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MARKET STRUCTURE AND THE PRICING OF ELECTRICITY AND NATURAL GAS*

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US Electricity and natural gas markets have traditionally been serviced by one of two market structures. In some markets, electricity and natural gas are sold by a regulated dual-product monopolist, while in other markets, electricity and natural gas are sold by separate regulated single-product monopolies. I analyze whether electricity and natural gas prices depend on the market structure and compare these results to the predictions of a number of theories. The results are most consistent with the political economy theories suggesting that regulators respond to interest group activity.

I. INTRODUCTION

US ELECTRICITY AND NATURAL GAS RETAIL MARKETS have developed into two distinct market structures.[1] In some jurisdictions, a dual-product monopolist supplies both electricity and natural gas, while in others, two single-product monopolists separately offer electricity and natural gas. In this paper, I examine whether prices for electricity and natural gas differ across the two market structures.

Prices in the two market structures may differ for a number of reasons. Most notably, electricity and natural gas are substitutes in consumption.[2] This implies that, absent regulation, a dual-product firm will have an incentive to price both electricity and natural gas higher than two comparable single-product firms. This incentive is tempered by potential cost differences in the two market structures—originating from the fact that natural gas is an input into the generation of electricity. The costs of the

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[1] Natural gas firms refer to natural gas distribution firms, which remained regulated entities after the deregulation of the natural gas exploration/production industry. Beginning in 1998, electricity markets within the United States began to restructure—allowing competition in the generation sector of the industry. The data used in this study stop at 1995. Therefore for the purposes of this study, electricity firms are regulated monopolies.

[2] Electricity and natural gas are substitutes for a number of uses. Most notably in heating, cooking and motor devices.

dual-product electricity firm, *ceteris paribus*, are weakly lower than the costs of the single-product firm, since the dual-product firm faces the marginal cost of natural gas, while the single-product electricity firm faces the marginal price. If these cost savings are significant, then the dual-product electricity firm may price lower than the single-product firm.[3]

Finally, the political economy literature suggests that prices may differ in the absence of demand and cost differences. This work, beginning with Stigler [1971] and Peltzman [1976], argues that regulated prices will reflect the regulators' preferential weights assigned to specific consumer groups. Furthermore, Becker [1983] suggests that lobbying activity among interest groups (consumer groups, in the case of this paper), which is a source of the regulators' preferences, will be proportional to the expected gains from lobbying and inversely proportional to the costs of lobbying. Consistent with this literature analyses of *within*-fuel pricing find that prices are inversely proportional to the gains and efficacy of lobbying activity of consumer groups.[4]

A dual-product monopolist affords regulators with another avenue for responding to lobbying activity. If inter-firm transfers are costly in a single-product setting, then a dual-product setting provides regulators with an additional means of cross-subsidization. Specifically, consumers of one fuel can 'subsidize' consumer groups of another fuel; therefore, in a dual-product setting, we might expect cross-subsidization to exist not only across consumer classes (e.g., residential and industrial consumers), but also across fuel types (e.g., electricity and natural gas consumers). This additional avenue may drive a wedge between the prices we observe in single-product and dual-product settings.

Using data on pricing, demand and cost conditions of electricity and natural gas investor owned utilities, I test whether prices systematically differ across the two market structures. I then compare these results to the potential sources for price differences described above. The results suggest that after controlling for cost and demand differences, the relative electricity and natural gas prices of single- and dual-product firms are most consistent with the political economy models of regulation. The results are not consistent with the increase in market power related to selling both electricity and natural gas or the potential cost savings from integration. Specifically, I find that electricity consumers subsidize natural gas consumption; natural gas prices are lower and electricity prices are higher in a dual-product setting. Furthermore, residential electricity consumers

[3] Not surprisingly, given the incentive to raise rivals' costs, single-product electricity firms typically bypass the single-product natural gas firms and purchase their natural gas supplies direct from the well-head.

[4] For example, Nelson [1982], Nelson and Roberts [1989] and Klein and Sweeney [1999] find support for the Peltzman theory in the natural gas industry.

face the largest burden of this cross-product subsidy, while industrial electricity consumers do not subsidize natural gas consumers. In contrast, industrial natural gas consumers receive the largest subsidy, while residential natural gas consumers are not subsidized.

