THE INTERSTATE AND INTRASTATE INCIDENCE OF OKLAHOMA'S SEVERANCE TAX ON NATURAL GAS

By

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CHAPTER I

INTRODUCTION

Purpose of the Study

One of the features for a good tax, to state government officials, is that a large share of the tax burden is exported (Olson, 1984). Public finance economists have addressed, at some length, the ability of states to export a portion of their tax burden. The theoretical analysis by McLure (1964, 1969, 1970, 1978), Gillis (1978), and McDonald (1980) has suggested that a state is likely to impose a tax on a natural resource if

1. its market share of the taxed resource is significant, and
2. its export demand curve is inelastic relative to its supply curve.

Under these circumstances, a state can export a portion of such a tax to other states. A state with a rich endowment of a natural resource is likely to use the natural resource as a vehicle for exporting the tax to other states in order to fulfill the objective of maximizing tax exportation (Shelton and Vogt, 1982).

In 1984, 32 states in the U.S. levied taxes on the extraction of natural resources, raising 7.249 billion dollars, about 3.4 percent of all state tax revenues. The wide use of taxes on the extraction of natural resources can be seen in Table I. As Table I indicates, 8

TABLE I

SEVERANCE TAX REVENUES (Percent of Total State Taxes)
1970 and 1984

STATE	1970	1984
TEXAS	14.2	22.6
ALASKA	12.5	70.6
LOUISIANA	29.5	25.3
OKLAHOMA	11.1	26.4
WYOMING	5.1	48.4
NEW MEXICO	13.3	26.7
KENTUCKY	N*	7.5
NORTH DAKOTA	2.6	29.2
FLORIDA	N	2.2
MONTANA	3.7	24.8
ALABAMA	N	4.4
KANSAS	N	6.5
MISSISSIPPI	2.9	5.9
MINNESOTA	1.9	1.5
MICHIGAN	N	N

Source: Olson, State Taxation of the Oklahoma Oil and Gas Industry, Oklahoma State University, January, 1986.

*N = Less than 1 percent.

states now derive over 20 percent of their taxes from levies on resource extraction. The increasing trend of imposing severance taxes on energy resources to finance state government activities may reflect the fact that state governments believe that a portion of these taxes can be exported to other states.

Despite the theoretical importance of exportability for a state, however, little empirical research has been done to estimate the geographic incidence of particular severance taxes for particular states. The purpose of this study is to estimate the incidence of the Oklahoma severance tax on natural gas. Although some empirical estimates of the exportation of Oklahoma's severance taxes have been made by McLure (1967), Phares (1980), and Olson (1984), the present study, which stems from Shleton and Vogt's coal severance taxes model (1982), differs from these studies in that

1. it estimates the tax burden through use of a market equilibrium model,

2. it covers a longer period of time,

3. it incorporates important changes of economic situation and governmental policy in the model, and

4. it not only estimates the tax exportation ability of state government of Oklahoma but also estimates the tax share that falls on resident buyers within Oklahoma.

Methodology of the Study

Two empirical models are developed in this study in order to estimate the incidence of the severance tax on natural gas in both the intrastate and interstate natural gas markets. These models are constructed within a formal supply and demand framework which incorporates the most important determinants of the demand for and the supply of natural gas. Two reduced form equations derived from the demand and supply models are estimated, using ordinary least square techniques. Certain parameters of the estimated reduced form equations yield information about the incidence of the severance tax on natural gas.

Organization of the Study

The chapters of this study are organized as follows. Chapter II presents some information about the tax structure of Oklahoma and the natural gas industry. Chapter III presents the theoretical background of this study and reviews some relevant previous studies. Chapter IV presents the empirical models. Chapter V presents the empirical results of the study. Chapter VI provides a brief summary and conclusions of the study.

CHAPTER II

SEVERANCE TAXES IN OKLAHOMA AND THE NATURAL GAS INDUSTRY

The main objective of this chapter is to provide background information for the theoretical and empirical analysis of the natural gas industry presented later in this study. This chapter consists of four sections. The first section provides a brief description of the severance taxes imposed in Oklahoma and of Oklahoma's tax structure. The second section gives an overview of the natural gas industry. The third section describes the natural gas markets and section four outlines governmental policy concerning the natural gas industry.

Severance Taxes and the Tax Structure of Oklahoma

The Imposition of Severance Taxes

The State Government of Oklahoma imposes a variety of taxes on oil and gas producers. The most important of these are the gross production tax, the corporation income tax, the general sales tax, and the corporation franchise tax. The gross production tax includes three different taxes: the severance tax, the gas conservation excise tax, and the petroleum excise tax (Olson, 1986).

Severance taxes are levied on extractors of natural resources either on a per unit (a fixed amount per physical unit produced) or an ad valorem (a percentage of the dollar value produced) basis. Oklahoma imposes an ad valorem severance tax on the gross revenue from the production of petroleum, natural gas, mineral oil, casinghead gas, asphalt, and on ores bearing lead, zinc, gold, silver, copper, and uranium.

The first severance tax on oil and gas was imposed in 1910 with a rate of 0.5 percent of gross revenues. This rate was raised to 0.75 percent in 1913, to 3 percent in 1916, and to 5 percent in 1935. In 1971, the rate was raised to the current level of 7 percent on the gross value of petroleum, mineral oil, natural gas, and casinghead gas, except for stripper wells where the tax rate is 5 percent of the first $150 of value produced in each month with the balance taxed at 7 percent.

A 0.75 percent tax rate is levied on the gross value of production of asphalt and on ores bearing lead, zinc, gold, silver, and copper. A 5 percent tax is levied on uranium-bearing ores.

The Tax Structure of Oklahoma

Most of Oklahoma's severance tax collections come from levies on oil and gas production. The importance of tax revenues for Oklahoma can be seen in Table II. While the total amount of revenues from severance taxes increased from 20.3 million dollars in 1950 to 690.5 million dollars in 1984, the percentage of severance tax revenues as a percentage of total taxes rose from 14.6 percent in 1950 to 25.2

TABLE II

SEVERANCE TAX REVENUES, FOR SELECTED FISCAL YEARS, 1950-1984

FISCAL YEAR	AMOUNT ($ millions)	AS PERCENT OF TOTAL STATE TAXES
1950	20.329	14.6
1955	28.632	15.4
1960	32.400	13.5
1965	37.794	12.2
1970	49.350	11.1
1975	128.113	18.7
1980	404.823	24.1
1984	690.535	25.2

Source: Olson, State Taxation of the Oklahoma Oil and Gas Industry, Oklahoma State University, January, 1986.

percent in 1984, indicating that state government relied more and more on severance tax revenues in recent years.

In the 1950's and 1960's, severance tax collections grew slowly due to the relatively stable prices of oil and natural gas. In that period, prices grew moderately and there was a downward trend in oil production. During the period of 1970-1984, severance tax revenues grew more rapidly than total state taxes, primarily as a consequence of the large increases which occurred in world oil and domestic natural gas prices. Table III shows the average annual growth rates in state tax revenues for different taxes in different time periods.

Table III reveals the growth rates of the major taxes for the periods 1950-1960, 1960-1970, 1970-1980, and 1980-1984. The most striking feature of the change in Oklahoma's tax structure is the rapid increases in revenues from severance and income taxes for the period 1970 to 1984, as compared to the decades of the 1950's and 1960's. By contrast, growth of revenue of selective sales taxes remained very stable during the entire 1950-1984 period. Growth in revenues from the general sales tax during the 1970-1984 period falls between the explosion in severance and income tax revenues and the stable selective sales tax revenues.

The relative importance of major tax sources over time is illustrated in Figure 1. Because state tax sources have grown at different rates since 1950, the relative importance of these taxes have also changed since then. Selective sales taxes are still an important source of state tax revenues, but their relative importance has declined from 44.6 percent in 1950 to 16.9 percent in 1984. The relative decline in selective sales tax collections during the 1970's

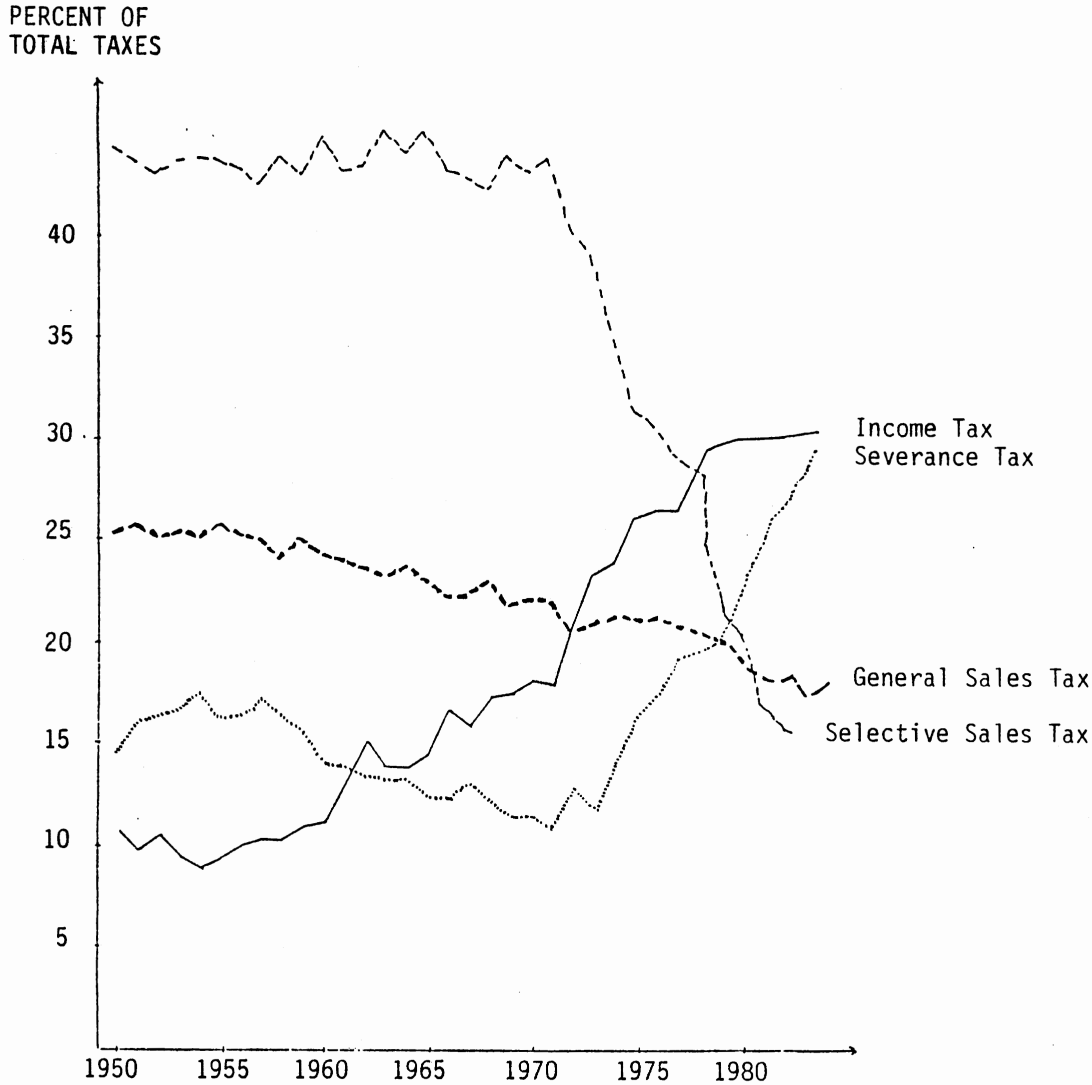
TABLE III

AVERAGE ANNUAL GROWTH RATE IN STATE TAX REVENUES
1950-1960; 1960-1970; 1970-1980; 1980-1984

	1950 1960	1960 1970	1970 1980	1980 1984
Total State Tax Revenue	5.5	6.5	13.9	11.0
Seletive Sales Tax*	5.6	5.9	6.1	5.5
General Sales Tax	5.0	5.4	7.1	10.6
Severance Tax	5.1	4.2	11.1	14.2
Income Taxes	5.8	10.7	11.6	14.9
Other Taxes	7.6	8.0	7.9	7.4

Source: Sandmeyer, Wasson, and Greer, Report: A Study of Oklahoma State Taxes, Oklahoma State University, February, 1979; U.S. Department of Commerce, Bureau of Economic Analysis, Survey of Current Business, August, selected years.

*Selective sales tax include the following taxes: motor fuels, alcoholic beverages, tobacco products, insurance premium, public utilities, and motor vehicle excise taxes.



Source: Sandmeyer, Wasson, and Greer, Report: A Study of Oklahoma State Taxes, Oklahoma State University, February, 1979; U.S. Department of Commerce, Bureau of Economic Analysis, Survey of Current Business, August, selected years.

Figure 1. Major Taxes as Percent of Total Taxes, By Year, 1950-1984

has been more than offset by the relative increase in severance and income taxes.

The Use of Severance Taxes

Severance tax revenues have been earmarked by previous legislation for particular purposes in Oklahoma. Table IV shows that percentage prescribed by law that is apportioned to particular purposes in Fiscal Year 1984. Over half of total severance tax revenues were earmarked for the General Revenue Fund and used principally to finance common schools, colleges and universities, highways, and prisons. Over 25 percent was used to finance retirement programs of state employees. These percentages will change with changes in the relative importance of oil and natural gas production. If natural gas assumes a more important role in the future and the apportionment formula remains unchanged, a growing percentage of severance tax revenues will be apportioned to retirement programs (Olson, 1986).

The Natural Gas Industry

The natural gas industry has been described as the invisible industry---the gas is colorless and odorless, comes from reservoirs deep in the earth, and moves to market in buried pipelines. The industry delivered about one-fourth to one-third of the energy consumed in the United States in past decades (Table V). Most of the gas produced in the United States originates in the West South Central region, in particular in the Gulf Coast states of Texas and Lousiana,

TABLE IV

APPORTIONMENT OF SEVERANCE TAX REVENUES, BY PERCENTAGE, FOR FISCAL YEAR 1984

	Apportioned To					
Tax On	General Revenue Fund	OK Ret. Fund	Pension Syst Reserve Fund	Local School Districts	County Roads	OK Tax Comm. Fund
OIL						
Percent	84.28			7.14	7.14	1.43
NATURAL GAS						
Percent	28.57	<--------55.71[a]-------->		7.14	7.14	1.43

Source: Olson, State Taxation of the Oklahoma Oil and Gas Industry, Oklahoma State University, January, 1986.

