TR-12
1968

Input-Output as a Method of Evaluation of the Economic Impact of Water Resources Development

R.L. Canion
W.L. Trock

Texas Water Resources Institute

Texas A&M University

INPUT-OUTPUT AS A METHOD OF EVALUATION OF THE ECONOMIC IMPACT OF WATER RESOURCES DEVELOPMENT

By

Robert Larry Canion

and

Warren L. Trock

TECHNICAL REPORT NO. 12

MAY, 1968

This study was partially supported by the
Office of Water Resources Research,
The Department of the Interior under
P.L. 88-379, Project A-004-TEX.

ACKNOWLEDGMENTS

This study was supported in part by Project A-004-TEX of the Office of Water Resources Research, The Department of the Interior, through the Water Resources Institute of Texas A&M University.

The authors wish to express appreciation to the following faculty members of Texas A&M University for their assistance: Dr. E. T. Smerdon and Fred Schmer of the Water Resources Institute, Drs. A. B. Wooten, D. S. Moore and W. L. Trock of the Department of Agricultural Economics and Dr. I. O. Linger of the Department of Economics. A special indebtedness is owed to Mr. Brad Lisenbee in the Data Processing Center for his valuable assistance.

ABSTRACT

In this report the results of a study of the use of input-output analysis to evaluate the economic impact of water resources development are presented. Blackburn Crossing reservoir on the Upper Neches River was the subject development, and the Leontief system of input-output accounts is the basic tool of the analysis.

In previous research, unrelated to water resources development, Carter and Martin developed the idea of using a matrix of primary resource coefficients to determine resource requirements necessary to sustain a given level of final demand and with it, total economic output. By specifying the relationship between resource requirements and output, total resource requirements can be computed given either final demand or total output. In this study the possibility of inverting the process and determining final demand or total output, given the level of primary resources, was investigated.

Data for the period 1952 were assembled to build the basic input-output model of the economic activity of the watershed. The functional relationship of water as a resource and total output was then determined and the model was employed to forecast the impact on the watershed of an increase in the supply of water. A check on the forecast was provided by data assembled for the 1958 period which were descriptive of total output following an enlargement of Blackburn Crossing reservoir which yielded increased water supplies.

The results of the forecasting activity were sufficient to conclude that the analytical tool employed along with the water use-output relationship is useful in estimating impact of water developments. Problems encountered can be resolved so that the accuracy of the technique is acceptable.

Descriptors -- / economic evaluation / *economic impact / *economic prediction / *input-output analysis / *water resources / *Texas / *Rio Grande / planning / regional analysis / river basin development /

CONTENTS

LIST OF TABLES

CHAPTER I

INTRODUCTION

Among the basic resources essential to the development of other resources, as well as to life itself, is water. Being only one of the essentials, water, no matter how abundant, can neither insure survival nor create prosperity. But a shortage of water can threaten both. Since an adequate supply of water tends to be the critical element in controlling patterns of development, it is well, then, that we pause to take stock of our water supply as well as our other physical resources.

Texas has a water supply the size and extent of development of which is the envy of many other states. Water has contributed immeasurably to the strength and prosperity of the state and it can and should keep on doing so. Nevertheless, a point has been reached where growing water problems and rising water costs have created a need for us to take a careful look at water resources to see where we stand.[1]

---

[1]C. L. McGuinnes, Water for the United States--An Analysis of the Report of the Senate Select Committee on Natural Resources. Natural Resources Journal, Vol. 2, No. 2 (August, 1962), pp. 218-224.

The Texas Economy

Up to the mid-1940's the Texas economy was relatively simple and largely agricultural. The pre-war period was generally one of national abundance of agricultural production and Texas was primarily a producer of raw materials which were processed into finished products elsewhere. Under such circumstances, water requirements were relatively small, and the problem of water supply was not especially critical. Both state and federal efforts in connection with Texas water problems have largely reflected preoccupation with the flood hazard present in many localities.[2]

Over the past decade, changes and increases in national wants have produced a change in the relative importance of Texas water problems and the urgency of actions required to solve them. This change is occurring at an accelerating rate as water demands for production of goods steadily mount. First, portions of the state are rapidly converting from an agricultural to an industrial economy. The rapid rise of industry

---

[2] Water Supply and the Texas Economy, An Economic Appraisal of the Texas Water Problems, prepared by the Department of Interior, Bureau of Reclamation, Area Planning Office, Austin, Texas, July, 1953.

with its attendant population increase creates water demands heretofore considered improbable. Second, the state has a large and growing national outlet for increased agricultural production, and it can profitably employ unused water for highly productive irrigation projects. The economic rewards to the state from industrialization, and from expansion of irrigated agriculture can be enormous.

Texas Water Problems

Texas faces a multiplicity of water problems including inadequate water supplies for irrigation, municipal and industrial uses, poor drainage of millions of acres of fertile lands, insufficient main-channel flood-control, under-developed hydropower-electric power and inadequate water recreation facilities. All of these problems are interrelated; none can be dealt with independently without affecting to some extent the solution of the others. All affect the economy of the state. Plans for water-resource development should be based on full appraisal of all these problems, their interrelation, and the relative importance and place of each in an over-all solution.

Texas is a virtual warehouse of undeveloped resources, many of which can be processed locally into products in national demand. Not the least of Texas' resources is its abundant but maldistributed, and largely unregulated and under-used surface waters. Texas borders embrace water resources which, if regulated and distributed to points of potential use, could satisfy needs much larger than those now existing. Currently, the state is using only a small percentage of its available water resources.[3] The circumstances of expanding national economic requirements and a vast Texas resource reserve presents the state an outstanding opportunity--an opportunity for a considerable increase in a per capita income that is now materially below the national average.

Much of the potential industrial production obtainable from Texas resources and a substantial part of the state's potential increases in agricultural production cannot be achieved unless under-used water supplies are further developed and redistributed to points of potential use. The development of several sections of the state has now reached the limit permitted by available water resources. Other areas are rapidly approaching their industrial and irrigated

---

[3] Ibid.

agricultural limit of development since water supplies cannot be economically increased under foreseeable conditions. Provision of such supplies is one of the primary keys to realization of the economic opportunities available to Texas and is perhaps the state's most important water problem.

As water demands grow and remaining supplies shrink, many decisions will have to be made as to the use of water to be favored when there is not enough for all proposed uses. Studies are needed to develop guidelines that can be used in making such decisions so as to realize the greatest economic and social return from use of limited supplies of water.[4]

Problems of Water Planning

The state has a responsibility to develop water policies and programs which it conceives to be in its own interest in order, among other things, to provide a means of evaluating federal proposals for water resource development. If development of an integrated water supply plan for Texas and construction of works necessary to implement such a plan are desired, extensive and

---

[4]C. L. McGuinnes, op. cit., p. 218.

detailed engineering and economic investigations will be required. In order to provide both for prompt development of works to meet immediate future needs and for integration of such works into a long-range, integrated plan, such investigations should be initiated as soon as possible.

Studies of the past and current effects of existing projects on the local, regional, and national economy are needed in order to develop guides for analyzing the effects of future projects. Such studies, in addition to leading to improvements in the planning of future projects, might lead to modification of existing projects for greater efficiency or productivity.[5]

Nearly all of the studies of needs related to water resources have concluded that we need more basic data on water, and this conclusion is valid. Yet, even now, we have large collections of data which have not been analyzed, and the study of them would pay dividends in making future data collection programs more effective and economical. New analytical and computing methods are needed both to make better use of the data and to show what kinds of data should be collected in preference to others.[6]

---

[5] *Ibid.*, p. 220.

[6] *Ibid.*, p. 223.

Objectives of the Study

The needs of water resource planners for projections of economic activity by planning areas has stimulated the application of new techniques of regional economic analysis. Many of these techniques rely heavily on the computer for analysis of the large amounts of population, employment, and industrial output data.

The regional input-output model is one important new method that has been developed by econometricians and regional analysts for projecting regional economic activity. The first objective of this study, therefore, is to build an input-output model of the economic activity of the watershed under study.

Once input-output models have been built, it is important that the relationship between various sectors of the economy and water use be built into these models. The second objective of this study, then, will be to determine the relationship between the use of water as a resource and the economic activity of the various sectors.

A third objective is to estimate the influence of an additional water supply on the level of economic activity in the watershed. Since a development of this resource is underway, a method of estimation of impact will be useful.

CHAPTER II

DESCRIPTION OF THE STUDY AREA

Location

The study area, which consists of parts of Anderson, Cherokee, Henderson, Smith, and Van Zandt counties, is within the East Texas Timberland farming area. Farming in this area has recently undergone a transition. Where in the past there were many small farms with emphasis on cotton, today the farms are larger with more engaged in livestock, poultry, vegetables, and horticultural specialties. Surface drainage is from moderate to rapid. The annual rainfall has varied from about 29 inches to 67 inches over this portion of the Neches River basin.[1] Upland soils are light-colored, acid, sandy loams, and sands. Bottomland soils are light brown to dark gray, acid, sandy loams, clay loams, and some clays. Principal vegetation on the upland includes loblolly and shortleaf pine and oak with hardwoods and some pine on the bottomland. The study area is within about 100 miles of the

---

[1]Report on Master Plan for Water Supply Reservoirs. Prepared for the Upper Neches River Municipal Water Authority by Forrest and Cotton, Inc., Consulting Engineers, Dallas, Texas, February 1961, p. 4.

heavily-populated Dallas-Fort Worth complex with its highly diversified economic activities and is well located with respect to transportation facilities. The area is traversed by a network of highway and rail lines and the proposed barge navigation project on the Trinity River would provide water transportation within 15 miles of Palestine and Athens.[2]

Physiography and Geology

The area of study in this report lies entirely within the Gulf Coastal Plain, a wide, gently-undulating plain bordering the Gulf of Mexico. The Coastal Plain owes its general features to the presence of relatively soft, nonresistant rocks alternating with more resistant strata, a gentle gulfward dip of beds, low elevation above sea level, vegetation, and certain climatic conditions.

Strata underlying the Gulf Coastal Plain generally slope seaward at angles slightly steeper than the present land surfaces. The more resistant strata break the gentle slope of the land with low, landward-facing escarpments. Most of the area between main cuestas and on back slopes of main cuestas consists of rolling hills and prairies

---

[2] Ibid., p. 9.

with relief generally of 100 to 200 feet. Streams flowing within the area of rolling hills and prairies have flood plains 1 to 10 miles wide and occur about 100 to 150 feet below the general elevation of the surrounding land. Flood plains are much narrower and are further below the general land surface where streams cut through cuestas.

The study area is a part of an extensive structural and depositional province known as the Gulf of Mexico Basin. A maximum of about 30,000 feet of sediment is known from the deepest part of this basin. Formations exposed in most of the area are Paleocene in age. Rocks of early and late Paleozoic age, Jurassic age, and possible Triassic age have been encountered in the subsurface.

Water Resources

Occurrence

Water resources are large owing to relatively high rainfall, major streams and reservoirs and extensive productive aquifiers. Average annual runoff for most drainage basins within the area is about 400 to 650 acre feet per square mile, but as low as 300 acre feet for some areas and as much as 1000 acre feet for others.[3] Ground water is available principally from the Carrizo-Wilcox aquifiers. Secondary, though locally important, aquifiers are sands of Cretaceous formations and alluvial sands and gravels. Fresh water is available from aquifiers at most places within the study area.

Uses

Chief uses of water in the area are for domestic use and industry. Seventy per cent of total consumption was for municipal and industrial use. Nearly equal amounts of municipal and industrial water were taken from surface and ground water resources. Rainfall is generally adequate for crops, though locally irrigation is used as a supplement. Surface water sources supply about 65 per cent of water used for irrigation.

Industrial use is generally classed in three main categories: cooling, boiler, and process. Cooling water is selected for its temperature and source of supply, though chemical quality is also significant. Any characteristic that adversely affects heat exchange surface is undesirable. Process water is generally rigidly

---

[3]W. L. Fisher, Rock and Mineral Resources of East Texas, Bureau of Economic Geology, Report No. 54, University of Texas, Austin, Texas, June 1965, p. 15.

controlled. Water used in clay-water mixtures has been shown to affect ceramic properties of the clay. Water used in the manufacture of textiles must be low in dissolved solids and free of iron and manganese. Manufacture of high-grade paper requires water in which heavy solids are absent or present in only small quantities. Unlike cooling and boiler water, much of the process water is consumed or undergoes a change in quality in the process and is not available for reuse.

Relatively large quantities of water are used in processing and beneficiation of such materials as iron ore, sand and gravel, and industrial sand. Considerable quantities of water are required in the initial stage in solution mining of salt. After production is established, approximately 800 gallons of water are needed to produce one ton of salt. Water is used in a variety of other industrial operations in the area (food processing, manufacture of wood and paper products, oil and gas refining, and chemical industries), and though quantity and/or quality are not always critical, availability of a dependable water supply is important to most kinds of industry.

Quality

Quality of surface water is variable. Hardness, primarily a measure of the content of calcium and magnesium, is generally less than 60 ppm in waters within the area. Waters of the area are slightly acid with pH commonly as low as 6.4 Dissolved solids range from 120 to 200 ppm in most of the area.[4]

Water from the Carrizo-Wilcox aquifier generally is high in content of sodium bicarbonate, low in content of dissolved solids, and soft.[5] In or near outcrop some of the water is acidic. It is generally soft enough for use in boilers though locally the water may be high in silica. In some cases, iron may be objectionably high, and carbonaceous materials may give an undesirable color. Aquifier transmittability is low to medium.

Human Resources

Residence of population of the area is 54 per cent rural and 46 per cent urban. The trend within the area in the past 20 years has been one of decrease in overall county population but with an increase in the larger towns and cities. Population patterns, based on per cent of change in succeeding censuses, are similar for the study area and the state as a whole. Within the

---

[4] Ibid., p. 18.

[5] Ibid.

area, a fairly large increase in population was recorded for the 1940 census; this increase was due largely to expansion of the oil and gas industry and the deurbanization effect of the depression of the 1930's.

The working force is about 34 per cent of the population. Distribution of basic employment is as follows: agriculture and forestry, 20 per cent; mining (including petroleum production), 7 per cent; and basic services, 37 per cent. Most factory workers are Anglo-American, though Negroes and Latin-Americans are being integrated into certain industrial jobs. Generally, worker adaptation to industrial routine has been satisfactory. Strikes, unions, and labor disputes have been relatively few.

Energy Resources and Availability

Availability of energy resources is important in any type of industry. In the manufacture of products from industrial minerals, especially bulky materials that must be processed and generally utilized in or near areas where they occur, availability of energy is critical.