The remainder of the paper is organized as follows: Section 2 provides a background of the electricity and natural gas industries. Section 3 outlines the political economy of electricity and natural gas rates under the two market structures, while section 4 discusses the other sources for price differences. Section 5 outlines the empirical model and discusses the econometric issues. The results of the base model are presented in section 6, while section 7 extends the empirical model. Section 9 concludes the paper.

II. INDUSTRY BACKGROUND

Until very recently, the US electricity industry differed little across states. Even with recent regulatory restructuring in a number of states, the vast majority of electricity companies remain regulated.[5] In the traditional structure, electricity firms are vertically integrated across the four major components of electricity production: electricity generation, transmission to different portions of the firm's service area, distribution to its consumers, and billing.

The generation of electricity takes place using a variety of technologies-—all of which use some form of energy to spin a turbine, that in turn produces electricity. The two most common technologies are steam and hydroelectric. Other examples are combustion turbine, wind and geothermal generation. Steam generators burn some fuel, such as coal, natural gas or oil (except for nuclear generators, which use the heat created from nuclear reactions), to heat a water boiler, producing steam. The force of the steam turns a turbine. Hydroelectric generators use the energy of water flowing down a river, or trapped in a reservoir, to turn a turbine.

Hydroelectric generation is less costly than steam generation for two reasons. First, because typically only one generating unit is placed on a water source and the owner of the generator has the property rights to this water, given a water supply the marginal *operating* cost of hydroelectric resources is near zero, up to the capacity level.[6] Therefore, a firm's decision to operate a plant is dependent on the intertemporal shadow values of water use—since the water source may be scarce. If water resources are sufficiently abundant,

[5] Despite the recent trend toward deregulation in the electric generation industry, regulation of the transmission and distribution portion of the industry continues. Therefore, the pricing of electricity networks will remain an issue. In addition, given the likelihood of market power during high demand periods and the recent problems in California when the transmission networks of electricity markets become congested, restructuring in many markets may not take place.

[6] On any given water source, there are usually limitations on the use of the water source. For example, minimum flow constraints are set so as to assure the health of the downstream fish, and maximum flow constraints are set so as to limit the possibility of floods.

then the shadow value is also near zero. Second, unlike steam plants, hydroelectric plants are much more flexible to operate, as they do not require the heating of a boiler. A steam plant that is not currently generating electricity may take a number of days before it is fully functional, whereas hydroelectric resources can turn on and off almost instantaneously. Despite these advantages, the use of hydroelectric generation is largely limited by geographical location and conservation concerns. Hydroelectric generation requires a large enough river system, and therefore in many locations hydroelectric generation is not practical.

Other than hydroelectric generation, no one generation technology clearly dominates the others. This is true for both geographical reasons, since the relative prices of fuels differ across the country, and also because of the nature of electricity demand. The demand for electricity varies considerably across the day and year. Because of this and the inability to store electricity, firms carry a portfolio of generation technologies, each varying in the level of fixed costs and marginal costs of operation. For example, nuclear units are high fixed cost/low marginal cost units and run almost continuously, whereas oil burning plants are low fixed cost/high marginal cost units that generate electricity only during peak time periods. Between these technologies are coal and natural gas burning units.

Regulation of electricity firms has a long history dating back to the late 1800s. The regulatory environment of a firm depends on the ownership structure of the firms. The most common ownership structure is an investor owned utility (IOU), where the firm is privately held by shareholders. In some areas, municipally owned companies exist, with the firm owned and operated by the locality. Still in other areas, federally owned firms operate.

The majority of regulation takes place at the state level, although the Federal Energy Regulatory Commission (the FERC) oversees some aspects of the industry—most notably interstate trading. Rate-of-return regulation remains the most common form of regulation. Under rate-of-return regulation, rate hearings are periodically held where the regulators calculate the value of capital the firm employs and set rates for different consumers groups, such that the firm earns some desired rate of return on the capital.[7]

The natural gas industry also differs little across states. The current structure of the industry is comprised of three sectors: 'producers', pipelines and distributors.[8] 'Producers' of natural gas locate natural gas reserves under the ground and sell the reserves at what is known as the

[7] See Joskow [1974] for a discussion of the political economy of rate hearings.

