOR)_t \quad (7.90)$$

where:

$(SLC)_t$ = total state and local government revenue collections in Oklahoma in year t.

Disposable Income. Disposable income is obtained by subtracting federal individual income tax $(IIT)_t$ and state and local individual income tax collections $(ICT)_t$ from total personal income $(TPI)_t$ as follows:

$$(TDI)_t = (TPI)_t - (IIT)_t - (ICT)_t \qquad (7.91)$$

where:

$(TDI)_t$ = total disposable income in Oklahoma in year t.

Disposable income per capita is estimated by dividing disposable income $(TDI)_t$ by Oklahoma population $(P)_t$.

$$(DIP)_t = (TDI)_t/(P)_t \qquad (7.92)$$

where:

$(DIP)_t$ = disposable income per capita in Oklahoma in year t.

Projecting State Energy Requirements and Trade

State Energy Trade. State energy trade by source is the residual between estimated state energy requirements and state energy supply. Assuming a linear relationship between energy use and output level, the traditional input-output model can be used to project sector energy requirements [36]. The assumption of this projection is that technological efficiency in energy use and the distribution of energy by source is constant for the projected period. Alternative assumptions are tested in this study and presented in the following chapters.

As discussed in section three of this chapter, the disposition of output of the supply determined energy sectors was $X_2 = A_{21} X_1 + A_{22} X_1 + D_2 + T_2$. The state net energy trade is derived from this equation as:

$$T_2 = (I-A_{22})\ X_2 - A_{21}\ X_1 - D_2$$

This equation is presented in the simulation model as follows:

$$(ET)_t = [I-A_{33}] - (XE)_t - A_{34}\ (XD)_t - (FE)_t \qquad (7.93)$$

where:

$(ET)_t$ = column vector of state net energy trade (T_2) by source in year t.

$(FE)_t$ = column vector of final energy demand (D_2) by source in year t.

I = identify matrix.

A_{33} = direct energy requirements by source (A_{22}) per unit of output of the energy sectors.

A_{34} = direct energy requirements by source (A_{21}) per unit of output of the non-energy sectors.

Final demand sectors consuming energy consist of three categories--household, federal government, and state and local government. Total final energy requirements are estimated as follows:

$$(FET)_t = (FEH)_t + (FEF)_t + (FES)_t \qquad (7.94)$$

where:

$(FET)_t$ = total sum of final energy demand in year t

$(FEH)_t$ = total final energy demand by household in year t.

$(FEF)_t$ = total final energy demand by federal government in year t.

$(FES)_t$ = total final energy demand by state and local government in year t.

Household Energy Demand. Total energy demand (FEH) by household is estimated as a function of total disposable income (TDI).

$$(FEH)_t = (a_{16})_t \, (TDI)_t \qquad (7.95)$$

$$(a_{16})_t = (a_{16})_{t-1} \, a_{17} \qquad (7.96)$$

where:

$(a_{16})_t$ = ratio of total energy demand $(FEH)_t$ by household to total disposable income $(TDI)_t$ in year t.

(a_{17}) = one plus annual grotwh rate in a_{16}.

To estimate the demand for each energy source by household the ratio of energy source to total energy demand by household is used.

$$(FPH)_t = a_{18}(FEH)_t \qquad (7.97)$$

$$(FNH)_t = a_{19}(FEH)_t \qquad (7.98)$$

$$(FCH)_t = a_{20}(FEH)_t \qquad (7.99)$$

$$(FTH)_t = a_{21}(FEH)_t \qquad (7.100)$$

$(FPH)_t$ = petroleum products demand by household in year t.

a_{18} = ratio of petroleum products demand to total energy demand by household.

$(FNH)_t$ = natural gas demand by household in year t.

a_{19} = ratio of natural gas demand to total energy demand by household.

$(FCH)_t$ = coal demand by household in year t.

a_{20} = ratio of coal demand to total energy demand by household.

$(FTH)_t$ = electricity and hydropower demand by household in year t.

a_{21} = ratio of electricity and hydropower demand to total energy demand by household.

Federal Government Energy Demand. Total energy demand $(FEF)_t$ by federal government is estimated as a function of state federal government purchases $(TFP)_t$.

$$(TFE)_t = I' \ (TFP)_t \tag{7.101}$$

$$(FEF)_t = (a_{22})_t \ (TFE)_t \tag{7.102}$$

and

$$(a_{22})_t = (a_{22})_{t-1} \ a_{23} \tag{7.103}$$

where:

$(TFE)_t$ = total federal government purchases for energy and non-energy sectors in year t.

I' = row vector of 1's.

$(a_{22})_t$ = ratio of total energy demand by federal government to total federal government purchases in year t.

a_{23} = one plus annual growth rate of a_{22}.

Each energy source is computed as a share of total energy demand by the federal government:

$$(FPF)_t = a_{24} (FEF)_t \qquad (7.104)$$

$$(FNF)_t = a_{25} (FEF)_t \qquad (7.105)$$

$$(FCF)_t = a_{26} (FEF)_t \qquad (7.106)$$

$$(FTF)_t = a_{27} (FEF)_t \qquad (7.107)$$

where:

$(FPF)_t$ = petroleum products demand by federal government in year t.

a_{24} = ratio of petroleum products demand to total energy demand by federal government.

$(FNF)_t$ = natural gas demand by federal government in year t.

a_{25} = ratio of natural gas demand to total energy demand by federal government.

$(FCF)_t$ = coal demand by federal government in year t.

a_{26} = ratio of coal demand to total energy demand by federal government.

$(FTF)_t$ = electricity and hydropower demand by federal government in year t.

a_{27} = ratio of electricity and hydropower demand to total energy demand by federal government.

State and Local Government Energy Demand. Total final energy demand by state and local government is estimated as a function of total personal income (TPI).

$$(FES)_t = (a_{28})_t \, a_{29}(TPI)_t \tag{7.108}$$

and

$$(a_{28})_t = (a_{28})_{t-1} \, a_{29} \tag{7.109}$$

a_{28} = ratio of total energy demand by state and local government to total personal income.

a_{29} = one plus annual growth rate in a_{28}.

The share of each energy source to total energy demand by state and local government is computed as follows:

$$(FPS)_t = a_{30} \, (FES)_t \tag{7.110}$$

$$(FNS)_t = a_{31} \, (FES)_t \tag{7.111}$$

$$(FCS)_t = a_{32} \, (FES)_t \tag{7.112}$$

$$(FTS)_t = a_{33} \, (FES)_t \tag{7.113}$$

where:

$(FPS)_t$ = petroleum products demand by state and local government in year t.

a_{30} = ratio of petroleum products demand to total energy demand by state and local government.

$(FNS)_t$ = natural gas demand by state and local government in year t.

a_{31} = ratio of natural gas demand to total energy demand by state and local government.

$(FCS)_t$ = coal demand by state and local government in year t.

a_{32} = ratio of coal demand to total energy demand by state and local government.

$(FTS)_t$ = electricity and hydropower demand by state and local government in year t.

a_{33} = ratio of electricity and hydropower demand to total energy demand by state and local government.

The column vector of total final energy demand by energy source $(FE)_t$ is composed of the final demand for energy from petroleum products $(FP)_t$, natural gas $(FN)_t$, coal $(FC)_t$ and electricity and hydropower $(FT)_t$. Total demand of each energy source is determined as follows:

$$(FP)_t = (FPH)_t + (FPF)_t + (FPS)_t \qquad (7.114)$$

$$(FN)_t = (FNH)_t + (FNF)_t + (FNS)_t \qquad (7.115)$$

$$(FC)_t = (FCH)_t + (FCF)_t + (FCS)_t \qquad (7.116)$$

$$(FT)_t = (FTH)_t + (FTF)_t + (FTS)_t \qquad (7.117)$$

The final energy demand by energy source $(FE)_t$ is then a column vector composed of the following:

$$(FE)_t = (FP)_t + (FN)_t + (FC)_t + (FT)_t \qquad (7.118)$$

$$(FE)_t = \begin{bmatrix} (FP)_t \\ (FN)_t \\ (FC)_t \\ (FT)_t \end{bmatrix}$$

State Energy Consumption. State energy consumption by energy source is the difference between state energy production $(XE)_t$ and state energy trade $(ET)_t$ by energy source.

$$(EC)_t = (XE)_t - (ET)_t \qquad (7.119)$$

where:

$(EC)_t$ = column vector of total state energy consumption by energy source in year t.

CHAPTER VIII

BASELINE PROJECTIONS OF THE OKLAHOMA SIMULATION MODEL

The Oklahoma simulation model presented in Chapter VII is used to simulate baseline values for state economic variables by year from 1972 to 2000. Data for the 1972 base year Oklahoma social accounts were contained in Chapters III to VI. Data needed for projecting the Oklahoma social accounts are presented and discussed in the following section of this chapter.

Employment, income, government revenue and expenditure, disposable income, gross state product, and energy production, consumption and trade are projected to year 2000. The level of the projection is not as important as the long term trend. Alternative projections assuming different growth rates for parameters of the model are important for purposes of analyzing changes in the structure of the Oklahoma economy. The impact of alternative strategies for energy use and development are analyzed in Chapter IX by comparing those results with the baseline projections of this chapter.

Data Sources for the Baseline Projection Parameters

The Oklahoma simulation model requires a number of parameter ratios and growth rates as detailed in Tables XXV and XXVI of

Chapter VII. Values assigned to these parameters are presented in Table XLV of Appendix B. Importance of these parameters cannot be minimized because they provide much of the driving force for the model. Improvements in the estimation of these parameters should lead to overall improvement of the simulation model.

Ratios used in the model are generally point estimates derived from 1972 base year data. Much of the data used in estimating these ratios are contained and described in the various social accounts presented in Chapters III to VI.

Rates of growth as used in the model are derived from other studies or estimated using time series data and a logarithmic exponential function. The estimating function used is the following:

$$y_t = b_o \; e^{gt}$$

where

Y_t = value of the variable as measured through time

e = natural logarithm

t = time

b_o and g = parameters

The rate of growth of y is equal to:

$$\frac{d\,y}{d\,t}\;\frac{1}{y} = g\;b_{\upsilon}\;e^{gt}\;\frac{1}{y} = g$$

The parameter g is estimated using ordinary least squares regression.

The growth rate in capital-output ratios (A_2) are estimated using national data between 1963 and 1975 obtained from the U. S. Bureau of Labor Statistics [101]. Growth rates of exports (A_8) for non-energy sectors are estimated using national sector outputs from 1967 to 1972 as reported in [80]. This assumes Oklahoma's share of national output remains constant over time. Growth rates of energy production (A_{12}) by energy sector are calculated using state data between 1970 and 1976 obtained from the U.S. Bureau of Mines [110] and the Edison Electric Institute [15] issues from 1971 to 1976. Growth rates of employment-output ratios (A_{16} and A_{18}) and growth rates of wage and salary employment to total employment ratios (A_{20} and A_{22}) for both non-energy and energy sectors are estimated from time series data between 1963 and 1975 and contained in the U.S. Bureau of Labor Statistics [104]. Growth rates of wage and salary payments (A_{24} and A_{26}) and proprietor income (A_{28} and A_{30}) for non-energy sectors are calculated using state data from 1970 to 1976. The data are available by major sector and Schreiner [69] was used to allocate the data to input-output sectors of the model.

Growth rates of ratios of demand for durables (a_2), non-durables (a_4) and services (a_6) to disposable income are estimated using national data between 1968 and 1975 obtained from the Statistical Abstract of the United States, issues 1972 to 1977. Growth rates of federal government purchases for defense (a_7) and non-defense (a_8) are estimated from time series data between 1967 and 1972 obtained from the U.S. Office of Economic Opportunity, Federal Government Outlays in Oklahoma issues from 1968 to 1973. Growth rates of property income (a_{11}), other labor income (a_{12}), transfer payments (a_{13}) and ratio of social security payments to wage and salary income (a_{15}) are estimated using data from 1967 to 1972 and obtained from the U.S. Bureal of Economic Analysis [80].

Ratios of household energy consumption to disposable income (a_{16}), federal government energy consumption to total federal government purchases (a_{22}) and state and local government energy consumption to personal income (a_{28}) for the baseline projections are assumed to remain constant during the simulated time period. In this case, the annual growth rates for these ratios are zero.

Population Projections

Population is exogenously determined in the present form of the Oklahoma simulation model. Population is projected starting from an initial base year count by cohorts and applying birth, death and migration rates to these cohorts. Trends in death rates by cohort are also incorporated to adjust population growth over time. Table XLVI in Appendix C contains the parameters for projecting Oklahoma population.

Population projections serve as input for final demand projections. Personal consumption expenditures and state and local government expenditures are based on the absolute size of population. Change in final demand over time varies with the change in population. Population projections for Oklahoma from 1973 to 2000 are presented in Table XXVII and Figure 4. Population estimates obtained from the Oklahoma Employment Security Commission [50] are also contained in Figure 4. Population projections are indicated by a solid line, whereas published estimates are shown with a broken line in Figure 4.

TABLE XXVII

POPULATION PROJECTIONS FOR OKLAHOMA,
1973-2000

Year	Population	Year	Population
1973	2,664,700	1987	3,150,770
1974	2,696,780	1988	3,188,700
1975	2,729,250	1989	3,227,090
1976	2,762,110	1990	3,265,950
1977	2,795,370	1991	3,305,270
1978	2,829,030	1992	3,345,060
1979	2,863,090	1993	3,385,340
1980	2,897,560	1994	3,426,100
1981	2,932,450	1995	3,467,350
1982	2,967,750	1996	3,509,100
1983	3,003,480	1997	3,551,340
1984	3,039,650	1998	3,594,100
1985	3,076,240	1999	3,637,380
1986	3,113,280	2000	3,681,170

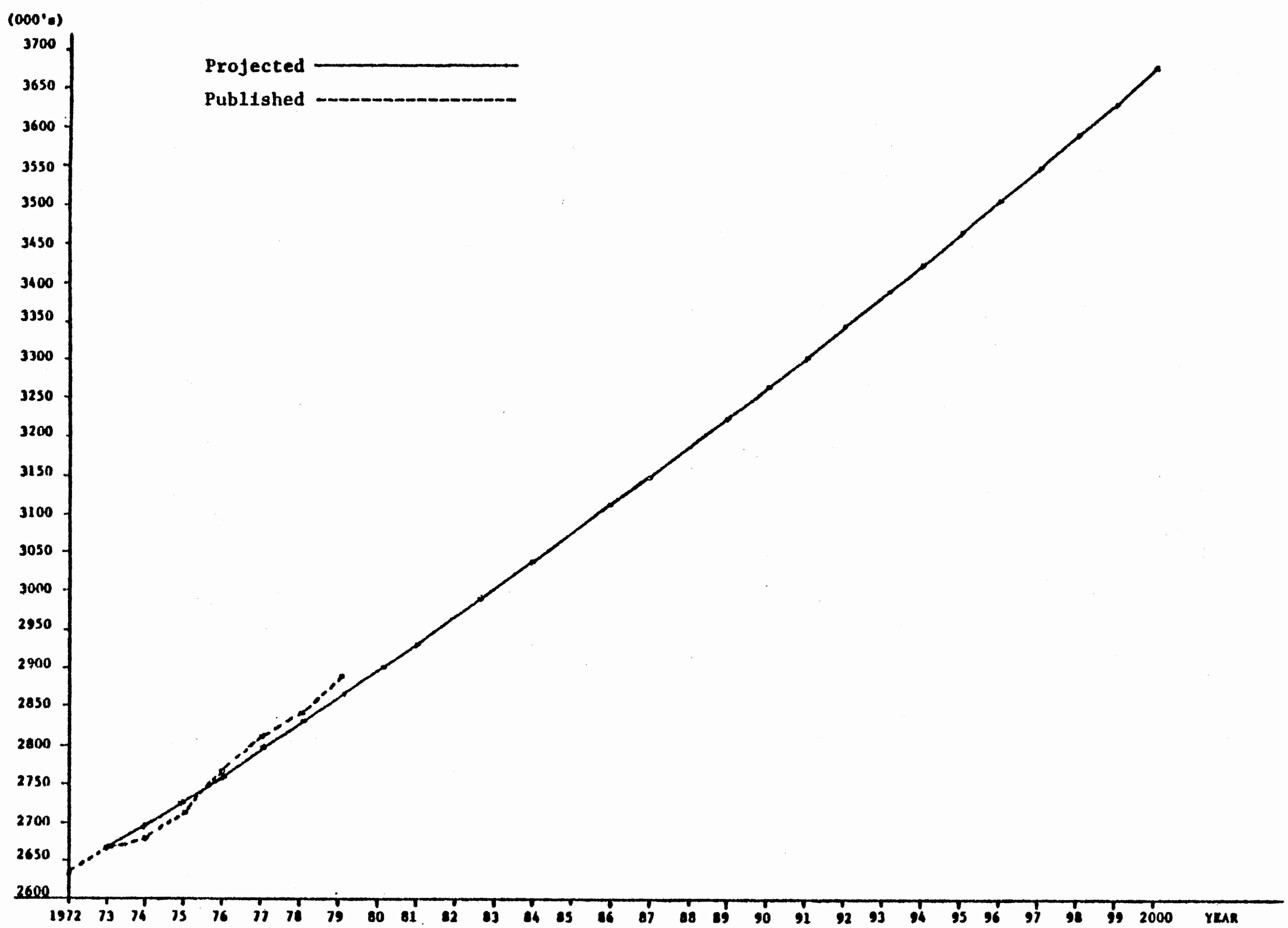

Figure 4. Population Projections, Oklahoma

Oklahoma population is expected to equal 3,681,170 in the year 2000 which is an increase of 38.1 percent over the 28-year simulated period.