[a]The first $125 million of this portion of revenues from natural gas goes to the Oklahoma Teachers Retirement Fund. The remainder is allocated to the Pension System Reserve Fund.

TABLE V

CONSUMPTION OF ENERGY BY SOURCE FOR SELECTED YEARS, UNITED STATES
(Trillion BTU)

Year	Coal	Natural Gas	Petroleum	Nuclear Electric Power	Hydro-Electric Power	Other	Total	Natural Gas Consumption As % of Total Energy Consumption
1960	9831.5	12385.4	19919.3	6.0	1656.8	2.3	43795.6	28
1965	11582.2	15768.7	23245.7	43.2	2057.6	7.0	52685.9	29
1970	12268.4	21794.7	29521.6	239.3	2654.1	15.0	66435.6	32
1975	12655.2	19947.3	32732.2	1899.8	3129.0	72.2	70539.1	28
1980	15451.2	20394.8	34204.4	2739.2	3117.5	114.3	75086.4	26
1984	17012.2	18504.6	31053.1	3538.4	3774.0	174.2	74045.1	25

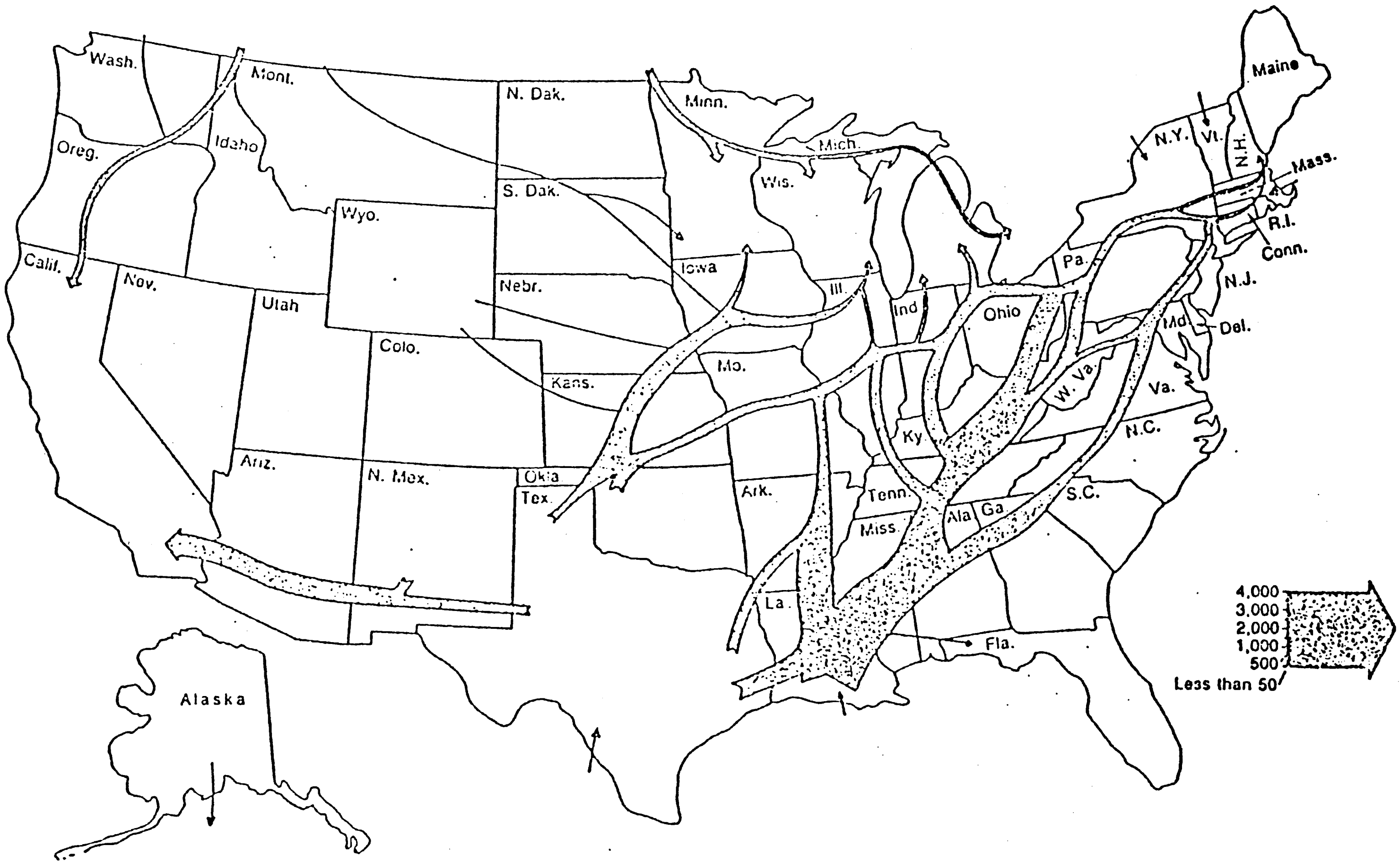
Source: U.S. Department of Energy, Energy Information Administration, State Energy Data Report Consumption Estimates, 1960-1984, Washington, D.C.: Government Printing Office, April, 1986.

while markets are distributed more uniformly throughout the U.S. The southwest states of New Mexico, Oklahoma, Kansas, Texas, and Louisiana, accounted for nearly 80 percent of marketed U.S. production in 1984 as shown in Table VI and, consequently, supply pipelines are concentrated in the Southwest. Figure 2 shows the principal interstate natural gas flows. As this figure shows, gas is not only consumed in the area near to the producing states, but also moves over some very long distances from the Southwest into New England, California, and the upper Midwest. While most parts of the United States are now served by a natural gas pipeline and while consumption is national, natural gas production and transportation are important regional industries rooted firmly in the southwestern United States.

The Development of the Natural Gas Pipeline Industry

The first natural gas company in the United States was formed in 1858 in Fredonia, New York. Natural gas had been discovered by chance as it seeped to the surface, and was used to light homes and inns in the Fredonia area. The Fredonia Gas Light Company distributed and sold the gas to homes and businesses for lighting. Due to the limited technology, early attempts at long distance transmission of gas were mostly failures.

In 1872, natural gas was first shipped over a significant distance to homes in Titusville, Pennsylvania. The gas entered Titusville through a 2-inch, cast-iron pipeline from a well five miles to the north. The technology for moving gas gradually improved



Source: U.S. Deparment of Energy, Energy Information Administration, Natural Gas Annual 1984, Vol. 1, Washington, D.C.: U.S. Government Printing Office, December, 1985.

Figure 2. Principal Interstate Natural Gas Flow Summary, 1984

TABLE VI

MARKETED PRODUCTION OF NATURAL GAS BY MAJOR PRODUCING STATE, 1984

PRODUCING STATE	QUANTITY (Millions of cubic feet)	AS PERCENT OF DOMESTIC PRODUCTION
LOUISIANA	5,825,055	30.3
TEXAS	6,185,021	32.3
OKLAHOMA	1,985,869	10.3
NEW MEXICO	957,366	5.0
KANSAS	465,979	2.4
OTHER STATES	3,810,335	19.8

Source: U.S. Department of Energy, Energy Information Administration, Natural Gas Annual 1984, Vol. 1, Washington, D.C.: U. S. Government Printing Office, December, 1985.

through the nineteenth century. Originally, natural gas was used only in the vicinity of its discovery, and markets were limited by the lack of long distance transportation.

The discovery and use of natural gas followed the path of early oil wildcatters from Pennsylvania and West Virginia into the Lima field of Indiana and Ohio. These wildcatters would have regarded natural gas as a complete nuisance if it had not often been a sign that oil was nearby. When a gas well was discovered without producing oil, the gas was either vented into the air or flared while the wildcatter moved on. Industrial customers were among the first to recognize the potential value of Appalachian natural gas as a fuel and began piping gas into their plants from nearby wells. In 1883, the Chartiers Valley Gas Company became the first company to produce, gather, and transmit gas to industrial users---several large Pittsburgh industries. The recognition of the value of natural gas was followed by the construction of a considerable network of gathering and transmission lines throughout the Appalachian oil and gas fields.

In the 1920's, the elements that would shape the modern gas industry were put into place: ready markets for natural gas; the discovery of huge fields in Kansas, Oklahoma, Texas, and Louisiana; producing states' enactment of conservation laws to stop the flagrant waste of natural gas; and the development of welded pipe capable of sustaining high pressures.

The natural gas business continued to follow the route of the oil wildcatters after the turn of the century, and discoveries of oil-associated gas and small gas fields were made through eastern

Kansas, Oklahoma, and North Texas. More important, however, was the discovery in 1918 of the Panhandle field forty miles north of Amarillo, Texas, and the Hugoton field in 1919 near Liberal, Kansas. These were major gas fields---giant reserves of dry natural gas in extreme horizontal and vertical traps, offering stable, long-term source of supply. Stability and duration were critical to an industry making huge, long-term investments in transmission equipment to move the gas out of the fields.

Conservation laws adopted to prevent waste of the fuel also helped to assure the stability and continuation of natural gas supplies. In 1915, Oklahoma became the first state to prohibit physical and economic waste and to give broad regulatory powers over petroleum to a state conservation commission. All of the major petroleum-producing states followed; Kansas was the last to establish regulatory authority in 1935. Conservation laws lent certainty to the life of natural gas supplies and encouraged investments in gathering lines and transmission equipment.

The technology of natural gas transmission is superficially simple, requiring pipe, compressors to increase pressure in the pipe and to move the gas, and regulators to reduce high pipeline pressures for local distribution. This technology matured slowly, however, and the first real breakthrough toward reducing leakage and allowing high-pressure shipments finally occurred in the mid-1920's. In the year of 1925, Magnolia Petroleum Company replaced the old-style bolted pipeline sealed by rubber couplings with an all-welded pipe that greatly reduced leakage. The Magnolia line moved gas about 200 miles from north Louisiana to Beaumont, Texas. The Magnolia line was quickly copied and improved upon. In 1926, the Interstate Natural Gas Company constructed a 22-inch pipeline over the 170 miles from Monroe, Louisiana, to Baton Rouge. By 1931, the first 1,000-mile pipeline was being built from the Texas Panhandle to Chicago.

At the end of World War II, the elements necessary for sustained growth of the natural gas pipeline industry---strong economic growth, available credit, proven technology, and the continued discovery of new reserves in the Southwest---came together for the first time since 1930. Southwestern gas production clearly dominated that of other regions of the country (Table VII). Pipelines reached into the Southwest from many parts of the United States, often opening new markets for the industry.

The growth of the natural gas industry may be most easily judged by comparing it with the more visible railroad industry. In 1983, the natural gas industry was nearly twice as big as the railroad industry on the basis of book value; its annual operating expenses were one-third larger than those of the railroad industry; and there were more miles of long-distance gas transmission pipelines crossing the country (250,000 miles) than there were miles of railroad track.

The Natural Gas Markets

Before natural gas is consumed by end-users, it passes through several markets: a) the drilling market; b) the wellhead market, c) the resale market, and d) the end-use market. Each of these has its own characteristics and importance to the sale and purchase of natural gas.

TABLE VII

PERCENTAGE DISTRIBUTION OF MARKETED PRODUCTION OF NATURAL GAS BY REGION, 1920-1983

YEAR	MARKETED PRODUCTION (trillion cubic ft)	--% DISTRIBUTION OF MARKETED PRODUCTION-- SOUTHWEST	CALIFORNIA	APPALACHIAN	OTHER
1920	.80	33.9	8.2	54.6	3.3
1925	1.19	47.4	15.7	28.8	8.1
1930	1.94	61.3	17.2	17.2	4.3
1935	1.92	65.2	14.8	16.0	4.0
1940	2.66	68.4	13.2	14.5	3.9
1945	3.91	73.1	12.8	9.8	4.3
1950	6.28	79.9	8.8	6.3	5.0
1955	9.41	85.5	5.7	4.5	4.3
1960	12.80	87.2	4.1	3.4	5.3
1965	16.04	88.2	2.9	2.6	7.6
1970	21.92	90.2	1.7	2.1	4.8
1975	20.11	91.2	1.2	2.1	5.0
1980	19.88	88.2	1.6	2.3	7.9
1983	16.82	85.2	2.5	3.1	11.2

Source: U.S. Bureau of Mines, Natural Gas Annual and Minerals Yearbook, various years, 1920-1975; U.S. Department of Energy, Energy Information Administration, Natural Gas Annual 1984, Vol. 1, Washington, D.C.: U.S. Government Printing Office, December, 1985.

Note: Southwestern states are Kansas, Louisiana, New Mexico, Oklahoma and Texas. The Appalachian states are Kentucky, New York, Ohio, Pennsylvania, and West Virginia.

The Drilling Market

This market is heavily influenced by the relative prices of oil and gas and their current and expected availability. The results of drilling activity have major long-term effects on the behavior of downstream gas markets because the supplies available in any one year are the product of drilling in previous years. When the prices paid of newly discovered gas were substantially higher than old supplies in the early years of the NGPA*, the effects on downstream markets were especially dramatic and prices rose quickly.

The Wellhead Market

Most of the United States' gas supplies are purchased in the wellhead market from producers by large pipeline companies that transport the gas to end-use markets. At the wellhead, the number of producers and their relative holdings make the seller's side of the market workably competitive. On the purchaser (pipeline) side of the market there may be some regional or local monopsony power; that is, some or all producers may have little or no choice of buyers for some or all of their production. The wellhead market is characterized by the presence of long-term contracts that currently restrict the flexibility of pipeline companies to meet demand.

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*The Natural Gas Policy Act (NGPA) is discussed later in this section.