[8] Although the use of gas as an energy source in the US dates back to the 19th century, large-scale harnessing of *natural* gas as an energy source did not take place until the 1950s. Prior to the use of natural gas, synthetic gas was used; however, because of the similar infrastructure involved with distributing synthetic gas and natural gas, many of the distribution companies today have their roots in this time period.

wellhead—these transactions are known as first sales. Pipeline companies purchase the gas at the wellhead and ship the gas through pipelines to a distribution company, transacting at the city-gate price. The distribution company is the retail arm of the industry (the IOUs in the case of dual-product firms), selling natural gas to end-use consumers—such as industrial, commercial and residential consumers. The firms are known as local distribution companies (LDCs). Although vertical integration does exist, it does not dominate the industry, as it does in the electricity industry.

The current regulatory structure varies by the sector. The 1978 Natural Gas Policy Act largely deregulated the first sales of natural gas; this sector is considered to be competitive. The distribution of natural gas remains tightly regulated. Pipelines and transmission firms buy natural gas at the wellhead for shipment elsewhere. The interstate transport of natural gas to the LDCs is regulated by the FERC. Regulated utilities purchase natural gas at the wellhead and then distribute it to end-users.

The regulatory structure of the LDCs is much like that of the electricity industry. Indeed the regulatory institutions are the same as the respective electricity firms, i.e., the state public utility commissions. Rates for distribution and transmission are also set using a cost-based method, where the rates are designed for the firm to earn a specific rate-of-return on capital and set through rate hearings.

III. INTEREST GROUPS, MARKET STRUCTURE AND PRICE DIFFERENCES

Stigler [1971] and Peltzman [1976] argue that regulated prices will reflect the relative weights regulatory agencies place on the consumer surplus of their constituents. In addition, they argue that we would expect the regulators' weights to be positively correlated with the political efficacy of the different consumer classes. For example, given that industrial consumers are more concentrated, we would expect industrial consumers to have higher weights, relative to residential consumers, who are more dispersed. This would lead to lower rates for industrial consumers. There is support for this in the relative prices across consumer classes, as industrial rates are lowest, followed by commercial rates, with residential rates being the highest.[9] Becker [1983] provides a more formal analysis of interest group activity, focusing on tax policy; however his results are also applicable to regulatory pricing. He finds that relative taxes will depend on the political efficacy of the interest groups, as well as the deadweight loss of taxation associated with each interest group. Therefore, we would expect firms with more elastic

[9] This is also cost based. Residential consumers require a lower voltage in electricity and exhibit greater variation in both electricity and natural gas consumption. Both of these factors lead to higher marginal costs for residential consumers, compared to industrial consumers; however, a number of studies have found that the price difference is not entirely explained by differences in costs. See for example the papers cited above.

demand to face lower regulated prices, since the deadweight loss from price increases is proportional to the elasticity of demand (in absolute value).[10]

The existence of interest group activity may also influence the relative pricing of single-product and dual-product firms. In a dual-product setting, revenues from electricity consumers are able to go toward keeping the 'natural gas firm' solvent, and revenues from natural gas consumers are able to go toward keeping the 'electricity firm' solvent. In contrast, in a single-product setting this would require inter-firm transfers, which would entail both contractual and political costs.

To see the effect of inter-fuel transfers, consider a regulator's problem of maximizing a weighted average of the consumer surplus from electricity and natural gas consumers, subject to the constraint that the firm, or firms, earn at least some required profit level. For simplicity, assume there are two types of consumer classes for each product, residential and industrial consumers, denoted as r and i, respectively and that inter-firm transfers are too costly to undertake. In a single-product setting, we have two maximands. Following Ross [1984], we can write the regulator's problems as:

$$\begin{aligned} &\max\ \alpha_{re} Z_{re}(p_{re}) + \alpha_{ie} Z_{ie}(p_{ie}) \\ &\text{s.t.}\ \Pi_e \geq \Pi_e^* \end{aligned} \tag{1}$$

and,

$$\begin{aligned} &\max\ \alpha_{r,ng} Z_{r,ng}(p_{r,ng}) + \alpha_{i,ng} Z_{i,ng}(p_{i,ng}) \\ &\text{s.t.}\ \Pi_{ng} \geq \Pi_{ng}^* \end{aligned} \tag{2}$$