Employment Projections

Trends in employment are directly affected by trends in sectoral output and employment-output ratios. Estimates of wage and salary, proprietor, and total employment from 1973 to 2000 are presented in Table XXVIII and Figure 5. Employment projections are indicated by solid lines and published estimates are shown by broken lines in Figure 5. Published data were obtained from the Oklahoma Employment Security Commission [46] and the Oklahoma Department of Agriculture [39] [40]. Total baseline employment is projected to be 1,041,730 in 1973 and 1,764,951 in 2000, which is an increase of 69.4 percent in twenty-eight years. Projected wage and salary employment is equal to 1,383,269 in 2000 compared to 806,352 in 1973. Proprietor employment is estimated at 381,683 in 2000 compared to 235,379 in 1973. The increase in wage and salary employment is more significant than the increase in proprietor employment. Declining proprietor employment in the agricultural sectors, which account for 44.3 percent of total proprietor employment in 1972, is eventually offset by the increase in proprietor employment of the non-agricultural sectors.

Income Projections

Baseline projections of wage and salary payments, proprietor income, property income, other labor income, transfer payments and total personal income from 1973 to 2000 in constant 1972 prices are presented in Table XXIX. Total personal income is expected to increase from

TABLE XXVIII

WAGE AND SALARY, PROPRIETOR AND TOTAL EMPLOYMENT PROJECTIONS, OKLAHOMA, 1973-2000

Year	Wage & Salary Employment	Proprietor Employment	Total Employment
1973	806,352	235,379	1,041,730
1974	801,568	234,063	1,035,631
1975	807,246	2365,606	1,042,852
1976	815,789	237,968	1,053,758
1977	825,885	240,739	1,066,624
1978	837,132	243,803	1,080,935
1979	849,227	247,074	1,096,300
1980	862,171	250,553	1,112,724
1981	876,424	254,339	1,130,763
1982	892,156	258,434	1,150,590
1983	909,104	262,793	1,171,897
1984	926,675	267,338	1,194,013
1985	945,015	272,077	1,217,092
1986	964,258	277,029	1,241,287
1987	984,456	282,208	1,266,664
1988	1,005,923	287,693	1,293,616
1989	1,028,691	293,480	1,322,171
1990	1,052,774	299,575	1,352,350
1991	1,078,591	306,112	1,384,703
1992	1,105,996	313,030	1,419,026
1993	1,134,771	320,255	1,455,025
1994	1,165,018	327,806	1,492,825
1995	1,196,825	335,720	1,532,545
1996	1,230,294	344,022	1,574,316
1997	1,265,546	352,740	1,618,287
1998	1,302,712	361,905	1,664,616
1999	1,341,912	371,543	1,713,454
2000	1,383,269	381,683	1,764,951

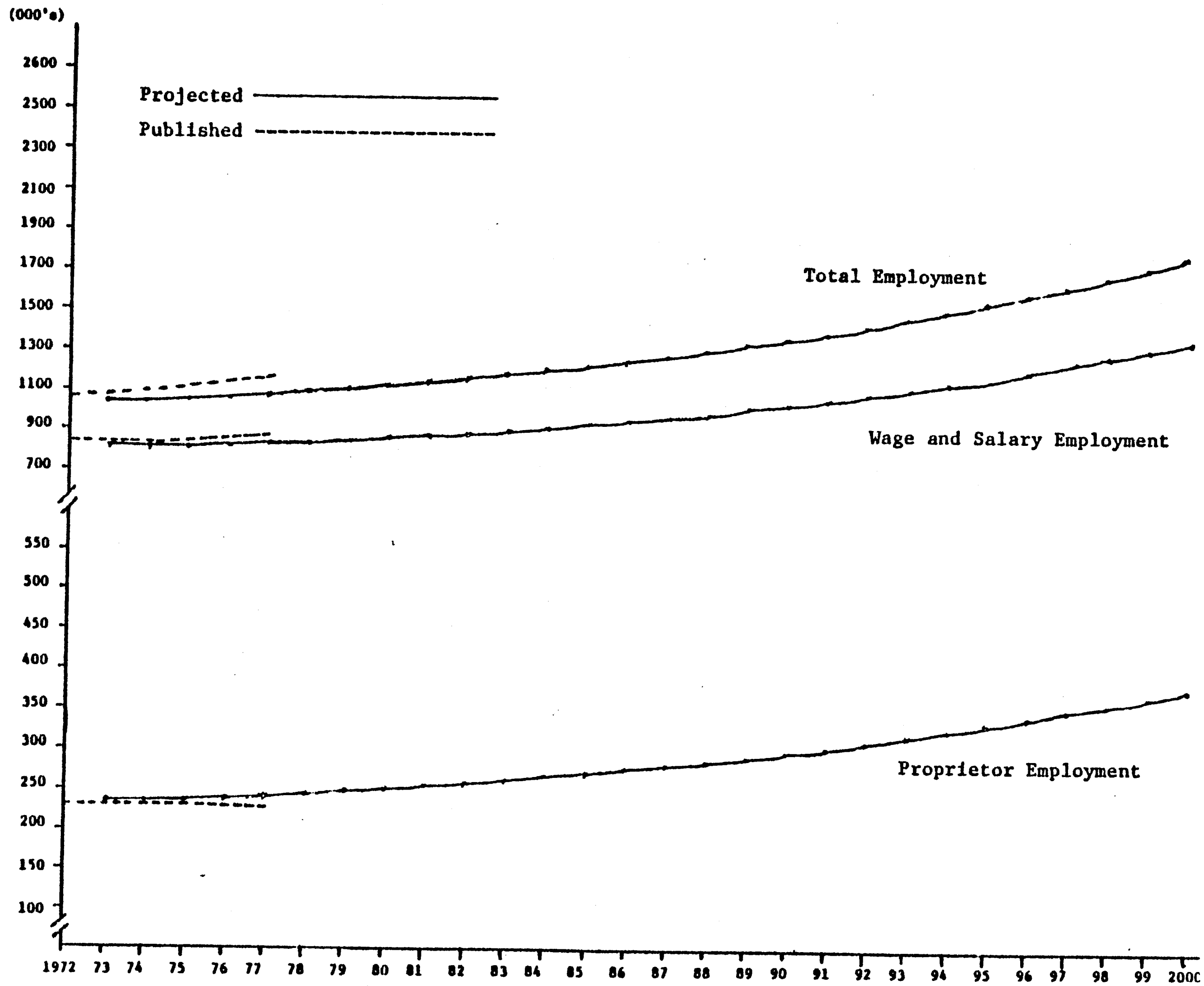

Figure 5. Total Employment, Wage and Salary Employment, and Proprietor Employment Projections, Oklahoma

TABLE XXIX

PROJECTED WAGE AND SALARY PAYMENTS, PROPRIETOR INCOME, PROPERTY INCOME, OTHER LABOR INCOME, TRANSFER PAYMENTS, AND TOTAL PERSONAL INCOME, IN CONSTANT PRICES, (1972=100), OKLAHOMA, 1973-2000 ($1,000)

Year	Wage & Salary Payments	Proprietor Income	Property Income	Other Labor Income	Transfer Payments	Total Personal Income
1973	6,094,556	1,030,707	1,610,750	420,251	1,322,625	10,118,713
1974	6,225,482	1,048,138	1,693,100	453,215	1,428,969	10,458,971
1975	6,437,374	1,079,590	1,779,660	488,765	1,532,279	10,901,875
1976	6,676,703	1,116,111	1,870,645	527,104	1,643,058	11,388,905
1977	6,937,102	1,155,743	1,966,281	568,450	1,761,846	11,912,938
1978	7,216,815	1,198,057	2,066,807	613,039	1,889,222	12,472,767
1979	7,514,262	1,242,746	2,172,473	661,126	2,025,807	13,067,555
1980	7,830,438	1,289,895	2,283,540	712,985	2,172,267	13,699,315
1981	8,171,012	1,340,056	2,400,286	768,911	2,329,315	14,374,903
1982	8,539,429	1,393,404	2,523,001	829,225	2,497,717	15,098,773
1983	8,934,279	1,449,882	2,651,989	894,269	2,687,294	15,870,743
1984	9,350,232	1,509,230	2,787,572	964,415	2,871,926	16,686,935
1985	9,790,404	1,571,541	2,930,087	1,040,064	3,079,557	17,551,684
1986	10,257,686	1,637,044	3,079,888	1,121,647	3,302,200	18,469,320
1987	10,753,995	1,705,951	3,237,347	1,209,629	3,540,938	19,443,348
1988	11,284,549	1,778,802	3,402,856	1,304,512	3,796,937	20,480,678
1989	11,851,636	1,855,776	3,576,827	1,406,838	4,071,444	21,585,278
1990	12,457,395	1,937,073	3,759,692	1,517,190	4,365,796	22,761,101
1991	13,108,953	2,023,603	3,951,907	1,636,198	4,681,430	24,017,382
1992	13,807,098	2,115,286	4,153,948	1,764,542	5,019,883	25,356,768
1993	14,551,819	2,211,904	4,366,318	1,902,952	5,382,804	26,781,201
1994	15,347,405	2,313,737	4,589,546	2,052,220	5,771,964	28,297,086
1995	16,197,532	2,421,217	4,824,187	2,213,195	6,189,259	29,910,552
1996	17,106,683	2,534,731	5,070,823	2,386,798	6,636,723	31,628,524
1997	18,079,943	2,654,699	5,330,069	2,574,019	7,116,537	33,458,613
1998	19,122,870	2,781,575	5,602,569	2,775,925	7,631,041	35,409,007
1999	20,241,269	2,915,826	5,889,000	2,993,668	8,182,741	37,488,249
2000	21,441,377	3,057,938	6,190,075	3,228,491	8,774,327	39,705,415

$10,118,713,000 in 1973 to $39,705,415,000 in 2000 at constant 1972 prices. Total personal income made a significant increase mainly due to increase in property income, labor income and transfer payments during the simulated period of time.

Wage and salary payments are projected to increase from $6,094,556,000 in 1973 to $21,441,377,000 in 2000 at constant 1972 prices. This is a projected 251.8 percent increase. Proprietor income, including farm and nonfarm sources, is projected to increase from $1,030,707,000 in 1973 to $3,057,938,000 in 2000 or a 196.7 percent increase.

Property income is projected to increase from $1,610,750,000 to $6,190,075,000; other labor income is projected to increase from $420,251,000 to $3,228,491,000; and transfer payments are projected to increase from $1,332,625,000 to $8,774,327,000 over the 1973 to 2000 period respectively. These baseline projections are highly influenced by the rates of increase estimated for the 1967 to 1972 period.

Projections of Government Revenues and Expenditures

Baseline projections of state and local government revenue are presented in Table XXX. Total state and local government revenue is projected to increase from $1,517,489,000 in 1973 to $6,450,184,000 in 2000 at constant 1972 prices for an increase of 325.1 percent. Based on the estimated relationship of revenue source to total personal income, all the components of state and local government revenue are projected to increase from 1973 through 2000 at constant 1972

TABLE XXX

PROJECTIONS OF STATE AND LOCAL GOVERNMENT REVENUE IN CONSTANT PRICES, (1972=100), OKLAHOMA, 1973-2000 ($1,000)

Year	Sales Tax	Gasoline Tax	Income Tax	Other Taxes	Federal Aid	Other Revenue	Total Revenue
1973	110,079	96,735	135,948	280,782	496,304	397,641	1,517,489
1974	113,703	98,573	148,585	290,224	512,119	411,014	1,574,217
1975	118,420	100,965	165,035	302,514	532,705	428,420	1,648,058
1976	123,606	103,594	183,123	316,029	555,342	447,560	1,729,255
1977	129,187	106,424	202,586	330,571	579,699	468,154	1,816,622
1978	135,150	109,447	223,378	346,107	605,720	490,156	1,909,957
1979	141,484	112,659	245,468	362,612	633,366	513,531	2,009,120
1980	148,212	116,071	268,932	380,143	662,730	538,359	2,114,447
1981	155,407	119,719	294,023	398,891	694,131	564,910	2,227,081
1982	163,116	123,628	320,907	418,978	727,777	593,358	2,347,765
1983	171,338	127,796	349,578	440,400	763,658	623,696	2,476,467
1984	180,030	132,204	379,891	463,050	801,595	655,773	2,612,543
1985	189,240	136,873	412,009	487,047	841,788	689,757	2,756,714
1986	199,013	141,829	446,090	512,511	884,440	725,820	2,909,702
1987	209,386	147,088	482,265	539,540	929,713	764,100	3,072,092
1988	220,434	152,690	520,791	568,326	977,928	804,867	3,245,036
1989	232,198	158,655	561,816	598,979	1,029,270	848,277	3,429,195
1990	244,720	165,004	605,486	631,608	1,083,922	894,487	3,625,228
1991	258,100	171,788	652,145	666,470	1,142,314	943,859	3,834,675
1992	272,364	179,021	701,889	703,638	1,204,568	996,497	4,057,978
1993	287,534	186,713	754,793	743,166	1,270,776	1,052,477	4,295,459
1994	303,678	194,899	811,093	785,231	1,341,234	1,112,051	4,548,187
1995	320,862	203,611	871,017	830,005	1,416,228	1,175,461	4,817,184
1996	339,158	212,888	934,822	877,679	1,496,080	1,242,977	5,103,605
1997	358,649	222,771	1,002,792	928,464	1,581,142	1,314,899	5,408,717
1998	379,420	233,303	1,075,230	982,587	1,671,797	1,391,550	5,733,887
1999	401,564	244,531	1,152,453	1,040,286	1,768,440	1,473,264	6,080,538
2000	425,177	256,504	1,234,798	1,101,813	1,871,494	1,560,399	6,450,184

prices. The projected 1973 to 2000 increases are: state sales tax from $110,079,000 to $425,177,000; gasoline, fuels excise and special fuels use tax from $96,735,000 to $256,504,000; individual income tax from $135,948,000 to $1,234,798,000; other state and local taxes from $280,782,000 to $1,101,813,000; other revenues from $397,641,000 to $1,560,399,000; and federal aid to the state and local government from $496,304,000 to $1,871,494,000.