The Resale Market

The majority of natural gas consumed in the nation passed through a resale market where local distribution companies purchase gas from major pipeline companies. In most cases, distributors have a limited number of supply options. Even when a distributor is served by more than one pipeline company, there are often contractual restraints on the degree to which the distributor can shift purchases from a more to a less expensive pipeline company. Most distributors, therefore, have little ability to influence the price of the gas they buy.

The End-Use Market

In this market, consumers of gas purchase supplies from distributors, pipeline companies, and producers. End-users can be divided into five types: residential, commercial, industrial with the capability of burning alternate fuels, other industrial, and electric utilities. Most end-users purchase gas from distribution companies that hold a monopoly franchise on the right to furnish gas to a service territory. These end-users have little or no ability to seek a less expensive supplier. In the short-run, they may reduce gas purchases by undertaking conservation measures, and in the long-run, they may switch to alternative fuels. Nonetheless, in most circumstances, their influence over the gas market is slight. Some large industrial customers (and a few others) purchase gas directly form pipeline companies. These end-users may communicate their willingness to buy gas directly to the agents who purchase the gas (the pipeline companies). When these direct sale customers can use an alternate fuel (usually residual fuel oil), they can switch fuels and affect the pipeline companies directly. A few end-users, accounting for about 15 percent of total sales in 1984, buy gas directly from producers. They often arrange with a pipeline company to transport the gas. This practice has occurred fairly frequently in intrastate markets and is becoming more widespread in interstate markets through certain industrial sales programs (in which the pipeline company acts as broker between producer and end-user). Table VIII shows the natural gas consumed by end-users in the United States for 1960-1984.

Among the end-users, the industrial sector consumes more natural gas than any other sector, followed by the residential sector. These two sectors account for more than 60 percent of total consumption of natural gas in the U.S. in the past two decades (Table IX). In the industrial sector, gas was very price competitive on a heat-value basis in most areas of the country. The exception was the Southwest, which is largely an intrastate market with some very inexpensive gas under long-term contracts. This explains the fact that most of the Oklahoma natural gas was consumed by the industrial sector and electric utilities (Tables X and XI). Sharp oil price increases in the middle and late 1970's rendered residual oil largely uncompetitive with natural gas in industrial fuel applications.

In recent years, the competition of residual fuel oil with gas in the industrial market is back to where it was before 1973. Since the price of residual oil was and is highly dependent on the price of crude oil, which can be subject to wide swings, industrial gas prices must be flexible in order to compete in industrial markets.

TABLE VIII

CONSUMPTION OF NATURAL GAS IN THE UNITED STATES, BY END-USE SECTOR, 1960-1984

YEAR	RESIDENTIAL	COMMERCIAL	INDUSTRIAL	ELECTRIC UTILITIES
	-Sector-			
	Billion cubic feet			
1960	3,103	1,020	5,771	1,725
1965	3,903	1,444	7,112	2,321
1970	4,837	2,398	9,249	3,932
1975	4,924	2,508	8,365	3,158
1980	4,752	2,611	8,198	3,681
1984	4,555	2,524	7,231	3,111

Source: U.S. Department of Energy, Energy Information Administration, State Energy Data Report Consumption Estimates, 1960-1984, Washington, D.C.: U.S. Government Printing Office, December, 1985.

TABLE IX

CONSUMPTION OF NATURAL GAS BY END-USE SECTOR, AS PERCENT OF TOTAL CONSUMPTION, UNITED STATES, 1960-1984

YEAR	-Sector-			
	RESIDENTIAL	COMMERCIAL	INDUSTRIAL	ELECTRIC UTILITIES
1960	26.7	8.8	49.7	14.8
1965	26.4	9.8	48.1	15.7
1970	23.7	11.7	45.3	19.3
1975	26.0	13.2	44.1	16.7
1980	24.7	13.6	42.6	19.1
1984	26.1	14.5	41.5	17.9

Source: U.S. Department of Energy, Energy Information Administration, <u>State Energy Data Report Consumption Estimates, 1960-1984</u>, Washington, D.C.: U.S. Government Printing Office, December, 1985.

TABLE X

CONSUMPTION OF NATURAL GAS BY END-USE SECTOR, OKLAHOMA, 1960-1984

YEAR	Sector: RESIDENTIAL	COMMERCIAL	INDUSTRIAL	ELECTRIC UTILITIES
	Billion cubic feet			
1960	60.0	29.0	128.0	83.0
1965	65.0	27.0	236.0	127.0
1970	77.0	44.0	218.0	235.0
1975	80.0	42.0	223.0	301.0
1980	77.0	47.0	246.0	330.0
1984	83.8	45.8	282.9	232.9

Source: U.S. Department of Energy, Energy Information Administration, State Energy Data Report Consumption Estimates, 1960-1984, Washington, D.C.: U.S. Government Printing Office, April, 1986.

TABLE XI

CONSUMPTION OF NATURAL GAS BY END-USE SECTOR,
AS PERCENT OF TOTAL CONSUMPTION
OKLAHOMA, 1960-1984

YEAR	-Sector-			
	RESIDENTIAL	COMMERCIAL	INDUSTRIAL	ELECTRIC UTILITIES
1960	20.0	9.7	42.7	27.6
1965	14.3	5.9	51.9	27.9
1970	13.4	7.7	38.0	40.9
1975	12.3	6.5	34.6	46.6
1980	11.0	6.7	35.1	47.1
1984	13.0	7.1	43.8	36.1

Source: U.S. Department of Energy, Energy Information Administration, <u>State Energy Data Report Consumption Estimates, 1960-1984</u>, Washington, D.C.: U.S. Government Printing Office, April, 1986.

TABLE XII

OVERVIEW OF THE NATURAL GAS POLICY ACT OF 1978

Sections	Decription	Price Escalation Formula	Status as of 1/1/85
SUPPLY INCENTIVES			
102	New natural gas outside existing fields; new reservoirs; new outer continental shelf fields	Annual inflation plus real growth premium	Deregulated
103	New onshore wells within existing fields	Annual inflation	Deregulated
107	High-cost gas	Deregulated immediately	Deregulated
108	Stripper wells	Same as 102	Regulated
CONSUMER PROTECTION			
104	Old interstate gas	Same as 103	Regulated
106a	Renegotiated interstate contracts	Same as 103	Regulated
109	All other gas	Same as 103	Regulated
INTRASTATE MARKET			
105	Intrastate gas	Tied to new gas prices	Deregulated
106b	Renegotiated intrastate contracts	Same as 103	Deregulated if contract price is greater than $1.00 per thous. cubic feet

Source: The Congress of the United States, Congressional Budget Office, Understanding Natural Gas Price Decontrol, Washington, D.C.: U.S. Government Printing Office, April, 1983.

The Natural Gas Policy Act of 1978

The federal government has regulated the interstate market for natural gas since 1938. For many years, as the interstate system developed, the market was stable. In 1954, the U.S. Supreme Court decided that the Federal Power Commission was responsible for regulation of wellhead purchases. In the early 1970's, however, interstate natural gas prices were still subject to relatively stringent cost-oriented pricing standards and were not allowed to increase as rapidly as oil prices, and most intrastate gas markets had no restrictions on wellhead prices. Higher oil prices favored oil rather than gas exploration and the relatively free intrastate gas markets meant that new gas discoveries could be bid away from the interstate markets. Many interstate pipeline companies were unable to meet their sales commitments or to replenish their reserves. Curtailments of gas deliveries to customers were widespread during the mid and late 1970's.

The Natural Gas Policy Act (NGPA) was passed in 1978 to alleviate these and other market problems for natural gas. The NGPA of 1978 combined price controls and deregulation by creating nationwide price ceilings and by allowing phased deregulation of certain categories of gas. It sought thereby to reduce regulation significantly without major dislocations. An overview of NGPA is presented in Table XII. As this table illustrates, the sections of the NGPA can be classified into three major categories: those that provide supply incentives; those that provide consumer protection; and those that promote uniformity in gas markets by regulating intrastate prices.

Supply Incentives. The incentive provisions were designed to increase the nation's natural gas supply. In general, newly discovered gas, as defined in the NGPA, is allowed to have gradually increasing prices projected to reach an assumed equivalent of the price of oil by 1985. Thereafter, the wellhead price will be decontrolled. Several categories of new gas were defined, each of which was given distinct price and decontrol treatment. The section 102 category covers gas found outside 2.5 miles of an existing well, gas found 1,000 feet below the completion depth of an existing well, gas from outer continental shelf leases, and production from new reservoirs. The price ceilings allow the gas defined by section 102 to increase in price at the annual rate of inflation plus a real growth premium. New onshore gas produced within existing fields is included in section 103, with its price increasing only at the annual inflation rate. Both Section 102 and Section 103 gas were deregulated on January 1, 1985. "High cost" gas is defined in Section 107 to include gas from wells drilled below 15,000 feet and gas produced from geopressurized brine, coal seams, Devonian shales, and other high-cost sources. This gas was decontrolled in 1978.

Consumer Protection. Consumers were to be protected by continued price controls on the gas already in production, termed "old gas." Section 104 sets the ceiling price for natural gas already dedicated to interstate commerce. The maximum lawful price in contracts that are renegotiated is determined by the provisions set forth in Section 106 of the NGPA. The Section 106a price is the higher of either the contract price in the expiring contract or $0.54

per million British thermal units (BTU's), both escalating at the annual inflation rate. Section 109 is a catch-all category. Each of these categories remains regulated until their gas is exhausted.

Intrastate Gas Regulation. The last major part of the NGPA imposed price controls on intrastate gas to limit the ability of intrastate users to bid supplies away from interstate users. For Section 105 gas, the price ceilings are tied to new prices (Section 102). Section 106b includes provisions for setting renegotiated intrastate prices that closely follow the methods employed in Section 106a. Most of the intrastate gas categories were deregulated in 1985.

In summary, a severance tax has been imposed on natural gas producers since 1910 by the state government of Oklahoma. Severance tax revenues have played a more and more important role in Oklahoma's tax structure in recent years. In 1984, severance tax revenues accounted for 25.2 percent of total tax revenues. The natural gas industry delivered about one-fourth to one-third of the energy consumed in the United States in recent decades. Most of the gas produced in the United States originates in the West South Central region. Oklahoma, alone, produced about one-tenth of the total in 1983. Most of the natural gas is delivered by interstate pipeline companies to end-users. Except for the Southwest, the industrial sector consumes more natural gas than any other sector among the end-use sectors. The interstate natural gas market has been regulated by the federal government since 1938. In the early 1970's, because interstate natural gas prices were not allowed to increase as rapidly as intrastate gas prices, intrastate users bid away new gas discoveries from the interstate market. Many interstate pipeline companies were thus unable to meet their sales commitments or to replenish their reserves. The Natural Gas Policy Act of 1978 was passed to alleviate this situation for natural gas markets through stimulating the natural gas supply by deregulating some of the natural gas wellhead prices, protecting consumers by continuing price controls on "old gas," and limiting the ability of intrastate users to bid supplies away from interstate users by imposing price controls on intrastate natural gas.

CHAPTER III

THE THEORETICAL BACKGROUND

The main objective of this chapter is to present a theoretical analysis of the tax incidence and exportation, since the primary purpose of this study is to estimate the portion of the Oklahoma natural gas severance tax that is shifted forward to consumers in both the intrastate and interstate markets. In this chapter, we start with a brief description of the framework adopted in this study, followed by a presentation of the general principles of tax incidence and exportation. Some of the more relevant previous studies are reviewed in the last section of this chapter.

The Framework

Tax incidence and exportation analysis can be conducted in various ways. First, the analysis can be conducted in either a unilateral or a multilateral framework. Unilateral analysis, according to Morgan and Mutti (1985), considers tax incidence and exportation from the perspective of a tax change in only one state, while the multilateral approach considers simultaneously the effects of changes in tax policies in several states. Second, tax incidence analysis can also be conducted using two different approaches: either a partial-equilibrium or a general-equilibrium approach. A partial-equilibrium analysis focuses on the product and factor markets directly affected by the tax. A general-equilibrium analysis also considers the possible outcome due to the change of relative prices elsewhere in the economy because of the imposition of the tax. A partial-equilibrium approach is sufficient to consider the short-run effects of a tax policy change if these effects are largely confined to the product and factor markets directly affected. But in the long-run, when mobile factors enter or leave the taxing state, production opportunities and relative prices elsewhere in the economy change; as a result, a general-equilibrium approach is more appropriate (Morgan and Mutti, 1985). Finally, the incidence of a production tax in regulated product market is different from what would occur if that product market were not regulated.

The energy crisis of 1973 has encouraged a number of studies of energy taxes. Most of them have been focused primarily on the impact of energy taxes on energy prices and output. Generally, these studies were concerned with the allocative effects of energy taxes on the production, exploration, and development of primary energy resources, or with the incidence and the exportation ability of certain types of energy taxes. The present study falls into the category of the latter types of studies.

Most of the tax incidence and exportation studies were conducted either in a partial-equilibrium or a general-equilibrium framework under the assumption of unregulated product markets. Among the former studies, Gillis (1977), Shelton and Morgan (1977), Morgan and Mutti (1981), and Shelton and Vogt (1982) used a unilateral approach to analyze the incidence of production taxes, while Church (1981, 1982) Zimmerman (1981), and Kolstad and Wolak (1983) adopted a multilateral approach.

The present study is conducted in a partial-equilibrium, unilateral framework; that is, we only consider the incidence and exportation of the severance taxes on natural gas in Oklahoma, other things being equal. The theoretical background presented in this chapter assumes unregulated product markets. Since the natural gas markets have long been regulated by the federal government, however, the effects of such regulation is discussed in Chapter IV.

