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The effects of deregulation on the structure of the Texas natural gas production industry

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"THE EFFECTS OF DEREGULATION ON THE STRUCTURE OF THE TEXAS NATURAL GAS PRODUCTION INDUSTRY"

by

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A thesis submitted in partial fulfillment of the requirements for the degree of

Master of Arts

in

Economics

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ABSTRACT

Buying, selling, and transporting natural gas through underground pipelines has historically been regulated. However, in 1978 the Natural Gas Policy Act was passed, reducing the control that regulators had over the price of natural gas. In addition, the 1989 Natural Gas Wellhead Decontrol Act and the Federal Energy Regulatory Commission's Order #636 in 1992, continued deregulation of both natural gas prices and transportation from the point of sale to the customer's burner tip.

Analysts have argued these regulatory changes have increased competition in the natural gas industry. This paper presents an empirical analysis of the Texas natural gas production industry in order to determine the impact of regulatory change on the structure of the industry. The empirical analysis confirms that deregulation has increased competition among Texas natural gas producers.
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CHAPTER I
HISTORY AND INTRODUCTION

The U.S. natural gas industry has been evolving over the last fifty years. During this time, natural gas has gone from a fuel that producers have flared, to one which producers invest nearly $1,000,000 per well to drill for, extract, and purify the fuel for resale. In addition, natural gas has grown from 11.9% of aggregate U.S. energy consumption in 1944 to 32.6% of aggregate U.S. energy consumption in 1994. Natural gas production has also risen by 13.4% from 1983 to 1993, while natural gas consumption has risen by about 19% during the same time frame. These changes have been the result of: 1) The environmental movement which encourages consumption of natural gas vis-à-vis other fuels. Natural gas emits fewer particulates, carbon oxides, nitrogen dioxides and sulfur dioxides in comparison to oil or coal; 2) Politicians have encouraged the use of domestic energy sources since the energy crisis of the 1970's and the Persian Gulf war in the early 1990's. Natural gas benefits from this political environment as most of the U.S. demand can be supplied by domestic and Canadian production; 3) Regulatory changes have affected the incentives firms have to enter or exit the market. Collectively, these

1 Source: Oil and Gas Journal, “Natural Gas Statistics Sourcebook”, pg. 83.
4 Source: AGA 1994 Gas Facts, pg. 34. The U.S. imports small amounts of natural gas from Mexico and minor amounts of liquefied natural gas (LNG) from Algeria, otherwise all domestic U.S. demand is met through Canadian or domestic U.S. production.
changes have increased the importance of natural gas in meeting the needs of domestic aggregate energy demand.

As well as increasing in relative importance, natural gas markets have also experienced a regulatory transition. Regulation began in 1909 with state oversight of intrastate transportation and consumption of natural gas. This was followed by the 1938 Natural Gas Act and the 1954 Supreme Court Phillips decision which established regulation for the interstate transportation and sale of natural gas. However, the 1978 Natural Gas Policy Act, the 1989 Natural Gas Wellhead Decontrol Act, and Order #636 in 1992 from the Federal Energy Regulatory Commission, have collectively deregulated the industry. The goal of deregulation has been to eliminate federal and state oversight which was an impediment, and no longer a surrogate, for competition in the transportation and sale of natural gas. Even though proponents of deregulation have touted its beneficial impact, there has yet to be an empirical analysis which examines the effect of deregulation on the structure of the natural gas production industry. This paper is an empirical analysis of four firm concentration ratios in the Texas natural gas production industry. The paper determines how regulatory change has affected four-firm concentration in the production of Texas natural gas by including dummy variables for legislation implemented to deregulate the industry^5. If the dummy variable coefficients have a statistically significant negative sign then deregulation has decreased Texas natural gas production concentration ratios and increased competition among Texas producers.

^5 In an article entitled “Highlights: Natural Gas 1992: Issues and Trends” (1992) the Energy Information Administration suggests that “Open access increased competition at the wellhead, giving rise to an active spot market for the sale of natural gas, thus encouraging production.” However no empirical evidence of increased competition is offered.

^6 The four-firm concentration ratio is defined as the proportion of total natural gas industry sales made by the top four natural gas producers or marketers.
The Texas natural gas production industry was studied for two reasons. First, national concentration data is not inexpensively available on a monthly basis. Second, Texas supplies the largest proportion of U.S. demand (over 33%) by producing over 6.9 trillion cubic feet of gas annually. Texas production comes primarily from onshore wells in the west Texas area which have access to national gas markets. Texas also has the largest reserves, highest well count (over 46,000 wells), and the greatest value of marketed production at $10.8 billion of any state in the continental U.S. Due to the significance of Texas markets, the impact of deregulation should be manifest in an analysis of Texas data.

The next Chapter is an introduction to natural gas markets and a more detailed discussion of the impact of deregulation on those markets. Chapter III is a literature review which summarizes scholarly work related to the topic and establishes a theoretical basis for the regression equation run in Chapter IV. Chapter IV presents the empirical model with five dummy variables, one for each piece of major legislation which deregulated the industry. Chapter V offers closing remarks.

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CHAPTER II
REGULATION AND NATURAL GAS MARKETS

Supplying natural gas demand involves two functions: 1) the production and sale of the gas commodity and; 2) the shipment of the commodity through underground pipes to consumers. Producers extract natural gas through wells from underground reservoirs, selling the gas by daily, monthly, or yearly negotiation of contracts at the point where the gas is removed from the ground, i.e. at the wellhead. Producers often aggregate production, selling it to a marketer who acts as the producers' agent to other customers. Wellhead contract negotiations between consumers and producers, or marketers, typically involve the quantity of gas to be sold, the price, delivery and receipt points for the gas, and the delivery date.

