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AN ECONOMIC ANALYSIS

OF

DECLINING PETROLEUM SUPPLIES IN TEXAS:

INCOME, EMPLOYMENT, TAX, AND PRODUCTION EFFECTS AS MEASURED BY INPUT-OUTPUT AND SUPPLY-DEMAND SIMULATION MODELS

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Governor's Energy Advisory Council
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PREFACE AND ACKNOWLEDGEMENTS

This report is the result of the last two of a three part set of studies completed by the Governor's Planning Office for the State of Texas for the Governor's Energy Advisory Council concerning the supply and demand for energy in the State of Texas. The first report dealt with the historical production and consumption of energy in Texas during the period 1950 - 1973, and is entitled "Energy Supply and Demand in Texas for the Period 1950 - 1973". This report is concerned with an economic analysis of declining petroleum supplies in Texas and summarizes the analysis of the economic impacts of energy supply and demand projections for purposes of providing information about various government energy policy alternatives and their expected effect on the economy of the State of Texas.

The study is the product of a cooperative effort. Dr. A. E. Dukler, Executive Director, and Dr. Robert D. Finch, Assistant Executive Director of the State of Texas Governor's Energy Advisory Council, were responsible for the overall direction of this and more than forty other studies completed by the Council.

Mr. Jack Huffman of the Governor's Planning Office obtained much of the input data for the analyses and drafted charts for the report. Ms. Joy Travis and Ms. Peggy Arias of the Governor's Planning Office assisted with data preparation and provided valuable assistance in editing the final report. Mr. William C. McCray and Mr. John Perrin of the Division of Management Science reviewed the report and provided helpful review comments and suggestions.

Dr. Russell G. Thompson, Mr. Rodrigo J. Lievano, Mr. Robert R. Hill, and Mr. John Stone of the University of Houston, NSF (RANN) Studies, provided valuable input to the project as a result of their concurrent work for the Governor's Energy Advisory Council. Without their cooperation and timely input, this study would have been lacking in crucial areas of analysis concerning price response estimates and fuel substitutions possibilities.

Dr. Finch was responsible for functional administration of the work from the Governor's Energy Advisory Council. Under Dr. Finch's direction, the projects of the Governor's Energy Advisory Council were coordinated in a manner such that this economic project received the results of other projects as input for the analysis.

It should also be recognized that this study would not have been possible except for the timely availability of (1) the Texas Input-Output Model developed by the Governor's Division of Planning Coordination during 1968 - 1971 under funding from the Department of Housing and Urban Development and sponsorship of the State of Texas Governor's Office, and (2) a simulation model developed at the Texas Water Development Board during 1972 - 1973 under partial funding by the Office of Water Resources Research, U. S. Department of the Interior.

The number of persons who provided guidance and assistance to this study is too large to permit a listing of their names. However, the authors gratefully acknowledge the assistance of Texas Industry officials who supplied data, fellow researchers who assisted with data and information, and members of the Governor's Energy Advisory Council who identified many of the policy issues for which analyses were needed.

It is emphasized, however, that the analyses and interpretations presented herein are those of the authors and do not necessarily represent the views of those who assisted or otherwise participated in the work of the Governor's Energy Advisory Council.

ABSTRACT

AN ECONOMIC ANALYSIS OF DECLINING PETROLEUM SUPPLIES IN TEXAS: INCOME, EMPLOYMENT, TAX, AND PRODUCTION EFFECTS AS MEASURED BY INPUT-OUTPUT AND SUPPLY-DEMAND SIMULATION MODELS

(The State of Texas Energy Projects S/D 2, "Energy Demand in Texas for the Period 1975-2000" and S/D 3, "Impact on the Texas Economy of Changes in the Energy Industry")

The purposes of these projects were to project demand for Texas produced energy for the 1975-2000 period and to develop estimates of relationships among production, processing, and distribution of oil, gas, distillates, coal, and nuclear energy in Texas. The present and future role of petroleum as a source of taxable income, employment, economic growth, importance as a raw material for the chemical industry, and changes in the economy of Texas that can be expected as a result of declining availability of domestic oil and gas were analyzed.

Consumer demand of the 11.8 million people of Texas, out-of-state demand, government sector demand, and demands for capital are estimated. Energy prices, oil and gas supply response to prices, price elasticity of demands and income elasticity of demands for the outputs of each sector are estimated and entered as data for the analyses. Capital requirements, population, and consumption are lagged variables and entered in simultaneous time-series equations through which labor force, consumer demand and capital data are brought to bear. An input-output simulation model of the Texas economy calculates production levels and associated energy requirements to meet consumer demands.

The computer calculates annual simulations of the time stream of standard economic indicators including employment, personal incomes, taxes, savings, industrial sector output, gross state product and prices

of natural gas, electricity, and petroleum products. Projections are made of both aggregate energy demand and individual fuel demands by user class for each of five policy variables and eight parameter estimates. The impacts of reducing exports of crude oil and natural gas as compared with increasing imports when supplies are short can be estimated. The magnitude of fuel substitution from changing relative prices of fuels can be estimated for the current technology of use for natural gas, petroleum products, coal, and nuclear fuels.

The impacts of prices, fuel substitutions and oil imports are measured in terms of population, employment, income, state and local taxes, oil and gas industry taxes, quantities of energy supplies and consumed, output levels and growth of each individual industry sector, and the structure of trade relationships among Texas industries. The results indicate that the key policy options are domestic wellhead price regulation and federal import tax fees or quotas. Although higher prices for domestic oil and gas at the wellhead mean higher prices to Texas consumers of refinery products, natural gas, and electricity, they also mean increased future production from the Texas petroleum industry, which, in aggregate, more than offset the higher cost of energy to Texas consumers. Restrictions on imports through import fees or quotas slow the growth of the refinery and petrochemical industry in Texas. The impact of such reductions are significant. Reductions in import levels, that now approach 25 percent of Texas crude "runs to stills," would have a positive benefit to Texas in the form of reduced risk from the potential economic impact of foreign oil embargoes. Fuel substitutions can ease the pressure on the oil and gas resource base in Texas in the long term, but the short and intermediate term results of fuel substitutions are relatively insignificant.

TABLE OF CONTENTS

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF FIGURES (Continued)

LIST OF FIGURES (Continued)

LIST OF TABLES

LIST OF TABLES (Continued)

DOLPH BRISCOE
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AN ANALYSIS OF INCOME, EMPLOYMENT, TAX, AND PRODUCTION EFFECTS FROM DECLINING PETROLEUM SUPPLIES UPON THE TEXAS ECONOMY USING INPUT-OUTPUT AND SUPPLY-DEMAND SIMULATION MODELS*

Milton L. Holloway, Ph.D.; Herbert W. Grubb, Ph.D.; and W. Larry Grossman**

Introduction

Since 1950, Texans and the Texas economy have placed almost total reliance upon crude oil and natural gas for energy. Other fuels have been ignored, primarily for economic reasons. The relative supply-demand relationships for oil and gas have resulted in low prices for these fuels in relation to lignite, coal, geothermal, wind, solar and other sources of energy. The relative high capital cost for nuclear electric power generation has kept this source of energy at a comparative disadvantage in Texas.

The markets for many petroleum products--gasoline, fuel oil, lubricants, plastics, chemicals, and electricity generated from natural gas have increased steadily and are the basis from which the demands for crude petroleum are derived. The purchasers of crude petroleum and natural gas have enjoyed stable and relatively constant prices while the

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* This report was prepared at the request of the Governor's Energy Advisory Council of Texas and presents the results of two individual energy supply/demand studies conducted at the direction of the Energy Supply/Demand Committee. The two projects were labeled S/D-2 and S/D-3. The views presented herein do not necessarily represent those of Texas public officials.

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quantities produced have increased steadily. As a result, the quantities marketed have increased rapidly with the equally rapid growth in demand. Producers discovered ample reserves; market supply outpaced demand; and, as a result, supply exerted a downward pressure upon price which exceeded the upward pressure exerted by increasing demands. In fact, the long run tendency of an oversupply of crude oil and natural gas has led to statewide proration of oil and gas production in order to provide market stability.

The Energy Problem in Texas

Around 1970, following about a decade of declining reserves and increasing demands, crude petroleum and natural gas producers were no longer willing to offer larger and larger quantities at the same prices. Larger quantities could only be offered at higher prices, and then only after a significant time lag for exploration, discovery of new reserves, and installation of new capital equipment. Petroleum demand, however, continued to grow at a rapid pace as consumers' incomes and the related tendency to purchase energy-intensive products continued. As a result, the customary stability of petroleum markets has given way to rapid price increases and market shortages of many petroleum-based products and services. The market has become a "seller's" market.

It is pointed out and emphasized that market shortages are price-quantity phenomena; i.e., shortages occur when consumers wish to purchase more during a given time period than producers are willing to sell at some given price during the same time period. When markets are open and buyers and sellers are free to negotiate prices and quantities when shortages occur, some buyers will bid up the price and secure the quantity they desire at the new, higher price. As the price increases, some buyers will drop out of the markets altogether while others will reduce the quantity purchased. A new equilibrium price will be established, and the so-called shortage will no longer exist. However, under the current conditions of increasing marginal cost of oil and gas supplies, the price per unit will be higher, and the quantity sold per unit of time will probably be lower than that which would have otherwise existed.

As fuel prices increase, some consumer groups are more adversely affected than others. Higher prices and reduced quantities of gasoline result in relatively lower welfare of low income consumers since a relatively larger portion of their income is spent on petroleum products for transportation and heating fuel. The income effects to petroleum labor and capital owners from higher petroleum prices may improve the overall welfare of this group in relation to other groups.

When dramatic changes such as those observed in fuel markets during 1973 and 1974 occur, the entire economy is adversely affected; and general economic stability is threatened. There are attempts to pass fuel price increases along to consumers throughout the economy. In addition, fuel shortages occur; and economic activity is disrupted.

Texas is a major petroleum exporter to the rest of the U.S., and nearly one-fourth of the total Texas production of crude oil and natural gas is from leases within Texas on state-owned lands. Thus, the state, through state-owned lands, has a significant influence on the production of energy in Texas and the supply of petroleum products to national markets. In the past, petroleum producers located in Texas have supplied approximately 40 percent of the total oil and natural gas consumed within the U.S. economy and, at the same time, have increased the Texas capacity for consumption of crude oil and natural gas by expanding the refinery and petrochemical industries. Approximately 60 percent of the nation's petrochemical production and 40 percent of the nation's refinery production is located in Texas.

During the past 20 years the Texas economy has expanded from a base of agriculture and oil and natural gas production and export to out-of-state markets, to a more broadly based and more highly interdependent industrial economy with its associated and attendant supporting service sectors. Thus, the Texas oil and natural gas sectors have had growing markets within the State as well as rapidly expanding markets elsewhere within the nation.

During the 1950 to 1970 era, the petroleum industry expanded output rapidly enough to meet market demands without significant price increases. Since 1970, the oil and natural gas industries of Texas and elsewhere in the U. S. have not been able to increase output rapidly enough to meet market demands at previous price levels. In Texas, total output per year has actually declined since 1971; and crude oil imports from abroad have increased significantly to almost 20 percent of crude runs to stills during the summer months of 1974. Thus, the Texas oil and gas industries have shifted from that of domestic production with heavy exports to industries with a mixture of domestically produced and imported crude which when refined is then sold into the Texas and national markets.

Texas is a regional economy which trades with other regions of the nation. The export base has expanded to include value added in the form of finished refinery products as well as value of product made from Texas-produced crude petroleum. The economic entities of oil and natural gas production, petroleum refining, petrochemicals, agriculture, manufacturing, services, and government tax revenues impinge heavily upon labor employment levels, personal income, and the economic well-being of the 11.8 million Texas population.

The national economy and its Texas components have become extremely dependent upon petroleum fuels and chemical and plastics products. Large investments have been made in petroleum-using equipment to the extent that few short-run substitutions of fuels and products are possible. Thus, maintenance of the oil and gas producing industries is crucial to economic stability and growth in the short run within both the national and state economies. The actions of government and the private sector concerning imports, production, and consumption of energy, and research and development for new sources of energy will greatly affect the future economic well-being of Texas and the nation, and, information concerning the impacts of various alternatives is required.

The effects of various market changes and public policies in Texas depend greatly upon the nature and structure of the existing energy-producing industries, the nature and structure of the industries which purchase and use fuels and feedstocks to produce other products, and the position of Texas industries in national energy markets. The petroleum refining industry is composed of a relatively small number of large national and international conglomerate-type corporations; whereas at the crude petroleum production and the finished product distribution (fuel distributors) levels there are, in addition to the corporations engaged in refining, a significant number of smaller independents. The independent crude petroleum producers usually specialize in exploration, development, and production. The integrated petroleum corporations purchase crude petroleum produced by independents, engage in crude petroleum production, refine crude petroleum, and sell a part of their refinery outputs to independent distributors. These corporations engage in international crude petroleum production, trading, and marketing. They compete with each other in the domestic and world markets. Pricing and output policies of any individual major integrated petroleum conglomerate can affect market price with great consequence upon the markets and welfare of Texas and U. S. petroleum consumers and producers.

Major industries, including petrochemical industries, use crude petroleum and selected light fractions of petroleum as feedstocks or raw materials and also use petroleum fuels to produce heat for product manufacture. The structure of these industries and markets appears to be analogous to that of the petroleum refining conglomerates; i.e., there are a small number of large corporations whose individual production and pricing policies can affect the entire market for chemicals and plastics products. More importantly, however, these intermediate petroleum users, given sufficient time, can find substitute fuels with which to produce heat and process steam. A major shift of petrochemicals and electric power generation from petroleum to coal and nuclear fuels would result in a marked downward shift in demand for petroleum fuels and thereby would be expected to diminish the upward pressures on crude petroleum prices, other things being equal.

The market for petroleum products at each of several levels of production and processing is a national market in which Texas production is a major but diminishing component of supply. The effects of market changes and government policy will be greatly influenced by the national supply role of Texas petroleum producing industries as well as the fact that the Texas economy is also a significant user and consumer of petroleum products. Policies and market conditions which affect both producers, on the supply side, and consumers, on the demand side, within the State will also be affected by national policies pertaining to environmental standards influencing the use of coal and nuclear fuels, national import-export policies regarding international trading of petroleum fuels, incentives impinging upon producers and consumers of fuels, and taxing of fuel producers and consumers. The reduction of Texas consumer demand for energy will probably have no appreciable affect upon national energy demands; whereas such a reduction in Texas energy demands, independent of and in the absence of parallel reductions in demands elsewhere, would have a disproportionately negative effect upon Texas employment, incomes, and government tax revenues.

In contrast to policies and market conditions having a negative effect upon Texas's internal demands and consumption of energy, policies and market conditions pertaining to petroleum production can have a positive and wide-spread effect upon the Texas economy. Generally, the more complete the production, refining, and processing of energy, the greater the employment and income effects within Texas. Therefore, Texas' economic development objectives, whereby there would be an increase in the opportunity for Texans to obtain jobs in petroleum, petroleum-related industries and the supporting finance and service industries, would be improved through policies that would encourage Texas oil and gas production, refining, and manufacturing. In the absence of Texas-based crude petroleum production, the importation of refinery feedstocks would serve these types of objectives even though the finished products may be marketed outside the state. Since a major share of the market for Texas-produced energy is outside the state, it is appropriate that Texas policymakers and analysts view the Texas petroleum industries as suppliers of energy and related products to the national markets. However, it is imperative that the analysis of economic effects of market changes should not overlook the important Texas internal consumer demand aspects of the problem, being cognizant of the fact that Texas' crude petroleum reserves, although significant in quantity, are finite and therefore exhaustible. Both production and consumption of energy in the long run will be particularly sensitive to capital investments which encourage production of substitute fuels. Unless policies which encourage orderly expansion of petroleum production and orderly increases in production of substitute fuels are adopted, energy markets will continue to be disorderly and chaotic. The result of widely fluctuating energy market prices and quantities is poor consumer and producer welfare in comparison to consumer and producer welfare under stable energy market conditions. The purpose of this analysis is to provide information whereby alternative policies can be evaluated and compared.

The Texas Economy From 1950-1970

The Texas economy has a broad base in which agriculture, industry, utilities, and services have grown in size and increased in interdependence. All sectors have a degree of direct and indirect dependence upon petroleum supplies. Relevant statistics are presented in this section to indicate where the energy industry fits into the Texas economy as well as to indicate the energy industries' contributions to the Texas economy.

Population Characteristics

The population of Texas has increased from 9,579,677 in 1960 to 11,196,730 in 1970. [1/] During this period the annual growth rate has been approximately 1.5 percent. In 1970 the Texas population was 5.51 percent of the total United States population, compared to 5.34 percent in 1960.

The proportion of Texans living in urban areas increased from 41 percent in 1930 to 79.7 percent in 1970 (Table I-1). The combined population of the four largest SMSA's was 46.1 percent of the total state population in 1970.

Females have increased from 49.8 percent of the population in 1950 to 51.1 percent in 1970 (Table I-2). In the age groups of 18 through 24 years and 65 years and over, in 1970 females outnumber males (Table I-2).

During the period 1950-1970, the age groups 5 through 17 years, and the group 65 years and over have consistently increased as a proportion of the total population, whereas the 25-44 years group has consistently decreased (Table I-2).

The median years of school completed by Texans 25 years of age or over has increased from 8.5 years in 1940, to 9.3 years in 1950, to

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1/ U. S. Bureau of the Census, <u>1970 Census of Population</u>, Advance Report, General Population Characteristics: (PC(V2)-45, Texas, U.S. Government Printing Office, Washington, D. C., February 1971).

Table I-1. Texas Population by Place of Residence - 1930 - 1970 [a/]

Year	Total	Rural		Urbanized Area	
		Number	Percent	Number	Percent
1930	5,824,715	3,435,367	58.979	2,389,348	41.021
1940	6,414,824	3,503,435	54.615	2,911,389	45.385
1950	7,711,194	3,098,528	40.182	4,612,666	59.818
1960	9,579,677	2,393,666	24.987	7,186,011	75.013
1970	11,196,730	2,275,784	20.325	8,920,946	79.765

a/ U. S. Bureau of the Census, 1940, 1950, 1960, and 1970, U. S. Census of Population, Part 45, Texas, U. S. Government Printing Office, Washington, D. C.

Table I-2. Age Groups as a Percent of Texas Population in 1950, 1960, and 1970 - By Sex.

Age Group	Male			Female			Total		
	1950[a/]	1960[a/]	1970[b/]	1950[a/]	1960[a/]	1970[b/]	1950[a/]	1960[a/]	1970[b/]
Under 5 Years	5.9	6.2	4.5	5.7	6.0	4.4	11.6	12.2	8.9
5 Through 17 Years	11.2	13.1	13.7	10.8	12.7	13.2	22.0	25.8	26.9
18 Through 24 Years	5.8	4.7	6.1	5.7	4.7	12.6	11.5	9.4	18.7
25 Through 44 Years	15.0	12.8	11.7	15.1	13.3	11.3	30.1	26.1	23.0
45 Through 64 Years	9.1	9.2	9.2	9.0	9.5	4.5	18.1	18.7	13.7
65 Years and Over	3.2	3.5	3.7	3.5	4.3	5.1	6.7	7.8	8.8
All Ages	50.2	49.5	48.9	49.8	50.5	51.1	100.0	100.0	100.0

a/ U. S. Bureau of the Census, U. S. Census of Population: 1960, Volume II, Characteristics of the Population, Part 43, Texas, U. S. Government Printing Office, Washington, D. C., 1963.

b/ U. S. Bureau of the Census, 1970 Census of Population - Advance Report, General Population Characteristics: PC (V2)-45, Texas, U. S. Government Printing Office, Washington, D. C., February 1971.

10.4 years in 1960 and to 11.2 in 1970.[1/] A continued increase in educational attainment is indicated since a median educational year of 11.7 had been attained in 1960 by those Texans between the ages of 14 and 24 years who were no longer enrolled in school.[2/]

Employment and Income Payments by Major Industry

The Texas civilian labor force averaged 4.1 million during 1972[3/] (Table I-3). Significant changes in the composition of the labor force occurred as mechanization, technology, and changing industry growth reduced the number of employees in agriculture, petroleum, and natural gas industries (Figure I-1). Increasing population and urbanization have increased the demand for business and personal services. The increased importance of these industries is illustrated by the fact that in 1960 there were 187 jobs in service-producing sectors (transportation, communications, utilities, wholesale and retail trade, F.I.R.E., services, and government) for every 100 jobs in goods-producing industries while the 1972 data show 212 jobs in these service-producing industries for every 100 jobs in goods-producing industires (Table I-3).[4/]

In 1970, 53.4 percent of the population 14 years old and over participated in the labor force as compared to 55.4 percent in 1960. Although 65.1 percent of the total labor force of 1967 was employed in the service production

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1/ U. S. Bureau of the Census, U. S. Census of Population: 1960, Volume I, Characteristics of the Population, Part 45, Texas, U. S. Government Printing Office, Washington, D. C., 1963, and U. S. Census of Population, 1970, General Social and Economical Characteristics, Texas, U. S. Government Printing Office, 1972.

2/ Ibid., Table 102.

3/ Detailed Characteristics, Texas, 1970 Census of Population, U. S., Department of Commerce, Bureau of the Census, Washington, D. C., 1972.

4/ Ibid.

Table I-3. Texas Employment by Industry Group - 1967 - 1972 [a/]

Major Group	Average Number of Employees		Average Employment by Industry as a Percent of Total Employment	
	1967	1972	1967	1972
			(Percent)	
Agriculture, Forestry and Fisheries *	245,728	217,577	7.0	5.3
Construction	205,800	251,600	5.9	6.1
Mining	104,000	102,800	3.0	2.5
Manufacturing	664,300	741,100	19.0	18.1
Chemicals & Allied Products	47,900	61,600	1.4	1.5
Petroleum Refining	33,400	35,300	1.0	0.9
Primary Metals	36,800	34,400	1.1	0.8
Paper & Allied Products	14,600	17,200	0.4	0.4
Transportation	152,900	156,200	4.4	3.8
Communications	45,400	56,000	1.3	1.4
Public Utilities	44,400	50,500	1.3	1.2
Wholesale	224,100	272,000	6.4	6.6
Retail	544,900	679,200	15.6	16.6
F.I.R.E.	164,400	216,800	4.7	5.3
Services	494,500	644,200	14.1	15.7
Government	607,000	711,400	17.3	17.4
Total Average Employment	3,497,428	4,099,377	100.0	100.0

[a/] Source: Estimates of Civilian Labor Force in Texas. Texas Employment Commission in cooperation with Bureau of Labor Statistics and Manpower Administration, U. S. Department of Labor, 1969,1973.

* Estimates based on Sector Output Data, Unpublished Report, Office of Information Services, Austin, Texas, 1974.

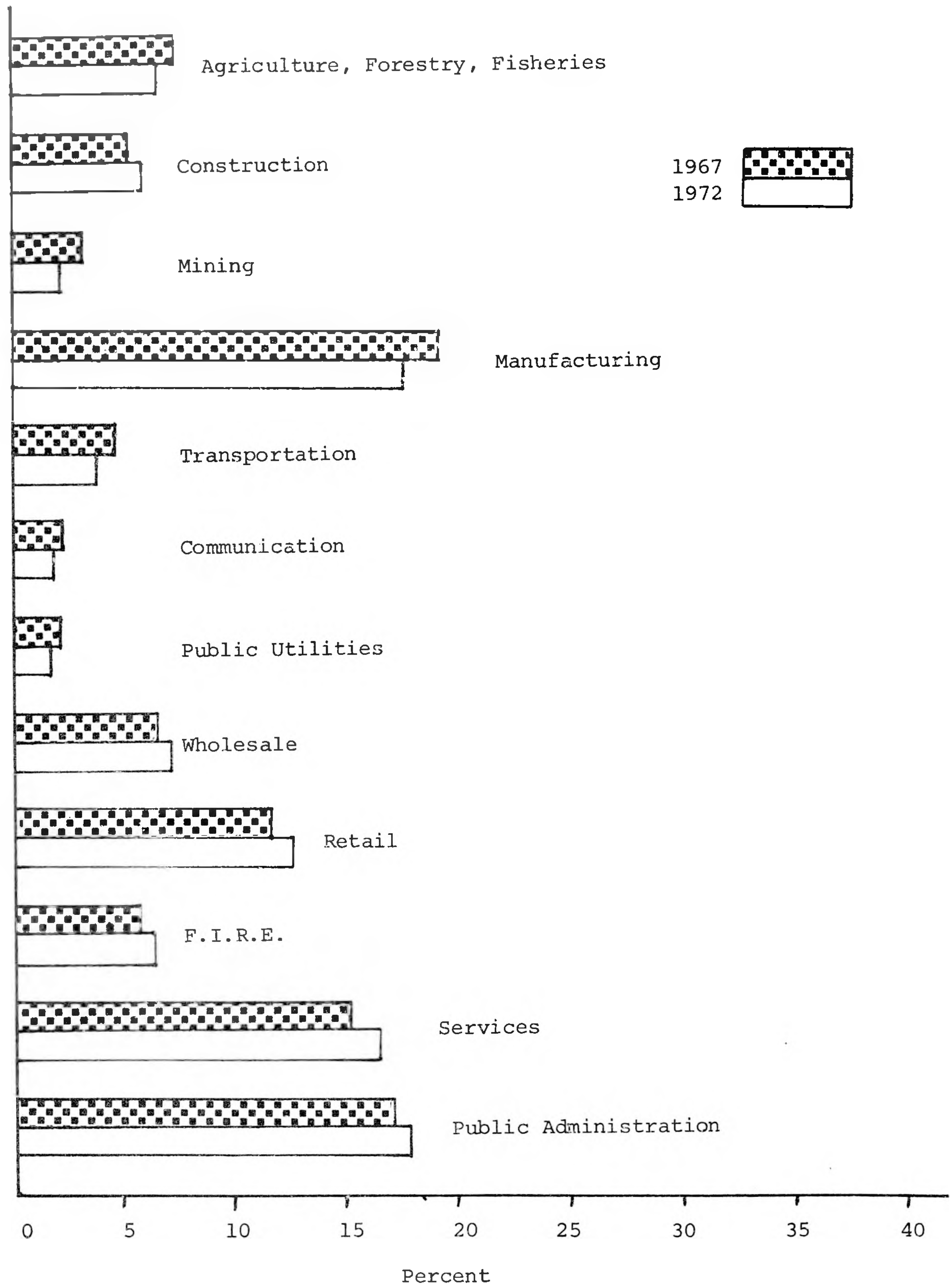

Figure I-1. Texas Employment by Industry Group as a Percent of Total State Employment -- 1967 and 1972.

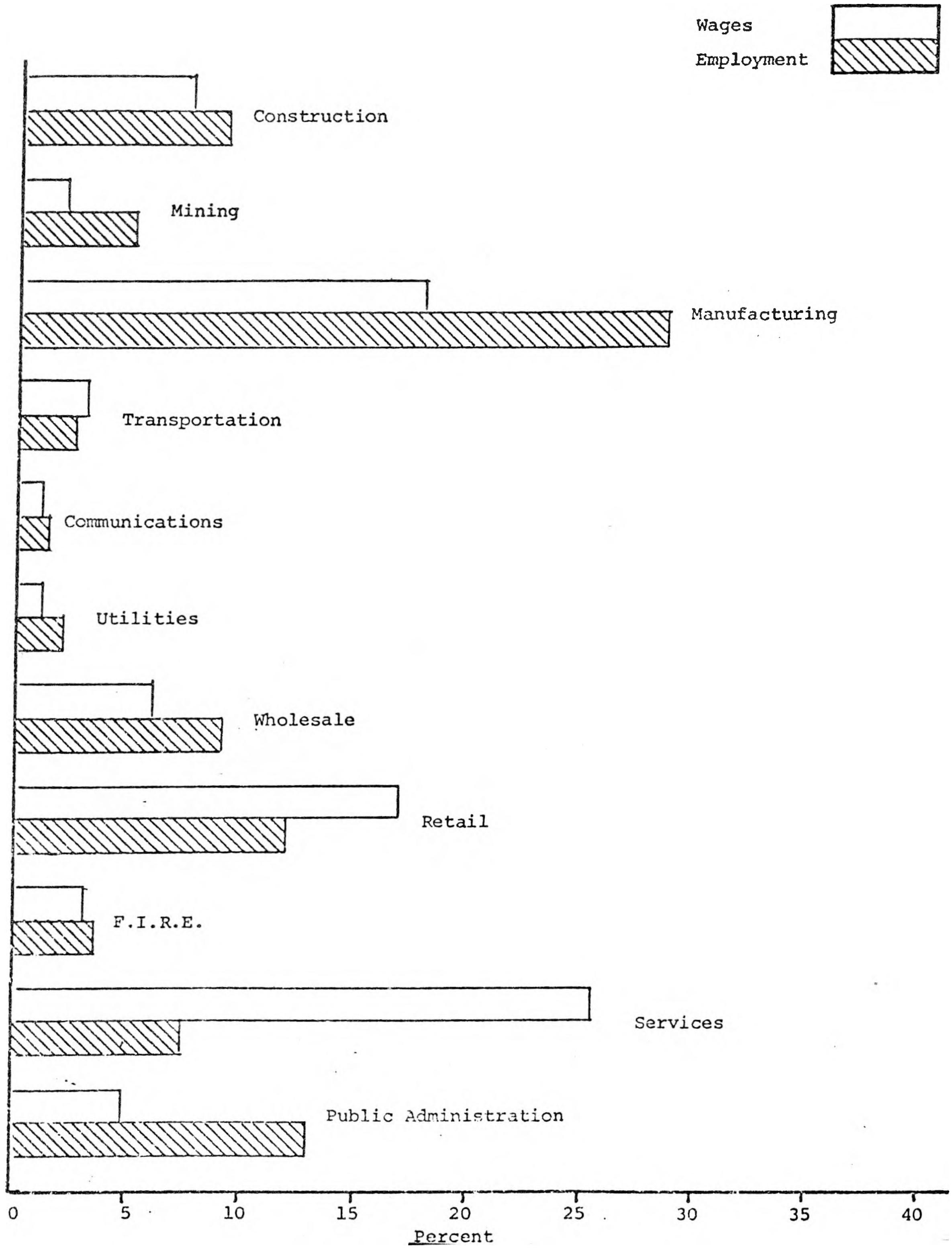

Figure I-2. Earnings and Employment of Texas Industry Groups as Percent of the Total Earnings and Employment--1972.

industries, the service-producing sector employment represented only 44.6 percent of the total earnings received by Texas employees (Tables I-3 and I-6). Employment in the energy industries in Texas in 1967 accounted for 246 thousand employees or 6.0 percent of total state employment while output of the same industries accounted for 19.3 billion dollars of product or 13.68 percent of the state total (calculated from Appendix Tables 9 and 10).

Table I-4 indicates the occupation composition of the Texas labor force for 1960 and 1970. The largest classification in 1970 is clerical and kindred workers with the percentage of total employment rising from 10.5 to 13.6 percent during the 1960 to 1970 period. The data indicate a declining proportion of workers in agricultural categories while service categories increased. Employment of chemical, mining, and petroleum engineers accounted for .386 percent of the labor force in 1960 and .470 percent in 1970. The number of mining engineers, however, decreased from 1847 in 1960 to 290 in 1970 as drilling operations in Texas declined.

An important index of economic activity is personal income. Personal income is defined as: "The current income of persons . . . from all sources." It is measured before deduction of income and other personal taxes, but after deduction of personal contributions to social security, government retirement, and other social insurance programs. Personal income includes income received from business, federal, state and local governments, households, institutions, and foreign countries. Personal income consists of wages and salaries (cash and in-kind including tips and bonuses as well as contractual compensation), various types of supplementary earnings termed other labor income (the largest item being employer contributions to private pension and welfare funds), the net incomes of owners of unincorporated businesses (farm and non-farm with the latter

Table I-4. Civilian Labor Force (14+) in Texas by Selected Occupants, 1960 and 1970.

Occupation	1960 Experienced Civilian Labor Force (14+)		1970 Experienced Civilian Labor Force (14+)	
	Number	Percent	Number	Percent
Professional Technical & Kindred Workers (Including Computer Specialists)	371,749	10.1	576.122	13.3
All Engineers	41,105	1.2	66,719	1.5
Chemical	3,557	(0.1)	5,220	(0.1)
Civil	8,157	(0.2)	9,722	(0.2)
Electrical & Electronic	7,052	(0.2)	14,007	(0.3)
Mining	1,847	(0.05)	290	(0.007)
Petroleum	1,482	(0.04)	4,124	(0.09)
Craftsmen & Kindred Workers	462,119	13.3	571,291	13.2
Operatives, Except Transport	356,709	10.3	455,052	10.5
Transport Equipment Operatives	149,996	4.3	159,499	3.7
Service Workers, Except Private Households	319,980	9.2	449,933	10.4
All Other	1,784,796	51.6	2,048,753	47.4
TOTAL	3,466,454	100.0	4,327,369	100.0

Source: Detailed Characteristics, Texas, 1970 Census of Population, U.S. Department of Commerce, Bureau of the Census, Washington, D.C., 1972.

including the incomes of independent professionals), net rental income, dividends, interest, and government and business transfer payments (consisting in general of disbursements to persons for which no services are rendered currently, such as unemployment benefits, social security payments, and welfare and relief payments). [1/]

Gross personal income in Texas increased from $10.48 billion in 1950 to $40.51 billion in 1972. Per capita income was $1,349 in 1950 and $4,085 in 1972 (Table I-5). During the period 1960-1972, per capita income increased 111 percent as compared to the 1950-1960 increase of 43 percent (Figure I-3).

When stated in constant 1967 dollar values, the 1972 per capita income is $3,260. The increase in per capita income from 1960 to 1972 is 44.8 percent in constant dollars, as compared to a 20.4 percent increase in constant dollars from 1950 to 1960.

Tax Revenues and Government Spending in Texas

As in other states and the United States in general, government services and related taxes in Texas have increased significantly during the 1950-1972 period. Social programs funded heavily from the federal government in health, education, and welfare programs have contributed greatly to this growth. In addition, large increases in military spending during the Korean and Vietnam Wars occurred in Texas because of the strategic location of military training bases. Also, farm programs designed to reduce agricultural surpluses were the source of a large growth in federal government spending in Texas since the state is a major producer of cotton, grain sorghum, and wheat.

1/ Description of Methodology for Estimation of County Income, a staff memorandum of the Office of Business Economics, U.S. Department of Commerce (February 1970), page 3.

Table I-5. Personal Income in Texas and the U.S., Selected Years, 1950 - 1972.

Year	Total Personal Income		Per Capita Personal Income		Texas as a Percent of the U.S.
	Texas	U.S.	Texas	U.S.	
	(Million Dollars)		(Dollars)		
1950	10,486	226,214	1,349	1,496	.902
1955	14,438	308,265	1,667	1,876	.889
1960	18,627	399,947	1,935	2,222	.871
1965	25,016	538,690	2,411	2,785	.866
1970	40,514	808,223	3,600	3,966	.908
1971	42,772	864,989	3,743	4,195	.892
1972	47,404	947,066	4,085	4,549	.898

Source: U. S. Department of Commerce, Bureau of Economic Analysis, Revised Personal Income Tables. Survey of Current Business, Volume 54, No. 8, U. S. Government Printing Office, Washington, D. C., August, 1974, Pages 32 and 33.

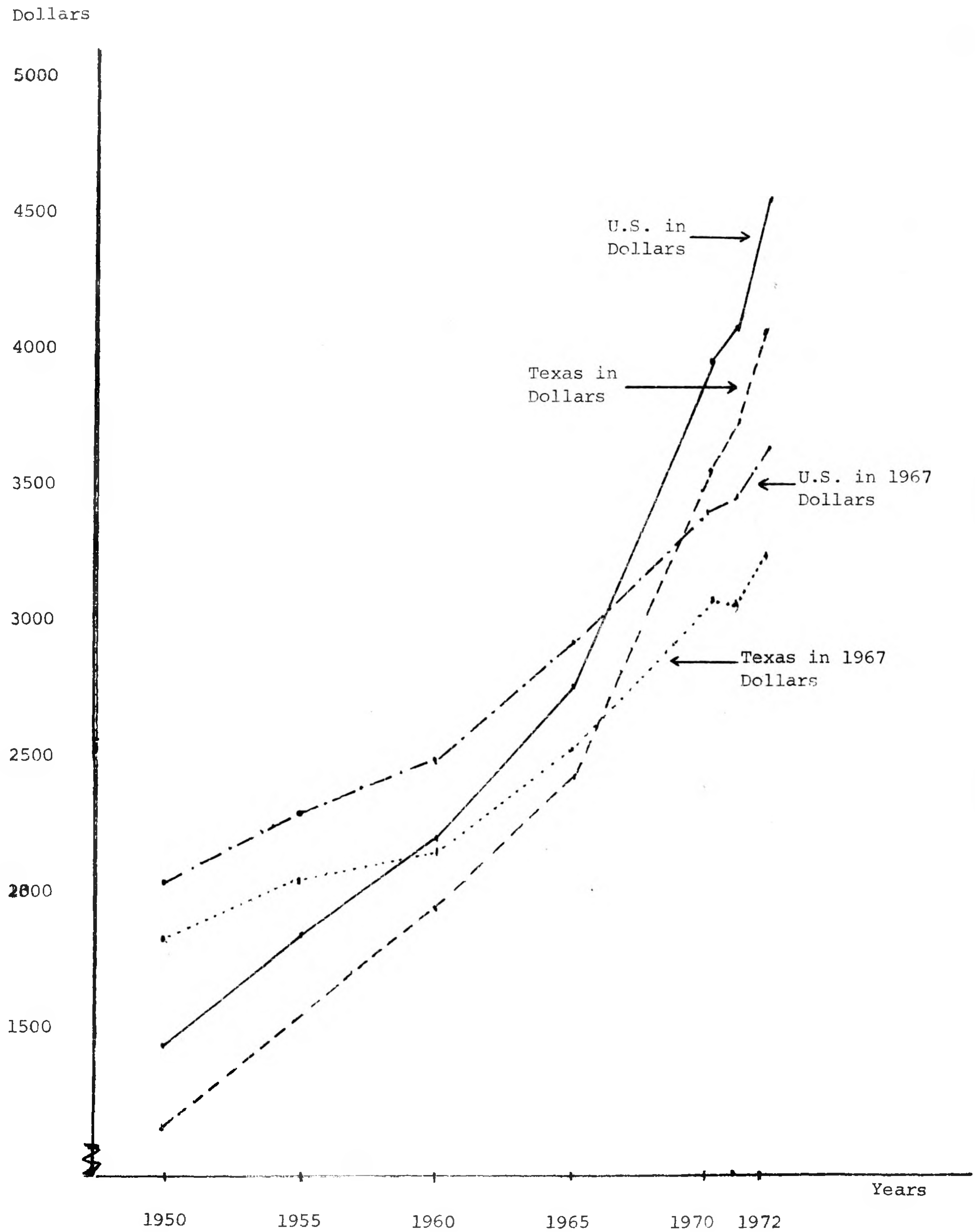

Figure I-3. Per Capita Personal Income for Texas and the U.S., 1950-1972.

Table I-6. Personal Earnings in Texas by Broad Industrial Sector.

Industrial Sector Source of Earnings	Year		
	1962	1967	1972
	(Billions of Dollars)		
Total Earnings	16.72	23.93	36.90
Farm Earnings	1.24	1.10	1.68
Total Non-Farm Earnings	15.48	22.82	35.20
Government Earnings	3.00	4.60	7.12
Total Federal	1.64	2.48	3.53
Federal Civilian	.75	1.15	1.76
Military	.89	1.33	1.76
State and Local	1.33	2.12	3.58
Private Non-Farm Earnings	12.51	18.23	28.12
Manufacturing	3.11	4.92	7.30
Mining	.91	.94	1.13
Contract Construction	.99	1.61	2.51
Transportation, Communications, Public Util.	1.33	1.78	2.84
Wholesale & Retail Trade	3.15	4.40	6.86
Finance, Insurance, & Real Estate	.85	1.25	2.05
Services	2.12	3.25	5.32
Other	.05	.07	.11

Source: U. S. Department of Commerce, Bureau of Economic Analysis: "Personal Income by Major Sources and Earnings by Broad Industrial Sector," from Regional Economics Information System. Washington, D.C., December, 1974.

Table I-7. Civilian Personal Earnings by Industrial Source as a Percent of Total Civilian Earnings: Texas and U.S. - 1967.

Industrial Source	Texas a/	U.S. b/
	(Percent)	
Farms	4.9	3.5
Mining	4.2	1.1
Contract Construction	7.1	6.2
Manufacturing	21.8	30.4
Wholesale and Retail	19.5	17.2
Finance, Insurance and Real Estate	5.5	5.3
Transportation, Public Utilities, and Communications	7.9	7.2
Services	14.4	14.6
Government	14.5	14.2
Other	0.3	0.3
TOTAL	100.0	100.0

a/ Source: Computed from Table I-6.

b/ U. S. Department of Commerce, Bureau of Economic Analysis, Survey of Current Business, Volume 48, No. 8, U. S. Government Printing Office, Washington, D.C., August, 1968, Page 21, Tables 63 and 70.

The growth in demand for public services related to health, education, welfare, natural resource development, and environmental protection at the state level has also contributed to growth in state government spending. Funds to support the new and increased government services required new tax sources which were met in the early 1960's by the initiation of a state sales tax. Major tax sources for the state currently include a 4.0 percent sales tax, royalties from the lease of state-owned lands, property taxes, and a state gasoline tax. The growth in federal, state, and local government spending and taxes is summarized by program and tax source below.

In the current-year-dollar terms, the total federal government revenue collections from Texas have increased by 542 percent between 1950 and 1970 (Table I-8). The proportion of the total coming from personal income and employers' contributions to social insurance taxes has changed from 60.8 percent in 1950 to 73.6 percent in 1970, an increase of 12.8 percent. This change in the distribution of the federal tax load resulted from both the change in tax rates and the growth of industry in the state. The federal taxes derived directly from oil and gas production and processing cannot be reconstructed from available data but are tied closely to a federal gasoline tax levied at the gasoline pump and from corporation profit taxes in the petroleum production and petroleum distribution and processing industries. During the 1960's the petrochemical industry grew rapidly in Texas and also became a significant taxpayer to the federal government. Royalty payments to the federal government from oil and gas leases have been historically unimportant since federally--owned offshore leasing has not been done. However, this is now becoming a significant source of federal revenues, given the increased outer continental shelf leasing for oil and gas production.

Table I-8. Federal Government Revenues in Texas, 1950, 1960, and 1970.

Year	Individual Income and Employment		Corporation (including excess profit taxes.)		Total	
	(Million Dollars)	(Percent Change)	(Million Dollars)	(Percent Change)	(Million Dollars)	(Percent Change)
1950	785.0		341.6		1290.6	
1960	2059.0	+162.3	623.0	+ 82.4	2973.0	+130.3
1970	6097.0	+196.1	1184.3	+ 90.1	8281.4	+178.5

Source: U.S. Department of Commerce, Bureau of the Census, Statistical Abstract of the United States, U. S. Government Printing Office, Washington, D.C., 1970, 1973.

Table I-9. Federal Government Spending in Texas, Selected Years 1950 - 1970.

Year	Department of Defense		Department of Health, Education & Welfare		Department of Agriculture		Total	
	[Million Dollars]	[Percent Change]	[Million Dollars]	[Percent Change]	[Million Dollars]	[Percent Change]	[Million Dollars]	[Percent Change]
1967	5289.3		1525.3		1018.8		10,624.3	
1969	5775.6	+ 9.2	2068.8	+ 35.6	1166.5	+ 14.5	12,471.4	+ 17.4
1970	5044.0	-12.7	2343.6	+ 13.3	1054.9	- 9.6	11,128.6	- 10.8

Source: Office of Economic Opportunity, Executive Office of the President, Federal Outlays: Texas Summary U. S. Government Printing Office, 1967, 1969, 1970.

Total federal spending in Texas between 1967 and 1970 has remained relatively constant during recent years with most of the growth coming from the Department of Health, Education, and Welfare (Table I-9). This category shows a 71.5 percent growth between 1967 and 1970. There was a 4.6 percent decline in defense spending and 3.5 percent increase in agricultural spending during the same time period (Table I-9).

State and local revenues from Texas during the 1950-1970 period are shown in Table I-10 and Table I-11. In current-year-dollar terms, total state collections have increased by 802 percent. The proportion of the total which was property taxes in 1970 decreased to 1.7 percent from the higher 4.4 and 3.9 percentages, respectively, in 1960 and 1950. This large change in the tax collection distribution was primarily due to the implementation of a state sales tax.

Local government revenues increased at a slower rate than state revenues and with a different distribution than the state collections (Table I-10 and I-11). Property taxes constitute a much larger proportion of revenue sources at the local level as compared to the state.