State and local government expenditures are projected in five components: education expenditures, highway expenditures, public welfare, health and hospitals and other state and local government expenditures. Projections of state and local government expenditures are presented in Table XXXI. Total state and local government expenditures are projected to equal $6,825,200 in 2000 compared to $1,780,818,000 in 1973 at 1972 prices. Education expenditures are projected to increase from $671,707,000 to $2,436,774,000; highway expenditures from $240,636,000 to $826,988,000; public welfare expenditures from $296,774,000 to $1,049,265,000; health and hospital expenditures from $125,643,000 to $562,235,000; and other state and local government expenditures from $446,058,000 to $1,949,933,000.

Projections of Other Economic Variables

Baseline projections of disposable income, personal and disposable income per capita, gross state product, and total federal government revenue in Oklahoma are presented in Table XXXII. Total disposable income defined as total personal income minus federal individual income taxes and state and local individual income taxes is projected to increase from $8,685,228,000 in 1973 to $34,204,007,000 in 2000.

TABLE XXXI

PROJECTIONS OF STATE AND LOCAL GOVERNMENT EXPENDITURE IN CONSTANT PRICES, (1972=100), OKLAHOMA, 1973-2000 ($1,000)

Year	Education Expenditures	Highway Expenditures	Public Welfare	Health and Hospitals	Other Expenditures	Total Expenditures
1973	671,707	240,636	296,774	125,643	446,058	1,780,818
1974	679,649	252,699	300,161	127,607	452,824	1,812,940
1975	701,494	259,839	309,473	133,010	471,437	1,875,253
1976	729,928	269,132	321,596	140,044	495,664	1,956,363
1977	761,196	279,351	334,926	147,778	522,304	2,045,555
1978	794,839	290,347	349,268	156,969	550,969	2,141,523
1979	830,780	302,094	364,591	163,990	581,59;	2,244,046
1980	868,965	314,574	380,870	174,435	614,126	2,352,970
1981	909,524	327,830	398,162	184,467	648,684	2,468,666
1982	952,897	342,006	416,652	195,195	685,638	2,592,389
1983	999,369	357,195	436,465	206,691	725,234	2,724,953
1984	1,048,930	373,393	457,594	218,949	767,461	2,866,326
1985	1,101,329	390,519	479,933	231,911	812,106	3,015,797
1986	1,156,846	408,664	503,001	245,643	859,408	3,174,161
1987	1,215,758	427,918	528,717	260,215	909,603	3,342,210
1988	1,278,291	448,356	555,376	275,682	962,882	3,520,587
1989	1,344,888	470,122	583,767	292,155	1,019,624	3,710,557
1990	1,415,803	493,300	614,000	309,696	1,080,046	3,912,845
1991	1,491,291	517,972	646,183	328,368	1,144,363	4,128,177
1992	1,571,944	544,332	680,567	348,318	1,213,082	4,358,243
1993	1,657,933	572,436	717,226	369,587	1,286,346	4,603,529
1994	1,749,381	602,324	756,213	392,207	1,364,263	4,864,388
1995	1,846,701	634,132	797,703	416,280	1,447,182	5,141,997
1996	1,950,285	667,987	841,863	441,902	1,535,438	5,437,475
1997	2,060,579	704,035	888,884	469,183	1,629,411	5,752,092
1998	2,178,071	742,435	938,974	498,245	1,729,517	6,087,242
1999	2,303,286	783,360	992,356	529,217	1,836,204	6,444,422
2000	2,436,774	826,988	1,049,265	562,235	1,949,938	6,825,200

TABLE XXXII

PROJECTIONS OF OTHER ECONOMIC VARIABLES IN CONSTANT PRICES (1972=100), OKLAHOMA, 1973-2000 ($1,000)

Year	Disposable Income	Personal Income Per Capita	Disposable Income Per Capita	Gross State Product	Total Federal Revenue
1973	8,685,228	3,797	3,259	26,432,290	1,982,742
1974	8,978,703	3,878	3,329	27,108,996	2,038,714
1975	9,360,711	3,994	3,430	27,984,854	2,111,572
1976	9,780,779	4,123	3,541	28,976,826	2,191,688
1977	10,232,762	4,262	3,661	30,032,287	2,277,891
1978	10,715,619	4,409	3,378	31,143,209	2,369,983
1979	11,228,629	4,564	3,922	32,308,335	2,467,826
1980	11,773,528	4,728	4,063	33,527,503	2,571,751
1981	12,356,227	4,902	4,214	34,803,615	2,682,885
1982	12,980,571	5,088	4,374	36,143,053	2,801,961
1983	13,646,402	5,284	4,544	37,549,857	2,928,950
1984	14,350,374	5,490	4,721	39,023,951	3,063,214
1985	15,096,228	5,706	4,907	40,563,220	3,205,465
1986	15,887,696	5,932	5,103	42,171,893	3,356,416
1987	16,727,804	6,171	5,309	43,854,262	3,516,644
1988	17,622,510	6,423	5,527	45,614,480	3,687,285
1989	18,575,236	6,689	5,756	47,458,733	3,868,991
1990	19,589,394	6,969	5,998	49,391,066	4,062,414
1991	20,672,947	7,266	6,155	51,416,221	4,269,073
1992	21,828,179	7,580	6,525	53,541,681	4,489,402
1993	23,056,764	7,911	6,811	55,770,101	4,723,721
1994	24,364,227	8,259	7,111	58,104,001	4,973,084
1995	25,755,856	8,616	7,428	60,549,245	5,238,499
1996	27,237,621	9,013	7,761	63,111,591	5,521,105
1997	28,816,088	9,421	8,114	65,797,361	5,822,155
1998	30,498,319	9,852	8,486	68,613,393	6,142,995
1999	32,291,683	10,306	8,878	71,566,911	6,485,030
2000	34,204,007	10,786	9,292	74,665,383	6,849,754

Personal income per capita and disposable income per capita which are defined as total personal income and total disposable income divided by population, are expected to increase from $3,797 to $10,786 and $3,259 to $9,292 from 1973 through 2000, respectively. Gross state product which is defined as value added for business sectors plus federal and state and local government wage and salary payments is projected to increase from $26,432,290,000 in 1973 to $74,665,383,000 in 2000. Federal government revenue in Oklahoma is projected to equal $6,849,754,000 in 2000 compared to $1,982,742,000 in 1973. All value of these variables are reported in constant 1972 prices.

Projections of State Energy

Baseline projections of state energy production, consumption and trade by energy source in trillion BTU's from 1973 to 2000 are presented in Table XXXIII. Each category is composed of petroleum products, natural gas coal and electricity and hydropower.

Estimates of state energy production are determined exogenously and fitted into the simulation model. Total energy production is projected to equal 3,226,895 trillion BTU's in 2000 compared to 3,258,327 trillion BTU's in 1973, decreasing by 1.0 percent during the simulated period of time. A declining trend in natural gas and petroleum production is expected. Natural gas is projected to decrease from 1,863,607 trillion BTU's to 1,834,147 trillion BTU's and petroleum products from 1,229,350 trillion BTU's to 924,742 trillion BTU's over the 1973 to 2000 period. Coal is expected to increase from 58.784 trillion BTU's in 1973 to 143.476 trillion in 2000 and electricity and hydropower from 106.693 trillion BTU's in 1973 to 324.530 trillion

TABLE XXXIII

PROJECTIONS OF STATE ENERGY PRODUCTION, CONSUMPTION AND ENERGY TRADE BY ENERGY SOURCE IN BILLION BTU, OKLAHOMA, 1973-2000

	Energy Production					Energy Consumption					Energy Trade				
Year	Petroleum Products	Natural Gas	Coal	Electricity & Hydropower	Total	Petroleum Products	Natural Gas	Coal	Electricity & Hydropower	Total	Petroleum Products	Natural Gas	Coal	Electricity & Hydropower	Total
1973	1,229,350	1,863,607	58,784	106,586	3,258,327	325,259	643,329	1,885	77,082	1,047,555	904,091	1,220,278	56,899	29,505	2,216,772
1974	1,216,454	1,862,508	60,760	111,074	3,250,796	332,105	656,468	1,902	79,234	1,069,709	884,348	1,206,040	58,857	31,840	2,181,086
1975	1,203,693	1,861,409	62,801	115,750	3,243,653	342,824	674,084	1,953	82,090	1,100,951	860,869	1,187,325	60,848	33,660	2,142,701
1976	1,191,066	1,860,311	64,911	120,623	3,236,911	354,606	692,963	2,000	85,206	1,134,775	836,461	1,167,348	62,911	35,416	2,102,136
1977	1,178,572	1,859,213	67,092	125,701	3,230,578	367,381	713,157	2,051	88,543	1,171,132	811,191	1,146,056	65,041	37,158	2,059,446
1978	1,166,209	1,858,116	69,346	130,993	3,224,664	381,042	734,535	2,105	92,082	1,209,764	785,167	1,123,581	67,242	38,911	2,014,901
1979	1,153,975	1,857,020	71,676	136,508	3,219,179	395,505	757,027	2,161	95,815	1,250,508	758,470	1,099,993	69,515	40,693	1,968,671
1980	1,141,187	1,855,924	74,085	142,255	3,213,451	410,838	780,716	2,221	99,754	1,293,527	731,032	1,075,209	71,864	42,501	1,920,607
1981	1,129,892	1,854,829	76,574	148,244	3,209,539	427,341	805,954	2,288	103,945	1,339,528	702,551	1,048,875	74,286	44,299	1,870,011
1982	1,118,039	1,853,735	79,147	154,485	3,205,406	445,047	832,782	2,362	108,410	1,388,600	672,993	1,020,952	76,785	46,075	1,816,806
1983	1,106,311	1,852,641	81,806	160,989	3,201,747	463,861	861,078	2,439	113,137	1,440,515	642,450	991,563	79,367	47,852	1,761,232
1984	1,094,706	1,851,548	84,555	167,766	3,198,575	483,576	890,573	2,516	118,088	1,494,753	611,130	960,975	82,039	49,679	1,703,822
1985	1,083,222	1,850,456	87,396	174,829	3,195,903	504,369	921,504	2,595	123,291	1,551,760	578,854	928,951	84,801	51,538	1,644,144
1986	1,071,859	1,849,364	90,333	182,190	3,193,746	526,314	953,947	2,677	128,770	1,611,708	545,546	895,416	87,655	53,420	1,582,037
1987	1,060,616	1,848,273	93,368	189,860	3,192,117	549,478	987,974	2,761	134,539	1,674,752	511,138	860,299	90,606	55,321	1,517,364
1988	1,049,490	1,847,182	96,505	197,853	3,191,030	574,103	1,023,869	2,851	140,639	1,741,462	475,387	823,313	93,654	57,214	1,449,568
1989	1,038,481	1,846,092	99,747	206,182	3,190,502	600,246	1,061,691	2,945	147,089	1,811,972	438,235	784,401	96,802	59,093	1,378,531
1990	1,027,587	1,845,003	103,099	214,863	3,190,552	627,974	1,101,507	3,044	153,904	1,886,429	399,613	743,496	100.055	60,959	1,304,123
1991	1,016,808	1,843,915	106,563	223,908	3,191,194	657,622	1,143,684	3,151	161,132	1,965,589	359,186	700,230	103,412	62,776	1,225,605
1992	1,006,141	1,842,827	110,144	233,335	3,192,447	689,139	1,188,156	3,263	168,783	2,049,341	317,003	654,670	106,881	64,552	1,143,106
1993	995,587	1,841,739	113,844	243,158	3,194,328	722,472	1,234,863	3,379	176,858	2,137,571	273,115	606,876	110,466	66,301	1,056,758
1994	985,143	1,840,653	117,670	253,395	3,196,861	757,780	1,283,979	3,499	185,386	2,230,644	227,363	556,674	114,170	68,010	966,217
1995	974,809	1,839,567	121,623	264,063	3,200,062	795,196	1,335,639	3,624	194,394	2,328,853	179,613	503,928	117,999	69,669	871,209
1996	964,583	1,838,482	125,710	275,180	3,203,955	834,869	1,390,000	3,755	203,915	2,432,539	129,715	448,481	121,955	71,265	771,416
1997	954,465	1,837,397	129,934	286,766	3,208,562	876,968	1,447,240	3,891	213,984	2,542,082	77,497	390,157	126,043	72,782	606,478
1998	944,457	1,836,313	134,299	298,838	3,213,902	921,674	1,507,547	4,034	224,636	2,657,891	22,778	328,766	130,266	74,202	556,012
1999	934,545	1,835,229	138,812	311,419	3,220,005	969,168	1,571,107	4,183	235,911	2,780,369	-34,623	264,122	134,629	75,508	439,637
2000	924,742	1,834,147	143,476	324,530	3,226,895	1,019,641	1,638,116	4,339	247,849	2,909,946	-94,899	196,030	139,137	76,681	316,948

BTU's in 2000.

Estimates of state energy consumption are determined endogenously by the simulation model. Total state energy consumption is projected to equal 2,909.946 trillion BTU's in 2000 compared to 1,047.555 trillion BTU's in 1973. Consumption of petroleum products is projected to increase over the 1973 to 2000 period from 325.259 trillion BTU's to 1,019.641 trillion BTU's, natural gas from 643.329 trillion BTU's to 1,638.116 trillion BTU's, and coal from 1.885 trillion BTU's to 4.339 trillion BTU's. Electricity and hydropower consumption is expected to increase from 77.082 trillion BTU's in 1973 to 247.849 trillion BTU's in 2000.

State energy trade is the difference between state energy production and state energy consumption. Oklahoma experiences a net energy surplus in which total state energy trade is projected to equal 316.948 trillion BTU's in 2000 compared to 2,210.772 trillion BTU's of energy surplus in 1973. The decline in net energy trade is due to the projected decline in natural gas and petroleum products production throughout the simulated period. Oklahoma is expected to have a deficit of 94.899 trillion BTU's of petroleum products in 2000 compared to a surplus of 904.091 trillion BTU's in 1973 and a surplus of 196.030 trillion BTU's of natural gas in 2000 compared to a surplus of 1,220.278 trillion BTU's in 1973. It has been observed that little of Oklahoma's coal is consumed in the state compared to what is produced. Consequently, the net coal trade is expected to increase from 56.899 trillion BTU's in 1973 to 139.137 trillion BTU's in 2000. The surplus in electricity and hydropower is projected to increase from 29.505

trillion BTU's in 1973 to 76.681 trillion BTU's in 2000. The projected surplus of electricity and hydropower is utilized by neighboring states.

CHAPTER IX

ECONOMIC IMPACT ANALYSIS AND POLICY IMPLICATIONS

Economic Impact Analysis

The current energy crunch and sharply increasing energy prices have become a serious problem that can no longer be neglected since nearly all economic activity uses energy. It is clear that a sudden reduction in energy supply and rising energy prices can have severe consequences on any economy-especially for those industries which use energy products not only as fuel but also as raw materials. From an economic point of view, it is expected that in the long run the price mechanism would lead to a new market equilibrium at higher prices in the event of a reduction of energy. Higher prices should stimulate increased activity in energy exploration and development in Oklahoma and increased energy production.