Natural Gas and Petroleum Products

Principal and most available source of energy within the area is that derived from oil, natural gas and associated natural-gas liquids.[6] Not only is the petroleum and gas industry important to the economy of the area, but it has been and is a major attraction for other industries seeking oil and gas as raw materials or as resources of low-cost energy. Gas fields and gas transmission lines are extensive and generally accessible from most points. Abundant supplies of shut-in gas are locally available, commonly at low relative cost, in areas distant from gas transmission lines.

Lignite

Abundant reserves of low coal or lignite are important low-cost energy sources. In recent years lignite was mined at Malakoff, Henderson County, for fuel in generating power at Texas Power and Light Company's Trinidad station.[7]

Electric Power

The area is served by an extensive network of power lines and generating stations. Most stations are hydroelectric but a few small stations generate power through burning of gas. Most stations have a capacity up to 100,000 kw; Trinidad station in western Henderson County has a capacity of 161,200 kw. The abundance of existing and planned reservoirs, natural gas, and lignite provides a broad base for power generation.

---

[6] *Ibid.*, p. 23.

[7] *Ibid.*, p. 23.

Transportation Facilities

Transportation facilities in East Texas are adequate to support expanded industrialization. The Texas Highway System is one of the best in the country, including, in addition to Federal and State highways, an extensive network of paved, well-maintained farm-to-market or auxiliary roads.

Rail mileage was highest in the early 30's, but has declined gradually since that time as motor transport over highways has replaced some of the rail lines, especially those serving isolated lumbering operations. Chief rail traffic is in heavy bulk commodities, including livestock, cotton, petroleum products, lumber and pulpwood, sand and gravel, crushed rock, clay, and machinery and other iron and steel products.

Major airlines serve the larger cities on a regularly scheduled basis. Many communities which do not have commercial air service provide airports suitable for private craft. Some points have air-freight service.

Neches River Basin

The Neches River Basin, which has a drainage area of 10,034 square miles, heads in Van Zandt, Henderson and Smith Counties and flows southerly to southeasterly for a distance of about 416 river miles where it empties into Sabine Lake near Beaumont, Texas. The main river system has two main branches, the Neches River and its longest tributary, the Angelina, which joins the Neches River at Mile 126.1. Above their confluence the Neches River has a drainage area of 3,819 square miles.[8] The watershed divide for the main stem of the Neches River is at about elevation 530 feet m.s.l., and it falls to elevation 290 at the Blackburn Crossing Dam in a length of about 62 miles. The principal tributary streams above the Blackburn Crossing Dam are Flat and Kickapoo Creeks.

The Blackburn Crossing Reservoir, which is being constructed to its size at the present time will be located in Anderson, Cherokee, Henderson and Smith Counties. The dam is located at River Mile 354 on the Neches River about 1 1/4 miles upstream from U. S. Highway 175 between Athens and Jacksonville. The river at that point forms the boundary between Anderson and Cherokee Counties. The dam will intercept runoff from a drainage area of about 850 square miles. The initial construction provides a storage capacity of 30,500 acre-feet at a normal pool elevation of 317.0 and a lake surface area of 4,000 acres. The design water surface will

---

[8] Ibid., p. 53.

be at Elevation 336.2 and the top of dam at Elevation 343.0. The initial project yields about 45 million gallons of water per day.[9] The final development at the Blackburn Crossing site will consist of a concrete spillway with crest at Elevation 345.0, which would also be the normal pool level. The lake will have a total storage capacity of 411,800 acre-feet, of which 18,500 acre-feet would be for sedimentation. The enlarged lake will have a surface of 25,560 acres. The design water surface will be at Elevation 355.3 and the top of dam at Elevation 364.0. The project will produce a dependable yield of 192.7 million gallons of water per day.[10]

The Upper-Neches River Municipal Water Authority

The Upper-Neches River Municipal Water Authority, a conservation and reclamation district, was created by the Legislature of the State of Texas for the purpose of storing, controlling, conserving, protecting, distributing, and utilizing storm and flood waters and the unappropriated flow of the Neches River and its tributaries and to prevent the escape of any such waters without first obtaining therefrom a maximum of public benefit, by the construction of a dam or dams across the Neches River and

---

[9] *Ibid.*, p. 53.

[10] *Ibid.*, p. 53.

its tributaries in Anderson, Cherokee, Henderson and Smith Counties.[11] The Authority is empowered "to cooperate and enter into contracts with cities, persons, firms, cooperations, and public agencies for the purpose of supplying and selling them water for municipal, domestic, industrial, and other purposes permitted by law." The Authority is not limited as to the area it may serve, but cities and areas constituting the District shall be accorded priority in the allocation of the District's available water.

The Upper-Neches River Municipal Water Authority is constructing the Blackburn Crossing Dam and Reservoir on the Neches River in accordance with rights granted by the State Board of Water Engineers and contained in Water Permit no. 1832, dated July 12, 1956.[12] The Authority was granted the right to store storm and flood waters in the Blackburn Crossing Reservoir in the amount of 410,000 acre-feet, and divest therefrom for beneficial use, waters in the amount of 84,000 acre-feet per year for industrial purposes, and 112,000 acre-feet per year

---

[11] Report on Master Plan for Water Supply Reservoirs. Prepared for the Upper Neches River Municipal Authority by Forrest and Cotton, Inc., Consulting Engineers, Dallas, Texas, February, 1962, p. 1.

[12] Ibid., p. 2.

for municipal purposes. It also has the right to use the bed and banks of the Neches River to the confluence with the Angelina River for transmission of the water to any downstream point of intended use.

CHAPTER III

METHODOLOGY AND ANALYTICAL TECHNIQUES

The specific analytical tool involved is the Leontief system of input-output accounts. The value of goods and services of every industry is classified and arranged so that the sectors from which they are an output and to which they are an input are immediately apparent. Then using rather simple mathematical transformations, coefficients are derived that give quantitative insights into the operations of the economy and enable us to investigate and analyze the effects of one industry on another.

Input-output, or interindustry models are capable of specifying quite detailed economic relationships in the geographical area under study. The matrix of interdependence coefficients, computed on the inverse of the technical coefficient matrix, relates changes in output of any industry to levels of output in any other sector. Moreover, these coefficients can be used directly or indirectly to estimate changes in net incomes of individual sectors. Once the input-output model has been constructed for a watershed area in the initial stage of development, this model together with a primary resources technical coefficients matrix, can be used to estimate the impact on the watershed economy of the final stage of development.

Theoretical regional input-output models defining industries spacially as well as by type, were developed by Isard,[1] Chenery,[2] and Leontief. These were followed by empirical studies for regions of the United States including the work of Moses at Harvard,[3] the Moore and Petersen models for Utah and California, the University of Maryland's model for Maryland, and Iowa State's series of models by Heady, Peterson, Schnittker, and Carter. With the exception of the Iowa State models, all models of United States regions were for the year 1947. The basic source of data for most of these regional studies was the comprehensive 1947 input-output model for the United States constructed by the Bureau of Labor Statistics. In general, a regional input-output model differs from the

---

[1]Walter Isard, "Interregional and Regional Input-Output Analysis: A Model of a Space Economy," The Review of Economics and Statistics, Vol. 33, 1951, pp. 318-328.

[2]Hallis B. Chenery, Paul G. Clark and Uera Cao Pinna, The Structure and Growth of the Italian Economy, (Special Mission to Italy for Economic Cooperation), Rome, Italy, Mutual Security Agency, 1953.

[3]Leon N. Moses, "The Stability of Interregional Trading Patterns Input-Output Analysis," American Economics Review, Vol. 45, December, 1955.

basic model only in that another dimension--space or location--is included.

An input-output model is a set of linear equations describing intersector flows of goods and services.[4] Three separate stages of analysis are involved. In the first stage, a flow table is constructed in which the output of each sector of an economy is allocated to every sector that uses this output. This table then, shows how the output of each industry is distributed among other industries and sectors. At the same time it shows the inputs to each industry from other industries and sectors.[5] For this stage of analysis, physical units may be used, but, to facilitate later analysis and to aggregate into a workable number of sectors, all flows are generally converted to monetary units, usually the value to the producer. A complete accounting of the flows of all goods and services from one sector to another results. If it is assumed that constant input-output ratios hold for each and every sector, all sectors become endogenous and the system is referred to as a "closed model."[6] A more

---

[4]William E. Martin and Harold O. Carter, A California Interindustry Analysis Emphasizing Agriculture, Part I: The Input-Output Models and Results, Gionnini Foundation Research Report No. 250, February 1962.

[5]Ibid., p. 5.

[6]Ibid., p. 6.

common assumption, however, is that constant input-output ratios hold only for those sectors normally considered as intermediate production activities such as manufacturing, while final demand activities such as households and governments are autonomous. Where this assumption is made the system is termed open.

In the second stage, a matrix of technical coefficients is developed. Here, the basic assumption of input-output analysis is involved. A linear relationship is assumed to exist between the purchases of a sector and the level of output of that sector.

A technical coefficient describes the amount of inputs required from each industry to produce one dollar's worth of the output of a given industry.[7] Technical coefficients may be expressed either in monetary or physical units. Two steps are involved in the calculation of technical coefficients: (1) gross output for each industry is determined for the period covered by the flow table, and (2) all entries in each industry's column in the table are divided by the total output for each industry.[8] The technical coefficient A_{ij} is thus derived from a single

---

[7]William H. Miernyk, The Elements of Input-Output Analysis, New York, Random House, 1966, p. 21.

[8]*Ibid.*, p. 21.

observation of the ratio $\frac{(x_{ij})}{(X_j)}$, which is the purchase of output of industry i by industry j, divided by the gross output of industry j, as shown by the equation $a_{ij} = \frac{x_{ij}}{X_j}$.[9] Each sector of the model is now described in terms of a common unit: dollar inputs per dollar ouput. The direct dependence of each sector or any other sector is now quantifiable.

The direct purchases that will be made by a given industry from all other industries for each dollar's worth of current output is shown by the matrix of technical coefficients. But this does not represent the total addition to output resulting from additional sales from any one sector. An increase in final demand for the products of an industry will lead to both direct and indirect increases in the output of all industries.[10] If, for example, there is an increase in demand for the products of industry A, there will be direct increases in purchases from industries B, C, and so on. But in addition, when industry B sells more of its output to industry A, B's demand for the products of industries C, D, etc., will increase also. These effects will spread throughout the entire economy.

---

[9] William E. Martin, op. cit., p. 7.

[10] William H. Miernyk, op. cit., p. 25.

An integral part of input-output analysis is the construction of a table which shows the direct and indirect effects of changes in final demand. It shows the total expansion of output in all industries as a result of the delivery of one dollar's worth of output by each industry. There are various methods for computing the combined direct and indirect effects. One is an iterative or step-by-step method. Another method which is shorter and more amenable to computer adaptation involves the use of interdependence coefficients. The third, and perhaps most useful, matrix summarizes not only the direct, but also the indirect and circular effects of one sector on another. Each interdependence coefficient shows the output required from one industry per dollar of output of another industry delivered to final demand. The interdependence coefficients are computed directly from the technical coefficient matrix, being the inverse of the difference between an identity matrix and the matrix of technical coefficients.[11]

An important part of the study will be to determine the influence of the available water supply on the level of economic activity in the watershed area. At a given point in time, the available supply of scarce

---

[11]William E. Martin, op. cit., p. 7.

primary resources is one of the determinants of output by sectors of the economy. Available resources can be viewed as imposing restrictions on output. The interdependency matrix of the watershed input-output model provides the basis for predicting individual industry outputs given a specific level of final demand. If the functional relationship between resource requirements and output is specified, total resource requirements given final demand may be computed.[12]

A primary resources coefficient matrix expresses primary resources required as inputs per unit of output by an individual industry. In the primary resources matrix the coefficients are derived from a single observation of the ratio $B_{hj} = \frac{R_{hj}}{X_j}$ where R_{hj} is the amount of primary resource h required by industry j and X_j is the total output of industry j.[13] Thus by multiplying the matrix of primary resource technical coefficients, times the matrix of interdependency coefficients, a matrix of coefficients expressing primary resource inputs per dollar of delivery to final demand is created.

---

[12] Ibid., p. 14.

[13] William E. Martin, op. cit., p. 15.

Assumptions

Several assumptions are implicit in making a study such as the one proposed, the prime one being that of the watershed firm concept. Under this assumption the watershed area is taken as an economic unit, that is, the watershed can be said to represent a center of economic activity and a composite decision-making unit or "watershed firm" integrating interests of one or more private and/or public decision-making units. The concept can be broadened to include interests outside the watershed proper, if such off-site interests are measurably affected by on-site decisions.

The assumptions and the validity of assumptions of input-output analysis have been discussed in detail by many writers. The essential assumptions are concerned with the nature of production: (1) input-output coefficients are assumed fixed and (2) aggregation errors are absent in combining industries or commodities into a manageable number of sectors.

The fixed coefficient assumption has several implications which are considered contradictory to actual production possibilities. It implies that all inputs are uniformly affected by a change in scale of production, thus ignoring the distinction between fixed and variable inputs and between the short-and-long-run. It assumes that substitution possibilities due to changes in relative prices or availabilities are unimportant. Cameron[14] in a time series analysis of selected input coefficients concluded that his results generally supported the assumption of fixed production coefficients in the short-run. Yet, Chenery[15] in a broad review of the accomplishments in this area only infers that because of the properties of input-output matrices, errors in the coefficients do not lead to cumulative errors in the solutions, but on the contrary tend to compensate for each other. The most important coefficients should be discovered and additional attention devoted to quantifying these, while assuming small errors in the great bulk of coefficients will not cause difficulties. Continuing technological changes, however, make it advisable for complete or partial revision of input-output tables every four or five years.

Regional Impact Analyses

The primary use of regional models have been in making local and regional impact studies. Local and regional

---

[14]B. Cameron, "The Production Function Leontief Models," Review of Economic Studies, Vol. XX, No. 1, pp. 62-69.

[15]Hollis B. Chenery and Paul G. Clark, Interindustry Analysis, New York, John Wiley and Sons, Inc., 1959.

impact studies are designed to measure the direct, indirect and induced income and employment effects of changes in final demand in one or more sectors of the local or regional economy.[16] In an impact analysis attention is focused on the total changes in an economy which are expected to result from exogenous changes--changes in final demand in some of the major sectors of an input-output system. Most regional impact studies have been concerned with measuring the effects of changes in final demand for existing industries in the region. Some, however, have been concerned with the total impact on an area.