Once the gas is sold, it is shipped by investor or municipally owned utilities who invest in underground pipes which distribute gas to end users. This transportation function is segregated into two steps; 1) shipping gas from the wellhead across state boundaries, called interstate transportation, accomplished by interstate pipelines and 2) transporting the gas within state boundaries to the end user, usually accomplished by Local Distribution Companies (LDCs). Historically, interstate pipelines gathered and purchased gas at the wellhead, transported it to LDCs, who repurchased it and transported it to the end-user. In most cases, interstate pipelines owned the gas from the wellhead to

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1 There are a number of jurisdictional and legal issues involved when determining what authority will regulate a pipeline. For a discussion of some of these issues see Federal Energy Regulatory Commission Order issued February 15, 1994 in Docket No. CP93-258.
the point of intersection with an LDC, who purchased it from the interstate pipeline and
resold it to the customer. Customers of interstate pipelines, mostly LDCs, signed long
term interstate transportation agreements for the right to transport and purchase gas from
interstate pipelines. These rights provided LDCs the means to ship gas across state
boundaries to their source of demand. The agreements for transportation rights usually
specified the price of the capacity, the types of services provided, and the term. Most of
the available interstate pipeline capacity rights have been owned by LDCs through
interstate transportation agreements with terms of over twenty years.

Until the onset of deregulation, the price of wellhead supply and the cost,
placement, and access to interstate pipelines was regulated by the Federal Energy
Regulatory Commission (FERC). The FERC, and its predecessor the Federal Power
Commission (FPC), received statutory authority to regulate the interstate transportation of
natural gas from the 1938 Natural Gas Act (NGA). The 1938 NGA was a reaction to the
increasing amount of natural gas that was being used in interstate commerce which was
exempt from state regulation according to a 1927 Supreme Court decision. The NGA
responded to the regulatory gap by providing the FPC with authority to determine “just
and reasonable” interstate transportation rates, the responsibility to ascertain the “actual
legitimate cost” of pipelines properties for the purpose of establishing rates, and the power
to order an interstate pipeline company to extend or improve its transportation facilities.
In a 1942 amendment, an interstate pipeline was required to obtain a Certificate of Public
Convenience and Necessity from the commission before construction and extension of


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service. The Certificates authorized the pipeline to serve customers within a predefined territory within which the pipeline could continue to expand without obtaining further Certificates. This amendment granted interstate pipelines monopoly transportation rights within a predefined service area in exchange for regulation by federal authorities. The primary customers of interstate pipelines have been, and continue to be LDCs.

Although the 1938 NGA gave the FPC and the FERC the authority to regulate all aspects of the interstate transportation of natural gas, it was not until 1954 that the FERC was granted authority to regulate the purchase and sale of natural gas at the wellhead. In 1954 the Supreme Court heard the case of Phillips Petroleum Company vs. the State of Wisconsin, the cities of Kansas City, Milwaukee, and Detroit, and the county of Wayne, Michigan. The plaintiffs argued that the rates of Phillips Petroleum should be regulated by the FPC under the statutory authority provided by the 1938 NGA. The Supreme Court ruled, “Protection of consumers against exploitation at the hands of natural gas companies was the primary aim of the Natural Gas Act” and that “... the legislative history indicates a congressional intent to give the Commission jurisdiction over the rates of all wholesales of natural gas in interstate commerce, whether by pipeline company or not and whether occurring before, during, or after transmission by an interstate pipeline company.” This decision forced the FPC to regulate the price of gas at the wellhead which, coupled with the FPC’s authority to regulate the price of interstate transportation, gave the FPC ultimate authority to determine the final price of gas bundled with interstate transportation service.

4 "Gas Rate Fundamentals". American Gas Association. 1978, pg. 98. Certificates of Public Convenience and Necessity define where interstate service will be provided and at what cost.

In tandem with the FPC’s regulatory responsibility, state Public Utility Commissions (PUC’s) regulate the intrastate transportation and sale of natural gas. Regulation of intrastate sales and transportation began in 1907 as privately-owned utilities expanded. Due to the high proportion of fixed assets invested in utility service, decreasing average costs were prevalent. These cost characteristics led many to conclude that natural gas distribution closely resembled a natural monopoly. As a result, state legislators in New York created the first regulatory commission to curb potential abuses of natural monopoly power. The new regulatory commission was supported by local utilities as they favored regulation vis-a-vis municipalization. New York’s regulation evolved into a state PUC with the authority to regulate all aspects of LDC’s distribution and sales of natural gas, including price, terms of service, placement of gas distribution facilities, and which customers would be served by the utility. These aspects of regulation ensure a monopoly market for local distribution of natural gas in exchange for regulation by state authorities. New York’s PUC became the model by which other PUCs were created. By 1930, every state except Delaware had a utility regulatory commission, with regulatory power similar to New York’s.

According to this regulatory framework, a typical natural gas customer would purchase and transport gas through an LDC who purchased the gas from, and transported the gas through, an interstate pipeline. The interstate pipeline would have purchased its

6 Gas Rate Fundamentals. American Gas Association, 1987. Pg. 73 - 77. A natural monopoly is defined as a firm which exhibits increasing returns to scale and decreasing average costs over a large range of output.

7 See, AGA’s, “Gas Rate Fundamentals”, Pub. 1978, pg. 93. One of the important features of regulation which ensures a monopoly market is the ability of the PUC to scrutinize all utility investments in facilities to serve customers. By so doing, PUC’s can control which customers are served by which utilities and where.


9 See Appendix I, diagram entitled “Historical Structure of Natural Gas Industry”. 

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gas commodity from a producer or marketer at the wellhead. Primarily LDCs distributed gas to end-users and purchased gas from interstate pipelines, and interstate pipelines principally purchased gas from marketers or producers and shipped gas to LDCs. The entire transaction, from the wellhead to the customer’s burner tip, was monitored and regulated by both the FERC and state regulatory commissions. LDCs were a monopoly transporter and seller of gas to their customers and were faced with monopsony by purchasing and transporting gas solely from interstate pipelines. This market structure suffered from several flaws. End consumers of the gas commodity could not negotiate the gas commodity price nor choose their transportation provider. The market price to customers did not send appropriate price signals as all costs incurred by the LDC, including gas commodity and all transportation costs, were bundled into one rate which was litigated before either the FERC or a state regulatory commission. Customers could not choose which services, gas procurement or transportation service, they would like at separate rates. In addition, customers could not obtain transportation service directly from an interstate pipeline, bypassing the LDCs transportation and procurement services, because virtually all interstate transportation capacity was under contract to LDCs.