General Principles of Tax Incidence and Exportation

Tax Incidence

A severance tax is a tax imposed on the production (extraction) of energy and natural resources. When a severance tax is imposed on a particular resource, producers will try to shift the tax burden to buyers in order to avoid paying the tax. In Figure 3, before the tax, the equilibrium point is (Q_0, P_0), where producers produce Q_0 of natural gas and consumers pay P_0 per unit of natural gas. If an ad valorem tax is imposed, the supply curve shifts in the form of a swivel from S to S'. The new equilibrium point is at (Q_1, P_1), where producers produce Q_1 of natural gas, consumers pay P_1 per unit of natural gas. The difference between P_1 and P_2 is the severance tax. The rate of ad valorem tax equals $(P_1-P_2)/P_2$. The tax revenue received by state government is $(P_1-P_2)*Q_1$,

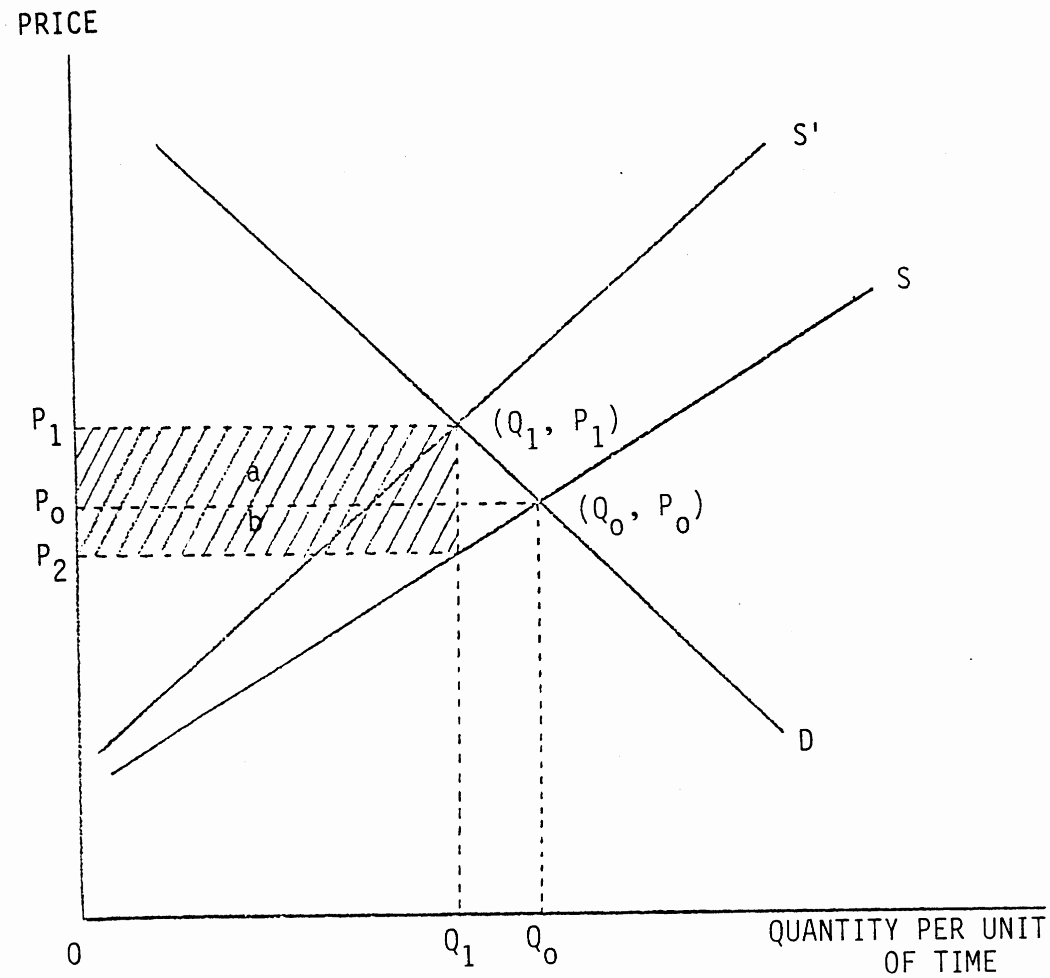


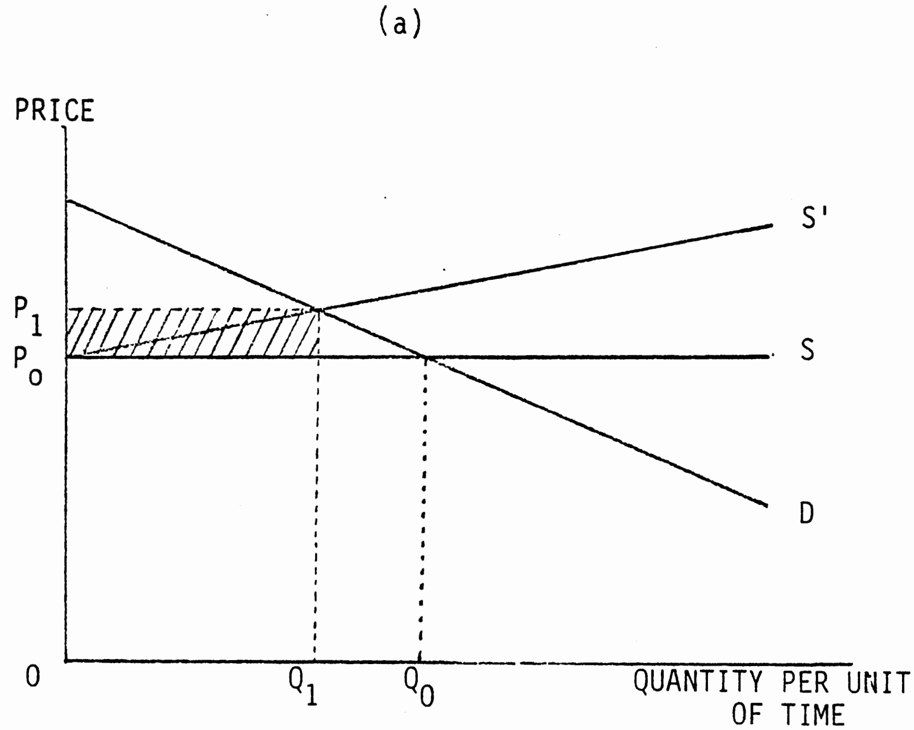
Figure 3. Incidence of an Ad Valorem Tax

equals to the area a plus b, of which area a is paid by consumers and area b is paid by producers.

The ability to avoid the tax burden for producers and consumers depends on the price elasticities of the supply and demand curve. The more elastic the supply curve and the more inelastic the demand curve, the more tax burden consumers have to pay. In Figure 4, panel (a) shows that with a perfectly elastic supply curve, consumers pay all of the tax. On the other hand, the more elastic the demand curve and the more inelastic the supply curve, the more tax producers have to pay. Panel (b) shows that with a perfectly elastic demand curve, producers pay all of the tax. In general, the conditions shown in Figure 3 are assumed most realistic, where producers and consumers each pay part of the tax.

Exportation of Tax

Suppose a state's objective is to maximize taxes exported for a given amount of taxes collected. Under this objective, the state attempts to use the natural resource as a vehicle for exporting the tax to other states. Such behavior would be possible for a state with a rich natural resource endowment. Figure 5 shows a state for which the interstate market is the relatively larger market. D_d is the intrastate demand curve and D_x is the interstate demand curve. D_T, the horizontal summation of D_d and D_x, is the total demand curve, and S is the supply curve. Before a tax is imposed, the total quantity demanded is Q_T, the amount exported to other states is Q_x, and Q_d is the quantity consumed in the state.



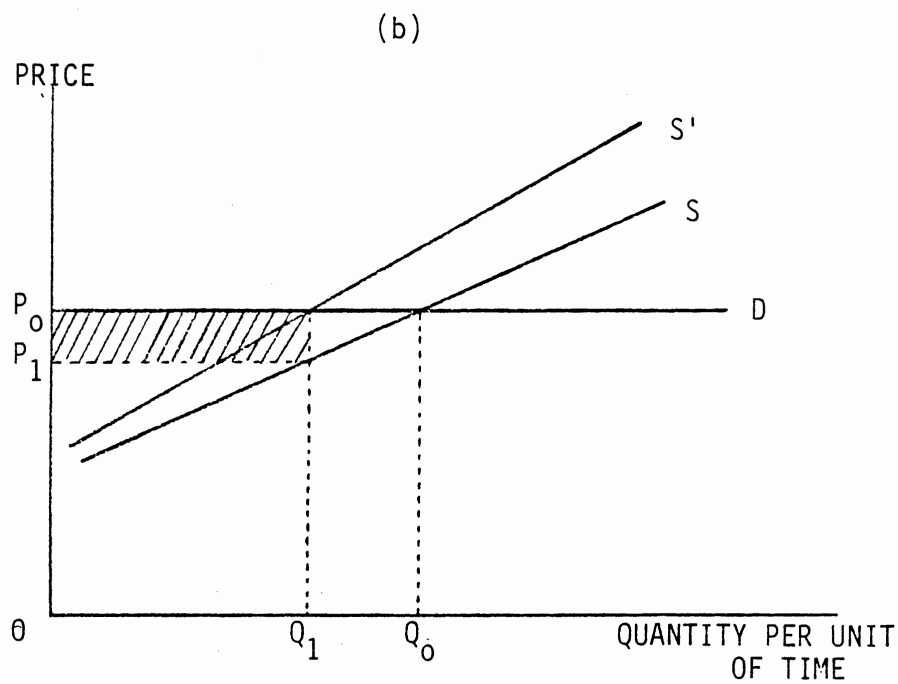


Figure 4. Tax Incidence with Perfectly Elastic Supply and Perfectly Elastic Demand Curves

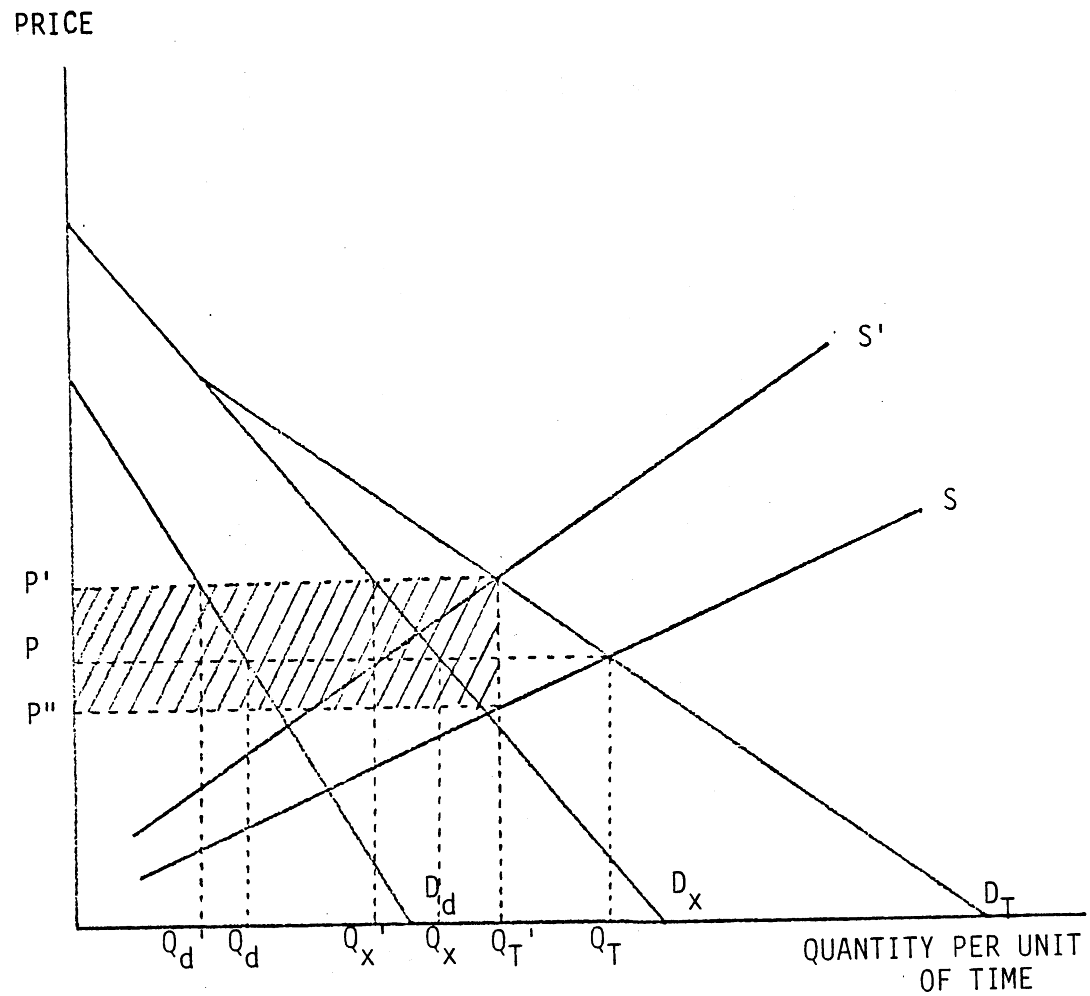


Figure 5. Tax Incidence in Intra- and Inter-State Markets

The effect of imposing a severance tax can be demonstrated by Figure 5. Suppose an ad valorem tax rate has been chosen and the supply curve shifts upward to the left from S to S'. The new total quantity supplied, Q_T', is smaller than the initial quantity supplied, Q_T. Quantities supplied to the interstate and intrastate markets are Q_x' and Q_d', respectively. The price rises to P' from P, and producers receive P". The difference between P' and P" is the severance tax. The ad valorem tax rate is (P'-P")/P". The tax revenue received by state government is $(P'-P")*Q_T'$, of which $(P'-P)*Q_x'$ is paid by out-of-state residents, and $(P'-P)*Q_d'$ is paid by state residents. Thus, $(P'-P)*Q_x'/(P'-P")*Q_T'$ is the portion of the tax exported to non-residents. In general, the more dominant the state in the interstate market, the greater the ability of the state to export its tax. The way a state exports its tax through higher prices in interstate markets is called "forward shifting" because the tax incidence falls directly on consumers in other states. A state with more dominant power in interstate markets is more likely to pursue a goal of maximizing taxes exported.

The rest of the tax revenue, $(P-P")*Q_T'$, is paid by producers or owners of mineral rights, that is, the tax is shifted backward to producers or mineral rights owners. Only when producers or mineral rights owners happen to be out-of-state residents, will this portion of tax be exported. The effects of backward shifting would be to reduce economic rents, profits, or other resource payments.