Effects of new events that have no historical trend are generally not included in projections provided by models similar to the Oklahoma simulation model. These events, whether economic or non-economic, may have considerable impact on energy production, consumption and trade. Air pollution control of sulfur oxide emissions, mine safety regulations and the current energy supply and price determination by Oil Producing and Exporting Countries (OPEC) indicate some of the institutional and political forces that necessarily lie outside the capability of any model to predict on the basis of historical trend. However, it is possible to evaluate the impacts of increased energy production and increased efficiency in energy utilization in terms of state employment; income; government revenue and expenditure; and energy trade.

Analysis of an Energy Production Increase

The growth rates of petroleum products, natural gas and coal production are increased by 25 percent. Effects of increased energy production are measured against the baseline projections provided in Chapter VIII to determine the impact on state employment, income, government revenues and expenditures, gross state product, and energy trade.

The impact of a 25 percent increase in the growth rates of petroleum products and natural gas production on total employment and total personal income is presented in Table XXXIV. For instance, total employment is expected to increase by 1,042 in 1980, 2,036 in 1990, and 2,606 in 2000. Total personal income is expected to increase by $9,745,000 in 1980, $23,199,000 in 1990, and $36,259,000 in 2000.

The impact of a 25 percent increase in the growth rates of petroleum and natural gas production on the public sectors is presented in Table XXXV. As the result of the proposed increase, total state and local government revenue is expected to increase in 1972 dollars by $1,625,000 in 1980, $3,868,000 in 1990, and $6,045,000 in 2000. Total state and local government expenditure is expected to increase in 1972 prices by $1,549,000 in 1980, $4,010,000 in 1990, and $6,404,000 in 2000. The expected increase in federal government revenue in 1972 dollars is $1,603,000 in 1980, $3,817,000 in 1990, and $5,956,000 in 2000.

TABLE XXXIV

CHANGES IN TOTAL EMPLOYMENT AND TOTAL PERSONAL INCOME AS A RESULT OF 25 PERCENT INCREASE IN THE GROWTH RATES OF PETROLEUM PRODUCTS AND NATURAL GAS PRODUCTION

Year	Changes in Total Employment	Changes in Total Personal Income (1972 Dollars)
1975	370	3,242,000
1980	1,042	9,745,000
1985	1,625	16,701,000
1990	2,036	23,199,000
1995	2,374	29,883,000
2000	2,606	36,259,000

TABLE XXXV

CHANGES IN TOTAL STATE AND LOCAL GOVERNMENT REVENUE AND EXPENDITURE AND TOTAL FEDERAL GOVERNMENT REVENUE AS A RESULT OF 25 PERCENT INCREASE IN THE GROWTH RATES OF PETROLEUM PRODUCTS AND NATURAL GAS PRODUCTION (1972 DOLLARS)

Year	Changes in Total State & Local Government		Changes in Total Federal Govern-Ment Revenue
	Revenue	Expenditure	
1975	540,000	368,000	533,000
1980	1,625,000	1,549,000	1,603,000
1985	2,784,000	2,830,000	2,748,000
1990	3,868,000	4,010,000	3,817,000
1995	4,982,000	5,248,000	4,916,000
2000	6,045,000	6,404,000	5,965,000

Results of the impact of the 25 percent increase in the growth rates of petroleum products and natural gas production in terms of state energy trade are presented in Table XXXVI. Total energy trade is expected to increase by 24,210.773 billion BTU's in 1980 and 71,285. 753 billion BTU's in 2000. Trade in petroleum products is expected to change by 23,915.302 billion BTUs in 1980 and 69,430.966 billion BTUs in 2000. Natural gas is expected to increase by 362.720 billion BTU's in 1980 and 2,086.246 billion BTU's in 2000. Coal trade is expected to decrease by 1.561 billion BTU's in 1980 and 5.292 billion BTU's in 2000. The expected decreases in electricity and hydropower trade are 65.688 billion BTU's in 1980, 226.167 billion BTU's in 2000. Coal and electricity consumption are increased due to the increase in the growth rates of petroleum products and natural gas production. Therefore increases in coal and electricity consumption must be offset by equal decrements of energy trade as indicated in Table XXXVI.

The impact of a 25 percent increase in the growth rate of coal production is further analyzed in terms of state energy trade and the results are presented in Table XXXVII. As the result of the proposed increase in coal production, total state energy trade is expected to increase by 4,777.191 billion BTUs in 1980 and 35,044.311 billion BTUs in 2000. This is the net effect of an increase in energy trade from coal and a decrease in energy trade from petroleum products, natural gas and electricity and hydropower.

The impact of a 25 percent increase in the growth rate of coal production on total employment and total personal income is presented in Table XXXVIII. Total employment is expected to increase by 109

TABLE XXXVI

CHANGES IN STATE ENERGY TRADE AS A RESULT OF 25 PERCENT INCREASE IN THE GROWTH RATES OF PETROLEUM PRODUCTS AND NATURAL GAS PRODUCTION

(BILLION BTUs)

Year	Petroleum Products	Natural Gas	Coal	Electricity & Hydropower	Total
1975	9,411.475	126.838	-0.510	-22.210	9,515.593
1980	23,915,302	362.720	-1.561	-65.688	24,210.773
1985	37,062.807	662.341	-2.829	-110.711	37,611.608
1990	48,985.871	1,065.631	-3.704	-150.613	49,897.185
1995	59,741.758	1,535.061	-4.597	-190.071	61,082.151
2000	69,430.966	2,086.246	-5.292	-226.167	71,285.753

TABLE XXXVII

CHANGES IN STATE ENERGY TRADE AS A RESULT OF 25 PERCENT IN THE GROWTH RATE OF COAL PRODUCTION

(BILLION BTU'S)

Year	Petroleum Products	Natural Gas	Coal	Electricity & Hydropower	Total
1975	-16.743	-16.791	1,543.287	-13.706	1,496.048
1980	-65.052	-66.582	4,954.698	-45.872	4,777.191
1985	-132.716	-134.674	9,694.959	-90.819	9,336.334
1990	-228.287	-229.409	16,166.285	-152.853	15,555.736
1995	-363.190	-361.503	24,880.523	-237.559	23,918.271
2000	-549.578	-541.744	36,487.401	-351.096	35,044.311

in 1980; 353 in 1990; and 775 in 2000. Total personal income is expected to increase by $1,072,000 in 1980; $4,281,000 in 1990; and $11,539,000 in 2000, in 1972 prices.

The results of the impact of the 25 percent increase in the growth rate of coal production on the public sector are presented in Table XXXIX. Total state and local government revenue is expected to increase by $179,000 in 1980, by $714,000 in 1990, and $1,924,000 in 2000, all in 1972 prices. Total state and local government expenditure is expected to increase by $164,000 in 1980, $702,000 in 1990, and $1,929,000 in 2000. The expected increase in federal government revenue is $176,000 in 1980, $705,000 in 1990, and $1,898,000 in 2000. Similar analysis can be made for other economic variables.

Analysis of Energy Efficiency

Energy efficiency in the final demand sectors is assumed to increase by 25 percent in the year 2000 compared to the efficiency in the 1972 base period. To acquire this increased efficiency, the growth rates of ratios of final energy demand for households to total disposable income (a_{17}), final energy demand for federal government to total federal government expenditures (a_{23}), and final energy demand for state and local government to total personal income (a_{29}), are proposed to decrease at the rate of 1.02 percent annually from 1972 to 2000. Energy coefficients for the processing sectors have not been changed.

The results of the impact in terms of state energy trade are presented in Table XL. Total energy trade is expected to increase by 29,242.906 billion BTU's in 1980 and 269,164.939 billion BTU's in 2000. Trade is expected to increase in petroleum products by 16,110.546

TABLE XXXVIII

CHANGES IN TOTAL EMPLOYMENT AND TOTAL PERSONAL INCOME AS A RESULT OF 25 PERCENT INCREASE IN THE GROWTH RATE OF COAL PRODUCTION

Year	Changes in Total Employment	Changes in Total Personal Income (1972 Dollars)
1975	25	239,000
1980	109	1,072,000
1985	215	2,341,000
1990	353	4,281,000
1995	537	7,220,000
2000	775	11,539,000

TABLE XXXIX

CHANGES IN TOTAL STATE AND LOCAL GOVERNMENT REVENUE AND EXPENDITURE AND TOTAL FEDERAL GOVERNMENT REVENUE AS A RESULT OF 25 PERCENT INCREASE IN THE GROWTH RATE OF COAL PRODUCTION (1972 DOLLARS)

	Changes in Total State and Local Government		Changes in Total Federal Government Revenue
Year	Revenue	Expenditure	
1975	40,000	26,000	39,000
1980	179,000	164,000	176,000
1985	390,000	376,000	385,000
1990	714,000	702,000	705,000
1995	1,204,000	1,198,000	1,188,000
2000	1,924,000	1,929,000	1,898,000

billion BTU's in 1980 and 148,306.551 billion BTU's in 2000; natural gas by 9,901.262 billion BTU's in 1980 and 91,126.926 billion BTU's in 2000; and electricity including hydropower by 3,231.100 billion BTU's in 1980 and 29,731.462 billion BTU's in 2000. Change in coal trade is significant. Since energy production is not affected by the proposed change, energy consumption is expected to decline by equal amounts as indicated for energy trade in Table XL.

Policy Implications

Production Trends for Petroleum Products and Natural Gas

Oklahoma's economy depends on the use of large amounts of energy, particularly natural gas and petroleum products, for generating electricity and other industrial operations. Its economic growth depends strongly upon its ability to continue as a major energy producer. This ability, in turn, depends on the extent of Oklahoma's remaining energy resources and on state and national policies regarding energy development.

The projected data on energy indicate decreased total energy production. The declining trend in total energy production is attributed to the decline in production of petroleum products and natural gas. Results of the impact analysis of a 25 percent increase in the rate of growth of petroleum products and natural gas production indicate Oklahoma will continue to have a positive net energy trade well into the next century. However, to stimulate higher energy production requires increased exploration of new oil and gas deposits and enhanced recovery of existing deposits. This means drilling for deposits located at

TABLE XL

CHANGES IN STATE ENERGY TRADE AS A RESULT OF 25 PERCENT INCREASE IN ENERGY EFFICIENCY IN THE FINAL DEMAND SECTORS

(BILLION BTU'S)

Year	Petroleum Products	Natural Gas	Electricity & Hydropower	Total
1975	4,927.003	3,028.007	988.315	8,943.629
1980	16,110.546	9,901.262	3,231.100	29,242.906
1985	32,732.808	20,115.551	6,563.873	59,412.256
1990	57,361.399	35,248.683	11,501.322	104,111.403
1995	94,011.598	57,767.555	18,848.164	170,627.318
2000	148,306.551	91,126.926	29,731.462	269,164.939

greater depths and technological advances in recovery methods. The comprehensive energy outlook essential for effective energy program planning.

Energy Conservation

Conserving energy by reducing consumption and making more efficient use of energy consumed can be an important part of the solution to the energy problem. The most important means of achieving energy conservation are through economic incentives, restrictive legislation, and education of the general public to conserve energy.

However, the economic and social development of the state has been directly related to abundant energy supplies at relatively low cost. The quality of life in the state has improved with increased use of energy. The current energy shortages and rising energy prices since the 1973 oil embargo have increase public awareness of the need to conserve energy and to use available energy supplies as wisely as possible. But, the level of per capita energy consumption is still extremely high. Energy demands are expected to increase further in the future pushing still higher energy prices. Increased energy demand will be due to growth of population, industrial development and the desire to improve life styles. To meet the increasing energy demand, further exploitation of alternative energy resources along with energy conservation will be required.

Alternative Sources of Energy

The search for alternative energy choices is of great concern at the present time. With high energy prices, more options exist now than ever before in meeting energy needs. Such options include coal, nuclear energy, biomass, solar energy, goethermal, energy from oil shales, tide, wind and gasohol. These alternative energy sources are increasingly becoming more feasible with increased energy prices. Numerous problems, however, still need to be solved before these alternative energy sources are made extensively available. The exploitation and development of such energy sources as nuclear and solar energy demand high investments involving great resks and uncertainties in terms of environmental results.

The most realistic and secure source of energy at this time and for some time in the future is coal. The immediate response to the energy crisis by government and the energy industries should be to emphasize energy sources that can be integrated easily in the vast existing transportation, distribution, and combustion systems. Because coal is the largest remaining U.S. energy reserve, it is logical to consider conversion of this fuel into synthetic oil and gas so that they can be transported by existing pipelines, stored in existing storage tanks, and burned in standard cars, boilers and home furnaces and, most important, used in the generation of electricity to be distributed via existing grids. The transition to this energy source would disrupt investments, equipment, and life styles the least amount. In view of the nation's dwindling oil and natural gas reserves, this appears to be the best way that the United States can become less dependent upon foreign energy sources in the foreseeable future [6].

For Oklahoma, the opportunity for investment in coal production is enormous. Coal is the most abundant fossil fuel in the state and can provide a growing share of total energy production. Oklahoma's coal deposit is 17th in the nation. The coal field extends over 15,000 square miles (21 percent of state area) of eastern Oklahoma. The field has at least 2.5 billion tons of steam coal, suitable for electricity generation [25]. At current prices ($22 per ton), that is $55 billion worth of coal sitting in 19 Oklahoma counties. In addition, there are 700 million tons of high quality metallurgical coal, worth about double steam coal. Most of Oklahoma coal production is presently shipped to other states with some exported to Japan, Mexico, and West Germany. Among the major direct users of Oklahoma coal are the electricity generating industries in Missouri, Kansas, and Iowa; coke for steel mills in Colorado and Texas; and cement industries in Arkansas and Texas [8].

Very little of the coal produced in Oklahoma is used in the state. Oklahoma coal generally exceeds the sulfur content allowed under present state anti-pollution standards. The state air quality standards allow 1.2 pounds of SO_2 emmissions per million British Thermal Units (BTU) of fuel. This is equivalent to about 0.7 to 0.8 percent sulfur content in coal with a heat value of 12,000 to 14, 000 BTU per pound. The Oklahoma Geological Survey [24] estimated that the weighted average sulfur content of coal resources in the state is 2.2 percent with a local maximum and minimum sulfur content of 5.0 and 0.4 percent, respectively. Consequently, the Oklahoma gas and electric companies use low-sulfur coal shipped from Wyoming to generate 2,930 mega watts of electricity in 1975 [109]. However, Oklahoma coal, once washed and scrubbed of sulfur pollutants, could become more cost effective than coal hauled all the way from Wyoming. Wyoming coal costs from $5 to $7 per ton but, by the time it reaches Oklahoma, freight has pushed the cost to $22 per ton. And Wyoming coal contains only 8,000 BTU per ton. Oklahoma coal could be bought from a moderate-sized firm, scrubbed and trucked to the electricity generating plant for $22 and have coal containing 12,000 BTU per ton [63].

Oklahoma coal represents still another energy source in an already energy rich state. As the nation becomes increasingly aware of the value of coal as a secure source of energy, the future appears bright for the coal industry in Oklahoma.

CHAPTER X

SUMMARY, EVALUATION, AND LIMITATIONS

Summary

The increasing dependence upon energy for society's economic and cultural needs with rapidly rising demand for and declining supplies of conventional energy products, led to the current national energy problems. In Oklahoma, however, energy production is also an extremely important element of it's economic base. This study investigates the long-term structural adjustments of the state economy in relation to alternative energy choices. The major objective of this study is to construct a comprehensive energy data base for Oklahoma for 1972 and to integrate this information into a dynamic simulation and input-output model for purposes of evaluating the alternative energy choices and projecting economic variables such as employment, income, population, and government revenues. The data base is constructed using secondary data. The Oklahoma input-output structure consists of eighty-one processing sectors, seven dummy and special industries, and eight final demand sectors.