Over the last 20 years regulatory reform has been aimed at correcting these market imperfections. As a result of deregulation, most LDC customers can gain access to wellheads outside their home state by subleasing contractual interstate transportation capacity on interstate pipelines. Once access to the wellhead is obtained, customers can negotiate their own gas commodity contracts with wholesale suppliers and producers bypassing the LDCs and interstate pipeline’s procurement services. In addition, large customers\(^\text{10}\) can now build their own distribution facilities and connect directly to an interstate pipeline, bypassing the LDCs transportation services. Large customers may also

\(^{10}\) Only large commercial and industrial customers have sufficient load to make purchasing their own gas supply worth the cost of monitoring and negotiating for their own gas supply.
connect directly to a group of producing gas wells and bypass all services provided by both LDCs and interstate pipelines. Regulatory change has thus reduced both the interstate pipelines monopsony and LDCs distribution monopoly. Customers can now choose which services they would like from competing suppliers. Three regulations passed to achieve these goals were the Natural Gas Policy Act of 1978 (NGPA), the Natural Gas Wellhead Decontrol Act of 1989 (NGWDA), and FERC Order #636 in 1992.

The Natural Gas Policy Act (NGPA) of 1978 reduced the FERC's control over the wellhead price of gas granted by the 1954 Supreme Court Phillips decision. The NGPA phased-in price deregulation for different categories of gas supply over a period of nine years. The phased-in approach, along with continuing price controls on certain categories of gas, was intended to prevent a price spike after deregulation. The NGPA deregulated wholesale prices by January 1, 1985 for new onshore gas well gas produced

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11 The major gas producing basins in the United States are located throughout Texas, New Mexico, Colorado, Oklahoma, California, and Kansas. Therefore this type of bypass threat is unique to these areas.

12 See Appendix II, diagram entitled “Timeline for Natural Gas Industry Deregulation”.


15 Phillips, Charles F. Jr. “The Regulation of Public Utilities”. 2nd Edition, 1988. Pages 638-639. A new onshore well was defined as: 1) a new well at least 2.5 miles from the nearest marker well; or 2) a new well 1,000 feet deeper than the nearest deepest marker well within a 2.5 mile radius. A new well was defined as: 1) a well where the surface drilling began on or after February 19, 1977; or 2) a well whose depth increased by means of drilling on or after February 19, 1977 to a completion location which is located at least 1,000 feet below the depth of the deepest completion location of such well attained before February 19, 1977.
at more than 5000 feet and July 1, 1987 for new onshore gas well gas produced at less than 5000 feet. All gas categorized as “old gas”\(^{16}\) well gas remained under price control.

The Natural Gas Wellhead Decontrol Act\(^{17}\) (NGWDA) of 1989 eliminated all price controls remaining after the NGPA. The act called for deregulation of wholesale natural gas prices by May 15, 1991 for “newly spudded”\(^{18}\) well gas and January 1, 1993 for “old gas”. Old gas represented the largest quantity of gas still under price control. Together the NGPA and the NGWDA eliminated the FERC’s role of setting natural gas commodity prices at the wellhead and allowed the interaction of natural gas buyers with producers and marketers to determine wellhead prices.

The NGPA and the NGWDA attempted to increase competition by allowing wholesale gas prices to fluctuate according to supply and demand conditions at the wellhead. FERC Order #636\(^{19}\) attempted to increase competition by providing more direct access to wellhead supply. This goal was accomplished in primarily two ways: 1) Interstate pipelines were required to separate their procurement and transportation services and allow customers a choice of which services they wanted at separate rates; 2) Order #636 created a market for unutilized interstate capacity rights. Unutilized capacity rights can be subleased by customers desiring access to wellhead supply outside their own state from other interstate pipeline capacity holders. Allowing customers to purchase unused capacity rights gives customers access to wellheads beyond their own state boundaries. Customers purchasing unused capacity rights can complete their transaction through Electronic Bulletin Boards (EBBs). The FERC required interstate pipelines to

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\(^{16}\) Gas that was first produced from a well before February 19, 1977.


\(^{18}\) Gas that was under an existing contract where surface drilling did not start until after July 27, 1989.

create EBBs so customers could complete capacity trades and post completed capacity release deals electronically. EBBs have developed into an efficient method for customers to obtain access to wellheads outside their own state boundaries.

Together regulatory reforms have allowed LDC customers to negotiate gas supply arrangements at the wellhead and transport gas on subleased interstate pipeline capacity. Customers can now ship gas through either the LDC's distribution system or a pipeline owned by the customer and directly connected to an interstate pipeline. This process replaced interstate pipelines buying the gas commodity and transporting it to LDC's who re-purchased it and transported it to the end-user. These changes in the marketplace have alleviated the need for continuing regulatory oversight by the FERC and state commissions. The FERC has issued policy statements supporting the establishment of market based rates and alternatives to traditional regulatory oversight. In addition, state commissions have encouraged LDCs to provide new service choices while ensuring captive customers are not exploited.
CHAPTER III

REVIEW OF RELATED RESEARCH

This study employs an empirical model\(^1\) to determine the effect of natural gas industry deregulation on four firm concentration ratios in the Texas natural gas production industry. The four firm concentration ratio is intended to measure the intensity of competition faced in the natural gas market. The higher the four firm concentration ratio the less intense competition faced by industry participants. The study shows that a statistically significant decrease in the four firm concentration ratio occurred at the onset of government deregulation, increasing competition among Texas natural gas producers.

The theoretical link between concentration ratios and industrial competition is attributed to Joe S. Bain. Bain (1951) showed that industries where the largest eight firms held a market share in excess of 70% had significantly higher returns\(^2\). The article created a theoretical link between market structure, the conduct of market participants, and overall industrial performance as measured by price-cost margins\(^3\). This structure, conduct, performance (S-C-P) paradigm implies that firms in a highly concentrated industry (high four firm concentration ratio) are more likely to participate in collusive

\(^1\) The empirical model is presented in Chapter IV.


\(^3\) Price-cost margins are often calculated by taking the total value of shipments less payroll and materials costs divided by the total value of shipments. The higher this proportion the greater prices, and likely firm conduct in the marketplace, deviates from the perfectly competitive outcome.
behavior, restrain output, and raise prices toward a monopoly level. Therefore, as concentration ratios decrease, collusive behavior becomes more difficult, competitive pressures mount, and price cost margins shrink. This S-C-P paradigm has been tested by numerous authors since Bain’s study in 1951. Bain (1956), W.G. Shepherd (1972), and Almarin Phillips (1972) have all found positive relationships between concentration and price-cost margins. More recently, Robert W. Kilpatrick (1976) and John E. Kwoka, Jr. (1981) have both tested the S-C-P theory and found that concentration ratios are positively related to price-cost margins. Kilpatrick studied the correlation coefficients between average concentration ratios and rates of return for all four and five digit SIC.