Short-Run and Long-Run Shifting

In the short-run, the price elasticity of demand for natural gas is relatively low due to the limited ability of consumers to secure alternate supplies of natural gas and to switch to substitute fuels. This means that a substantial part of the severance tax will be shifted forward to consumers in the short-run. The upper limit to the portion of the tax exported in this way for the state is the proportion of natural gas exported (Olson, 1984).

In the long-run, the state will probably be able to export a smaller percentage of natural gas severance tax due to the increasing ability of consumers to find alternate sources of natural gas or to switch to alternate fuels. The long-run demand curve becomes more elastic, limiting the ability of producers to shift the tax forward through higher prices.

The tax that is not shifted forward must either fall on the producers or to owners of mineral rights. In general, in the long-run, the tax will be shifted to the least mobile resource, the mineral rights owners. Only when these owners are non-state-residents can the severance tax be exported to other states in the long-run.

Deductibility from Federal Taxes

When state government imposes severance taxes, it will receive all of the revenues from these taxes. But not all of these taxes are paid by consumers, producers, and mineral rights owners. Severance taxes are deductible from some federal taxes, such as the federal windfall profits tax, and the federal corporate and personal income taxes. In regard to natural gas, no windfall profit tax is imposed by the federal government for the time being. State severance taxes reduce corporation profits, however, and hence reduce the tax base of the federal corporate income tax. Since part of after-tax corporation profits are distributed to individuals who must pay the federal personal income tax, state severance taxes indirectly reduce the federal personal income tax base. The amount by which federal taxes fall depends on the federal marginal tax rates on corporate and personal income and the percentage of corporate profits after taxes distributed as dividends. The following example demonstrates the exportation of state severance taxes via the deductibility of federal taxes (derived from Olson, 1984).

Suppose the state imposes a 7 percent ad valorem tax on natural gas produced by a corporation with $100,000 of before tax profit. The marginal tax rates for the federal corporate income tax and the federal personal income tax are assumed to be 46 percent and 40 percent, respectively. Fifty percent of after tax corporate profits are assumed distributed to stockholders as dividends.

The portion of the state severance tax exported to federal taxpayers through the deductibility of the federal corporate income tax is:

$$\frac{\{(100{,}000*.46)-[(100{,}000-7{,}000)*.46]\}}{7{,}000} = .46$$

The portion of the state severance tax exported to federal taxpayers through the deductibility of the federal personal income tax is:

$$\frac{\{[100{,}000*(1-.46)]*.5*.4)-\{(100{,}000-7{,}000)*(1-.46)*.5*.4\}}{7{,}000} = .108$$

The 46 percent and 10.8 percent figures in the above example represent the deductibility of state severance taxes from federal taxes. Hence, we may say that out of every dollar of state severance taxes, 56.8 cents (=.46+.108) is exported to federal taxpayers via tax deductibility.

In summary, there are three ways to export severance tax incidence for a state government:

1. through higher prices to consumers in other states,
2. through tax deductibility of federal taxes, and
3. through backward shifting to non-resident mineral owners.

In the short-run, the tax is exported in large part by route (1); in the long-run, it is done via route (3). Route (2) is relevant in both the short-run and the long-run.

Review of Previous Studies

The Ability to Tax a Natural Resource

Most of the studies about the ability of a state government to export a tax on a natural resource agree that the most important determinant of that ability is the market dominance of the taxed resource by the taxing state (Gillis, 1979; Hogan and Shelton, 1973; McDonald, 1980; McLure, 1978, 1981; and Morgan and Mutti, 1981). A state is more likely to tax its natural resource if it is one of the few producing states than if there are many states producing that natural resource (McLure, 1978), to import a higher tax rate if it dominates the supply of that resource (Gillis and McLure, 1975), and to impose a tax on a natural resource if it can export the tax to other states (Richardson and Scott, 1983).

Richardson and Scott (1983) note that state severance tax rates and collections from mineral resources are related to the industrial structure of the extracting industry and geographic resource location patterns. The industrial structure of the extracting industry is critical in determining how much revenue a state can collect from any specific severance tax. A state, they claim, if it is the sole state in which a resource is located, can collect more revenue if there are many extractive firms within the state as opposed to if there is only one such firm. This is because the monopolist tends to restrict output---and thus the tax base---to levels lower than in the competitive market structure. On the other hand, the geographic resource location patterns are also related to the state's power to tax. The generally accepted hypothesis, they point out, is that the more dispersed the resource across states, the less likely that a state can effectively tax the resource. Or, alternatively, the more concentrated the resource is geographically, the more likely that a state can effectively tax the resource. Table XIII summarizes the generally accepted theoretical conclusions.

According to Richardson and Scott's investigation, there are about 30 states producing measurable natural gas and the four-state concentration ratio is 85.3. Among the producing states, 27 states impose a severance tax on natural gas and eight of them have tax rates equal or over 5 percent. Markham (1978), calculates the four-firm concentration ratio for oil and gas production companies to be 25.1 percent. Such a concentration ratio is typically associated with a low probability of interdependence among the firm (Bain, 1972). These characteristics place the natural gas industry in approximately the middle cell of the top row in Table XIII. Hence, when examining natural gas severance tax rates across the U.S., we would find

TABLE XIII

STATE'S SEVERANCE TAX POTENTIAL FOR SPECIFIC RESOURCE

Number of Firms in Industry	Number of States in Which Resource is Located		
	Many	Few	One
Many	Poor	Fair	Excellent
Few	Poor	Fair	Good
One	Poor	Fair	Good

Source: Richardson and Scott, "Resource Location Patterns and State Severance Taxes: Some Empirical Evidence," Natural Resources Journal, 23(2), April, 1983.

1. rates are higher than on most of the other taxed resources,

2. there are differential rates across states, and

3. a large proportion of the producing states levying the tax.

In summary, a state's power to tax a natural resource is related to the industrial structure of that extracting industry and geographic resource location patterns. The empirical evidence supports the general hypothesis that the more concentrated the geographical location of a natural resource, the greater a state's power to levy a tax on that resource.

The Ability to Export a Tax

McLure (1978) considers that the four determinants of the ability of a political jurisdiction to export its taxes are

1. the degree of dominance of the relevant market by the taxing jurisdiction,

2. the elasticity of demand for the taxed resource,

3. the mobility of production factors, and

4. the industrial structure of the market.

McLure claims that it is unlikely that a state with a small share of the national market for a given natural recourse would be able to export a severance tax on that resource to consumers in other states through higher prices for the resource. It would be prevented from doing so by competition from untaxed suppliers in other states. It is more likely that the tax could be born in the short-run by the owners of the firm extracting the resource and in the long-run, when contracts are renegotiable, by owners of deposits of the resource. If the owners of the firms in the industry or the owners of the resource deposits happened to be non-residents of the taxing jurisdiction, the tax could very well be exported, but the exporting could not be to consumers, as commonly expected.

McLure (1981) stresses the importance of the elasticities of demand and supply and the market shares of the taxing and non-taxing states. Suppose a severance tax is levied on only one state, the fraction of the tax that will be reflected in higher prices, and therefore potentially exportable to consumers in other states, F, is given by the following expression:

$$F = \frac{S}{S + D} * \frac{\alpha s_t}{\alpha s_t + \beta s_n} \qquad (3.1)$$

where

S = the elasticity of the aggregate supply curve,

D = the elasticity of the aggregate demand curve (defined to be non-negative),

s_t = the elasticity of supply in the taxing state,

s_n = the elasticity of supply in the rest of the country,

α = the fraction of national output produced in the taxing state,

β = the fraction of national output produced in the rest of the country.

For non-negative values of s_t and s_n, the value of F lies between zero and one.

If the taxing state produced the entire national output, $\alpha = 1$ and $\beta = 0$, then the expression can be reduced to:

$$F = \frac{S}{S + D} \qquad (3.2)$$

On the other hand, if the taxing state produces an insignificant fraction of national output, i.e., α approaches zero, then F is also insignificant.

In general, α is significantly greater than zero, but substantially less than one. For simplicity reasons, McLure assumes the elasticities of supply in the taxing and non-taxing states are equal. Then F can be expressed as:

$$F = \frac{S}{S + D} * \frac{\alpha s_t}{\alpha s_t + \beta s_n}$$

$$= \frac{S}{S + D} * \frac{s_t}{(\alpha + \beta) s_t}$$

$$= \frac{S}{S + D} * \alpha \qquad \text{Since } \alpha + \beta = 1. \qquad (3.3)$$

The importance of market share of the taxing state can be understood from equation (3.3). The larger the value of α, the larger the value of F; that is, the larger the fraction of the tax that the taxing state can export. The role of market dominance can be further understood by considering the result under the case of perfectly elastic supply and/or perfectly inelastic demand. In this case, $S = \infty$ and/or $D = 0$. The value of F is equal to the value of α, the market share of the taxing state. Thus, α is the largest value F can have. Conrad (1978), who also emphasizes the importance of the elasticities of demand and supply and the market shares of the taxing and non-taxing states, reaches similar conclusions to McLure's.

Gillis (1975, 1978), not only considers market dominance as a determinant of tax incidence, but also claims that dominace can result from the coordinated actions of several jointly-dominant states, rather than those of one state. McDonald (1980) points out that if an oil severance tax is levied by all producing states, but production is confined to a few states only, than the latter jurisdictions can in effect shift some of the tax burden to consumers in other states. The result is different if an oil severance tax is levied by only one state producing a portion of the national output of oil. The state confronts a demand curve that is more elastic than the industry curve, since the output of other areas is a close substitute for its product, and more of the tax is born by land owners in the taxing state in the long-run. By tending to raise the relative price of oil in the taxing state, the tax increases the demand for oil in other jurisdictions, raising prices and increasing land owners' rent. Hence, the burden of the tax is born partly by land owners in taxing state and partly by consumers in all states, with the incidental effect of increasing rents in the non-taxing states. The relative size of these effects depends on the share of the industry's capacity accounted for by the taxing state. If the share is large, then the state's demand elasticity need not differ much from the industry's, rents in the state will not decline much in response to the tax, and the increase in prices and rents in other states will be relatively greater. If the share is very small, the state's demand elasticity will approach infinity, rents in the state will bear nearly all of the burden of the tax, and the rise in prices and rents in other state will be minimal.

Finally, Morgan and Mutti (1981, 1985) stress that the regulatory environment in which natural gas is produced and sold allows for the pass-through of severance (and other) taxes to consumers.

In summary, a state's ability to export its severance tax burden on natural gas is related to:

1. the market dominance of the state for the taxed resource,
2. the elasticity of deamnd for the taxed resource,
3. the industrial structure of the market, and
4. regulatory pass-through provisions.

Implications for Study of the Oklahoma Severance Tax

Intrastate Market

a. Oklahoma producers are dominant in this market,

b. historically, much of the gas in this market has been sold under long-term contract with pass-through provisions, and

c. there are many Oklahoma gas producers.

Items (a) and (b) suggest that producers face a relatively inelastic demand curve. Item (c) suggests that the intrastate market is reasonably competitive.

Interstate Market

a. Oklahoma producers are not dominant in this market,

b. most gas was sold historically under long-term contract,

c. taxes on gas producers are comparable in size for Oklahoma, Texas, and Louisiana (Olson, 1986), and

d. there are many suppliers.

Item (a) suggests a relatively elastic demand facing Oklahoma producers; items (b) and (c) suggest a relatively inelastic demand.

Only empirical analysis can determine which effects are stronger. Item (d) suggests that the market is competitive in the absence of regulation.

These conditions suggest that a competitive model can be used to analyze the intrastate market, and that a relatively large percent of the tax will be shifted forward to consumers. They also suggest that a competitive model can be used to analyze the interstate market during the recent period of deregulation, and that there is a possibility of a large percent of the tax being exported.

In this study, we examine these markets with aid of an empirical model first developed by Shelton and Vogt to examine the incidence of a severance tax on coal. These authors use information about the cost and quality of each coal shipment received by electric utilities, published by the Department of Energy on Form 423, to conduct a formal supply and demand analysis to estimate the severance tax incidence on western coal-producing states.

An implicit demand function expresses the quality of coal that the utility will purchase as a function of the delivered price and other determinants of demand. Hence, the demand function can be expressed as:

$$Q_d = a + bP_d + \Sigma c_i X_i + e \qquad (3.4)$$

where

Q_d = the demand for coal by each electric utility,

P_d = the delivered price of coal,

X_i = the other determinants of demand for coal, and

e = the error term.

Similarly, an implicit supply function relates each mine's desired quantity to minemouth price of coal and other determinants of supply can be expressed as:

$$Q_s = \alpha + \beta P_m + \Sigma r_j Z_j + \varepsilon \qquad (3.5)$$

where

Q_s = the supply of coal by each coal mine,

P_m = the minemouth price of coal,

Z_j = the other determinants of supply of coal, and

ε = the error term.

The difference between the selling price to consumer and the price received by mineowners represents the transportation tariff plus the full severance tax. That is:

$$P_d = P_m + \text{Tariff} + \text{Severance Tax} \qquad (3.6)$$

When a transaction has occurred, desired supply quantity (Q_s) equals the desired demand (Q_d). From a set of observed transactions and received prices, they estimate the supply and demand system in the reduced form model. Equations (3.4), (3.5), and (3.6) are combined to produce:

$$P_d = A + \Sigma B_j Z_j + \Sigma C_i X_i + D\ \{\text{Tariff} + \text{Severance Tax}\} \qquad (3.7)$$

where

$A = (\alpha - a)/(b - \beta)$,

$B = r_j/(b - \beta)$,

$C_i = c_i/(b - \beta)$,

$D = B/(\beta - b)$,

and

$0 < D < 1$.

The share of tax passed forward to utilities is expressed as the estimated value of D. The empirical analysis of Shelton and Vogt indicates that about 29 to 40 percent of the coal severance taxes are passed forward to consumers in other states by the western coal-producing states.