The social accounting system for Oklahoma for 1972 is presented in five major accounts: (1) interindustry, (2) capital, (3) human resources, (4) government, and (5) energy. The interindustry account is the base of the social accounting system. The capital account, the human resource account, the government account, and the energy account are connected to the interindustry account.

The interindustry account consists of the transactions matrix, a direct coefficients matrix, and a direct and indirect coefficients matrix. The transaction matrix is basically derived from the 1972 input-output structure of the U.S. economy. By collecting the state sector output totals the location quotient approach is utilized to construct the state transaction matrix. State direct input coefficients are assumed the same as the national direct coefficients for self-sufficient and surplus producing sectors. Adjustments are made to the national direct coefficients of deficit producing sectors using location quotients to allow for state imports. State direct input requirements and total requirements are obtained by mathematical manipulation. The transactions matrix is an empirical description of the flow of inputs and outputs in the state economy in 1972. The direct coefficients matrix estimates the initial, direct effect on sectors of the economy when a given sector expands its output. The total requirements matrix estimates the total direct and indirect effect on the processing sectors from an increase in final demand for output of the processing sectors.

A capital account is important for a dynamic model. It provides the basis to evaluate the change in capacity on the capital economy due to economic growth or a structural change resulting from an energy choice. The capital account includes estimates of a capital coefficient matrix, capital-output ratios, the capital stock, investment coefficients, capacity levels, capital unit matrix, and depreciation coefficients. The capital coefficient matrix forms the core of this account. Each capital coefficient is an estimate of the amount of capital goods purchased from a row sector per dollar of capital expenditures made by each column sector. Capacity operating levels for 1972 in each sector are estimated by using peak period employment data. Capital-output ratios are defined as the ratio of the total cost of plant and equipment to output at capacity. The capital stock matrix consists of the total value of capital goods in each sector. Depreciation rates represent annual depreciation per dollar of depreciable assets.

The human resource account is an important part of the social accounting system. Estimates of population, employment and income are included in this account to provide measures of regional impacts of alternative energy choices on the level of employment, income and population. The population section is a separate component of the simulation model. A cohort approach is used to project total Oklahoma population. The main parameters are: birth rates, death rates, trend in death rates, migration rate and initial population. The employment section includes sector wage and salary employment, proprietor employment, total employment, and output-employment ratios. Sector total employment represents wage and salary plus proprietor employment. Output-employment ratios indicate the value of the output produced by each employee in each sector. The income section includes wage and salary and proprietor incomes, wage and salary and proprietor income rates, total personal income, and disposable income. Wage and salary and proprietor income rates indicate the wage and salary and proprietor income payments per employee, respectively, in each sector. Total personal income is determined by summation of sector wage and salary and proprietor incomes, property income, other labor income, and transfer payments and subtraction of personal contributions to social insurance. Disposable income is determined by subtracting personal taxes from total personal income. Per capita personal income and per capita disposable income are estimated by dividing total personal income and disposable income by total population of Oklahoma.

The government account is also an important element in the social accounting system in providing the basis for estimating government expenditures and revenues due to alternative energy choices. Government account is constructed around two groups of activities: federal government and state and local government. Federal government expenditures are estimated on a trend basis. State and local government revenues are estimated by regression in six components: (1) state sales tax, (2) individual income tax, (3) gasoline and fuels excise tax, (4) all other state and local taxes, (5) federal aid to state and local governments, and (6) all other state and local revenues. State and local government expenditures are estimated in a similar way to the state and local government revenues. State and local government expenditures include expenditures on (1) education, (2) highways, (3) public welfare, (4) health and hospitals, and (5) all other state and local government expenditures.

The energy account is the unique component of the social accounting system and the core of the entire study. It provides the basis to evaluate the state energy requirements, state energy trade and measures of regional impact of alternative energy choices upon the level of employment, income government revenues, and population. The energy account presents sector disaggregation of energy consumption and energy production by basic energy sources — petroleum products, natural gas, coal, and electricity and hydropower measured in BTU. Direct energy requirements per unit output are estimated by sector and energy source.

The simulation model is formulated around an input-output system of analysis. The model consists of a series of 119 major equations constructed in a recursive sequence to describe the dynamic behavior of the state economy. Operation of the model for a given year involves: (1) estimating final demand; (2) determining sector output; (3) projecting state economic variables such as employment, income, government revenues, and gross state product; and, (4) projecting state energy requirements and energy trade.

The standard solution to the input-output model as presented in Chapter III, $X = (I - A)^{-1}Y$, has been altered to accommodate the separation of the processing sectors of the state economy into two groups. The first group includes the non-energy sectors whose outputs are determined by the final demand for their output and by the direct requirements of the energy sectors. The second group includes the energy sectors whose outputs are determined exogenously and fed into the model. In accordance with this division of processing sectors, the disposition of output equation is partitioned into submatrices representing supply output determined energy and demand output determined non-energy sectors. Using the subscript "1" for demand output non-energy sectors and subscript "2" for supply output energy sectors the equation for disposition of output is written:

$$\begin{bmatrix} X_1 \\ \hline X_2 \end{bmatrix} = \begin{bmatrix} A_{11} & \vdots & A_{12} \\ \hline A_{21} & \vdots & A_{22} \end{bmatrix} \cdot \begin{bmatrix} X_1 \\ \hline X_2 \end{bmatrix} + \begin{bmatrix} D_1 + T_1 \\ \hline D_2 + T_2 \end{bmatrix}$$

where A_{ij}'s are partitions of the direct coefficients matrix, X's are the outputs, D's are final demands with no trade, and T's are the trade. The matrix equation can be rewritten as two equations, the first representing the disposition of output for the non-energy sectors:

$$X_1 = A_{11}X_1 + A_{12}X_2 + D_1 + T_1$$

$$X_2 = A_{21}X_1 + A_{22}S_2 + D_2 + T_2$$

The output of the energy sectors, X_2, is exogenous. The two solutions required and determined in the simulation and input-output model are the values of X_1 and T_2 in which the equations are written as follows:

$$X_1 = (I - A_{11})^{-1} [A_{12}X_2 + D_1 + T_1] \text{ and } T_2 = (I - A_{22})\ X_2 - A_{21}X_1 - D_2$$

where T_2 is the state energy trade. The formation of these equations differs from the "standard solution" of input-output models in view of the adjustments made. However, the general formulation of the model is consistent with the input-output structure. The model is formulated in Fortran and run on the computer.

Evaluation

Baseline projections of economic variables in the Oklahoma simulation model are on an annual basis so that time paths from the base year 1972 to the terminal year 2000 can be traced and analyzed. Input data for these simulations are presented in Chapters III-VI and in Appendices A, B, and C. The input data are linked to a simulation model formulated in Chapter VII. The terminal year, 2000, was selected to observe the effects of alternative energy choices and other uses in Oklahoma. Empirical estimates of variables of primary interest to planners in business, industry and government are presented: population, employment, government revenues and expenditures, income, gross state product, and state energy production, consumption and trade. Oklahoma population is projected to increase by 38.1 percent from 1973 to 2000 with an average rate of increase of about 1.2 percent annually. Population projection closely follows the trend in its determining factors such as birth rates, death rates, trend in death rates and migration rates. According to the projections, Oklahoma population is expected to increase consistently throughout the 28-year simulated period of time.

Total employment is expected to increase by 69.4 percent from 1973 to 2000. Wage and salary employment is projected to increase from 1973 to 2000 by 71.6 percent whereas proprietor employment by 62.2 percent. The slower rate of growth in proprietor employment is due basically to the decline in the proprietor employment in the agricultural sector which constitutes the large majority of total proprietor employment. As the economic activity increases a continued decline in proprietor employment in the agricultural sector is expected which offsets the increase in proprietor employment of the other sectors. This is an indication of capital intensity and concentration of large size farms in the agricultural sector and an out-migration of farm population to the urban areas for employment.

Total personal income constitutes wages and salary payments, proprietor income, property income, other labor income, transfer payments less personal contributions to social insurance. Total personal income is expected to increase by 292.4 percent from 1973 to 2000. Individual rates of increase for the components of total personal income are: wage and salary payments by 251.8 percent, other labor income by 668.2 percent, property income by 284.3 percent, and transfer payments by 558.4 percent. Wage and salary payments follow patterns which are similar to wage and salary employment projections. Proprietor income also follows the trend in proprietor employment and is expected to increase by 196.7 percent from 1973 to 2000.

Disposable income which is directly affected by personal income and federal and state and local government individual income taxes, is expected to increase from 1973 to 2000 by 293.8 percent whereas disposable income per capita and personal income per capita are expected to increase by 185.1 percent and by 184.1 percent, respectively. Gross state product is expected to increase by 182.5 percent from 1973 to 2000.

In this study there is a level of public services determined by the simulation model. This includes the projections of federal government revenues and state and local government revenues and state and local government expenditures. Total state and local government revenues from 1973 to 2000 are expected to increase by 325.1 percent while individual rates of increase for the six components of state and local government revenues are: state sales taxes by 286.2 percent, gasoline fuels excise and special fuel use tax by 165.2 percent, individual income tax by 808.3 percent, other state and local taxes by

292.4 percent, federal aid to state and local governments by 277.1 percent and other state and local revenues by 292.4 percent.

Total state and local government expenditures are expected to increase from 1973 to 2000 by 283.3 percent, whereas the individual rates of increase of the five components of state and local government expenditures are: education expenditures by 270.8 percent, highway expenditures by 243.7 percent, public welfare expenditures by 253.6 percent, health and hospital expenditures by 347.5 percent, and other state and local government expenditures by 337.2 percent. Federal government revenues are expected to increase by 245.5 percent from 1973 to 2000.

Projections of energy production are determined exgenously and incorporated into the simulation model. Total annual rate of growth of energy production is expected to decrease from 1973 to 2000 by 1.0 percent. The declining trend in total energy production and consequently the energy trade is attributed to the decline in the production of petroleum products and natural gas. Natural gas and petroleum products are expected to decrease from 1973 through 2000 at average annual rates of 0.1 percent and 1.1 percent, respectively. Coal and electricity are expected to increase at average annual rates of 3.4 percent and 4.2 percent, respectively.

Total energy consumption is expected to increase from 1973 to 2000 by 177.8 percent, whereas the rates of increase for individual components of energy consumption are: petroleum products by 213.5 percent, natural gas by 154.6 percent, coal by 130.2 percent, and electricity by 221.5 percent.

Projected state energy trade is estimated as the difference between energy production and energy consumption. Total state net energy trade is expected to decrease from 1973 to 2000 by 85.7 percent whereas the rates of change for individual components of energy trade vary in different directions. Energy trade is expected to decline by 110.5 percent for petroleum products and by 83.9 percent for natural gas. Projected coal trade is expected to increase by 144.5 percent and electricity is expected to increase by 159.9 percent from 1973 to 2000.

The impact analysis consists of measuring the effect of a 25 percent increase in the growth rates of petroleum products and natural gas production, 25 percent increase in the growth rate of coal production, and 25 percent increase in the energy efficiency in the year 2000 compared to the energy efficiency in the 1972 base period. The expected changes on total employment, personal income, government revenue and expenditure and state energy trade due to the assumed changes were presented for evaluation.

Total employment is expected to increase by 2,606 and income by $36,259,000 in 2000, in 1972 prices, from a 25 percent increase in the growth rates of petroleum products and natural gas production. Total state and local government revenue and expenditure are expected to increase by $6,045,000 and by $6,404,000 in 2000, in 1972 prices, respectively. Total federal government revenue is expected to increase by $5,965,000 in 2000, in 1972 prices. Total state energy trade is expected to increase by 71,285.753 billion BTU's in 2000. Energy trade increases by energy sources are: petroleum products by 69,430.966 billion BTU's, natural gas by 2,086.246 billion BTU's, coal by

5.292 billion BTU's, and electricity including hydropower by 226.167 billion BTU's, in 2000.

Total energy trade is expected to increase by 35,044.311 billion BTU's in 2000 because of the assumed 25 percent increase in the annual growth rate of coal production. Energy trade of individual energy sources is expected to decrease: petroleum products by 549.578 billion BTU's, natural gas by 541.744 billion BTU's, and electricity including hydropower by 351.096 billion BTU's in 2000. Coal trade is expected to increase by 36,487.401 billion BTU's in 2000. Total employment is expected to increase by 775 and total personal income is expected to increase by $11,539,000 in 2000, in 1972 prices. Total state and local government revenue and expenditure are expected to increase by $1,924,000 and by $1,929,000 in 2000, in 1972 prices, respectively. Total federal government revenue is expected to increase by $1,898,000, in 2000, in 1972 prices.

Energy efficiency is assumed to increase by 25 percent in the year 2000 compared to the efficiency in 1972 base period. To achieve this efficiency the growth rates of ratios of final energy demand by household to total disposable income, final energy demand by federal government to total federal government expenditure, and final energy demand by state and local government to total personal income, are proposed to decrease each at the rate of 1.02 percent annually from 1972 to 2000. Because of this change total energy trade is expected to increase by 269,164.939 billion BTU's, in 2000. Energy trade of individual energy sources is expected to increase: petroleum products by 148,306.551 billion BTU's, natural gas by 91,126.926 billion BTU's, and electricity including hydropower by 29,731.462 BTU's, in 2000.

Change in coal trade is very insignificant.

Limitations

Data Limitations

The lack of appropriate data is a major constraint for the simulation model of this study. The study used secondary data based on national coefficients. Data limitations occur since a vast amount of data are required and time and funds prohibited the collection of primary data. With primary data, the model could have been developed in greater detail, allowing a more comprehensive analysis.

The capital account has data limitations. National data for 1967 are used to estimate the capital coefficient matrix. They are the latest and most detailed data available for the study period. Marginal rather than average capital-output ratios and state rather than national capital-output ratios should be used. Capacity levels are estimated using employment peaks on a quarterly basis rather than the preferable quarterly industrial production indexes. Additional refinements of the human resource account are also possible. National figures on birth rates, death rates and trends in these rates are used in the population model. Oklahoma data consistent with the model are not available.

The energy account has data limitations by sector disaggregation and energy source both for processing and final demand sectors. The national and regional ratios of sector distribution of energy consumption by energy source are used at the state level. Lack of time series data in energy consumption by final demand sectors in estimating annual growth rates for each energy source is a limitation.

Model Limitations

Model assumptions also limit the study. The simulation model is built around the input-output model and thus has basic input-output assumptions. The most serious assumption is that technical coefficients are fixed which implies no input substitution and constant technology. For shortrun projections, the fixed coefficient assumption is not a major limitation. However, fixed input coefficients for a 28 year projection of an economy experiencing rapid changes, can limit usefulness of results. To provide for some adjustment, capital-output and labor-output ratios follow a trend to reflect improved technologies. The accelerator principle assumed in the capital investment equation and the constant export share assumption in the export equation are limitation inherent in the model.

Moreover, it has been observed that energy prices particularly for petroleum products and natural gas have been rapidly increasing with the sharply rising demand for and declining supply of energy products. Consequently an alteration of social and economic structures may occur over time. In due course, new developments and substitutions of energy products may create environmental impacts due to changing energy choices over time.

Additional Research

Further research is needed to alleviate the above mentioned data and model limitations. With more data, additional equations could be included in the model, making it more realistic in testing such strategies as state energy programs and environmental policy. For instance, to evaluate the energy resource usage patterns requires more complex modeling of such factors as effects of environmental and other government legislation, higher prices of imported energy, different levels of technological change and other related factors. The implementation of federal or state and local government energy programs and environmental restrictions may effect the state economy differently. The impacts of these government programs can be analyzed and measured in terms of jobs created and income and government revenue generated if appropriate adjustments are made with the simulation model. A more detailed model will provide more information concerning the condition of the state economy in general and the state energy in particular. Moreover, a more detailed model would involve a great deal of time and money, as primary data would have to be collected.