The Correlation Coefficient is a measure of the degree of association between two variables. It ranges from a -1 to a +1. A positive number indicates variables which increase and decrease in unison, while a negative number indicates variables which move in opposite directions. For the formula to calculate the correlation coefficient see Gujarati, Damodar N. “Basic Econometrics”, 2nd Edition, McGraw-Hill, 1988. Pgs. 67-68.

SIC is the Standard Industrial Classification system used by the United States for classifying firms for the purpose of studying their industry. The more digits included in the code the more detailed the description of the industry.
code industries listed by the Census Bureau in 1963. The correlation coefficients ranged from .25 to .5, all showing a positive relationship between concentration ratios and rate of return. Kwoka used the 1972 Census of Manufactures to develop a multivariate regression with price-cost margin, defined as industry value-added minus payroll and divided by value of shipments, for the dependent variable. Various N-firm concentration ratios were included as independent variables. Kwoka found that two and three firm concentration ratios were statistically significant indicators of industry price-cost margins and the degree that firms exercised market power. In addition to these studies, the Department of Justice and Federal Trade Commission have issued joint Antitrust Guidelines for horizontal mergers which support the S-C-P paradigm. The Guidelines state, “A merger is unlikely to create or enhance market power or to facilitate its exercise unless it significantly increases concentration and results in a concentrated market, properly defined and measured. Mergers that either do not significantly increase concentration or do not result in a concentrated market ordinarily require no further analysis.” Based upon the linkage between concentration and competitive behavior supported by these studies, four firm concentration ratios were used in this paper to determine the effect deregulation has had on the competitiveness of the natural gas production market.

Although the literature generally supports the S-C-P paradigm, numerous articles have begun to question whether or not an N-firm concentration ratio is the appropriate

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12 An N-firm concentration ratio signifies any number of firms market shares comprising the concentration ratio. Kwoka studied 10 separate concentration ratios ranging from 1 firm to 10 firms.


measure for market structure and competitiveness. There are three commonly used measures of market structure, 1) N-firm concentration ratios, 2) the leading firm's market share, and 3) the Herfindahl-Hirschman Index (HHI). N-firm concentration ratios have already been discussed and the leading firm's market share is a ratio of the top firms production to the industry's production. The HHI is best summarized by the formula:

\[ \sum_{i=1}^{n} (MS_i)^2 \]

Where: (MSi) represents the market share of firm i and there are n firms in the market.

The HHI gives heavier weight to firms with large market shares than to firms with small shares as a result of squaring the market shares. This feature of the HHI corresponds to the S-C-P theory that the greater the concentration of output in a small number of firms (a high HHI) the greater the likelihood that, other things equal, competition in a market will be negligible. In addition, the HHI measures the impact of all firms on the structure of the industry vis-a-vis measuring only the top one, four, or eight firms as with concentration ratios.

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15 See Gale, Bradley T and Branch, Ben S. “Concentration versus Market Share: Which Determines Performance and Why Does It Matter?”, The Antitrust Bulletin, Spring 1982. Pgs. 83-105 for an alternative to the S-C-P paradigm. This article shows that ROI (before-tax profits, divided by invested capital) is dependent upon leading firm market share but not on the four firm concentration ratio. The authors conclude that “Market share increases profits through the benefits of scale economies.” In other words, these authors believe that efficient firms outcompete other less efficient firms, gaining market share and becoming more profitable.

16 Total production is the example used here, however a single market share can be calculated using income, sales, or other relevant data.

Recent literature has begun to support the HHI as the best overall indicator of market structure and competition. Amato (1995) used 1982 Census of Manufactures data to run J-tests on a linear regression using price-cost margins as the dependent variable and the HHI, four firm concentration ratio, and the leading firm's market share as independent variables$^{18}$. The J-test identifies the relevant variables in a regression by mathematically comparing the results of one regression equation against the results of a similar, but restricted, equation. According to Amato results, models with the HHI and the leading firm's market share consistently passed the J-test, while models with the four firm concentration ratio did not. Amato concludes, "First, there is evidence to support the claim that the Hirschman-Herfindahl index provides a superior proxy to the four firm concentration ratio as a measure of market structure. Support for this finding lies in the results of J-tests that treat the choice between the Hirschman-Herfindahl and CR4$^{19}$ as a test of nonnested hypothesis. The J-tests conclude that the Hirschman-Herfindahl index should be included in the model, while CR4 can be deleted."$^{20}$

In addition to Amato's work, Hannah and Key (1977) developed a list of desirable characteristics for a measure of market structure$^{21}$. They suggest that the measure:

1) Increase when sales are transferred from a smaller firm to a larger firm.
2) Increase when a merger occurs.
3) Increase when customers have a bias toward larger firms.


$^{19}$ Amato uses this notation for the four firm concentration ratio.


4) Decrease when customers are equally likely to conduct business with a larger firm as with a smaller firm.

5) Remain unaffected by the entry or exit of insignificant firms.

Hannah and Key observe “How does the concentration ratio, the commonest of all measures of market structure, stand up? Reasonably well, since although it does not necessarily react positively to a merger or sales transfer it will never be perverse in the direction of change.” However, in conjunction with this praise, Hannah and Key assert some of the major deficiencies. “The deficiencies of this measure are obvious, and widely recognized. The choice of N is arbitrary, much information is wasted and dramatic shifts in industrial structure can occur to which the index will be wholly impervious. So long as they affect only members of the top N, or the rest of the industry, the CRN is unaffected by them.”

Scherer (1980) adds to Hannah and Key’s evaluation of the concentration ratio by proposing the following six specific deficiencies in the measure:

1) Concentration ratios often rely on U.S. Census of Manufactures data. This data has difficulty disaggregating sales by a single firm into separate product lines, which can bias concentration ratios.

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23 Hannah and Key use this notation to denote any number of different concentration ratios, i.e. two firm, four firm, eight firm, etc.


2) The Census of Manufactures often does not include relevant substitutes in the definition of the market. Ignoring substitutes overestimates monopoly power held by firms in an industry.