CHAPTER IV

EMPIRICAL MODELS

This chapter contains two sections. The first presents the market conditions of natural gas before and after the NGPA. The next section develops two empirical models based on a formal supply and demand framework.

The Market Conditions of Natural Gas

As explained in Chapter II, the NGPA was passed in 1978 to reduce shortages by means of a new regulatory process that would increase supplies and reduce demands. Figure 6, taken from MacAvoy (1979), illustrates the market conditions of natural gas before and after the NGPA. D_2 is intrastate demand, D_1 is interstate demand, and total demand is $D = D_1 + D_2$. The price R is the average regulated ceiling price at the wellhead set before passage of the NGPA, and the price R' is the price after the NGPA was enacted. Before 1978, the intrastate market was not regulated so that additional supply cleared market at P_2 for quantity Q_2. But at the regulated price, demand in the interstate market, Q_1, exceeds its share of the total regulated supply, Q_1', leaving $Q_1 - Q_1'$ as a shortage in interstate market. After 1978, the regulated price of gas, R', was sufficient to clear both markets.

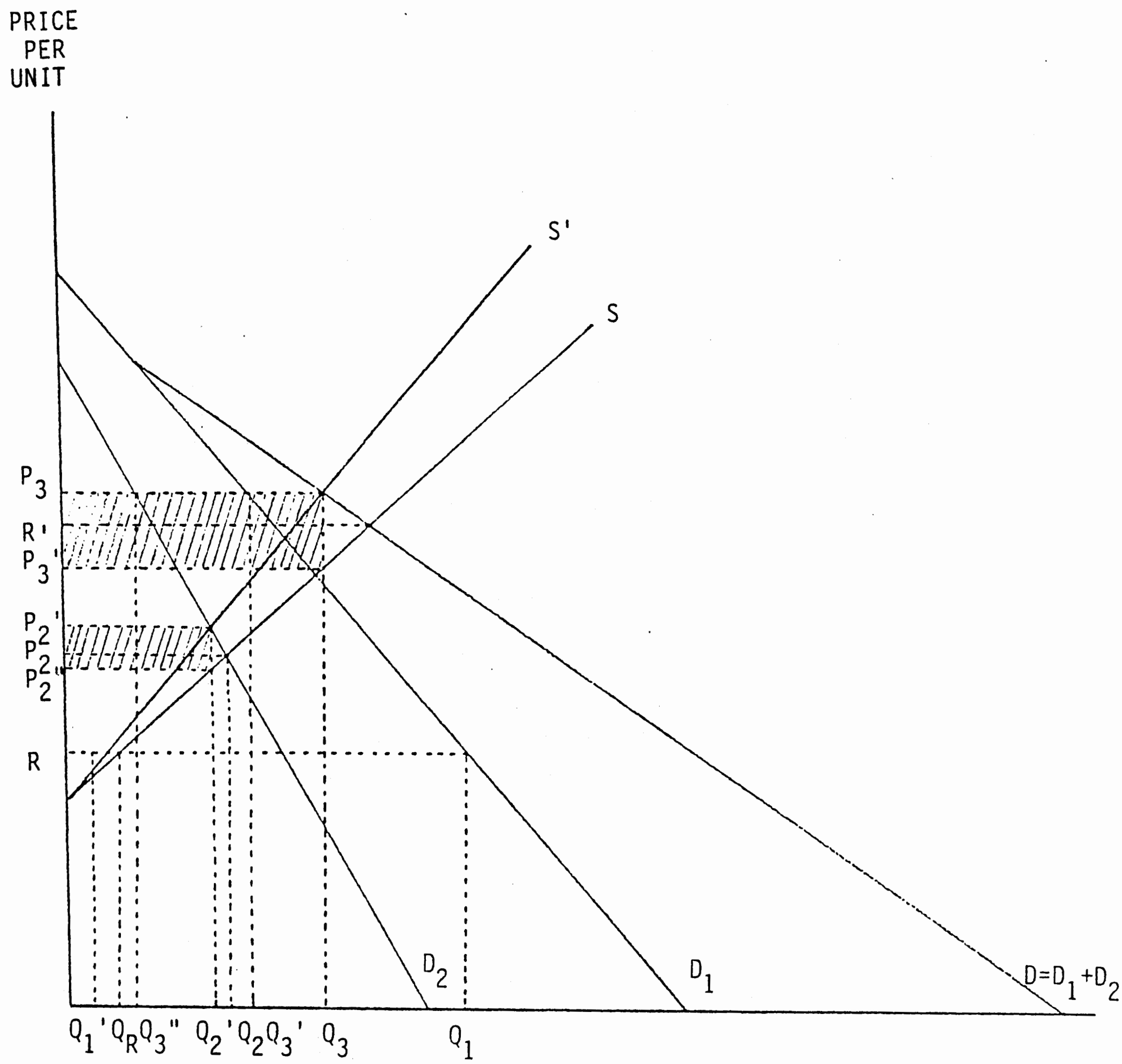


Figure 6. Natural Gas Market Conditions Before and After the NGPA

Suppose an ad valorem tax is imposed, the supply curve shifts upward to the left, from S to S'. The equilibrium point of intrastate market before NGPA changes from (Q_2, P_2) to (Q_2', P_2'). The tax paid by state residents is $(P_2'-P_2)*Q_2'$. After 1978, the market clears at (Q_3, P_3), the tax revenue that state government receives is $(P_3-P_3')*Q_3$, of which $(P_3-R')*Q_3''$ is paid by state residents, $(P_3-R')*Q_3'$ is paid by residents of other states, and $(R'-P_3')*Q_3$ is paid by producers. Thus, $(P_3-R')*Q_3'/(P_3-P_3')*Q_3$ is the portion of tax exported to other states.

Model Specification

Two empirical models are presented here based on a formal supply and demand framework. Market adjustments due to the imposition of a severance tax occur through changes in the pre-tax wellhead price of natural gas. Hence, the severance tax incidence that falls on consumers can be determined by estimating the difference between the equilibrium market price and the sum of the wellhead price and other expenses. In each equation, all prices, costs, and taxes of natural gas are expressed in terms of dollars per thousand cubic feet and are deflated by the implicit price deflator for GNP.

The Intrastate Model

The Demand Function. The demand function for natural gas, according to Liu (1983), can be expressed as follows:

$$D = a_1 + a_2D_{(-1)} + a_3PG + a_4PE + a_5PO + a_6GSP + U_1 \qquad (4.1)$$

where

D = the annual total demand for natural gas in Oklahoma, billion cubic feet,

$D_{(-1)}$ = the total demand for natural gas in the previous year in Oklahoma,

PG = the deflated natural gas price in Oklahoma,

PE = the deflated electricity price in Oklahoma, dollars per million BTU,

PO = the deflated #2 oil price in Oklahoma, dollars per million BTU,

GSP = the deflated gross state product of Oklahoma, million dollars, and

U_1 = the random disturbance term.

The Supply Function. The supply function of natural gas, according to Akkina and Malhotra (1981), and Moody, Valentine, and Krurant (1985), can be expressed as

$$S = b_1 + b_2 WP + b_3 S_{(-1)} + b_4 TR(-1) + U_2 \qquad (4.2)$$

where

S = the annual production of natural gas in Oklahoma, billion cubic feet,

WP = the deflated wellhead price of natural gas in Oklahoma,

$S_{(-1)}$ = the one-year-lagged annual production of natural gas in Oklahoma,

TR(-1) = the one-year-lagged total reserves in Oklahoma, billion cubic feet, and

U_2 = the random disturbance term.

The Reduced Form. The final price of natural gas paid by consumers can be expressed as

$$PG = WP + TX + OC \qquad (4.3)$$

where

TX = the severance tax on natural gas, and

OC = the operation costs for distributors.

When the market is at equilibrium, desired supply quantity (S) equals the desired demand (D). From a set of observed quantities and prices paid by consumers, we can estimate the supply and demand system in reduced form. Equations (4.1), (4.2), and (4.3) can be combined to produce:

$$PG = \frac{a_1-b_1}{b_2-a_3} + \frac{a_2}{b_2-a_3} D(-1) + \frac{a_4}{b_2-a_3} PE + \frac{a_5}{b_2-a_3} PO + \frac{a_6}{b_2-a_3} GSP$$

$$+ \frac{b_2}{b_2-a_3} TX + \frac{b_2}{b_2-a_3} OC - \frac{b_3}{b_2-a_3} S(-1) - \frac{b_4}{b_2-a_3} TR(-1) \qquad (4.4)$$

or

$$PG = A + \Sigma B_i X_i + \Sigma C_j Z_j + DTX + DOC \qquad (4.5)$$

where

X_i = the determinants of demand,

Z_i = the determinants of supply,

$$A = \frac{a_1-b_1}{b_2-a_3}$$

$$B_i = \frac{a_i}{b_2-a_3}$$

$$C_j = \frac{b_j}{b_2-a_3}$$

$$D = \frac{b_2}{b_2 - a_3}$$

and

$$0 < D < 1.$$

The Variables. Equation (4.4) indicates the relationship we wish to estimate empirically. The relationships between dependent and independent variables are explained below.

1. The one-year-lagged demand ($D_{(-1)}$).

For most of the consumers, an immediate switch to other kinds of fuel is quite difficult. The ability to switch is also constrained by the long-term contracts that are signed between producers and distributors. Thus, the one-year-lagged demand variable ($D_{(-1)}$) shows some inertia in consumption behavior, at least in the short run.

2. The price of electricity (PE).

Electricity is considered to be a substitute for natural gas. If the price of electricity rises, we expect the price of natural gas to rise through the increasing demand for natural gas. Hence, we expect there is a positive relationship between the price of natural gas (PG) and the price of electricity (PE).

3. The price of #2 oil (PO)*.

#2 oil is also considered a substitute for natural gas. A positive relationship is expected between PG and PO.

*Coal is also considered a substitute for natural gas, however, in this study, coal prices are not statistically significant in both models.

4. The income variable (GSP).

Higher income will stimulate the consumption of natural gas and drive up the price of natural gas. Therefore, we expect there is a positive relationship between income and price of natural gas.

5. The severance tax (TX).

In equation (4.4), severance tax is measured by the difference between the market equilibrium price of natural gas (PG) and the sum of wellhead price of natural gas and operation costs. That is,

TX = PG - WP - OC.

In normal situations, suppliers have the ability to shift some of the tax burden to consumers. An increase in severance tax increases the price of natural gas. Hence, a positive relationship between PG and TX is expected.

6. The one-year-lagged annual production ($S_{(-1)}$).

Most of the natural gas production is sold to pipeline on long-term contracts creating inertia in the supply system. We incorporate this aspect of gas production into the model through a lagged dependent variable.

7. The one-year-lagged total reserves [TR(-1)].

The decision to produce out of existing reserves is limited by the total reserves available. Hence, one-year-lagged total reserves enter into equation (4.4) to show the production ability of natural gas companies is limited by the total reserves available. More reserves means more production is possible, which in turn, drives down the price of natural gas. Therefore, a negative relationship is expected between PG and TR(-1).

8. The operation costs (OC).

The retail gas price reflects not only the purchased cost of gas (wellhead price), but also the amount transmission and distribution companies must add to cover their costs of doing business. These costs include transmission and distribution, storage and administration, also known as operation and maintenance costs (American Gas Association, 1983). An increase in operation costs increases the retail price of natural gas. A positive relationship is expected between PG and OC.

<u>The Test Statistic</u>. The empirical hypothesis to be tested in this study is whether or not natural gas severance taxes are passed on to consumers. The share of taxes passed forward to consumers is expressed as the estimated value of the severance tax coefficient, D, or $\frac{b_2}{b_2 - a_3}$. From equations (4.1) and (4.2), b_2 and a_3 are expected to be positive and negative, respectively. Hence, the estimated value of D must be greater than 0 and is expected to fall between 0 and 1.

The Interstate Model

Due to price regulation on interstate markets before 1978, the interstate model is tested only for the period after 1978. The short-run demand for and supply of natural gas in this market are discussed below.

<u>The Demand Function</u>. The demand function for natural gas is similar to the one specified for the intrastate market. It can be expressed as

$$D = a_{1n} + a_{2n}GNP + a_{3n}GNP_{(-1)} + a_{4n}PG + a_{5n}PO + a_{6n}PE + a_{7n}DUMD + U_{1n} \quad (4.6)$$

where

D = the quarterly total demand for natural gas in the U.S., billion cubic feet,

GNP = the deflated quarterly national gross product, billion dollars,

$GNP_{(-1)}$ = the one-quarter-lagged deflated quarterly national gross product,

PG = the deflated U.S. average natural gas price,

PO = the deflated #2 oil price in the U.S., dollars per gallon,

PE = the deflated electricity price in the U.S., cents per kilowatt hour,

DUMD = the dummy variable; 0 for 2nd and 3rd quarter of a year, 1 for 1st and 4th quarter of a year, and

U_{1n} = the random disturbance term.

The Supply Function. The short-term supply function, according to Richardson and Scott (1979), can be expressed as:

$$S = b_{1n} + b_{2n}WP + b_{3n}WP_{(-1)} + b_{4n}PWG + b_{5n}TC + U_{2n} \quad (4.7)$$

where

S = the quarterly total supply of natural gas in the U.S., billion cubic feet,

WP = the deflated U.S. wellhead price of natural gas,

$WP_{(-1)}$ = the deflated U.S. wellhead price of natural gas in previous quarter,

PWG = the number of producing gas wells,

TC = the total operating cost of gas wells, million dollars, and

U_{2n} = the random disturbance term.

<u>The Reduced Form</u>. The final market price of natural gas paid by end-users can be expressed as:

$$PG = WP + TX + OC \qquad (4.8)$$

where

TX = the severance tax on natural gas, and

OC = the operation costs for distributors.