Data Problems in Regional and Interregional Input-Output Analysis

All the interregional input-output tables constructed in the United States to date, and all of the early regional tables were based upon input coefficients taken from the national table. The procedure in constructing each table was to obtain (or estimate) total gross output figures for each industry and sector in the region or regions to be analyzed. These figures, for each industry and sector, were then multiplied by national input

---

[16] William H. Miernyk, op. cit., p. 69.

coefficients. The result in each case was a table of inter-industry flows based on the assumption that regional input patterns are identical to national input patterns. The lack of data on a regional basis--particularly of accurate data on shipment from region to region--forces researchers to turn to this expedient.

The major problem involved in using national input coefficients to construct regional or area tables is that of variations in industry-mix and product-mix from region to region. This problem is minimized if a table of national coefficients is available in great detail. If, for example, the industrial classification used in constructing a national table follows the four-digit Standard Industrial Classification, and if the distribution of industries within the region is available in similar detail, the national coefficients may not differ significantly from regional coefficients.

An important forward step in regional input-output analysis was taken by Moore and Petersen when they constructed their input-output table for Utah.[17] These authors followed Isard's procedure in estimating total gross output figures for the 26 sectors of their transactions

---

[17]Frederick T. Moore and James W. Petersen, "Regional Analysis: An Inter-industry Model of Utah," The Review of Economics and Statistics, Vol. 37, No. 4, November, 1955, p. 371.

table from published sources. Their next step was to use national input coefficients to determine interindustry flows as a first approximation. Following this, the row and column distributions for each sector were modified in the light of differences in regional productive processes, marketing practices, or product-mix. These modifications were based on all the information they could obtain about individual industries, upon technical data, and upon estimates constructed from employment and income data. The Moore-Petersen study served as a model for other regional researchers and marked a major step forward in regional input-output analysis.

Selection of Data

The most useful data for a study of the nature proposed would include a complete record of material inputs, labor requirements, shipments, construction, inventories, taxes, and profits of all industrial, government, trade, and service establishments located in the watershed area. With such comprehensive information, it would be possible to construct an input-output table which would indicate accurately the interindustry flows and external relationship of the area economy. However, the data available seldom approaches the ideal and for this study fell considerably short of it.

The task of separating and distributing the multitude of products involved is beyond the capabilities of the individual researcher, even if complete current data are available to him. For most of the many watershed industries input information is not available for any one given year. To develop new input information on any one industry would require a study of major proportions. The one source of complete information in a form usable for input-output work is the 1958 Bureau of Labor Statistics' input-output model for the United States. Dr. Kirksey's study of the Sabine-Neches area of south-east Texas has been another valuable source of usable data.[18] Both the Bureau of Labor Statistics and Dr. Kirksey's study list technical coefficients--value of inputs per dollar's worth of output--for industrial sectors for the United States and for the general study area respectively. The input structure of the individual industries and sectors was derived using the individual technical coefficients from these two sources.

---

[18]C. D. Kirksey, An Interindustry Study of the Sabine-Neches Area of Texas, Bureau of Business Research, The University of Texas, Austin, 1959.

General Plan of the Study

The basic approach to this study has been to construct a flow table, representing the interindustry flows of the watershed area economy. The procedure used was to make an economic survey of the watershed to establish the basic economic pattern and output of the various sectors and industries.

The Industrial Classification

As a starting point for the construction of the area flow table, the national interindustry relations study for 1958 was adopted. There is considerable merit in beginning the analysis with this classification system, since it is based on the Standard Industrial Classification utilized in the collection of federal industrial statistics, and it allows use to be made of information developed in the 1958 study. Accordingly, the economy of the watershed area was examined for industrial activity in each of the industries listed in the study; if there was any activity, the particular industry was included in an initial classification. The industries emphasized in the aggregation were chosen according to a priori hypotheses and preliminary evidence of their relative importance in the area.

Construction of the Transaction Table

In the preparation of the area flow table the first step was to obtain a monetary control total for the gross output of each industrial sector. In some cases coefficient data existed for direct estimation of gross output; in other cases, however, data on output were scarce, and indirect estimation procedures were used.

In filling in the body of the table, it was found that information on the distribution of sales or the cost structure (inputs) was meager, so national input coefficients were assumed to apply to the watershed area. The gross output estimates multiplied by these national input coefficients completed each sector column. The body of the table was filled in column by column in this fashion. After the national input coefficients were used in conjunction with the estimated area industrial control totals to fill in the body of the table, all available information on individual industries, technical data, etc. were used to modify the distribution of the outputs. Modifications in the input structure were made until the resulting table appeared reasonable in the light of all available information. The checks on individual entries or groups of entries provided by the industry studies provided a base with which to compare the row and column distributions.

The estimation of the final demand sectors required somewhat different treatment. Final demand in the 1958 Bureau of Labor Statistics study consisted of personal consumption expenditures, gross private fixed capital formation, net inventory change, gross exports and federal, state and local government purchases. Data for these items are not available on a local basis. Since the distribution of the output of each sector plus final demand is equal to the total output of each sector, final demand was determined by summing the output of each sector and subtracting this figure from the total output figure. This amounts to balancing the output equation for each sector by adjusting the final demand in each sector.

Estimation Procedure

The estimation procedure for output varied for the different sectors of the area economy. In some sectors total output figures were available in detail while in others only vague output figures were available. In the following discussion, estimation procedure will be separated into two general categories; manufacturing sectors and other sectors. The manufacturing sectors include all sectors engaged in manufacturing of any kind. Other sectors include the agricultural sectors, mining, construction, trade, finance, real estate, personal service and households. The estimated total output figures for these sectors are shown in Tables 3.1 and 3.2.

Other Sectors

For the livestock and livestock products, other agricultural products, agricultural forestry products and mining sectors total output figures were available, making it unnecessary to estimate these output figures. For these four sectors, the source and an explanation of what is contained in the total output figures are listed.

1. Livestock and Livestock Products--value of all livestock and livestock products sold; source, U. S. Census of Agriculture: 1959 Final Report, Vol. 1, Part 37, Table 5.
2. Other Agricultural Products--value of field crops, vegetables, fruits and nuts sold; source, U. S. Census of Agriculture: 1959 Final Report, Vol. 1, Part 37, Table 5.
3. Agricultural Forestry Products--value of forest products and horticultural specialty products sold; U. S. Census of Agriculture: 1959 Final Report, Vol. 1, Part 37, Table 5.

Table 3.1 ESTIMATED OUTPUT IN AGRICULTURAL, MINING, CONSTRUCTION AND OTHER SECTORS, WATERSHED STUDY AREA, 1958

Sector	Output (Dollars)	Value Added Coefficient	Estimated Output (Dollars)
1. Livestock and Livestock Products	18,814,754		18,814,754
2. Other Agricultural Products	6,115,495		6,115,495
3. Agricultural Forestry Products	4,330,014		4,330,014
4. Mining	76,965,974		76,965,974
5. Construction	60,852,521		60,852,521
6. Trade	329,272,000	.72446	238,544,393
7. Finance	154,562,000	.56018	86,582,541
8. Real Estate	215,417,688	.72225	155,585,425
9. Personal Services	18,719,000		18,719,000

Table 3.2. Estimated Output in Manufacturing Sectors, Watershed Study Area, 1958

	Sector	Employees, Study Area (Number)	Value-Added per Employee, Texas Industries (Dollars)	Value Added Study Area (Dollars)	Value Added Coef-ficient	Estimated Output (Dollars)
1.	Food & Kindred Products	1,010	7,906	7,985,066	.25615	31,173,398
2.	Apparel, etc.	1,235	4,254	5,253,736	.38041	13,810,686
3.	Lumber & Wood Products	551	6,708	3,696,230	.32181	11,485,396
4.	Wooden Containers	370	4,510	1,668,997	.36561	4,564,862
5.	Household Furniture	152	6,580	1,000,244	.41598	2,404,491
6.	Other Furniture	78	6,302	491,616	.44735	1,098,951
7.	Printing & Publishing	305	8,094	2,468,783	.47213	5,229,032
8.	Chem., Paints, etc.	397	17,681	7,019,640	.38572	18,198,522
9.	Petroleum Ref.	337	13,909	4,687,333	.20050	23,378,219
10.	Rubber & Plastic Products	68	13,426	912,968	.45535	2,004,980
11.	Glass & Glass Products	267	11,132	2,972,244	.55467	5,358,579
12.	Stone & Clay Products	504	6,316	3,183,334	.48315	6,588,707
13.	Primary Metals	2,200	7,084	15,584,930	.39415	39,539,864
14.	Heating & Plumbing	487	8,653	4,214,079	.38382	10,979,308
15.	Construction Machinery	58	8,684	503,672	.44130	1,141,336
16.	Machine Shops & Metalworking	39	8,381	326,865	.50562	646,461
17.	Service Ind. Machinery	589	8,760	5,159,640	.34131	15,116,725
18.	Household Appl.	293	7,251	2,124,543	.37225	5,707,299
19.	Aircraft Rep. & Pts.	7	93,039	651,273	.47004	1,385,569
20.	Motor Equip. & Mch.	79	5,293	418,162	.35902	1,164,722
21.	Misc. Mfg.	159	7,532	1,197,610	.40292	2,972,308

4. Mining--value of minerals produced in 1958; Texas Minerals--Kinds and Value, by county. Texas Almanac 1961-1962, p. 138-140.

For the construction sector, it was necessary to impute a value for total output. The total output figure for this sector was derived by multiplying the input coefficient for construction in each of the sectors in the technical coefficient table times the output of that sector. The products represented the purchases of each sector from the construction sector. The sum of these purchases gives the estimated total output for the construction sector.

Trade includes both retail and wholesale sales. In order to eliminate the likelihood of double counting, it was decided to use the value added figure for this total. This was done by multiplying the total sales by the value added coefficient taken from the Bureau of Labor Statistics input-output table for the United States. Finance and real estate were treated in the same way. For finance, bank deposits were used as the control or output total, multiplied by the value added coefficient to eliminate double counting. For real estate the total value of property assessed for taxation as shown by the 1958 tax rolls was used for the total, multiplied by the value added coefficient to give the adjusted output total.

Personal services includes the value of various hotel services, amusements, such as theatres, automobile repair services, etc.

For the household sector the estimation procedure for total output was somewhat different than for the other sectors. The total output figure is actually a residual figure. This residual was calculated by summing the technical coefficients for each sector and subtracting this number from one. The technical coefficients, as pointed out in the estimation of construction output, represent the portions of total output of a sector which are purchased as inputs by other sectors. Consequently the sum of the technical coefficients for a sector is equal to one. Multiplying the technical coefficient for households in each sector times the output of each sector gives the input of households for each sector. Then by summing these figures an estimate of total output for the household sector is obtained.

Manufacturing Sectors

The estimation procedure for each of the manufacturing sectors was the same. Manufacturing industries in each county were established along with size and number of plants. Average employment size for each plant and manufacturing plant was then established. Since, however, by using average employment size for each plant and industry for the nation as a whole resulted in an employment figure substantially above published figures for the five county study area, each industry estimate of number of employees was reduced by 10%. The resulting employment figure of 9185 compared favorably with a total of 9466 employed in manufacturing for 1959, the nearest year for which reliable total employment estimates were available. The difference, 281, could easily represent a 3% increase in employment in manufacturing, a not unreasonable assumption.

The next step was the estimated value--added for manufacturing sectors of the study area. Value-added-per-employee data for Texas industries were used in the estimation. They are more appropriate than like statistics for the United States.

By multiplying value-added-per-employee times the estimated number of employees in each industry in the study area, the value added in each industry was established. Taking these figures and dividing them by the value added coefficient for each industry established a fairly good estimate of total output for each industry. These output figures were then aggregated into the sectors appearing in the input-output table.

Estimation of Water Use

The procedure for estimating the use of water, especially among the manufacturing sectors, was very much the same as that used in estimating total output. In this case, however, it was not possible to come up with a figure for each and every manufacturing sector, only those that used water in one form or another in one or more steps of the manufacturing process are included. The procedure was to calculate the value added per acre foot of fresh water used. Since only national data were available the figures reflect national averages rather than regional. Since, too, water use was measured in billions of gallons it was necessary to convert gallons to acre feet. These acre feet totals for each industry were divided into the value added figures to give value added per acre foot of water used.

The estimates of use of fresh water among manufacturing sectors in the watershed was determined by dividing the value added per acre foot of fresh water for industries in the United States into the value added for each industry sector in the study area. These estimates of water use were then adjusted to reflect the use of fresh water from public water systems. The data used in the estimation procedure and the estimates of water use by industry are included in Table 3.3.

Data relative to water use were then related to output of industry sectors in the watershed. The relationships are shown in Table 3.4.

Outside the manufacturing sector, there are only two sectors considered to be water users of any significance. These are mining which includes oilwell drilling, and agriculture. It was found that while a significant amount of total water was used in agriculture, none of it was provided by a public water supply source or any other off-farm source. For this reason no water use figure appears for agriculture.

Mining, on the other hand, presented another case. The only reliable figures available were those for the year 1962. The figures were for gallons of new water per dollar value of production.[19] By multiplying value of production by this figure, the total use in gallons of water used by the mining industry was derived. From this figure it was necessary to calculate the amount of fresh water used, since not all new water used is fresh. It was determined from published figures that 94.616% of all new water used is

---

[19]Alvin Kaufman, and Barbara Lloyd, Water Use in the Mineral Industry, U. S. Department of the Interior, Bureau of Mines, Table 4, p. 15.