3) Census of Manufacture data is often too broadly or too narrowly defined.

4) Import competition is ignored by Census of Manufacture data.

5) Structural characteristics of the market must be considered. For example, a large number of equal size firms selling the same cola may seem competitive until it is discovered they all have franchise agreements with Pepsi.

6) When strong product differentiation exists, the four firm concentration ratio may understate the true exercise of monopoly power.

Nonetheless, Scherer recognizes that "Given these deficiencies what practical steps may be taken to avoid mistakes in the use and interpretation of concentration ratios? The most important is to recognize that pitfalls exist: concentration indices are at best a one dimensional indicator of monopoly power, and their use must be governed by common sense."^{26}

Nonetheless, the four firm concentration ratio is recognized as a reasonable proxy for the HHI index, as well as a statistically significant indicator of price-cost margins and competitiveness. Scherer (1980) shows the HHI and the four firm concentration ratio are highly correlated, providing similar results when used in regression analysis. However, Kwoka (1981) criticizes the idea that concentration ratios are viable measures of market structure solely because they are highly correlated with the HHI. Kwoka determines that concentration ratios are indicators of price-cost margins irrespective of the high correlation between the HHI and the four firm concentration ratio. In addition, Waterson and Cowling (1976) studied the change in price-cost margins and the change in four firm

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concentration ratios from 1958 to 1962 in Census of Production data\textsuperscript{27}. They used changes in the variables over time versus utilizing cross-sectional data, as previous studies have done, in order to prevent model misspecification. They suggest cross-sectional studies, which look at concentration across a number of industries at one time, are misspecified because they omit the elasticity of demand as a relevant variable in determining profits. The elasticity of demand can be omitted if the assumption of constant elasticity of demand across a number of industries holds. Waterson and Cowling propose that holding the elasticity of demand constant for one industry over time is better than an assumption of constant demand elasticities across industries. Their study shows that changes in the four firm concentration ratio over time are positively related to changes in the price-cost margin over time.

Along with this evidence of the validity of concentration ratios as a measure of market structure and competitiveness, Sleuwaegen and Dehandschutter (1986) show that the HHI is related to the four firm concentration ratio in a horn-shaped fashion\textsuperscript{28}. In other words, at low values of the four firm concentration ratio it tends to follow the HHI closely, while at higher levels there is greater divergence of the two measures. They state, "Given the horn-shaped relationship, it follows that the choice between H\textsuperscript{29} and C\textsubscript{k} in profit regressions should not matter too much for low concentration industries (C\textsubscript{4} < .50)


\textsuperscript{29} H is used by Sleuwaegen and Dehandschutter to signify the HHI. Also the notation C\textsubscript{k} is used by the authors to denote any level of concentration ratio, i.e. two, three, four firm, etc. The authors also use the notation C\textsubscript{4} to denote the four firm concentration ratio.
but may become very important for high concentration industries (C4 ≥ .50).”\textsuperscript{30} They conclude by showing that the explanatory power (measured by the R-squared\textsuperscript{31}) of a regression of low concentration industry (C4 < .50) profitability on the HHI is virtually unaffected when concentration ratios are substituted for the HHI. They also show that the explanatory power of a regression of high concentration industry (C4 ≥ .50) profitability on the HHI is significantly affected when concentration ratios are substituted for the HHI. Additionally, Sleuwaegen, De Bondt, and Dehandschutter (1989) based upon their previous study in 1986, discuss the benefits of using both four firm concentration ratios and HHI in analyzing market structure and competition\textsuperscript{32}. They conclude that analyzing an N-Firm concentration ratio in conjunction with the HHI provides a better understanding of the degree of monopoly power held by firms in an industry.

Although there is debate about the appropriate measure for market structure, concentration ratios have not been rejected as a reasonable index. Even though it is widely recognized that the HHI is a superior measure to the N firm concentration ratio, Sleuwaegen and Dehandschutter (1986) show that the two measures are nearly identical if utilized in an industry with C4 < .50. The Texas natural gas production industry C4 is a maximum of .33 during the study period. Therefore according to Sleuwaegen and Dehandschutter four firm concentration ratios, in the case of Texas natural gas


\textsuperscript{31} The R-squared shows the amount of the variation of Y values from their mean that is explained by the regression equation. It has a maximum value of 100% which would result when all data points lie exactly on the regression line. For the formula to calculate the R-squared see Gujarati, Damodar N. “Basic Econometrics”, 2nd Edition, McGraw-Hill, 1988. Pgs. 66-68.

production, carry virtually the same information as the HHI would provide. In addition, information is not readily available to the general public in order to calculate the HHI. Additionally, this study did not use Census data so many of the pitfalls that Scherer (1980) details are not applicable. For these reasons, this research uses the four firm concentration ratio to model the competitiveness of the Texas natural gas production industry.

Beyond the measure chosen in this study to gauge market structure and competition, various authors have studied other variables which determine market structure and competition. Rosenbaum and Reading (1991) studied the relationship between the Herfindahl index and import shares in regional portland cement markets. They found that as the Herfindahl index increases, import shares begin to rise. In addition, Carlton and Perloff (1994) suggest barriers to entry and exit, product differentiation, and government regulation can have a significant impact on market structure, as measured by either concentration ratios or the Herfindahl index.

After consideration of these studies, import shares (Rosenbaum and Reading), barriers to exit and product differentiation (Carlton and Perloff) were not modeled as variables in this study. This is due to the nature of natural gas markets during the study period. Natural gas is a very homogeneous product, with little history of product innovation. Considering producers can stop production with a turn of a valve at the wellsites, barriers to exit are virtually non-existent. In addition, import shares were a relatively small proportion of total marketed production during the study period and were


35 Natural gas can be distinguished by its Btu and water or hydrocarbon content. Gas is dehydrated at the wellsites removing the water and hydrocarbons. Gas is then mixed, leveling the Btu content, as it travels by pipeline. Therefore, gas becomes a very homogeneous product after basic processing and transportation.
therefore not included as a variable\textsuperscript{36}. However, barriers to entry and government regulation (Carlton and Perloff) variables were included for the study. Previous discussion of related research supports a model with the four firm concentration ratio as the dependent variable and proxies for government regulation and barriers to entry as independent variables.