The first order conditions imply:

$$\begin{aligned} \frac{p_{re} - c_{re}}{p_{re}} &= \frac{\lambda^e - \alpha_{re}}{\varepsilon_{re}\lambda^e} \\ \frac{p_{ie} - c_{ie}}{p_{ie}} &= \frac{\lambda^e - \alpha_{ie}}{\varepsilon_{ie}\lambda^e} \end{aligned} \tag{3}$$

and,

$$\begin{aligned} \frac{p_{r,ng} - c_{rg}}{p_{r,ng}} &= \frac{\lambda^{ng} - \alpha_{r,ng}}{\varepsilon_{r,ng}\lambda^{ng}} \\ \frac{p_{i,ng} - c_{i,ng}}{p_{i,ng}} &= \frac{\lambda^{ng} - \alpha_{ig}}{\varepsilon_{i,ng}\lambda^{ng}} \end{aligned} \tag{4}$$

where λ^e and λ^{ng} are the Lagrange multipliers associated with the electricity and natural gas firms' profitability constraints, respectively and ε_{jk} is the absolute value of the elasticity for group j and product k.

[10] Becker's [1983] results imply that under certain instances the relative prices from interest group and regulator interaction will be proportional to Ramsey prices.

In the dual-product setting, there is a single maximand and we have:

$$
(5)\qquad
\begin{aligned}
\frac{p_{re}-c_{re}}{p_{re}} &= \frac{\lambda^d-\alpha^d_{re}}{\varepsilon_{re}\lambda^e}\\
\frac{p_{ie}-c_{ie}}{p_{ie}} &= \frac{\lambda^d-\alpha^d_{ie}}{\varepsilon_{ie}\lambda^d}\\
\frac{p_{r,ng}-c_{r,ng}}{p_{r,ng}} &= \frac{\lambda^d-\alpha^d_{r,ng}}{\varepsilon_{r,ng}\lambda^d}\\
\frac{p_{i,ng}-c_{i,ng}}{p_{i,ng}} &= \frac{\lambda^d-\alpha^d_{i,ng}}{\varepsilon_{i,ng}\lambda^d}
\end{aligned}
$$

where λ^d is the Lagrangian multiplier associated with the dual-product firm's profitability constraint. Provided the differences between the α^d_{jk}'s and the α^s_{jk}'s are not 'too great,' λ^d will lie between λ^e and λ^{ng}.[11] From this, we can see that even if the regulator's weights across consumer classes and fuels are the same (e.g., $\alpha_{re}=\alpha_{r,ng}$), prices will differ between single-product and dual-product settings, provided $\lambda^e \neq \lambda^{ng}$. Specifically, for a given consumer class j for product k, we have:

$$
(6)\qquad \frac{p^d_{jk}-c_{jk}}{p^d_{jk}} - \frac{p^s_{jk}-c_{jk}}{p^s_{jk}} = \frac{\lambda^d\alpha^s_{jk}-\lambda^s\alpha^d_{jk}}{\varepsilon_{jk}\lambda^d\lambda^s}
$$

There are two sources for $\lambda^e \neq \lambda^{ng}$. One source is differences in demand elasticities across the two fuels. The more elastic is demand, the larger the loss in weighted consumer surplus from an increase in the firm's required profit level. The literature suggests this effect would lead to $\lambda^e < \lambda^{ng}$. The bypass of the IOU for commercial and industrial consumers is much more prevalent in natural gas than in electricity, suggesting a more elastic residual demand for natural gas IOUs.[12] Second, if scale economies differ between the two fuels, *ceteris paribus*, λ^e and λ^{ng} will differ. Greater scale economies

[11] To see this, λ is the decrease in weighted consumer surplus from increasing the required profits of the firm by one dollar. If the dual-product firm is simply the sum of the single-product firms and the weights do not change, then λ^d will just be a convex combination of λ^e and λ^{ng} since some of the increase in profits will come from a loss in consumer surplus and an increase in the deadweight loss of both electricity and natural gas consumers. In principle, a shift in the relative weight to industrial consumers will increase λ^d because there will be greater 'weighted' deadweight loss.