Table 3.3. Estimated Water Use by Manufacturing Sectors, Watershed Study Area, 1958

No.	S.I.C. Code	Employees (Number)	Value Added (Million Dollars)	Water Use, All Purposes (Billion Gallons)	Water Use, All Purposes (Acre Feet)	Value Added per Acre Foot (Dollars)	Estimated Water Use Watershed (Acre Feet)	Fresh Water, Public Sources (Percent)	Estimated Water Use Public Sources (Acre Feet)
1.	2011	130,636	1,230	72	233,244	5,273	139	39.47	54.86
2.	2013	6,976	91	2	6,138	14,825	14	50.	7.00
3.	2015	11,857	60	5	15,345	3,910	145	60.	87.00
4.	2023	5,618	80	11	33,759	2,369	230	9	20.70
5.	2024	5,952	129	3	9,207	14,011	4	33.33	1.33
6.	2026	53,396	599	19	58,311	10,272	128	52.63	67.36
7.	2032	20,586	318	15	46,035	6,907	33	67.00	22.11
8.	2033	57,980	555	32	8,208	5,651	170	40.62	69.05
9.	2035	6,905	78	4	12,276	6,353	5	50	2.50
10.	2042	3,422	82	2	6,138	13,359	19	25.15	4.77
11.	2051	28,471	277	3	9,107	30,359	53	67.	35.51
12.	2071	30,018	345	20	61,380	5,620	56	20.	11.20
13.	2086	18,166	202	4	12,276	16,454	39	100.	39.00
14.	2094	2,240	26	4	12,276	2,117	116	25.	29.00
15.	2097	619	6	5	15,345	391	260	20.	52.00
16.	2099	15,722	432	17	52,173	8,280	13	23.52	3.05
17.	23			0	0	0	0	0	0
18.	2421	42,089	321	120	368,280	871	971	4.16	40.39
19.	2431	4,970	38	1	3,069	12,381	35	6.00	2.1
20.	2432	17,886	138	13	39,897	3,458	563	23.07	129.88
21.	244-	4,034	23	1	3,069	7,494	176	6.00	10.56
22.	2499	3,043	25	1	3,069	8,145	35	6.00	2.10
23.	2511	12,941	84	1	3,069	27,370	2	100.	2.00
24.	2611	7,052	72	6	18,414	3,910	22	16.66	3.66
25.	2653	6,758	64	5	15,345	4,170	63	20	12.60
26.	2711	73,597	766	5	15,345	49,918	39	40.	15.60
27.	2751	31,975	288	7	21,483	13,405	26	85.72	22.28
28.	2752	3,118	26	1	3,069	7,471	0	100.	0
29.	2813	3,214	76	88	270,072	28	3,929	3.409	133.93
30.	2852	14,039	278	8	24,552	11,322	9	37.50	3.37
31.	2861	5,219	74	34	104,346	709	151	2.94	4.43
32.	2873	1,422	45	2	6,130	7,331	111	4.00	4.44
33.	2899	1,714	154	31	95,139	1,618	3,600	3.22	115.92
34.	2911	134,773	2,392	1,311	4,023,459	594	7,891	9.76	770.16
35.	3069	78,718	736	39	119,691	6,149	148	28.20	41.73
36.	3221	44,166	480	8	24,552	19,550	152	37.50	57.00
37.	325-	554	2	1	3,069	651	680	9.	61.20
38.	3273	1,444	16	2	6,138	2,606	195	9.	17.55
39.	3281	2,981	18	3	9,207	1,955	130	9.	11.70
40.	3293	3,148	22	3	9,207	2,389	86	33.33	28.66
41.	3297	2,393	40	7	21,483	1,861	114	9.	10.26
42.	3321	49,223	460	24	73,656	6,245	2,480	20.83	516.58
43.	3361	9,862	84	2	6,138	13,685	7	50.00	3.50
44.	3432	6,610	62	1	3,069	20,202	110	77.	84.70
45.	3433	10,913	123	1	3,069	40,078	32	100.	32.00
46.	3441	11,129	77	1	3,069	25,089	2	77.	1.54
47.	3442	10,072	93	2	6,138	15,151	3	100.00	3.00
48.	3443	30,380	264	4	12,276	21,505	21	75.00	15.75
49.	3481	11,213	95	2	6,138	15,477	3	50.	1.50
50.	3531	66,499	735	7	21,483	34,213	7	42.85	2.99
51.	354-	48,786	506	5	15,345	32,974	3	60.	1.80
52.	3585	34,626	388	4	12,276	31,606	163	75.	122.25
53.	3599	15,699	161	3	9,207	17,486	11	66.66	7.33
54.	3639	93,717	1,088	18	55,242	19,695	108	61.11	65.99
55.	3729	143,392	1,358	12	36,828	36,814	18	75.00	13.50
56.	3732	92,755	756	23	70,587	10,710	5	17.39	.86
57.	3811	36,922	357	2	6,138	58,162	1	50.00	.50
58.	3941	5,799	44	1	3,069	14,336	73	50.00	36.50
59.	3981	8,410	126	2	6,138	20,527	3	50.00	1.50
							23,605		2,921.25

[a]U. S. Bureau of the Census, U. S. Census of Manufacture: 1958 Industrial Water Use, Subject Report M. C. 58 (1) - 11, Table 2, page 11-10.

Table 3.4. Estimated Output per Acre Foot of Water Used, Watershed Study Area, 1958

	Sector	Total Output (Dollars)	Water Use (Acre Foot)	Output per Acre Foot (Dollars)	Water Coefficient
1.	Livestock & Livestock Products	18,814,754			0
2.	Other Agric. Products	6,115,495			0
3.	Agric. Forestry Products	4,330,014			0
4.	Mining	76,965,974	478	161,016	.00621
5.	Construction	60,852,521			0
6.	Food & Kindred Products	31,173,397	506	61,607	.01623
7.	Apparel, etc.	13,801,684			0
8.	Lumber & Wood	11,485,396	175	65,630	.01523
9.	Wooden Containers, etc.	4,564,862	27	169,068	.00591
10.	Household Furniture	2,404,491	2	1,202,245	.00083
11.	Other Furniture & Fixtures	1,098,951			0
12.	Printing & Publishing	5,229,032	38	137,607	.00726
13.	Chem. Paints, etc.	18,198,522	262	69,460	.01439
14.	Petroleum Refining, etc.	23,378,219	770	30,361	.03293
15.	Rubber & Plastic Products	2,004,980	42	47,737	.02094
16.	Glass & Glass Products	5,358,579	57	94,010	.01063
17.	Stone & Clay Products	6,588,707	129	51,075	.01957
18.	Primary Metals	39,539,865	520	76,038	.01315
19.	Heating, Plumbing, etc.	10,979,308	137	80,140	.01247
20.	Construction & Related Machinery	1,141,336	3	380,445	.00262
21.	Machine Shops & Metalwork, etc.	646,460	11	58,769	.01201
22.	Service Industry Machinery	15,116,725	122	123,907	.00807
23.	Household Appliances	5,707,299	67	85,183	.01173
24.	Aircraft Repair & Parts	1,385,569	14	98,969	.01010
25.	Motor Equipment & Vehicles	1,164,720			0
26.	Miscellaneous Manufacturing	2,972,308	40	74,307	.01345
27.	Trade	238,544,394			0
28.	Finance	86,582,540			0
29.	Real Estate	155,585,427			0
30.	Personal Services	18,719,000			0
	Total	870,450,529	3,400		

fresh water. Multiplying this percentage figure times the amount of new water used, which has been converted to acre feet, gives the amount of fresh water used by the mining industry. Only two per cent of this new fresh water comes from sources other than self-operated or company systems, so that only two per cent of new fresh water can be supplied by public supply sources.[20] Figures for both 1958 and 1963 were obtained in this manner using the 1962 data.

---

[20] *Ibid.*, p. 18.

CHAPTER IV

THE WATERSHED MODEL

The watershed model was conceived to examine the interdependence between the various sectors and industries of the watershed economy. Basically the input-output model is a general theory of production. The problem is to determine the levels of production in each sector which are required to satisfy the given level of total output.

The static closed model is based upon three fundamental assumptions. These are that:

1. Each group of commodities is supplied by a single production sector.
2. The inputs to each sector are a unique function of the level of output of that sector.
3. There are no external economies on diseconomies.

The economy consists of n + 1 sectors of these; one sector--that representing final demand--is autonomous. The remaining n sectors are non-autonomous, and structural interrelationships can be established among them.

Basic Mathematical Formulation

The model may be described as in the following equations in which X is the gross output of sector i, where i denotes a non-autonomous sector, x_{ij} the output of the producing industry i purchased by the non-autonomous sector j and Y_i is final demand for sector i.

Under the assumptions of input-output theory:

(1) $X_i = \sum_{j=1}^{n} x_{ij} + Y_i$ for all X_i where $i = j$.

An open system may be described mathematically as follows, in which i and j = 1, 2, 3, . . . n.

$$X_1 = x_{11} + x_{12} + \ldots x_{1j} + \ldots x_{1n} + Y_1$$
$$X_2 = x_{21} + x_{22} + \ldots x_{2j} + \ldots x_{2n} + Y_2$$
$$X_3 = x_{31} + x_{32} + \ldots x_{3j} + \ldots x_{3n} + Y_3$$
$$\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots$$
$$\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots$$
$$X_i = x_{i1} + x_{i2} + \ldots x_{ij} + \ldots x_{in} + Y_i$$
$$X_n = x_{n1} + x_{n2} + \ldots x_{nj} + \ldots x_{nn} + Y_n.$$

Constant technical coefficients are assumed for all X_i industries as in the following equation, $A_{ij} = \frac{x_{ij}}{X_j}$.

Substituting this equation into the above equation and transposing we have: $X_i - \sum_{j=1}^{n} A_{ij}X_j = Y_i$.[1]

This equation is representative of the distribution of output of the sectors. The system may be written in matrix

---

[1]William E. Martin and Harold O. Carter, A California Interindustry Analysis Emphasizing Agriculture, Part I: The Input-Output Models and Results, Gionnini Foundation Research Report No. 250, February 1962, p. 6.

form as in $X - AX = Y$, in which X is a column sector of outputs, A is the matrix of technical coefficients, and Y is a column sector of final demands. Solving for the outputs required from each sector to deliver a specified final demand gives: $X = (I - A)^{-1} Y$ in which I is an identity matrix of the same dimension as A.[2]

Interpretation of this solution is as follows: Given final demand for the area products Y, and the matrix of interdependency coefficients $(I - A)^{-1}$, specific outputs are required of each area industry X.

Consequently, given a change in final demand for the watershed area products, and the interdependency coefficients matrix, the change in required output from each watershed area sector can be determined. Each interdependency coefficient (A_{ij}) must therefore be interpreted as showing the output required of industry i in response to one dollar's worth of final demand for products of industry j.

Definitions and Classifications

Sector Classifications

Brief descriptions of the specific sectors included in the model follow. Although an attempt was made to

---

[2] *Ibid.*, p. 12.

aggregate industries that are homogenous in both input structure and produce type, other important considerations were (1) the form of secondary data sources and (2) available time and funds.

Brief definitions of the commodity or industry included in each sector are given below.

1. Livestock and Livestock Products--beef, poultry and poultry products, dairy products, sheep, lambs and wool and swine.
2. Other Agricultural Products--field crops, vegetables, fruits and nuts.
3. Agricultural Forestry Products--forest, horticultural and specialty products on farms. Commercial logging, timber operations, and forest products grown on nonfarm places are included under wood and lumber products.
4. Mining--iron ore mining, crude petroleum and natural gas, stone and clay mining and quarrying, and chemical and fertilizer mineral mining.
5. Construction--residential and nonresidential nonfarm building and construction.
6. Food and Kindred Products--meat packing plants, prepared meats, poultry dressing plants, condensed and evaporated milk, ice cream and frozen desserts, canned

fruits and vegetables, pickles and sauces, prepared animal feeds, bread and related products, candy and related products, bottled and canned soft drinks, grease and tallow, manufactured ice and food preparations.

7. Apparel and Miscellaneous Fabricated Textile Products--work clothing, women's blouses, dresses, suits, coats and skirts, women's undergarments and miscellaneous apparel, curtains and draperies, textile bags, canvas products, trimming and stitching and textile products not elsewhere classified.

8. Lumber and Wood Products--logging camps, sawmills and planingmills, millwork plants, prefabricated wood products and wood products not elsewhere classified.

9. Wooden Containers and Paperboard Boxes--wooden containers, nailed wooden boxes, paperboard boxes and corregated shipping containers.

10. Household Furniture--wooden furniture upholstered and wooden furniture not upholstered, and mattresses and bedsprings.

11. Other Furniture and Fixtures--public building furniture, and furniture and fixtures not elsewhere classified.

12. Printing and Publishing--newspapers and periodicals, book publishing and printing, letterpress and typesetting.

13. Chemicals, Paints and Selected and Allied Products--industrial gases, paints and varnishes, gum and wood chemicals, agricultural chemicals, and chemical preparations.
14. Plastics and Synthetic Materials--plastic materials, synthetic rubber, cellulosic man-made fiber, organic fibers and noncellulosic fibers.
15. Petroleum Refining and Related Industries--petroleum refining, paving mixtures and blocks, asphalt felts and coatings, lubricating oils and greases, and petroleum and coal products not elsewhere classified.
16. Glass and Glass Products--flat glass, glass containers, pressed and blown glass, and products of processed glass.
17. Stone and Clay Products--structural clay products, brick and structural tile, ceramic wall and floor tile, concrete blocks and bricks, concrete products, ready-mix concrete, cut stone and stone products, and non-metallic minerals.
18. Primary Ferrous and Nonferrous Metals Manufacturing--gaskets and insulations, gray iron foundries, and aluminum castings.
19. Heating, Plumbing and Fabricated Structural Metals Products--non-electric heating equipment, fabricated

structural steel, metal sash, doors and trim, boiler shop products, and sheetmetal work.

20. Construction, Mining, Oilfield Machinery and Equipment.
21. Other Metal Products--fabricated wire products, special dies and tools and machine shop products.
22. Service Industry Machinery--automatic vending machines, refrigeration machinery, and service industry machinery not elsewhere classified.
23. Aircraft--aircraft parts and repair.
24. Household Appliances--household cooking equipment, household laundry equipment, electric housewares and fans, and household appliances not elsewhere classified.
25. Motor Equipment, Vehicles and Other Transportation Equipment--truck and bus bodies, ship and boat building and repair, and trailer coaches.
26. Miscellaneous Manufacturing--scientific instruments, games and toys and brooms.
27. Trade--wholesale and retail sales.
28. Finance--banks and saving and loans.
29. Real Estate--real estate and rentals.
30. Personal Service--hotel and personal services, automobile repair services, amusements and theaters.
31. Households--wages, depreciations, profit, etc., and government services. Value added by manufacture.

The Flow Tables

Table 4.1 summarizes the interindustry flows of goods and services within the study area by sector of origin and destination. The entries in each row of Table 4.1 lists by producers' prices the amount of a sector output consumed by itself and each of the other sectors in the economy. For example, reading across the first row in section 1, livestock and livestock products sold $3,027,858 worth of output to the livestock and livestock product industry, that is to itself. It sold $444,474 worth of products to other agricultural products, $602,911 to agricultural forestry products, none to mining, $137,527 to the construction sector, $7,780,568 to the food and kindred products sector, $2,241,986 to real estate, $7,488 to personal services and $4,571,942 to final demand. The final column lists the total output of the sector ($18,814,754). The other rows in the table are read in the same way, each figure represents the amount of output sold by the sector listed on the left to each sector at the top of the column.