\textsuperscript{36} Although imports shares have been rising they averaged less than 5\% of total marketed production during the study period.
CHAPTER IV

EMPIRICAL MODEL AND ANALYSIS

Industry analysts have arbitrarily concluded that deregulation has created a more competitive natural gas wellhead market\(^1\). However, there has yet to be an empirical study\(^2\) of the impacts that deregulation has had upon the structure of the Texas natural gas wellhead industry, as measured by the four firm concentration ratio. The following empirical model was created, based upon the discussion in Chapter 3, to analyze the effects of deregulation on the market structure and competitiveness of Texas natural gas production:

\[
4 \text{ firm concentration ratio} = \beta_1 + \beta_2 \text{ (Ave. Footage Drilled for New Wells)} + \beta_3 \text{ (National Index of Industrial Production)} - \beta_4 \text{ (Lagged Natural Gas Prices)} - \beta_5 \text{ (NGPA Jan. 1985)}
\]

\(^{1}\) An article in Consumers' Research Magazine entitled "Why You Pay Too Much For Natural Gas", May 1989 states "During the past several years, dramatic breakthroughs have been achieved in bringing greater competition in the natural gas industry, thereby reducing gas prices for consumers, removing restraints on the use of gas, and restoring consumer confidence in the adequacy of the natural gas resource base. While the industry operates in a much healthier environment then it did a few years ago, much remains to be done." However, no empirical evidence of 'greater competition' is offered.

\(^{2}\) De Vany and Walls have studied changes in prices caused by deregulation of the natural gas industry. They conclude that natural gas commodity prices behave as if competition is intensifying. An excerpt of their complete study is given in Public Utilities Fortnightly, "The Triumph of Markets in Natural Gas", April 15, 1995, pg. 21.
Monthly data was collected for January 1977 through December 1994. Data for average total footage drilled and natural gas prices was extracted from the Monthly Energy Review (MER) published by the Energy Information Administration of the Department of Energy. The index of national industrial production was obtained from FAME ECONOMICS, a Macroeconomic database. Data on monthly production used in calculating the four firm concentration ratio, were provided by GASEARCH a Texas based data acquisition service. Each of the independent variables are described in more detail below.

**Footage Drilled** - The variable was included to measure entry barriers and was the average depth, in feet, of new gas wells. Deeper drilling means higher costs of entry for new firms, and less firms able to enter, leading to higher four firm concentration.

**Industrial Production** - An index of total U.S. industrial production was used to model this variable. As the economy slows, as evidenced by lower industrial production, demand for gas should fall, decreasing prices and causing higher cost firms to exit or shut in their production. This process should lead to higher four firm concentration ratios.

---

3 The data obtained from GASEARCH had a small number of anomalies, i.e. production and revenue amounts for a certain producer during one month that were unreasonably large. These data anomalies were removed before calculation of the four firm concentration ratio and the development of the final empirical model.

Lagged Natural Gas Prices - This variable is the average monthly natural gas price for all natural gas produced in the U.S., lagged 12 months. The variable was lagged in order to prevent a simultaneity problem between current natural gas prices and current four firm concentration. Higher lagged natural gas prices should stimulate additional entry by new firms and decrease concentration.

Dummy Variables for Government Regulation - Intercept dummy variables were included to measure the impact of deregulation. The dummies were given a value of 0 before the effective date of the new regulation and 1 after the effective date. Dummy variables were included for the NGPA’s January 1985 and July 1987 deregulation dates, the NGWDA’s May 1991 and January 1993 deregulation dates, and for Order #636. If policy makers accomplished their goals of increasing competition through these regulations then at least some of the coefficients should be negative and significant.

The initial regression using Ordinary Least Squares (OLS) exhibited autocorrelation, or a strong association between error terms of the regression. Autocorrelation violates one of the assumptions of OLS theory, causing OLS estimators to be inefficient. To correct for autocorrelation the data were adjusted using an estimate of the relationship between the actual error terms. After adjustment the following results were obtained:

---

5 Please see Appendix III, a graph of the error terms of the initial regression as well as the results of a regression of the error terms as a function of the error terms lagged one period. An alternative model using a time trend variable was also run with the results contained in Appendix III. The time trend variable model also exhibited autocorrelation.

Variable Coefficient Standard Error T - Statistic
Constant .068799 .007825 8.7925
Footage Drilled 1.34 x 10^-7 1.86 x 10^-7 .723
Industrial Prod. Index -.00228 .00059 -3.843
Lagged Prices -.0099 .005093 -1.94
NGPA Jan. 1985 -.00581 .008512 -0.683
NGPA July 1987 -.01802 .00869 -2.073
NGWDA May 1991 -.00545 .0085 -0.639
NGWDA Jan. 1993 .0178 .0088 2.01
Order #636 .00485 .0088 .549

Where: NGWDA = Natural Gas Wellhead Decontrol Act
NGPA = Natural Gas Policy Act
N = 215 F-Stat = 11.687 Adjusted R^2 = .2855 D-W Stat = 1.91

After adjustment for autocorrelation, the adjusted equations error terms were saved. These error terms were regressed against themselves lagged one period. This regression showed no relationship between the error terms and the error terms lagged one period suggesting the autocorrelation problem was corrected. According to the results in the matrix, the following conclusions can be drawn for each variable:

Footage Drilled - Based on the statistically insignificant but positive coefficient for this variable, the further firms must drill to extract new gas, the less firms that enter the industry, and the higher four firm concentration will be. However, according to the results entry barriers were not a significant indicator of market structure in the production of natural gas during the study period.

National Industrial Production Index - The statistical significance of this variable suggests that market concentration is impacted by the business cycle. The negative coefficient means that as the overall economy improves, more Texas firms enter the
natural gas production industry, decreasing four firm concentration. In other words, increases in industrial production stimulates natural gas demand which encourages entry by new firms and lowers concentration.

**Lagged Natural Gas Prices** - The coefficient was negative and statistically significant, suggesting current concentration falls when lagged natural gas prices increase. This result supports the results from the national industrial production index variable. As natural gas prices increase, through changing supply and demand conditions, new firms find it profitable to enter and concentration falls.