The energy industry and products provide a significant income source to state government. Three major sources include royalties, production taxes, and motor fuel taxes (Table I-12). The sum of these three sources in 1970 was in excess of 8 percent of the total state revenues.

State and local expenditures by function are summarized in Tables I-13 and I-14 for selected years. Local government data were not available for the 1950's and early 1960's. Nearly 50 percent of the total state expenditures have been for education; welfare expenditures were second in total expenditures, while natural resource spending has been the smallest category (Table I-13).

Table I-10. State Government Revenues in Texas, Selected Years, 1950 - 1971.

Year	Property Taxes	Other Taxes	Charges and Misc.	Federal Transfers	Other Transfers	Total Revenues
			(Million Dollars)			
1950	21.2	322.7	27.5	110.9	3.0	485.3
1960	37.6	397.3	150.8	362.7	2.4	950.8
1965	47.9	1,219.2	305.0	575.5	6.8	2,154.4
1970	63.8	2,134.4	514.8	1,102.8	15.0	3,830.9
1971	61.6	2,510.4	533.3	1,259.6	12.7	4,377.6

Source: U.S. Department of Commerce, Bureau of the Census, State Governmental Finances, 1950, 1960. U. S. Government Printing Office, Washington, D.C. U. S. Department of Commerce, Bureau of the Census. Governmental Finances in 1965-1966, 1970-1971, 1971-1972. U.S. Government Printing Office, Washington, D.C.

Local government expenditures have also been concentrated on education, comprising from nearly 40 percent in 1963 to almost 50 percent in 1971-72. Total local expenditures for education exceeded that for the state in all years (Tables I-13 and I-14).

Table I-11. Local Government Revenues in Texas, Selected Years, 1963 - 1971.

Year	Property Taxes	Other Taxes	Charges & Misc.	Federal Gov. Transfers	Other Transfers	Total Revenues
			(Million Dollars)			
1963	879.6	62.2	354.8	38.3	492.4	1,827.2
1965	1,027.0	66.3	436.3	50.9	643.1	2,223.6
1970	1,508.0	220.7	756.9	137.4	1,062.4	3,685.5
1971	1,652.2	252.1	826.4	181.8	1,157.1	4,069.6

Source: U.S. Department of Commerce, Bureau of the Census, Governmental Finances 1963-1964, 1965-1966, 1970-1971, 1971-1972. U.S. Government Printing Office, Washington, D. C.

Table I-12. Selected State Government Revenues from Energy Production and Use in Texas, Selected Years, 1950 - 1970.

Year	Royalties from State Owned Lands	Oil and Gas Production Taxes	Motor Fuel Taxes	Total
		(million dollars)		
1950	14.0	107.6	87.3	208.9
1960	31.5	202.8	199.7	434.0
1970	44.7	290.8	312.3	647.8

Source: Robert S. Calvert, Comptroller. Annual Report of the Comptroller of Public Accounts, State of Texas. 1950, 1960, 1970. Austin, Texas.

Table I-13. State Government Expenditures in Texas, Selected Years, 1950 - 1972.

Year	Legislative, Judicial, Executive	Natural Resources	Highways	Education	Welfare	Other	Total
			(Million Dollars)				
1950	8.041	8.143	123.486	211.820	132.037	43.696	527.223
1960	17.392	13.463	386.700	425.969	187.915	152.945	1,184.384
1970	46.282	28.115	633.170	1,208.872	553.840	484.467	2,954.746
1972	65.892	36.074	605.232	1,648.156	997.059	457.633	3,810.046

Source: Robert S. Calvert, Comptroller: Annual Report of the Comptroller of Public Accounts, State of Texas, 1950, 1960, 1970, 1972, Austin, Texas.

Table I-14. Selected Local Government Expenditures Texas, Selected Years 1963 - 1972.

Year	Education	Highways	Health	Police, Fire, and Sanitation	Welfare	Capital Outlay	Other	Total
				(Million Dollars)				
1963-64	870.1	94.3	77.3	179.7	8.8	448.1	309.5	1,987.8
1967-68	1,238.8	111.7	110.9	247.6	11.2	609.7	402.0	2,731.9
1969-70	1,554.5	128.5	179.3	321.3	12.4	648.0	491.0	3,335.0
1970-71	1,838.8	139.5	215.7	378.6	13.0	714.5	560.2	3,860.3
1971-72	2,031.0	144.1	248.6	416.2	15.8	821.7	656.0	4,333.4

Source: U.S. Department of Commerce, Bureau of the Census, Governmental Finances, in 1963-1964, 1967-1968, 1969-1970, 1970-1971, 1971-1972. U. S. Government Printing Office, Washington, D.C.

II. METHOD OF ANALYSIS

The approach to the problem of evaluating and comparing the effects of declining petroleum supplies and the associated price increases upon the Texas economy has been to:

(1) Estimate the potential supply of crude oil and natural gas from Texas at various possible prices,

(2) Estimate the demand for crude oil and natural gas for Texas in-state and out-of-state export markets,

(3) Estimate market equilibrium prices and price elasticity of demand for major petroleum products for the nation and for Texas markets,

(4) Estimate consumption of finished goods and services by Texas consumers,

(5) Estimate sales of Texas produced goods to out-of-state markets (Texas exports).

(6) Estimate fuel consumption by major fuel using industries at market equilibrium prices mentioned in number three above,

(7) Incorporate information from numbers one-six above into an Input-Output Simulation Model of the Texas economy and simulate the economy-wide distributive effects of changing petroleum prices and quantities upon individual sector production, energy use, employment, wages and salaries paid to employees, taxes paid to government, and petroleum imports.

In order to integrate the many interrelated impacts into a consistent framework for analysis, an input-output simulation model was constructed utilizing an existing input-output model of the Texas economy,[1/] an existing simulation model for resource allocation analysis modified for energy analysis,[2/]

1/ Grubb, Herbert W., The Structure of the Texas Economy, Office of the Governor, Austin, Texas, March, 1973.

2/ Holloway, Milton L., "An Economic Simulation Model for Analyzing Natural Resource Policy," Southern Journal of Agricultural Economics, Volume 6, Number 1, July, 1974.

and the results of companion studies of supply and demand elasticities for key energy markets in Texas.[1/] The methods and data are described below. The technical appendix sets forth the mathematical relationships for those readers who wish to study the analytic models in detail. For those readers who are only interested in the results, the remainder of this section may be ignored;and the reader should proceed immediately to the section entitled "Economic Impacts of Alternative Energy Demand Projections."

Estimating Future Petroleum Supplies

The search for crude petroleum reserves, the drilling of producing wells, installation of equipment with which to produce discoveries that are deemed to be of commercial value, and the actual operation of producing equipment depend upon three major factors--the physical factors surrounding or controlling the geologic formations in which crude petroleum is found, the size of reservoirs and the profitability of the petroleum industries. Among the factors involved in the profitability of petroleum production are the costs of exploration, rate of finding reserves of commercial significance, costs of drilling and equipping producing wells, costs of gathering facilities, the quantity of production per well, and the prices at which crude oil and natural gas can be sold. The quantity and cost of capital available for exploring drilling, the uncertainty of discovering oil or natural gas, and the relatively high costs of drilling each well are all barriers to entry into the business and therefore are major factors that determine the quantity of crude petroleum brought to market.

The quantity of crude oil and natural gas in place is fixed, but the portion of that total which is ultimately recovered will depend on a number

1/ Thompson, Russell G., Rodrigo J. Lievano and Robert R. Hill, "Energy Supply and Demand Analysis," preliminary draft prepared for the Governor's Energy Advisory Council, University of Houston, Houston, Texas, December, 1974.

of factors. Petroleum producers are continually faced with the management problem of determining how much (within physical pumping limits) of current reserves to market in the current time period. The portion of the original oil and gas in place which can be physically withdrawn is determined by the current and future recovery technology. The quantity actually pumped, under free market conditions, is determined primarily by the price of the product, given certain lag times for exploration, drilling, pipeline installation, and the availability of investment capital by the producer.

The expected quantity supplied as a function of price for both oil and gas has been estimated for two price levels for Texas oil and gas[1/]--the price levels which existed in the late 1960's prior to the recent "energy crisis" and the estimated equilibrium prices expected by 1985 if price regulation were removed.

The supply models for crude oil and natural gas were developed to estimate how profit maximizing producers of oil and gas will respond to increased wellhead prices. The results of the models show the estimation of the price effect on exploration and development of new reserves and the production of oil and gas from presently known and newly developed reserves. The model is composed of two parts: (1) Model 1 describes the exploration process, the development process, and the production process over time from newly found reserves. (2) Model 2 describes the production of oil and gas over time from known reserves as of 1972.

Model 1 makes use of statistical estimates of the historical response of drilling to price. New reserves from exploratory drilling

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1/ Thompson, Russell G., Rodrigo J. Lievano, and Robert R. Hill, Preliminary Estimates from "Energy Supply and Demand Analysis". Preliminary draft prepared for the Governor's Energy Advisory Council, University of Houston, December, 1974.

are estimated from available U.S. Bureau of Mines data for crude oil and from recent historical averages for natural gas. The drilling and reserves estimates provide the basis for estimating a profit maximizing schedule for development and production from the new reserves. The model assumes a three year exploration and development lag and includes limits on yearly availability of drilling equipment. A fifteen percent rate of interest was used to discount all reserves and costs. Model 1 estimates the profit-maximizing schedule of production of oil and gas over time from estimated new reserves in 1972 and subsequent years.

Model 2 calculates the profit-maximizing schedule of oil and gas production from known reserves as of 1972 and adds these estimates to the results of Model 1. Oil and gas production from known reserves is assumed to decrease exponentially with time. The results of Model 1 modify the decline rate in accordance with the estimated new reserves found and developed. [1/] A general expression of the mathematical model is given in the technical appendix and the interested reader may refer to the Thompson report cited above for the specific mathematical formulation and results. The estimated supply functions for oil and gas for two price sets: (1) $3.30 per barrel for oil and $.21 per mcf for gas (1967 dollars) and (2) $8.65 per barrel for oil and $.66 per mcf (1974 dollars) for gas are reported in the following chapter.

The oil and gas supply curves are used to estimate data for the input-output simulation model to determine the quantity of Texas oil and gas available in each simulated time period for either out-of-state shipments or sales to Texas industry. The model allows the analysis of

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1/ Ibid, pp. 20-21.

import policies by estimating the effects of increasing imports of crude oil and natural gas or reducing exports of crude oil and natural gas to insure that estimated supply and demand are equated.

Estimating Future Texas Economic Activity and Energy Demands

The Texas economy is composed of more than 130,000 individual business establishments and approximately 170,000 farms. The range of activity includes practically all livestock and crops grown in the United States, construction, mining of crude oil and natural gas, sand and gravel, iron ore, and small quantities of other metals, manufacturing of a wide range of finished products, intermediate parts and materials used in manufacturing elsewhere, heavy machinery for use in construction and oil field operations, electronics, and transportation equipment, transportation services of all types, electric, natural gas, communication and water sanitation utilities, wholesale and retail trade, finance, insurance, and real estate services, business, professional, medical and entertainment services, education and government services.

The Texas economy has a broad base but is highly specialized within individual sectors. A large quantity of trading among the many producing establishments takes place within the state's economy and between Texas and the remainder of the United States' economy. Establishments located in Texas export agricultural, energy, and manufactured commodities to the urban centers of the United States and in turn import selected raw materials and finished consumer goods. Trading among the sectors of the Texas economy and trading between the Texas regional and the national economies has resulted in a highly interdependent economy. Due to a high degree of interdependence among the sectors of the Texas economy, the fact that many of Texas' markets are located outside Texas, and that practically all sectors use energy in some form, the availability and price of fuels is of widespread significance to the economy. The level of employment, incomes received from employment, the kinds of products that can be produced, the value of production, taxes that can be paid to government, investment of capital, and growth and maintenance of the present economy are all directly and indirectly dependent upon energy resources. In Texas as well as elsewhere in the United States, petroleum fuels are extremely important in the short run and well into the foreseeable future because a significant proportion of energy-using equipment consumes only portable fuels derived from petroleum. There is no readily available substitute for either the equipment or materials from which to make portable fuels. In addition, many present petroleum using stationary facilities such as electric power generating plants cannot be converted to coal or lignite fuels for a number of reasons including technical conversion impossibilities, inadequate space and facilities for physically handling coal and cinders at the plant site, and the fact that coal production is not presently operating at a level sufficiently high to supply the necessary fuel.

A change from petroleum to coal for boiler fuel appears to be underway as an intermediate term substitution of fuels, but the change requires widespread construction of new coal burning furnaces and associated equipment. This route to fuel substitution requires years of time and hundreds of millions of dollars of new capital investment. The consequences of such widespread and massive capital investments in such fuel substitions will be a redirection of the growth trends of both the national and the Texas economies. Major structural changes in investment, employment, and consumption are anticipated. The analytic methods outlined below have been developed for the purpose of predicting and measuring the changes and the probable results of such changes upon production, employment, income, and tax paying capabilities of the Texas economy.

The Input-Output Simulation Model

The basic methodology employed in the projection of energy demands for Texas is to model the important economic relationships which determine energy resource use and to operate the model on the computer to obtain solutions. The relationships include those which exist at a given point in time representing market transactions between specified classes of producers and "final demand" (households, governments, capital formation, and exports) and the physical relationships between units of product output and resource inputs, especially the energy resource (see Appendix for equations of the model). Also included are the time-sequence relationships which relate (1) industry production in one period to production in the previous period by the change in expansion capital; (2) consumption in the current period to incomes in previous periods; and (3) the population of consumers in the current period to the population in the previous period and to the relationship between supply and demand for labor in the previous period.[1/]

The method for estimating the above relationships, which are relevant during one production period, is an input-output model developed for Texas during 1968-1971 using data from the 1967 production period.[2/] The base year

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1/ Holloway, Milton L., "An Economic Simulation Model for Analyzing Natural Resource Policy," Southern Journal of Agricultural Economics, Volume 6, Number 1, July 1974.

2/ Grubb, Herbert W., The Structure of the Texas Economy, Office of the Governor, Austin, Texas, March, 1973.

input-output model is modified and updated to current and projected input relationships within the workings of the simulation model for major fuel industries--chemicals, petroleum refining, electric utilities, primary metals and pulp and paper. Other requirements include the results of energy supply-demand analyses and surveys of these industries. The following sections explain the basic components of a static input-output model and identify time-dependent relationships which have been estimated and incorporated into the input-output simulation model.

The Texas interindustry or input-output model is a mathematical measurement of trade relationships (market transactions) among Texas industries, as well as the relationship of Texas to out-of state industries through imports and exports (Figure II-1). The illustration shows the entire Texas economy expressed in forty-eight buying industries and forty-eight selling industries. A particular industry buys energy inputs from energy producers, other primary resources, and goods in process; pays taxes and wages; and imports additional products for inputs into production. As a seller, the industry sells products to other industries (Block A in Figure II-1), households, governments, capital formation, and exports (Blocks B,C, D, and E). For each industry, total sales equal total purchases. (Appendix Tables 2, 3, and 4, give detailed illustrations of input-output tables).

The empiriical estimates of relationships are based on primary survey data from most of Texas industries, supplemented by budget data from the agricultural industries, and various census reports of total output for the base period. The list of sectors with sector names and the

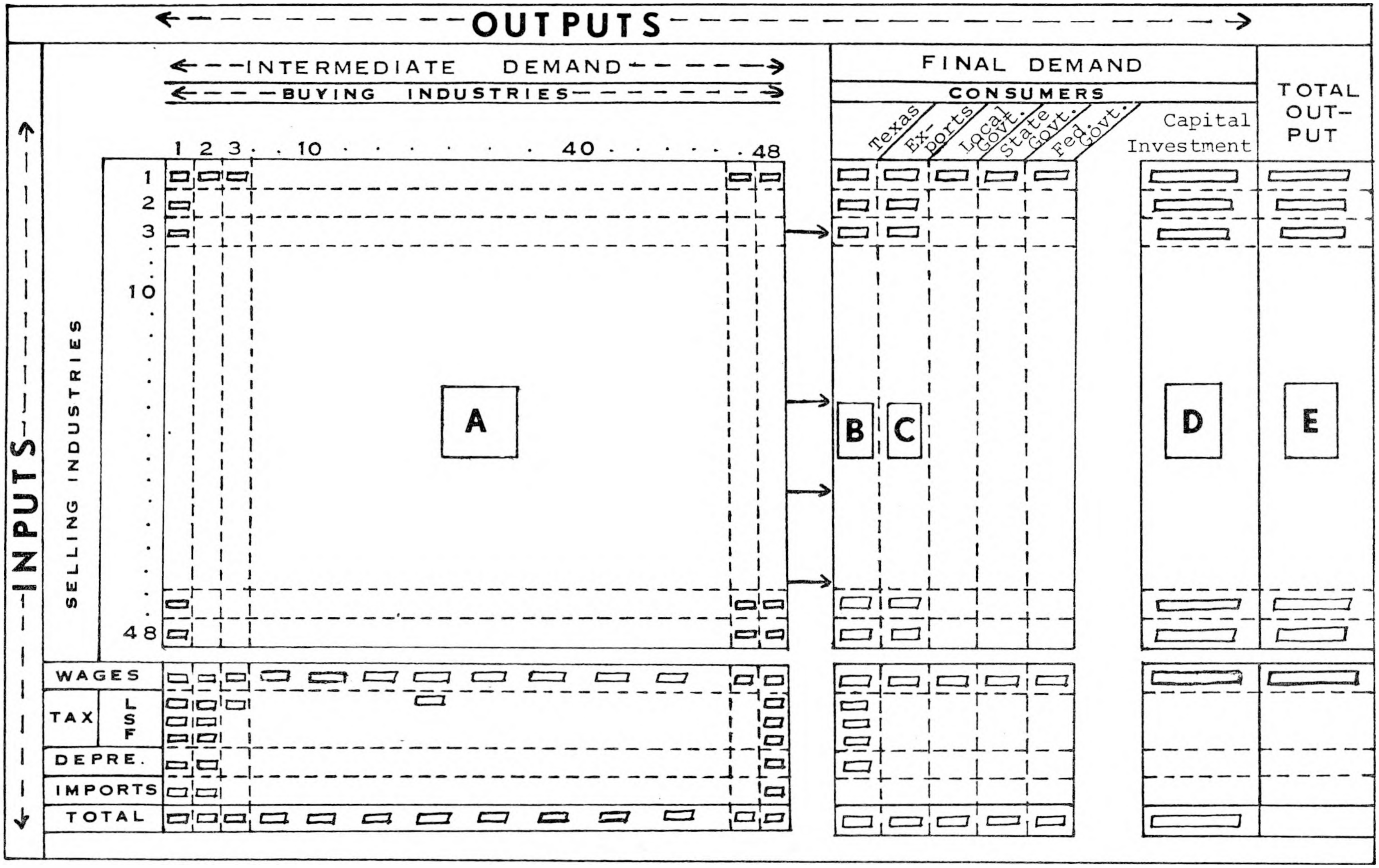

Figure II-1. Illustration of an Annual Input-Output Table.

Standard Industrial Classifications [1] of the individual producing establishments contained within each sector is found in Table II-1.

The simulation model is recursive for successive annual simulations. The 1967 data and relationships of the Input-Output Model provide the beginning conditions for the simulation. The level of final demand, when expressed in terms of the Input-Output Model, is the driving force of the model. Thus, when final demand is known for a given time period, the model is solved to determine the level of output that is required from each sector in order to satisfy final demands. The computerized routine calculates an annual solution to the simulation model and uses the solution for a given year as data for calculating the solution for the following year. The results of the 1968 solution, for example, are used as data for calculating the estimated solution to the model for 1969. The results of the 1969 solution are used in calculating the 1970 model and so on for the following years of the simulation period. However, estimated technical changes, price changes, consumption changes, and fuel substitution relationships are incorporated into the model as the simulations are done.

Policy Variables and Assumptions

The simulation model has been specifically designed to permit the analyst to use a range of parameter values selected to represent alternative energy policies. For example, both the price and the quantity of imported oil can be varied to analyze the effects of various import

[1] Office of Statistical Standards, Executive Office of the President, _Standard Industrial Classification Manual_, Washington, D.C., 1967.

Table II-1. List of Sectors of the Input-Output Simulation Model. a/

Sector Number	Industry	Sic Groups a/
1	Irrigated Crops	0112-0123
2	Dryland Crops	0212-0219
3	Livestock and Poultry	0132-0235
4	Agricultural Services	0712-0741, 5962, 5969
5	Primary Forestry and Fisheries	0811-0989
6	Crude Petroleum	1311
7	Natural Gas Liquids	1321
8	Oil and Gas Field Services	1381, 1382, 1389
9	Other Mining	1011-1499
10	Residential Construction	1511
11	Comm., Ed., and Instit. Const.	1512, 1513, 1700
12	Facility Construction	1611, 1621
13	Food Processing	2011-2087
14	Textile and Apparel	2211-2399
15	Logging, Wood, and Paper	2411-2799
16	Chlorine and Alkalies	2812, 2813
17	Cyclic Crudes and Intermediate Pigments	2815
18	Organic Chemicals	2818
19	Inorganic Chem., Plastics, and Rubber	2819-2822
20	Drugs, Chemicals, Soaps, and Paint	2831-2899
21	Petroleum Refining	2911
22	Other Petroleum Products	2951, 2952, 2992, 2999
23	Tires, Rubber, Plastics	3011-3199
24	Glass, Clay, Stone, Cement	3221-3273
25	Primary Metal Processing	3312-3499
26	Industrial Equipment Manufacturing	3522-3599
27	Electric Appliance Manufacturing	3611-3699
28	Aircraft, Motor Vehicle	3721-3799
29	Instruments, Photography, Games	3811-3999
30	Rail Transportation	4011, 4013, 4021, 4041
31	Intercity Highway Transportation	4131, 4132, 4111, 4119, 4121
32	Motor Freight Transportation	4212-4231
33	Water Transportation	4411-4469
34	Air Transportation	4511, 4521, 4582, 4503
35	Pipeline Transportation	4612, 4613, 4619
36	Other Transportation	4141, 4251, 4271-4272, 4712-4789
37	Telephone and Broadcast Communications	4811, 4821, 4832, 4833, 4899

(Continued)

Table II-1 (Continued).

Sector Number	Industry	SIC Groups [a]
38	Gas Services	4922-4925
39	Electric Services	4911
40	Water and Sanitary Services	4941-4961,9302
41	Wholesale Trade	5012-5099
42	Retail Trade	5211-5499, 5611-5999
43	Auto Dealers and Repair Shops	5511-5531, 5541, 7531-7549
44	Fin., Ins., and Real Estate	6011-6799
45	Prof., Bus., and Personal Services	8111, 7211-7399, 7512-8099, 8911-8811
46	Lodging, Amusement, Recreation	7011-7041, 7832-7949
47	Education	
48	Outdoor Recreation	8211-8242
49	Households	N/A
50	Property Payments	N/A
51	Federal Government	9119-9199
52	State Government	9241-9299
53	Local Government	9341-9399
54	Imports	N/A

[a] The Standard Industrial Classification Code (SIC) as defined in Standard Industrial Classification Manual; Executive Office of the President, 1967.

policies upon the Texas economy as measured in terms of value of output, fuel consumption, employment levels, personal income, taxes paid to local, state and federal governments, and a number of other factors. These characteristics of the model are summarized under three headings:

I. Available Policy Variables for Analysis

A. Import prices of oil, gas, coal, and nuclear fuel
B. Domestic prices of oil and gas.
C. Import quantities of oil and gas
D. Substitution of fuels by industry for heavy fuel-using sectors
E. User exemptions and industrial priorities for fuel use during shortage periods.

II. Model Parameters Concerning General Economic Conditions Which are Variable

A. Changes in labor productivity by sector
B. Growth in government services and export demand
C. Level of natural population growth rate
D. Average propensity to consume from household incomes
E. Personal income tax rates
F. Long-term unemployment rate
G. Various income and price elasticity parameters
H. Energy requirements per unit of output by industry and governments

III. Model Parameters Concerning General Economic Conditions Not Subject to Change During the Simulation

A. Technology changes affecting non-labor resources
B. Capital requirements per unit of output
C. No price changes or input substitutions are possible for industry inputs except fuels and feedstocks. Price increases in primary resources (oil, gas, coal, and nuclear) are passed along by the first-stage industrial user (refineries, gas services, and electric utilities) to final consumers, and next-stage processors. The price increases stop at this point.

The specific data requirements and mathematical equations whereby the parameters of the model are brought into the analysis are stated and explained in the Technical Appendix. There are a large number of possible combinations of policies and parameter assumptions. Public policy-makers and private sector planners need analyses of the effects of these combinations. The Input-Output Simulation Model has been solved for the combination of policies and parameters shown in Figure II-2

Policy Variables \ Parameter Estimates	Labor Productivity	Government & Export Growth	Natural Population Growth Rate	Average Propensity To Consume	Personal Income Tax Rate	Long-Term. Unemploy. Rate	Income and Price Elasticity of Demand	Energy Requirement Per Unit Output
Import Prices of Oil and Gas	X	X	C	C	C	C	C	C
Domestic Prices of Oil, Gas, Coal and Nuclear	X	X	C	C	C	C	C	C
Import Quantities of Oil and Gas	X	X	C	C	C	C	C	C
Industry Fuel Distribution	X	X	C	C	C	C	C	C
Exemptions and Priorities for Fuel Use	X	X	C	C	C	C	C	C

Figure II-2. Combinations of Major Energy Policy Variables and Important Parameter Estimates Which Can Be Varied.

Note: X = combinations of variables changed during the analysis.

C = parameter values in the columns which were held constant during the analysis.

III. THE IMPACT OF PRICE ON ENERGY SUPPLY AND DEMAND, DISTRIBUTION OF FUEL USE AND THE STRUCTURE OF THE TEXAS ECONOMY: INPUTS TO THE SIMULATION MODEL

Three major inputs to the simulation model are required to adequately estimate the economic effects of changes in energy production and consumption in Texas. First, the relationships between crude oil and natural gas price increases and future production indicate the quantity of Texas crude oil and natural gas available for Texas consumption and for exports to the rest of the nation. Secondly, fuel using industries in Texas are expected to change their level and distribution of fuel use in response to increased relative prices of crude oil products and natural gas. These estimates are required as input to the simulation model. Thirdly, price changes resulting in changes in the level of fuel use and fuel substitutions, and import levels for crude oil and natural gas influence the trade relationships between Texas industries. These calculations are described and illustrated in this section to demonstrate their importance.

To further elaborate, one of the most important questions for analysis and quantification in a market economy is the response of supply and demand to price, and it is important to understand that the question has both a short-term response to price changes and a long-term response to price changes which in many cases is significantly greater because of certain inflexibilities or fixities in consumption and production activities. Large differences in short-term and long-term responses to price are especially characteristic of many markets involving energy production, processing, and consumption. Lag times of several years duration are required to initiate exploration, drilling, and pipeline construction before marketing of new oil supplies is possible. The changing of boilers from natural-gas-fired to coal-fired units for converting fuels to steam energy to drive turbines requires time and favorable expected returns from the investment. The changing of engine efficiencies and the production of new engines capable of using fuels other than gasoline and diesel in response to rising relative prices of gasoline require several years of development time. The existing stock of automobiles has an average useful life of approximately five years. Thus, any major improvement in efficiencies of engines will not have a significant immediate effect upon gasoline consumption. Such inflexibilities throughout the system of production and consumption of energy are important factors in estimating market response to price changes.

Changes in the production, consumption, and substitution of fuels in response to price changes affect the trade relationships among industries in Texas. These changes are estimated and reflected in the quantification of these relationships in the input-output simulation model at the appropriate point in time as described in the previous section and mathematically specified in the Technical Appendix.

The Effect of Price on Supply and Demand for Energy

The projections in the following chapter from the input-output simulation model utilize four sets of supply prices for crude oil and natural gas for purposes of evaluating alternative price policies and bracketing the likely range of possible production and consumption outcomes. First, a set of baseline projections assuming a continuation of 1967-1970 prices are made simulating the forces which would have been expected to occur under the pre-nineteen seventy conditions of supply response to price levels. In subsequent projections, both the domestic and import prices of crude oil and natural gas were increased annually from the beginning simulation year of 1968 to the specified levels by 1980. The domestic prices for crude oil and natural gas were specified at the long-term market prices estimated by Thompson,[1/] $8.65 per barrel for crude oil and $.66 per mcf for natural gas (1974 dollars). Import prices for foreign crude oil and natural gas were taken to be either (1) equal to the above domestic prices or (2) $14.00 per barrel for crude oil and $2.00 per mcf for natural gas (1974 dollars) by 1980.

The Texas crude oil supply curve for both the old price levels ($3.30 per barrel for crude oil and $.21 for natural gas in 1967 dollars), and the estimated equilibrium prices of $8.65 per barrel for crude oil and $.66 for natural gas (1974 dollars) are shown in Figure III-1 and III-2. In both the crude oil and natural gas cases (with approximately the 1967 relative price levels) the annual production had already peaked by 1973 and was beginning to decline. Estimates of both oil and gas supply indicate a continual decline under the old prices as reserves are depleted. Very little new reserves and new production would be encouraged at the 1967-1970 prices. The estimated annual supply resulting from the higher equilibrium prices shows a marked increase by 1985. The increase in price from $3.30 per barrel (1967 dollars) to $8.65 per barrel (1974 dollars) is estimated to bring forth an additional 538 million barrels of total liquids per year by 1985. The natural gas response from the wellhead price increase of $0.45 per mcf from $.21 per mcf (1967 dollars)

1/ *Op. Cit.*, page 24.

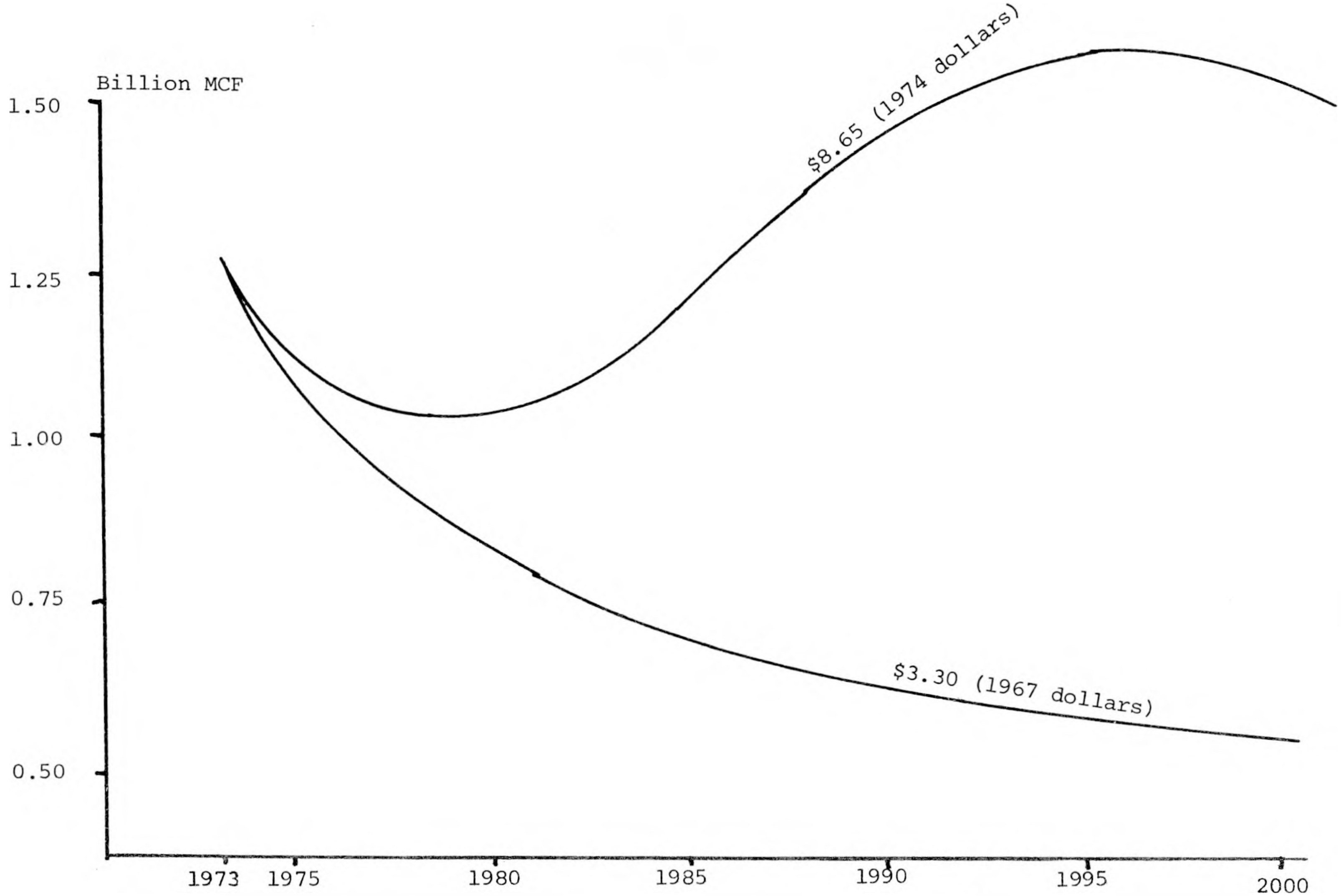

Figure III-1: Projected Texas Crude Supplies at $3.30 (1967 dollars) and $8.65 (1974 dollars) Per Barrel (Given Natural Gas Prices of $0.21 (1967 dollars) and $0.66/MCF (1974 dollars), Respectively.

Source: Adapted from Thompson, Russell G., Rodrigo J. Lievano, and Robert R. Hill, "Energy Supply and Demand Analysis." Preliminary Draft prepared for the Governor's Energy Advisory Council, University of Houston, December, 1974.

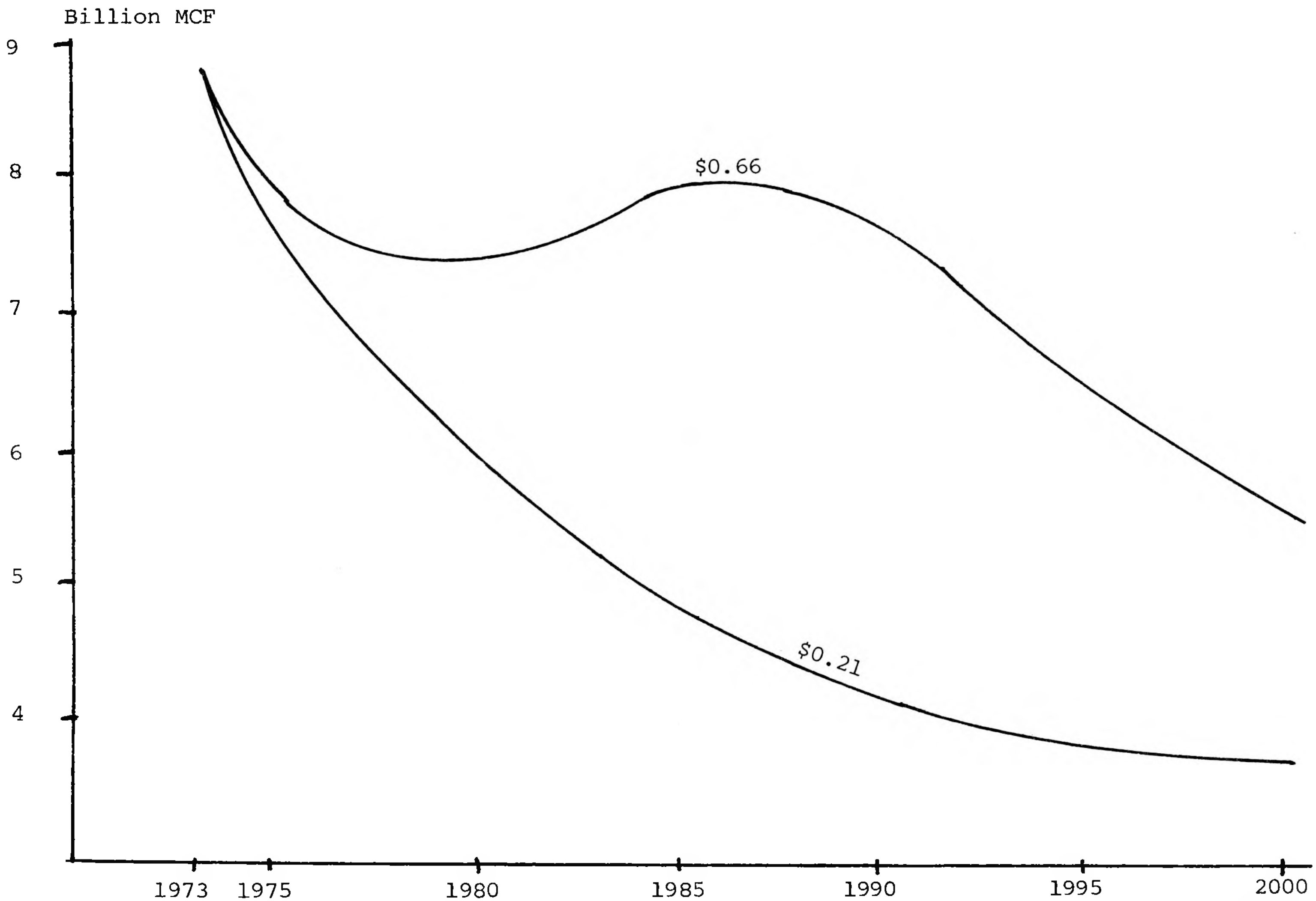

Figure III-2: Projected Natural Gas Supplies at $0.21 (1967 Dollars) and $0.66 (1974 Dollars) Per MCF [Given Crude Oil Prices of $3.30 (1967 Dollars) and $8.65/BBL (1974 Dollars) Respectively.]

Source: Adapted from Thompson, Russell G., Rodrigo J. Lievano, and Robert R. Hill, "Energy Supply and Demand Analysis," Preliminary Draft prepared for the Governor's Energy Advisory Council, University of Houston, December, 1974, for data points to 1985.

to $.66 per mcf (1974 dollars) is estimated to be 3.56 billion cubic feet per year by 1985. Both curves decline prior to the year 2000 but remain continually above the estimated supply under the $3.30 per barrel and $.21 per per mcf prices. [1/]

The demand response to price changes for fuels and electricity occurs at several key markets. The demand side of the markets is represented by users of electricty for power and petroleum products for fuels in manufacturing, agriculture, mining, construction, transportation, communications, trades, services, governments, and households. The total energy demand by sector is the summation of the demand for natural gas, natural gas liquids, refinery products (gasoline, fuel oil, feedstocks, jet fuel), and electricity. Estimates of demand response to price are made through the use of price elasticities of demand for electricity, gasoline, and natural gas. The price elasticity of demand for a fuel estimates the percent change in the quantity of fuel taken from the market from a one-percent change in its own price. The elasticity estimates for electricity, gasoline, and natural gas are summarized in Table III-1. Note that the long-term elasticities are in each case significantly greater than the short-term elasticities.

The price elasticity of demand estimates from Table III-1 were used systematically to estimate individual sector demand response to electricity and fuel price changes for most sectors in the simulation model. The following sector identifications and sector numbers refer to the

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1/ The Thompson model did not calculate gas supply estimates past 1985. Other supporting analyses indicate a decline in production past 1985 at the specified prices. Thus, the function was assumed to decline exponentially from 1985 to 2000.

Table III-1: Price and Income Elasticities of Demand for Electricity, Gasoline, and Natural Gas.

Product	Price Elasticity of Demand		Income Elasticity of Demand	
	Short Run	Long Run	Short Run	Long Run
Electricity				
Residential[a] (Household)	-0.10	-0.65	0.30	1.80
Commercial[b]	-0.11[d]	-1.50	N/A	N/A
Industrial[b]	-0.12[d]	-1.70	N/A	N/A
Gasoline[a]	-0.20	-1.40	0.15	1.10
Natural Gas[c]				
Residential (Household	-0.44[f]	-1.63	n/a	1.08[c]
Commercial			N/A	N/A
Industrial	-0.70[f]	-1.33	N/A	N/A

NA: Not Applicable
na: not available

a/ Source: Thompson, Russell G., Rodrigo J. Lievano, and Robert R. Hill "Energy Supply and Demand Analysis," preliminary draft prepared for the Governor's Energy Advisory Council, University of Houston, December, 1974.

b/ Source: Chapman, D., T. Tyrell, and T. Mount, "Electricity Demand Growth and the Energy Crisis," Science, Volume 178, No. 4062, November 17, 1972.

c/ Source: Tummala, V., "Alternative Methods of Estimation in the Demand for Natural Gas." Unpublished Ph.D. dissertation, Michigan State University, 1968.

d/ Estimated by the ratio of residential to commercial and residential to industrial in the Chapman, Tyrell and Mount study.

e/ Source: Mullendore, Walter E. and Arthur L. Ekholm "Projections of Final Demand for Texas," unpublished materials, Office of the Governor, Austin, Texas, August, 1972.

f/ **For the 1975-1980 period, price elasticity of demand for natural gas is probabaly in the -0.10 to -0.20 range.**

listing in Table II-1. For purposes of this study, the short-run industrial price elasticities of demand were used to estimate demand response to price for sectors in the manufacturing group of industries, excluding "heavy fuel using industries," (Sectors 13 through 29 excluding Sectors 15-20 and 25), agriculture (Sectors 1 through 5), mining (Sectors 6 through 9), and construction (Sectors 10 through 12). Short-run commercial price elasticities of demand were applied to transportation (Sectors 30 through 36), communications (Sector 37), utilities (Sectors 38 through 40 excluding 39), trades and services (Sector 41 through 48), and government (Sectors 50 through 52). Short-run residential price elasticities of demand were applied to the household sector (Sector 49). As prices for fuels increase, the demand elasticities indicate the change in the quantity of fuel taken by the sector. This information is used in the simulation model to determine the estimated dollar value of purchases from fuel producers in the model for most sectors identified in the simulation model.

The Effect of Price on Fuel Use Distribution by Major Fuel Using Industries

Direct solutions to fuel substitutions were calculated (corresponding to the $8.65 oil and $0.66 gas prices) using the Thompson Integrated Linear Programming Model[1/] for certain "heavy fuel-using sectors" in the simulation model. The percent distribution of fuel use from the Thompson model was incorporated into the Input-Output Simulation Model for chemicals, primary metals, pulp and paper, and electric utilities--the sectors not included in the above sets of sectors using price elasticities. That is, for given price changes for crude oil and natural gas, the integrated model gave the estimated distribution of fuel use by sector. This distri-

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1/ Op. Cit.

bution was used at the appropriate point in time in the simulation model corresponding to the appropriate price levels to determine the estimated purchases of fuels. An alternative set of fuel distributions for the same set of heavy fuel-using sectors was constructed from survey data. The Thompson Model solutions were taken as a "high coal" case, and the survey data was taken as a "low coal" case.

The distributions of fuel use by the heavy fuel-using sectors as specified over time and incorporated into the model are shown in Table III-2. The distributions from the Thompson Model indicate how industries would be expected to respond to relative price changes assuming they minimize their costs. The distributions from the survey data indicate what industry leaders believe will take place under the long-term equilibrium price estimates. Note that the electric utility sector is expected to have 39 percent coal use by 1985 in the case of the survey data and 76 percent in the case of the Thompson Model solution.

The average price of crude oil to Texas refineries and the average price of natural gas to gas services are calculated in the model as the weighted average of Texas and import prices. The change in the price of refinery products, natural gas to consumers, and electricity is calculated as a function of the change in crude oil, natural gas, coal and lignite, and nuclear fuel prices (Technical Appendix page 30-31). Given the average price of primary energy and price elasticities of demand for the products, the model estimates the change in the quantities taken off the market at those prices by each industry sector. This price and quantity information is the basis for changing the estimated trade relationships between economic sectors within the input-output simulation model.

Table III-2. Distribution of Fuel Use by Industry Sector for Heavy Fuel-Using Industries, 1975-2000.