Each column of Table 4.1 represents a sector's input structure. Again using the livestock and livestock sector as an illustration, it is shown that the livestock and livestock products sector bought $3,027,858 worth of products from itself (row 1). It in turn purchases $4,709,898

15 Rubber & Plastics	16 Glass & Glass Products	17 Stone & Clay	18 Primary Metals	19 Heating & Plumbing	20 Construction Machinery	21 Machine Shops	22 Service Industry Machines	23 Household Appliances	24 Aircraft Repair	25 Motor Equipment	26 Misc. Manufactg.	27 Trade	28 Finance	29 Real Estate	30 Personal Services	31 Final Demand	Total Output
0	0	0	0	0	0	0	0	0	0	0	0	0	0	2,241,986	7,488	4,571,942	18,814,754
0	0	3,426	0	0	0	0	0	0	0	0	3,745	0	0	3,404,209	3,744	-6,374,494	6,115,495
0	0	0	0	0	0	0	0	0	0	0	0	0	0	3,112	0	2,641,908	4,330,014
3,749	61,892	657,355	2,756,719	0	0	110	0	0	0	93	0	9,542	0	351,623	0	71,648,399	76,965,974
1,905	2,358	3,031	181,553	0	262	10,007	18,140	3,596	2,466	3,948	51,243	1,941,751	391,353	14,825,735	279,662	38,722,165	60,852,521
801	0	5,666	8,699	0	0	0	1,361	57	0	0	8,917	1,326,307	0	157,141	43,428	21,443,647	31,173,397
136,858	6,830	2,899	31,236	11,175	856	737	11,489	4,052	1,233	4,915	8,649	229,003	103,033	73,125	101,270	8,021,721	13,801,684
1,279	80,018	11,866	40,311	26,801	1,415	679	40,281	9,075	2,155	21,907	53,056	145,512	0	59,127	7,675	1,362,826	11,485,396
18,606	503,043	22,673	32,818	54,128	993	2,016	202,262	87,436	1,025	815	66,996	1,111,617	79,656	28,005	12,355	1,050,479	4,564,862
190	17,169	0	3,163	10,870	183	789	16,780	970	0	7,839	1,308	33,396	0	7,779	17,034	1,973,404	2,404,491
391	0	0	195	17,677	0	84	10,128	1,598	2,342	4,880	6,688	1,149,784	0	3,112	5,241	-493,990	1,098,951
6,235	7,984	19,262	86,657	5,819	479	556	3,477	3,653	1,108	594	5,528	589,205	1,287,882	143,139	946,994	1,208,765	5,229,032
405,210	201,251	146,335	410,028	56,324	2,694	491	171,726	61,981	2,827	9,108	5,707	310,108	0	214,708	120,925	9,808,365	18,198,522
4,832	16,504	74,057	231,704	57,971	5,010	0	44,594	7,305	3,298	3,692	571,575	1,822,479	305,636	911,731	101,270	6,841,536	23,378,219
61,754	20,363	67,271	95,291	15,042	17,131	2,676	171,575	186,343	8,591	32,472	67,679	593,976	174,031	110,466	192,057	-2,655,481	2,004,980
12,832	626,634	5,139	2,372	40,843	34	91	41,722	10,444	180	8,735	11,949	264,784	0	14,003	48,482	3,767,329	5,358,579
7,078	151,648	1,120,278	306,980	68,182	6,597	6,794	89,642	44,460	5,182	6,313	32,041	300,566	0	49,787	34,443	-1,922,130	6,588,707
7,490	11,628	30,969	11,050,602	3,438,610	240,936	144,348	1,799,797	907,062	183,148	134,886	190,614	57,251	0	79,349	16,847	15,024,987	39,539,865
882	2,197	4,349	54,960	249,132	17,965	3,090	349,347	89,890	845	52,704	2,378	243,315	0	23,338	52,600	3,832,739	10,979,308
20	0	461	15,025	32,718	124,725	11,836	7,407	1,769	227	6,103	892	69,378	0	18,670	13,290	-1,050,125	1,141,336
28,252	32,473	89,277	1,037,526	450,371	39,308	61,239	456,374	581,003	54,716	47,556	80,995	248,086	0	124,468	201,791	-5,905,714	646,461
40	1,018	395	5,536	90,689	1,792	821	781,686	165,569	1,873	2,795	2,794	88,261	0	32,673	32,758	13,898,537	15,116,725
882	2,036	0	10,280	74,110	183	860	2,299,254	61,125	3,048	5,847	4,161	59,636	0	26,450	141,328	2,785,728	5,707,299
4,032	0	857	1,582	16,359	742	2,010	97,201	799	265,336	5,241	24,284	169,367	0	32,673	1,085,515	-332,697	1,385,569
622	0	1,318	92,573	121,321	22,256	12,929	194,401	23,057	9,145	239,538	27,583	551,038	31,170	63,790	683,244	-1,538,875	1,164,722
11,789	9,431	19,205	51,797	107,487	1,438	5,818	215,262	178,810	23,818	5,160	193,289	381,671	73,595	56,011	336,568	787,786	2,972,308
49,292	208,663	205,106	1,380,337	397,890	40,244	20,797	821,443	240,277	25,605	36,479	161,367	3,962,222	836,387	2,683,849	666,396	211,854,160	238,544,394
11,609	57,032	65,426	289,632	87,505	8,001	44,894	121,538	18,606	4,171	4,659	20,152	3,957,451	21,087,178	5,187,218	337,504	51,007,820	86,582,540
760,932	38,683	52,248	153,415	67,633	6,232	8,074	194,401	29,963	7,828	5,205	35,608	12,642,853	6,733,524	3,184,834	912,551	116,403,874	155,585,427
52,906	95,416	123,736	382,746	161,066	17,942	9,206	178,075	494,138	4,933	21,233	61,408	14,777,825	3,639,930	4,398,400	1,681,715	-16,448,993	18,719,000
1,957,206	3,371,837	3,746,405	20,816,158	5,319,585	584,969	345,508	6,768,362	2,494,261	871,274	506,002	1,271,702	191,508,210	51,839,565	117,074,921	10,634,825		551,944,555
2,004,980	5,358,579	6,588,707	39,539,865	10,979,308	1,141,336	646,461	15,116,725	5,207,299	1,385,569	1,164,720	2,972,308	238,544,394	86,582,540	155,585,427	18,719,000	551,994,557	870,450,532

Table 4.1. Interindustry Flows of Goods and Services, Dollar Values, by Sector of Origin and Destination, Watershed Study Area, 1958

	1	2	3	4	5	6	7	8	9	10	11	12	13	14
	Livestock Products	Other Ag. Products	Ag. Forestry Products	Mining	Con-struction	Food Products	Apparel & Misc. Products	Lumber & Wood Products	Wooden Containers	Household Furniture	Other Furniture	Printing & Publishing	Chemicals & Allied Products	Petr… Refi…
1. Livestock & Livestock Products	3,027,858	444,474	602,911	0	137,527	7,780,568	0	0	0	0	0	0	0	
2. Other Agricultural Products	4,709,898	184,504	1,521,090	0	0	2,295,921	8,143	276,109	0	0	0	0	20,209	
3. Agricultural Forestry Products	351,459	228,964	4,547	0	0	0	7,039	1,070,783	0	0	0	0	22,292	
4. Mining: Pet. & Natl. Gas	4,892	17,368	0	168,554	599,397	5,923	0	0	0	0	0	0	90,593	[illegible]
5. Construction	167,075	98,276	996	2,123,491	5,477	111,601	4,831	858,533	16,160	1,371	329	53,964	66,051	[illegible]
6. Food & Kindred Products	2,104,807	734	73,870	0	9,736	5,210,945	0	0	737	20,342	77	0	742,854	14,
7. Apparel & Misc. Fab. Text. Pro.	5,833	9,112	0	0	1,826	66,399	4,928,720	8,694	2,282	3,895	7,[illegible]	0	29,482	2,
8. Lumber & Wood Products	1,317	428	0	491,043	3,265,955	1,870	138	2,903,163	1,692,285	391,259	65,[illegible]	784,[illegible]	6,164	
9. Wooden Contnrs. & Paperbd. Boxes	9,972	26,786	28,102	147,005	0	468,848	108,895	38,361	166,435	44,772	20,886	26,250	151,119	15,
10. Household Furniture	000,000	0	0	0	172,213	0	40,991	25,153	13,695	35,586	31,0[illegible]	0	0	
11. Other Furniture & Fixtures	000,000	0	0	0	148,480	0	36,298	4,135	2,511	17,986	21,792	2,092	157,417	
12. Printing & Publishing	3,575	1,896	260	50,798	6,694	58,918	15,182	41,233	22,550	866	1,110	681,604	4,006	1,
13. Chemicals, Paints & Reltd. Prod.	24,459	298,314	6,062	527,987	310,348	108,172	22,635	4,594	7,441	49,052	18,199	74,275	1,[illegible],572	1,621,
14. Petroleum & Nat. Gas Refining	96,927	1,347,425	159,610	4,408,611	1,248,694	135,916	9,385	103,254	29,489	5,098	2,299	4,654	4,116,[illegible]	[illegible]
15. Rubber & Plastic Products	15,052	40,607	35,590	1,872,582	300,003	69,205	214,340	72,473	23,007	97,262	10,000	6,275	88,241	4,
16. Glass & Glass Products	2,446	0	0	3,077	196,554	289,601	138	13,438	6,573	33,879	40,914	0	11,9[illegible]	1,
17. Stone & Clay Products	752	6,544	0	2,616,074	3,348,106	1,247	138	44,104	3,469	6,204	1,000	52	117,180	44,
18. Primary Metals	752	183	0	2,917,000	2,794,348	37,769	3,174	459	181,910	57,804	192,312	6,275	237,491	1,
19. Heatg., Plumb., & Struct. Metals	0	0	0	143,926	5,819,935	0	138	4,135	1,287	7,646	13,9[illegible]	0	6,169	4,
20. Construction Machinery	0	0	0	1,759,442	137,527	0	1,656	0	0	0	361	157	0	
21. Machine Shops & Metal Work	22,013	10,763	24,984	1,754,824	506,901	47,695	0	35,490	23,555	148,161	43,167	9,621	71,704	317,
22. Service Industry Machinery	0	0	0	0	0	0	0	345	0	168	10,297	0	779	
23. Household Appliances	0	0	0	0	288,805	0	0	0	137	2,691	730	0	0	
24. Aircraft Repair & Parts	0	0	0	0	0	0	2,070	345	0	129	1,031	1,002	778	
25. Motor Equipment & Vehicles	16,933	9,724	0	610,340	1,826	0	0	5,168	548	170	4,309	944	0	
26. Miscellaneous Manufacturing	752	122	1,386	18,472	135,701	14,652	261,404	7,891	0	11,397	21,192	14,22[illegible]	[illegible],876	1,
27. Trade	667,924	268,226	12,167	3,688,210	6,583,025	1,150,610	566,145	498,581	195,191	133,113	58,020	223,032	457,509	249,
28. Finance	134,714	74,609	14,419	2,971,656	341,383	164,907	76,461	72,013	28,622	12,768	5,208	117,235	314,873	147,
29. Real Estate	208,467	467,346	44,816	13,111,154	184,383	139,033	150,852	74,311	43,229	29,166	11,814	283,202	[illegible],186	179,
30. Personal Services	177,235	223,277	16,238	4,125,376	2,392,721	920,550	146,988	173,774	51,492	49,628	14,726	295,65[illegible]	[illegible],174	249,
31. Households	7,059,642	2,355,811	1,792,966	33,456,341	31,974,956	12,113,047	7,195,923	5,149,707	2,052,955	1,244,155	531,553	2,721,445	7,[illegible],255	18,566,
Total Inputs	18,814,754	6,115,495	4,330,014	76,965,974	60,852,521	31,173,397	13,801,684	11,485,396	4,564,862	2,404,491	1,098,951	5,229,032	19,1[illegible],522	23,378,

from other agricultural products, $2,104,807 from food and kindred products, and $7,059,642 worth of products was purchased from the household sector which includes imports and wages paid for labor. The outlays of all the other sectors may be similarly traced by examining their respective columns.

Technical Coefficients

Table 4.2 shows the direct purchases of each sector from every other sector per dollar of output in 1958. All entries in Table 4.2 can be calculated directly from Table 4.1. For example, other agricultural products purchased by livestock and livestock products ($4,709,898) divided by the total output of the livestock and livestock products sector ($18,814,754) is equal to .25033. All other entries in the other columns and rows can be calculated in the same way.

Each entry in Table 4.2 shows the value of goods and services required from the row sector per dollar of output by the column sector. For instance, for each dollar of output produced by the livestock products sector the following amount of goods and services were directly required: 16.0 cents internally; 25.0 cents of other agricultural products; 1.8 cents of agricultural