Additional research is needed to apply the Oklahoma simulation model as an inter-regional model in analyzing the economy of eastern Oklahoma, particularly the coal region. Such an analysis would indicate the economic conditions within the region, as well as how the economic conditions of the region effect or are effected by the conditions of the rest of the state. The model could project economic variables and analyze the impact of alternative planning actions. The impact of investment and expansion of the coal industry, other government energy programs and environmental restrictions could be determined from the inter-regional simulaton model. The implementation of an inter-regional simulation model would again require a large amount of primary data. However, the results would be useful to industrial, governmental and agricultural planners.

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APPENDIXES

APPENDIX A

METHODS AND SOURCES USED FOR THE CONSTRUCTION
OF SECTOR CONTROL TOTALS OF OUTPUT,
OKLAHOMA, 1972

CLASSIFICIATION OF INDUSTRIES

The Oklahoma model consists of 81 endogenous industries and 15 exogenous industries. Production is grouped into 88 industries as the industrial categories, input-output numbers and SIC composition are given in the table on the following page. Seventy-nine of these are combinations of industries as defined in the Standard Industrial Classification Manual, 1972 edition [23]. Two are government enterprises, which are not identified in the SIC. Seven are special industries established because they improve the classification if industries for input-output purposes [80]. Table XLI summarizes a classification of all the categories. All data refer to 1972 in current prices.

Definition of Industries and Sources of Data

1. Agricultural, Forestry, and Fishery Sectors

The output of the agricultural industries is the value of all farm production. It is defined on a commodity basis. The output total for a given industry covers all farm production of the products primary to that industry, whether they are produced for sale or for their own use and whether or not they are produced on farms whose major products were primary to that industry.

TABLE XLI

INDUSTRY CLASSIFICATION OF THE 1972 OKLAHOMA INPUT-OUTPUT TABLE

Industry Number and Title	Related Census-SIC Codes (1972 Edition)
Agriculture, Forestry, and Fisheries	
1. Livestock and livestock products	pt. 01, pt. 02
2. Other agricultural products	pt. 01, pt. 02
3. Forestry and fishery products	081-4, 091, 097
4. Agricultural, forestry, and fishery services	0254, 07 (excl. 074), 085, 092
Minirg except fuels	
5. Iron and ferroalloy ores mining	101, 106
6. Nonferrous metal ores mining	102-5, pt. 108,109
7. Stone and clay mining and quarrying	141-5, pt. 148, 149
8. Chemical and fertilizer	147
Construction	
9. New construction	pt. 15-17, pt. 108, pt. 1112, pt. 1212, pt. 148
10. Maintenance and repair construction	pt. 15-17, pt. 138
Manufacturing	
11. Ordnance and accessories	3482-4, 3489, 3761 3795
12. Food and kindred products	20
13. Tobacco manufactures	21
14. Broad and narrow fabrics, yarn and thread mills	221-4, 226, 228
15. Miscellaneous textile goods and floor coverings	227, 229
16. Apparel	225, 23 (exel. 239)
17. Miscellaneous fabricated textile products	239
18. Lumber and wood products, except containers	241-3, 2448, 249
19. Wood containers	2441, 2449
20. Household furniture	251
21. Other furniture and fixtures	252-4, 259
22. Paper and allied products, except containers and boxes	261-4, 266
23. Paperboard containers and boxes	265
24. Printing and publishing	27
25. Chemicals and selected chemical products	281, 286-7, 289
26. Plastics and synthetic materials	282
27. Drugs, cleaning and toilet preparations	283-4
28. Paints and allied products	285
29. Paving and Roof Materials	295
30. Rubber and miscellaneous plastics products	30
31. Leather tanning and finishing	311
32. Footwear and other leather products	313-7, 319
33. Glass and glass products	321-3
34. Stone and Clay products	324-9

TABLE XLI (Continued)

Industry Number and Title	Related Census-SIC Codes (1972 Edition)
35. Primary iron and steel manufacturing	331-2, 339, 3462
36. Primary nonferrous metals manufacturing	333-6, 3463
37. Metal containers	341
38. Heating, plumbing, and fabricated structural metal products	343-4
39. Screw machine products and stampings	345, 3465-6, 3469
40. Other fabricated metal products	342, 347,349
41. Engines and turbines	351
42. Farm and garden machinery	352
43. Construction and mining machinery	3531-3
44. Materials handling machinery and equipment	3534-7
45. Metalworking machinery and equipment	354
46. Special industry machinery and equipment	355
47. General industrial machinery and equipment	356
48. Miscellaneous machinery, except electrical	359
49. Office, computing, and accounting machines	357
50. Service industry machines	358
51. Electrical transmission and distribution equipment and industrial apparatus	361-2, 3825
52. Household appliances	363
53. Electric lighting and wiring equipment	364
54. Radio, T.V. and communication equipment	365-6
55. Electronic components and accessories	367
56. Miscellaneous electrical machinery, equipment, and supplies	369
57. Motor vehicles and equipment	371
58. Aircraft and parts	372
59. Other transportation equipment	373-5, 3792, 3799, 2451
60. Professional, scientific, and controlling instruments and supplies	381, 3822-4, 3829, 384, 387
61. Optical, ophthalmic, and photographic equipment and supplies	383, 385-6
62. Miscellaneous manufacturing	39
Transportation, Communication, and Utilities	
63. Transportation and warehousing	40-2, 44-7
64. Communications, except radio and T.V.	481-2, 489
65. Radio and T.V. broadcasting	483
66. Water Supply and Sanitary Services	494, 495, 496

TABLE XLI (Continued)

Industry Number and Title	Related Census-SIC Codes (1972 Edition)
Wholesale and Retail Trade	
67. Wholesale and retail trade	50-57, 59, 7396, 8042
Finance, Insurance, and Real Estate	
68. Finance and insurance	60-74, 67
69. Real estate and rental	65-6, pt. 1531
Services	
70. Hotels and lodging, personal and repair services (except auto)	70-72, 762-4, pt. 7699
71. Business services	73 (excl. 7396), 7692, 7694, pt. 7699
72. Eating and drinking places	58
73. Automobile repair and services	75
74. Amusements	78-9
75. Health, educational, and social services and nonprofit organizations	074, 80 (excl. 8042), 32-84, 86, 8922
Government Enterprises	
76. Federal Government enterprises	not applicable
77. State and local government enterprises	not applicable
Energy Sector	
78. Petroleum Production	291, 299, 131 pt., 132 pt.,
79. Natural Gas Production	492, 131 pt., 132., 138 pt.
80. Coal Mining	1111, pt. 1112, 1211, pt. 1211
81. Electricity and Hydro Power	491
Dummy and Speical Industries	
82. Noncomparable imports	
83. Direct Imports	
84. Scrap, used, and secondhand goods	
85. Government industry	
86. Rest of the world industry	
87. Household industry	
88. Inventory valuation adjustment	
89. Value Added	
90. Total Inputs	

TABLE XLI (Continued)

Industry Number and Title	Related Census-SIC Codes (1972 Edition)
Final Demand	
91. Personal consumption expeditures	
92. Gross private domestic fixed investment	
93. Change in business inventories	
94. Net export	
95. Federal government purchases, national defense	
96. Federal government purchases, nondefense	
97. State and local government purchases, education	
98. State and local government purchases, other	
99. Total Final Demand	
100. Total Output	

Detailed information for the value of the agricultural commodities in 1972 are obtained mainly from the Oklahoma Agriculture, 1972 [39], Agricultural Statistics, 1972 [71]. The data are supplemented by the Farm Income Situation [74], 1973 Fisheries of the United States [97] and 1969 Census of Agriculture [82] and 1974 Census of Agriculture [83].

I/01. Livestock and Livestock Products

The output of this industry includes the output of primary products and secondary products and receipts. The major secondary receipts are the farm rental received and secondary dairy products. The list of items included and estimated values are presented in Table XLII.

TABLE XLII

ESTIMATED OUTPUT FOR LIVESTOCK AND LIVESTOCK PRODUCTS OKLAHOMA, 1972

Components	Values ($'000)
Cattle and Calves	1,033,790
Hogs and Pigs	12,672
Sheep and Lambs	1,769
Wool	286
Farm Dairy Products	76,940
Chickens	3,347
Turkeys	6,408
Eggs	13,219
Honey and Beeswax	977
Farm Rental Received	47,205
TOTAL	1,196,613

Farm rental received are allocated to livestock and livestock products and to other agricultural products (mainly crops) by assuming each sector's share in proportion to their total output.

I/02. Other Agricultural Products

The output of this industry includes farm production for open market sale. It includes a portion of farm rental received and government payments. The estimated values of the components included in this industry are presented in Table XLIII.

I/03. Forestry and Fishery Products

The output of this industry includes raw furs, standing timber, Christmas trees, tree seeds and seedlings, gums, barks and miscellaneous forest products and products of fisheries. The estimated values of the items produced in Oklahoma includes the following:

Components	Value ($'000)
Forest	668
Greenhouse and Nursery	9,924
Fishery Products	94
TOTAL	10,686

I/04. Agricultural, Forestry and Fishery Services

Output is defined on an activity basis and includes (1) cotton ginning, fruit picking, crop dusting, custom work and other agricultural services, (2) poultry hatching, (3) animal breeding, (4) forestry services and operation of fish hatcheries. The estimated values of the activities that took place in Oklahoma are:

TABLE XLIII

ESTIMATED OUTPUT FOR OTHER AGRICULTURAL PRODUCES, OKLAHOMA, 1972

Components	Values ($'000)
Wheat	152,490
Oats	4,999
Barley	9,477
Rye	1,462
Corn for Grain	9,289
Sorghum for Grain	38,197
Sorghum for Silage	500
Cotton Lint and Cotton Seed	48,397
Soybeans for Beans	15,101
Peanuts for Nuts	33,971
Alfalfa Seed	1,766
All Hay	92,768
Broom Corn	1,056
Lespedeza Seed	50
Hairy Vetch Seed	202
Strawberries	593
Vegetables (watermelon, spinach, snap beans)	2,726
Peaches	1,862
Pecans	2,028
Government Payments	99,579
Farm Rental Received	21,995
TOTAL	557,543

Components	Value ($'000)
Cotton Ginning	6,361
Machine Hire and Custom Work	39,194
Chicks Hatched	
Broiler Type	411
Egg Type	699
Turkey Poults Hatching	570
TOTAL	47,235

In 1972 there were 332,000 bales of cotton at $19.16 cost per bale. The custom work in general is assumed equal to the values of machine hire and custom work. The value is estimated on the basis of the values of 1969 [82] and 1974 Census of Agriculture [83]. The values of the chicks hatched estimated on the basis of number of chicks hatched and the cost per 100 hatched. There were 2,282,000 broiler type at $18.00 per 100 and 2,598,000 egg type at the cost of $26.90 per 100. Oklahoma turkey poults hatched in 1972 were 1,007,000. To estimate the value the price at national average of 0.566 per bird hatched is used. Other agricultural, forestry and fishery services are not available for consideration.

2. Mining Except Fuels Sector

Non-energy mining industries are defined on an establishment basis which include extraction of solid minerals occurring naturally. That is, each industry includes the value of shipments and receipts from all economic activities, both primary and secondary performed by the establishments. The output of the non-energy mining sector specified by the list of industries mentioned below are based on the values of receipts plus the value of minerals used in the non-energy mining sector. The state values of production for the four industries comprising the mining sector are as follows:

I/O	Industry Title	Value ($'000)
5.	Iron and Ferroalley Ores Mining	0
6.	Nonferrous Metal Ores Mining	2,804
7.	Stone and Clay Mining and Quarrying	27,676
8.	Chemical and Fertilizer Mineral Mining	20
	TOTAL	30,500

Estimates concerning the value of production for the non-energy mining industries are based largely on the data from 1972 census of Mineral Industries [87] supplemented by the U.S. Bureau of Mines, Minerals Yearbook 1972 [106]. The census source provides data on total receipts for each 3 or 4 SIC digit mining industry; these are subsequently aggregated to the desired classification defined for the state input-output study.

3. Construction Sector

Output of new construction and maintenance and repair construction, reflect the value created by erecting and maintaining structures and other facilities. Output of new construction is defined on an activity basis and measures the value put-in-place of private and public original erections, additions and alternations which increase or alter the stock of facilities [64].

New construction includes building and non-building facilities. It also includes the value of materials used in residential construction performed by households on a do-it-yourself basis. Equipment that is an integral part of the facility and essentials for its general use is included in the value of construction. Construction covers the value of work of construction contractors, operative builders and establishments performing oil and gas field services that are performed in the mining industries.

Maintenance and repair construction includes the value created by any economic sector in maintaining or restoring the existing stock of facilities [64]. The cost of which are charged to current expense. It also includes an estimated value of materials used in residential maintenance performed by households on do-it-yourself basis [64]. Total value of output includes the maintenance by government agencies or non-construction firms with their own employees. The output values for construction industries in Oklahoma are as follows:

I/O	Industry Title	Value ($'000)
9.	New Construction	1,423,337
10.	Maintenance and Repair Construction	180,627
	TOTAL	1,603,964

The values of output for the construction industries appear in the 1972 Census of Construction Industries [84] and U.S. Bureau of Mines, 1972 Minerals Yearbook [106].

4. Manufacturing Sector

Output of each industry in the manufacturing sector consisting of 52 sectors is defined as the value of production of the industries in that sector. Manufacturing outputs are based on establishment in that sector and therefore include receipts from primary and secondary activities performed by the various establishments [64].

Because the value of shipments constitutes the major portion of the value of production, as defined for an input-output industry, is generally considered a relatively good proxy of the pattern of state outputs. Minor items included in the definition of output, but excluded from the value of shipments, consist of work-in process and finished goods inventory changes. Therefore, shipments data are then groups by input-output industry definition and aggregated in 52 industries. Each industry's output is estimated by adding the value of shipments and the value of inventory change in which case the total available state value of inventory change is allocated to the various industries inproportion to the distribution of value of shipment of each industry to the total state value of shipments. Output estimates of the industries in the manufacturing sector are presented in Table XLIV. The values of shipments and inventory changes for the manufacturing sector are obtained from the 1972 Census of Manufacturing [86].

The general services are divided into four major sectors namely (1) Transportation, Communication and non-energy Utilities, (2) Wholesale and Retail Trade, (3) Finance, Insurance and Real Estate, and (4) Services. These broad sectors are given jointly because same techniques are used to estimate each sector's output. No source indicates the output directly for the state. Therefore, it needs to be estimated from the national data. For the estimates, it is assumed that the ratio of output between Oklahoma and the United States is the same as the ratio of employment between Oklahoma and the United States. In other words it is assumed that the labor productivity of Oklahoma is equal to that of the nation. By this method, output is estimated for each sector as shown below.

5. Transportation, Communication and Utilities Sector

The output of this sector is defined on a modified activity basis. It is the value of receipts received by all private establishments.