Sector	Function	Function Evaluation in 1985	Function Evaluation in 1990	Function Evaluation in 2000
			(proportion)	
Steam Electric Power Survey Data[a]	$f_1(t) = \begin{cases} 0.0, \ t < 1975 \\ -.0931 + .0133K, \ 1975 \leq t < 1975 \\ .24056 - .0063K, \ 1985 \leq t < 2000 \end{cases}$	.1330	.1020	.0390
	$f_2(t) = \begin{cases} 1.000, \ t < 1975 \\ 1.3679 - .0526\ K, \ 1975 \leq t < 1975 \\ .5259 - .0028\ K, \ 1985 \leq t < 2000 \end{cases}$	.4737	.4643	.4363
	$f_3(t) = \begin{cases} 0.0, \ t < 1975 \\ 0.0, \ 1975 \leq t < 1985 \\ -.4522 + .0266\ K, \ 1985 \leq t < 1990 \\ -.4383 + .0259\ K, \ 1990 \leq t < 2000 \end{cases}$	0	.1315	.3905
	$f_4(t) = \begin{cases} 0.0, \ t < 1975 \\ -.2748 + .0393\ K, \ 1975 \leq t < 1985 \\ .6857 - .0174\ K, \ 1985 \leq t < 1990 \\ .67184 - .0168\ K, \ 1990 \leq t < 2000 \end{cases}$	.3933	.3022	.1342

Where:

f_1 = portion of fuel use from fuel oil

f_2 = portion of fuel use from natural gas

f_3 = portion of fuel use from nuclear fuel

f_4 = portion of fuel use from coal and lignite

t = calendar year 1975, 1976, ..., 2000

k = t minus 1967

(Continued)

Table III-2 (Continued)

Sector	Function	Function Evaluation in 1985	Function Evaluation in 1990	Function Evaluation in 2000
			(proportion)	
LP Model b/	$f_1' = \begin{cases} 0.0, & t < 1975 \\ 0.038, & 1975 \leq t < 1985 \\ 0.0 & 1985 \leq t < 2000 \end{cases}$	.0380	0	0
	$f_2'(t) = \begin{cases} 1.0, & t < 1975 \\ 1.4912 - .0756\ K & 1975 \leq t < 1985 \\ .2440 & 1985 \leq t < 2000 \end{cases}$	.2060	.2440	.2440
	$f_3'(t) = \begin{cases} 0.0, & t < 1975 \\ 0.0, & 1975 \leq t < 1985 \\ -.4451 + .0262\ K, & 1985 \leq t < 2000 \end{cases}$	0	.1313	.3933
	$f_4'(t) = \begin{cases} 0.0, & t < 1975 \\ -.5292 + .0756\ K, & 1975 \leq t < 1985 \\ 1.2011 - .0262\ K, & 1985 \leq t < 2000 \end{cases}$	.7560	.6247	.3627

Where:

f_1' = portion of fuel use from fuel oil

f_2' = portion of fuel use from natural gas

f_3' = portion of fuel use from nuclear fuel

f_4' = portion of fuel use from coal or lignite

t = calendar year 1975, 1976, ..., 2000

K = t minus 1967

(Continued)

Table III-2 (Continued)

Sector	Function	Function Evaluation in 1985	Function Evaluation in 1990	Function Evaluation in 2000
			(proportion)	
Chemicals Survey Data [a/]	$g_1(t) = \begin{cases} 0.0, & t < 1975 \\ -.2630 + .0376\ K, & 1975 \le t < 1985 \\ .3757 & 1985 \le t < 2000 \end{cases}$	.3762	.3757	.3757
	$g_2(t) = \begin{cases} 1.00, & t < 1975 \\ 1.3680 - .0526\ K, & 1975 \le t < 1985 \\ .5174 - .0025\ K, & 1985 \le t < 2000 \end{cases}$	.4738	.4624	.4374
	$g_3(t) = 0.0,\ 1975 \le t < 2000$	0	0	0
	$g_4(t) = \begin{cases} 0.0, & t < 1975 \\ -.1050 + .0150\ K, & 1975 \le t < 1985 \\ .1069 + .0025\ K, & 1985 \le t\ 2000 \end{cases}$	.1500	.1619	.1869
	Where: g_1 = portion of fuel use from fuel oil g_2 = portion of fuel use from natural gas g_3 = portion of fuel use from nuclear fuel g_4 = portion of fuel use from coal and lignite			
LP Model [b/]	$g_1'(t) = \begin{cases} 0.0, & t < 1975 \\ -.0287 + .0042, & 1975 \le t < 1985 \\ .0421 & 1985 \le t < 2000 \end{cases}$	.0427	.0421	.0421
	$g_2'(t) = \begin{cases} 1.0, & t < 1975 \\ 1.540 - .0772\ K, & 1975 \le t < 1985 \\ .2279 & 1985 \le t < 2000 \end{cases}$	.2276	.2279	.2279

(Continued)

Table III-2 (Continued)

Sector	Function	Function Evaluation in 1985	Function Evaluation in 1990	Function Evaluation in 2000
			(Proportion)	
	$g_3'(t) = 0.0,\ 1975 \leq t < 2000$	0	0	0
	$g_4'(t) = \begin{cases} 0.0, & t < 1975 \\ -.5113 + .073\ K, & 1975 \leq t < 1985 \\ .7300 & 1985 \leq t < 2000 \end{cases}$	.7297	.7300	.7300
	Where: g_1 = portion of fuel use from fuel oil			
	g_2 = portion of fuel use from natural gas			
	g_3 = portion of fuel use from nuclear fuel			
	g_4 = portion of fuel use from coal and lignite			
Primary Metals Survey Data [a]	$h_1(t) = \begin{cases} 0.0, & t < 1975 \\ -.1197 + .0171\ K, & 1975 \leq t < 1985 \\ .1437 & 1985 \leq t < 2000 \end{cases}$	.1710	.1437	.1437
	$h_2(t) = \begin{cases} 1.00, & t < 1975 \\ 1.3946 - .0564\ K, & 1975 \leq t < 1985 \\ .4636 & 1985 \leq t < 2000 \end{cases}$	.4358	.4636	.4636
	$h_3(t) = 0.0,\ 1975 \leq t < 2000$	0	0	0
	$h_4(t) = \begin{cases} 0.0, & t < 1975 \\ -.2749 + .0393\ K, & 1975 \leq t < 1985 \\ .3927 & 1985 \leq t < 2000 \end{cases}$	.3932	.3927	.3927

(Continued)

Table III-2 (Continued)

Sector	Function	Function Evaluation in 1985	Function Evaluation in 1990	Function Evaluation in 2000
	Where: h_1 = portion of fuel use from fuel oil h_2 = portion of fuel use from natural gas h_3 = portion of fuel use from nuclear fuel h_4 = portion of fuel use from coal and lignite			
LP Model[b/]	No Data			

a/ Source: Distributions for 1985 for electric power generation is from primary survey data of the electric power industry in Texas conducted by the Governor's Office of Information Services, July, 1974. Distributions for 1985 for chemicals and primary metals is from information derived from primary survey data of the industry fuel use, in support of H. W. Pringle, Jr., Project S/D-10, "Impact of and Potential for Energy Conservation Practices in Industry," University of Houston, Houston, Texas, December, 1974.

b/ Source: Distributions for 1985 are from solutions to the Thompson Integrated Linear Programming Model for national conditions under estimated equilibrium prices of $8.65 per barrel for crude oil and $0.66 per mcf for natural gas.

Effect of Prices and Imports on the Structure of the Texas Economy

The technical changes which are expected to occur in the future would cause a change in the trade relationships among Texas industries, and thus a change in the relative importance of various industries to the state's economy. The importance of a particular industry to the Texas economy is dependent not only on its own size as measured by its employment, output, wages, and taxes paid, but also on the extent of trade with other industries within the economy. The larger the portion of total inputs purchased from within Texas, the larger the impact on the total economy from changes in levels of activity. A mathematical measurement of the interrelationships is called a multiplier. For example, the final demand multiplier is defined as the total dollar output effect on all sectors from a one unit change in the delivery of products to final demand by a particular sector.

The final demand multiplier for each model sector is shown in Table III-3 for 1970 and model projections to 1985 under "free import" assumptions. The multipliers indicate which industries were estimated most important in terms of their "multiplier" effect during 1970 conditions and during projected 1985 conditions. For example, the petroleum refining sector was estimated responsible for 1.97694 dollars of Texas industry output for each $1.00 of petroleum refining product delivered to final demand in 1970. Note that the sector having the largest multiplier (2.50385 in 1970) was Sector Number 17, Cyclic Crudes and Intermediate Pigments. In general, the chemical sectors (Sectors 16 through 20), Livestock and Poultry (Sector Number 3) and Food Processing (Sector Number 13) have the highest multipliers since these sectors purchase a very large portion of their input requirements from Texas industries. Also note that petroleum refining

Table III-3. Final Demand Multipliers for Each Sector of the Texas Economy, 1970 and Projected 1985.[a]

Sector Number	Industry	1970 Output	1970 Multiplier	Projected 1985 Output	Projected 1985 Multiplier
		($ Million)	(Dollars)	($ Million)	(Dollars)
1	Irrigated Crops	1,116.68	1.81469	1,980.78	1.86422
2	Dryland Crops	772.21	1.80025	1,410.59	1.83619
3	Livestock, Poultry	1,799.22	2.18738	2,911.59	2.20799
4	Agriculture Services	357.77	1.69402	613.32	1.71915
5	Forest, Fishery	95.77	1.44523	163.68	1.45819
6	Crude Petroleum	5,812.44	1.36873	11,467.18	1.37316
7	Natural Gas Liquids	817.89	1.80255	1,485.07	1.82231
8	Oil, Gas Field Service	772.37	1.41813	1,450.38	1.42932
9	Other Mining	259.95	1.37515	462.69	1.39629
10	Residential Construction	1,377.90	1.47570	1,903.90	1.48319
11	Commercial, Educational, Residential Const.	3,025.11	1.59594	5,069.89	1.60735
12	Facility Construction	2,405.16	1.50341	3,864.55	1.51442
13	Food Processing	4,203.69	1.96850	6,913.94	1.98520
14	Textile, Apparel	937.39	1.22164	1,624.11	1.22874
15	Logging, Wood, Paper	1,770.95	1.50896	3,165.35	1.52340
16	Chlorine, Alkali	160.61	2.02614	327.01	2.38565
17	Cyclic Crude, Intermediate Pigments	235.05	2.50385	520.67	3.10441
18	Organic Chemicals	2,241.43	2.01646	4,852.10	2.30997
19	Inorganic Chemicals, Plastics, Synthethics	1,261.16	1.94586	3,188.86	2.07900
20	Organic Chemicals, Soap, Paint	746.47	1.72635	1,519.25	1.82048
21	Petroleum Refining	7,242.39	1.97694	21,109.30	1.56626
22	Other Petroleum Products	94.55	2.04541	154.52	2.16758
23	Tire, Rubber, Plastic, Leather	369.14	1.65325	767.14	1.69805
24	Glass, Clay, Stone, Cement	728.43	1.59904	1,199.23	1.62343
25	Primary Metal Process	2,866.04	1.45200	4,780.00	1.48065
26	Industrial Equipment Manufacturing	1,600.11	1.35370	3,015.72	1.36282
27	Electrical Applicance Manufacturing	1,076.80	1.19015	2,397.66	1.19532
28	Air, Motor Vehicle, Transportation Mfg.	3,118.86	1.19278	3,926.80	1.19665
29	Instruments, Photography, Games	1,221.36	1.53739	1,848.04	1.54819
30	Rail Transportation	572.60	1.44703	1,052.67	1.46353

(Continued)

Table III-3 (Continued)

Sector Number	Industry	1970 Output	1970 Multiplier	Projected 1985	
				Output	Multiplier
		($ Million)	(Dollars)	($ Million)	(Dollars)
31	Intercity Highway Transportation	129.51	1.48722	232.03	1.52069
32	Motor Freight Transportation	965.49	1.72278	1,692.54	1.76020
33	Water Transportation	380.57	1.37224	679.54	1.38864
34	Air Transportation	297.55	1.47194	518.82	1.51186
35	Pipeline Transportation	417.72	1.65635	752.86	1.68634
36	Other Transportation Service	27.38	1.44861	53.57	1.45480
37	Communications	980.76	1.37481	1,856.43	1.38287
38	Gas Services	2,437.16	2.06784	3,722.40	2.13017
39	Electric Services	1,214.77	1.73254	3,107.18	1.61772
40	Water, Sanitary Services	246.63	2.07315	432.09	2.12474
41	Wholesale Trade	4,641.73	1.28693	8,196.32	1.29796
42	Other Retail Trade	4,894.92	1.38216	8,534.81	1.39182
43	Auto Dealership, Repair, Service Station	1,828.78	1.29030	3,182.58	1.29724
44	F.I.R.E.	4,777.09	1.38176	9,043.20	1.39126
45	Services	5,387.65	1.35338	9,830.63	1.36340
46	Lodging Amusement, Recreation	587.53	1.55934	1,051.84	1.57883
47	Education	2,175.24	1.29926	4,079.24	1.31077
48	Outdoor Recreation	59.87	1.28041	109.78	1.28720

a/ These multipliers are derived from the open Input-Output Model and measured in 1967 dollars.

(Sector Number 21), and Electric Services (Sector Number 39) multipliers decline significantly from 1970 to 1985. These changes are due to increasing use levels of imported crude oil, coal, and nuclear fuels as Texas supplies decline relative to Texas demand.

The multiplier for projected 1985 conditions for petroleum refining is reduced from 1.97694 in 1970 to 1.56626 in 1985 or a 20.77 percent decrease. The multiplier for electric utilities is shown to decrease by 6.63 percent. These sector multiplier changes indicate the possible magnitude of change due to changes in two key Texas industries. Other multipliers are increased, however, as higher fuel costs are passed along to fuel users throughout the economy. Changes in the Texas economic structure as represented by the multipliers for key energy related sectors are reported in each section of the analysis in the following chapter.

IV. ECONOMIC IMPACTS OF ALTERNATIVE ENERGY DEMAND PROJECTIONS

The economic impacts of changes in the energy industry depend upon a large number of factors including the response of energy supply and demand to price, taxes and subsidies levied by government, government import policies, changes in tastes and preferences of consumers, fuel substitution possibilities, and other market and non-market influences. The important production and consumption responses to price changes and fuel substitutions for major fuel using industries have been modeled and included in the following analysis. The trade relationships between industries and government spending and taxing characteristics are also represented in the model of the Texas economy. The economic impacts are quantified in several terms including changes in employment, incomes, taxes, industry dollar value of output, and other resource use. The following sections treat the analysis of the economic impacts from selected alternative public policies regarding energy pricing, production, and import levels.

Important Variables and Their Measurement

The simulation model results for each simulated time period consist of industry output levels, labor, and energy use by type for each of forty-eight industrial sectors, households and governments; income and tax payments for each sector; Texas household final demand for each sector's output; final demand of federal, state, and local governments; expansion of capital for capital-producing sectors; and exports for each sector selling products out-of-state. In addition, various summary data from the simulation model are presented for each simulated time period including household personal income, taxes and savings, and household energy use by fuel type including natural gas, gasoline, and electricity. Estimated energy use by type for governments and exports of energy in the form of crude oil, natural gas, natural gas liquids, refinery products, and petrochemical products are also included. Estimated imports of natural gas, crude oil, coal, and nuclear fuel are reported by importing sector. Due to the number of data items and the limitation of space, however, only selected variables thought to be of particular interest to energy policymakers are reported.

The variables reported herein include (1) total energy use by primary source; (2) employment; (3) personal income; (4) state and local taxes; (5) oil and gas industry tax payments; (6) quantity of imports and exports of crude oil, natural gas, nuclear fuel, and coal; and (7) prices of fuels for various user classes. Since changes in import levels and prices for certain energy-producing and energy-consuming industries significantly affects the structure of the Texas economy, these changes are also reported along with a discussion of the importance of the change.

The supply, demand, imports, and exports of crude oil, natural gas, coal, lignite, nuclear fuel, natural gas liquids, and refinery products are reported in terms of their BTU content. This measure allows conversion to a common denominator for comparing total energy use among industries, total import and export levels of energy, and total energy production in Texas. The conversion factors for various energy forms are summarized in Table IV-1 for convenient reference.

Table IV-1. Energy Conversion Factors.

Crude Oil	$5.800 \cdot 10^6$	BTU/bbl
Natural Gas	1,032	BTU/cf
Lignite	$15 \cdot 10^6$	BTU/ton
Nuclear Fuel	$2.018 \cdot 10^{12}$	BTU/ton
Natural Gas Liquids	$4.011 \cdot 10^6$	BTU/bbl
Gasoline	$5.248 \cdot 10^6$	BTU/bbl
Fuel Oil	$5.825 \cdot 10^6$	BTU/bbl
Jet Fuel	$5.670 \cdot 10^6$	BTU/bbl
Feedstock	$4.011 \cdot 10^6$	BTU/bbl
Electricity	3,412	BTU/kwh

Alternative Energy Demand Projections

The following sets of demand projections were completed to investigate the economic implications of alternative public policies on the Texas economy. The effects of (1) import prices and quotas for oil and gas, (2) increased domestic prices for oil and gas, and (3) new distributions of fuel use by industry, governments, and households in response to price changes are compared in a series of demand projections.

The demand projections for energy in each of the following sections are dependent upon growth rates in government spending and export demands for Texas goods and services. Since no extensive trade model for Texas with the rest of the nation and world exists and since growth in government spending cannot be modeled in direct relationship to the economy, it was necessary to rely on trend projections of export levels and government spending. The growth rates used in the following projections are based on a recent study by Mullendore.1/ A variation of the rates from the Mullendore study was used, however,to bracket the possible future growth. First, the growth rates were interpreted as linear rates and considerer to constitute a low growth case for governments and export demand. Secondly, the growth rates were interpreted as annual compound rates and considered to constitute a high growth case for governments and exports. Table IV-1 lists the growth rates by sector. Note that the highest growth rates, based on recent data used in the Mullendore estimates, are concentrated in the petrochemical industry (Sectors Number 16-20).

Baseline Energy Demand Projections Under Conditions of No Import Restrictions On Foreign Crude Oil

Baseline projections of the supply and demand for energy in Texas were made for comparisons of alternative policy effects based of the growth in Texas supply and Texas demand plus export demand under 1967-1970 prices and fuel use patterns by industry, governments, and households. The

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1/ Mullendore, Walter, E., and Arthur L. Ekholm, "Projections of Final Demand for Texas," Unpublished Report, Office of the Governor, Austin, Texas, August, 1972.

Table IV- 2 Estimated Growth Rates for Goverments and Export Demand.

Sector No.	Sector Name	Federal Military	Federal Non Military	State (Annual Rate)	Local	Exports
1.	Irrigated Crops	-.0053	.0560	.0490	.0480	.030
2.	Dryland Crops	-.0053	.0560	.0490	.0480	.030
3.	Livestock + Poultry	-.0053	.0560	.0490	.0480	.028
4.	Agricultural Services	-.0053	.0560	.0490	.0480	——
5.	Forest + Fishery	-.0053	.0560	.0490	.0480	——
6.	Crude Petroleum	-.0053	.0560	.0490	.0480	.034
7.	Natural Gas Liquids	-.0053	.0560	.0490	.0480	.034
8.	Oil + Gas Field Service	-.0053	.0560	.0490	.0480	.033
9.	Other Mining	-.0053	.0560	.0490	.0480	.033
10.	Residential Construction	-.0053	.0560	.0490	.0480	——
11.	Commercial, Education, Residential Const.	-.0053	.0560	.0490	.0480	——
12.	Facility Construction	-.0053	.0560	.0490	.0480	——
13.	Food Processing	-.0053	.0560	.0490	.0480	.033
14.	Textile + Apparel	-.0053	.0560	.0490	.0480	.033
15.	Log, Wood + Paper	-.0053	.0560	.0490	.0480	.038

(Continued)

Table IV-2 (Continued)

Sector No.	Sector Name	Federal Military	Federal Non Military	State	Local	Exports
				(Annual Rate)		
16.	Chlorine + Alkali	-.0053	.0560	.0490	.0480	.053
17.	Cyl. Crude, Inter. Pigments	-.0053	.0560	.0490	.0480	.053
18.	Organic Chemicals	-.0053	.0560	.0490	.0480	.053
19.	Inorganic Chemicals, Plastics, Synthetics	-.0053	.0560	.0490	.0480	.067
20.	Organic Chemicals, Soap, Paint	-.0053	.0560	.0490	.0480	.057
21.	Petroleum Refining	-.0053	.0560	.0490	.0480	.034
22.	Other Petroleum Production	-.0053	.0560	.0490	.0480	—
23.	Tire, Rubber, Plastic, Leather	-.0053	.0560	.0490	.0480	.062
24.	Glass, Cyl., Stn. + Cement	-.0053	.0560	.0490	.0480	.042
25.	Primary Metal Process	-.0053	.0560	.0490	.0480	.033
26.	Industrial Equipment Manufacturing	-.0053	.0560	.0490	.0480	.048
27.	Electrical Appliance Manufacturing	-.0053	.0560	.0490	.0480	.061
28.	Air, Motor Vehicle, Tr. Manufacturing	-.0053	.0560	.0490	.0480	.028
29.	Instr., Photography, Games	-.0053	.0560	.0490	.0480	.060

(Continued)

Table IV-2 (Continued)

Sector No.	Sector Name	Federal Military	Federal Non Military	State	Local	Exports
				(Annual Rate)		
30.	Rail Transportation	-.0053	.0560	.0490	.0480	.039
31.	Intercity Highway Transportation	-.0053	.0560	.0490	.0480	——
32.	Motor Freight Transportation	-.0053	.0560	.0490	.0480	.039
33.	Water Transportation	-.0053	.0560	.0490	.0480	.039
34.	Air Transportation	-.0053	.0560	.0490	.0480	.039
35.	Pipeline Transportation	-.0053	.0560	.0490	.0480	.039
36.	Other Transportation Service	-.0053	.0560	.0490	.0480	.039
37.	Communications	-.0053	.0560	.0490	.0480	.019
38.	Gas Services	-.0053	.0560	.0490	.0480	.062
39.	Electric Services	-.0053	.0560	.0490	.0480	——
40.	Water + Sanitation Services	-.0053	.0560	.0490	.0480	——
41.	Wholesale Trade	-.0053	.0560	.0490	.0480	.046
42.	Other Retail Trade	-.0053	.0560	.0490	.0480	.046
43.	Auto Dl., Repair, Service Station	-.0053	.0560	.0490	.0480	.047

(Continued)

Table IV-2 (Continued)

Sector No.	Sector Name	Federal Military	Federal Non Military	State	Local	Exports
				(Annual Rate)		
44.	F.I.R.E.	-.0053	.0560	.0490	.0480	.047
45.	Services	-.0053	.0560	.0490	.0480	.062
46.	Lodging, Amusements, Recreation	-.0053	.0560	.0490	.0480	.044
47	Education	-.0053	.0560	.0490	.0480	___
48.	Outdoor Recreation	-.0053	.0560	.0490	.0480	___

Source: Mullendore, Walter E., and Arthur L. Ekholm, "Projections of Final Demand for Texas," Unpublished Report, Office of the Governor, Austin, Texas, August, 1972.

Texas supply of crude oil and natural gas for each year 1974-2000 was estimated from the supply functions in Figure II-1 and II-2 assuming continuation of the $3.30 crude oil price and $.21 natural gas price. Supply prices of refinery products, natural gas to consumers, natural gas liquids, and electricity were accordingly held at their 1967-1970 price levels; thus the distribution of fuel use by industry does not change over the projection period in the baseline case. The residential, government and industrial demand for refinery products, natural gas to consumers, natural gas liquids, and electricity grow in response to population and per capita income growth, assuming a continuation of recent growth rates in Texas export and government's demand for final goods and services. Shortages between Texas supply and Texas plus export demand for natural gas are satisfied by (1) first reducing direct exports of natural gas to the rest of the nation and (2) if shortages are not satisfied when exports are driven to zero,[1/] reducing supplies available to the lowest valued Texas user. Shortages between Texas supply and Texas plus export demand for crude oil are satisfied by increasing foreign imports of crude oil. The simulation model estimates Texas production, consumption, imports, and exports of energy based on the supply and demand relationships.

The projected baseline total energy production and consumption in quadrillion BTU's are shown in Figure IV-1. The Texas supply of energy in this case is from oil and gas sources and declines (Figure II-1 and II-2) under conditions of $3.30 (1967 dollars) per barrel for crude oil and $.21 (1967 dollars) per mcf for natural gas. The demand for Texas

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1/ Positive export levels can be specified to represent continuation of long-term contractual obligations by Texas suppliers. The following analysis allows the exports to go to zero.

Export and Government Demand includes energy and non energy products. For exponential growth of these demands Texas energy consumption is higher than for linear growth.

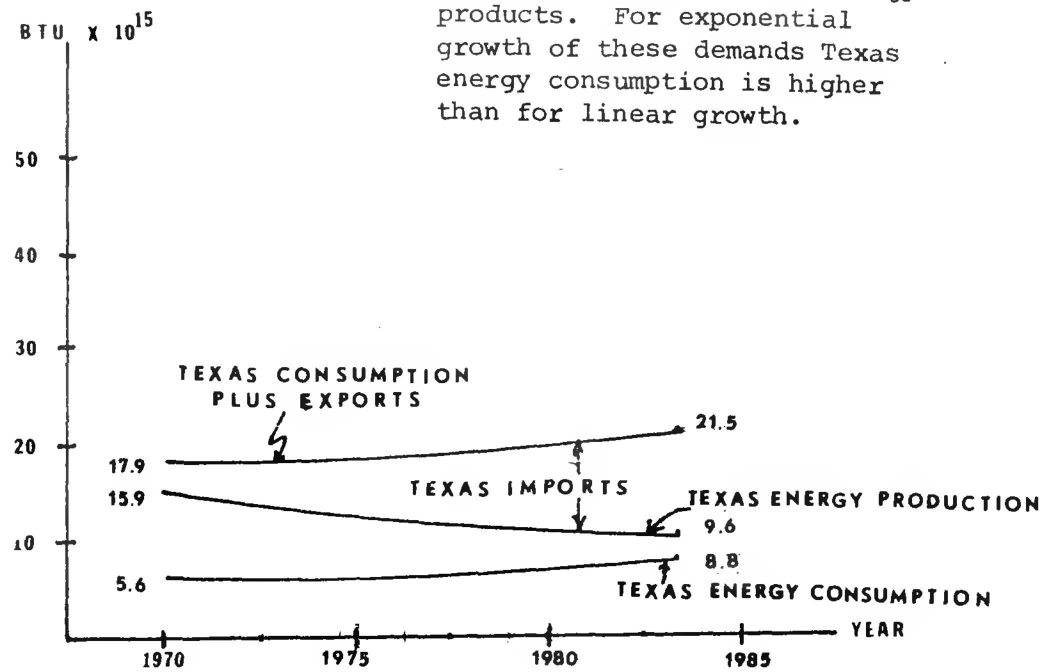

Figure IV-1a: Exponential Growth in Export and Government Demand

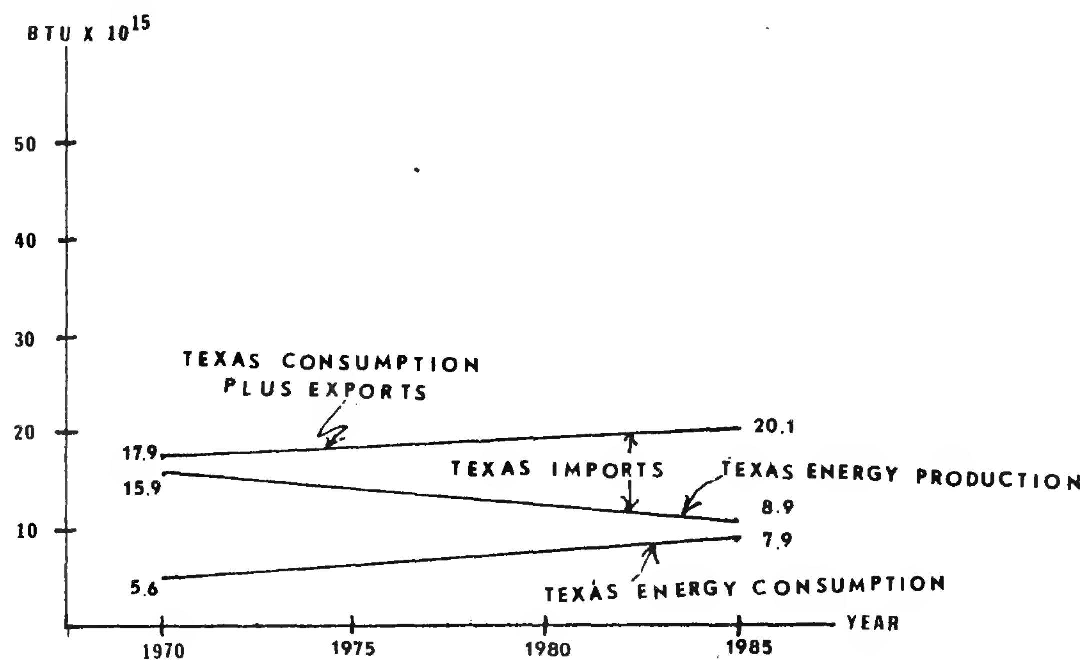

Figure IV-1b: Linear Growth in Export and Government Demand

Figure IV-1: Baseline Projections of Production and Consumption of Energy in Texas Under Conditions of No Import Restrictions, Two Assumptions Concerning Export and Government Demand Growth, 1970 - 2000.

energy is the household, government, and industrial demand. Texas energy consumption exceeds Texas production following 1983 in the baseline case for electricity, feedstock, and fuels if governments and export demand for Texas products continue to grow at recent exponential rates (Figure IV-1a). If the growth rates for governments and exports diminish to a linear growth rate, however, Texas total energy consumption would not exceed Texas energy production until after 1985 (Figure IV-1b). The imports of crude oil required to balance the total demand (Texas plus export demand) and total supply (Texas supply plus imports of oil) are indicated by the difference between Texas energy production and total Texas consumption plus exports in Figures IV-1a and IV-1b. At the point where Texas crude oil production equals Texas imports of crude oil, total interstate and foreign imports of crude oil and interstate imports of natural gas are 11.9 and 11.2 quadrillion BTU's respectively (Figures IV-1a and IV-1b). The model solution at this point indicates that adjustments in prices, fuel substitutions, production and/or consumption levels must take place by 1983 or 1985, respectively, since Texas would not realistically become an importer of crude oil only to satisfy export demand for unrefined crude oil.[1/]

The implied growth in crude oil imports consistent with the balance of supply and demand for energy in Texas is a 717 percent increase from 1970 to 1983 for the exponential growth case and 664 percent from 1970 to 1985 for the linear growth case. This increase is both from foreign sources and interstate sources and is estimated to grow from 247 million

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1/ The simulation model calculations stop when the growth in import levels of crude oil equals Texas production of crude oil.

barrels in 1970 to 2.018 billion barrels in 1983 for the exponential growth case and to 1.884 billion barrels by 1985 for the linear growth case (Table IV-3). The export levels of crude oil to the rest of the nation are shown to increase from 457 million barrels in 1970 to 695 million barrels in 1983 and 657 million barrels in 1985 for the exponential and linear growth cases, respectively (Table IV-3).

The growth in total energy consumption by major groups of users in the baseline case is shown in Figure IV-2. These major groups are aggregations of the sectors listed in Table II-1. Figure IV-2a illustrates the growth in energy requirements when exports and government demands are assumed to grow at linear rates while Figure IV-2b illustrates the growth when exports and government demand are assumed to grow at exponential rates. In both cases the industrial demand is the largest category accounting for 38.66 percent of the total Texas demand in 1970 and 37.62 percent of the total in 1985 for the linear export and government demand growth. Table IV-4 summarizes the distributions of energy use by the major sectors--industrial, non-energy; residential, commercial, and governments; loss in electric power generation;1/ and transportation for 1970 and 1985. The distributions do not change significantly over time. The changes among assumptions concerning export and government growth rates were very small and consequently are not shown in Table IV-4. Fuel substitutions and use rates per unit of output are constant in the baseline case, and any differences between 1970 and 1985 are due to differences in relative growth rates of total final demand including

1/ The generation of electricity to transform one form of energy to another under current technology results in a net loss of approximately 67 percent of the energy.

Table IV-3. Baseline Projections of Imports and Exports of Crude Oil and Natural Gas Under Conditions of No Crude Oil Import Restrictions, Two Assumptions Concerning Export and Government Demand Growth, Selected Years, 1970-1985.

Year	Imports				Exports			
	Linear Export and Government Demand Growth		Exponential Export and Government Demand Growth		Linear Export and Government Demand Growth		Exponential Export and Government Demand Growth	
	Crude Oil	Natural Gas	Crude Oil	Natural Gas	Crude Oil	Natural Gas	Crude Oil	Natural Gas
	(million barrels)	(billion cubic feet)	(million barrels)	(billion cubic feet)	(million barrels)	(billion cubic feet)	(million barrels)	(billion cubic feet)
1970	247	554	247	554	457	4,299	457	4,299
1975	814	343	871	341	518	3,175	532	3,007
1980	1,364	237	1,553	231	587	702	629	153
1983	1,669	192	2,018	191	629	0	695	0
1985	1,884	170	NA	NA	657	0	NA	NA

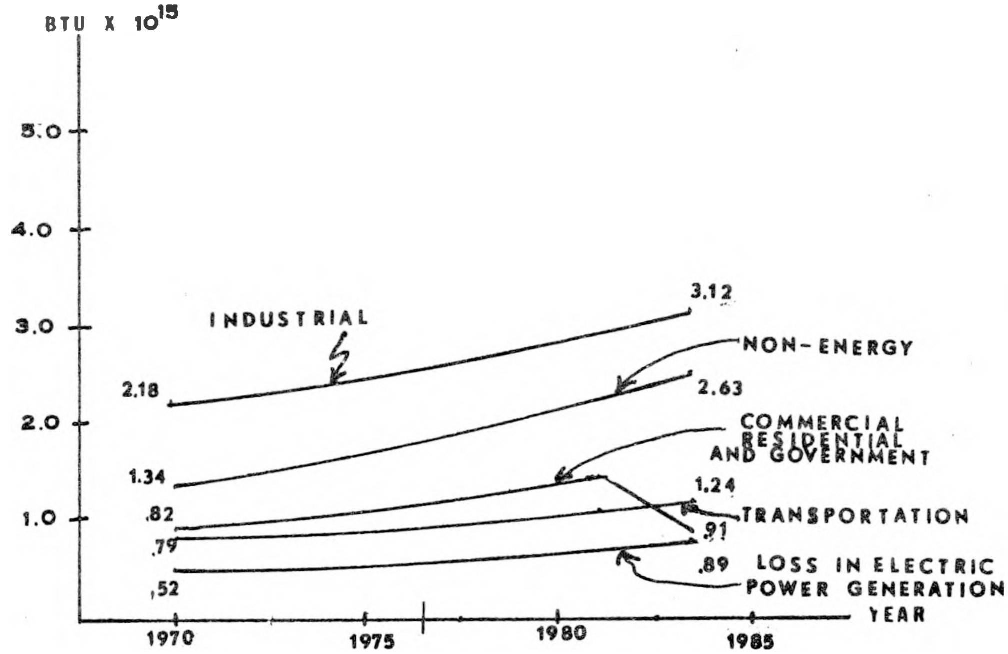

Figure IV-2a: Exponential Growth in Export and Government Demand

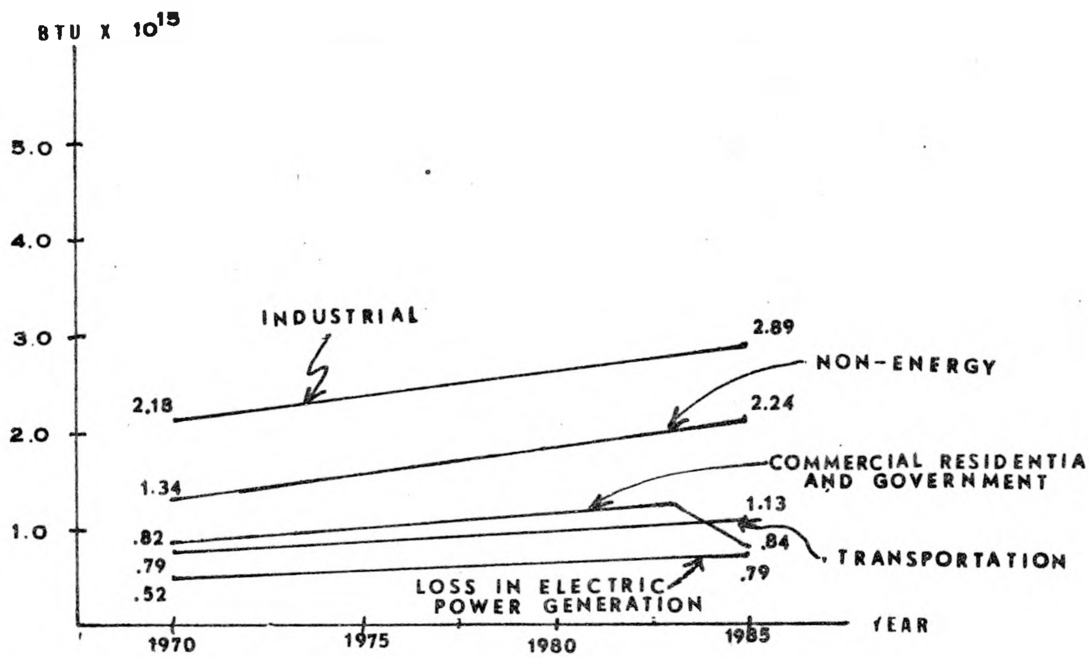

Figure IV-2b: Linear Growth in Export and Government Demand

Figure IV-2: Baseline Projections of Total Texas Energy Consumption for Five Categories of Users Under Conditions of No Import Restrictions, Two Assumptions Concerning Export and Government Demand Growth, 1970 - 2000.

Table IV-4 . Distribution of Total Texas Energy Consumption for Five Categories of Users in 1970 and 1985 Given Linear Growth Rates for Texas Governments and Export Demand for All Goods and Services, Baseline Case.

Category of User	1970 Distribution of Consumption	1985 Distribution of Consumption: Linear Export and Government Demand Growth
	(percent)	(percent)
Industrial	38.74	36.63
Non-Energy	23.86	28.39
HH, Com., & Govt.[a/]	14.40	10.65
Loss in Electric Power Generation	9.13	10.01
Transportation	13.87	14.32
TOTAL	100.00	100.00

[a/] HH means households, Com. means commercial, and Govt. means governments.

Texas household demands, government demands, capital expansion demands, and export demands for each of the forty-eight sectors of the model (see Table II-1 for a description of the sectors). Note that energy consumption by the commercial, government, and residential sector is shown to decrease sharply after 1980. As natural gas supplies are depleted and no substitutions are estimated in the baseline case, exports are first driven to zero then the lowest valued users' consumption is cut back indicating where consumption could be reduced with the least adverse effect on Texas income generating capacity.

Energy demands by Texas households for gasoline, natural gas, and electricity in the baseline case grow over time as population and per capita incomes grow. Higher per capita disposable incomes result in higher per capita energy demand as estimated by income elasticity coefficients (Appendix Table 15). The resulting consumption projections by households under two assumptions concerning growth rates for governments and export demand for Texas goods and services are shown in Figure IV-3. Table IV-5 summarizes the distributions for 1970 and 1985. Note that gasoline use in BTU's constitutes 66.89 percent of the total in 1970 and 86.81 percent of the total in 1985 for the linear export and government demand growth case. No significant differences occurred between the results of the linear and exponential growth assumptions for exports and governments. Since natural gas supplies were short by 1985 and exports were already driven to zero (Table IV-5), household use was also driven to zero to maintain industry production.

The projections of employment, population of household heads, personal income and taxes for the baseline case associated with the demands and supplies of energy illustrate the growth from general economic activity

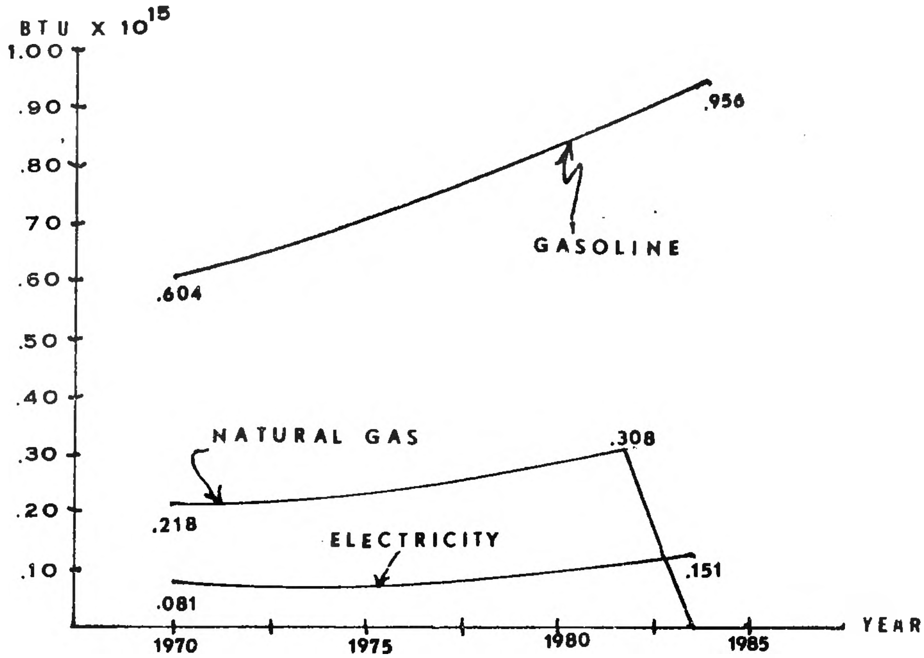

Figure IV-3a: Exponential Growth in Export and Government Demand

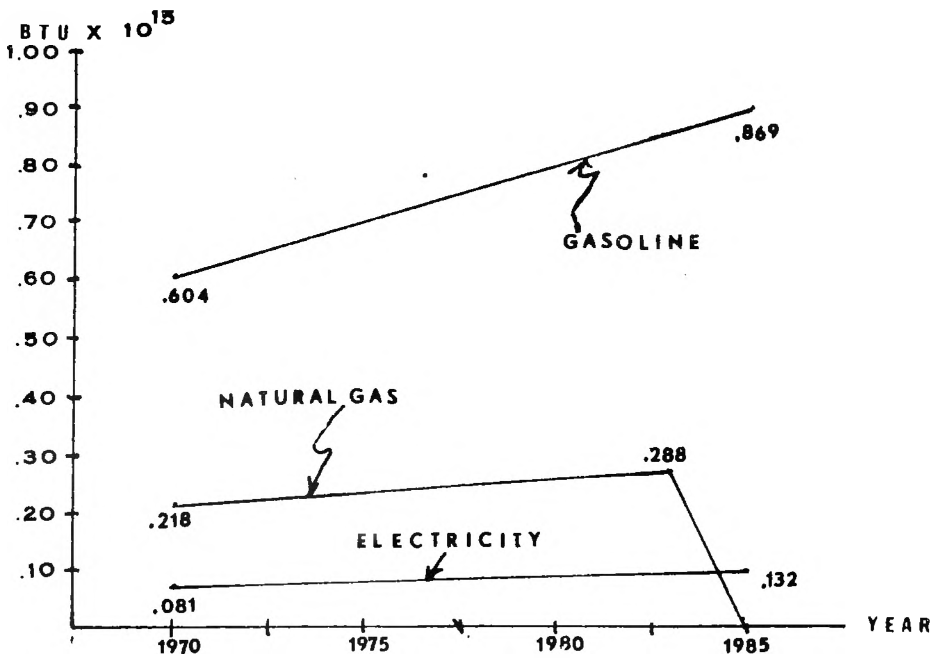

Figure IV-3b: Linear Growth in Export and Government Demand

Figure IV-3: Baseline Projections of Residential Consumption of Gasoline, Natural Gas, and Electricity Under Conditions of No Import Restrictions, Two Assumptions Concerning Export and Government Demand Growth, 1970-2000.

Table IV-5. Distribution of Texas Residential (Household) Energy Consumption by Three Fuel Sources in 1970 and 1985 Linear Growth Rates for Texas Governments and Export Demand for All Goods and Services, Baseline Case

Category of Fuels	1970 Distribution of Consumption	1985 Distribution of Consumption
		Linear Export and Government Growth
	(percent)	(percent)
Gasoline	66.89	86.61
Natural Gas	24.14	0.0[a/]
Electricity	8.97	13.19
Total	100.00	100.00

a/ Natural gas supplies are short and deliveries of gas to exports and residential use have been reduced to zero in the model.

with pre-nineteen seventy prices and declining supplies of oil and gas. Figure IV-4 compares employment and population of household heads under two assumptions concerning the growth in export and governments demand for Texas goods and services. The exponential growth assumption results in projections of an estimated 386 thousand additional employees by 1985 over that for the linear growth case.

Personal income and total state and local tax revenues for the baseline projections under two assumptions concerning the growth in export and governments demand for Texas goods and services are shown in Figure IV-5. The oil and gas industry contributions[1/] are also shown

1/ The oil and gas industry tax contributions to state and local taxes is defined as (1) the royalty and wellhead taxes at the production level for oil and gas, (2) property taxes on oil reserves, (3) state and local taxes for the pipeline, refining, petrochemical, and gas services industries, and (4) gasoline taxes on gasoline.