The reduced form becomes:

$$PG = \frac{a_{1n}-b_{1n}}{b_{2n}-a_{4n}} + \frac{a_{2n}}{b_{2n}-a_{4n}} GNP + \frac{a_{3n}}{b_{2n}-a_{4n}} GNP(-1) + \frac{a_{5n}}{b_{2n}-a_{4n}} PO$$

$$+ \frac{a_{6n}}{b_{2n}-a_{4n}} PE + \frac{a_{7n}}{b_{2n}-a_{4n}} DUMD + \frac{b_{2n}}{b_{2n}-a_{4n}} TX + \frac{b_{2n}}{b_{2n}-a_{4n}} OC$$

$$- \frac{b_{3n}}{b_{2n}-a_{4n}} WP(-1) - \frac{b_{4n}}{b_{2n}-a_{4n}} PWG - \frac{b_{5n}}{b_{2n}-a_{4n}} TC \qquad (4.9)$$

or

$$PG = An + \Sigma B_{in}X_{in} + \Sigma C_{jn}Z_{jn} + D_nTX + D_nOC \qquad (4.10)$$

where

X_{in} = the determinants of demand,

Z_{jn} = the determinants of supply,

$$A = \frac{a_{1n} - b_{1n}}{b_{2n} - a_{4n}}$$

$$B_{in} = \frac{a_{in}}{b_{2n} - a_{4n}}$$

$$C_{jn} = \frac{b_{jn}}{b_{2n} - a_{4n}}$$

$$D_n = \frac{b_{2n}}{b_{2n} - a_{4n}}$$

and

$0 < D < 1.$

<u>The Variables</u>. The relationships between dependent and independent variables in equation (4.9) are explained below.

1. The gross national product (GNP).

As explained in the intrastate model, higher income will stimulate the consumption of natural gas and drive up the price of natural gas. A positive relationship is expected between GNP and PG.

2. The one-quarter-lagged national gross product ($GNP_{(-1)}$).

The trend of consumption behavior might not be changed in a short period of time. Thus, an increase in national gross product in previous period might increase the consumption of natural gas in current period. We expect a positive relationship between $GNP_{(-1)}$ and PG.

3. The price of #2 oil (PO).

As explained in the previous section, #2 oil is considered a substitute for natural gas. A positive relationship is expected between PG and PO.

4. The price of electricity (PE).

Electricity is also considered a substitute for natural gas. A positive relationship is expected between PG and PE.

5. The dummy variable (DUMD).

The demand for natural gas reaches its peak during the heating season. To capture this effect, a dummy variable is employed; 0 for the 2nd and 3rd quarter of a year and 1 for 1st and 4th quarter of a year. We expect a positive relationship between PG and DUM.

6. The severance tax (TX).

As was explained in discussion of the intrastate model, severance tax is part of the cost for natural gas producers. Hence, a positive relationship between PG and TX is expected.

7. The operation costs (OC).

As also explained in the previous section, the relationship between OC and PG is expected to be positive.

8. The one-quarter-lagged wellhead price of natural gas ($WP_{(-1)}$).

An increase in natural gas price of current period will stimulate the production of natural gas in next period. So will the increase in natural gas price of previous period stimulate current period's production, and drive down the price of natural gas in the current period. We expect there is a negative relationship between PG and $WP_{(-1)}$.

9. The number of producing wells of natural gas (PWG).

The production ability of natural gas companies is not only limited by the total reserves available, in the long-run, but also limited by the number of producing wells of natural gas, in the short-run. More production wells means producers can produce more natural gas out of existing reserves, which in turn, drives down the price of natural gas. Therefore, we expect a negative relationship between PG and PWG.

10. The total operating cost of natural gas wells (TC).

This cost includes maintenance expenses and operating expenses of natural gas wells. If TC increases, total cost increases, the final price of natural gas paid by consumers, PG, also increases, hence, a positive relationship is expected between PG and TC.

The Test Statistic. The portion of severance tax that a state exports to other states depends on the estimated value of severance tax coefficient, D_n, or $\frac{b_{2n}}{b_{2n}-a_{4n}}$. The value of this coefficient is expected to fall between 0 and 1.

To summarize, we developed two empirical models in this chapter based on demand and supply framework of natural gas. The ability of natural gas companies to shift some of the severance tax burden to consumers and the ability of state government to export natural gas severance taxes depends on the tax coefficient, D, in both markets.

CHAPTER V

EMPIRICAL ESTIMATES

In Chapter III we presented the theoretical background of this study and in Chapter IV we described the empirical models. The empirical results, based on regression results, are presented in this chapter. The results of OLS linear regression are provided for both intrastate and interstate markets.

Data Sources

To estimate the severance tax incidence, annual data is used for intrastate market for the period 1960-1981, and quarterly data is used for interstate market for the period 1980:1-1984:4. The data sources of the demand for natural gas (D), the supply for natural gas (S), the market price of natural gas (PG), the wellhead price of natural gas (WP), the total reserves of natural gas (TR), the operation costs (OP), the number of producing wells of natural gas (PWG), and the total operating cost of natural gas wells (TC) for both markets are obtained from Natural Gas Monthly, Natural Gas Annual, Statistics on Interstate Natural Gas Pipeline Companies, and State Energy Data Report Consumption Estimates (U.S. Department of Energy).

The price of #2 oil (PO) and the price of electricity (PE), for both markets are obtained from Monthly Energy Review (U.S. Department of Energy).

The GNP implicit price deflator (1972 =100), the gross national product (GNP), and the gross state product (GSP) are obtained from various issues of the Survey of Current Business (U.S. Department of Commerce).

The Empirical Results

Intrastate Model

The results of the multiple regression equations based on the intrastate model specified in Chapter IV are summarized in Table XIV. For each equation, the estimated regression coefficients of the variables are listed in the table along with the coefficient of multiple determination (R^2) and the value of the t-statistic for the coefficient. Significance tests have been performed on individual regression coefficients. One asterisk indicates the coefficient is significantly different from zero at the 90 percent level; two, the 95 percent level; and three, the 99 percent level. F-tests are made to determine the overall significance of estimated equations. One, two, or three asterisks attached to the value of the F-ratio indicate alternative levels of significance as described earlier.

For equation (5.1), the natural gas demand in Oklahoma, about 91 percent of the variation in the demand for natural gas variable (D), can be explained by the five independent variables and the F-ratio is highly significant at the 99 percent level. For equation (5.2), the natural gas supply in Oklahoma, about 97 percent of the variation in the natural gas supply variable (S) can be explained by the three variables and the F-ratio is highly significant at the 99 percent

TABLE XIV

EQUATION ESTIMATES: INTRASTATE MODEL

Equation (5.1)

$$\underset{}{D} = \underset{(0.02)}{11.28} - \underset{(-0.28)}{73.52PG} + \underset{(3.63)^{**}}{0.84D(-1)} + \underset{(0.34)}{0.01GSP} + \underset{(0.01)}{5.06PE} - \underset{(-0.40)}{15.79PO}$$

$R^2 = 0.902$ F = 27.75*** D-W = 1.67

Equation (5.2)

$$S = \underset{(-0.89)}{-150.68} + \underset{(3.29)^{***}}{291.24WP} + \underset{(2.67)^{**}}{0.89S(-1)} + \underset{(17.42)^{***}}{0.02TR(-1)}$$

$R^2 = 0.966$ F = 161.06*** D-W = 2.46

Equation (5.4)

$$PG = \underset{(-21.35)^{***}}{-1.74} - \underset{(-2.12)^{*}}{0.00012D(-1)} + \underset{(13.91)^{***}}{0.00089GSP} + \underset{(15.49)^{***}}{0.10746PE} + \underset{(2.74)^{***}}{0.02988PO}$$

$$+ \underset{(11.66)^{***}}{0.9058TX} + \underset{(1.86)^{*}}{0.72410C} + \underset{(.12)}{0.000006S(-1)} + \underset{(8.15)^{***}}{0.00002TR(-1)}$$

$R^2 = .999$ F = 1664.72*** D-W = 3.15

t-statistics are in parentheses
* indicates significant at the 90 percent level.
** indicates significant at the 95 percent level.
*** indicates significant at the 99 percent level.

level. In order to estimate the severance tax incidence, equation (5.4), the reduced form equation derived from (5.1) and (5.2), was tested. For equation (5.4), about 99 percent of the variation in the natural gas price variable (PG) can be explained by the eight independent variables. The coefficients of these variables have the predicted signs except for the one-year-lagged supply of natural gas variable, $S_{(-1)}$, and the one-year-lagged reserves variable, $TR_{(-1)}$. All coefficients, except for the one-year-lagged reserves variable, $TR_{(-1)}$, are significant at the 90 percent level.

Table XV shows the simple correlation coefficients between each independent variable in (5.4). As shown in Table XV, no serious multicollinearity problem exists. The Dubin-Watson tests were performed for all three equations. The results show that there is no serious serial correlation problem in (5.1), (5.2), and (5.4).

As explained in the previous Chapter, the share of taxes passed forward to consumers is expressed as the estimated value of the severance tax coefficient. Hence, according to the regression results, about 91 percent of the severance tax is passed forward to resident buyers within Oklahoma, that is, for every one dollar natural gas severance tax revenue collected in intrastate market, about 91 cents come from state residents of Oklahoma.

The severance tax coefficient shows that a large protion of tax incidence falls on state residents of Oklahoma. That means the intrastate demand for natural gas might be relatively inelastic. this is true, if we take the logarithmic form of equation (5.1), the price elasticity of demand for natural gas is -0.27.

Morgan and Mutti (1981) point out that the field (wellhead) price of natural gas accounts for only about one-third of delivered price,

TABLE XV

SIMPLE CORRELATION COEFFICENTS OF DETERMINANTS OF NATURAL GAS PRICE IN INTRASTATE MARKET

	D(-1)	GSP	PE	PO	TX	OC	S(-1)	TR(-1)
D(-1)	1.00							
GSP	-0.13	1.00						
PE	-0.04	0.23	1.00					
PO	-0.02	-0.65	0.02	1.00				
TX	-0.29	-0.61	-0.25	0.47	1.00			
OC	-0.00	-0.67	-0.49	-0.02	0.46	1.00		
S(-1)	-0.33	-0.77	0.16	0.55	0.76	0.50	1.00	
TR(-1)	0.20	-0.02	-0.29	0.12	0.36	0.93	0.00	1.00

makes demand for natural gas fairly inelastic. Although substitute fuels are readily available in Oklahoma, as long as the prices for equivalent BTU content in alternative fuels are higher than the price of natural gas, which is the case in Oklahoma, most of the severance tax on natural gas would be shifted forward to end-user in the intrastate market.

The rest of the tax, about 9 percent, must fall on the producers or mineral rights owners. Only when producers or mineral rights owners happen to be out-of-state residents, the tax will be exported. Hence, the maximum possibility for state government to export natural gas severance tax is 9 percent.

The percentage of severance tax exported to federal taxpayers through the deductibility of federal taxes, if we apply the tax rates in Chapter III, is 56.8 percent. Hence, the maximum of total severance tax exported in this market is 65.8 percent (=.09 + .568), and the minimum is 56.8 percent.

Interstate Model

Table XVI summarizes the regression results for the interstate model. For each equation, the estimated regression coefficients of the variables, the R^2 value, and the F-ratio are listed in the table. The t-ratio for each variable is listed in the parenthesis below each coefficient. One, two, or three asterisks attached to the value of the t-ratio and F-ratio indicate the level of significance as described in the previous section.

Equations (5.6) and (5.7) are the demand for and the supply of natural gas, respectively, in the interstate model. For equation

TABLE XVI

EQUATION ESTIMATES: INTERSTATE MODEL

Equation (5.6)

$$\underset{(4.19)***}{D = 10145.86} - \underset{(-0.53)}{267.04PG} + \underset{(1.29)}{0.70GNP} - \underset{(-2.96)***}{1.40GNP(-1)} - \underset{(-2.94)***}{1938.8PE}$$

$$+ \underset{(0.66)}{1243.68PO} + \underset{(11.00)***}{1458.95DUMD}$$

$R^2 = 0.955$ F = 42.83*** D-W = 1.72

Equation (5.7)

$$\underset{(11.20)***}{S = 6944.09} + \underset{(2.14)**}{3348.24WP} - \underset{(-4.01)***}{5987.63WP(-1)} - \underset{(-2.64)**}{0.06PWG} + \underset{(3.63)***}{0.58TC}$$

$R^2 = 0.791$ F = 13.25*** D-W = 1.13

Equation (5.9)

$$\underset{(-3.31)***}{PG = -0.6819} - \underset{(-0.96)}{0.00004GNP} + \underset{(3.46)***}{0.00015GNP(-1)} + \underset{(3.04)**}{0.23523PE} + \underset{(0.12)}{0.01731PO}$$

$$\underset{(-1.14)}{-0.02842DUMD} + \underset{(7.12)***}{0.96857TX} + \underset{(10.01)***}{0.87553OC} + \underset{(4.13)***}{0.62046WP(-1)}$$

$$+ \underset{(1.81)*}{0.000005PWG} + \underset{(1.66)}{0.00014TC}$$

$R^2 = 0.998$ F = 341.51*** D-W = 2.94

t-statistics are in parentheses
* indicates significant at the 90 percent level.
** indicates significant at the 95 percent level.
*** indicates significant at the 99 percent level.

(5.6), about 96 percent of the variation in the demand for natural gas variable (D) can be explained by the six independent variables and the F-ratio is highly significant at the 99 percent level. For equation (5.7), about 79 percent of the variation in the supply of natural gas variable (S) can be explained by the three independent variables and the F-ratio is highly significant at the 99 percent level. Equation (5.9) was tested in order to estimate the severance tax burden that falls on residents outside Oklahoma. For equation (5.9), about 99 percent of the variation in the natural gas price (PG) can be explained by the ten independent variables and the F-ratio is highly significant at the 99 percent level. Five of the coefficients of these variables have the predicted signs and are significant at the 99 percent level. It is noted that the severance tax variable (TX) and the operation cost variable (OC) appear to be two relatively most important variables in explaining the variation in the dependent variable, PG.

As shown is Table XVII, there is no serious multicollinearity problem between each independent variable in (5.9). The Dubin-Watson tests show that no serious serial correlation problem exists in (5.6), (5.7), and (5.9).