13 Chemicals & Allied Products	14 Petroleum Refining	15 Rubber & Plastics	16 Glass & Glass Products	17 Stone & Clay	18 Primary Metals	19 Heating & Plumbing	20 Construction	21 Machine Shops	22 Service Industry	23 Household Appliances	24 Aircraft Repair	25 Motor Equipment	26 Miscellaneous Manufacturing	27 Trade	28 Finance	29 Real Estate	30 Personal Services
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	.01441	.00040
0.00111	0.	0.	0.	.00052	0.	0.	0.	0.	0.	0.	0.	0.	.00126	0.	0.	.02198	.00020
.00122	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	.00002	0.
.00500	.02521	.00187	.01155	.09977	.06972	0.	0.	.00017	0.	0.	0.	.00008	0.	.00004	0.	.00226	0.
.00363	.04043	.00095	.00044	.00046	.00358	0.	.00023	.01548	.00120	.00063	.00178	.00339	.01724	.00814	.00452	.09529	.01494
.04082	.00061	.00020	0.	.00086	.00022	0.	0.	0.	.00009	.00001	0.	0.	.00300	.00556	0.	.00101	.00232
.00162	.00012	.06307	.00120	.00044	.00079	.00120	.00075	.00114	.00076	.00071	.00089	.00422	.00291	.00096	.00119	.00047	.00541
.00035	.00004	.00162	.01511	.00174	.00102	.00235	.00124	.00105	.00326	.00159	.00170	.02396	.01785	.00061	0.	.00038	.00041
.00845	.00061	.00728	.03201	.01103	.00083	.00493	.00087	.00312	.01138	.01532	.00074	.00070	.02254	.00466	.00092	.00018	.00066
0.	0.	.00007	.00227	0.	.00008	.00099	.00016	.00122	.00111	.00017	0.	.00673	.00044	.00014	0.	.00005	.00091
.00865	0.	.00015	0.	0.	.00001	.00161	0.	.00013	.00067	.00028	.00169	.00419	.00225	.00482	0.	.00002	.00028
.00033	.00006	.00311	.00149	.01203	.00118	.00053	.00042	.00085	.00023	.00064	.00080	.00051	.00186	.00247	.01487	.00092	.05059
.17032	.06060	.24609	.03793	.02221	.01037	.00513	.00236	.00076	.01136	.01086	.00204	.00782	.00192	.00130	0.	.00138	.00646
.24158	.01828	.00241	.00308	.01124	.00586	.00528	.00439	0.	.00295	.00128	.00238	.00317	.19230	.00764	.00353	.00586	.00541
.00486	.00038	.03090	.00380	.01021	.00241	.00137	.01501	.00414	.01135	.03265	.00620	.02788	.02277	.00249	.00201	.00071	.01026
.00074	.00013	.00639	.09826	.00078	.00006	.00382	.00003	.00014	.00276	.00183	.00013	.00750	.00402	.00111	0.	.00009	.00259
.00645	.00192	.00353	.02830	.17003	.01004	.00621	.00578	.01051	.00593	.00779	.00374	.00542	.01078	.00126	0.	.00032	.00184
.01305	.00006	.00396	.00218	.00470	.27948	.21110	.22329	.22329	.11906	.15893	.06001	.11581	.06413	.00024	0.	.00051	.00090
.00035	.00014	.00044	.00041	.00066	.00139	.02260	.01574	.00478	.02311	.01575	.00061	.04525	.00080	.00102	0.	.00015	.00281
0.	0.	.00001	0.	.00007	.00038	.00298	.10928	.00284	.00049	.00031	.00016	.00524	.00030	.00029	0.	.00012	.00071
.00405	.01357	.01444	.00606	.01355	.02624	.04102	.03444	.09473	.03019	.10180	.03949	.04083	.02725	.00104	0.	.00080	.01078
.00004	0.	.00002	.00019	.00006	.00014	.00826	.00065	.00127	.05171	.02901	.00063	.00240	.00094	.00037	0.	.00021	.00175
0.	0.	.00044	.00038	0.	.00026	.00675	.00016	.00133	.15210	.01071	.00220	.00502	.00140	.00025	0.	.00017	.00755
.00004	0.	.00246	0.	.00013	.00004	.00149	.00065	.00311	.00643	.00014	.19150	.00450	.00817	.00071	0.	.00021	.05799
0.	.00003	.00031	0.	.00020	.00234	.01105	.01950	.02000	.01286	.00404	.00660	.18849	.00928	.00231	.00036	.00041	.03650
.00129	.00006	.00588	.00176	.00293	.00131	.00979	.00126	.00900	.01424	.03133	.01719	.00443	.06503	.00160	.00085	.00036	.01798
.03531	.01027	.03456	.03894	.03113	.03491	.03624	.03526	.03217	.05434	.04210	.01848	.03132	.05429	.01661	.00966	.01725	.03560
.00851	.00633	.00579	.00971	.00993	.00732	.00797	.00701	.00757	.00804	.00326	.00301	.00400	.00678	.01659	.24355	.03334	.01803
.01100	.00768	.01047	.00722	.00793	.00388	.00616	.00545	.01249	.01286	.00525	.00565	.00447	.01198	.05300	.07777	.02047	.04875
.01600	.01029	.02539	.01781	.01878	.00968	.01467	.01572	.01424	.01178	.08658	.00356	.01823	.02066	.06195	.04204	.01827	.08984
.41524	.79418	.52729	.61991	.56861	.52646	.48451	.51253	.53446	.44774	.43703	.62882	.43444	.42785	.80282	.59873	.75248	.56813

Table 4.2. Technical Coefficients, Watershed Economy, Watershed Study Area, 1958

	1 Livestock Products	2 Other Ag. Products	3 Ag. Forestry Products	4 Mining	5 Con- struction	6 Food Products	7 Apparel & Misc. Products	8 Lumber & Wood Products	9 Wooden Containers	10 Household Furniture	11 Other Furniture	12 Printing & Publishi
1. Livestock & Livestock Products	.16093	.07268	.13924	0.	.00226	.24959	0.	0.	0.	0.	0.	0.
2. Other Agricultural Products	.25033	.03017	.35129	0.	0.	.07365	.00059	.02400	0.	0.	0.	0.
3. Agricultural Forestry Products	.01868	.03744	.00104	0.	0.	0.	.00051	.09323	0.	0.	0.	0.
4. Mining: Pet. & Natl. Gas	.00026	.00284	0.	.00219	.00985	.00019	0.	0.	0.	0.	0.	0.
5. Construction	.00888	.01607	.00023	.02759	.00009	.00358	.00035	.07475	.00354	.00057	.00030	.0103
6. Food & Kindred Products	.11187	.00012	.01706	0.	.00016	.16716	0.	0.	.00003	.00866	.00007	0.
7. Apparel & Misc. Fab. Text. Prod.	.00031	.00149	0.	0.	.00003	.00213	.35711	.00077	.00050	.00162	.00201	0.
8. Lumber & Wood Products	.00007	.00007	0.	.00638	.05367	.00006	.00001	.25277	.17072	.16272	.05947	.15004
9. Wooden Contnrs. & Paperbd. Boxes	.00053	.00438	.00649	.00191	0.	.01504	.00789	.00334	.03646	.01762	.01864	.0050
10. Household Furniture	0.	0.	0.	0.	.00283	0.	.00297	.00219	.00300	.01480	.02924	0.
11. Other Furniture & Fixtures	0.	0.	0.	0.	.00244	0.	.00263	.00036	.00055	.00748	.01983	.0006
12. Printing & Publishing	.00019	.00031	.00006	.00066	.00011	.00189	.00110	.00359	.00494	.00036	.00161	.13035
13. Chemicals, Paints & Reltd. Prods.	.00130	.04878	.00140	.00686	.00510	.00347	.00164	.00040	.00163	.02040	.01656	.01439
14. Petroleum & Natural Gas Refining	.00182	.22633	.01302	.05728	.02052	.00436	.00068	.00899	.00646	.00712	.00291	.00089
15. Rubber & Plastic Products	.00080	.00664	.00591	.02433	.00493	.00222	.01553	.00631	.00504	.04045	.09310	.00120
16. Glass & Glass Products	.00013	0.	0.	.00004	.00323	.00929	.00001	.00117	.00144	.01409	.03723	0.
17. Stone & Clay Products	.00004	.00107	0.	.03399	.05502	.00004	.00001	.00384	.00976	.00258	.00172	.00091
18. Primary Metals	.00004	.00003	0.	.03790	.04592	.00057	.00023	.00004	.03985	.02404	.09310	.00120
19. Heatg., Plumb. & Struct. Metals	0.	0.	0.	.00187	.09564	0.	.00001	.00036	.00026	.00318	.01271	0.
20. Construction Machinery	0.	0.	0.	.02286	.00226	0.	.00012	0.	0.	0.	.00013	.00003
21. Machine Shops & Metal Work	.00117	.00176	.00577	.02280	.00833	.00153	0.	.00309	.00516	.06161	.03928	.00184
22. Service Industry Machinery	0.	0.	0.	0.	0.	0.	0.	.00003	0.	.00007	.00037	0.
23. Household Appliances	0.	0.	0.	0.	.00376	0.	0.	0.	.00003	.00112	.00067	0.
24. Aircraft Repair & Parts	0.	0.	0.	0.	0.	0.	.00015	.00003	0.	.00005	.00100	.00134
25. Motor Equipment & Vehicles	.00090	.00159	0.	.00793	.00003	0.	0.	.00045	.00012	.00025	.00301	.00019
26. Miscellaneous Manufacturing	.00004	.00002	.00032	.00024	.00223	.00047	.01894	.00060	0.	.00474	.02124	.00273
27. Trade	.03550	.04386	.00281	.04792	.10818	.03691	.04102	.04341	.04276	.05536	.05166	.04380
28. Finance	.00716	.01220	.00333	.03861	.00561	.00529	.00554	.00627	.00627	.00531	.00519	.02242
29. Real Estate	.01108	.07642	.01035	.17035	.00303	.00446	.01093	.00647	.00947	.01213	.01075	.04651
30. Personal Services	.00942	.03651	.00375	.05360	.03932	.02953	.01065	.01513	.01198	.02064	.03140	.04696
31. Households	.37855	.38520	.43792	.43469	.52545	.38857	.52138	.44837	.44973	.51743	.54010	.52045

forestry products; 11.1 cents of food and kindred products; 3.5 cents of trade; 1.1 cents of real estate; and 38.0 cents households. The rest, (each column of total inputs is equal to one dollar), is made up of minor purchases from the other row sectors. The other columns provide similar information for the remaining sectors.

Interdependence Coefficients

Table 4.3, the matrix of interdependence coefficients for the study area, was computed from Table 4.2. The unique characteristic of this matrix is that indirect and circular relationships between sectors, as well as the direct relationships are summarized. Each coefficient shows the direct and indirect requirements for products of the row sector per dollar of delivery to final demand of products of the column sector. So a dollar's worth of final demand for livestock products is associated with $1.28 internally, $.359 from other agricultural products, $.038 from agricultural forestry products, $.0297 from construction, $.0356 from chemicals and related products, $.101 petroleum refining, $.08 trade, $.027 finance, $.055 real estate, and $.0466 personal services. The other columns depict similar direct and indirect input requirements per dollar of delivery to final demand.

Table 4.3. Interdependency Coefficients, Watershed Economy, Watershed Study Area, 1958

	1 Livestock Products	2 Other Ag. Products	3 Ag. Forestry Products	4 Mining	5 Con-struction	6 Food Products	7 Apparel & Misc. Products	8 Lumber & Wood Products	9 Wooden Containers	10 Household Furniture	11 Other Furniture	12 Printi[ng] & Publis[hing]
1. Livestock & Livestock Products	1.28261	.10888	.22434	.00549	.00610	.39493	.00159	.03290	.01340	.01065	.00405	.007
2. Other Agricultural Products	.35972	1.07919	.43387	.00734	.00722	.20465	.00315	.09061	.03576	.01899	.00819	.018
3. Agricultural Forestry Products	.03817	.04342	1.02235	.00209	.00775	.01655	.00200	.13033	.05054	.02323	.01033	.023
4. Mining: Pet. & Natl. Gas	.00562	.01273	.00680	1.01606	.02701	.00417	.00135	.00556	.00727	.00743	.01434	.002
5. Construction	.02977	.04248	.02327	.05451	1.01396	.02110	.00647	.10975	.04967	.02636	.01590	.040
6. Food & Kindred Products	.17569	.02117	.05393	.00330	.00338	1.25632	.00171	.00875	.00432	.01531	.00366	.003
7. Apparel & Misc. Fab. Text. Pro.	.00343	.00485	.00308	.00452	.00255	.00697	1.55881	.00386	.00138	.00865	.00613	.001
8. Lumber & Wood Products	.00717	.00886	.00842	.01791	.07878	.01566	.01123	1.35328	.52435	.21859	.19605	.240
9. Wooden Contnrs. & Paperbd. Boxes	.00672	.00756	.01103	.00438	.00390	.02332	.01471	.00770	1.09172	.02487	.02716	.008
10. Household Furniture	.00026	.00035	.00023	.00052	.00349	.00035	.00500	.00351	.00464	1.01623	.02999	.000
11. Other Furniture & Fixtures	.00085	.00136	.00073	.00092	.00365	.00080	.00483	.00144	.00152	.00887	1.02144	.001
12. Printing & Publishing	.00447	.00535	.00334	.00834	.00640	.00773	.00450	.00918	.01119	.00533	.00502	1.15
13. Chemicals, Paints & Reltd. Pro.	.03560	.09150	.04490	.02827	.01842	.02735	.01351	.01641	.01283	.04577	.03384	.02
14. Petro. & Natural Gas Refining	.10133	.27113	.15074	.07391	.03509	.06398	.01317	.04669	.02843	.02565	.02276	.018
15. Rubber & Plastic Products	.00597	.01057	.01117	.02959	.00986	.00682	.02704	.01261	.01140	.04712	.01527	.00
16. Glass & Glass Products	.00255	.00103	.00809	.00119	.00502	.01361	.00092	.00282	.00308	.01760	.04358	.001
17. Stone & Clay Products	.00395	.00693	.00376	.04819	.07229	.00347	.00168	.01507	.00871	.00990	.00988	.00
18. Primary Metals	.00897	.01343	.00993	.08529	.12348	.00975	.00839	.01880	.07008	.06973	.16924	.01
19. Heatg., Plumb. & Str. Metals	.00349	.00494	.00277	.00923	.10053	.00269	.00109	.01182	.00594	.02718	.01652	.00
20. Construction Machinery	.00048	.00079	.00057	.02722	.00428	.0043	.00042	.00078	.00071	.00179	.00221	.00
21. Machine Shops & Metal Work	.00692	.01041	.01234	.03520	.02327	.00694	.00353	.01069	.01331	.07673	.05699	.00
22. Service Industry Machinery	.00021	.00029	.00017	.00048	.00134	.00024	.00020	.00034	.00025	.00055	.01060	.00
23. Household Appliances	.00060	.00083	.00048	.00122	.00541	.00072	.00039	.00096	.00068	.00195	.00305	.00
24. Aircraft Repair & Parts	.00354	.00482	.00282	.00654	.00526	.00490	.00285	.00340	.00290	.00392	.00451	.00
25. Motor Equipment & Vehicles	.00487	.00598	.00343	.01610	.00631	.00443	.00210	.00381	.00311	.00501	.00850	.00
26. Miscellaneous Manufacturing	.00176	.00228	.00177	.00364	.00627	.00269	.03278	.00287	.00202	.00931	.02604	.09
27. Trade	.08036	.07217	.04392	.07571	.13479	.08242	.07369	.08547	.08470	.08804	.08389	.07
28. Finance	.02708	.03153	.02138	.06867	.01993	.02333	.01644	.02071	.01061	.01818	.01766	.044
29. Real Estate	.05557	.10201	.05708	.19466	.02450	.03871	.02627	.02933	.02827	.02985	.02704	.071
30. Personal Services	.04666	.06382	.03677	.08369	.06537	.06545	.02838	.04312	.03682	.04416	.03412	.07