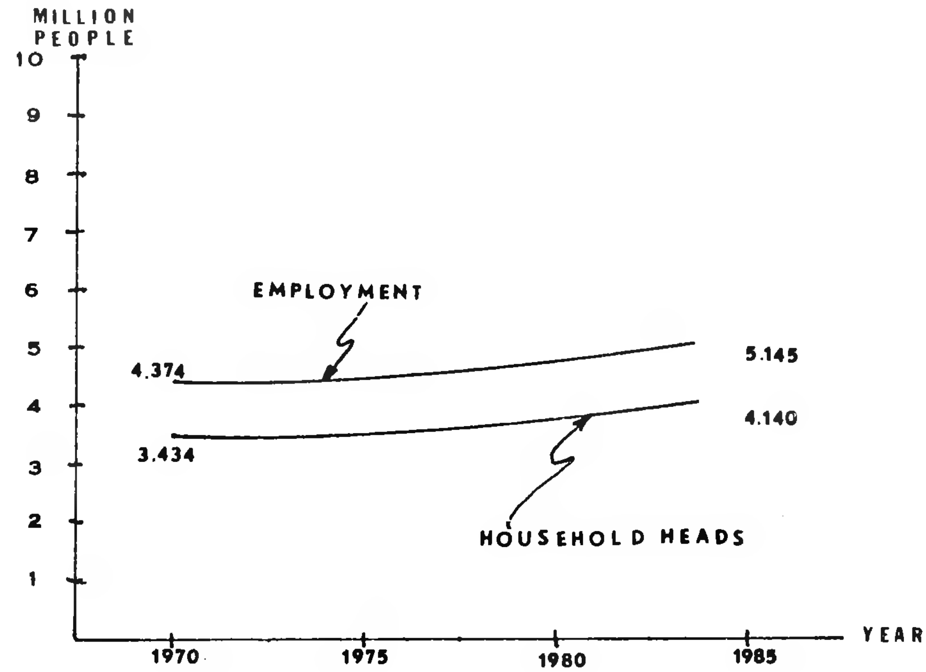

Figure **IV-4a:** Exponential Growth in Export and Government Demand

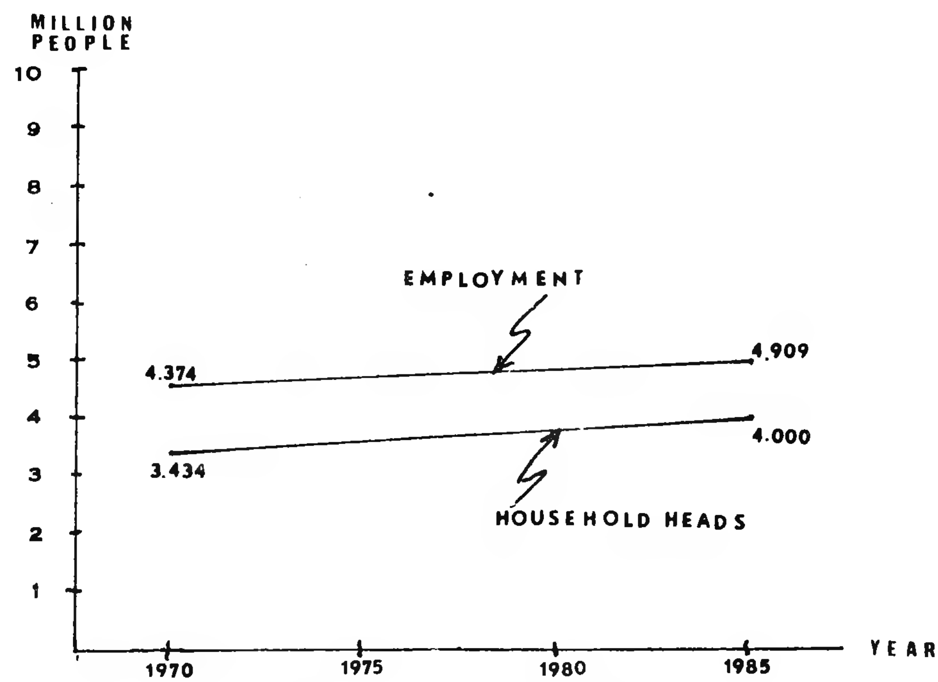

Figure IV-4b: Linear Growth in Export and Government Demand

Figure IV-4: Baseline Projections of Texas Population of Household Heads and Employment Under Conditions of No Import Restrictions, Two Assumptions Concerning Export and Government Demand Growth, 1970 - 2000.

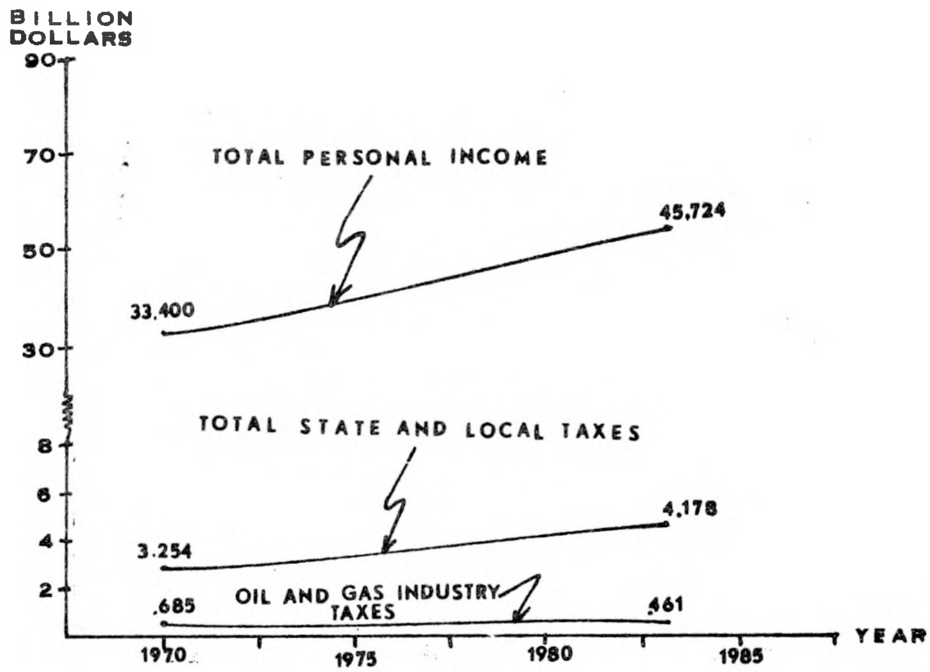

Figure IV-5a: Exponential Growth in Export and Government Demand

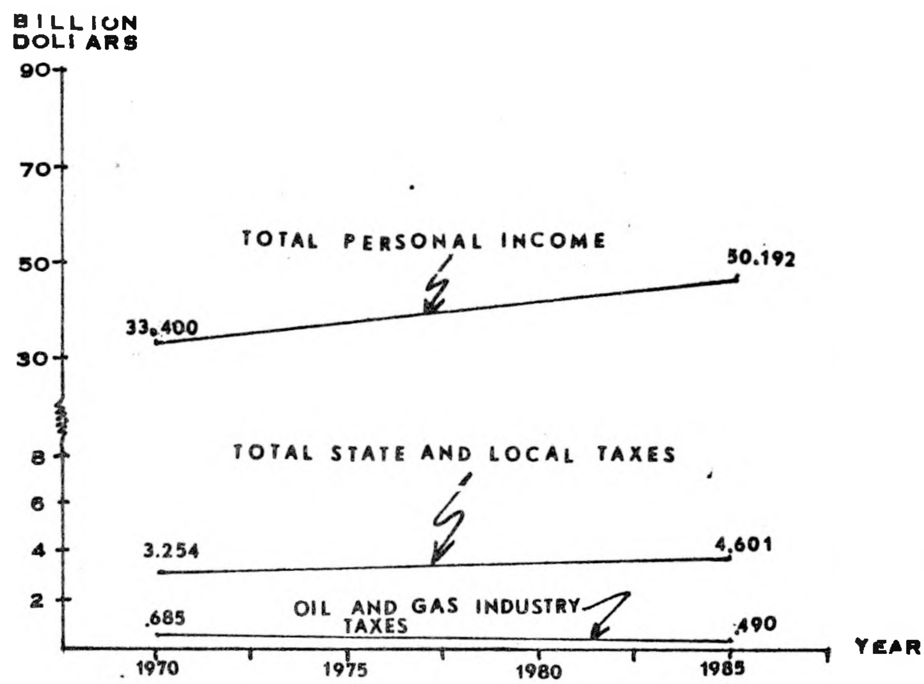

Figure IV-5b: Linear Growth in Export and Government Demand

Figure IV-5: Baseline Projections of Texas Total Personal Income, Total State and Local Taxes, and Oil and Gas Industry Tax Contributions in 1967 Dollars Under Conditions of No Import Restrictions, Two Assumptions Concerning Export and Government Demand Growth, 1970 - 2000.

for comparison. The exponential case estimates total Texas personal income at 50.192 billion dollars in 1983 compared to 45.724 billion dollars in 1985 for the linear case (1967 dollars). The growth in state and local taxes tends to follow the growth in income in both cases. Since the production of oil and gas is declining throughout the 30-year period in the baseline case, the portion of state and local tax revenues from the oil and gas industry declines also from 21.1 percent in 1970 to 9.14 percent in 1985 in the linear case (Figure IV-5b) and 9.17 percent in 1983 in the exponential case (Figure IV-5a).

The large growth in import levels required to balance Texas plus export demand for crude oil and crude oil products has a structural impact on the Texas economy in the baseline case. As imports increase the "leakage" increases and the Texas economy becomes less interdependent. The final demand multipliers indicate the degree of interdependency and are shown in Table IV-6 for important petroleum using sectors. Note that the multiplier for Petroleum Refining would decrease by 31.6 percent by 1985. Additional "leakages" through increased imports, however, will have a smaller total impact than previous increases. That is, an additional one million barrel increase in imports will result in an incrementally smaller decrease in the multiplier indicating a smaller negative total impact than the previous one million barrel increase in imports. As indicated from the 31.6 percent decrease in the petroleum refining multiplier, this sector has less and less impact on the Texas economy in terms of its own output level and the total effect on other industries in Texas.

Table IV-6 . Baseline Projections of Final Demand Multipliers for Eleven Important Petroleum Using Sectors in Texas Under Conditions of No Import Restrictions for Crude Oil and Linear Growth in Export and Government Demand, 1970 and 1985.

Sector	Final Demand Multiplier[a/]		
	1970	1985	Percent Change
		(Dollars)	
Crude Petroleum	1.36672	1.36444	-0.167
Natural Gas Liquids	1.79479	1.77847	-0.918
Chlorine & Alkali	1.95056	1.91105	-2.067
Cylic Crudes, Intermed-idates and Pigments	2.36611	2.14870	-11.012
Organic Chemicals	1.94855	1.88820	-3.196
Inorganic Chemicals, Platics and Syn.	1.91283	1.88299	-1.585
Organic Chemicals, Soaps, Paints	1.70335	1.67217	-1.865
Petroleum Refining	1.97830	1.50324	-31.602
Pipeline Transportation	1.64378	1.63418	-0.587
Gas Services	2.03557	2.03291	-0.131
Electric Services	1.66263	1.66060	-0.122

a/ The final demand multiplier measures the total economy dollar value of output change from a one dollar change in the delivery of final products to households, governments, and/or exports.

Market Forces Energy Demand Projections Under Conditions of No Import Restrictions on Foreign Crude Oil

Projections of energy supply and demand in Texas under conditions of no import restrictions on crude oil and estimated equilibrium prices for domestic oil and gas were made for comparison with the baseline case and to estimate the overall economic impact of production and consumption response to price increases. The projections include the effects of estimated fuel substitutions by Texas heavy-fuel-using-industries and direct demand reduction from increased prices by other industries, households, and governments.

The estimated production response from equilibrium price increases to $8.65 per barrel (1974 dollars) for oil and $0.66 per mcf (1974 dollars) for natural gas as shown in Figures III-1 and III-2 were taken as the projected Texas production. Demand projections for energy with the input-output simulation model were based on (1) estimated increases in retail natural gas, refinery products, and electricity prices from increased prices of natural gas and crude oil at the wellhead and increased cost of production from the use of imported coal, (2) the associated fuel substitutions by individual heavy fuel using industries, and (3) price elasticity estimates for non-heavy-fuel-using-industries, commercial industries, governments, and residential (household) users.

The total energy production and consumption for the market forces case in quadrillion BTU's are shown in Figure IV-6. Figures IV-6a and IV-6b show the results under assumptions of exponential and linear growth rates, respectively, for governments and exports. The Texas production is always greater than Texas consumption in the linear and exponential export and government demand growth rate cases. Import

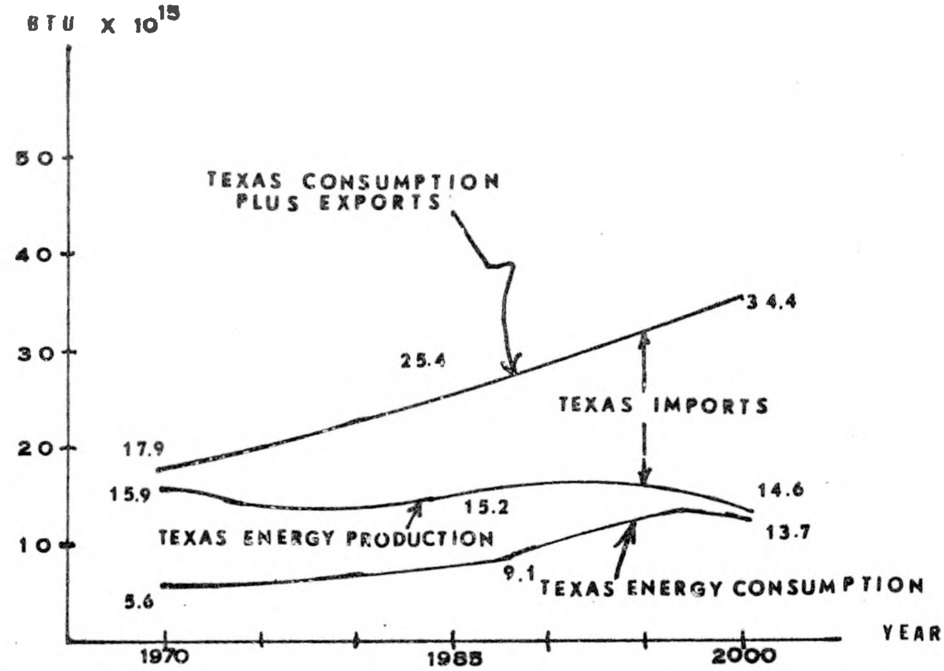

Figure IV-6a: Exponential Growth in Export and Government Demand

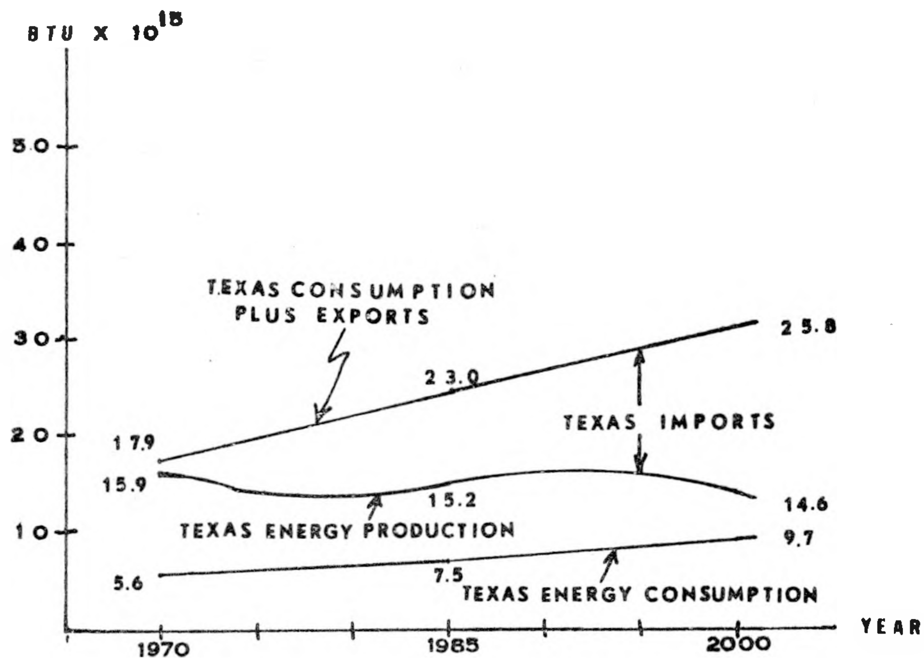

Figure IV-6b: Linear Growth in Export and Government Demand

Figure IV-6: Market Forces Projections of Production and Consumption of Energy in Texas Under Conditions of No Import Restrictions, Two Assumptions Concerning Export and Government Demand Growth, 1970-2000.

requirements to balance Texas supply and Texas plus export demand are estimated to be 10.2 and 7.8 quadrillion BTU's by 1985, respectively, for the exponential and linear cases (including 1.1 - 1.4 billion barrels of imported crude oil).

The magnitude of imports and exports for crude oil in the market forces case indicate the increased direct exports and reduced import requirements which are possible because of the relatively large increase in Texas production (Table IV-7). The market forces import levels by 1985 in the linear growth case are lower than import levels in the baseline case by 749 million barrels (Table IV-3 and Table IV-7). The increased quantities of crude oil available are used in Texas industry while maintaining exports of crude oil and refinery products to the rest of the nation.

The increased production of natural gas in Texas in the market forces case is sufficient to provide an additional 10-15 years of gas for export and Texas use. Since large quantities of foreign natural gas cannot be imported the projected Texas consumption plus exports is dependent only on Texas production with limited interstate imports. The increased Texas production in the market forces case is projected to provide for Texas requirements plus continued exports until 1995-2000 as compared to 1983-1985 in the baseline case (Table IV-3 and Table IV-7).

The baseline and market forces cases for Texas supply and demand for energy are compared in Figure IV-7 in the case of linear growth in export and government demand for Texas goods and services. The supply in the baseline case includes only crude oil and natural gas; the supply in the market forces case includes crude oil, natural gas,

Table IV-7. Market Forces Projections of Imports and Exports of Crude Oil and Natural Gas in Texas Under Conditions of No import Restrictions on Crude Oil, Two Assumptions Regarding Governments and Export Demand Growth, Selected Years, 1970 - 2000.

	Imports				Exports			
	Linear Government and Export Growth		Exponential Government and Export Growth		Linear Government and Export Growth		Exponential Government and Export Growth	
	Crude Oil	Natural Gas	Crude Oil	Natural Gas	Crude Oil	Natural Gas	Crude Oil	Natural Gas
	(million barrels)	(billion cubic feet)	(million barrels)	(billion cubic feet)	(million barrels)	(billion cubic feet)	(million barrels)	(billion cubic feet)
1970	247	554	247	554	457	4,299	457	4,299
1975	643	335	652	332	518	3,288	532	3,134
1980	962	272	1,119	265	587	2,394	629	1,995
1985	1,135	295	1,439	280	657	3,220	743	2,494
1990	1,252	290	1,722	261	726	2,841	879	1,425
1995	1,365	206	2,150	171	795	903	1,039	0
2000	1,478	142	2,746	179	864	0	1,228	0

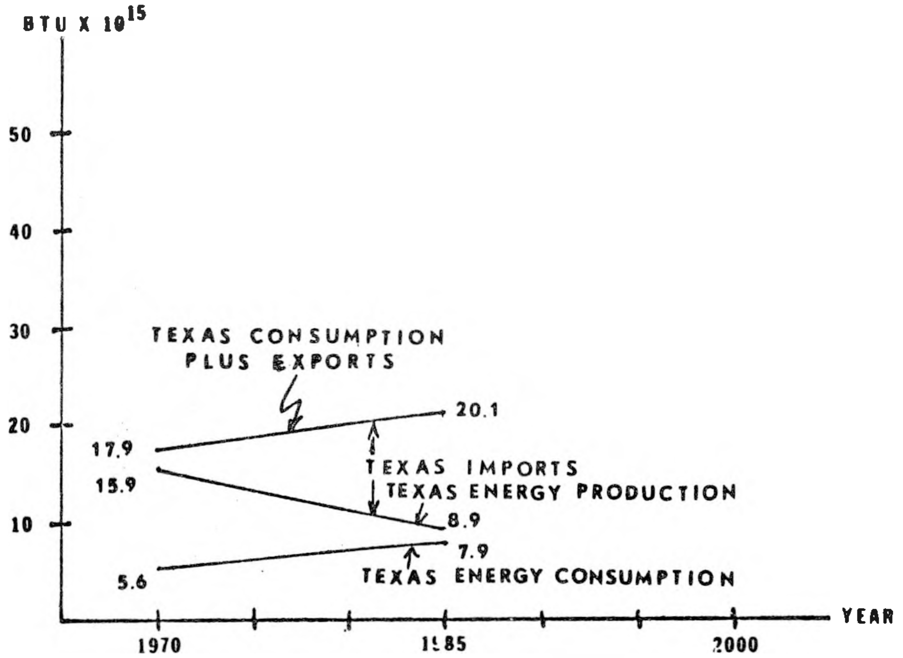

Figure IV-7a: Baseline Case

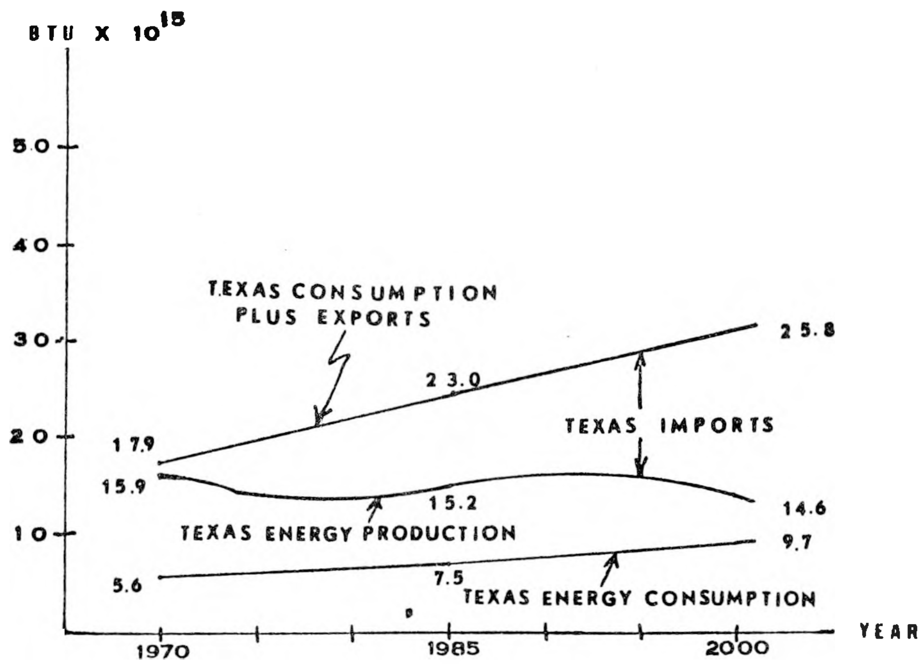

Figure IV-7b: Market Forces Case

Figure IV-7: Comparison of Baseline and Market Forces Production and Consumption of Energy in Texas Under Conditions of No Import Restrictions and Linear Growth in Export and Government Demand, 1970 - 2000.

and Texas lignite. The increase in Texas supply over the baseline case is estimated to be 6.514 quadrillion BTU's or 72.70 percent by 1985 and 8.399 quadrillion BTU's or 127.84 percent by 2000. The decrease in total Texas consumption from the baseline case level is 0.4 quadrillion BTU's or 5.06 percent by 1985.[1/] Note that Texas production equals Texas consumption following 1985 in the baseline case but production exceeds consumption to the year 2000 in the market forces case. Figure IV-8 compares both production and consumption in the market forces and baseline case when exports and governments demand are assumed to grow at exponential rates. In this set the production exceeds consumption in the market forces case although natural gas available for export has been reduced to zero and some Texas consumption has been reduced (Table IV-7).

The growth in total demand for energy by major groups of users in the market forces case is shown in Figure IV-9. The chart in Figure IV-9a illustrates the growth in demand when exports and government demands are assumed to grow at linear rates while Figure IV-9b illustrates the growth when exports and government demands are assumed to grow at exponential rates. Sufficient oil and gas, given substitutions and demand reductions from price increases, are projected to be available for all Texas industry to 2000 if governments and export demand grow linearly (Figure IV-9b). If governments and exports grow at exponential rates, however, the increased production and reduced consumption

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1/ The reduced level of consumption in 1980 from the increase in prices was estimated at 0.8 quadrillion BTU's or 11.0 percent from the baseline case. By 1985 in the baseline case supplies were already short and low valued users were deprived of gas (Figure IV-2 and Figures IV-3).

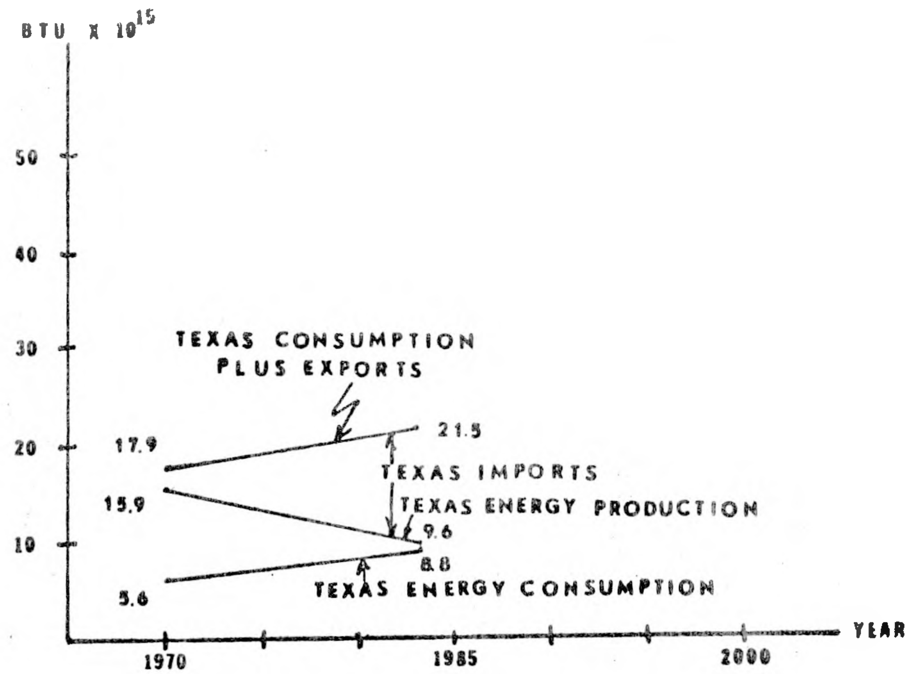

Figure IV-8a: Baseline Case

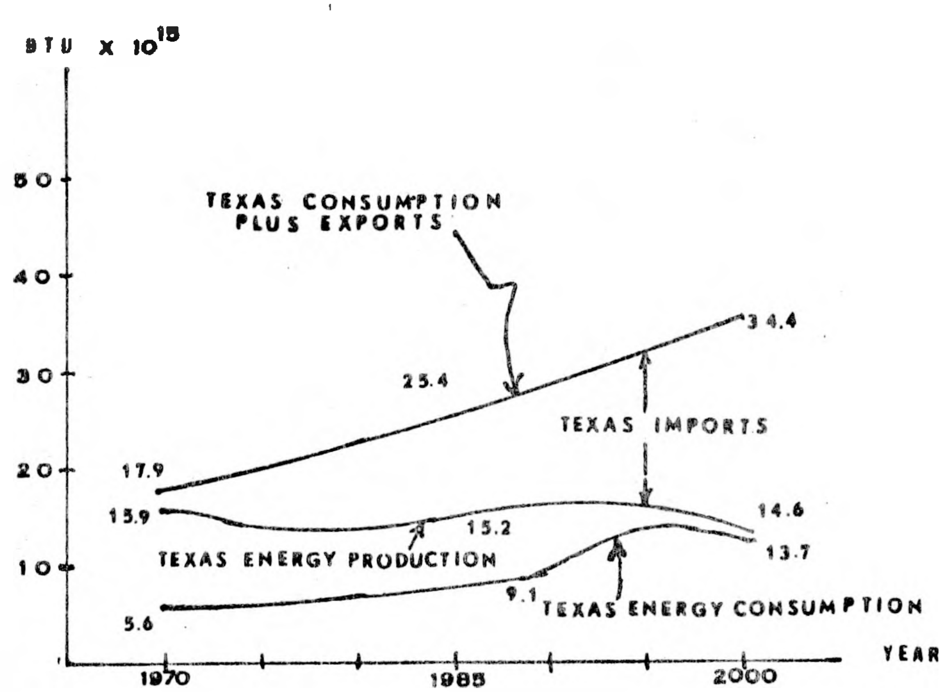

Figure IV-8b: Market Forces Case

Figure IV-8: Comparison of Baseline and Market Forces Projections of Production and Consumption of Energy in Texas Under Conditions of No Import Restrictions and Exponential Growth in Export and Government Demand, 1970 - 2000.

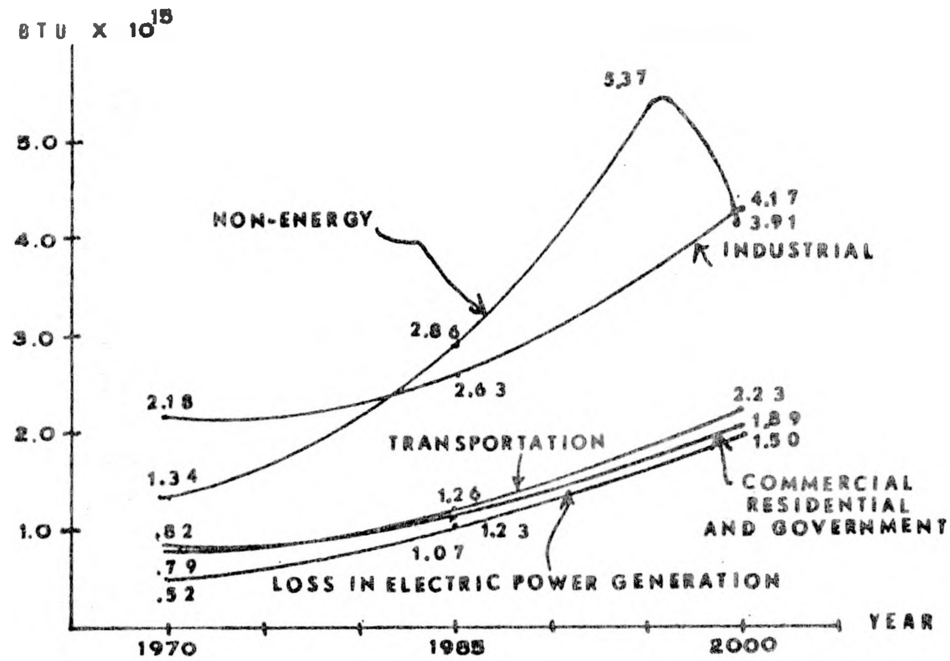

Figure IV-9a: Exponential Growth in Export and Government Demand

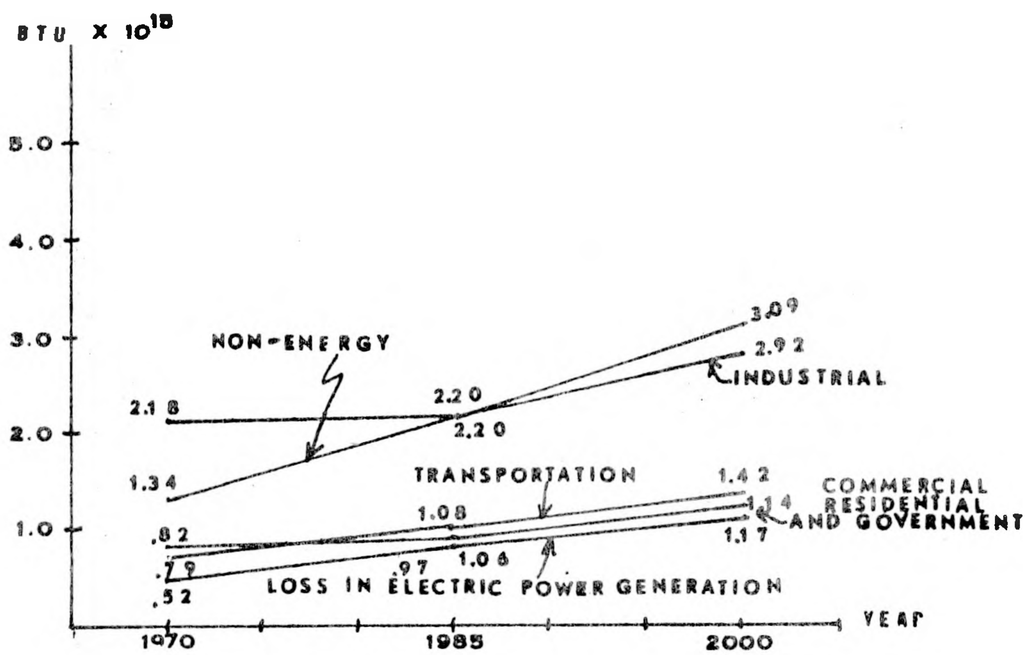

Figure IV-9b: Linear Growth in Export and Government Demand

Figure IV-9: Market Forces Projections of Total Texas Energy Consumption for Five Categories of Users Under Conditions of No Import Restrictions, Two Alternative Assumptions Concerning Export and Government Demand Growth, 1970-2000.

rates are not projected to be sufficient to meet Texas demands to 2000. Reductions in use by low valued users are implied by 1997 when exports are driven to zero and supplies are still short (Figure IV-9a and Table IV-7).

The effects of reduced demand from price increases can be seen by comparing the sector energy consumption growth with those in the baseline case (Figures IV-10 and IV-11). The largest user of energy in the group in 1970 was the industrial category with 38.74 percent of the total Texas demand. The non-energy category is the largest user by 1985, however, with 29.30 percent of Texas total energy use in 1985 while industrial use is reduced to an estimated 29.28. The distribution of Texas total energy demand among the five groups--industrial, non-energy, loss in electric power generation, commercial, residential (household) and government, and transportation--are summarized in Table IV-8. Comparisons are also made with the baseline case.

Energy demands by Texas households for gasoline, natural gas, and electricity in the market forces case grow over time as population and incomes grow, but are dampened by demand response to increased fuel prices. The resulting demand projections by households under two assumptions concerning growth rates for governments and export demand for Texas goods and services are shown in Figure IV-12.

The supply of natural gas sufficient to meet Texas industry, governments and household demand is projected to be short by 1993-1997 as natural gas exports are driven to zero. In the simulation model, household consumers are deprived of natural gas by 1993-1997 as shortages occur (Figure IV-12). The implication is that further substitutions and direct demand decreases are required before 2000 as Texas supplies of natural gas decline.

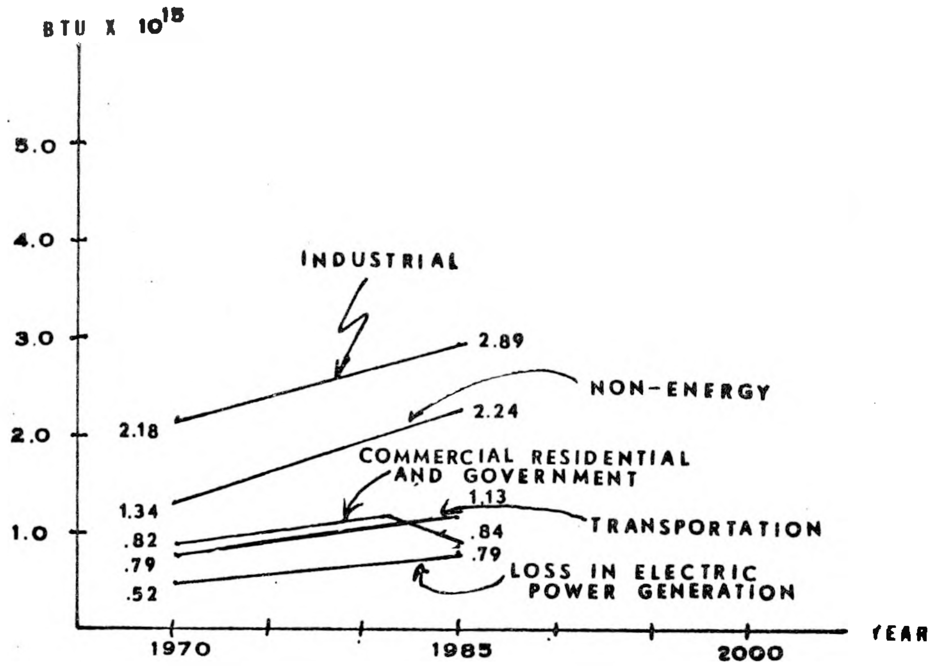

Figure IV-10a: Baseline, Case

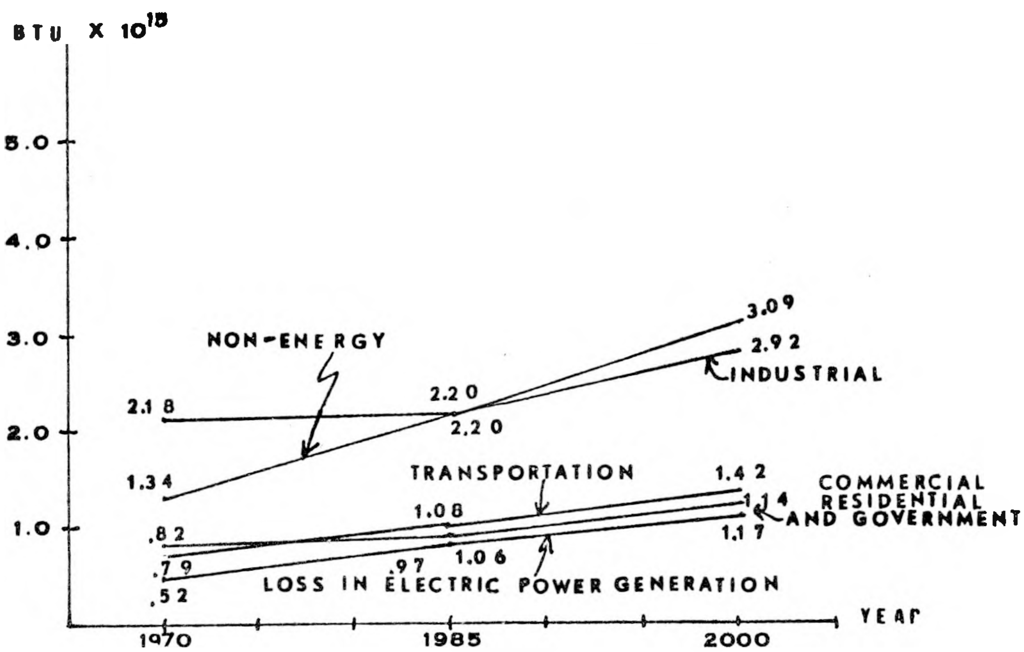

Figure IV-10b: Market Forces Case

Figure IV-10: Comparison of Baseline and Market Forces Projections of Total Energy Consumption for Five Categories of Users Under Conditions of No Import Restrictions and Linear Growth of Export and Government Demand, 1970 - 2000.

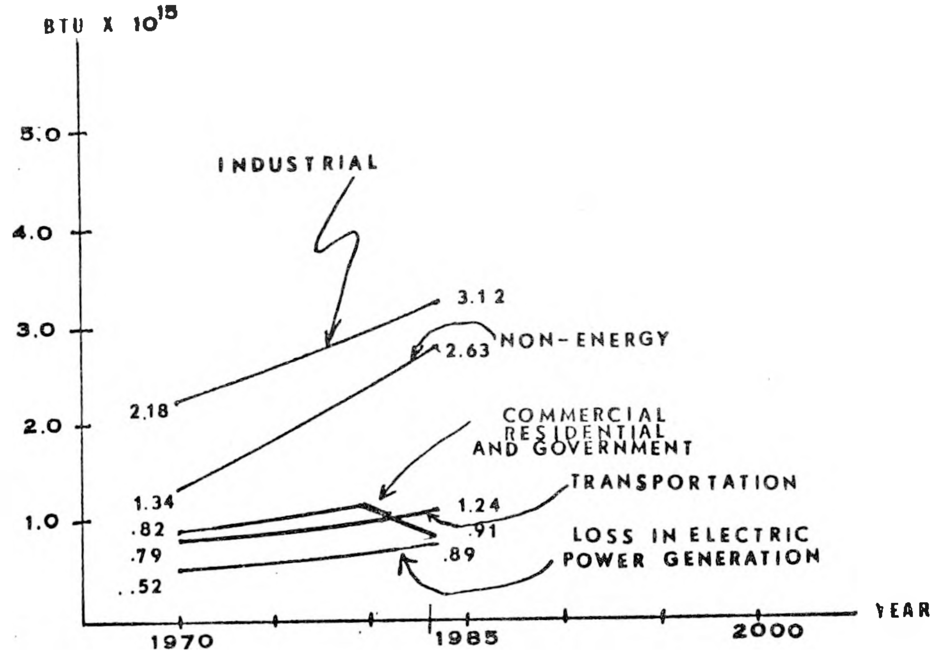

Figure IV-11a: Baseline Case

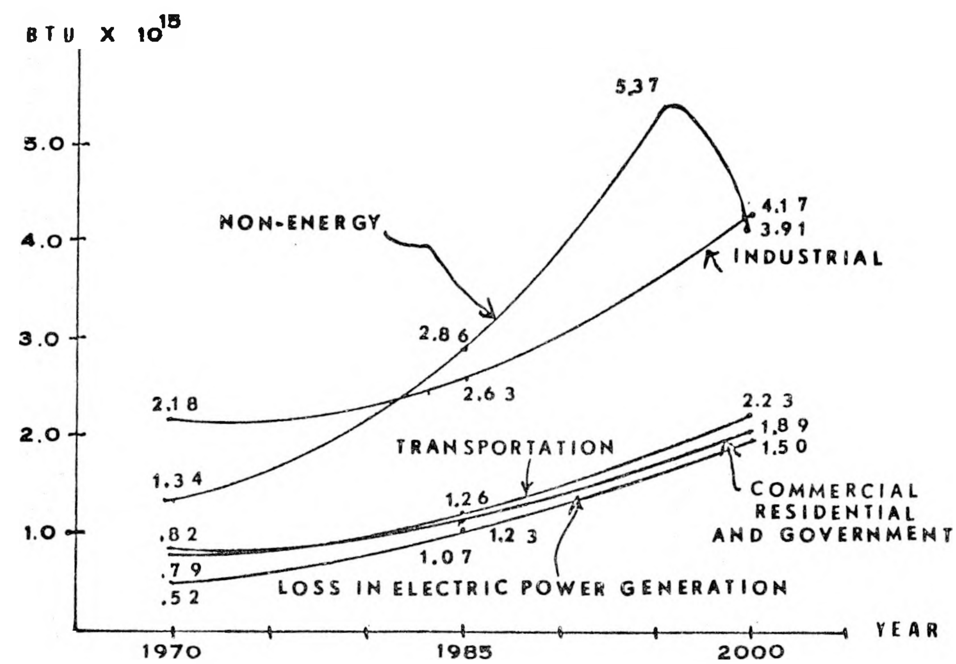

Figure IV-11b: Market Forces Case

Figure IV-11: Comparison of Baseline and Market Forces Projections of Total Energy Consumption for Five Categories of Users Under Conditions of No Import Restrictions and Exponential Growth of Export and Government Demand, 1970 - 2000.

Table IV-8. Distribution of Total Texas Energy Consumption for Five Categories of Users in 1970 and 1985 Under Two Sets of Growth Rates for Texas Governments and Export Demand For All Goods and Services, Market Forces Case Compared with Baseline Case.

Category of User	1970 Distribution of Consumption (Estimated Actual)	1985 Distribution of Consumption		
		Baseline Case	Market Forces Case	
		Linear Export and Government Growth	Linear Export and Government Growth	Exponential Export and Government Growth
	(percent)	(percent)	(percent)	(percent)
Industrial	38.74	36.63	29.28	29.06
Non-Energy	23.86	28.39	29.30	31.61
HH, Com. & Govt.[a/]	14.40	10.65	14.11	13.59
Loss in Electric Power Generation	9.13	10.01	12.92	11.82
Transportation	13.87	14.32	14.39	13.92
TOTAL	100.00	100.00	100.00	100.00

[a/] HH means households; Com. means commercial; and Govt. means government.