I/O	Industries	Value ($'000)
63.	Transportation and Warehousing	911,481
64.	Communications Except Radio and T.V.	313,093
65.	Radio and T.V. Broadcasting	53,655
66.	Water Supply and Sanitary Services	38,976
	TOTAL	1,317,976

6. Wholesale and Retail Trade Sector

The output of wholesale and retail trade is defined on a gross margins basis. It reflects a modified activity definition. Its major receipts are gross margins (operating expenses plus profits) from the reselling activities of wholesale and retail trade establishments. It is the value of services performed in handling goods. The output estimate is obtained as:

I/O	Industries	Value ($'000)
67.	Wholesale and Retail Trade	2,567,829

7. Finance, Insurance and Real Estate Sector

The output is defined as the value of receipts received for services in this sector. The output estimates for the industries included in this broad sector are as follows:

I/O	Industries	Value ($'000)
68.	Finance and Insurance	806,665
69.	Real Estate and Rental	2,059,183
	Total	2,865,848

8. Service Sector

The output is defined on an activity basis as the amount paid to the industries of this broad sector for their service activities. The values of output of the industries are given below:

I/O	Industries	Value ($'000)
70.	Hotels and Lodging, Personal and Repair Services (Except Auto)	343,597
71.	Business Services	637,560
72.	Eating and Drinking Places	584,785
73.	Automobile Repair and Services	298,335
74.	Amusements	113,010
75.	Health, Educ. and Social Services and Non-Profit Organ.	971,511
	TOTAL	2,948,798

The output for the industries in the general services are estimated by using the information in the Survey of Current Business, 1972 Input-Output Structure of the U.S. Economy [80]. Employment statistics both for the United States and Oklahoma industries are available in the County Business Patterns [88].

I/O

76. Federal Government Enterprise

This industry includes all the activities of those federal government agencies, with separate accounting records, that cover over half of their current operating cost by the sale of goods and services to the general public. State outputs of federal government enterprises includes three major components: (1) post office services, (2) the receipts of post exchanges, and (3) the value of services provided by other government enterprises [64]. No source indicates the state output directly. It is, therefore, estimated from national data. To construct state estimates of output of federal government enterprises, it is assumed that the ratio of output between Oklahoma and the United States is the same to the ratio of total government personnel consisting both the active duty military personnel and civilians between Oklahoma and the United States. By this method, output is estimated at $222,640,000. The main source of national output is the 1972 Survey of Current Business [80]. Government personnel statistics are obtained from Selected Manpower Statistics [98] and 1975 Statistical Abstract of the United States [91].

I/O

77. State and Local Government Enterprises

Output is defined as revenue received. This industry holds the activities of the state and local government agencies, with separate accounting records, that cover over half of their current operating costs by the sale of goods and services to the general public. State and local government enterprises includes: (1) gas and electric utilities, (2) water supply facilities, (3) transit facilities, (4) liquor stores, (5) water transportation and terminals, (6) air transportation facilities, (7) highway toll facilities and such activities as (8) sewers and sewage disposal, (9) low-cost housing and urban renewal, and (10) some miscellaneous activities such as offstreet parking and city markets [64]. State output for the state and local government enterprises is estimated on the basis of ratio of Oklahoma revenue to U.S. revenue for the items mentioned above multiplied by the industry output for the United States. The output of the Oklahoma state and local government enterprises is estimated at $116,832,000. Industry output for the United States is obtained by using the information in the 1972 Survey of Current Business [80]. The U.S. and Oklahoma revenues for the included activities are obtained from the 1972 Census of Governments [85].

9. Energy Producing Sector

Output of these sectors is defined as energy produced in BTU. The quantities usually reported are material quantities such as tons of coal, barrels of crude oil, cubic feed of natural gas, kilowat hour of electricity, etc. The initial material quantities of energy output in units to a particular energy source are converted to BTU units. The Bureau of Mines [7] American Gas Association [2] and National Coal Association [37] are the primary source for scale factors converting original measures to BTU. The raw data on physical units for the energy sources are obtained from the Bureau of Mines, Mineral Yearbook [106] and Edison Electricity Institute Yearbook [11]. The output in BTU are given by energy sectors as follows:

I/O	Industries	
78.	Petroleum Products Production	1242.382147
79.	Natural Gas Production	1864.707384
80.	Coal Mining	63.107200
81.	Electricity and Hydro-Power	102.280313
	TOTAL	3272.476998

10. Dummy and Special Industries

In accordance to the 1972 input-output industrial classification of Oklahoma economy, there are seven special industries established to improve the classification of industries for input-output purposes. These industries are identified individually as listed below.

11. Imports

Imports are divided into two categories namely non-comparable imports and direct imports. Imports that are not comparable to domestically produced commodities are shown in this category as noncomparable imports at foreign port value. This activity represents payments to foreigners for merchandise, services and the factors of production. Direct imports are payments for goods and services directly imported from other industries outside the state. The values of these categories for the various industries estimated on the basis of the location quotient approach derived in Chapter III.

12. Scrap, Used and Secondhand Goods

This is a "dummy" industry. It has not primary output and does not correspond to any SIC category. The output total is composed of transfer from various intermediate industries of currently produced scrap and from imports. The state output values and distribution of scrap, used and secondhand goods is based on the estimation made using the national coefficients [79].

13. Rest of the World Industry

This industry reflects the income and product originating in the rest of the world. It reflects foreign transactions relating to various activities, government receipts and payment of interest and foreign travel and living expenditures. State value for this category is estitravel and living expenditures. State value for this category is estimated on the basis of the national coefficients [79].

14. Household Industry

This industry measures income and product originating in households. Expenditures for goods and services by individuals appear as purchases by the household industry on the product side. Represented on the income side is the household income or output which includes wages and salaries, proprietor income, other labor income, property income and transfer payments. It is estimated to be $10.359 billion. The values are obtained from the 1975 Statistical Abstract of Oklahoma [5].

15. Inventory Valuation Adjustment

The purpose of this category is mainly to make the necessary adjustments to establish consistency for the change in business inventories. State value is based on the national coefficient [79]. It is estimated to be $61,722 million.

16. Final Demand Sectors

In accordance to the 1972 U.S. Input-Output Study six major categories of final demand are identified in this study. These are: (1) personal consumption expenditures (PCE), (2) gross private capital formation (GPCF), (3) net inventory change (NIC), (4) net export, (5) federal government purchases (SLGP). The federal government and state and local government purchases are subdivided each into two categories.

This section presents a brief overview of the methodology and data base behind the estimates for each category.

Personal Consumption Expenditures (PCE) Personal consumption expenditures represents the largest, the most important item of the six components of final demand at state and national level. The aggegate sum of PCE includes all actual expenditures for goods and services by private individuals plus the services rendered to individuals by non-profit institutions [67]. There is a lack of any really reliable comprehensive expenditures data on the differences in consumption patterns by residence, type of family and family income at state level. The Consumer Expenditures Survey (CES) published by the U.S. Department of Labor, Bureau of Labor Statistics [103] does not provide a comprehensive consumption expenditures state data for analysis [67]. Since no source indicates the personal consumption expenditures directly for the state, it needs to be estimated from the national data [80]. It is assumed that the ratio of personal income between Oklahoma and the United States is the same as the ratio of personal consumption expenditures between Oklahoma and the United States. In other words, it is assumed that the national average expenditure rate and saving rate are equal to the state rates. By this method the personal consumption expenditures (PCE) for the State of Oklahoma in 1972 is estimated at $7,887.032 million. The total estimated personal consumption expenditures for the state are allocated into the input-output industry groupings by using the national coefficients [79].

Gross Private Capital Formation (GPCF) The total amount of capital investment made by the private sector are included in this sector's output. This value consists of new capital formation, capital replacement needs and residential housing construction. The gross private capital formation (GPCF) in an input-output study shows how much capital is produced and sold by each industry and the types of capital goods consumed in a given year. For obtaining state gross private capital formation column vector, the ideal data would then be summed to obtain total gross private capital formation in the state. Available state data on capital formation are limited and nonexistent to figures on total expenditures by industry on plant and equipment [60]. To estimate the gross private capital formation for the state several steps are followed. First, capital expenditures by sector are estimated for the state. The 1963 and 1976 latest and detail national capital expenditures by sector are identified to estimate the capital expenditures for 1972. By estimating growth rates of capital expenditures by sector in five year period, the national capital expenditures by sector for 1972 are calculated. By using the state to national output ratios, the capital expenditures for the 81 processing sectors for the state are estimated. Second, the capital expenditures by sector are multiplied by the national 1976 capital coefficient matrix [76] to determine sector compositions of capital needs for each sector for the state. Third, a gross private capital formation column is obtained for the state by summing all sector requirements of a particular capital good.

The method used to estimate state gross private capital formation is based on the assumption that the capital technology for the state is the same as the capital technology shown in the national capital flow matrix and state estimates of total expenditures by industry on plant and equipment. The state gross private capital formation is estimated to be $2,306 million.

Net Inventory Change (NIC) Net inventory change measures the value of change in the physical volume of inventories held by business. For input-output, the inventory change for each industry consists of the total change in inventories of products primary to the industry irrespective of ownership. Each entry in net inventory change column represents book value rather than average prices during the year. However, the total value of change in inventory is converted to average prices during the year by means of the inventory valuation adjustment which appears as a single entry in row 85, within the net inventory change column [80].

Actual net inventory change figures for the agricultural sector are available from the Oklahoma Agriculture, 1974 [40]. The net inventory change of manufacturing industries for finished goods, work-in-process, and materials is derived from the 1972 Census of Manufactures [86]. Since reliable inventory data on the state level are almost nonexistent for the remaining input-output sectors, their values are estimated from the national figures. Percentage-of-gross-output figures are chosen as allocation factors to approximate the percentage distribution of net change in inventories [79]. Total net inventory change is estimated to be $84,150 million.

Net Export Exports and imports are usually computed as residuals. First a flow table is completed using the entires of previous sectors. Row entries are summed to show the demand for the product. Then this sum is subtracted from the estimate of sector output. If the residual is positive, it implies a surplus; whereas a negative residual implies a shortage. The net export is then the net surplus figures estimated by subtracting the imports from the exports [64]. The state export is estimated by using the location quotient approach as illustrated in Chapter III.

Federal Government Purchases (FGP) Federal government purchases of goods and services include the current and capital account purchases made for general operations by the federal government agencies plus the capital account purchases of federal government enterprises [60]. Federal government purchases are divided into defense (military) and nondefense (nonmilitary) purchases. The military category included the Department of Defense, the National Aeronautics and Space Agency and the Atomic Energy Commission, while the nonmilitary category included all other federal agencies except the current account purchases of federal government enterprises. The federal government purchases for Oklahoma are obtained from the Federal Outlays in Oklahoma published by the U.S. Department of Commerce, Office of Economic Opportunity [96]. The total federal government purchases for the state is $2,947.633 million, out of which $881.501 for defense and $2,066.132 for nondefense. Data that could be used to distribute federal government purchases for the state among the input-output industry groupings proved to be scarce or, in many cases, nonexistent. The national coefficients [79] are employed to allocate the federal government purchases for the state into the various input-output sectors.

State and Local Government Purchases (SLGP) State and local government purchases are the net direct purchases of goods and services include the expenditures made on current and capital account for the general governmental activities plus the purchases or capital account of state and local government enterprises and public utilities. Expenditures by state and local governments are usually classified by character and object or by function. The classification by character and object includes current operation capital outlays (for construction, equipment, land and existing structures), assistance and subsidies, interest on debt and insurance trust. To make more closely represent net purchases of goods and services, assistance and subsidies, current expenditures of government enterprises, interest on general debt and insurance trust expenditures, are excluded [79]. State and local government purchases are classified by two major functions: (1) education, and (2) others which include health and hospital, public welfare and sanitation, safety, highways and all other state and local government purchases [68]. State and local government purchases of goods and services for Oklahoma in 1972 equalled a total of $1,786,900 million, out of which $666.500 million for education and $1,100.400 million for other purchases. The total state and local government purchases for education and other government activities are distributed among the input-output sector by using the national coefficients [79]. The major source of data of state and local government purchases by function for Oklahoma is obtained from the Census of Governments [85].

APPENDIX B

VECTORS AND SCALARS WHICH WERE NOT PRESENTED IN THE SOCIAL ACCOUNTS

TABLE XLIV

ESTIMATED OUTPUT FOR MANUFACTURING SECTORS
OKLAHOMA, 1972

I/O	Industries	Value of Shipments	Inventory Change	Output Value
		($'000)		
11.	Ordnance and Accessories	4,183	69	4,252
12.	Food and Kindred Products	925,600	15,265	940,865
13.	Tobacco Manufacturers	101	1	102
14.	Broad and Narrow Fabrics, Yarn and Thread Mills	13,096	216	13,312
15.	Misc. Textile Goods and Floor Coverings	69,480	1,147	70,626
16.	Apparel	122,424	2,019	124,443
17.	Misc. Fabricated Textile Products	28,700	473	29,173
18.	Lumber and Wood Products Except Containers	127,935	2,110	130,045
19.	Wood Containers	3,315	55	3,370
20.	Household Furniture	28,500	470	28,970
21.	Other Furniture and Fixtures	15,000	247	15,247
22.	Paper and Allied Prod. Ecept Containers	80,800	1,333	82,133
23.	Paperboard Containers and Boxes	37,700	622	38,322
24.	Printing and Publishing	190,800	3,147	193,947
25.	Chemicals and Selected Chemical Products	48,747	804	49,551
26.	Plastics and Synthetic Materials	0	0	0
27.	Drugs, Cleaning and Toilet Preparations	6,482	107	6,589
28.	Paints and Allied Products	10,634	175	10,809
29.	Paving and Roofing Materials	51,798	854	52,852
30.	Rubber and Miscel. Plastic Products	270,900	4,468	275,368
31.	Leather Tanning and Finishing	101	1	102
32.	Footwear and Other Leather Products	23,901	394	24,295
33.	Glass and Glass Products	128,604	2,121	130,725
34.	Stone and Clay Products	149,396	2,464	151,860
35.	Primary Iron and Steel Manuf.	78,657	1,297	99,954
36.	Primary Nonferrous Metals Manuf.	69,880	1,153	71,033
37.	Metal Containers	975	16	991
38.	Heating, Plumb. and Struct. Metal Products	313,707	5,174	318,881
39.	Screw Machine Prods. and Stampings	9,456	156	9,612
40.	Other Fabricated Metal Products	97,079	1,601	98,680
41.	Engines and Turbines	5,756	95	5,851
42.	Farm and Garden Machinery	24,500	404	24,904
43.	Construction and Mining Machinery	300,700	4,959	305,659
44.	Materials Handling Mach. and Equip.	15,600	257	15,857
45.	Metal Working Mach. and Equip.	14,045	231	14,276
46.	Special Industry Mach. and Equip.	45,300	747	46,047
47.	General Industrial Mach. and Equip.	138,500	2,284	140,784
48.	Misc. Mach. Except Electrical	38,000	627	38,627
49.	Office, Computing and Accounting Machines	193,559	3,192	196,751
50.	Service Industry Machines	93,340	1,539	94,879

TABLE XLIV (Continued)

I/O	Industries	Value of Shipments	Inventory Change	Output Value
		($'000)		
51.	Electric Indust. Equip.and Apparatus	42,111	694	42,805
52.	Household Appliances	2,072	34	2,106
53.	Electric Lighting and Wiring Equip.	6,162	102	6,264
54.	Radio, T.V. and Commun. Equip.	264,549	4,363	268,912
55.	Electronic Components and Accessories	23,239	383	23,622
56.	Misc. Electrical Mach. and Supplies	7,269	120	7,387
57.	Motor Vehicles and Equipments	98,400	1,623	100,023
58.	Aircraft and Parts	121,382	2,002	123,384
59.	Other Transport. Equip.	81,368	1,342	82,710
60.	Scient.and Controlling Instruments	19,445	321	19,766
61.	Optical, Ophthalmic, and Photo. Equip.	12,727	210	12,937
62.	Misc. Manufacturing	62,825	1,036	63,861
	TOTAL	4,519,398	74,533	4,593,931