13 Chemicals & Allied Products	14 Petroleum Refining	15 Rubber & Plastics	16 Glass & Glass Products	17 Stone & Clay	18 Primary Metals	19 Heating & Plumbing	20 Con-struction Machinery	21 Machine Shops	22 Service Industry Machines	23 Household Appliances	24 Aircraft Repair	25 Motor Equipment	26 Misc. Manufactg.	27 Trade	28 Finance	29 Real Estate	30 Personal Services
.02157	.00248	.00649	.00355	.00274	.00162	.00139	.00118	.00137	.00206	.00204	.00082	.00244	.00410	.00403	.00286	.02268	.00414
.01413	.00203	.00510	.00666	.00383	.00184	.00184	.00143	.00180	.00280	.00265	.00112	.00434	.00653	.00364	.00395	.03077	.00466
.00351	.00075	.00195	.00782	.00188	.00078	.00121	.00077	.00303	.00204	.00188	.00072	.00477	.00460	.00093	.00098	.00254	.00225
.01831	.02929	.00873	.01943	.12471	.16219	.03620	.02786	.02912	.02069	.02342	.01065	.02094	.01718	.00168	.00127	.00591	.00442
.02367	.04668	.01178	.01249	.01321	.01458	.00950	.00804	.02518	.01178	.01299	.00753	.01516	.03749	.01726	.01956	.10244	.02861
.06445	.00580	.01749	.00416	.00441	.00242	.00192	.00174	.00153	.00294	.00317	.00106	.00282	.00715	.00802	.00111	.00518	.00527
.00496	.00107	.10341	.00380	.00345	.00322	.00407	.00479	.00423	.00520	.00739	.00349	.01347	.00892	.00290	.00369	.00180	.01204
.01146	.00554	.01286	.07967	.01747	.00702	.01171	.00717	.00994	.01993	.01624	.00701	.04843	.04536	.00768	.00828	.01004	.02118
.01355	.00215	.01369	.10818	.01576	.00284	.00808	.00295	.00556	.02046	.02035	.00265	.00512	.02795	.00590	.00196	.00125	.00364
.00057	.00025	.00073	.00322	.00028	.00037	.00152	.00065	.00185	.00181	.00088	.00034	.00911	.00115	.00052	.00021	.00048	.00168
.01136	.00107	.00367	.00102	.00079	.00067	.00239	.00073	.00087	.00183	.00135	.00257	.00625	.00347	.00524	.00028	.00060	.00138
.00397	.00194	.00765	.00624	.02050	.00495	.00450	.00415	.00471	.00495	.00942	.00279	.00494	.00655	.00811	.02714	.00496	.06644
1.23731	.08996	.31864	.05816	.04363	.02443	.01833	.01744	.01179	.03086	.03447	.01004	.03174	.03434	.00578	.00392	.00788	.01906
.31205	1.04499	.08676	.02474	.03585	.02332	.01991	.01598	.01200	.02172	.02410	.01289	.02025	.22497	.01274	.00924	.01926	.01985
.00871	.00264	1.03724	.00797	.01782	.00792	.00655	.02152	.00951	.02251	.04048	.01053	.04018	.02904	.00444	.00430	.00292	.01635
.00265	.00068	.00837	1.10980	.00168	.00061	.00502	.00092	.00104	.00473	.00357	.00078	.01174	.00586	.00201	.00045	.00087	.00433
.01381	.00809	.00963	.04118	1.21255	.02356	.01763	.01567	.02269	.01644	.01876	.00966	.01615	.02104	.00351	.00192	.00824	.00717
.03486	.01579	.02491	.01917	.02934	1.41493	.48098	.36642	.37129	.25813	.29227	.13102	.25928	.12356	.00826	.00524	.01569	.03666
.00348	.00516	.00240	.00228	.00306	.00454	1.02677	.02152	.01077	.03109	.02088	.00289	.06036	.00622	.00347	.00241	.01063	.00907
.00093	.00132	.00085	.00087	.00395	.00433	.00614	1.12510	.02431	.00303	.00413	.00195	.00973	.00205	.00064	.00024	.00076	.00199
.01430	.01882	.02264	.01232	.02510	.04634	.06620	.05866	1.12176	.06803	.13143	.06108	.07212	.04431	.00434	.00243	.00478	.02441
.00035	.00016	.00030	.00042	.00030	.00046	.00957	.00132	.00194	1.06019	.03188	.00118	.00424	.00148	.00070	.00023	.00048	.00274
.00055	.00046	.00104	.00090	.00056	.00091	.00916	.00121	.00256	.16401	1.01727	.00332	.00800	.00252	.00112	.00073	.00110	.00968
.00307	.00170	.00686	.00280	.00371	.00270	.00515	.00410	.00724	.01278	.01008	1.23852	.01075	.01448	.00653	.00520	.00364	.08108
.00284	.00204	.00373	.00259	.00468	.00811	.01974	.03204	.03174	.02360	.01634	.01323	1.23860	.01650	.00676	.00410	.00323	.05250
.00351	.00120	.01076	.00367	.00563	.00368	.01387	.00430	.01300	.02491	.03977	.02439	.00999	1.07242	.00387	.00309	.00206	.02487
.06240	.02488	.06335	.06322	.05688	.06443	.06798	.06480	.06243	.09100	.07777	.03647	.06786	.08398	1.02694	.02324	.03745	.06018
.02345	.01430	.01888	.02245	.02924	.02443	.02305	.02075	.02164	.02321	.01855	.01025	.01750	.02084	.02847	1.333072	.05033	.03613
.02968	.01887	.02726	.02282	.04238	.03244	.02456	.02181	.02941	.03203	.02741	.01502	.02174	.03025	.06343	.11277	1.03418	.06882
.03877	.02157	.04696	.93610	.04422	.03149	.03552	.03552	.03410	.04782	.11674	.01410	.04327	.04406	.07629	.07003	.04518	1.11763

Accuracy of the Flow Table

The relative accuracy of the entries cited in the flow table can be checked only in a crude way. As pointed out earlier the flow tables when read horizontally indicate the distribution of each sector's output and when read vertically indicate the purchases or expenditures of each sector. Then for any sector for which there is published expenditure data, we have a crude check of the relative accuracy of the entries in the flow table. One such sector for which published expenditure data is available is the livestock and livestock products sector. Total sales or output of the livestock and livestock products sector to itself and the other two agricultural sectors can be checked against specified expenditures by all agricultural sectors for livestock and livestock products. From the flow table it is determined that sales to these sectors amounted to $4,075,243, by the livestock and livestock products sector. At the same time published data[3] on expenditures for livestock and livestock products by the same three sectors amounted to $4,871,081. Total expenditures are thus underestimated in the flow table by some

---

[3]U. S. Bureau of the Census. U. S. Census of Agriculture: 1959. Vol. 1, Counties, Part 37, Texas, U. S. Government Printing Office, Washington, D. C., 1961.

$795,838 or by 19.5%. This is at least a reasonable approximation.

A second expenditure item that may serve as a crude accuracy check is animal feeds. Animal feeds, which are made up chiefly of grain, hay and forage, are produced almost exclusively by the other agricultural products sector, the food and kindred products sector, and agricultural forestry products sector and sold in large part to the livestock and livestock products sector. Expenditures for animal feeds total $7,568,000 while sales of the food and kindred products sector, other agricultural products sector and the agricultural forestry products sector to the livestock and livestock products sector total $7,166,164. The flow table underestimates expenditures by 5.3% which is a fairly accurate approximation.

Though these few sector flows and expenditure items are the only ones on which any kind of check for accuracy can be made, it is expected that the other flow entries have the same degree of accuracy.

Impact of Water Development

Once the input-output model has been constructed for the watershed area for a base period and the functional relationship between water as a resource requirement and total output is determined, this model can be used to forecast the impact on the watershed economy of increases in the supply of water available to industries.

A forecast of output by industry sector in the watershed study area was made for 1963, using (1) the functional relationship between water and output established for 1958 and (2) estimates of water use in 1963, developed in the same manner as were the estimates for 1958. Output per acre foot of water use in 1958 for each water using sector were multiplied by the estimated water use for each sector in 1963. For those sectors not using water as a resource requirement, estimates of output based on published data were used. The results of the forecast are found in Table 4.4.

Here it can be seen that total water use in 1958 amounted to 3400 acre feet and total output was $870,450,529. In 1963, total use of water had increased to 6293 acre feet and total output to $1,220,732,585. This forecast compares favorably with total output estimated independent of water use. (See Table 4.5.) As with the estimates of output in in the watershed for 1958, output by sector was estimated from value-added data. (See Chapter III.) The total for all sectors was found to be $1,124,722,532. This indicates that the estimate of output based on water use was a bit high, some $96,010,053 or 8.5%.

Table 4.4. Estimated Output Based on Water Use, Watershed Study Area, 1963

	Sector	Output, 1958 (Dollars)	Water Use, 1958 (Acre Feet)	Output per Acre Ft., 1958 (Dollars)	Water Use 1963 (Acre Feet)	Estimated Output 1963 (Dollars)
1.	Livestock, etc.	18,814,754				16,823,739
2.	Other Ag. Prod.	6,115,495				5,460,520
3.	Ag. Forestry Prod.	4,330,014				3,871,814
4.	Mining - Pet. & Natl. Gas	76,965,974	478	161,016	470	75,677,520
5.	Construction	60,852,521				35,728,952
6.	Food & Kindred Prod.	31,173,397	506	61,607	540	33,267,780
7.	Apparel, etc.	13,801,684				17,857,892
8.	Lumber & Wood	11,485,396	175	65,630	193	12,666,590
9.	Wood Containers	4,564,862	27	169,068	260	43,957,680
10.	Household Furn.	2,404,491	2	1,202,245	161	5,646,904
11.	Other Furniture	1,098,951			17	1,206,431
12.	Printing & Publishing	5,229,032	38	137,606		7,748,973
13.	Chemicals, Paints, etc.	18,198,522	262	69,460	569	39,522,740
14.	Pet. & Natl. Gas Refining	23,378,219	770	30,361	733	22,254,613
15.	Rubber & Plastic Products	2,004,980	42	47,737	215	10,263,455
16.	Glass Products	5,358,579	57	94,010	92	8,648,920
17.	Stone & Clay Products	6,588,707	129	51,075	856	43,720,200
18.	Primary Metals	39,539,865	520	76,038	938	71,323,644
19.	Heatg. & Plumbg.	10,979,308	137	80,140	279	22,359,060
20.	Const. Machy.	1,141,336	3	380,445	7	2,663,115
21.	Machine Shops, etc.	646,460	11	58,769	13	763,997
22.	Service Ind. Mach.	15,116,725	122	123,907	335	41,508,845
23.	Household Appl.	5,707,299	67	85,183	404	34,413,932
24.	Aircraft Repair & Pts.	1,385,569	14	98,969	1	98,969
25.	Motor Equip.	1,164,720			5	884,543
26.	Misc. Mfg.	2,972,308	40	74,307	205	15,232,935
27.	Trade	238,544,394				301,596,192
28.	Finance	86,582,540				127,658,216
29.	Real Estate	155,585,427				193,202,041
30.	Personal Services	18,719,000				24,694,000
	Total	$870,450,529	3,400		6,293	1,220,732,585

Table 4.5. Comparison of Output Estimates for 1963, Watershed Study Area

	Sector	Output Based on Water Use (Dollars)	Output Based on Value Added (Dollars)
1.	Livestock & Livestock Products	16,823,739	16,823,739
2.	Other Agricultural Products	5,460,520	5,460,520
3.	Agricultural Forestry Products	3,871,814	3,871,814
4.	Mining	75,677,520	75,735,814
5.	Construction	35,728,952	35,728,952
6.	Food & Kindred Products	33,267,780	37,195,955
7.	Apparel, etc.	17,857,892	17,857,892
8.	Lumber & Wood Products	12,666,590	15,223,441
9.	Wooden Containers, etc.	43,957,680	11,595,904
10.	Household Furniture	5,646,904	5,646,904
11.	Other Furniture & Fixtures	1,206,431	1,206,431
12.	Printing & Publishing	7,748,973	7,748,973
13.	Chemicals, Paints, Varnish, etc.	39,522,740	16,836,459
14.	Petroleum Refining, etc.	22,254,613	28,043,491
15.	Rubber & Plastic Products	10,263,455	16,859,411
16.	Glass & Glass Products	8,648,920	8,508,469
17.	Stone & Clay Products	43,720,200	13,626,523
18.	Primary Metals	71,323,644	50,348,036
19.	Heating, Plumbing, etc.	22,359,060	14,898,806
20.	Construction & Related Machinery	2,663,115	1,375,309
21.	Machine Shops, Metalwork, etc.	763,997	771,207
22.	Service Industry Machinery	41,508,845	27,914,572
23.	Household Appliances	34,413,932	51,081,862
24.	Aircraft Repair & Parts	98,969	157,099
25.	Motor Equipment & Vehicles	884,543	884,542
26.	Miscellaneous Manufacturing	15,232,935	12,169,957
27.	Trade	301,596,192	301,596,192
28.	Finance	127,658,216	127,658,216
29.	Real Estate	193,202,041	193,202,041
30.	Personal Services	24,694,000	24,694,000
	Totals	1,220,732,585	1,124,722,532

As stated in the discussion of methodology and analytical techniques, input-output or interindustry models are capable of specifying quite detailed economic relationships in the geographical area under study. It was also established earlier in the discussion of results that the relative accuracy of the flows of goods and services from which the technical coefficients are calculated is within acceptable limits. Even so, because of the properties of input-output matrices, errors in the coefficients do not lead to cumulative errors in the solutions but on the contrary tend to compensate for each other.[4] With these points in mind, a closer examination of the results of the forecasted economic activity is in order.

The method used for making the forecast was to multiply output per acre foot of water in 1958 by the estimated water used in 1963 for each water-using sector and to fill in the other sectors with data estimated independently of water-use relationships. The forecasted economic activity using this method overestimated total output by some 8.5 per cent. However, when the comparison is made between water-using sectors only, the

---

[4]Hollis B. Chenery and Paul G. Clark, <u>Interindustry Analysis</u>, New York, John Wiley and Sons, Inc., 1959.

discrepency between forecasted output and actual output becomes much greater. Restriction of the forecast to water-using sectors only magnifies the over-estimation error. The forecasted output based on water use for the 17 water-using sectors amounts to $478,518,493, while the actual output of these 17 sectors, estimated independently of water use, amounts to $382,342,315. The water-use based forecast overestimates output by 25 per cent, not an outrageous error as far as forecasts are concerned, but surely a significant one.

Productivity of Water

It is often useful to know what is happening to resource productivity in general. The concept of value-added is especially relevant and useful in the consideration of economic activity because unlike final product it is not greatly influenced by the price and volume of materials purchased from other areas. Value-added per acre foot of water used then, is the relevant measure of productivity in this case.

The effect that changes in productivity have on estimated output can be illustrated by taking three characteristic examples; one showing little change, one showing a significant increase in productivity and showing a significant decrease in productivity of water.