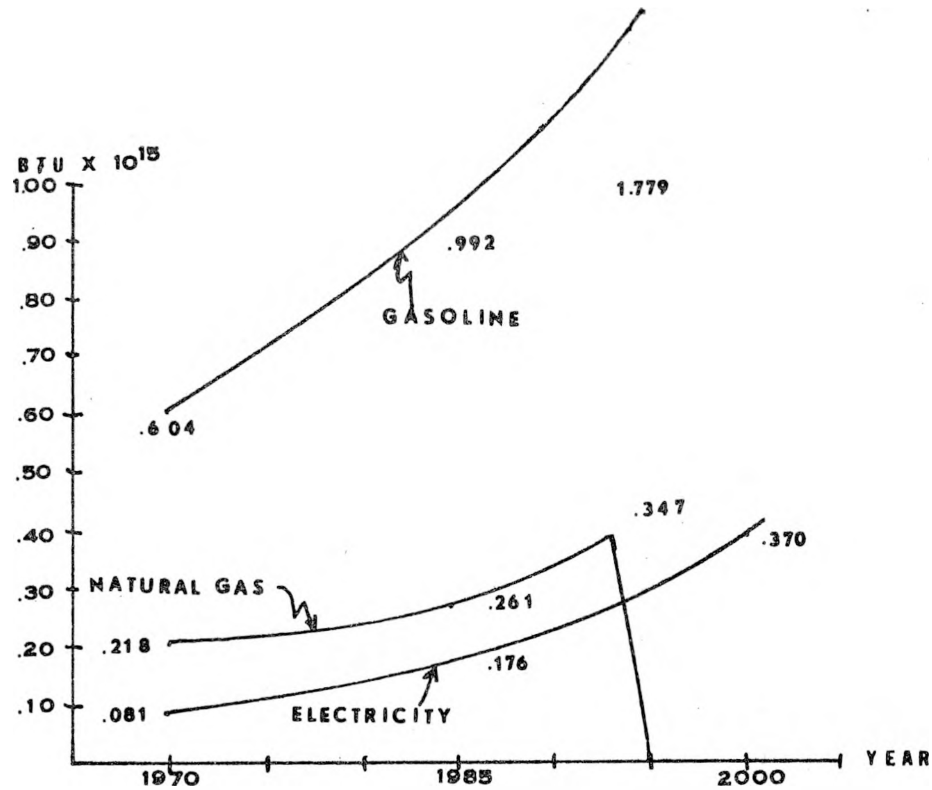

Figure IV-12a: Exponential Growth in Export and Government Growth

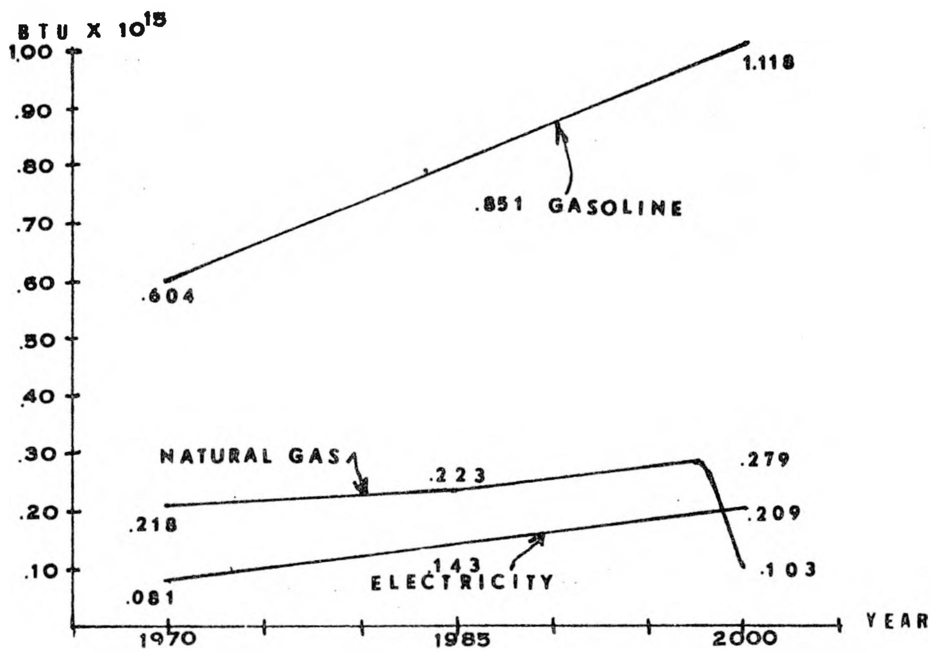

Figure IV-12b: Linear Growth in Export and Government Growth

Figure IV-12: Market Forces Projections of Household Consumption of Gasoline, Natural Gas, and Electricity Under Conditions of No Import Restrictions, Two Assumptions Concerning Export and Government Demand Growth, 1970-2000.

Comparisons of household consumption of gasoline, natural gas and electricity in the baseline and market forces cases under the two assumptions concerning export and government demand growth are shown in Figures IV-13 and IV-14. The household consumption of gasoline is reduced by 2.1 percent by 1985 as compared to the baseline case as a direct result of increases in gasoline prices and the indirect growth effect of the overall economy as a net result of increased Texas supplies of oil and gas and diminished demand due to fuel price increases throughout the economy. The consumption of natural gas is maintained to 1998 as opposed to 1985 in the baseline case; the demand for electricity is increased by 7.7 percent over the baseline case. In the case of electricity, the positive income effect on per capita consumption plus the increased population and income growth more than offsets the negative effect of price increases.

Table IV-9 summarizes the household energy demand distributions in the market forces case for 1970 and 1985, and compares the distributions with the baseline case. Note that gasoline use in BTU's constitutes 66.89 percent of the total in 1970 and 69.93 percent in 1985 for the market forces case as compared to 86.81 percent for 1985 in the baseline case, reflecting the model solution allocation of natural gas away from households when supplies were short in the baseline case. Increased production of natural gas from increased wellhead prices in the market forces case was sufficient for all Texas users and exports demand in 1985.

The projections of employment, population of household heads, personal income and taxes for the market forces case are associated with the demands and supplies of energy combined with the growth from general economic activity. The projections are consistent with the estimated equilibrium prices for oil and gas and the implied price changes for

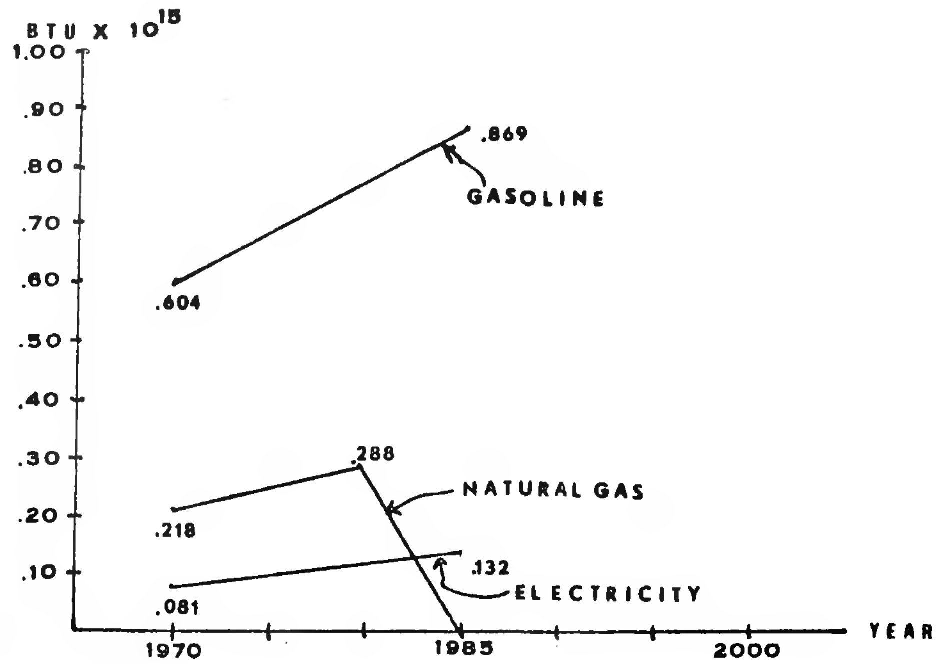

Figure IV-13a: Baseline Case

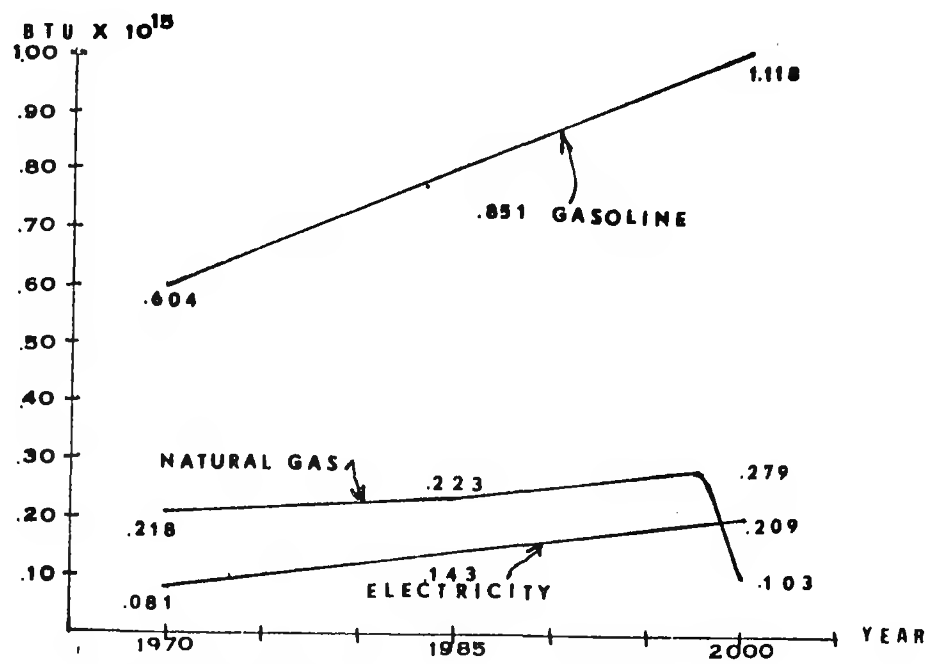

Figure IV-13b: Market Forces Case

Figure IV-13: Comparison of Baseline and Market Forces Household Consumption of Gasoline, Natural Gas, and Electricity Under Conditions of No Import Restrictions, and Linear Growth in Export and Government Demand, 1970 - 2000.

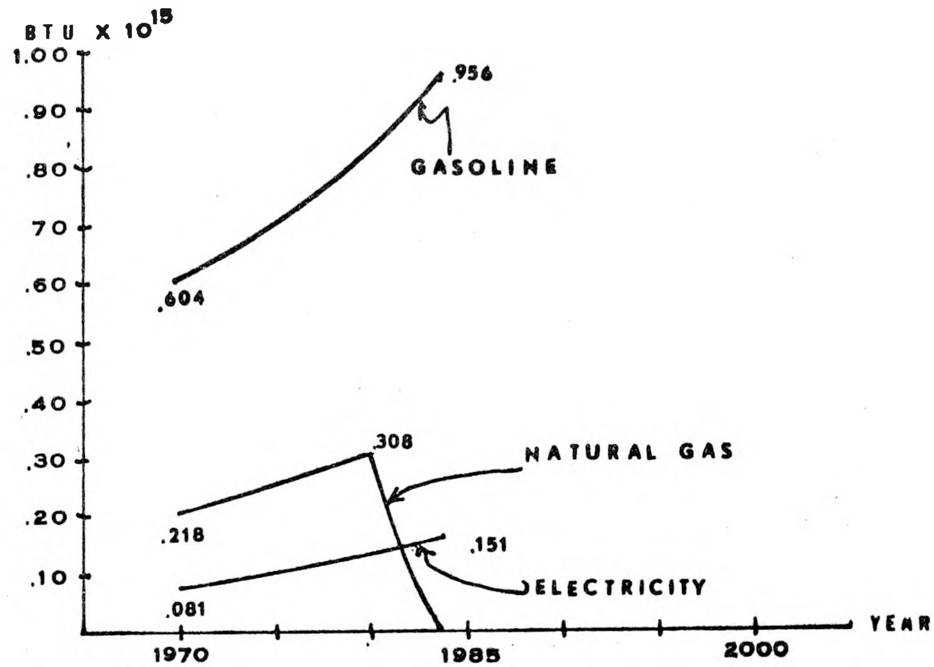

Figure IV-14a: Baseline Case

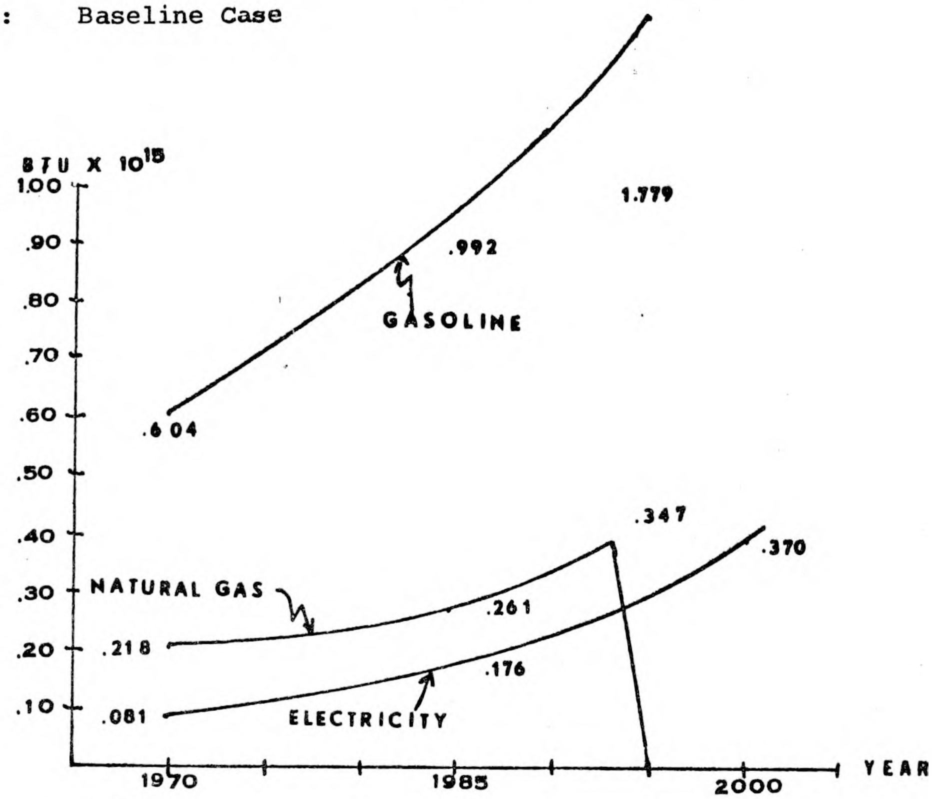

Figure IV-14b: Market Forces Case

Figure IV-14: Comparison of Baseline and Market Forces Household Consumption of Gasoline, Natural Gas, and Electricity Under Conditions of No Import Restrictions, and Exponential Growth in Export and Government Demand, 1970 - 2000.

Table IV-9. Distribution of Texas Residential Energy Consumption by Three Fuel Sources in 1970 and 1985 Under Conditions of No Import Restrictions, Two Assumptions Concerning Growth Rates for Texas Governments and Export Demand for All Goods and Services, Market Forces Case Compared with Baseline Case.

Category of Fuels	1970 Distribution of Consumption	1985 Distribution of Consumption		
		Baseline Case	Market Forces Case	
	Baseline and Market Forces Case	Linear Export & Government Growth	Linear Export & Government Growth	Exponential Export and Government Growth
	(percent)	(percent)	(percent)	(percent)
Gasoline	66.89	86.81	69.93	69.42
Natural Gas	24.14	0.0	18.32	18.26
Electricity	8.97	13.19	11.75	12.32
TOTAL	100.00	100.00	100.00	100.00

natural gas, refinery products, and electricity to industrial, commercial, and residential users. Figure IV-15 compares employment and population of household heads under two assumptions concerning growth in export and government demands for Texas goods and services. The exponential growth assumption results in projections of an estimated 5.776 million employment by 1985 and 8.152 million by 2000. The projections of the population of household heads for the exponential case are 4.638 and 6.594 million people for 1985 and 2000, respectively.

Comparisons of employment and heads of household projections in the baseline and market forces cases under the linear and exponential export and government demand growth assumptions are shown in Figure IV-16. The market forces projections result in an estimated additional total employment over the baseline case of 460 thousand in 1985 for the linear export and government demand growth cases. The increased employment in the exponential export and government demand case is estimated to be 360 thousand above the baseline case in 1983 (Figure IV-17).

Comparisons of total personal income, total state and local taxes, and oil and gas industry tax contribution projections (1967 dollars) under two assumptions concerning export and government demand growth for Texas goods and services are shown in Figure IV-18. The estimates consistent with the exponential assumption show 8.328 billion dollars of personal income in 1985 and 36.703 billion dollars by 2000 above that for the linear governments and export growth assumption. Total state and local tax collections in the exponential case are shown to be .738 and 3.352 billion dollars, respectively, for 1985 and 2000 over the linear case. Oil and gas industry tax collections are estimated to be .34 and .66 million dollars, respectively, in 1985 and 2000 above the linear case.

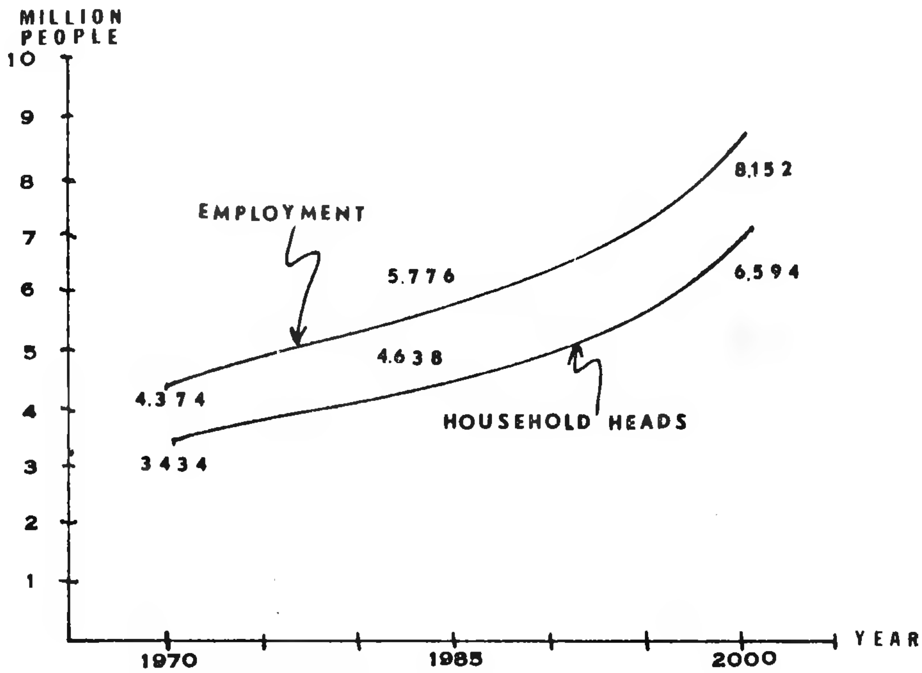

Figure IV-15a: Exponential Growth in Export and Government Demand

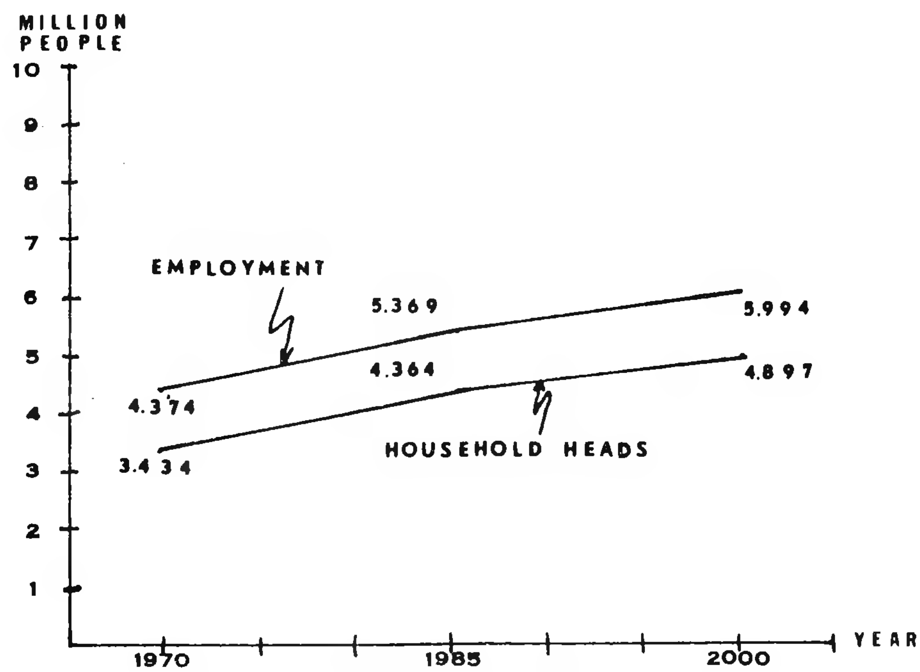

Figure IV-15b: Linear Growth in Export and Government Demand

Figure IV-15: Market Forces Projections of Texas Population of Household Heads and Employment Under Conditions of No Import Restrictions, Two Assumptions Concerning Export and Government Demand Growth, 1970 - 2000.

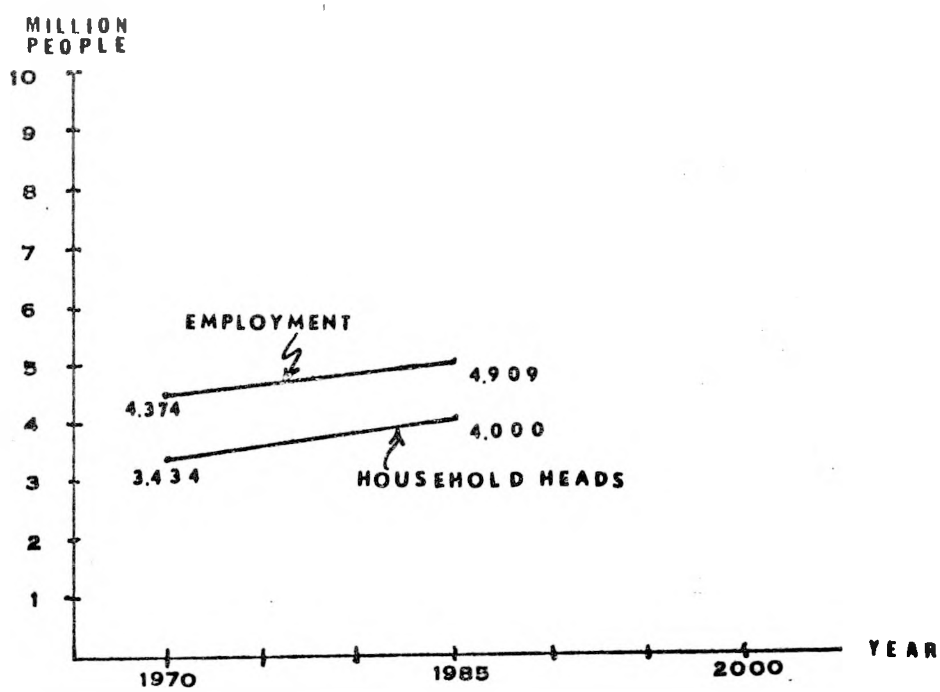

Figure IV-16a: Baseline Case

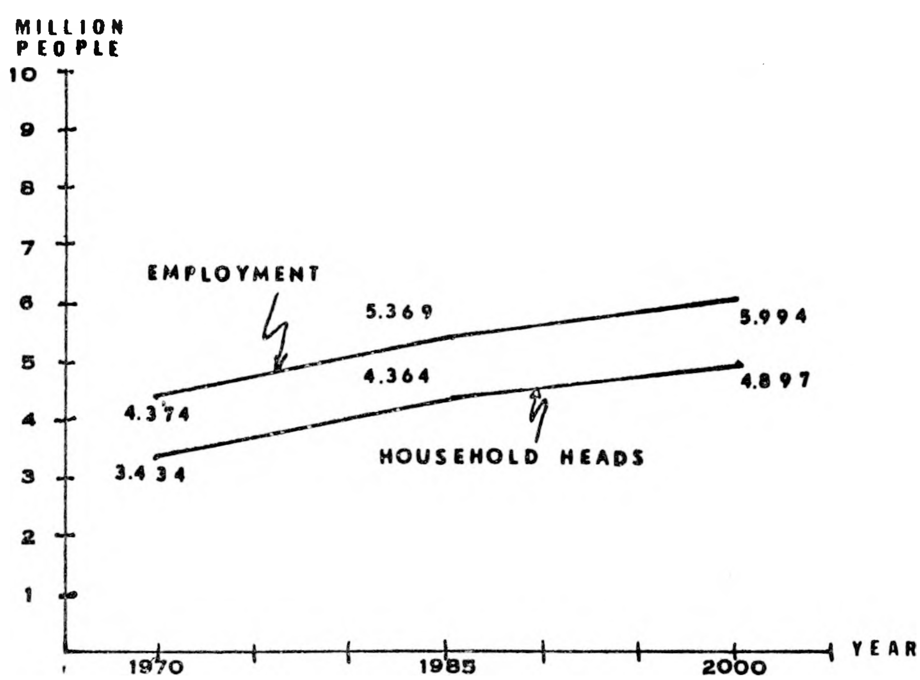

Figure IV-16b: Market Forces Case

Figure IV-16: Comparison of Baseline and Market Forces Projections of Employment and Household Heads, Under Conditions of No Import Restrictions and Linear Export and Governments Demand Growth, 1970 - 2000.

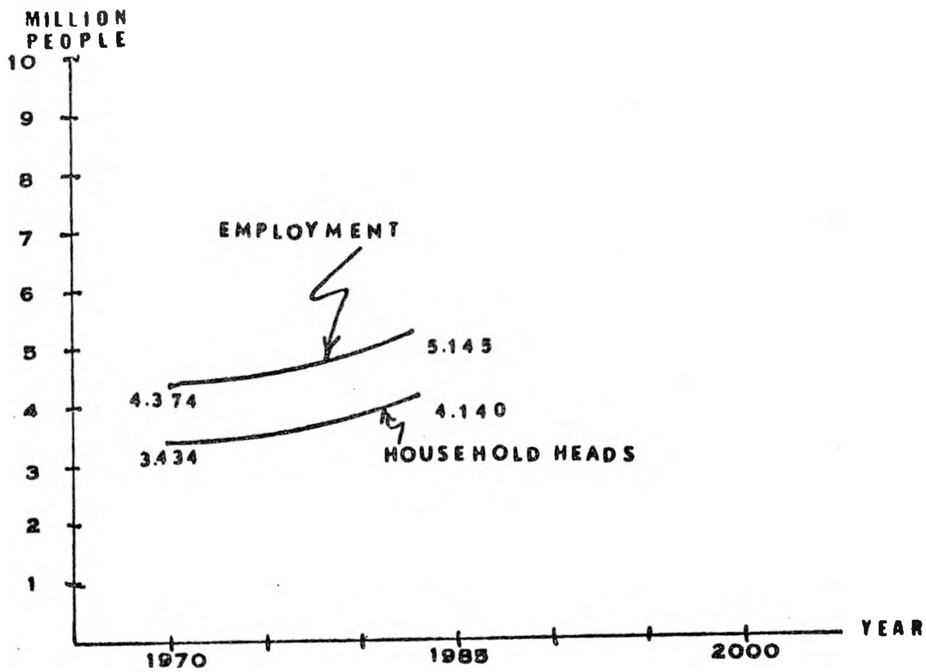

Figure IV-17a: Baseline Case

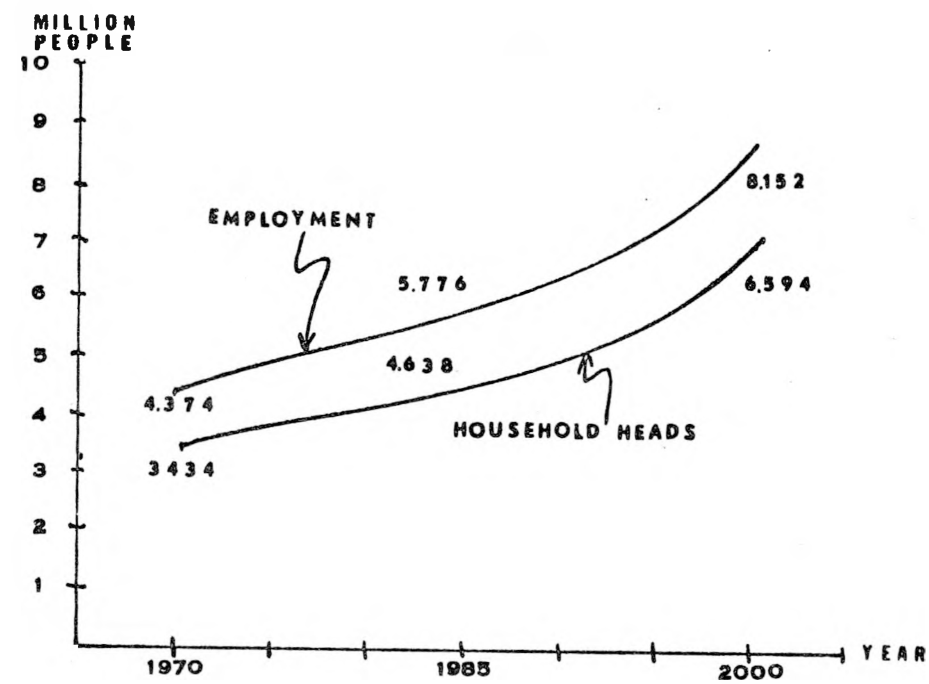

Figure IV-17b: Market Forces Case

Figure IV-17: Comparison of Baseline and Market Forces Projections of Employment and Household Heads, Under Conditions of No Import Restrictions and Exponential Export and Government Demand Growth, 1970 - 2000.

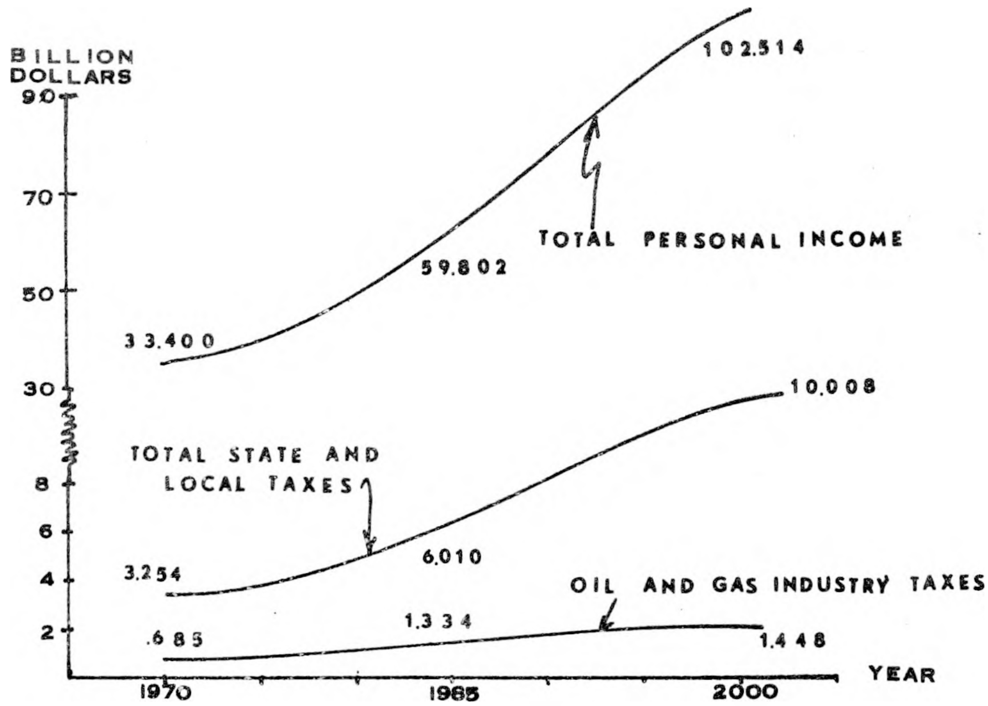

Figure **IV-18a:** Exponential Export and Government Demand

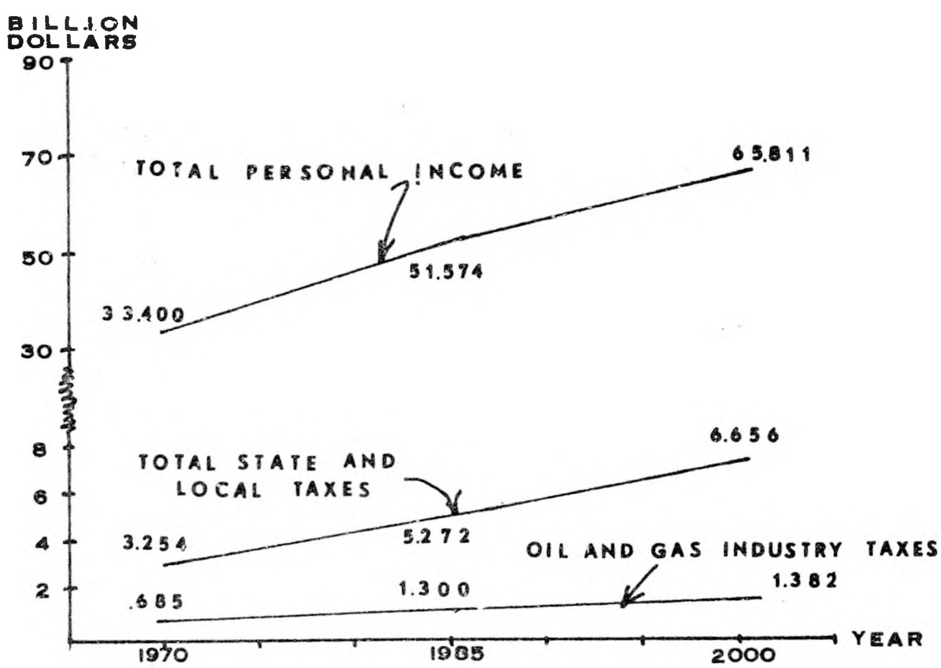

Figure **IV-18b:** Linear Export and Government Demand

Figure **IV-18:** Market Forces Projections of Texas Total Personal Income, Total State and Local Taxes, and Oil and Gas Industry Tax Contributions in 1967 Dollars Under Conditions of no Import Restrictions, Two Assumptions Concerning Export and Government Demand Growth, 1970-2000.

The oil and gas industry tax collection increases for the exponential case are due to larger growth in refining and petrochemical industries.

Comparisons of personal income, state and local taxes, and oil and gas industry taxes in 1967 dollars are shown in Figure IV-19 and IV-20 for the baseline and market forces projections for the two assumptions regarding government and export demand growth. The effect of increased prices of oil and gas and the related supply increase and demand decrease, directly and indirectly, result in an estimated 5.850 billion dollars of additional personal income over the base case in 1985 (Figure IV-19). The 1983 difference is equal to 5.096 billion dollars if the exponential growth in governments and export demand is assumed (Figure IV-20).

State and local tax increases over the baseline case are estimated at 1.094 billion dollars (1967 dollars) in 1985 for the linear export and government demand growth case (Figure IV-19) and 958 million dollars additional taxes in 1983 for the exponential exports and government demand growth assumption (Figure IV-20).

The oil and gas industry tax estimates are projected to be increased from the baseline case by 839 million dollars in 1985 for the linear case (Figure IV-19). The additional tax is estimated at 760 million dollars in 1983 for the exponential case (Figure IV-20). The increase in oil and gas tax revenues make up approximately 78 percent of the increase in state and local taxes cited above.

The distribution of primary energy use between natural gas, natural gas liquids, crude oil, coal and lignite, and nuclear fuels changed greatly in the market forces case as compared with the baseline case. Table IV-10 summarizes the distribution of total energy use by source for 1970, 1985, and 2000 in the market forces case. The distribution

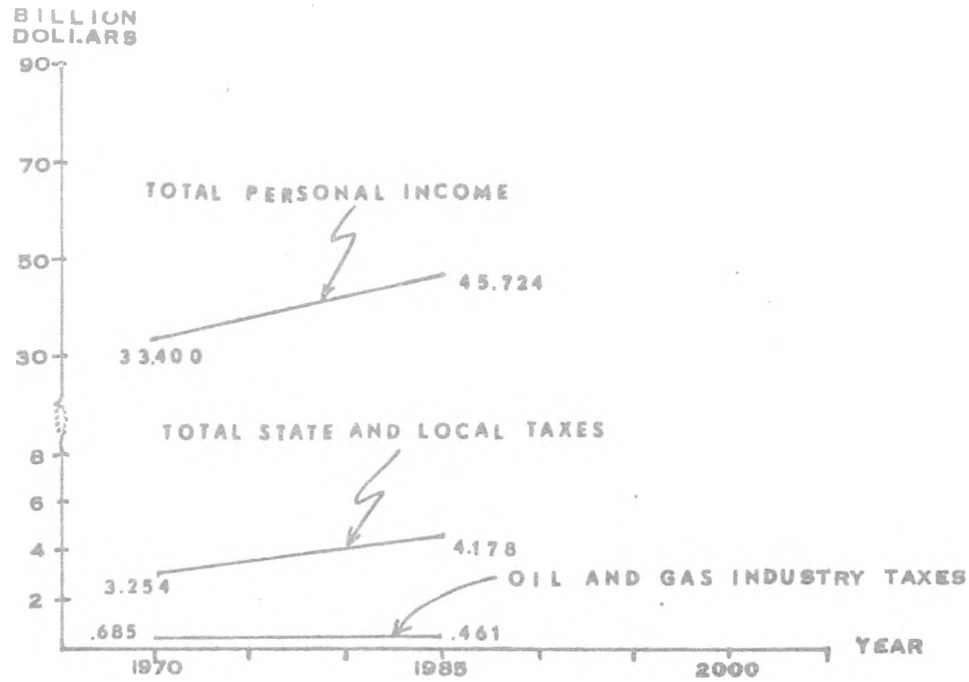

Figure IV-19a: Baseline Case

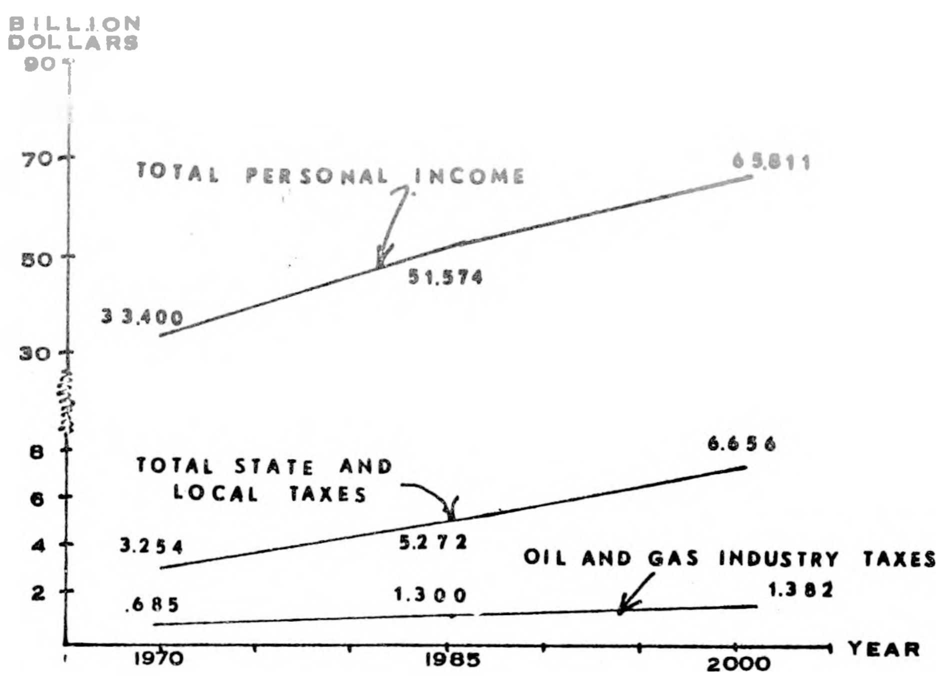

Figure IV-19b: Market Forces Case

Figure IV-19: Comparison of Baseline and Market Forces Projections of Texas Total Personal Income, Total State and Local Taxes, and Oil and Gas Industry Tax Contributions in 1967 Dollars Under Conditions of No Import Restrictions and Linear Export and Government Demand Growth, 1970-2000.

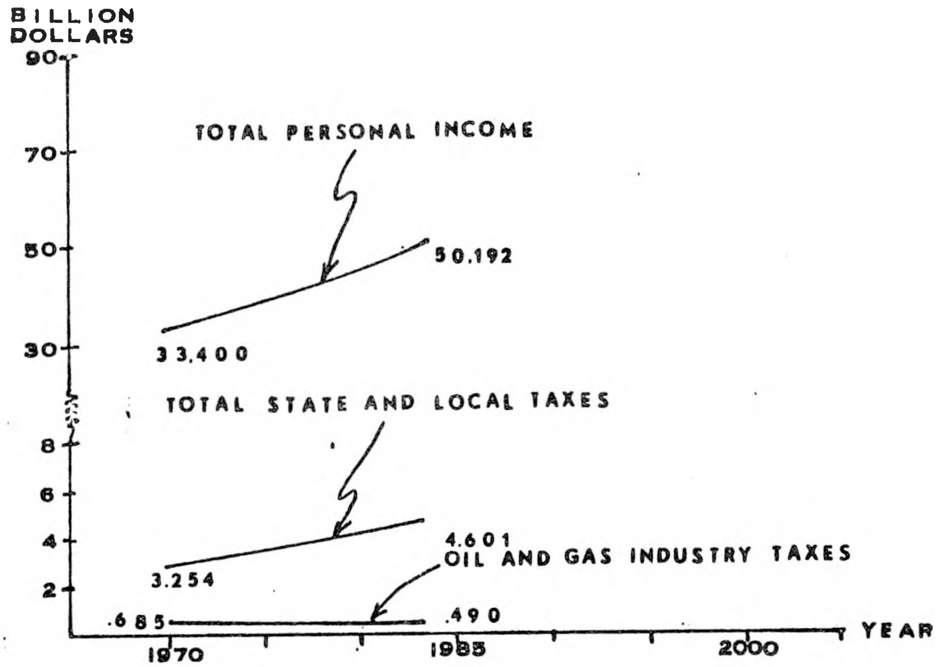

Figure IV-20a: Baseline Case

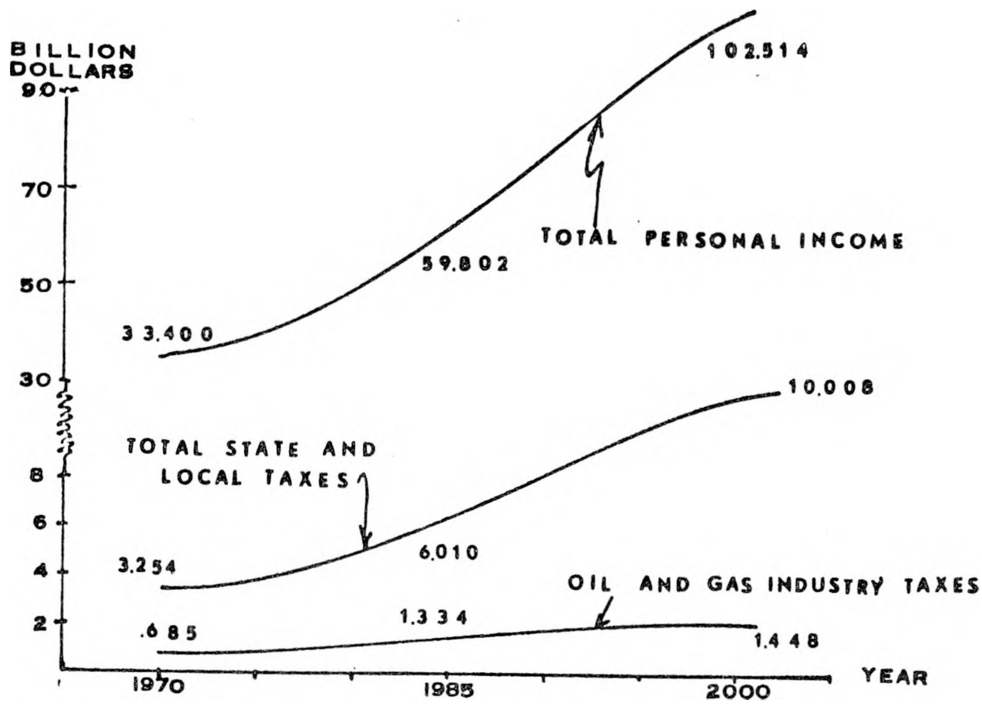

Figure IV-20b: Market Forces Case

Figure IV-20: Comparison of Baseline and Market Forces Projections of Texas Total Personal Income, Total State and Local Taxes, and Oil and Gas Industry Tax Contributions in 1967 Dollars Under Conditions of No Import Restrictions and Exponential Export and Government Demand Growth, 1970 - 2000.