TABLE XLV

VECTORS AND SCALARS WHICH WERE NOT PRESENTED IN THE SOCIAL ACCOUNTS

Matrix Sector	A_2	A_5	A_6	A_7	A_8	A_9	A_{10}	A_{11}	A_{16}	A_{20}	A_{24}	A_{28}	A_{31}
1	0.95045	0.0	0.00481	0.0	1.03840	0.01213	0.00066	0.00003	0.96750	1.00000	1.05055	1.03472	0.22066
2	0.95989	0.0	0.01516	0.0	1.03942	0.03485	0.00160	0.00100	0.96750	1.00000	1.05054	1.03472	0.55872
3	0.95980	0.0	0.00094	0.0	0.0	0.00176	0.00002	0.00002	0.96750	1.00094	1.05053	1.03472	0.64273
4	0.95786	0.0	0.0	0.00026	0.0	0.0	0.00029	0.00015	0.98764	1.00038	1.02888	1.03472	0.48588
5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6	0.95572	0.0	0.0	0.0	0.0	0.00751	0.0	0.0	1.00799	1.00000	1.02214	0.0	0.57004
7	1.00055	0.00004	0.0	0.0	0.0	0.00855	0.0	0.00052	0.98990	1.00000	1.02220	1.01019	0.60876
8	0.97211	0.00001	0.0	0.0	0.0	0.0	0.0	0.00001	0.98990	1.00000	1.C2758	0.0	0.55435
9	0.94285	0.0	0.0	0.0	0.0	0.0	0.09045	0.23389	0.99635	1.00027	1.01843	1.01228	0.42420
10	0.94285	0.0	0.0	0.0	0.0	0.0	0.01159	0.01964	0.99640	1.00028	1.01834	1.01228	0.58046
11	0.97398	0.00012	0.0	0.0	0.0	0.00076	0.0	0.00001	0.98408	1.00000	1.03152	0.0	0.57064
12	0.96602	0.0	0.16426	0.0	0.0	0.00514	0.01576	0.00580	0.97097	1.00007	1.03227	1.01224	0.27565
13	0.99305	0.0	0.00003	0.0	0.0	0.0	0.0	0.0	0.97451	1.00000	1.03416	0.0	0.48073
14	0.99004	0.0	0.00036	0.0	0.0	0.00326	0.00004	0.00009	0.97517	1.00000	1.03058	0.0	0.30640
15	0.99443	0.0	0.00501	0.0	1.06082	0.03584	0.0	0.00002	0.97517	1.00000	1.03173	0.0	0.25843
16	1.00275	0.0	0.03068	0.0	0.0	0.01441	0.00003	0.00037	0.97032	1.00002	1.03050	1.01239	0.33756
17	1.00278	0.0	0.00546	0.0	0.0	0.01337	0.00008	0.00027	0.97984	1.00000	1.03170	0.0	0.32422
18	0.93756	0.00265	0.0	0.0	0.0	0.00912	0.00029	0.00002	0.98279	1.00000	1.02993	1.01231	0.37909
19	0.97587	0.0	0.0	0.0	0.0	0.00787	0.0	0.0	0.97890	1.00000	1.03258	0.0	0.35194
20	0.96854	0.01995	0.0	0.0	0.0	0.01340	0.00016	0.00006	0.99498	1.00005	1.03047	1.01206	0.40409
21	0.97611	0.0071	0.0	0.0	0.0	0.01067	0.00131	0.00047	0.99142	1.00000	1.03309	1.01193	0.44382
22	0.97742	0.0	0.00415	0.0	0.0	0.00404	0.00199	0.00163	0.98067	1.00000	1.03594	0.0	0.38618
23	0.97777	0.0	0.00021	0.0	0.0	0.00449	0.00019	0.00013	0.98428	1.00000	1.03597	0.0	0.37561
24	0.97770	0.0	0.01897	0.0	1.03180	0.00898	0.01901	0.00714	0.98227	1.00003	1.03018	1.01229	0.48232
25	0.99137	0.0	0.00046	0.0	0.0	0.00612	0.00050	0.00071	0.98595	1.00002	1.03828	1.01193	0.43719
26	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.00000	0.0	0.0	0.0
27	0.98235	0.0	0.00137	0.0	0.0	0.00079	0.00008	0.00039	0.98410	1.00003	1.03432	1.02065	0.40075
28	0.98402	0.0	0.00018	0.0	0.0	0.00915	0.00028	0.00002	0.98676	1.00000	1.03828	1.01244	0.34894
29	0.96691	0.0	0.00308	0.0	1.03062	0.24799	0.0	0.0	0.99980	1.00008	1.03198	1.01267	0.38852
30	0.98392	0.0	0.01444	0.0	1.05248	0.01435	0.00072	0.000188	0.98319	1.00014	1.03090	1.01250	0.47808

TABLE XLV (Continued)

Matrix Sector	A_2	A_5	A_6	A_7	A_8	A_9	A_{10}	A_{11}	A_{16}	A_{20}	A_{24}	A_{28}	A_{31}
31	1.00121	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.98231	1.00000	1.03422	0.0	0.26518
32	1.00927	0.0	0.00663	0.0	0.0	0.02045	0.0	0.00004	0.98249	1.00000	1.0320	1.01032	0.42661
33	0.95503	0.00533	0.0	0.0	1.02628	0.01288	0.00067	0.00090	0.98047	1.00006	1.02168	1.01250	0.53401
34	0.94776	0.00575	0.0	0.0	0.0	0.01364	0.00011	0.00012	0.97309	1.00008	1.02934	1.01251	0.47861
35	0.97328	0.00002	0.0	0.0	0.0	0.01246	0.00007	0.00002	0.98422	1.00000	1.01089	0.0	0.40682
36	0.99796	0.00013	0.0	0.0	0.0	0.01685	0.0	0.0	0.98132	1.00000	1.01086	0.0	0.24817
37	0.96635	0.0	0.0	0.0	0.0	0.00109	0.00001	0.0	0.99741	1.00000	1.02652	1.00000	0.30815
38	0.97488	0.00121	0.0	0.0	1.02223	0.02581	0.0	0.0	0.99394	1.00000	1.02295	1.01228	0.39279
39	0.97782	0.00068	0.0	0.0	0.0	0.00405	0.00013	0.0	0.99096	1.00006	1.02290	1.01244	0.46354
40	0.97632	0.00784	0.0	0.0	0.0	0.01862	0.00068	0.00012	0.99051	1.00036	1.02508	1.01230	0.49965
41	0.97357	0.00013	0.0	0.0	0.0	0.0393	0.0	0.00010	0.98924	1.00000	1.03780	0.0	0.45277
42	0.99151	0.00018	0.0	0.0	0.0	0.01351	0.00006	0.00011	0.98047	1.00000	1.03782	1.01130	0.43423
43	0.97414	0.0	0.0	0.0	1.04100	0.04942	0.0	0.00133	0.99894	1.00000	1.03412	1.01206	0.46433
44	0.98921	0.0	0.0	0.0	0.0	0.02658	0.00001	0.0	0.99005	1.00000	1.03415	0.0	0.46389
45	1.00689	0.00029	0.0	0.0	0.0	0.00746	0.00006	0.00004	0.99725	1.00000	1.03856	1.01244	0.60108
46	0.99890	0.00042	0.0	0.0	0.0	0.02674	0.00023	0.00001	0.98208	1.00000	1.03673	1.01197	0.50656
47	1.00107	0.0	0.0	0.0	1.03060	0.04238	0.0	0.00032	0.98812	1.00000	1.03937	0.01221	0.50968
48	1.00108	0.00016	0.0	0.0	0.0	0.02520	0.00211	0.00040	0.98927	1.00003	1.03966	1.01223	0.55928
49	1.00109	0.00200	0.0	0.0	1.03727	0.04257	0.00269	0.00121	0.98337	1.00000	1.03960	1.01147	0.43378
50	0.97692	0.00460	0.0	0.0	1.03254	0.06017	0.00213	0.00048	0.98574	1.00000	1.03843	1.01246	0.42757
51	1.00106	0.00015	0.0	0.0	0.0	0.00676	0.00012	0.00046	0.98351	1.00000	1.03137	1.01065	0.49606
52	0.98475	0.00150	0.0	0.0	0.0	0.00055	0.00001	0.00001	0.98640	1.00008	1.03070	1.00000	0.42001
53	0.97697	0.00113	0.0	0.0	0.0	0.00299	0.00007	0.00001	0.99292	1.00000	1.03551	0.0	0.50189
54	1.00022	0.04496	0.0	0.0	0.0	0.01992	0.00194	0.00073	0.98875	1.00004	1.02821	1.01256	0.46312
55	1.00043	0.00067	0.0	0.0	0.0	0.00536	0.00002	0.00004	0.99550	1.00000	1.03789	1.01244	0.49271
56	0.97754	0.00267	0.0	0.0	0.0	0.00587	0.00002	0.00010	0.98542	1.00015	1.03796	1.01495	0.47734
57	0.95309	0.04065	0.0	0.0	0.0	0.00429	0.00051	0.00160	0.98422	1.00009	1.02727	1.01400	1.32840
58	1.00110	0.00054	0.0	0.0	0.0	0.01570	0.0	0.00003	0.98684	1.00000	1.02066	1.01302	0.46080
59	0.94056	0.01778	0.0	0.0	0.0	0.01490	0.00012	0.00078	0.98137	1.00005	1.03386	1.01317	0.36756
60	0.99904	1.00201	0.0	0.0	0.0	0.00959	0.00014	0.00061	0.98909	1.00004	1.02814	1.01495	0.52444
61	0.99991	0.00275	0.0	0.0	0.0	0.00901	0.00040	0.00046	0.98406	1.00000	1.02815	0.0	0.61513

TABLE XLV (Continued)

Matrix Sector	A_2	A_5	A_6	A_7	A_8	A_9	A_{10}	A_{11}	A_{16}	A_{20}	A_{24}	A_{28}	A_{31}
62	0.98520	0.03319	0.0	0.0	0.0	0.01430	0.00278	0.00074	0.97654	1.00014	1.02151	1.01227	0.39260
63	0.94313	0.0	0.0	0.06468	0.0	0.00744	0.01473	0.01004	0.97476	1.00006	1.03047	1.01228	0.60010
64	0.97343	0.0	0.0	0.03663	0.0	0.0	0.00428	0.00908	0.97550	1.00000	1.03046	0.0	0.82316
65	0.99447	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.99534	1.00000	1.04085	0.0	0.52594
66	0.96990	0.0	0.0	0.00508	0.0	0.0	0.00123	0.0	0.99540	1.00019	1.02424	1.01210	0.71462
67	0.97355	0.0	0.0	0.43978	0.0	0.00528	0.00892	0.01166	0.97074	1.00056	1.02066	1.01215	0.76763
68	0.99068	0.0	0.0	0.10982	0.0	0.0	0.00290	0.02165	0.99669	1.00002	1.02088	1.01228	0.56454
69	0.96959	0.0	0.0	0.33562	0.0	0.0	0.00477	0.01373	0.99600	1.00047	1.02086	1.01228	0.80813
70	0.95803	0.0	0.0	0.06385	0.0	0.0	0.0	0.00816	0.99751	1.00023	1.02887	1.01228	0.57275
71	0.98827	0.0	0.0	0.02065	0.0	0.0	0.02070	0.02840	0.99368	1.00007	1.02887	1.01228	0.68725
72	0.97355	0.0	0.0	0.11752	0.0	0.0	0.03178	0.00290	0.97904	1.00029	1.02058	1.01215	0.43148
73	0.98209	0.0	0.0	0.04319	0.0	0.0	0.00100	0.00356	0.99804	1.00009	1.02877	1.01228	0.46955
74	0.99710	0.0	0.0	0.02205	0.0	0.0	0.0	0.0	0.99471	1.00008	1.02879	1.01229	0.52366
75	0.94343	0.0	0.0	0.20749	0.0	0.0	0.0	0.07545	0.99355	1.00002	1.02887	1.01228	0.67756
76	0.0	0.0	0.0	0.00680	0.0	0.0	0.00072	0.00584	0.99860	1.00000	1.03045	0.0	0.74953
77	0.0	0.0	0.0	0.00623	0.0	0.0	0.00036	0.00021	0.99840	1.00000	1.05058	0.0	0.50173

		A_{12}	A_{18}	A_{22}	A_{26}	A_{30}	A_{32}
78	0.95231	0.98952	0.98469	1.00003	1.02204	1.01228	0.0000004840
79	0.94241	0.99941	0.98694	1.00000	1.02210	1.01228	0.0000003576
80	0.94244	1.03360	0.99823	1.00000	1.02214	0.0	0.0000001866
81	0.96990	1.04210	0.97502	1.00000	1.02424	1.01226	0.0000023138

a_1	0.14364	a_7	1.00712	a_{13}	1.06561	a_{19}	0.32346	a_{25}	0.29689	a_{31}	0.50804
a_2	0.98884	a_8	1.01262	a_{14}	0.05890	a_{20}	0.00000	a_{26}	0.00000	a_{32}	0.00000
a_3	0.40294	a_9	2.00000	a_{15}	1.03122	a_{21}	0.09490	a_{27}	0.02553	a_{33}	0.28518
a_4	0.99371	a_{10}	0.00900	a_{16}	28957.76368	a_{22}	3370.33138	a_{28}	2221.12123	a_0	0.90000
a_5	0.42776	a_{11}	1.05954	a_{17}	1.00000	a_{23}	1.00000	a_{29}	1.00000		
a_6	0.99480	a_{12}	1.03862	a_{18}	0.58163	a_{24}	0.44778	a_{30}	0.20678		

APPENDIX C

PARAMETERS FOR ESTIMATION OF TOTAL OKLAHOMA POPULATION

TABLE XLVI

PARAMETERS FOR ESTIMATION OF TOTAL
OKLAHOMA POPULATION

Age Distri-bution	Initial Population		Cohort Size		Birth Rates		Death Rates		Trend In Death Rates	
	Males	Females	Males	Females	Males	Females	Males	Females	Males	Females
00-15	351790	336721	15	15	0.0	0.0004	0.00058	0.00042	0.02190	0.02390
15-19	122876	118659	5	5	0.0	0.0581	0.00147	0.00057	0.00580	0.02040
20-29	185861	184744	10	10	0.0	0.1161	0.00181	0.00068	0.00880	0.01360
30-39	134245	143767	10	10	0.0	0.0373	0.00224	0.00124	0.01110	0.00960
40-44	69961	74695	5	5	0.0	0.0048	0.00420	0.00240	0.01070	0.01630
45-49	71692	75718	5	5	0.0	0.0	0.00691	0.00376	0.00770	0.01320
50-59	136992	139572	10	10	0.0	0.0	0.01474	0.00702	0.00540	0.01300
60-64	56675	65850	5	5	0.0	0.0	0.02790	0.01263	0.00420	0.01300
65-69	46435	57116	5	5	0.0	0.0	0.04040	0.02009	0.00360	0.01300
70-79	57710	78625	10	10	0.0	0.0	0.06861	0.05068	0.00510	0.01220
80 +	22463	37407	20	20	0.0	0.0	0.15918	0.11760	0.00870	0.01080

Source: U.S. Department of Commerce, Bureau of The Census, Statistical Abstract of The United States - 1976, Washington, DC 1976.

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VITA

Tesfa Giorgis Ghebremedhin

Candidate for the Degree of

Doctor of Philosophy

Thesis: A SOCIAL ACCOUNTING SYSTEM AND SIMULATION MODEL FOR ANALYZING ALTERNATIVE ENERGY CHOICES FOR OKLAHOMA AND PROJECTING ECONOMIC VARIABLES FROM 1972 TO 2000

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