In the glass and glass products sector there was little change in the productivity of water from 1958 to 1963. Productivity in 1958 was $58,277 per acre foot. With a total use of 92 acre feet in 1963 this would give a total value-added figure of $5,361,484. Since value-added in this sector is .61991 of total output, total output is estimated as $8,648,810. Actual productivity, however, had decreased only slightly to $57,331 per acre foot. Total productivity as shown by value-added, for 92 acre feet would amount to $5,274,452 and total actual output to $8,508,415. Both these figures are off slightly due to the necessity for rounding of decimals. Even so the actual output is overestimated by 1.65 per cent or by the exact amount that productivity in 1958 exceeds productivity in 1963.

The food and food products sector is one in which the productivity of water increased significantly from 1958 to 1963. Productivity actually increased from $23,938 to $26,765 per acre foot or by 11.8 per cent. As a result actual output exceeds estimated output by exactly 11.8 per cent.

The chemicals, paints, and related products sector illustrates the third characteristic change in productivity. Productivity decreased from $28,842 to $12,286 per acre foot or by 135 per cent. As a result estimated output exceeds actual output by 135 per cent.

In the following paragraphs value-added per acre foot of water used in each sector is discussed. (See Table 4.6.)

<u>Mining</u>--In 1958 value-added per acre foot amounted to $69,992, in 1963 this figure had increased slightly to $70,045 per acre foot. The difference between estimated and actual output is only slight, amounting to less than .5 per cent.

<u>Food and Kindred Products</u>--In this sector value-added per acre foot rose from $23,938 in 1958 to $26,765 in 1963. At the same time water use in this sector increased from 506 to 540 acre feet. The resulting forecast of output underestimates actual output by 10 per cent or 3.7 million dollars.

<u>Lumber and Wood Products</u>--Value-added per acre foot increased from $29,426 in 1958 to $35,366 in 1963. At the same time water use increased only slightly from 175 to 193 acre feet. The increase in value-added and in water use results in an underestimation of actual output by 2.6 million dollars or 17 per cent.

<u>Wooden Containers and Paperboard Boxes</u>--In this sector value-added decreased from $76,035 in 1958 to

Table 4.6. Comparison of Value-Added per Acre Foot, by Sector, Watershed Study Area, 1958 and 1963

Sector	Value Added per Acre Foot 1958 (Dollars)	Value Added per Acre Foot 1963 (Dollars)
1. Livestock & Livestock Products	0	0
2. Other Agricultural Products	0	0
3. Agricultural Products	0	0
4. Mining	69,992	70,045
5. Construction	0	0
6. Food & Kindred Products	23,938	26,765
7. Apparel, etc.	0	0
8. Lumber & Wood Products	29,426	35,366
9. Wooden Containers, etc.	76,035	20,057
10. Household Furniture	601,122	18,148
11. Other Furniture & Fixtures	0	0
12. Printing & Publishing	71,617	0
13. Chemicals, Paints, Varnish, etc.	28,842	12,286
14. Petroleum Refining, etc.	24,099	30,384
15. Rubber & Plastic Products	25,171	41,347
16. Glass & Glass Products	58,277	57,331
17. Stone & Clay Products	29,041	9,051
18. Primary Metals	40,031	28,258
19. Heating, Plumbing, etc.	38,829	25,873
20. Construction & Related Machinery	0	100,698
21. Machine Shops, Metalwork, etc.	31,409	31,706
22. Service Industry Machinery	55,478	37,308
23. Household Appliances	37,224	55,258
24. Aircraft Repair & Parts	62,233	98,786
25. Motor Equipment & Vehicles	0	76,856
26. Miscellaneous Manufacturing	31,792	25,399
27. Trade	0	0
28. Finance	0	0
29. Real Estate	0	0
30. Personal Services	0	0

$20,057 in 1963. Water use in the same period increased from 27 to 260 acre feet. The result is that estimated output based on water use far exceeds actual output.

Chemicals, Paints, and Related Products--Value-added decreased from $28,842 in 1958 to $12,286 in 1963. Water use at the same time increased from 262 to 569 acre feet. This results in an estimated output of $39,541,348 that exceeds the actual output of $16,836,459, by 23 million or by 135 per cent.

Petroleum Refining and Related Industries--In this sector value-added per acre foot increased from $24,099 to $30,384. At the same time water use decreased only slightly from 770 to 733 acre feet. The result is that the water-use estimate of output underestimates actual output by 5.8 million dollars or 21 per cent.

Rubber and Plastic Products--While value-added in this sector was increasing from $25,171 to $41,347 per acre foot, water use was increasing from 42 to 215 acre feet. The result is that estimated output is 6.6 million dollars or 39 per cent less than actual output.

Glass and Glass Products--Value-added in this sector decreased only slightly; from $58,277 down to $57,331 per acre foot. Water-use at the same time increased from 57 to 92 acre feet. Since value-added changed only slightly the difference between estimated and actual output is only slight also (less than 2 per cent).

Stone and Clay Products--While value-added was decreasing from $29,041 to $9,051 per acre foot in this sector, water use was changing from 129 to 856 acre feet, an increase of 660 per cent. The combination of decrease in value-added and increase in water use resulted to an estimated output figure far in excess of the actual output.

Primary Metals--Value-added per acre foot decreased from $40,031 to $28,258, at the same time water use was increasing from 520 to 938 acre feet. These two factors combine to result in an estimated output figure of $71,330,798 which greatly exceeds actual output of $50,348,036.

Heating, Plumbing, and Structural Metals--In this sector value-added decreased from $38,829 to $25,873 per acre foot. Water use, on the other hand was increasing from 137 to 239 acre feet. The resulting estimate of output exceeds actual output by about 50 per cent.

Machineshops, Metalwork, etc.--Both value-added and water use increased only slightly. This results in an estimated output that differs from actual output by less than 2 per cent.

Service Industry Machines--The combined decrease in value-added from $55,478 to $37,308 per acre foot and increase in water use from 122 to 335 acre feet results in an estimated output that exceeds actual output by some 14 million dollars or 50 per cent.

Household Appliances--While value-added was increasing from $37,224 to $55,258 per acre foot, water was also increased from 67 to 404 acre feet. The result then is an estimated output that is 17 millions of dollars or 50 per cent less than actual output.

Aircraft Parts and Repair--This is an unimportant sector as far as total output is concerned. While value-added increased from $62,233 to $98,786 per acre foot water use decreased from 14 to 1 acre foot.

Miscellaneous Manufacturing--In this sector value-added decreased from $31,792 to $25,399 per acre foot. Water use on the other hand increased from 40 to 205 acre feet. Estimated output, as a result, exceeds actual output by 3 million dollars or 20 per cent.

Household Furniture--This sector is being mentioned here because of its uniqueness. Water use increased in this industry from 2 acre feet to 161 acre feet between 1958 and 1963. Value-added on the other hand decreased from $601,122 to $18,148 per acre feet. Because of the extreme nature of the changes in value-added and water use, this sector was not included as one of the water-using sectors in the forecast.

Source and Magnitude of Error

The source of error in the forecast should be understandable at this point. In almost all sectors water use increased, in some sectors by as much as 900 per cent, while at the same time value-added decreased in seven sectors, increased in six sectors and remained approximately the same in three sectors. In the seven sectors in which value-added per acre foot decreased, the relative decrease was much greater than the relative increase in those six sectors in which value-added per acre foot increased. In those six sectors where value-added per acre foot increased, actual output was greater than estimated output by $35,549,715. In those seven sectors where value-added per acre foot decreased, estimated output was greater than actual output by $131,639,087. In those three sectors where value-added was approximately the same estimated output was greater than actual output by $87,896. The result of this, which has already been pointed out, is that estimates based on water use overestimates output by 96 million dollars or 25 per cent. Much of this error could have been removed if adequate records and data on water use had been available for the years 1958 and 1963. The year 1958 is the first year that reliable data is available on water use in manufacturing. By 1963 a second more detailed analysis had been published. While in 1963 more complete and detailed data were published, data for some sectors that were available in 1958 were not available in 1963. In some sectors, too, part of the change in value-added per acre foot of water used is probably due to changes in the degree of detail for which data were available for the period of the study. How much and what effect it has on the forecast cannot be determined, but in all probability it would have operated so as to reduce the percentage of error.

CHAPTER V

SUMMARY AND CONCLUSIONS

The origin of the idea for this study comes from several sources. Leontief has provided the basic work on input-output as a tool for economic analysis. Moore and Peteresen in their study show how the national input coefficients can be modified so as to be more characteristic of the regional and subregional levels. Carter and Martin furnished the idea of using a matrix of primary resource coefficients to determine resource requirements necessary to sustain a given level of final demand and with it total economic output. Thus by specifying the relationship between resource requirements and output total resource requirements may be computed given either final demand or total output. Carter and Martin accomplish this by multiplying the matrix of primary resource technical coefficients times the matrix of interdependency coefficients.

One of the basic assumptions of input-output analysis is that the technical and interdependency coefficients are relatively fixed. This same assumption applies as well to the primary resource technical coefficients and consequently to the inverse of these coefficients. These primary resource technical coefficients used by Carter and Martin when inverted become the output of water per acre foot.

The basic mathematical model was presented in Chapter IV. The important point here is that it is possible to determine the relationship between output and primary resource requirements. This relationship as stated in the assumptions is relatively stable. If, once this relationship has been specified, it can be used to determine the resource requirements given final demand or total output, then it should theoretically be possible to invert the process and determine the final demand or total output given the level of primary resources. The object of this study has been to test just such a theoretical possibility.

The input-output tables were developed in the earlier stages of this study. First, it was necessary to develop output totals for all sectors. The flow tables were developed from these totals by multiplying the output totals times the national input coefficients for each sector. These flow tables were then adjusted to reflect the local and regional trade, and input-output patterns. The accuracy of the flow tables and the over-all output totals were checked against published data. The accuracy was determined to be well within acceptable limits. It was from these flow tables that the technical input coefficients and interdependency coefficients were derived.

In the second stage a matrix of primary resource technical coefficients was developed. The primary resource used was water. The primary resource technical coefficient expresses in decimal form the amount of water in acre feet required to produce one thousand dollars of output in each sector. When inverted the coefficients show the amount of output produced by one acre foot of water.

In the third stage of this study a forecast of the economic activity of the area was made. This was accomplished by using the results of the first two stages. The inverse of the primary resources technical coefficient (output per acre foot of water), for 1958 was multiplied by the estimated water use for each sector in 1963. Since there were only 17 water-using sectors it was necessary to use estimates of output for the other 14 sectors of the area economy. The forecast based on this method places the total output of the area economy at $1,220,732,585 (see Table 4.4, Chapter IV). This figure, as pointed out in the discussion of results in Chapter IV, exceeds actual output of the economy by only 8.5 per cent. In Table 4.5 a comparison is made between the forecasted and actual output of the water using sectors only. The forecast based on water use exceeds actual output by 25 per cent. This is not considered to be a gross overestimation error. Much of this error is attributed to changes in the productivity of water from 1958 to 1963, and is explained in the discussion of source and magnitude of error. While much of the error in the forecast is explained by changes in the productivity, it does not tell why economic activity did not develop or expand as estimated. Location theory can shed light on this aspect of the problem.

Location Theory

Location theory suggests that growth in a given area's volume of economic activities is directly related to two factors: its access at competitive costs to the inputs of production and its access at competitive costs to markets for the outputs of this production. The quantity and quality of a region's resources are therefore significant for growth.

Taken by itself water does not constitute a resource base for the development and growth of manufacturing activities at any particular location. The availability of usable water is a necessary but by no means a sufficient condition for selecting a site for a manufacturing plant regardless of its size or type. In addition to the availability of physical materials, there are other factors that must be considered in analyzing the possibilites of growth in a specific area. Some of these factors are resources that are less tangible than others. For example, the quality and vigor of civic and business leadership and willingness to accept change are all important to economic growth. Technological developments create new requirements and markets for materials that could not previously be utilized economically. These and related factors affect the opportunities for economic development.

The results of this study show that the technique of forecasting economic development based on input-output analysis and the water-use-output relationship is a reliable and reasonably accurate technique. This technique can be used to evaluate the economic impact of water resources development on small watershed area.

BIBLIOGRAPHY

Cameron, B., "The Production Function Leontief Models," Review of Economic Studies, Vol. XX, No. 1, pp. 62-69.

Chenery, Hollis B., and Paul G. Clark, Interindustry Analysis, New York, John Wiley and Sons, Inc., 1959.

Chenery, Hallis B., Paul G. Clark, and Uera Cao Pinna, The Structure and Growth of the Italian Economy (Special Mission to Italy for Economic Cooperation), Rome, Italy, Mutual Security Agency, 1953.

Fisher, W. L., Rock and Mineral Resources of East Texas, Bureau of Economic Geology, Report No. 54, University of Texas, Austin, Texas, June 1965.

Isard, Walter, "Interregional and Regional Input-Output Analysis: A Model of a Space Economy," The Review of Economics and Statistics, Vol. 33, 1951, pp. 318-328.

Kaufman, Alvin, and Barbara Lloyd, Water Use in the Mineral Industry, U. S. Department of the Interior, Bureau of Mines, Table 4, p. 15.

Kirksey, C. D., An Interindustry Study of the Sabine-Neches Area of Texas, Bureau of Business Research, The University of Texas, Austin, 1959.

Martin, William E., and Harold O. Carter, A California Interindustry Analysis Emphasizing Agriculture, Part I: The Input-Output Models and Results, Gionnini Foundation Research Report No. 250, February 1962.

McGuinnes, "Water for the United States--An Analysis of the Report of the Senate Select Committee on Natural Resources," Natural Resources Journal, Vol. 2, No. 2 (August, 1962), pp. 218-224.

Miernyk, William H., The Elements of Input-Output Analysis, New York, Random House, 1966.

Moore, Frederick T., and James W. Petersen, "Regional Analysis: An Inter-industry Model of Utah," The Review of Economics and Statistics, Vol. 37, No. 4, November, 1955, p. 371.

Moses, Leon N., "The Stability of Interregional Trading Patterns Input-Output Analysis," American Economics Review, Vol. 45, December, 1955.

Report on Master Plan for Water Supply Reservoirs. Prepared for the Upper Neches River Municipal Water Authority by Forrest and Cotton, Inc., Consulting Engineers, Dallas, Texas, February, 1961; February, 1962.

U. S. Bureau of the Census. U. S. Census of Agriculture: 1959. Vol. 1, Counties, Part 37, Texas, U. S. Government Printing Office, Washington, D. C., 1961.

Water Supply and the Texas Economy, An Economic Appraisal of the Texas Water Problems, Prepared by the Department of Interior, Bureau of Reclamation, Area Planning Office, Austin, Texas, July, 1953.