This assumes the absence of significant economies of scope, which would tend to lower the shadow value in the dual-product setting, and significant increase in the lobbying power of the IOU, which would tend to increase the shadow value on the dual-product setting. Alternatively, we can assume that these effects tend to offset each other.

[12] In support of this, Lin, *et al.* [1987] estimate the long run elasticities for residential, commercial and industrial electricity demand to be -1.19, -1.33 and -1.16, respectively. In contrast, their estimates for residential, commerical and industrial natural gas long run elasticities are -1.22, -1.43 and -1.80, respectively.

make it more difficult for the regulator to price at first best (marginal cost); thus, the greater is the shadow price associated with increasing the firm's required profit level. There is little evidence in the literature that would indicate which of the two industries have greater scale economies, since few studies exist on natural gas local distribution companies. Sing [1987] estimates scale economies for dual-product electricity and natural gas firms. He reports the scale economies for only the mean firm and finds increasing returns to scale in electricity, but not in natural gas; however, given the skewed nature of the size of the firms, few firms are near the mean. Numerous papers have studied the existence of scale economies in the electricity industry, and the results are quite mixed.[13] Therefore, while the relative elasticities for the two fuels would suggest electricity prices would be higher in a dual-product setting, the absence of strong evidence with respect to scale economies makes it difficult to have a strong prior for either case.

IV. ALTERNATIVE SOURCES FOR PRICE DIFFERENCES

The proposition that regulators respond to interest group pressure almost surely implies that regulators will also respond to the lobbying activities of the utilities that they oversee. In fact, the issue of relative pricing of single- and dual-product electricity firms was first analyzed by Owen [1970] and Landon [1973] as a test of whether regulators respond to the increased market power of dual-product firms. Owen [1970] estimates a reduced form pricing equation, controlling for cost and demand variables, and includes a dummy variable equal to one if the firm sells both electricity and natural gas. His results suggest that dual-product firms have higher electricity prices. Owen interprets these results as evidence of regulatory imperfections, since dual-product firms will have a greater incentive to price higher than single-product firms.

His results were subsequently questioned by Landon [1973], who included additional cost and demand variables, as well as regional dummy variables (all of which are included in this analysis). The inclusion of these variables negated the effect the dual-product indicator variable. Landon interprets this as evidence that regulators do not respond to the incentives of firms.[14] The issue has since been unaddressed.

Despite these previous claims, the effect of greater market power on prices in a dual-product setting is not clear. A dual-product firm has an incentive to

[13] For example, Kaserman and Mayo [1991] find evidence of scale economies, while Lee [1995] finds that scale economies are exhausted.

[14] Landon included the quantity on the right hand side (without instrumenting for it). I do not include this variable. In addition, this study differs from Landon in a number of other repects. For one, the paper estimates the impact of dual-product firms on a more recent sample. Second, the paper estimates the effect on different classes of customers. Finally, the paper also analyzes natural gas pricing under dual-product firms.

TABLE I
POSSIBLE SOURCES OF PRICE DIFFERENCES BETWEEN SINGLE- AND MULTI-PRODUCT FIRMS

	Interest Group Activity	Market Power	Economies of Scope
Price of Electricity	$P^e_{dual} \lesseqgtr P^e_{sing}$	$P^e_{dual} \lesseqgtr P^e_{sing}$	$P^e_{dual} < P^e_{sing}$
Price of Natural Gas	$P^{ng}_{dual} > P^{ng}_{sing}$, if $P^e_{dual} < P^{ng}_{sing}$ $P^{ng}_{dual} < P^{ng}_{sing}$, if $P^e_{dual} > P^{ng}_{sing}$	$P^{ng}_{dual} > P^{ng}_{sing}$	$P^{ng}_{dual} < P^{ng}_{sing}$

price *both* electricity and natural gas higher because electricity and natural gas are substitutes in consumption. This would imply that, *ceteris paribus*, if regulators respond to the market incentives of dual-product firms, electricity and natural gas prices in a dual-product environment would be higher than those in a single-product setting. In terms of equations (3) through (5), an increase in market power would raise λ^d relative to *both* λ^e and λ^{ng}, through an increase in Π^*_d. A complicating factor is that natural gas is also an input for the generation of electricity. Therefore, regulators that respond to the incentives of single-product natural gas firms, will enable the single-product *natural gas* firm to raise the generation costs of the single-product *electricity* firm (increasing λ^e).