Table IV-10. **Distribution of Texas Energy** Consumption by Fuel Source in the Market Forces Case Under **Conditions of No Import Restrictions** on Crude Oil, Two Assumptions Concerning Growth Rates for Texas Governments and Export Demand for All Goods and Services, 1970, 1985 and 2000.

Primary Fuel Source	1970 Distribution of Consumption	1985 Distribution of Consumption		2000 Distribution of Consumption	
		Linear Export and Govt.Growth	Exponential Export and Govt.Growth	Linear Export and Govt. Growth	Exponential Export and Govt. Growth
	(percent)	(percent)	(percent)	(percent)	(percent)
Refinery Products	25.93	35.27	34.86	34.10	35.12
Natural Gas Liquids	17.81	21.37	21.49	22.15	20.26
Natural Gas	56.26	32.21	31.64	28.85	28.01
Coal and Lignite	0.0	11.16	12.01	7.37	7.99
Nuclear	0.0	0.0	0.0	7.53	8.62
Total	100.0	100.0	100.0	100.0	100.0

remained near constant at the 1970 level in the baseline cases since no fuel substitutions were made and no price increases were estimated. The estimated percentage of coal and lignite use increased to 11.16 percent of the total by 1985 but declined to 7.37 percent by 2000 as nuclear power generation was estimated to be brought on-line (linear export and governments demand growth case).[1/] The natural gas use percentage was estimated to decline rapidly during the 1970-1985 period from 56.26 percent in 1970 to 32.21 percent in 1985. The relative use of natural gas continues to decline slightly between 1985 and 2000 in the linear export and governments growth case and was estimated to be 28.85 percent of the total by 2000. The distribution for the exponential case indicates a slightly higher concentration of coal and lignite and nuclear fuel use by 1985.

The increased import levels for crude oil and increased prices for fuels and electricity are estimated to change the structure of the Texas economy significantly in the market forces case. As imports increase the "leakage" increases and the Texas economy becomes less interdependent. As fuel prices increase and total expenditures for fuels increase, profits in some sectors decrease. The decreased profits and increased fuel costs result in an increase in the interdependency of the economy. The net result of these changes are reflected in the multipliers of eleven heavy fuel using sectors (Table IV-11).

1/ The fuel distribution estimates incorporated in the simulation model bring nuclear electricity plants on line in 1986 and the portion of fuel use from nuclear sources rises steadily to 39 percent by the year 2000 (See Table III-2).

Table IV-11. Market Forces Projections of Final Demand Multipliers for Eleven Important Petroleum Using Sectors in Texas Under Conditions of No Import Restrictions for Crude Oil and Linear Growth in Export and Government Demand, 1970 and 1985.

Sector	Final Demand Multiplier a/		
	1970	1985	Percent Change
	(Dollars)		
Crude Petroleum	1.36672	1.37388	0.524
Natural Gas Liquids	1.79479	1.82626	1.753
Chlorine and Alkali	1.95056	2.40863	23.484
Cylic Crudes, Intermediates and Pigments	2.36611	3.16801	33.891
Organic Chemicals	1.94855	2.33381	19.772
Inorganic Chemicals, Plastics and Syn.	1.91283	2.09040	9.283
Organic Chemicals, Soaps, Paints	1.70335	1.83011	7.442
Petroleum Refining	1.97830	1.62722	-17.747
Pipeline Transportation	1.64378	1.68967	2.792
Gas Services	2.03557	2.14164	5.211
Electric Services	1.66263	1.65778	-0.292

a/ The final demand multiplier measures the total economy dollar value of output change from a one dollar change in the delivery of final products to households, governments, and/or exports.

The multiplier for petroleum refineries decreased by 17.7 percent and electric services decreased by 0.3 percent. Refineries are responsible for importing crude oil and electric utilities import coal for electric power generation. The other large users of petroleum products show increased multipliers due to increased expenditures from higher priced crude oil, natural gas and coal.

The Economic Impact of High Import Prices

The analysis of the previous section was focused on the impacts of price increases for crude oil and natural gas to estimated equilibrium prices for domestic crude oil and natural gas at $8.65 per barrel and $.66 per mcf for gas (1974 dollars), respectively, assuming import prices equal to domestic prices in the long term. Imported oil prices of $14.00 per barrel were specified to measure the economic impact of high import prices. In general, the higher prices of imported oil drive the marginal supply price of refinery products and electricity up, and the demand for the products down. The "leakage" from the economy as a result of increased import prices is significant and affects all parts of the economy.[1/]

The results of high import prices for crude oil as compared to the market forces case where domestic and import prices were equal are summarized in Table IV-12. The cases compared are for the exponential export and government demand growth case. The estimated total personal income in the high import price ($14.00 per barrel) is down 753 million dollars by 1985 and 1.188 billion dollars by 2000 as compared to the low import price case ($8.65 per barrel). The estimate of total employment is down by 66 thousand employees in 1985 and 73 thousand by 2000. The estimate of total state and local taxes in 1967 dollars is down by 116 million dollars in 1985 and 236 million dollars by 2000. The estimate of total state and local taxes in 1967 dollars is down by 116 million dollars in 1985 and 236 million dollars by 2000. As a consequence of the general decrease in economic activity due to

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1/ An increased "leakage" occurs relative to the lower prices of imported oil and gas since the derived demand of crude oil and natural gas is negative and less than unitary with respect to price; i.e., quantities purchased decrease but total dollar expenditures increase.

Table IV-12. Economic Impact of High Import Prices for Crude Oil Under Conditions of No Import Restrictions and Exponential Growth in Export and Government Demand, 1985 and 2000.

Selected Factors	1985 Impact		2000 Impact	
	Equal Domestic and Import Prices a/	High Import Prices b/	Equal Domestic and Import Prices a/	High Import Prices b/
Total Personal Income (billions of 1967 dollars)	59.803	59.050	102.514	101.326
Total Employment (million people)	5.776	5.710	8.152	8.079
Total State and Local Taxes (billions of 1967 dollars)	6.010	5.894	10.008	9.772
Texas Total Energy Consumption (quadrillion BTU's)	9.057	8.843	13.702 c/	13.950

a/ Oil and gas prices equal to $8.65 per barrel (1974 dollars) and $.66 per mcf (1974 dollars), respectively, for domestic and imported crude oil and natural gas.

b/ Domestic prices equal to $8.65 per barrel (1974 dollars) and $.66 per mcf (1974 dollars) for crude oil and natural gas, respectively; import prices for crude oil equal to $14.00 per barrel (1974 dollars).

c/ The projected consumption of natural gas declines for some users because of short supplies by 1993; thus total energy consumption is eventually forced down after 1997. The total energy consumption in 1997 was estimated to be 14.488 quadrillion BTU's.

decreased demand from higher priced petroleum based products, the estimated total energy demand is down by .214 and .649 quadrillion BTU's in 1985 and 1997, respectively (Table IV-12).

Crude oil imports in the high import price case ($14.00 per barrel) are estimated to decline by 28 million barrels in 1985 and 30 million barrels in 2000. The imported oil decreases amount to 1.9 percent in 1985 and 1.1 percent in 2000 when compared to the $8.65 import price case.

The Economic Impact of High Coal Use

The estimates of the previous market forces case were based in part on estimated fuel distributions for heavy industry users from survey data of industry expectations. The Thompson Integrated Linear Programming Model provided estimates of fuel distributions by 1985 for the nation given estimated equilibrium prices for oil and gas of $8.65 per barrel for oil and $.66 per mcf for gas (1974 dollars) and coal prices of $6.20 per ton (15 million BTU/ton equivalent) plus transportation costs. The coal use for heavy fuel-using industries estimated from the Thompson model was considered high for Texas because of the current fixed plant equipment devoted to the use of oil and gas. The distributions from the Thompson Model were used in this analysis as a "high" estimate of coal use to bracket the possible outcomes. Table IV-13 summarizes the results in terms of the percent distribution of primary energy consumption for 1985 and 2000 for the market forces case for both exponential and linear export and governments demand growth. Total coal and lignite demand by 1985 was estimated at 2.676 and 4.085 quadrillion BTU for 1985 and 2000, respectively, for the exponential case

Table IV-13. Distribution of Texas Energy Consumption by Source in the Market Forces Case Under Conditions of No Import Restrictions and High Coal Substitutions by Heavy Fuel Using Industries, Two Assumptions Concerning Growth Rates for Texas Governments and Export Demand for All Goods and Services 1970, 1985 and 2000.

Fuel Source	1970 Distribution of Consumption	1985 Distribution of Consumption		2000 Distribution of Consumption	
		Linear Export and Govt. Growth	Exponential Export and Govt. Growth	Linear Export and Govt. Growth	Exponential Export and Govt. Growth
	(percent)	(percent)	(percent)	(percent)	(percent)
Refinery Products	25.93	27.34	26.59	26.78	26.22
Natural Gas Liquids	17.81	20.74	20.79	21.06	21.49
Natural Gas	56.26	23.69	22.86	22.93	19.32
Coal and Lignite	0.0	28.23	29.76	22.03	25.43
Nuclear	0.0	0.0	0.0	7.18	7.54
TOTAL	100.0	100.0	100.0	100.0	100.0

and 2.104 and 2.184 quadrillion BTU's for 1985 and 2000, respectively, for the linear case. These quantities account for 29.76 and 25.43 percent of the total primary energy use in 1985 and 2000, respectively, in the exponential case and 28.23 and 22.03 percent of the total energy case in 1985 and 2000, respectively, in the linear case (Table IV-13).

The higher use of coal by electric power generation, chemicals, and primary metals as a substitute for natural gas indicates the importance of substitutions for natural gas as a fuel. Compared to the distributions in the "low" coal case (Table IV-10) natural gas use is shown to decrease from near 32 percent in 1985 to only 23 percent in 1985 for the high coal case. The percentages in 2000 are 28 percent in the low coal case and 22 percent in the high coal case. The high coal use case estimates would allow petrochemical use of natural gas from Texas production to continue to 2000 without depriving industry users of gas as was indicated in the low coal case for exponential governments and export demand growth (Figure IV-2b). Exports of natural gas, however, are driven to zero in the high coal case as in the low coal case.

Market Forces Energy Demand Projections Under Conditions of Import Restrictions

The previous section on "Market Forces Projections of Energy Demand Under Conditions of No Import Restrictions on Foreign Crude Oil" summarized the results of energy demand projections and associated income, employment, and taxes under the basic assumption that Texas would be able to import sufficient quantities of crude oil to meet any existing gaps between Texas energy supplies and the sum of Texas and projected export demand for crude oil and natural gas. This section analyzes the economic impact of oil import restrictions by comparing the energy demand projections, and related economic variables, resulting from restricted imports of crude oil with the "market forces" case of the previous section under conditions of no import restrictions on crude oil. The comparisons are made under exponential export and government demand growth assumptions.

Comparisons of the total Texas production and consumption for energy under conditions of (1) no restrictions on foreign crude oil imports (free imports) and (2) restricted imports are shown in Figure IV-21. The restricted imports case shows the results of reducing exports of Texas crude oil and natural gas as required to first satisfy Texas demand when Texas supply is short. If exports are driven to zero, the simulation model allocates the remaining supplies to the highest value users. The direct and indirect effects of the reduced level of economic activity as compared to the free imports case reduces the Texas energy consumption by .600 quadrillion BTU's by 1985 and .500 quadrillion BTU's by 2000. The total exports of energy are reduced from the free imports case by 5.435 quadrillion BTU's by 1985 and 12.864 quadrillion BTU's by 2000.

The restricted imports case results in a reduction of energy use by the petrochemical industry (non-energy), the industrial sector, and the transportation sector because of a reduction in output levels of the groups (Table IV-14). Table IV-15 shows the sector by sector comparison of output level changes by 1985 because of import restrictions. Note that the sectors most effected are the cyclic crudes and intermediate pigments sector (cyl.crd., inter. pig., sector #17), the petroleum refining sector (petro. refining, sector #21) and the gas services

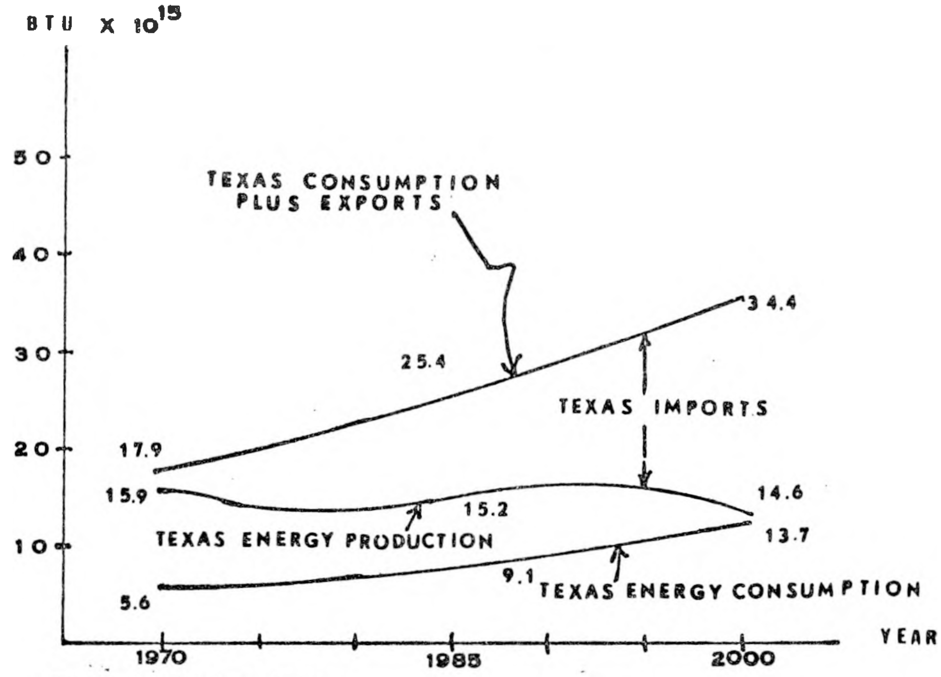


Figure IV-21a. Free Imports Case

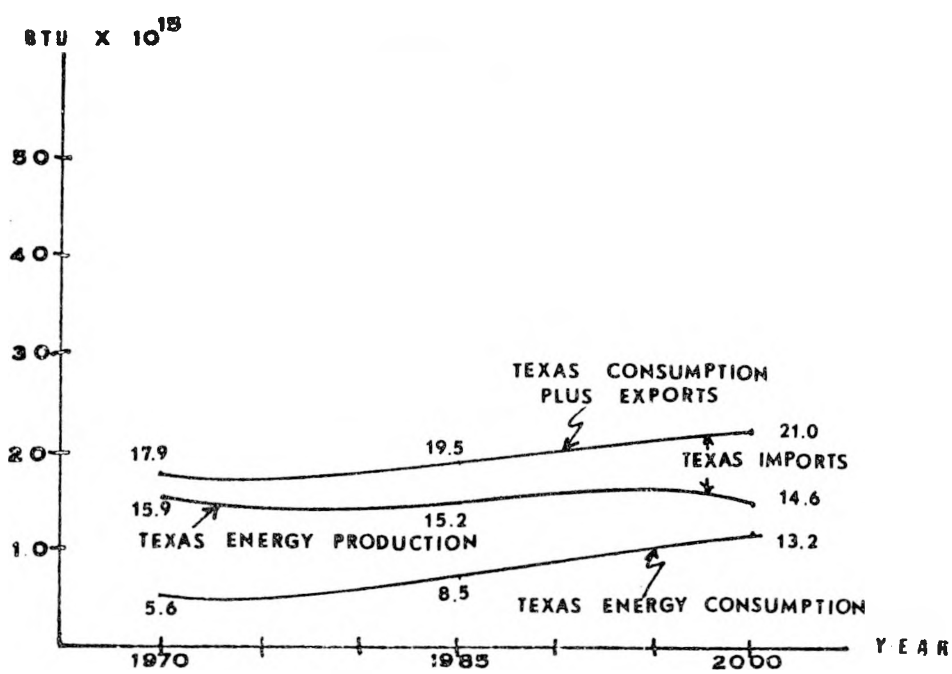


Figure IV-21b: Restricted Imports Case

Figure IV-21: Comparison of Total Energy Supply and Demand in Texas Under Conditions of Free Imports and Import Restrictions, Exponential Export and Government Demand Growth, 1970 - 2000.

Table IV-14. Comparison of Total Texas Energy Consumption for Five Categories of Users Under Conditions of Free Imports and Import Restrictions on Crude Oil, Exponential Export and Government Demand Growth, 1985 and 2000.

Sector	1985		2000	
	Free Imports Case	Restricted Imports Case	Free Imports Case	Restricted Imports Case
	(10^{15} BTUs)	(10^{15} BTUs)	(10^{15} BTUs)	(10^{15} BTUs)
Non-Energy	2.864	2.700	3.911	5.041
Industrial	2.635	2.437	4.166	3.360
Commercial, Residential, & Gov.	1.232	1.207	1.499	1.431
Loss in Electric Power Generation	1.065	1.051	1.893	1.905
Transportation	1.262	1.112	2.233	1.457
Total	9.058	8.507	13.702	13.194

Table IV-15. Comparison of Projected Output Levels for Forty-Eight Texas Industry Sectors Under Conditions of Free Imports and Import Restrictions on Crude Oil, Exponential Export and Government Demand Growth, 1985

Sector	Output: Free Imports Case	Output: Restricted Imports Case
	(millions of 1967 dollars)	(millions of 1967 dollars)
1. Irrigated Crops	1,981	1,975
2. Dryland Crops	1,411	1,407
3. Livestock & Poultry	2,912	2,899
4. Agricultural Services	613	611
5. Forest & Fishery	164	162
6. Crude Petroleum	11,467	11,428
7. Natural Gas Liquids	1,485	1,455
8. Oil & Gas Field Service	1,450	1,454
9. Other Mining	463	459
10. Residential Construction	1,904	1,885
11. Comm., Ed., Res. Const.	5,070	5,005
12. Facility Const.	3,865	3,846
13. Food Processing	6,914	6,871
14. Textile & Apparel	1,624	1,620
15. Log, Wood & Paper	3,165	3,139
16. Chlorine & Alkali	327	325
17. Cyl. Cro., Inter, Pig.	521	254
18. Organic Chemicals	4,852	4,811
19. Inorg. Ch., Plas., Syn.	3,189	2,181
20. Org., Chem., Soap. Pnt.	1,519	1,505
21. Petroleum Refining	21,109	18,538
22. Other Petroleum Production	155	153
23. Tire, Rubber, Plas., Lth	767	764
24. Gls., Cyl., Sin. & Cmt.	1,199	1,188
25. Primary Metal Process	4,780	4,718
26. Industry Eqp. Manufacturing	3,016	2,991
27. Electrical Appliance Mfg.	2,398	2,391
28. Air, Mtr. Vh., Tr. Mfg.	3,927	3,911
29. Instr., Photo., Games	1,848	1,843
30. Rail Transport	1,053	1,037

(Continued)

Table IV-15 (Continued)

Sector	Output: Free Imports Case (millions of 1967 dollars)	Output: Restricted Imports Case (millions of 1967 dollars)
31. Intcty. Highway Trans.	232	229
32. Motor Frgt. Trans.	1,693	1,670
33. Water Transportation	680	660
34. Air Transportation	519	513
35. Pipeline Transportation	753	685
36. Other Trans. Service	54	53
37. Communications	1,856	1,836
38. Gas Services	3,722	3,625
39. Electric Services	3,107	3,060
40. Water & Sanitary Service	432	426
41. Wholesale Trade	8,196	8,113
42. Other Retail Trade	8,535	8,443
43. Audo Dl., Rp., Ser. St.	3,182	3,150
44. F.I.R.E.	9,043	8,951
45. Services	9,831	9,724
46. Lodg., Amus., Recreation	1,052	1,041
47. Education	4,079	4,045
48. Outdoor Recreation	110	109

sector (gas services, sector #38). All other sectors are adversely affected because of the indirect effects of trading within the Texas economy.

The effects of restricted imports have an indirect effect on the household sector use of energy as incomes, employment, and population are reduced as compared with the free imports case. Figures IV-22 compares the projected Texas household use of gasoline, natural gas, and electricity in the free imports and restricted imports cases for the exponential assumption regarding export and government demand growth. The reduction in gasoline use by Texas households, for example, is projected to be .142 quadrillion BTU's by 1985 and .757 quadrillion BTU's by 2000 in the exponential case (Figure IV-22).

Employment is estimated to be reduced in the case of restricted imports as compared to the free imports case from 5.776 million in 1985 to 5.725 million (51 thousand employees) and from 8.152 million in 2000 to 8.125 (27 thousand employees). The population of household heads is also projected to decline from the free imports case (Figure IV-23). Note that short supplies of natural gas already exist in the free imports case by 1997 and therefore shortages of crude oil does not have as large an impact as in 1985 when natural gas supplies were adequate to meet demands.

Personal income, state and local taxes, and the oil and gas industry tax contributions would also be affected by the restriction of imports for oil as compared to the free imports case. The estimated reduction in Texas total personal income from import restrictions is 517 million dollars by 1985 in the exponential export and government demand growth case (Figure IV-24). The effect on personal incomes by

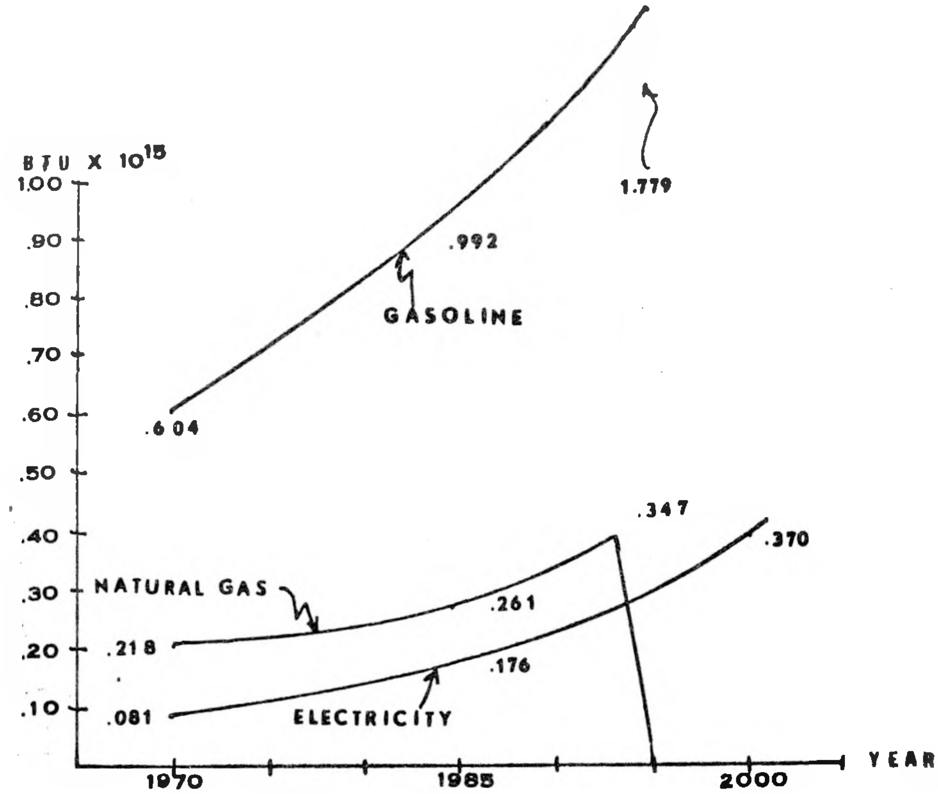


Figure IV-22a: Free Imports Case

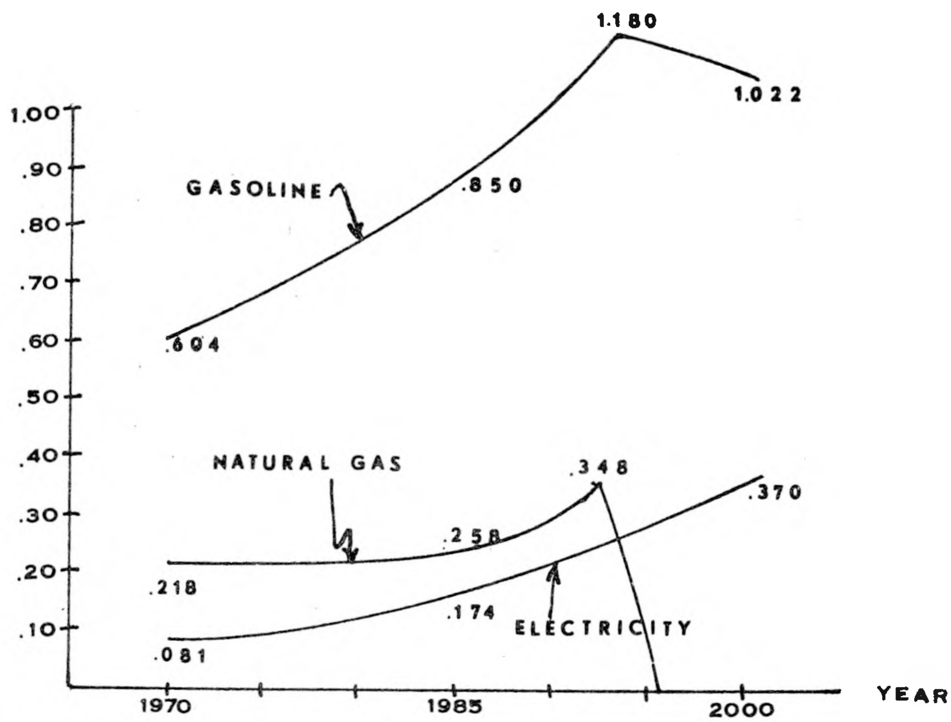


Figure IV-22b: Restricted Imports Case

Figure IV-22: Comparison of Residential Consumption of Gasoline, Natural Gas, and Electricity Under Conditions of Free Imports and Import Restrictions, Exponential Export and Government Demand Growth, 1970 - 2000.

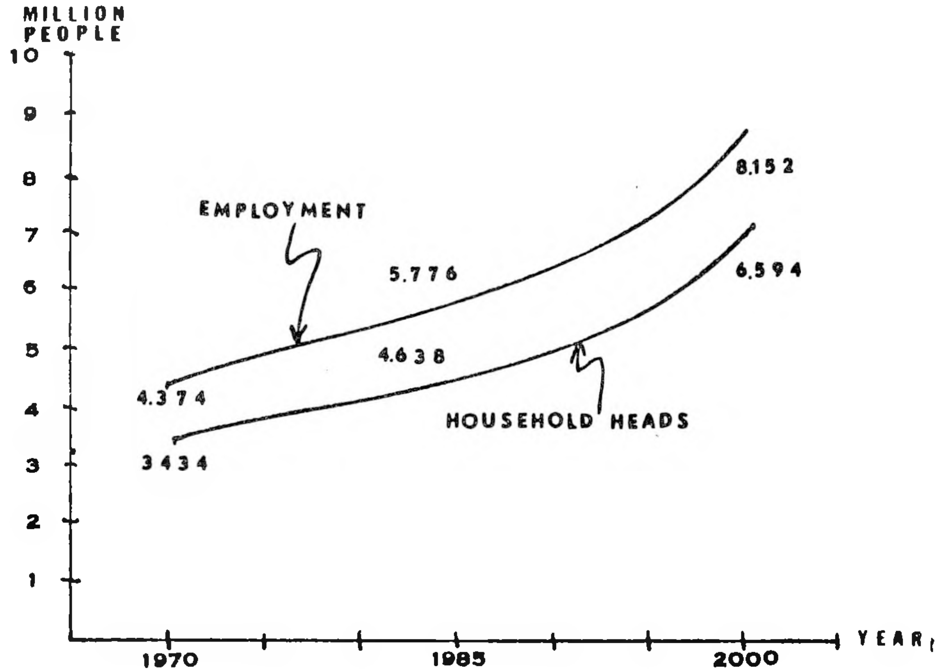


Figure IV-23a: Free Imports Case

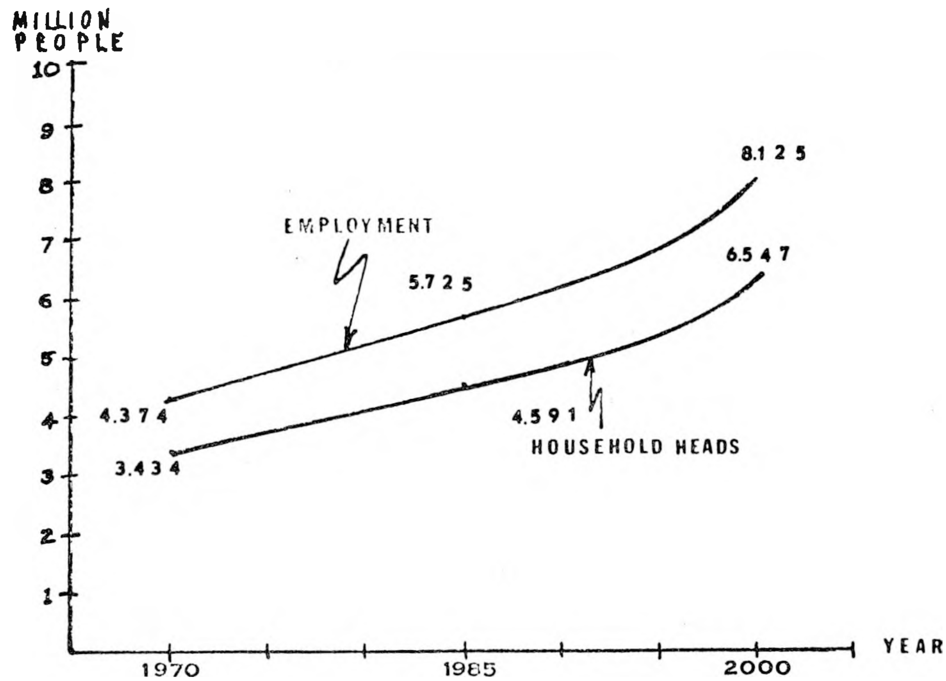


Figure IV-23b: Restricted Imports Case

Figure IV-23: Comparison of Texas Population of Household Heads and Employment Under Conditions of Free Import and Import Restrictions, Exponential Export and Government Demand Growth, 1970 - 2000.

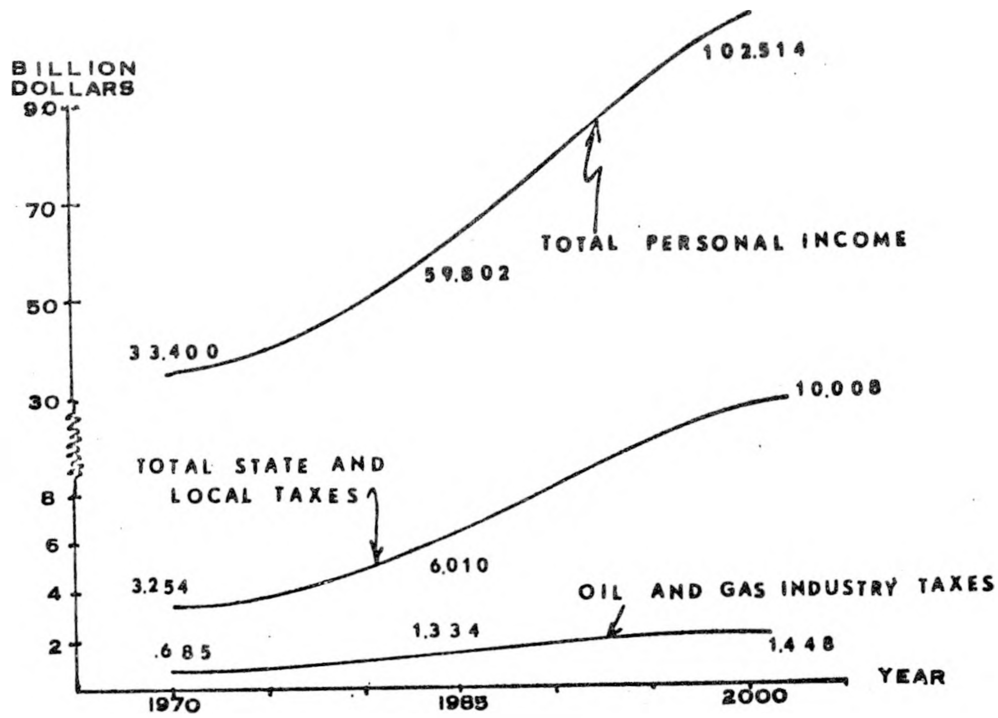


Figure IV-24a: Free Imports Case

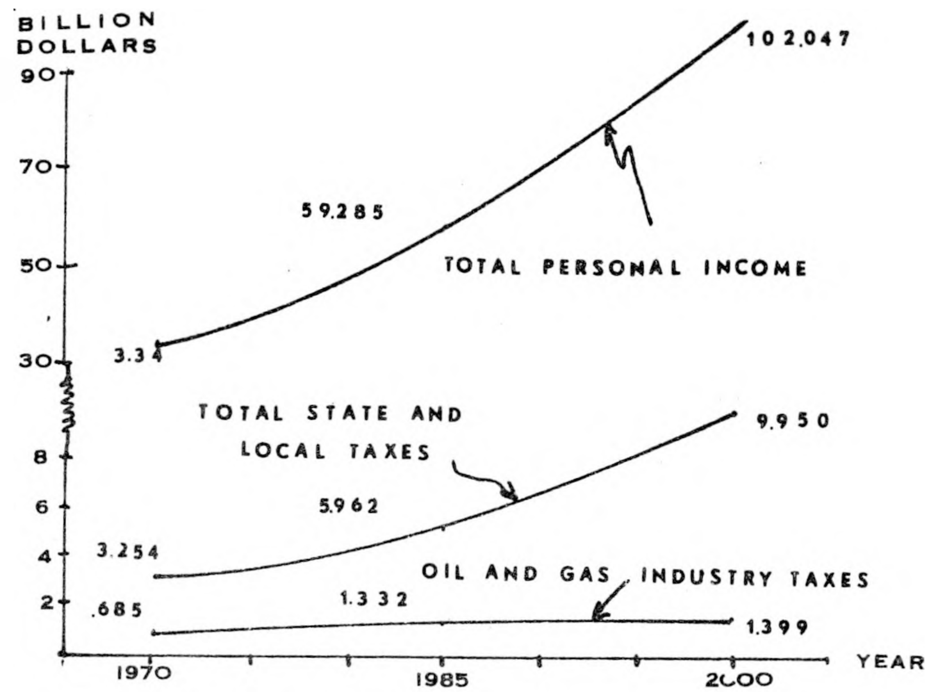


Figure IV-24b: Restricted Imports Case

Figure IV-24: Comparison of Texas Total Personal Income, Total State and Local Taxes, and Oil and Gas Industry Tax Contributions in 1967 Dollars Under Conditions of Free Imports and Import Restrictions and Exponential Export and Government Growth, 1970 - 2000.

the year 2000 is 467 million dollars (1967 dollars).

State and local tax collections would be adversely affected by the restriction on the importation of foreign oil to Texas due to a slow down in general economic activity and more specifically a decline in the refinery and certain petrochemical sectors' contribution. Total state and local taxes would be reduced by 48 million dollars per year (0.8 percent) by 1985 and 58 million dollars per year (0.6 percent) by 2000 under the exponential exports and governments growth rates (Figure IV-24). These percentage restrictions compare with personal income reductions of 0.9 percent in 1985 and 0.5 percent by 2000 (Figure IV-24).

The reduction in oil and gas industry tax contributions resulting from the import restriction when exponential export and government demand growth is assumed is estimated to be 2 million dollars per year (0.2 percent) by 1985 and 49 million dollars per year (3.4 percent) by 2000 (Figure IV-24). The decreases in revenues are primarily from reduced sales of other refinery products resulting from short supplies of crude oil.

V. SUMMARY AND CONCLUSIONS

SUMMARY

The Texas energy problem as summarized in the opening section of this report may be briefly stated in summary form as follows: (1) The Texas economy during the last 40 to 50 years has developed to a large degree upon an economic base of petroleum production, transportation, and refining; (2) Texas industry and agriculture have made large investments in fixed plant and equipment under expectations of a continuation of relatively low priced fuel and other petroleum products; (3) The nations' petrochemical industry has concentrated its operations and locations in Texas because of the transportation advantages of being near the source of feedstock and fuel supplies and now makes up a significant portion of the total Texas economic activity; (4) Since 1971 imports of crude oil have increased steadily, approaching 25 percent of Texas refinery requirements by August of 1974 and Texas production has begun to decline; (5) Recent national public policies including tax incentives and price regulation of natural gas have encouraged exploration and drilling abroad and discouraged exploration and drilling in the U. S. allowing a steady depletion of economic reserves for future production; (6) The immediate prospects for significantly increasing the supplies of Texas oil and gas to maintain the historical importance of Texas as a supplier of energy to the rest of the nation are small; (7) Higher prices for oil and gas required to stimulate exploration, drilling and production in the intermediate and long terms means increased prices now for a wide range of petroleum based products to Texas consumers and affects all Texas consumers who depend on automobiles for transportation and fuel for home heating and air conditioning;

The economic welfare of the poor, the aged, and the disadvantaged will be adversely affected in significant proportions; (8) Short term substitutes for refinery products and natural gas as fuel are limited primarily to lignite and/or coal, the use of which results in greater air and water pollution problems; and (9) National energy policy which will be set in the near term will have significant implications for economic growth and stability in Texas.

In view of the above statement of the problem, an economic evaluation of some of the significant economic parameters related to energy policy options was conducted to determine the economic importance of public energy policy in Texas. The analysis centers primarily on domestic price, import price, fuel substitution possibilities, import quantity restriction levels, and the associated economic impacts on the state of Texas. The impacts are measured in terms of population, employment, personal income, state and local taxes, oil and gas industry taxes, quantities of energy produced and consumed, output levels of individual industries, and the structure of trade relationships among Texas industries.

For purposes of providing a base from which to measure and relate changes, the Texas economy was projected from 1970 to 2000 using a forty-eight sector Texas Input-Output Simulation model constructed for the purpose. The projections include the demand for energy and labor, total population of household heads and associated income levels, and energy production. Since a trade model relating the Texas economy to the rest of the U. S. explaining changes in trade does not exist, it was necessary to rely on trend projections of export levels to 2000 for forty-eight industry sector classifications. Two such projections were made and maintained throughout the analysis in order to assess the importance of various export levels to the rest of the nation. The two projections are intended to bracket the possible range of export levels. The two projections were based on a recent detailed study of growth trends in government spending and export markets for the period 1970-1980. Both a linear and an exponential extension of these trends were used in the analysis.

The input-output simulation model used in the projections makes use of supply curves for oil and gas as a function of price from a companion study at the University of Houston and estimates of individual energy source demand response to price estimates and fuel substitutions by heavy fuel using industries. Thus, demand and supply response to price changes are included in the projections.

The projections of the supply and demand for energy in Texas under the baseline case assumptions (continuation of pre-nineteen seventy prices and fuel distributions by industry sector) indicate a continued decline in the Texas supply of oil and gas with Texas demand for refinery products, natural gas, natural gas liquids, and electricity growing to a crude oil and natural gas requirement equal to total Texas production of oil and gas by 1983 - 1986. In order to maintain growth trends in supplying crude oil, refinery products and petrochemical products to the rest of the nation, Texas would have to increase her imports of crude oil from approximately 247 million barrels in 1970 (interstate imports) to 1.6 - 2.0 billion barrels annually by 1985 (interstate plus foreign). Such import levels by the year 1983 are highly unlikely--these trends indicate the direction in which the economy was progressing prior to recent changes in price levels and without any major substitutions of energy sources.

The effects of price increases from near \$3.30 per barrel for oil and \$.21 per mcf for natural gas in 1967 (1967 dollars) to \$8.65 per barrel for oil and \$.66 per mcf for natural gas by 1980 (1974 dollars)--the estimated long term equilibirum prices for domestic oil and gas at the wellhead--were estimated to determine the economic importance of price increases which might be expected under deregulation of oil and gas prices. The supply response to these price levels over that for the old prices is estimated to be an increase of 6.514 quadrillion BTU's or 72.70 percent by 1985 (3.56 billion cubic feet of gas per year and 538 million barrels of oil per year). The associated decrease in total Texas energy demand from these price increases is estimated at 0.8 quadrillion BTU's or 11.0 percent by 1980.

The estimated distribution and levels of energy use by five categories including subsets of Texas industry, governments and households are significantly changed with the increased price levels. The five identified groups are (1) industry, (2) non-energy (petrochemicals), (3) households, commercial, and governments, (4) energy loss in electric power generation, and (5) transportation. The largest user of energy in the group in 1970 was the industrial category with 38.74 percent of total Texas energy use; the second largest group was the petrochemical complex which accounted for 23.86 percent of the Texas consumption in 1970. The estimates in the case of price increases for oil and gas (to estimated equilibrium levels of \$8.65 per barrel for oil and \$.66 per mcf for gas) and associated price increases for related petroleum products indicate that the petrochemical industry use would compose the largest group of users by 1985 with 29.3 - 31.6 percent of the Texas energy consumption.

The smallest user in the group is loss in electric power generation composing 9.1 percent of the energy use in 1970. The portion used by this sector grows, however, to 11.8 - 12.9 percent by 1985 with the increased prices.

The projections with increased price levels for domestic wellhead oil and gas, and the associated price increases for retail natural gas, gasoline, and electricity result in a changed level and distribution of use by Texas households. Natural gas use is projected to increase from .22 quadrillion BTU's in 1970 to .29 - .31 quadrillion BTU's by 1980. Natural gas supplies are projected to be adequate for Texas users including households for an additional 10 - 15 years as compared to the baseline case. Electricity use projections by households continue to rise compared to the baseline case even though the 1967 constant dollar electricity prices increase significantly by 1985. The consumption of gasoline by households also increased by 1985 relative to the baseline case. In the case of both household use of gasoline and electricity, and to a lesser degree, natural gas, the extra stimulus to the entire Texas economy from increased supplies of oil and gas and dependent industries increases population growth and average per capita incomes. These increases tend to offset the decrease in demand from higher prices and projected household consumption is estimated to increase over the baseline case by 1985. The 1970 distribution of energy use by households changes from 66.89, 24.14, and 8.97 percent for gasoline, natural gas, and electricity to 69.93, 18.32, and 11.75 percent for gasoline, natural gas, and electricity by 1985.

The increased oil and gas production from increased wellhead oil and gas prices is estimated to stimulate Texas population and employment growth. That is, the increased economic activity from increased production increases employment, directly and indirectly, and consequently the growth in Texas population through migration. Employment is projected to rise from the baseline case by 460 thousand (9.37 percent) by 1985. Approximately 14 percent of the increase is directly in the oil and gas industry; the remainder is the indirect employment effect elsewhere in the Texas economy.

Personal income in Texas is projected to increase from the baseline case by approximately 5.8 billion dollars (12.79 percent) in 1985. Total state and local taxes are also projected to increase over the baseline case by approximately 1.1 billion dollars (26.18 percent) by 1985. The portion of state and local taxes coming from the oil and gas industry, including royalty payments, wellhead taxes, and state sales taxes on the projection, distribution and refining of petroleum products is projected to increase 839 million dollars annually (182 percent) over the baseline case by 1985. The increase is directly and indirectly associated with the increased supply of oil and gas in response to price.

The economic impacts of high import prices for crude oil were analyzed by holding domestic oil prices at the estimated equilibrium level and increasing the price of imported crude oil in the simulation model to $14.00 per barrel. In general, the higher prices of imported crude oil increases the supply price of refinery products and electricity. The increased prices would result in decreased consumption of the products. The net however, is to increase the dollar purchases of imports while quantities imported decline. The "leakage" from the economy as a result of increased import prices is significant and affects all parts of the economy. The estimated decrease in Texas total personal income is 753 million dollars (1.26 percent) per year (167 dollars) by 1985 and 1.88 billion dollars (1.16 percent) per year (1967 dollars) by 2000 from the case of import prices equal equal to U.S. domestic prices. The estimate of decreased employment is 66 thousand jobs (1.09 percent) in 1985 and 73 thousand jobs (0.90 percent) by 2000. The impact on total state and local taxes in 1967 dollars is a 116 million dollar decrease (1.93 percent) in 1985 and a 236 million dollar decrease (2.36 percent) by 2000. The impact on total Texas demand for energy is a reduction of .214 (2.36 percent) and .649 (4.30 percent) quadrillion BTU's in 1985 and 2000, respectively.

The economic impact of zero oil and gas imports from foreign sources was analyzed by projecting energy production and consumption, income, employment and taxes under crude oil import limitations restricted to interstate sources. The reduction in Texas demand for energy as a result of the direct and indirect decline in economic activity was projected to be .600 quadrillion BTU's by 1985 and .500 quadrillion BTU's by 2000. The total exports of energy from Texas would be reduced from the free imports case by 5.435 quadrillion BTU's by 1985 and 12.864 quadrillion BTU's by 2000. Personal income in Texas was estimated to be lowered 517 million dollars (0.86 percent) per year by 1985 and reduced 467 million dollars (0.46 percent) per year by 2000. Total state and local taxes would be reduced by 48 million dollars per year (0.8 percent) by 1985 and 58 million dollars per year (0.6 percent) by 2000. Employment would be reduced by 51 thousand employees by 1985 (0.88 percent) and 27 thousand employees by 2000 (0.33 percent).