**NGPA January 1985** - The insignificance of this variable can be explained by two factors: 1) According to the NGPA's price deregulation by category of gas, little gas was actually deregulated on January 1, 1985. 2) Wholesale price regulation, beginning with the 1954 Supreme Court decision, had existed for over three decades and gas under existing contracts would not be available immediately for resale at market prices. Thus, because of the relatively large amount of gas still under price regulation, commodity prices were left relatively unaffected and firms did not have an immediate incentive to enter or exit the industry.

**NGPA July 1987** - The coefficient on this variable was significant and negative, suggesting that concentration fell after July 1, 1987. There are two possible reasons for this result: 1) The July 1987 date deregulated virtually all new gas. Therefore firms with new wells or new production could benefit from selling their gas free of federal control. This stimulated new gas to be produced by new natural gas firms causing concentration to

---

7 New gas was defined by the NGPA as gas first produced after 1977.
2) Market participants had gained experience with deregulated gas during the previous two years so consumers and firms were comfortable taking advantage of the new deregulated environment.

**NGWDA May 1991** - This variable was statistically insignificant. This may be the result of what type of gas was deregulated at this time. In May 1991 gas under an existing contract where surface drilling did not occur until mid-1989 was released from price control. This gas was relatively insignificant compared to all other “old gas". The release of a relatively small amount of gas from price control suggests both market prices and the quantity of gas still under price regulation were relatively unaffected by this deregulation date. Thus, firm's incentives to enter or exit the industry did not change as a result of this legislation.

**NGWDA January 1993** - The coefficient on this variable was statistically significant at the 95% level and positive. There have been two trends taking place in the industry over the study period. First, concentration consistently fell until about 1993 and then slightly increased over the next couple of years. Second, the number of total firms has fallen likely due to an increase in merger activity. Most of the merger activity has taken place during the last decade of the study period as firms reacted to the changing competitive environment initiated by the NGPA. As a result of the continuously favorable

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* Old gas is defined by the NGPA as gas first produced before 1977 and under the NGWDA was not to be deregulated until January 1993.

* See Appendix IV which is a graph of the four firm concentration ratio and the total number of firms in the Texas natural gas production industry over time.
merger environment, a reconcentration of the Texas natural gas production industry has occurred since 1993 resulting in a positive coefficient on this variable\(^{10}\).

**FERC Order #636** - According to regression results, FERC Order #636 did not have a significant impact upon producer concentration. Order #636 deregulated interstate transportation service encouraging more buyers to gain direct access to wellhead markets. However, even though more buyers were able to access wellhead supply, Order #636 did not directly deregulate wholesale prices and therefore did not have a direct impact on the incentives for firms to enter or exit the industry. In addition, previous FERC orders, including Order #436 and Order #500, had provided temporary means for natural gas users to gain direct access to wellhead supply. Therefore, by the time FERC Order #636 finalized rules allowing interstate pipeline capacity release and service unbundling, many customers were already wellhead market participants.

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\(^{10}\) See Appendix V which is a matrix showing the annual average number of total wells in the industry, the annual average of total wells controlled by the top four producers, and the annual average total U.S. natural gas price at the wellhead. From about 1990 until 1994 the top four producer's share of total industry wells has risen causing an increase in the four firm concentration ratio coinciding with the implementation of the NGWDA.
CHAPTER IV
CONCLUSION

The natural gas production industry has experienced a regulatory transition which has eliminated price controls, increased the interaction between buyers and sellers of the gas commodity, and provided direct access to wellhead markets. The Natural Gas Policy Act of 1978 (NGPA), the Natural Gas Wellhead Decontrol Act of 1989 (NGWDA), and FERC Order #636 in 1992 were regulatory milestones in advancing these goals. This legislation was passed to minimize or eliminate market imperfections, i.e. monopoly in distribution and sales of natural gas, that have been present for almost 90 years.

Proponents of deregulation have argued that competition has intensified in the natural gas industry, benefitting consumers, shippers, and producers of natural gas. However, little empirical work has been completed which determines the impact of deregulation on industry competition. The goal of this paper was to empirically determine the impact deregulation has had on Texas natural gas producers. Texas is the U.S. leader in the natural gas production industry, therefore the effect of deregulation should be manifest in an analysis of Texas data. The paper discussed the regulatory changes that have taken place in the U.S. and their impact on the Texas natural gas production industry four firm concentration ratio. Of the five dummy variables included to measure the impact deregulation has had on the four firm concentration ratio, 2 were statistically significant.
The first was the dummy for the NGPA in July, 1987 and the second was the dummy for the NGWDA in January, 1993.

According to empirical results, four firm concentration ratios declined after the NGPA in 1987 but increased after the NGWDA in 1993. This is evidenced by the statistically significant negative coefficient on the dummy variable for the NGPA and the statistically significant positive coefficient on the dummy variable for the NGWDA. Although the positive coefficient on the dummy for the NGWDA suggests competitive pressures decreased as a result of this legislation, the sign of the coefficient can be explained by the increase in the top four producer’s share of total industry wells. The increase in the top four producer’s share of total industry wells was likely caused by an increase in merger activity, i.e. the total number of industry wells has stayed relatively constant while the total number of wells owned and operated by the top four has increased. Mergers began in 1987 causing a decrease in the total number of firms in the industry to near 1976 levels. The decrease in the total number of firms eventually led to a slight reconcentration in natural gas production from 1993 to 1996 which coincided with the implementation of the NGWDA in 1993. Therefore, the coefficient on the NGWDA may not reflect the true impact of this legislation or may suggest that the impact was relatively minor and that the increase in merger activity was able to more than compensate for any increase in competition resulting from the NGWDA. In any case, four firm concentration has clearly fallen over time, with substantial decreases taking place after the implementation of the NGPA in 1987. The statistically significant negative coefficient for

---

1 See Appendix V. The top four producer’s share of total industry wells rose from 10.34% in 1990 to 11.49% in 1994.
the NGPA in 1987 confirms four firm concentration in Texas natural gas production has fallen as a result of deregulation. In addition, the total number of wells and firms in the industry substantially increased from 1986 to 1987 while prices dropped. Overall, the results support arguments that deregulation has increased competition throughout the Texas natural gas production industry.