With regard to the severance tax incidence, the regression coefficient of the severance tax variables (TX) shows that about 97 percent of the severance tax burden is shifted to residents outside Oklahoma.

The logarithmic form of equation (5.6) shows that the price elasticity of demand for natural gas is -0.08 in the interstate market. The reasons for this are similar to the ones for intrastate

TABLE XVII

SIMPLE CORRELATION COEFFICENTS OF DETERMINANTS OF
NATURAL GAS PRICE IN INTERSTATE MARKET

	GNP	GNP(-1)	PO	PE	DUMD	TX	OC	WP(-1)	PWG	TC
GNP	1.00									
GNP(-1)	-0.33	1.00								
PO	0.51	0.03	1.00							
PE	-0.23	0.51	-0.04	1.00						
DUMD	0.53	-0.59	0.23	-0.37	1.00					
TX	-0.06	-0.23	0.08	-0.48	-0.03	1.00				
OC	-0.18	0.24	0.42	0.35	-0.26	0.31	1.00			
WP(-1)	0.39	-0.19	0.26	-0.13	0.51	-0.70	-0.37	1.00		
PWG	0.47	-0.19	0.08	-0.13	0.57	-0.51	-0.50	0.75	1.00	
TC	-0.26	0.05	-0.36	-0.29	-0.44	0.71	-0.13	0.51	-0.49	1.00

market. Cheaper prices of natural gas makes natural gas a very competitive fuel in the national fuel market. In most of the U.S., the prices of natural gas are lower than the prices for alternative fuels of equivalent BTU content. Accesses for alternative fuels are not as easy as in the intrastate market. Even if alternative fuels are available, immediate switch to other kinds of fuel is quite difficult in the short run. All of these make the demand for natural gas even more inelastic in the interstate market. Hence, in the short run, large portions of severance taxes imposed by gas-producing states could be shifted forward to end-users in the interstate market.

The tax that is not shifted forward to consumers must be shifted backward to producers or mineral rights owners. Hence, the maximum of this portion of tax exported is 3 percent.

The percentage of severance tax exported to federal taxpayers though the deductibility of federal taxes, again, if we apply the tax rates in Chapter III, is 56.8 percent. Hence, the maximum of total severance tax exported in this market is 156.8 percent (=.97 + .03 + .568), and the minimum is 153.8 percent (=.97 + .568).

The large value of severance tax coefficients in both markets imply that supply of natural gas might be relatively elastic. As was mentioned in Chapter II, the interstate natural gas prices were subject to relatively stringent cost-oriented pricing standards and not allowed to increase as rapidly as oil prices in the early 1970's. The low-cost natural gas dominated the supply of natural gas at that time. Only recently, after the NGPA allowed some categories of gas to be deregulated, have costs of finding and producing gas been rising rapidly at the margin. Hence, the relatively elastic supply curve is a reasonable assumption during the study period.

In 1984, Oklahoma sold 1,161,866 million cubic feet of natural gas to other states through interstate pipeline companies and consumed 652,953 million cubic feet of natural gas within the state. Hence, over all the maximum of total natural gas severance tax exported in the year 1984 is

$$(.658)*\frac{652,953}{(652,953 + 1,161,866)} + (1.568)*\frac{1,161,866}{(652,953 + 1,161,866)} = 1.2406;$$

and the minimum is

$$(.568)*\frac{652,953}{(652,953 + 1,161,866)} + (1.538)*\frac{1,161,866}{(652,953 + 1,161,866)} = 1.189$$

That is, about 119 to 124 percent of Oklahoma's natural gas severance tax was exported in 1984.

Other Specifications

Besides the variables in equations (4.4) and (4.9), some other variables were also used to estimate the tax incidence.

The Price of Coal (PC)

Coal is considered a substitute for natural gas. A positive relationship is expected between PG and PC. Equation (4.4) becomes

$$PG = \frac{a_1-b_1}{b_2-a_3} + \frac{a_2}{b_2-a_3} D(-1) + \frac{a_4}{b_2-a_3} PE + \frac{a_5}{b_2-a_3} PO + \frac{a_6}{b_2-a_3} GSP$$

$$+ \frac{a_7}{b_2-a_3} PC + \frac{b_2}{b_2-a_3} TX + \frac{b_2}{b_2-a_3} OC - \frac{b_3}{b_2-a_3} S(-1)$$

$$- \frac{b_4}{b_2-a_3} TR(-1) \qquad (4.4)^*$$

The empirical estimate of (4.4)* is:

$$PG = \underset{(12.36)^{***}}{-1.64} - \underset{(-0.76)}{0.0004D(-1)} + \underset{(11.84)^{***}}{0.00086GSP} + \underset{(10.84)^{***}}{0.10179PE} + \underset{(2.75)^{***}}{0.03674PO}$$

$$- \underset{(-0.72)}{0.00205PC} + \underset{(10.19)^{***}}{0.8971TX} + \underset{(1.45)}{0.64230C} - \underset{(-0.38)}{0.00002S(-1)}$$

$$\underset{(5.45)^{***}}{-0.00001TR(-1)}$$

R^2 = .999 F = 1169.57*** D-W = 2.70

Equation (4.9) was also expressed as:

$$PG = \frac{a_{1n}-b_{1n}}{b_{2n}-a_{4n}} + \frac{a_{2n}}{b_{2n}-a_{4n}} GNP + \frac{a_{3n}}{b_{2n}-a_{4n}} GNP(-1) + \frac{a_{5n}}{b_{2n}-a_{4n}} PO$$

$$+ \frac{a_{6n}}{b_{2n}-a_{4n}} PE + \frac{a_{7n}}{b_{2n}-a_{4n}} DUMD + \frac{a_{8n}}{b_{2n}-a_{4n}} PC + \frac{b_{2n}}{b_{2n}-a_{4n}} TX$$

$$+ \frac{b_{2n}}{b_{2n}-a_{4n}} OC - \frac{b_{3n}}{b_{2n}-a_{4n}} NP(-1) - \frac{b_{4n}}{b_{2n}-a_{4n}} PWG - \frac{b_{5n}}{b_{2n}-a_{4n}} TC \quad (4.9)^*$$

The empirical estimate of (4.9)* is:

$$PG = \underset{(-2.28)^{**}}{-0.6262} - \underset{(-0.93)}{0.00005GNP} + \underset{(3.15)^{***}}{0.00015GNP(-1)} + \underset{(2.64)^{**}}{0.25151PE}$$

$$+ \underset{(0.16)}{0.02489PO} - \underset{(-0.34)}{0.00440PC} - \underset{(-1.12)}{0.03028DUMD} + \underset{(6.68)^{***}}{0.97627TX}$$

$$+ \underset{(9.05)^{***}}{0.885810C} + \underset{(3.59)^{***}}{0.60264WP(-1)} + \underset{(1.56)}{0.000005PWG} + \underset{(1.59)}{0.00014TC}$$

R^2 = .998 F = 276.07*** D-W = 2.99

As the empirical estimates show, the price of coal in both markets does not change the empirical results of equations (4.4) and (4.9) much. In both markets, PC does not improve R^2 and has an insignificant coefficient.

The Interest Rate (INT)

Higher prices will encourage production, as will rising interest rates, since income earned from the sale of natural gas can be invested and earn higher returns elsewhere. A negative relationship is expected between the interest rate and natural gas price since an increase in natural gas production will cause natural gas prices to fall. Equation (4.2) becomes:

$$S = b_1 + b_2WP + b_3S(-1) + b_4TR(-1) + b_5INT + U_2 \qquad (4.2)^*$$

The empirical estimate of equation (4.2)* is:

$$\underset{(-1.49)}{S = -519.44} - \underset{(-0.22)}{6707WP} + \underset{(11.98)^{***}}{0.83S(-1)} + \underset{(2.56)^{**}}{0.03TR(-1)} + \underset{(1.21)}{374.41INT}$$

$R^2 = 0.97$ $\qquad$ $F = 124.39^{***}$ $\qquad$ D-W = 2.23

However, the negative sign of WP contradicts our production theory, and the interest rate coefficient shows no statistical significance. Hence, we dropped INT from the model.

CHAPTER VI

SUMMARY AND CONCLUSIONS

This chapter summarizes the methodology and empirical results of the study. Some suggestions are made for future research based on the findings of this study.

Summary

Severance taxes have played a more and more important role in many states' tax structures. The wide use of taxes on energy resources to finance state government activities may reflect the fact that state governments believe that a portion of these taxes can be exported to other states. Despite the theoretical importance of exportability for a state, little empirical research has been done to estimate the geographic incidence of particular severance taxes for particular states. The main objective of the present study has been to estimate the incidence of Oklahoma's severance tax on natural gas on consumers in Oklahoma and other states. To do this, two empirical models, an intrastate model and an interstate model, were developed based on Shelton and Vogt's (1982) coal severance tax model. Both models are based on a formal demand and supply framework which incorporates the most important determinants of the demand for and the supply of natural gas. Two reduced form equations derived from these models were estimated, using ordinary least square techniques. The intrastate model was estimated for the period 1960-1981, using annual data. The interstate model was estimated for the period 1980:1-1984:4, using quarterly data.

By examining the evidence obtained from the empirical models, and based on the example in Chapter III, we find:

1. About 91 percent of the Oklahoma severance tax revenue collected from intrastate natural gas sales is paid by Oklahoma consumers. Nine percent of this tax revenue is paid by producers and mineral rights owners, only some of whom may be non-Oklahoma residents. Thus, less than 9 percent of this portion of the tax may be exported.

2. About 97 percent of the Oklahoma severance tax revenue collected from interstate natural gas sales is paid by out-of-state consumers. Three percent of this tax revenue is paid by producers and mineral rights owners. Since some of these may be non-Oklahoma residents, over 97 percent of this portion of the tax may be exported.

3. Over one-half of the taxes collected in both markets may be exported to federal taxpayers through federal tax deductibility. However, we have not estimated the actual percentage exported in this way.

4. Given the distribution of natural gas sales between intrastate and interstate markets in 1984, Oklahoma may have exported over 100 percent of its total natural gas severance taxes to residents of other states and federal taxpayers.

The empirical findings of this study show that a very large portion of Oklahoma natural gas severance taxes levied on interstate sales are exported. These results would follow from small price elasticity of demand, large price elasticity of supply, or institutional features which facilitated a fairly complete pass-through of taxes. The logarithmic form of the demand function suggests a low price elasticity, and thereby suggests a high price elasticity of supply. We have not examined the market's institutional or regulatory features carefully enough to determine their role.

Although some empirical estimates of the exportation of Oklahoma severance taxes have been done by several public finance economists, one of the features that makes this study different from other studies is that we have estimated the incidence of the Oklahoma severance tax on natural gas through the use of a market equilibrium model. In this way, the severance tax has been treated as a difference between the market price and the wellhead price. This magnitude is interpreted as reflecting the true ability of producers and consumers to avoid paying the tax. Through the use of a demand and supply framework, many important factors, such as changes in economic activity and seasonal fluctuations in demand for natural gas, could be incorporated in the models as determinants of the magnitude of the severance tax that fell on consumers.

Another feature of this study is that it not only provides an estimate of the tax exportation ability of state government of Oklahoma but it also provides an estimate of the tax share that fell on residents within Oklahoma. This is important to Oklahoma tax policy makers. Exportability is an important factor in evaluating a tax, but so is equity. Our empirical results show that most of the severance taxes collected from interstate markets could be exported. In this way, the severance tax meets the exportation criterion of a good tax. On the other hand, a large portion of tax also fell on residents of Oklahoma. If most of the natural gas consumed in Oklahoma were used by low-income residents, the tax would be regressive. It then would not meet the vertical equity criterion of a good tax. We do not know the distribution of expenditures for natural gas by income class in Oklahoma. However, the findings of this study provide valuable information for state tax policy makers trying to formulate a balanced tax policy in terms of both exportability and vertical equity.

Future Research

Perhaps the weakest link in our analysis is the use of national production cost data, rather than cost data specific to Oklahoma. Lack of data, however, precluded us from separating Oklahoma's natural gas production from that of the other major producing states and from applying production costs specific to natural gas production in Oklahoma. This is clearly a problem which needs future research. As discussed in Chapter III, market dominance can result from the coordinated actions of several jointly-dominant states. Thus, the exportation ability of the state government of Oklahoma might have been overestimated. Only a future study built around a multi-jurisdictional model will tell us this for sure. Morgan and Mutti (1985) have argued that if most of the severance taxes are passed forward to consumers rather than backward to stockholders, this may mobilize political support for severance tax limitation bill such as those for western coal producing states. Thus, it would be of continuing interest to the state government of Oklahoma to update this estimate of exportation ability.

Lack of data also precluded the accurate estimate of tax exportation through backward shifting of Oklahoma natural gas severance taxes. As the empirical results show, this portion of tax is quite small in both markets. Hence, this omission does not harm our empirical findings seriously. However, the portion of tax exported to federal taxpayers via federal tax deductability could be quite large. Mutti and Morgan (1983) have argued that any decline in federal tax revenues will result in a reduction in federal government expenditures, an increase in other federal taxes, or an increase in the federal debt. Each of these alternatives further redistributes the tax within the nation. Thus, a multilateral analysis which explicitly incorporates these choices may be well worth the effort. This would be important for state tax policy makers, as well, as a means of considering the feedback of a severance tax in a broader context.

It would also be worth the effort to distinguish the demand for natural gas among the various end-use sectors. The theoretical analysis of this study shows that the incidence of tax depends on the elasticity of demand of individual users and the price of the appropriate alternative fuel available to each user. Since user's abilities to switch to other fuels differ, so do the elasticities of demand for natural gas in the various end-use sectors. Hence, the incidence that falls on end-use sectors is also different. In the present study, we have used aggregate demand rather than individual end-use sector demands, and our empirical results may not be accurate representations of the incidence for any particular end-use sector. That is, our estimates may be an overestimate of the industrial sectors' tax burden, and an underestimate of the residential sector's tax burden, since the industrial users can switch to other fuels more easily than can residential users. This has implications for policy makers concerned about vertical equity, and a further study of tax incidence for individual end-use sectors is suggested.

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