CONCLUSIONS

A continuation of 1967-1970 relative prices for Texas crude oil and natural gas and a continuation of 1967-1970 fuel use patterns would have encouraged an excelerated growth in energy demand and a sharp decline in crude oil and natural gas supplies in Texas. By 1985 Texas natural gas production would not have been adequate to supply Texas demand for fuels and feedstocks even if all exports of natural gas were discontinued. Crude oil import requirements by 1985 would have grown to a magnitude equal to Texas production in order to maintain the historical export growth rates of crude oil and refinery products to the rest of the nation.

Increased prices of crude oil and natural gas at the wellhead are required several years prior to increased production response. Recent and possible future increases in crude oil and natural gas product prices will not reverse the decline in production until 1980. Price deregulation of crude oil and natural gas would allow domestic prices to increase above current levels by approximately 28 percent for crude oil and 100 percent for natural gas by 1985. Such price increases, combined with recent price increases, would be costly to Texas consumers now, but in the long term, the Texas economy would be economically better off as drilling and production increases, stimulating increased incomes and em-employment in Texas.

In the short term, fuel substitutions can not significantly reduce the pressure on crude oil and natural gas reserves, even at higher prices for crude oil and natural gas. However, if the use of coal and/or lignite (by electric utility, chemical, and primary metal industries) and nuclear fuel (by electric utilities) increases from present levels of near zero to 12 percent of total Texas energy requirements by 1985, Texas supplies of natural gas will be sufficent to meet Texas demands until the early 1990's without further price increases. If coal and/or lignite (by electric utility, chemical, and primary metal industries) and nuclear fuel use (by electric utilities) increases to 28 percent by 1985, Texas supplies of natural gas will be sufficient to meet Texas demands until the late 1990's without further price increases. However, greater substitutions and higher prices would be required to insure supplies of natural gas for feedstocks and to balance Texas supply and demand prior to 2000.

High import prices for curde oil, either through supply price increases or import fees, would reduce import levels but total expenditures on exports would increase, thereby increasing the "leakage" from the Texas economy. Quantity import restrictions to achieve U. S. energy independence would be very costly to Texas -- especially the refinery industry -- and would affect all Texas industries. Some benefit would be realized, however, due to decreased risks to Texas from potential oil embargoes.

TECHNICAL APPENDIX

The Simulation Model

This section of the Technical Appendix presents the mathematical composition of the simulation model as well as the components of the basic input-output model to which it relates. The second and third sections state and describe estimates of energy supply and demand functions, respectively, necessary as input to the projection model. A fourth section summarizes the statistical data used in the study, and the fifth section presents selected tabulations of the calculated values from the analyses.

Input-Output Model--Base Year

The Input-Output model of the Texas economy for year t is expressed in a system of simultaneous linear equations as listed below. Each equation represents one sector of the economy; there are as many equations as there are sectors of the economy.

$$
\begin{aligned}
X_{1t} &= x_{11t} + x_{12t} + x_{13t} + \cdots + x_{1nt} + y_{11t} + y_{12t} + \cdots + y_{1mt} \\
X_{2t} &= x_{21t} + x_{22t} + x_{23t} + \cdots + x_{2nt} + y_{21t} + y_{22t} + \cdots + y_{2mt} \\
&\vdots \\
X_{jt} &= x_{j1t} + x_{j2t} + x_{j3t} + \cdots + x_{jnt} + y_{j1t} + y_{j2t} + \cdots + y_{jmt} \\
&\vdots \\
X_{nt} &= x_{n1t} + x_{n2t} + x_{n3t} + \cdots + x_{nnt} + y_{n1t} + y_{n2t} + \cdots + y_{nmt}
\end{aligned}
$$

Where the typical elements of the typical equation are defined as follows:

X_{jt} = total value of production of sector j in year t,

x_{j1t} = value of sales by producing sector j in year t to producing sector one in year t,

x_{j2t} = value of sales by producing sector j in year t to producing sector two in year t,

y_{j1t} = value of sales by producing sector j in year t to final demand or consuming sector one in year t,

y_{jmt} = value of sales by producing sector j in year t to final demand or consuming sector m in year t.

Note that the equations stated above are merely the total value of output for time period t in the left hand members, while in the right hand members the customer list and total value of sales to each is listed and expressed as a term in each equation. This formulation of the model requires the distinction of sales to intermediate processing sectors and final customers and as a result permits the economic analyst to relate the production level of sector i to that of sector j, to relate the consumption of sector j's product by the population of the economy to the production requirements of sector j both in terms of direct inputs and indirect inputs through other sectors that use some of sector j's output as input in their respective production processes. These properties of the Input-Output model are the basis whereby the model can be developed and expanded into a powerful tool for purposes of simultaneously handling a large number of variables, introducing changes into the production processes of the economy such as fuel substitutions resulting from petroleum shortages and increased petroleum prices, and relating consumer responses and buying changes to measure effects upon individual sector markets for products and sources of supply of inputs. Changes in consumer markets due to population and income change can also be traded throughout the economy by using the Input-Output model.

In order to accomplish the analyses mentioned above the set of equations listed and defined above are expressed in an equivalent form of variables and parameters as follows:

$$X_{1t} = a_{11t}X_{1t} + a_{12t}X_{2t} + \cdots + a_{1nt}X_{nt} + Y_{1t}$$

$$X_{2t} = a_{21t}X_{1t} + a_{22t}X_{2t} + \cdots + a_{2nt}X_{nt} + Y_{2t}$$

$$\vdots \qquad\qquad \vdots \qquad\qquad \vdots$$

$$X_{jt} = a_{j1t}X_{1t} + a_{j2t}X_{2t} + \cdots + a_{jnt}X_{nt} + Y_{jt}$$

$$\vdots \qquad\qquad \vdots \qquad\qquad \vdots$$

$$X_{nt} = a_{n1t}X_{1t} + a_{n2t}X_{2t} + \cdots + a_{nnt}X_{nt} + Y_{nt}$$

by substituting the expression

$$a_{ijt}X_{it} = x_{ijt}$$

and summing the sales to final demand $(y_{j1t} + y_{j2t} + \cdots + y_{jmt})$ into one term Y_{jt}. Note that this latter summation is done here for brevity of expression. In the actual analyses, the final demand sectors are handled as individual sectors in the manner stated in the initial set of equations listed above.

The expression $a_{ijt}X_{it} = x_{ijt}$ is obtained by expressing the production requirements by sector i for sector j's output per unit of sector i's output in year t as follows:

$$a_{ijt} = \frac{x_{ijt}}{X_{it}}$$

Where a_{ijt} is the dollar value of output required by sector i from sector j per dollar of output of sector i in year t. Through the coefficient a_{ijt} the production inputs sector i requires from sector j in year t are expressed on a per unit of sector i's output level and thereby sector i and sector j are appropriately related or linked for analytic purposes. Note that the coefficients thus expressed carry a subscript t which relates to time. At different times (years), these coefficients differ because of price and technology changes. In this study, the input coefficients a_{ijt} are estimated for future time periods and incorporated into the simulation model to reflect changes due to economic conditions and changing technology. The method of estimating such change is stated in following sections.

The system of equations stated above is expressed in matrix algebra for ease of observation and to facilitate computer manipulation and solutions. The general matrix equation is

$$X_t = A_t X_t + Y_t$$

where X_t is the vector of outputs of the economy in year t. This term includes the left hand members of each of the previously stated mathematical sets of equations. The vector of final demands is Y_t for year t and is the matrix notation for the column of Y's stated in the system of equations listed immediately preceeding this matrix algebra expression. The input requirements for year t are expressed in the A_t matrix, where the typical element is a_{ijt}. The dimensions of the A_t matrix are n x n or there are n rows and n columns in this matrix. The dimensions of the output and final demand vectors are n x 1 or n rows

Appendix Table 1. Aggregation Level for Texas Input-Output Model

Sector Number	Industry	Sic Groups
1	Irrigated Crops	0112-0123
2	Dryland Crops	0212-0219
3	Livestock and Poultry	0132-0235
4	Agricultural Services	0712-0741, 5962, 5969
5	Primary Forestry and Fisheries	0811-0989
6	Crude Petroleum	1311
7	Natural Gas Liquids	1321
8	Oil and Gas Field Services	1381, 1382, 1389
9	Other Mining	1011-1499
10	Residential Construction	1511
11	Commercial, Educational, and Instit.	1512, 1513, 1700
12	Facility Construction	1611, 1621
13	Food Processing	2011-2087
14	Textile and Apparel	2211-2399
15	Logging, Wood, and Paper	2411-2799
16	Chlorine and Alkalies	2812, 2813
17	Cyclic Crudes and Intermediate Pigments	2815
18	Organic Chemicals	2818
19	Inorganic, Plastics, Rubber	2819-2822
20	Drugs, Chemicals, Soaps, and Paint	2831-2899
21	Petroleum Refining	2911
22	Other Petroleum Products	2951, 2952, 2992, 2999
23	Tires, Rubber, Plastics, Leather	3011-3199
24	Glass, Clay, Stone, Cement	3221-3273
25	Primary Metal Processing	3312-3499
26	Industrial Equipment Manufacturing	3522-3599
27	Electric Appliance Manufacturing	3611-3699
28	Aircraft, Motor Vehicle	3721-3799
29	Instruments, Photography, Games	3811-3999
30	Rail Transportation	4011, 4013, 4021, 4041
31	Intercity Highway Transportation	4131, 4132, 4111, 4119, 4121
32	Motor Freight Transportation	4212-4231
33	Water Transportation	4411-4469
34	Air Transportation	4511, 4521, 4582, 4503
35	Pipeline Transportation	4612, 4613, 4619
36	Other Transportation	4141, 4251, 4271-4272, 4712-4789
37	Communications	4811, 4821, 4832, 4833, 4899

(Continued)

Appendix Table 1 (Continued)

Sector Number	Industry	SIC Groups
38	Gas Services	4922-4925
39	Electric Services	4911
40	Water and Sanitary Services	4941-4961,9302
41	Wholesale Trade	5012-5099
42	Other Retail Trade	5211-5499, 5611-5999
43	Auto Dealers and Repair Shops	5511-5531, 5541, 7531-7549
44	F.I.R.E.	6011-6799
45	Other Services	8111, 7211-7399, 7512-8099, 8911-8811
46	Lodging, Amusement, Recreation	7011-7041, 7832-7949
47	Education	
48	Outdoor Recreation	8211-8242
49	Households	
50	Property Payments	
51	Federal Government	
52	State Government	
53	Local Government	
54	Imports	

and one column each. For the Texas simulation model, n = 48, or the Texas economy is expressed in 48 sectors. The list of equations is given in the text in the discussion on methodology. The time dimension or range of t is 1967 - 2000 or 33 years.

The solution to the matrix form of the model listed above is

$$X_t = [I-A_t]^{-1} Y_t$$

where the matrix $[I-A_t]^{-1}$ is the matrix of direct and indirect requirements per dollar of production to meet final demand Y_t in year t. The simulation model has equations which estimate the vector of Y_t's for a set of initial conditions; the Input-Output model is then solved for that year; the results of the solution are then used to estimate the vector of final demands for year t + 1 and a solution is then obtained to the Input-Output model for year t + 1 and so on until the end of the simulation period. During the simulation, the A matrix is modified to incorporate the effects of technological changes, price change or fuel substitutions upon the inputs of individual sectors. The relationships and data are stated and explained below. The assumptions are stated in the text in the methodological section. An illustration of the tables with explanations of how to read such tables is presented below.

A highly aggregated version of the 1967 Texas Input-Output model is shown in Appendix Tables 2, 3, and 4. These tables are presented here for the purpose of illustrating an Input-Output model, showing how to read and understand an Input-Output model, and showing how to use such a model for purposes of calculating the economywide impacts of changes in resources available to one sector. The larger 48 sector model was used in the analysis. In the Transaction Table of an Input-Output Model,

Appendix Table 2. Transactions Table - Texas, 1967 (Million Dollar)*

		PROCESSING SECTORS							FINAL DEMAND					
	Sales / Purchases	A F & F	M & C	Mfg.	T C & U	Trade	F.I.R.E	E & S	H H	GOVT	EXPORTS	CAP	CIC	TOTAL
		1	2	3	4	5	6	7	8	9	10	11	12	13
Processing Sectors	1. A F & F	589	30	1,380	0	17	0	1	203	471	1,193	0	-223	3,661
	2. M & C	29	703	2,910	1,005	19	56	36	182	49	1,656	5,636	1	12,284
	3. Mfg.	555	1,495	3,729	315	526	58	517	3,329	2,772	12,223	1,051	219	26,789
	4. T C & U	104	238	1,383	421	354	131	268	1,810	136	1,435	59	0	6,339
	5. Trade	409	164	348	99	234	41	150	7,649	59	861	644	2	10,660
	6. FIRE	114	271	211	200	429	329	216	1,827	90	720	0	0	4,407
	7. E & S	92	361	564	339	463	349	378	4,146	446	432	5	1	7,576
Final Payments	8. H H	1,184	4,016	4,956	1,814	5,163	2,029	4,360	1,953	3,268	0	0	0	30,743
	9. Govt	86	754	939	639	649	228	269	4,384	467	0	0	0	8,415
	10. Imports	246	1,941	6,428	351	1,026	104	723	5,196	2,135	0	523	0	18,673
	11. R E & D	253	2,311	3,941	1,155	1,780	1,082	656	64	0	0	0	0	11,242
	TOTAL	3.661	12.284	26.789	6.338	10.660	4.407	7.576	30.743	11,893	18.520	7.918	0	140,789

* 1. A.F. & F. = Agriculture, Forestry and Fisheries
2. M. & C. = Mining and Construction
3. Mfg. = Manufacturing
4. T.C. & U. = Transportation, Communications & Utilities
5. Trade = Wholesale and Retail Trade
6. FIRE = Finance, Insurance, and Real Estate
7. E. & S. = Education and Services
8. HH = Households
9. Govt. = Local, State and Federal Governments
10. Imports = Out-of-state purchasers
11. R.E.&D. = Retained Earnings and Depreciation

the dollar value of trading among the sectors of the economy is tabulated (Appendix Table 2). Sales are shown along the rows. Purchases are shown in the columns. For example, manufacturing (Mfg.) sold 555 million dollars to agriculture; 1,495 million dollars to mining and construction, and so on for a total of 26,789 million dollars during 1967. The manufacturing industry purchased 1,380 million dollars of goods from agriculture, forestry, and fisheries; 2,910 million dollars of goods from mining and construction; and so on for a total of 26,789 million dollars in 1967.

From the transactions table referenced above (Appendix Table 2), a number of related tables are derived which allow measurement of effects of changes in various industry variables on other industries. The Direct Requirements Table is calculated by dividing the column elements of Appendix Table 2 by the column totals of Appendix Table 2 (Appendix Table 3) and shows the dollar value of inputs per dollar of output for each respective industry. A second derivative is the Direct, Indirect, and Induced Requirements Table (Appendix Table 4). This table shows, based on the relationships existing in the survey (base) year, the individual industry and economywide production or output effects of a change in the delivery of an additional quantity of final product to consumers and exports by a particular sector. For example, this miniature version (Appendix Table 2) of the Texas Input-Output model shows that a one-million dollar increase in the delivery of agricultural products to Texas consumers and exports requires a 3.66 million dollar increase in total Texas industry output (Appendix Table 4, column 1); and the total is divided as follows: 1.23 million dollars from agriculture, forestry, and fisheries (AF&F); 0.093 million dollars from mining and construction (M&C); 0.408 million dollars from manufacturing (Mfg.); and so on.

Appendix Table 3. Direct Requirements Table - Texas, 1967 (Per Dollar of Output)*

Sector	A F & F	M & C	Mfg.	T C & U	Trade	FIRE	E & S	H H
	1	2	3	4	5	6	7	8
1. A F & F	0.1609	0.0024	0.0515	0.0000	0.0015	0.0000	0.0001	0.0065
2. M & C	0.0079	0.0572	0.1086	0.1585	0.0017	0.0125	0.0049	0.0059
3. Mfg.	0.1515	0.1217	0.1391	0.0496	0.0493	0.0131	0.0682	0.1082
4. T C & U	0.0283	0.0193	0.0516	0.0663	0.0332	0.0296	0.0353	0.0588
5. Trade	0.1118	0.0133	0.0129	0.0155	0.0219	0.0093	0.0198	0.2488
6. FIRE	0.0312	0.0220	0.0078	0.0316	0.0402	0.0747	0.0285	0.0594
7. E & S	0.0250	0.0293	0.0210	0.0534	0.0434	0.0792	0.0498	0.1348
8. H H	0.3233	0.3269	0.1850	0.2862	0.4843	0.4603	0.5754	0.0635
9. Govt.	0.0235	0.0613	0.0350	0.1008	0.0608	0.0518	0.0354	0.1426
10. Imports	0.0672	0.1580	0.2399	0.0554	0.0962	0.0236	0.0954	0.1689
11. R E & D	0.0689	0.1881	0.1471	0.1822	0.1669	0.2454	0.0866	0.0021
Total	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000

* See Appendix Table 2 for sector definitions.

Individual industries use inputs purchased from other industries and also require natural resources. Thus, a change in demand for one industry's products results in a change in demand for the natural resources used by that industry and an indirect change in demand for resources used by the industry's suppliers. The direct, indirect, and induced requirements table (Appendix Table 4) is used to calculate the total change in quantity of resource used as a result in a given change in markets for one sector's product. Or conversely, the same approach can be used to calculate the change in a given sector's output due to a shortage of a necessary input such as crude petroleum or natural gas. For example, agriculture uses approximately 17.16 MCF of natural gas directly per million dollars of output (Appendix Tables 10 and 13; weighted average natural gas inputs per million dollars of output). However, this is not the total quantity of natural gas required for agricultural production. Industries that produce agricultural inputs such as fertilizer, herbicides and insecticides and provide services to farmers and to other industries that supply inputs to agricultural supplying sectors also use natural gas either directly or indirectly in their respective production processes.

The indirect and induced uses of natural gas, although visible are not clearly expressed in meaningful quantitative terms and therefore are difficult if not impossible to take into account when either market trading or other forms of resource allocations are made. Thus, when shortages occur and competing users attempt to make rational decisions regarding quantities of resources to purchase, there is a serious danger that too much of the scarce resource will be purchased by some industries and not enough left to sell to supporting industries that are

Appendix Table 4. Direct, Indirect, and Induced Requirements Table - Texas (Per Dollars of Final Demand) *

Sector	A F & F	M & C	Mfg.	T C & U	Trade	FIRE	E & S	H H
	1	2	3	4	5	6	7	8
1. A F & F	1.2257	0.0277	0.0863	0.0219	0.0252	0.0209	0.0279	0.0322
2. M & C	0.0931	1.1199	0.1803	0.2305	0.0625	0.0697	0.0763	0.0751
3. Mfg.	0.4076	0.2929	1.3120	0.2358	0.2401	0.2017	0.2911	0.2897
4. T C & U	0.1526	0.1058	0.1329	1.1599	0.1368	0.1333	0.1553	0.1572
5. Trade	0.4105	0.2219	0.1935	0.2358	1.2902	0.2785	0.3316	0.4497
6. FIRE	0.1415	0.0975	0.0757	0.1159	0.1359	1.1738	0.1381	0.1481
7. E & S	0.2258	0.1740	0.1476	0.2120	0.2269	0.2668	1.2615	0.2920
8. H H	1.0037	0.7605	0.6207	0.7984	0.9934	0.9973	1.1560	1.6953
Total	3.6609	2.8005	2.7494	3.106	3.1113	3.1423	3.4381	3.1396

* See Appendix Table 2 for sector definitions.

remotely located in the trading cycle but that happen to be absolutely necessary as a producer of an ingredient of an ingredient of an ingredient several trades removed. As a result, overall production of highly desirable products, such as agricultural products, may be unnecessarily low in relation to what might have been produced had there been better knowledge about the indirect and induced requirements to produce agricultural products. Natural gas for producing fertilizer and steel for producing baling wire are both good illustrations of these types of indirect agricultural use of methane and iron ore. Similar examples of other equally important production relationships are obviously in existence within the economy. The markets for resources will make resource allocations, given time and price signals with which to work. The process can be more effective from the economic efficiency and time standpoints if there is better quantitative information about the indirect and induced resource requirements of each industry in the future than has been available in the past. Both private sector planners and public policymakers can benefit from such information. An Input-Output model provides some of the data need for improved resources allocation when supplies are critically short. An illustration based on the aggregated and simplified model (Appendix Table 2) is presented below.

In order to calculate the total quantity of natural gas required throughout the economy to support a given value of production for final demand, such as one million dollars of sales of raw agricultural commodities to out-of-state processors, the direct, indirect and induced requirements table (Appendix 4) is premultiplied by a compatible table of natural gas input coefficients (Appendix Table 5, columns 1-8).[1/]

[1/] Matrix multiplication methods are explained in any standard matrix algebra reference.

Appendix Table 5. Derivation of Direct, Indirect, and Induced Natural Gas Requirements per $Million of Sales to Final Demand--Texas*

Direct Natural Gas Requirements Matrix (MCF per Million Dollars Output)

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
17.16	.	.	.	.	.	.	.
.	1.66	.	.	.	.	.	.
.	.	54.45	.	.	. (zeros)	.	.
.	.	.	162.53	.	.	.	.
.	. (zeros)	.	.	6.32	.	.	.
.	.	.	.	.	8.90	.	.
.	.	.	.	.	.	8.76	.
.	.	.	.	.	.	.	1182.00

X

Matrix of Direct, Indirect, and Induced Requirements per Dollar of Sales to Final Demand

(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)
1.2257	0.0277	0.0863	0.0219	0.0252	0.0209	0.0279	0.0322
0.0931	1.1199	0.1803	0.2305	0.0625	0.0697	0.0763	0.0751
0.4076	0.2929	1.3120	0.2358	0.2401	0.2017	0.2911	0.2897
0.1526	0.2058	0.1329	1.1599	0.1368	0.1333	0.1553	0.1572
0.4105	0.2219	0.1935	0.2358	1.2901	0.2785	0.3316	0.4497
0.1415	0.0975	0.0757	0.1159	0.1359	1.1738	0.1381	0.1481
0.2258	0.1740	0.1476	0.2120	0.2269	0.2668	1.2615	0.2920
1.0037	0.7605	0.6207	0.7984	0.9934	0.9973	1.1560	1.6953

Appendix Table 5 (Continued)

=

Sector*	Direct, Indirect, and Induced Natural Gas Requirements Per Million Dollars of Sales to Final Demand							
	(17)	(18)	(19)	(20)	(21)	(22)	(23)	(24)
AF&F	21.0330	0.4753	1.4809	0.3758	0.4324	0.3586	0.4788	0.5526
M&C	0.1545	1.8590	0.2993	0.3826	0.1038	0.1157	0.1267	0.1247
Mfg.	22.1938	15.9484	71.4384	12.8393	13.0734	10.9826	15.8504	15.7742
T.C&U	24.8021	17.1957	21.6002	188.5185	22.2341	21.6652	25.2409	25.5497
Trade	2.5944	1.4024	1.2229	1.4903	8.1541	1.7601	2.0957	2.8421
FIRE	1.2594	0.8678	0.6737	1.0315	1.2095	10.4468	1.2291	1.3181
E & S	1.9780	1.5242	1.2929	1.8571	1.9876	2.3372	11.0507	2.5579
HH	1186.3734	898.9110	733.6674	943.7088	1174.1988	1178.8086	1366.3920	2003.8446
TOTAL	1303.5202	938.1836	831.6756	1150.2039	1221.3935	1226.4746	1422.4639	2052.5635

* Column and row titles correspond to those of Appendix Table 4.

(The natural gas inputs coefficients for this illustration are derived by calculating weighted averages from the data in Appendix Tables 10 and 13. Sectors 1-5 of Appendix Tables 10 and 13 correspond to sector 1, Agriculture in this example. Sectors 6-12 of Appendix Tables 10 and 13 are mining and construction, sectors 13-29 are manufacturing, sectors 30-40 are transportation, communications, and utilities, sectors 41-43 are trade, sector 44 is finance, insurance, and real estate, sectors 45-48 are services, and sector 48 is households respectively of this simplified illustration model.) The total quantity of natural gas required of the economy to support a one million dollar production of agricultural products for final demand is estimated at 1,303.52 MCF (Appendix Table 5, column 17). This total estimate includes 1,186.37 MCF of natural gas used by farm families, the agricultural hired labor force, and labor employed in supporting industries, that produce indirect farming inputs, for home heating and other household use (Appendix Table 5, column 17, row 8), 17.16 MCF used directly on the farm, and 99.98 MCF used in all other sectors of the economy. This latter estimate is the sum of the first seven rows of column 17, Appendix Table 5, adjusted for the direct natural gas inputs of agriculture per million dollars of sales to final demand (17.16 MCF) shown in row 1, column 1 of Appendix Table 5.

The estimated quantity of natural gas used directly and indirectly by each sector of the economy in support of one million dollars of agricultural production is read directly from that sectors' respective row in column 17 of Appendix Table 5. A similar analysis is shown for each of the other sectors of this particular model of the Texas economy (Appendix Table 5, columns 18-24). For example, manufacturing directly uses an estimated 54.45 MCF of natural gas per million of production for final demand (Appendix Table 5, row 3, column 3), but the entire economy's direct and indirect use of natural gas in support of the manufacturing sector's production of one million dollars of output for final demand is estimated at 831.67 MCF (Appendix Table 5, column 19). Of this total, 733.66 MCF are used by the manufacturing and manufacturing supporting sectors' labor forces for household heating and other household uses (Appendix Table 5, row 8, column 19). The remaining 98.01 MCF are used directly and indirectly by the manufacturing sector and those sectors that produce inputs used directly and indirectly by the manufacturing sector in the production of one million dollars of products for final demand. The individual sector share of the total natural gas required to produce one million dollars of manufacturing output for final demand is shown in the manufacturing sector column (column 19) of Appendix Table 5 on that sector's row.

The estimated economywide requirement of natural gas to support one million dollars of production for final demand for other major sectors of the Texas economy is shown in Appendix Table 5, columns 18, 20, 21, 22, 23, and 24. The interpretation is analogous to that outlined above for agriculture and manufacturing. The name of each sector number listed above is shown in the row to which the column corresponds (Appendix Table 5). A more detailed natural gas and other petroleum resource input analysis is done in the larger 48 sector model reported in the text of this report for the purpose of calculating individual sector output levels under alternative policies which can be expected to result in alternative levels of crude oil and natural gas suppliers. Natural resource shortages may result in production opportunity foregone and cause both economic losses and human welfare loss and suffering. The analysis presented above indicates how Input-Output models can be used to calculate both the direct and indirect effects of natural resource shortages upon the production levels of each sector of the economy.

Input-Output Model--Projected Changes

The model and illustrations presented above are known in economics as a static model and a static analysis. That is, the relationships (equations) pertain to one production period, in this case the base year 1967. In this study, projections of future consumption and future input coefficients were made and introduced into the simulation model at the year in time at which changes are expected. That is to say, time dependent relationships (equations) were estimated for both consumption and production activities. Each time dependent equation and the manner in which these equations were included in the static Input-Output model to develop the simulation model are explained below.

Consumption by the Texas population (Household Sector) depends upon the size of the population, per capita income, and prices of goods and services. Future consumption of each commodity and service produced by the Texas economy and those goods that are imported can be expected to change as each consumption determining variable changes. Time dependent equations and selected price and income elasticities of demand were used to estimate changes in final demand for the simulation model as the simulation progresses from the base year forward. For example, recent data indicate that consumer spending for gasoline is positively related to income changes and on a percentage basis, slightly less than proportional; that is, consumers increase expenditures for gasoline by eight percent from a ten-percent increase in incomes. The data also indicate that as gasoline price increases, gasoline consumption declines. For a ten percent increase in price, consumption declines by one percent in a short term and by fifteen percent in the long term. These types of coefficients were systematically incorporated into the Input-Output simulation model.

In addition to income and price factors, the size of the population or the number of consumers is an important determinant of consumption. At present, population in Texas is increasing at an annual rate of 1.5 percent. Population increases as a result of (1) natural growth (births minus deaths) and (2) net in-migration. Migration is determined largely by economic forces of supply and demand for labor. In the simulation model migration in the current time period is related to output levels of industry in the previous time period (which in turn determines the demand for labor) and to population in the previous time period.

The change in individual sector input coefficients (production functions) expected in the future are estimated and incorporated into the model through the capital and labor variables. Selected input substitutions of fuels are also estimated and permitted within the choice criteria of the simulation model. Changes in capital technology are not considered because of lack of data; i.e.; the stock of capital required to produce a given unit of product is assumed to remain constant throughout the simulation period. However, the capital stock of each sector is increased as projected demand for that sector's product requires net new additions of capital. For example, to increase the annual production capacity of pulp and paper mills by one million dollars requires an addition to the pulp and paper mill capital stock of approximately 1.15 million dollars of plant and equipment. These and analogous capital coefficients are used to relate projected consumption to individual sector output, and when output capacity is exceeded, the simulation model calculates the quantity of new capital required to meet the projected consumption levels. Production in time period t is related to production in time period t-1, and the capital stock addition to move to time period t from time period t-1 is calculated. Similar coefficients for labor inputs were also incorporated into the model. The coefficients were estimated from recent labor productivity data for each sector of the economy (Appendix Table 17).

The mathematical equations in which the factors mentioned above are expressed and through which these variables are brought to bear in the simulation model are shown in Appendix Figure 1. The Transaction Matrix, Primary Resource Requirements Matrix, Capital Requirements Matrix, Income Elasticity Coefficients Matrix, and Tax Rate Matrix are shown for the general case. In Appendix Figure 2, a flow diagram is presented which shows the sequence of steps of the simulation model as a solution is obtained for a typical production period. Note that the levels of government expenditures, determined by political forces, and export demands, determined by other economic regions are estimated from recent growth trends of these variables and are specified for the model; i.e.; are calculated outside the model and entered as data.

For a typical period solution, a set of "beginning conditions" is calculated using data from the previous production period. From these data the simulation model then estimates the next year's total final demand. The model then calculates output of each sector, given any existing constraints on availability of primary resources. Once a solution is found, resource use, personal incomes, taxes, employment, and a number of other variable values are calculated. Then a series of

TRANSACTION MATRIX

	Endogenous Sector				Exogenous Sector					Row Sum
1	x^q_{11}	x^q_{12}	....	x^q_{1n}	Y_{1h}	Y_{1s}	Y_{1f}	Y_{1e}	DK_1	X_1
2	x^q_{21}	x^q_{22}			Y_{2h}	Y_{2s}	Y_{2f}	Y_{2e}	DK_2	X_2
			x_{ij}						DK_i	X_i
n	x^q_{n1}	x^q_{n2}		x^q_{nn}	Y_{nh}	Y_{ns}	....		DK_n	X_n
Final	Z_{h1}	Z_{h2}	....	Z_{hn}	Z_{hh}	Z_{hs}	Z_{hf}			Z_h
	Z_{l1}	Z_{l2}	....	Z_{ln}	Z_{lh}	Z_{ls}	Z_{lf}			Z_l
Payments	Z_{s1}	Z_{s2}	....	Z_{sn}	Z_{sh}	Z_{ss}	Z_{sf}			Z_s
	Z_{f1}	Z_{f2}	....	Z_{fn}	Z_{fh}	Z_{fs}	Z_{ff}			Z_f
	Z_{v1}	Z_{v2}	....	Z_{vn}	Z_{vh}	Z_{vs}	Z_{vf}			Z_v
	Z_{m1}	Z_{m2}	....	Z_{mn}	Z_{mh}	Z_{ms}	Z_{mf}			Z_m
Col. Sum	X_1	X_2	....	X_n	$\bar{H}$	$\bar{S}$	$\bar{F}$	$\bar{E}$	$\overline{DK}$	

Primary Resource Requirements

$$R = \begin{bmatrix} r_{11} & r_{12} & \cdots & r_{1,nd} \\ r_{21} & r_{22} & & \vdots \\ \vdots & & r_{ij} & \vdots \\ r_{51} & \cdots & \cdots & r_{5,nd} \end{bmatrix}$$

Capital Requirements Matrix

$$K = \begin{bmatrix} k_{11} & k_{12} & \cdots & k_{1n} \\ k_{21} & k_{22} & & \\ \vdots & & k_{ij} & \\ k_{r1} & \cdots & \cdots & k_{rn} \end{bmatrix}$$

Household Tax Rates

$$TX = \begin{bmatrix} t_{f1} & t_{f2} & \cdots & t_{fn} \\ t_{s1} & t_{s2} & \cdots & t_{sn} \\ t_{l1} & t_{l2} & \cdots & t_{ln} \end{bmatrix}$$

Income Elasticity Coefficients

$$E = \begin{bmatrix} e_{11} & e_{12} & \cdots & e_{1m} \\ e_{21} & e_{22} & & \\ \vdots & & e_{ij} & \\ e_{n1} & \cdots & \cdots & e_{nm} \end{bmatrix}$$

A S S U M P T I O N S

(1) a_{ij} change with time.

(2) k_{ij} are constant over time.

(3) e_{ik} are constant over time.

(4) r_{ij} are constant over time with the exception of labor which change with time to reflect changes in technology.

(5) Primary energy and fuel prices change with time.

D E F I N I T I O N S

X_i = Gross Domestic Output of Sector i.

XM = X_i Vector plus $\bar{H}$, $\bar{S}$, and $\bar{F}$.

Y_{ih} = Purchases by Households from Sector i.

Z_{mh}, Z_{sh}, Z_{fh} = Purchases by Households from Imports and Taxes to Government.

Y_{is} = Purchases by State and Local Governments from Sector i.

$Z_{ms}, Z_{ss}, Z_{fs}, Z_{hs}$ = Purchases by State and Local Governments from Imports, Governments, and Households.

Y_{if} = Purchases by Federal Government from Sector i.

$Z_{mf}, Z_{sf}, Z_{ff}, Z_{hf}$ = Purchases by Federal Government from Imports, Governments, and Households.

Y_{ie} = Net Exports of Sector i Product, Including Exported Capital.

Y_i = $Y_{ih} + Y_{is} + Y_{if} + Y_{ie} + DK_i$ = Total Final Demand for Product of Sector i.

DK_i = Sector i Product Flowing to Capital Formation (Expansion Capital Plus Net Additions to Inventory).

Z_{mj} = Imports Used as Inputs by Sector j.

Z_{mh}, Z_{ms}, Z_{mf} = Imports by Households, Governments.

Z_{sj} = State and Local Government Tax Receipts from Sector i.

Z_{sh}, Z_{ss}, Z_{sf} = State and Local Goverment Tax Receipts from Households and Governments.

Z_{fj} = Federal Government Tax Receipts from Sector j.

Z_{fh}, Z_{fs}, Z_{ff} = Federal Government Tax Receipts from Households and Governments

Z_{hj} = Household Income from Sector j.

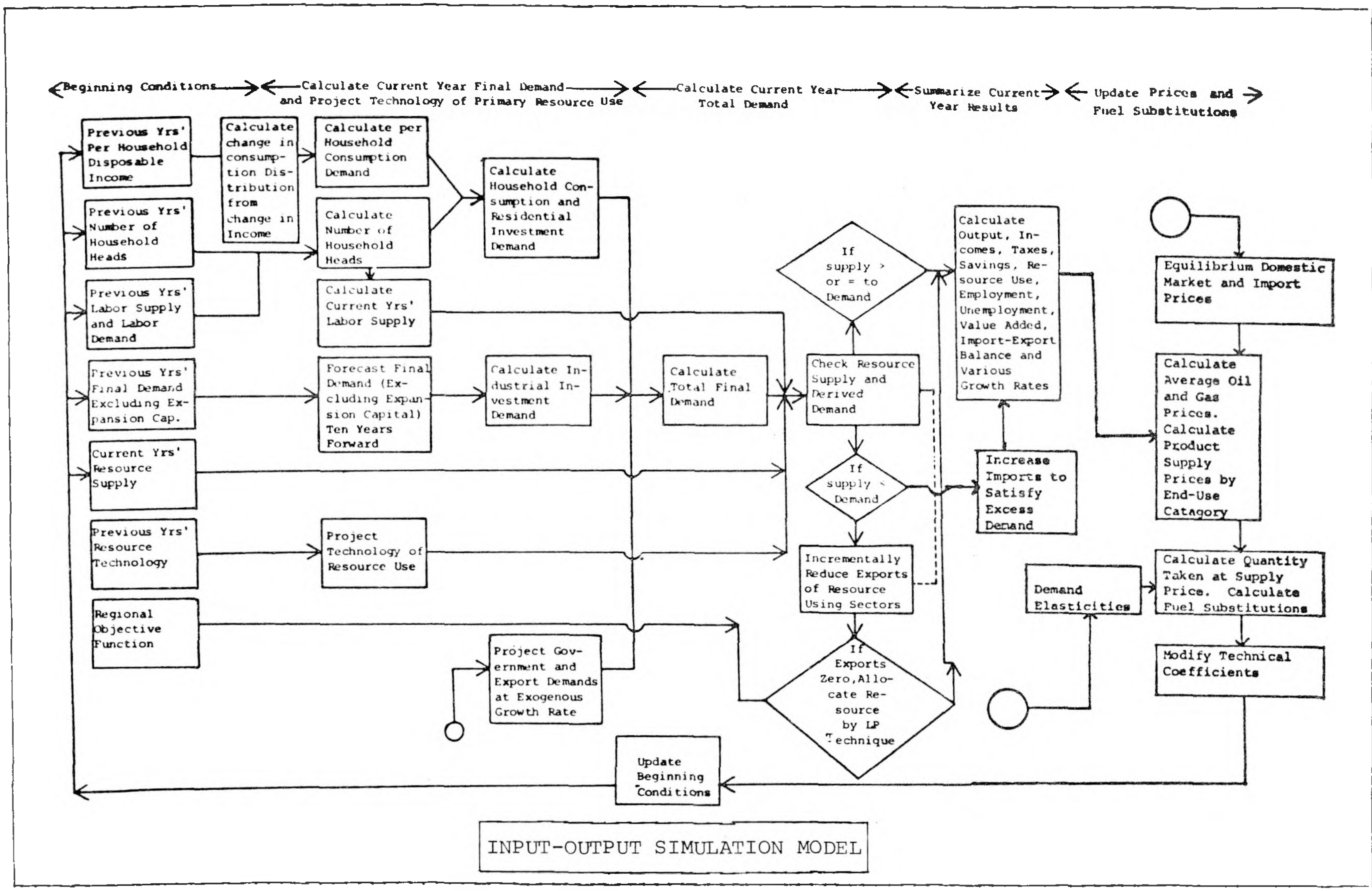
Z_{hh}, Z_{hs}, Z_{hf} = Household Income from Households and Governments.

i and j denote row and column in Transaction Matrix; i, j=1,.....,n endogenous sectors

np = n processing sectors plus final payment sectors.

nd = n processing sectors plus exogenous final demand sectors.

Appendix Figure 1. General Input-Output model with definitions, assumptions, and analytic and projection matrices.



Appendix Figure 2. Flow Diagram of Input-Output Simulation Model Calculating Routines.

price changes with related consumption levels and fuel substitutions are estimated for the next time period, and all beginning conditions are updated and made ready for use in calculating the model solution for the following year of the simulation.

The model contains an option for evaluating alternative policies regarding the export of Texas produced crude petroleum when in-state energy shortages occur, and regarding foreign imports of crude petroleum and imports of coal when in-state fuel shortages occur during a simulation analysis (Appendix Figure 2). The Texas energy supply constraint is carefully brought to bear upon the analysis through the use of estimated Texas supplies of crude oil and natural gas. These Texas oil and gas supply equations are included directly in the model as accounting controls upon the crude oil and natural gas sectors. Also, new technology in the form of nuclear and coal-fired steam electric power generation and coal-fired boilers in selected heavy industries is included. Substitution of fuels by major fuel-using industries in response to fuel price changes is reflected within the model through a systematic change in the input coefficients of these sectors. The detailed steps and equations are explained below.

The purpose of this analysis is to evaluate the direct and indirect economic effects of fuel shortages upon the Texas economy. One analytic option specifically provided in the simulation model is to hold fuel imports at zero and reduce Texas exports of crude petroleum and natural gas until in-state demand equals Texas supply if this is possible. If exports are reduced and calculated in-state demands for fuel still exceed in-state fuel supplies for any given production period of the simulation, the scarce petroleum resource is allocated among competing sectors. Linear programming is used to make the allocation. The objective function of the linear programming model is to maximize gross state product. The Input-Output model coefficients are used in this linear programming problem. The Input-Output model is then determined for that simulation period and the relevant economic variables are calculated and used in estimating the "beginning conditions" for the following year of the simulation analysis.

An alternative analytic option to solving the model when Texas supplies of fuels are less than calculated demands at estimated market prices is to import enough crude petroleum and coal to satisfy both the in-state and Texas export market demands. This option is exercised by arbitrarily relaxing the controls upon the import sector. The results of these simulations can be compared with those in which other import policies are in effect for purposes of estimating the effects of alternative import policies upon the Texas economy. The calculating details are explained below. Data sources and assumptions about data points pertaining to each equation are also identified and explained.

There are six sequential steps through which the simulation model passes when calculating an annual solution during a simulation (Appendix Table 6). In step 1, household consumption demand is estimated for each of the forty-eight processing sectors, household services, and imports. The population equation [(C-1) of Appendix Table 6] estimates current year's population of households as last year's population of households plus the exogenously specified natural rate of increase r(t), plus migration (positive or negative) determined by the gap between labor supply and labor demand in the previous time period--allowing for a long-term rate of unemployment represented by 1/UR, where UR equals one plus the unemployment rate. In this analysis the parameter r was taken to be 0.011, which was the 1967 natural rate of population increase. In the model, this parameter may be specified to change with time if the rate is expected to change significantly. The UR parameter was taken to be one plus 0.038, the approximate unemployment rate for Texas in the late 1960's and early 1970's. In the analyses, this parameter may also be changed with time.

The beginning level of population was taken to be the July 1, 1966 estimates from the Department of Commerce, Bureau of the Census, "Current Population Reports."1/ Employment and unemployment rates used for the base year were taken from Texas Employment Commission estimates. Labor available was estimated as employment plus unemployment in the base year. The labor participation rate was estimated as the ratio of the base year labor available to the number of household heads.

The per household consumption demand equation (C-2) estimates the total consumption per household for the current time period as an exponentially declining function of ten prior years' per household disposable income. The income estimates were constructed from the Survey of Current Business state estimates adjusted for state, local, and federal taxes paid (including individual contributions to social insurance) converted to per household levels based on the Bureau of the Census, Current Population estimates for 1965 through 1967, census counts for 1960 and interpolations for 1961 through 1964.2/ The coefficient "C" of the equation (C-2) was

1/ U.S. Department of Commerce, Bureau of the Census, "Current Population Reports," P-25, Nos. 356, 396, and 425, U.S. Government Printing Office, Washington, D.C., Jan. 1967, July 1968, and June 1969.

2/ U.S. Department of Commerce, Bureau of Economic Analysis, Survey of Current Business, Vol. 54, Number 8 , U.S. Government Printing Office, Washington, D.C., 1974.

taken to be the calculated value for the base year, given the consumption and personal income data mentioned above.

In step 2, the capital investment part of final demand in year t is calculated (Appendix Table 6). Current year (year t) expansion capital is a function of capital required to produce projected final demand excluding the expansion or growth part of capital. The equation (I-1) projects non-capital final demand (goods and services that are consumed rather than invested) as a linear extension of the previous three year moving average non-capital final demand. In effect, this equation is based on the assumption that businessmen base expectations of output markets for non-capital production items on recent growth trends. On the basis of this three year moving average of non-capital final demand, a ten year projection of capital requirements is made.[1/] Given projected non-capital final demand, the equation (I-2) is solved for $\Delta K(t)'$--the expansion capital requirements to provide the capacity to produce projected non-capital final demand $\hat{Y}K$. One-tenth of the requirement is taken for the current year's investment demand as expressed by the parameter RK in equation (I-1). Equation (I-2) is the matrix expression for the dual set of simultaneous equations:

$$CX(t) - E\Delta K(t)' = \hat{Y}K(t) \qquad \text{(I-2a)}$$

$$KX(t) - I\Delta K(t)' = \overline{KO}(t-1) \qquad \text{(I-2b)}$$

where:

C = (I-A)

A = Input coefficients calculated from the Transactions Table of the base year Input-Output model.

1/ Note: The system could operate on a one-year planning horizon, but annual fluctuations from such calculations are not justified for long-term simulations. The ten-year planning horizon smooths the projected growth in expansion capital.