Assuming concentration and price-cost margins are related as Bain (1951, 1956), Shepherd (1972), and Phillips (1972) all suggest, then the statistically significant decrease in four firm concentration after implementation of the NGPA in 1987 has increased competitive pressures for Texas natural gas producers. The increase in competition should benefit all market participants as prices are driven toward marginal costs. Deregulation of natural gas markets, where appropriate, should continue. In addition, providing more LDC small customers, including residential, small commercial, and small industrial customers access to purchase their own wellhead supply should be considered. Allowing these customers to benefit from direct wellhead access would immediately distribute the benefits of increased competition to all LDC customers not just the largest users on the LDC system.

In addition to determining the impact of deregulation on Texas natural gas production the study also determines the impact of entry barriers, business cycles, and lagged natural gas prices during the study period. The study shows that both business cycles and lagged natural gas prices can have a statistically significant impact on four firm concentration but that entry barriers were insignificant during the study period. The

---

2 See Appendix V.
significance of both the national industrial production index and lagged natural gas prices shows that Texas natural gas production industry market structure can be significantly influenced by changes in industry demand and supply.

Further research should be done which compares the deregulation of the natural gas industry to the deregulation of the electric industry. Although the electric industry is substantially more vertically integrated than the gas industry, i.e. more electric utilities directly own and operate production plants within their own jurisdictions, electricity is a commodity with the potential for market forces to determine price. Electricity is also a real time commodity, with the possibility for hourly market conditions affecting hourly electron prices. Although the electric industry has its own unique characteristics, utilizing the experience gained in deregulating the natural gas industry should be useful for developing policies and programs which provide the benefits of competition to electric customers. Federal and state regulators should be aware of the benefits of competition to all consumers and providers of utility services and move expeditiously toward deregulating those services which can be competitive in nature.
Appendix I

Historical Structure of the U.S. Natural Gas Industry

Local Distribution

- Local Distribution Company:
  - Monopoly in transportation and sale to consumers.
  - Regulated by State PUC:
    - Regulate all aspects of distribution, including rates, line extensions, sales.

Interstate Transportation

- Interstate Pipeline:
  - Monopsony in transportation and sale of gas to LDC's.
  - Regulated by FERC (FPC):
    - Regulate all aspects of interstate transportation and sales to LDC's.

Wellhead

- Producer or Marketer:
  - Sell gas predominantly to interstate pipelines.
  - Regulated by FERC (FPC):
    - Regulate price of gas, facility additions, and other aspects of production.

Consumers

- Other Large Consumers

- Local Distribution Company:
  - Monopoly in transportation and sale to consumers.

- Interstate Pipeline:
  - Monopsony in transportation and sale of gas to LDC's.
APPENDIX II

TIMELINE FOR NATURAL GAS INDUSTRY DEREGULATION


1938 - Natural Gas Act is enacted. Federal regulation of interstate pipelines begins.

1954 - Supreme Court rules that the Federal Power Commission has the authority to regulate the sale of natural gas to interstate pipelines.

1978 - Natural Gas Policy Act passed. This Act began the phase-in of complete deregulation of natural gas prices at the wellhead.

1989 - Natural Gas Wellhead Decontrol Act - Deregulated all natural gas prices at the wellhead that had not been previously decontrolled by the NGPA.

1992 - Federal Energy Regulatory Commission issues Order #636 which deregulates interstate transportation of natural gas; essentially providing greater access to wellhead supply for more buyers.
APPENDIX III

AUTOCORRELATION

INITIAL REGRESSION RESULTS

<table>
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<tr>
<th>Coefficients</th>
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<th>t Stat</th>
<th>P-value</th>
</tr>
</thead>
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<td>Footage</td>
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<td>industrial product</td>
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\[ F \] Significance F  Adjusted R Square  D-W STAT  N
129.8764158  2.36457E-76  0.827449402  0.34  216

ANALYSIS OF RESIDUALS

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A REGRESSION WITH A TREND VARIABLE WAS ALSO CONSIDERED

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ANALYSIS OF RESIDUALS

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Texas Natural Gas Production
Four Firm Concentration and Total Number of Firms
January 1976 - July 1996
APPENDIX V

MATRIX WITH NUMBER OF WELLS

<table>
<thead>
<tr>
<th>Year</th>
<th>Ave. # Wells Top 4</th>
<th>Ave. # Wells Industry</th>
<th>Top 4 Share</th>
<th>Ave. $/Mcf</th>
<th>Total # of Firms</th>
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<tr>
<td>1976</td>
<td>3264</td>
<td>36354</td>
<td>8.98%</td>
<td>0.58</td>
<td>3,984</td>
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<td>1977</td>
<td>3179</td>
<td>27811</td>
<td>11.43%</td>
<td>0.79</td>
<td>3,237</td>
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<tr>
<td>1978</td>
<td>3111</td>
<td>29221</td>
<td>10.65%</td>
<td>0.91</td>
<td>3,389</td>
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<tr>
<td>1979</td>
<td>5830</td>
<td>45113</td>
<td>12.92%</td>
<td>1.14</td>
<td>4,879</td>
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<tr>
<td>1980</td>
<td>6181</td>
<td>49229</td>
<td>12.56%</td>
<td>1.61</td>
<td>5,195</td>
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<tr>
<td>1981</td>
<td>6611</td>
<td>53805</td>
<td>12.29%</td>
<td>2.06</td>
<td>5,496</td>
</tr>
<tr>
<td>1982</td>
<td>6996</td>
<td>59096</td>
<td>11.84%</td>
<td>2.47</td>
<td>5,871</td>
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<tr>
<td>1983</td>
<td>7903</td>
<td>63101</td>
<td>12.52%</td>
<td>2.62</td>
<td>6,175</td>
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<tr>
<td>1984</td>
<td>7981</td>
<td>66804</td>
<td>11.95%</td>
<td>2.66</td>
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<tr>
<td>1985</td>
<td>6612</td>
<td>58918</td>
<td>11.22%</td>
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<tr>
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<td>5939</td>
<td>57239</td>
<td>10.38%</td>
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<td>6227</td>
<td>66041</td>
<td>9.43%</td>
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<td>6470</td>
<td>66373</td>
<td>9.75%</td>
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<td>1989</td>
<td>6418</td>
<td>66036</td>
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<tr>
<td>1990</td>
<td>6640</td>
<td>64215</td>
<td>10.34%</td>
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<td>1991</td>
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<td>3,667</td>
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BIBLIOGRAPHY


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