Appendix Table 6. Steps in Simulating Economy

STEP 1. Compute Household Consumption Demand for Time, t

a) Compute population of heads of household

$$P(t) = P(t-1)\left[r(t) + \frac{L_R(t-1)}{L_A(t-1)} \cdot UR\right] \qquad (C\text{-}1)$$

where:

P = population of heads of households, from Step 1 in (t-1)
r = natural population growth rate, exogenously determined
L_R = labor required, from Step 5 in (t-1)
L_A = labor available, from Step 5 in (t-1)
UR = unemployment factor

b) Compute per household total consumption demand

$$PC(t) = C\left[\frac{PDI(t-1)}{e^0} + \ldots + \frac{PDI(t-10)}{e^9}\right] \qquad (C\text{-}2)$$

where:

PC = total per household consumption demand
C = empirically determined constant
PDI = per household disposable income, from Step 5 in nine previous time periods.

c) Compute household consumption demand by sector (includes imports and services from households)

$$Y_{ih}(t) = \left[e_i\, w\left(\frac{PC(t-1)}{PC(t-2)} - 1\right) + 1\right] \frac{P(t)\; Y_{ih}(t-1)}{P(t-1)} \qquad (C\text{-}3)$$

where:

Y_{ih} = household consumption demand for processing sectors, household services, and imports
e_i = income elasticity coefficient
w = weight required to make $\Sigma_i Y_{ih} = PC$
$i = 1, \ldots, n+2$
n = number of processing firms.

STEP 2. Compute Industrial Investment Demand

a) Compute expected final demand ten years forward exclusive of private expansion capital

$$\widehat{YK}(t) = YK(t-1) + \left(\frac{\Delta YK_1 + \Delta YK_2 + \Delta YK_3}{3}\right) \cdot RK \qquad (I\text{-}1)$$

where:

$\widehat{YK}$ = expected final demand ten years forward exclusive of private expansion capital
YK = Final demand exclusive of private expansion capital
$\Delta YK_1 = YK(t-1) - YK(t-2)$
$\Delta YK_2 = YK(t-2) - YK(t-3)$
$\Delta YK_3 = YK(t-3) - YK(t-4)$
$RK = 10$

b) Compute private investment demand, $\Delta K(t)$, (matrix notation)

$$\begin{bmatrix} X(t) \\ \hline \Delta K(t)' \end{bmatrix} = \left[\begin{array}{c|c} C & -E \\ \hline K & -I \end{array}\right]^{-1} \begin{bmatrix} \widehat{YK}(t) \\ \hline \bar{K}_0(t-1) \end{bmatrix} \qquad (I\text{-}2)$$

where:

$\Delta K(t)'$ = private investment demand to meet expansion requirements for ten year projected final demand
$\Delta K(t) = \frac{1}{RK} \cdot \Delta K(t)' \quad C = (I-A)$
K = capital expansion matrix
E = operator which subtracts $1/10\Delta K$ from output level $X(t)$
I = Identity matrix
$\bar{K}_0 = K\, X(t-1)$
A = technical coefficients

c) Project Y_{F1}, Y_{F2}, Y_s, Y_L (Government Demands), and Y_e (exports) exogenously, at fixed annual rate of increase.

STEP 3. Compute Total Final Demand, $Y(t)$, (matrix notation)

$$Y(t) = Y_h(t) + Y_{F1}(t) + Y_{F2}(t) + Y_s(t) + Y_L(t) + \Delta K(t) + Y_e(t) \qquad (D\text{-}1)$$

where:

Y_h is determined from Step 1
Y_{F1}, Y_{F2}, Y_e, and portions of Y_s and Y_L are exogenously determined
ΔK is determined from Step 2

STEP 4. Compute Sector Output Given Resource Constraints (matrix notation)

Option a) Compute output levels

$$X(t) = (I-A)^{-1}\, Y(t) \qquad (P\text{-}1)$$

subject to: $R(t)\; XN(t) \le L(t)$
$Y'(t) \le Y(t)$

where:

X = output of processing sectors $i = 1, \ldots, n$
I = identity matrix
A = technical coefficients
Y = final demand from Step 3
Y' = final demand supplied from LP solution
R = resource requirements matrix
XN = vector of sector output, X, household consumption, PC, and government expenditures, $\bar{Y}_{F1}$, $\bar{Y}_{F2}$, $\bar{Y}_s$, $\bar{Y}_L$
L = resource availability

If $R(t)\; XN(t) > L(t)$, reduce $Y_e(t)$, then if constraint is still operative, maximize $\sum_{j=1}^{n} VA_j$, subject to $R(t)\; XN \le L(t)$ where differences between $Y'(t)$ and $Y(t)$ is imported. Household consumption patterns are maintained as estimated in Step 1.

Option b) Compute output levels given increased imports as required to meet demand.

STEP 5. Compute Labor Available, Labor Required, Per Household Disposable Income, Savings, Taxes, Primary Resource Use, and Projected Primary Resource Availability (Matrix notation)

a) Compute labor and natural resource use

$$R(t)\; XN(t) = r \qquad (R\text{-}1)$$

b) Compute labor available, $L_A(t)$

$$L_A(t) = lp\; P(t) \qquad (R\text{-}2)$$

where:

$lp(t)$ = labor force participation rate

c) Per household disposable income

$$PDI(t) = \left[\sum_j z_{hj}\, X_j(t) + Y_{hh}(t) + Y_{hF1}(t) + Y_{hF2} + Y_{hs}(t) + Y_{hL}(t) + Y_{he}(t)\right] - \left[Y_{Fh}(t) + Y_{sh}(t) + Y_{Lh}(t)\right] \div P(t) \qquad (R\text{-}3)$$

where:

$\Sigma z_{hj}X_j + Y_{hh} + Y_{hF1} + Y_{hF2} + Y_{hs} + Y_{hL} + Y_{he}$ = Total Personal Income

$Y_{Fh} + Y_{sh} + Y_{Lh}$ = Tax (t)

$$Y_{Fh}(t) = \left[e_F\left(\frac{PI(t-1)}{PI(t)} - 1\right) + 1\right] \frac{P(t)}{P(t-1)} \left[Y_{Fh}(t-1)\right] = \text{Federal Tax} \qquad (R\text{-}4)$$

$$Y_{sh}(t) = \left[e_s\left(\frac{PI(t-1)}{PI(t)} - 1\right) + 1\right] \frac{P(t)}{P(t-1)} \left[Y_{sh}(t-1)\right] = \text{State Tax} \qquad (R\text{-}5)$$

$$Y_{Lh}(t) = \left[e_L\left(\frac{PI(t-1)}{PI(t)} - 1\right) + 1\right] \frac{P(t)}{P(t-1)} \left[Y_{Lh}(t-1)\right] = \text{Local Tax} \qquad (R\text{-}6)$$

e) Compute Household Savings

$$Y_{vh}(t) = PI(t) - Tax(t)$$

STEP 6. Summarize Regional Accounts and Calculate next year's fuel prices and substitutions.

$$P_{ij}(t) = f_i(P_1(t))$$

$$Q_{ij}(t) = f_j[P_{ij}(t),\; Q_{ij}(t-1),\; E_{ij}]$$

$i = 1, 2 \ldots$ number of fuels
$j = 1, 2 \ldots$ number of user classes
$l = 1, 2 \ldots$ number of primary energy sources

I = Identity matrix

K = Expansion capital matrix

$\overline{KO}$ = Base year capital stock

E = An operator to calculate the annual part of the projected ten-year total capital requirements.

ΔK = Expansion capital

X = Sector output

The equation (I-2a) is recognized as the usual solution to a static annual input-output model if ΔK is moved to the right-hand side and added to $\hat{YK}$ yielding $CX(t) = Y(t)$

Where:

$$Y(t) = \hat{YK}(t) + \Delta K(t) = \text{total final demand}$$

The equation (I-2b) says that expansion capital, $\Delta K(t)$ equals the difference in the capital stock required to move from $X(t-1)$ to $X(t)$, the new level of output. That is:

$$\Delta K(t) = KX(t) - KX\ (t-1)$$

Where:

$$KX\ (t-1) = \overline{KO}$$

The final part of Step 2 consists of a set of equations for projecting the level of government and out-of-state export demand (Appendix Table 6). For analytic purposes two options have been identified and included in the model. The analyst can either include these vectors of final demand projected at historic linear growth rates or these vectors may be projected at an annual rate of increase over the previous year's level; i.e.; an exponential growth rate.

Total final demand is the sum of household consumption demand (Y_h), federal, state, and local government demand (Y_{F1}, Y_{F2}, Y_S, and Y_L), private expansion capital demand (ΔK), and export demand (Y_e) (Appendix Table 6, Step 3). Labor demand calculated in Step 5 is based on these data for households and governments. Energy demand for households, governments, and exports is computed from the data of these vectors listed in Step 3.

The method of solving the simulation model for year t when crude oil and natural gas supplies are less than the total required to permit production levels needed to satisfy projected final demands for year t is to use a linear programming model in which the Input-Output model coefficients are applied (Appendix Table 6, Step 4). The objective of the linear programming analysis is to find a solution to the simulation model which satisfies as much of projected year t final demand as possible subject to the crude petroleum supply constraints. The objective function coefficients of the linear programming model is value added as calculated from the Input-Output model.

The simulation model contains options whereby the economic effects of alternative crude petroleum import and export policies can be evaluated. In option (a), the model computes output levels required to meet final demand calculated in Step 3, subject to supply limitations of crude oil and natural gas. Supply functions for Texas crude oil and natural gas provide estimates of the quantity of oil and gas available for each time period. An assumed quantity of Texas lignite is also specified. If demand is greater than supply at the specified price level, out-of-state exports of crude oil and natural gas are reduced until the constraint is satisfied or exports are reduced to zero. If exports are reduced to zero, the remaining shortage is allocated among Texas industrial users by the linear programming technique of the model which reduces output of the Texas (and thus crude oil and/or natural gas requirements) until the constraint is satisfied. This option does not allow increased imports of petroleum or coal to satisfy energy supply shortages. As a result of the energy supply constraints and the subsequent allocation of Texas produced petroleum to the highest market valued user, some final demands within Texas will not be satisfied from Texas production. The simulation model then calculates the quantity of out-of-state imports of finished goods that are required to maintain Texas final demand consumption at the level at which Texas income indicates such consumption would occur.

Option (b) of Step 4 calculates the demand for crude oil, natural gas, coal, and nuclear fuel and compares the demand to Texas supply available under the specified price levels. If supply is short, imports are increased to make up the shortage at exogenously specified import prices. The input coefficients of the Input-Output model are then adjusted to reflect the relative increase in imports and the relative reduction in purchases from Texas oil, gas, and coal producers. The simulation model permits the analysts to vary the prices for imported crude oil, natural gas, coal, and nuclear fuels so as to calculate the economic effects of alternative costs of imported energy materials.

In Step 5 of the simulation solution, the results obtained in Step 4 are used to calculate each sector's level of use of labor, water and energy resources. In addition, calculations are also made for other factors including household income, taxes paid to local, state, and federal governments, household savings, and labor available. Per capita disposable income is calculated as per capita personal income minus federal, state, and local taxes. Personal savings are calculated as the residual of personal income after taxes and consumption. Equations (R-4), (R-5), (R-6) calculate federal, state, and local taxes, respectively, as a function of personal income, population, and tax elasticities based on the current tax structure for personal taxes. The base year personal income data were from official published sources. The population data are the same as in Step 1, and the tax elasticity coefficients were obtained from a previously completed special report. 1/

Step 6 of the simulation solution summarizes various accounts and updates variables for use in the next year's simulation. In addition, prices of petroleum refinery products (gasoline, jet fuel, feedstocks, and fuel oil), natural gas from distributors, and electricity to various classes of consumers are calculated as a function of the weighted average price for primary energy, crude oil, natural gas, coal, and nuclear fuel. In the case of imported oil and gas, the weighted average price is a function of the price levels of imports and the quantity imported as determined by Texas in-state and export demand minus Texas in-state supply. The prices for electricity are estimated as functions of fuel cost increases from a survey of the electric utility industry. The functions are:

$\%\Delta P_{ec} = 0.214\ \%\Delta FC$

$\%\Delta P_{ei} = 0.378\ \%\Delta FC$ Δ is the symbol meaning change

$\%\Delta P_{eh} = 0.186\ \%\Delta FC$

Where:

P_{ec} = price of electricity to commercial sectors

P_{ei} = price of electricity to industrial sectors

P_{eh} = price of electricity to household sector

FC = fuel cost for electric power generation

1/ Mullendore, Walter E., and Arthur L. Ekholm, " Projections of Final Demand for Texas," Unpublished report, Office of the Governor, Austin, Texas, August 1972.

The price functions for natural gas by three consumer classes are written as:

$$\%\Delta P_{gc} = K_g \; \%\Delta P_g$$

$$\%\Delta P_{gi} = K_g \; \%\Delta P_g$$

$$\%\Delta P_{gn} = K_g \; \%\Delta P_g$$

Δ is the symbol meaning change.

Where:

P_{gc} = gas price to commercial sectors

P_{gi} = gas price to industrial sectors

P_{gh} = gas price to household sector

P_g = price of gas on the input side

K_g = constant such that long range profit due to price increase for the natural gas services sector is near zero.

The price functions for petroleum products are similar to those for natural gas and relate the price of gasoline, price of jet fuel, the price of feedstocks, and the price of fuel oil to the price of crude oil to the refinery sector. The general form of the equations is as follows:

$$\%\Delta P_q = K_r \; \%\Delta P_c$$

$$\%\Delta P_j = K_r \; \%\Delta P_c$$

$$\%\Delta P_f = K_r \; \%\Delta P_c$$

$$\%\Delta P_o = K_r \; \%\Delta P_c$$

Δ is the symbol meaning change.

Where:

P_q = wholesale price of gasoline from the refinery

P_j = wholesale price of jet fuel from the refinery

P_f = wholesale price of feedstocks from the refinery

P_o = wholesale price of fuel oil from the refinery

P_c = weighted average price of crude oil to refineries

K_r = constant such that long profit due to price increases for the refinery sector is near zero.

The supply prices for the various fuels in combination with the price elasticities of demand determine the quantity taken by residential, commercial, governments, and selected industrial sectors. Fuel substitutions for the heavy fuel-using sectors, chemicals, primary metals, pulp and paper, and electric utilities are predetermined by the Houston Integrated Linear Programming Model given the price of crude oil, natural gas, and coal.[1/]

The adjustments mentioned above are made at the end of the model solution for an individual year and are the beginning conditions for the calculations of the next year's simulation. The data used are presented in a series of tables at the end of this section.

Texas Crude Oil and Natural Gas Supply Functions

The quantity of crude oil and natural gas in place is fixed, but the portion of that total which is ultimately recovered will depend on a number of factors. In addition, the option is always available (within physical pumping limits) to pump and market a given portion of the remaining reserves in the current time period or to postpone pumping until a later time. The portion of the original oil and gas in place which can be physically withdrawn is determined by the current and future recovery technology. The quantity actually pumped, under free market conditions, is determined primarily by the price of the product and the cost of operating, given certain lag times for exploration, drilling, pipeline installation, and the availability of investment capital by the producer. The general form of the supply estimating equations is:[2/]

Exploratory Effort:

$$F_t = f\ (S_{t-1},\ P_{Gt},\ P_{ot}) \qquad (1)$$

1/ Thompson, Russell G., Rodrigo J. Lievano, and Robert R. Hill, Preliminary Estimates from "Energy Supply and Demand Analysis." Preliminary draft, prepared for the Governor's Energy Advisory Council, University of Houston, December, 1974.

2/ Ibid.

where:

F_t = footage drilled in year t

S_{t-1} = success ratio in year t-1

P_{Gt} = price in 1972 dollars per mcf of natural gas at the wellhead

P_{ot} = price in 1972 dollars per barrel of crude oil at the wellhead

Given:

$$S_{t-1} = a + b\ S_{t-2} \quad (2)$$

Where the parameters a and b are estimated using least squares regression with data from 1955 to 1968.

Addition to Reserves;

$$R_t = r\ (F_t) \quad (3)$$

$$G_t = g\ (F_t) \quad (4)$$

Where:

R_t = additions to crude oil proved reserves per foot of drilling in year t

G_t = additions to natural gas proved reserves per foot of drilling in year t

Development and Production:

$$C_{nt} = c\ (PVEC_t,\ PVDC_t,\ PVOC_t,\ PVR_t) \quad (5)$$

Where:

C_{nt} = initial capacity to be developed from new reserves found in year t,

$PVEC_t$ = present value of exploration costs in year t,

$PVDC_t$ = present value of development costs in year t,

$PVOC_t$ = present value of operating costs in year t,

PVR_t = present value of reserves in year t.

Given:

F_t from (1)

R_{nt}, the new reserves found in year t

P_{Gt} and P_{ot}, the wellhead price of gas and oil

C_o, the initial capacity in barrels per year

W_o, the initial number of producing wells

I_w, the investment in 1972 dollars per development well

I_{EW}, the investment in 1972 dollars per exploratory well

F_o, the average footage per exploration well

R_t from (3)

G_t from (4)

r, the rate of discount

T_o, the economic depletion of well producing in 1972

T_e, the lag time in years from the start of year t until the reserves found in year t can be developed to initial capacity.

Production from Proved Reserves in 1972:

$$PD_{ot} = p\ (R_o, P_G, P_o, I_a) \quad (6)$$

$$PD_{Gt} = g\ (R_G, P_G, P_o, I_a) \quad (7)$$

Where:

PD_{ot} = production of oil from proved reserves

PD_{Gt} = production of gas from proved reserves

R_o = proved reserves of oil

R_G = proved reserves of gas

P_o = wellhead price of oil

P_G = wellhead price of gas

I_a = investment alternative

The oil and gas supply functions were combined with the Input-Output Simulation Model to determine the quantity of Texas oil and gas available in each simulated time period for either export or use in Texas industry. The model allows the analysis of import policies by analyzing the effects of increasing imports of oil and gas or reducing exports of oil and gas to insure that projected supply and demand balance, based on the Texas oil and gas supply functions.

Texas Energy Demand Functions: Price and Income Elasticities

The demand for energy by principal classifications of users, including industrial use of fuels and electricity as well as household use of electricity, natural gas, and gasoline, responds to price, changes in tastes and preferences, income, the availability of substitutes, and prices of substitutes. The increased price of crude oil and natural gas, as mentioned in the previous section on supply response, implies sharp increases in the cost of petroleum refinery products, natural gas for fuel, feedstocks for petrochemicals, and electricity. As producers of these energy products try to pass costs along to their consumers, varying degrees of difficulty will be found depending upon the consumer classification and the related price elasticities of demand. The general form of the energy demand estimating equations is:[1/]

Residential Electricity Demand;

$$\varepsilon_t = \ell\,(P_t, Y_t, \dot{D}_t, \varepsilon_{t-1})$$

1/ Thompson, Russell, G., Rodrigo J. Lievano, and Robert R. Hill, "Energy Supply and Demand Analysis," Preliminary draft prepared for the Governor's Energy Advisory Council, University of Houston, December, 1974.

where:

ε_t = KWH electricity consumption in time t

P_t = price of electricity per KWH in time t

V_t = personal income in time t

D_t = number of cooling degree-days in time t

Transportation Gasoline Demand;

$$W_t = g\ (P_t, Y_t, W_{t-1})$$

where:

W_t = gasoline consumption in time t

P_t = price of gasoline in time t

V_t = personal income in time t

W_{t-1} = gasoline consumption in time t-1

Industrial Demand;

The industrial demand for energy was estimated through the use of a large-scale linear programming model of eight major fuel-using industries; petroleum refining, organic chemicals, inorganic chemicals, cyclics, alkalies and chlorine, synthetic rubber, fertilizers, and electric power generation. The model allows demand estimates by fuel source, given water and air pollution effluent control standards and fuel prices. Given a set of output requirements, supplies of raw material inputs, and water and air efficient limitations, the model gives the optimal mix of inputs and processes which minimizes production costs.

Estimates of price and income elasticity of demand for those fuels included in the work by Thompson and associates at the University of Houston were used in the simulation model (Appendix Table 7).[1/] For other fuels, estimates from recent national studies were used. Specifically, price and income elasticity of demand for residential use of electricity and total use of gasoline in Texas from the University of Houston study were used (Appendix Table 7). The Chapman and Tummala estimates were used in the case of natural gas and industrial and commercial electricity demand. [2/] In addition, an integrated linear programming model of heavy fuel-using sectors from the University of Houston study was used to determine the fuel mix directly for certain heavy fuel-using sectors in the model under given price assumptions rather than using price elasticities. [3/]

Data and Parameter Estimates

Parameter estimates and data for beginning conditions discussed in the previous section are presented in the following set of tables (Appendix Tables 8-17). Included are population and income data, output levels by Input-Output model sector, "energy" coefficients by Input-Output model sector for refinery products, natural gas, electricity, and natural gas liquids and income elasticity coefficients for relating household income changes to the distribution of consumption espenditures by Input-Output model sector. Equations fitted to indexes of labor productivity by major sector are also shown in Appendix Table 17.

1/ Ibid.

2/ Chapman, D., Tyrell, T., and Mount, T., "Electricity Demand Growth and the Energy Crisis," Science, Volume 178, No. 4062, November 17, 1972; and Tummala, V., "Alternative Methods of Estimation in the Demand for Natural Gas," Unpublished Ph.D. dissertation, Michigan State University, 1968.

3/ op. cit.

Appendix Table 7. Price and Income Elasticities of Demand for Electricity, Gasoline, and Natural Gas

Product	Price Elasticity of Demand		Income Elasticity of Demand	
	Short Run	Long Run	Short Run	Long Run
Electricity				
Residential[a/]	-0.10	-0.65	0.30	1.80
Commercial[b/]	-	-1.50	-	-
Industrial[b/]	-	-1.70	-	-
Gasoline[a/]	-0.20	-1.40	0.15	1.10
Natural Gas[c/]				
Residential and Commercial	-0.44	-1.63	-	-
Industrial	-0.70	-1.33	-	-

a/ Source: Thompson, Russell G., Rodrigo J. Lievano, and Robert R. Hill "Energy Supply and Demand Analysis," preliminary draft prepared for the Governor's Energy Advisory Council, University of Houston, December, 1974.

b/ Source: Chapman, D., T. Tyrell, and T. Mount, "Electricity Demand Growth and the Energy Crisis," Science, Volume 178, No. 4062, November 17, 1972.

c/ Source: Tummala, V., "Alternative Methods of Estimation in the Demand for Natural Gas." Unpublished Ph.D. dissertation, Michigan State University, 1968.

Appendix Table 8. Texas Population and Households, 1960-1967.

Year	Population[1/] (1,000 Units)	Households[2/] (1,000 Units)	Ratio of Population[3/] to Households
1960	9,579	2,778	3.449
1961	9,820	2,861	3.432
1962	10,053	2,944	3.415
1963	10,159	2,989	3.399
1964	10,270	3,037	3.382
1965	10,378	3,084	3.365
1966	10,492	3,154	3.327
1967	10,599	3,205	3.307

1/ 1960 and 1970 are April 1 Census Counts of total resident population. 1961 through 1967 are July 1 annual estimates of total resident population from U. S. Department of Commerce, Bureau of the Census, "Current Population Reports," P-25, No. 460, U.S. Government Printing Office, Washington, D.C., June, 1971.

2/ 1960 and 1970 are April 1 Census Counts of total households. 1965, 1966, and 1967 are July 1 estimates of total households from U. S. Department of Commerce, Bureau of the Census, "Current Population Reports," P-25, No. 356, 396, and 425. U. S. Government Printing Office, Washington, D.C., June, 1967, July, 1968, and June, 1969. 1961 through 1964 were estimated from population and interpolated population per household ratios.

3/ Calculated from known data. 1961 through 1964 estimates were calculated as straight line interpolation between 1960 and 1965.

Appendix Table 9. Texas Personal Income, Taxes and Savings, and Per Household Personal Disposable Income, 1960-1967.

Year	Personal Income [a/] (Million Dollars)	Personal Taxes [b/] (Million Dollars)	Personal Disposable Income (Million Dollars)	Per Household Disposable Income (Dollars)
1960	18,677	2427	16,250	5852.8
1961	19,624	2597	17,027	5951.4
1962	20,630	2751	17,879	6073.0
1963	21,694	2937	18,757	6275.3
1964	23,162	2914	20,248	6667.1
1965	25,016	3142	21,874	7092.7
1966	27,643	3692	23,951	7593.8
1967	30,743	4256	26,487	8264.2

Source: a. U.S. Department of Commerce, Bureau of Economic Analysis, Survey of Current Business, Revised Personal Income Tables, Volume 54, No. 8, August 1974, p. 32-33.

b. Sum of state, federal, and local taxes paid by individuals Total estimated from Bureau of Economic Analysis, Personal Contribution for Social Insurance, U.S. Internal Revenue Service, Statistics of Income, and U. S. Bureau of the Census, Governmental Finances. U. S. Government Printing Office, Washington, D. C.

Appendix Table 10. Total Value of Output by Input-Output Model, Texas, 1967.

Sector	Industry	Value of Output (Million Dollars)
1	Irrigated Crops	1,009.275
2	Dryland Crops	693.248
3	Livestock and Poultry	1,659.969
4	Agricultural Services	325.697
5	Primary Forestry and Fisheries	88.060
6	Crude Petroleum	4,453.742
7	Natural Gas Liquids	732.604
8	Oil and Gas Field Services	627.032
9	Other Mining	233.100
10	Residential Construction	1,315.554
11	Commercial, Educational, and Instit.	2,740.164
12	Facility Construction	2,181.531
13	Food Processing	3,893.601
14	Textile and Apparel	848.670
15	Logging, Wood, and Paper	1,611.699
16	Chlorine and Alkalies	140.700
17	Cyclic Crudes and Intermediate Pigments	201.500
18	Organic Chemicals	1,928.410
19	Inorganic, Plastics, Rubber	1,053.593
20	Drugs, Chemicals, Soaps, and Paint	659.038
21	Petroleum Refining	6,333.422
22	Other Petroleum Products	85.869
23	Tires, Rubber, Plastics, Leather	324.652
24	Glass, Clay, Stone, Cement	664.570
25	Primary Metal Processing	2,600.501
26	Industrial Equipment Manufacturing	1,413.231
27	Electric Applicance Manufacturing	923.485
28	Aircraft, Motor Vehicle	3,028.568
29	Instruments, Photography, Games	1,077.436
30	Rail Transportation	517.453
31	Intercity Highway Transportation	121.092
32	Motor Freight Transportation	890.482
33	Water Transportation	340.678
34	Air Transportation	275.512
35	Pipeline Transportation	379.333
36	Other Transportation	24.715
37	Communications	902.302
38	Gas Services	1,618.066
39	Electric Services	1,039.165
40	Water and Sanitary Services	229.711

(Continued)

Appendix Table 10.(Continued)

Sector	Industry	Value of Output (Million Dollars)
41	Wholesale Trade	4,254.993
42	Other Retail Trade	4,585.171
43	Auto Dealers and Repair Shops	1,704.704
44	F.I.R.E.	4,357.776
45	Other Services	4,953.845
46	Lodging, Amusement, Recreation	546.566
47	Education	1,944.160
48	Outdoor Recreation	54.650
49	Households	
50	Federal Government (Military*	

Appendix Table 11. Employment Per One Million Dollars of Output by Input-Output Model Sector, 1967.

Sector	Industry	Employment Per One Million Dollars of Output (number)
1	Irrigated Crops	73.448
2	Dryland Crops	79.647
3	Livestock and Poultry	84.944
4	Agricultural Services	42.629
5	Primary Forestry and Fisheries	22.273
6	Crude Petroleum	9.520
7	Natural Gas Liquids	7.226
8	Oil and Gas Field Services	76.911
9	Other Mining	28.560
10	Residential Construction	
11	Commercial, Educational, and Instit.	62.793
12	Facility Construction	31.020
13	Food Processing	23.875
14	Textile and Apparel	84.552
15	Logging, Wood, and Paper	75.578
16	Chlorine and Alkalies	34.262
17	Cyclic Crudes and Intermediate Pigments	12.578
18	Organic Chemicals	14.211
19	Inorganic, Plastics, Rubber	9.894
20	Drugs, Chemicals, Soaps, and Paint	22.554
21	Petroleum Refining	5.734
22	Other Petroleum Products	32.064
23	Tires, Rubber, Plastics, Leather	42.727
24	Glass, Clay, Stone, Cement	42.722
25	Primary Metal Processing	35.879
26	Industrial Equipment Manufacturing	48.389
27	Electric Applicance Manufacturing	38.852
28	Aircraft, Motor Vehicle	31.293
29	Instruments, Photographry, Games	26.275
30	Rail Transportation	78.044
31	Intercity Highway Transportation	105.126
32	Motor Freight Transportation	75.018
33	Water Transportation	67.605
34	Air Transportation	66.069
35	Pipeline Transportation	14.735
36	Other Transportation	216.443
37	Communications	59.905
38	Gas Services	12.897
39	Electric Services	23.964
40	Water and Sanitary Services	79.085

(Continued)

Appendix Table 11.(Continued)

Sector	Industry	Employment Per One Million Dollars of Output (number)
41	Wholesale Trade	55.897
42	Other Retail Trade	112.335
43	Auto Dealers and Repair Shops	72.881
44	F.I.R.E.	40.691
45	Other Services	87.502
46	Lodging, Amusement, Recreation	123.183
47	Education	103.679
48	Outdoor Recreation	101.784
49	Households	35.771
50	Federal Government (Military*	-
51	Federal Government (Non-Military)*	74.947
52	State Government*	99.652
53	Local Government*	503.648

a/ Employment divided by output values from Appendix Table 11. Households, Federal Government, State Government, and Local Governments Coefficients are employment divided by million dollars of payments made to households. Employment data are from the Texas Employment Commission.

* Labor Requirements per one million dollars of payments to households in 1967.

Appendix Table 12. Purchased Refinery Product Requirements Per Unit of Output by Input-Output Model Sector, 1967.

Sector	Industry	Refinery Products Per One Million Dollars of Output (Thousand Barrels)
1	Irrigated Crops	7.918
2	Dryland Crops	11.031
3	Livestock and Poultry	2.059
4	Agricultural Services	3.862
5	Primary Forestry and Fisheries	4.497
6	Crude Petroleum	.464
7	Natural Gas Liquids	7.527
8	Oil and Gas Field Services	3.812
9	Other Mining	2.853
10	Residential Construction	.014
11	Commercial, Educational, and Instit.	.027
12	Facility Construction	1.428
13	Food Processing	.554
14	Textile and Apparel	.251
15	Logging, Wood, and Paper	.934
16	Chlorine and Alkalies	3.753
17	Cyclic Crudes and Intermediate Pigments	23.648
18	Organic Chemicals	5.810
19	Inorganic, Plastics, Rubber	1.016
20	Drugs, Chemicals, Soaps, and Paint	1.704
21	Petroleum Refining	3.217
22	Other Petroleum Products	71.656
23	Tires, Rubber, Plastics, Leather	.166
24	Glass, Clay, Stone, Cement	.664
25	Primary Metal Processing	1.059
26	Industrial Equipment Manufacturing	.567
27	Electric Applicance Manufacturing	.165
28	Aircraft, Motor Vehicle	.341
29	Instruments, Photographry, Games	.769
30	Rail Transportation	6.915
31	Intercity Highway Transportation	17.309
32	Motor Freight Transportation	10.823
33	Water Transportation	9.067
34	Air Transportation	6.326
35	Pipeline Transportation	4.371
36	Other Transportation	.890
37	Communications	.975
38	Gas Services	.235
39	Electric Services	.630
40	Water and Sanitary Services	.914

(Continued)

Appendix Table 13. Purchased Natural Gas Requirements Per Unit of Output by Input-Output Model Sector, 1967

Sector	Industry	Natural Gas Per One Million Dollars of Output (Billion Cubic Feet)
1	Irrigated Crops	.0550
2	Dryland Crops	-
3	Livestock and Poultry	.0028
4	Agricultural Services	.0123
5	Primary Forestry and Fisheries	.0011
6	Crude Petroleum	.0015
7	Natural Gas Liquids	-
8	Oil and Gas Field Services	.0040
9	Other Mining	.0257
10	Residential Construction	.0008
11	Commercial, Educational, and Instit.	.0011
12	Facility Construction	.0005
13	Food Processing	.0079
14	Textile and Apparel	.0073
15	Logging, Wood, and Paper	.0084
16	Chlorine and Alkalies	.4364
17	Cyclic Crudes and Intermediate Pigments	.4514
18	Organic Chemicals	.2717
19	Inorganic, Plastics, Rubber	.0450
20	Drugs, Chemicals, Soaps, and Paint	.0156
21	Petroleum Refining	.0694
22	Other Petroleum Products	.0510
23	Tires, Rubber, Plastics, Leather	.0136
24	Glass, Clay, Stone, Cement	.1114
25	Primary Metal Processing	.0464
26	Industrial Equipment Manufacturing	.0075
27	Electric Applicance Manufacturing	.0031
28	Aircraft, Motor Vehicle	.0021
29	Instruments, Photographry, Games	.0068
30	Rail Transportation	.0039
31	Intercity Highway Transportation	.0083
32	Motor Freight Transportation	.0348
33	Water Transportation	.0003
34	Air Transportation	.0044
35	Pipeline Transportation	.0366
36	Other Transportation	.0040
37	Communications	.0030
38	Gas Services	.1175
39	Electric Services	.7448
40	Water and Sanitary Services	.0614

(Continued)

Appendix Table 12. (Continued)

Sector	Industry	Refinery Products Per One Million Dollars of Output (Thousand Barrels)
41	Wholesale Trade	2.014
42	Other Retail Trade	.461
43	Auto Dealers and Repair Shops	.556
44	F.I.R.E.	.213
45	Other Services	1.298
46	Lodging, Amusement, Recreation	.227
47	Education	.058
48	Outdoor Recreation	1.793
49	Households*	155.038
50	Federal Government (Military*	119.047
51	Federal Government (Non-Military)*	178.901
52	State Government*	178.810
53	Local Government*	178.957

*Refinery products requirements per one million dollars of payments for refinery products in 1967.

Appendix Table 13.(Continued)

Sector	Industry	Natural Gas Per One Million Dollars of Output (Billion Cubic Feet)
41	Wholesale Trade	.0067
42	Other Retail Trade	.0070
43	Auto Dealers and Repair Shops	.0040
44	F.I.R.E.	.0089
45	Other Services	.0055
46	Lodging, Amusement, Recreation	.0221
47	Education	.0135
48	Outdoor Recreation	.0018
49	Households	1.1820
50	Federal Government (Military*	3.1721
51	Federal Government (Non-Military)*	3.1437
52	State Government*	3.1888
53	Local Government*	3.1042

*Natural gas requirements per one million dollars of payments for natural gas and natural gas services in 1967.

Appendix Table 14. Purchased Electricity Requirements Per Unit of Output by Input-Output Model Sectors, 1967

Sector	Industry	Electricity Per One Million Dollars of Output (Million kwh)
1	Irrigated Crops	.6178
2	Dryland Crops	
3	Livestock and Poultry	
4	Agricultural Services	1.0898
5	Primary Forestry and Fisheries	.0443
6	Crude Petroleum	.1930
7	Natural Gas Liquids	.5969
8	Oil and Gas Field Services	.0819
9	Other Mining	.6594
10	Residential Construction	.0864
11	Commercial, Educational, and Instit.	.0826
12	Facility Construction	.0499
13	Food Processing	.5678
14	Textile and Apparel	.6492
15	Logging, Wood, and Paper	1.0106
16	Chlorine and Alkalies	1.4631
17	Cyclic Crudes and Intermediate Pigments	1.7408
18	Organic Chemicals	4.6605
19	Inorganic, Plastics, Rubber	2.6369
20	Drugs, Chemicals, Soaps, and Paint	.6466
21	Petroleum Refining	.6376
22	Other Petroleum Products	.6250
23	Tires, Rubber, Plastics, Leather	1.2808
24	Glass, Clay, Stone, Cement	1.4811
25	Primary Metal Processing	1.7349
26	Industrial Equipment Manufacturing	.4334
27	Electric Applicance Manufacturing	.3941
28	Aircraft, Motor Vehicle	.2133
29	Instruments, Photography, Games	.6807
30	Rail Transportation	.1813
31	Intercity Highway Transportation	.5863
32	Motor Freight Transportation	1.1025
33	Water Transportation	.1321
34	Air Transportation	.0490
35	Pipeline Transportation	1.5201
36	Other Transportation	.1111
37	Communications	.5928
38	Gas Services	.0504
39	Electric Services	-
40	Water and Sanitary Services	3.1443

(Continued)

Appendix Table 14. (Continued)

Sector	Industry	Electricity Per One Million Dollars of Output (Million kwh)
41	Wholesale Trade	.6726
42	Other Retail Trade	.8525
43	Auto Dealers and Repair Shops	.6512
44	F.I.R.E.	.8814
45	Other Services	.5103
46	Lodging, Amusement, Recreation	1.8846
47	Education	1.0036
48	Outdoor Recreation	1.5067
49	Households	48.1201
50	Federal Government (Military*	72.2283
51	Federal Government (Non-Military)*	72.2283
52	State Government*	72.2283
53	Local Government*	72.2283

* Electricity requirements per one million dollars of payments for electricity in 1967.

Appendix Table 15. Purchased Natural Gas Liquids Requirements Per Unit of Output by Input-Output Model Sector, 1967.

Sector	Industry	Natural Gas Liquids Per One Million Dollars of Output (Thousand Barrels)
1	Irrigated Crops	-
2	Dryland Crops	-
3	Livestock and Poultry	-
4	Agricultural Services	.1127
5	Primary Forestry and Fisheries	.2180
6	Crude Petroleum	.0049
7	Natural Gas Liquids	.0035
8	Oil and Gas Field Services	.0606
9	Other Mining	-
10	Residential Construction	-
11	Commercial, Educational, and Instit.	.0009
12	Facility Construction	.0004
13	Food Processing	.0791
14	Textile and Apparel	.0046
15	Logging, Wood, and Paper	.0379
16	Chlorine and Alkalies	45.1052
17	Cyclic Crudes and Intermediate Pigments	-
18	Organic Chemicals	38.8147
19	Inorganic, Plastics, Rubber	.0203
20	Drugs, Chemicals, Soaps, and Paint	.2200
21	Petroleum Refining	20.7696
22	Other Petroleum Products	.1933
23	Tires, Rubber, Plastics, Leather	1.3599
24	Glass, Clay, Stone, Cement	.0092
25	Primary Metal Processing	-
26	Industrial Equipment Manufacturing	.0197
27	Electric Applicance Manufacturing	.3948
28	Aircraft, Motor Vehicle	.0149
29	Instruments, Photography, Games	.0073
30	Rail Transportation	-
31	Intercity Highway Transportation	-
32	Motor Freight Transportation	-
33	Water Transportation	-
34	Air Transportation	-
35	Pipeline Transportation	-
36	Other Transportation	-
37	Communications	-
38	Gas Services	-
39	Electric Services	-
40	Water and Sanitary Services	.0344

(Continued)

Appendix Table 15.(Continued)

Sector	Industry	Natural Gas Liquids Per One Million Dollars of Output (Thousand Barrels)
41	Wholesale Trade	.0806
42	Other Retail Trade	.0629
43	Auto Dealers and Repair Shops	.0156
44	F.I.R.E.	-
45	Other Services	-
46	Lodging, Amusement, Recreation	-
47	Education	-
48	Outdoor Recreation	-
49	Households	264.5463
50	Federal Government (Military*	264.8936
51	Federal Government (Non-Military)*	275.0000
52	State Government*	275.0000
53	Local Government*	-

*Natural gas liquids requirements per one million dollars of payments for electricity in 1967.

Appendix Table 16. Income Elasticity Coefficients by Input-Output Model Sector, 1967.

Sector	Industry	Percent Change In Consumption From a One Percent Change In Disposable Income[a]
1	Irrigated Crops	.6443
2	Dryland Crops	.6443
3	Livestock and Poultry	.2574
4	Agricultural Services	-
5	Primary Forestry and Fisheries	.7106
6	Crude Petroleum	-
7	Natural Gas Liquids	1.0863
8	Oil and Gas Field Services	-
9	Other Mining	-
10	Residential Construction	-
11	Commercial, Educational, and Instit.	1.0010
12	Facility Construction	-
13	Food Processing	.6196
14	Textile and Apparel	.7127
15	Logging, Wood, and Paper	1.0360
16	Chlorine and Alkalies	1.5885
17	Cyclic Crudes and Intermediate Pigments	-
18	Organic Chemicals	1.5885
19	Inorganic, Plastics, Rubber	1.5885
20	Drugs, Chemicals, Soaps, and Paint	1.5885
		1.1000
21	Petroleum Refining	1.1000[b]
22	Other Petroleum Products	.5859
23	Tires, Rubber, Plastics, Leather	1.2054
24	Glass, Clay, Stone, Cement	.7463
25	Primary Metal Processing	.9211
26	Industrial Equipment Manufacturing	1.2531
27	Electric Applicance Manufacturing	1.7102
28	Aircraft, Motor Vehicle	.6773
29	Instruments, Photography, Games	1.4089
30	Rail Transportation	.9735
31	Intercity Highway Transportation	.9735
32	Motor Freight Transportation	.9735
33	Water Transportation	.9735
34	Air Transportation	.9735
35	Pipeline Transportation	-
36	Other Transportation	.9735
37	Communications	1.7759
38	Gas Services	1.0863
39	Electric Services	1.8000[b]
40	Water and Sanitary Services	1.0863

(Continued)

Appendix Table 16. (Continued)

Sector	Industry	Percent Change In Consumption from a One Percent Change In Disposable Income
41	Wholesale Trade	.8740
42	Other Retail Trade	.8740
43	Auto Dealers and Repair Shops	.8740
44	F.I.R.E.	1.3461
45	Other Services	.9231
46	Lodging, Amusement, Recreation	.9213
47	Education	1.3166
48	Outdoor Recreation	1.0000
49	Households	-
50	Federal Government (Military*	
51	Federal Government (Non-Military)*	1.3325
52	State Government*	.1315
53	Local Government*	.0770
54	Imports	.6405

* Percent change in taxes from a one percent change in income.

a/ Source: Mullendore, Walter E., and Arthur L. Ekholm, "Projections of Final Demand for Texas," Unpublished materials. Office of the Governor, Austin, Texas, August, 1972.

b/ Source: Thompson, Russell G., Rodrigo J. Lievano, and Robert R. Hill, "Energy Supply and Demand Analysis," Preliminary draft. Prepared for the Governor's Energy Advisory Council, University of Houston, November, 1974.

Appendix Table 17. Projections of Changes in Labor Productivity.

Equation a/	Intercept	Regression Coefficient b/	R^2	F Value
Agriculture				
Linear	.4186	.0300 (9.610)	.9107	92.350
Exponential	1.6750	.0168 (11.502)	.9351	132.288
Mining				
Linear	.4653	.0283 (42.449)	.9948	1,801.889
Exponential	1.7022	.0161 (49.325)	.9961	2,432.935
Construction				
Linear	1.009	.1278 (.835)	.1882	.697
Exponential	2.004	.0006 (.848)	.1910	.719
Manufacturing				
Linear	.5919	.0228 (24.824)	.9849	616.253
Exponential	1.7908	.0117 (31.348)	.9905	982.713
Transportation				
Linear	.5082	.0260 (19.096)	.9749	364.669
Exponential	1.7367	.0140 (25.842)	.9861	667.785
Communication				
Linear	.2969	.0374 (28.544)	.9885	814.734
Exponential	1.5867	.0235 (43.297)	.9950	1,874.617
Elect. Gas and San.				
Linear	.3328	.0370 (83.214)	.9986	6,924.585
Exponential	1.5970	.0228 (39.986)	.9941	1,598.900
Trade				
Linear	.6214	.0206 (29.747)	.9894	884.866
Exponential	1.8077	.0105 (36.845)	.9931	1,357.622
F.I.R.E.				
Linear	.7079	.0137 (15.492)	.9626	240.015
Exponential	1.8551	.0070 (16.679)	.9675	275.178
Services				
Linear	.8947	.0052 (7.886)	.8752	62.195
Exponential	1.9520	.0024 (7.851)	.8743	61.640
Government				
Linear	.8480	.0082 (2.894)	.5532	8.378
Exponential	1.9315	.0035 (2.783)	.5381	7.745

a/ The exponential equations are expressed as:

$$\text{Log } Y = a + bX$$

Where:

Y = index of labor productivity

X = time in years

b/ The numbers in parenthesis are Student "t" values. The data source for labor indexes was the Bureau of Labor statistics output per employee for 1950 through 1970. The equations for the construction category both had insignificant slope efficients implying that a constant index of 1.00 is the appropriate equation. In all other cases except the services and government sectors, the log functions fit slightly better than the linear functions. Alternative simulations were made using each set of equations.

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