Combined, the 'substitution effect' and the 'raising your rivals' costs effect' render the relative prices of single- and dual-product electricity firms to be ambiguous; however, because single-product electricity firms are large enough to bypass the single-product natural gas firm, it is likely that the 'substitution effect' would dominate. Therefore, we would expect the dual-product electricity price to be higher. Furthermore, if market power is driving a wedge between single- and dual-product prices, then natural gas prices should be higher in a dual-product setting.

The existence of economies of scope would also cause prices to depend on the market structure. If there exists contracting costs between the single-product electricity and natural gas firms, then the marginal cost of delivered natural gas and the marginal price paid by a single-product electricity firm will differ. This would imply that electricity prices in a dual-product setting would be lower than those in a single-product setting. In terms of equations (3) through (5), economies of scope would lower λ^d relative to both λ^e and λ^{ng}. If the scope economies are large enough, we expect prices for both electricity and natural gas to be lower in a dual-product setting.[15]

Table I summarizes the implied price differences from interest group efforts, market power and economies of scope.

[15] Sing [1987] finds that economies of scope for the mean dual-product firm do not exist, but do exist in other ranges of the cost function.

V. ECONOMETRIC ANALYSIS

V(i). *The Data*

To test whether the prices for electricity and natural gas depend on the market structure, I make use of two unbalanced panel data sets on electricity and natural gas IOUs. Both data sets span the years 1990 to 1995 and are for vertically integrated IOUs. The sources of the data are described in Appendix B. Both data sets report total revenue and total output by consumer class. Additional data were collected on the determinants of marginal cost, demand and resource availability, and are described below.

Tables II and III list the summary statistics for the two data sets. To get a sense as to whether prices and other variables differ in a dual-product setting, Tables IV and V list the means of the variables for the single-product firms, as well as for the dual-product firms. The respective means suggest that electricity consumers have higher rates in a dual-product setting, while natural gas consumers face lower rates. There does not appear to be an appreciable difference in the means of the demographic and cost variables between the different market structures.

TABLE II
SUMMARY STATISTICS FOR ELECTRICITY DATA

Variable	Mean	Std Dev	Min	Max
AvgRev for *Elec* ($\$/MWH$)	4.92	1.48	2.37	10.34
D_i	0.38	—	0	1
P^g_{it}	2.25	0.30	1.09	3.33
$\%Gas_{it} \times P^g_{it}$	0.30	0.54	0	2.80
P^{coal}_{it}	1.49	0.23	0.96	2.24
$\%Coal_{it} \times P^{coal}_{it}$	0.50	0.34	0	1.34
P^{oil}_{it}	3.34	0.62	1.93	4.93
$\%Oil_{it} \times P^{oil}_{it}$	0.21	0.42	0	2.32
$\%Hydro_{it}$	0.06	0.11	0	0.63
$\%Nuke_{it}$	0.12	0.14	0	0.51
$PeakStdDev_{it}$	459.02	627.57	5.59	8642.75
$\%Res_{it}$	0.33	0.07	0.09	0.53
$\%Ind_i$	0.34	0.14	0	0.81
PopDensity	196.51	201.82	4.70	1042.00
$Income_{it}$ (1989\$1000 *s*)	18.22	2.17	13.21	25.91

TABLE III
SUMMARY STATISTICS FOR NATURAL GAS DATA

Variable	Mean	Std Dev	Min	Max
AvgRev for *NatGas* ($\$/BTUs$)	3.73	0.81	1.46	6.72
D_i	0.26	—	0	1
$P^{citygate}_{it}$	2.15	0.30	0.96	3.45
$\%Res_{it}$	0.52	0.19	0.00	0.96
$\%Ind_{it}$	0.20	0.20	0.00	0.99
$Income_{it}$ (1989\$1000s)	18.36	2.53	11.75	26.65

TABLE IV
ELECTRICITY COST AND DEMAND CHARACTERISTICS BY MARKET STRUCTURE

Variable	Single-Product Mean	Dual-Product Mean
AvgRev for *Elec* (\$/*MWH*)	4.81	5.11
P^{g}_{it}	2.26	2.24
P^{coal}_{it}	1.53	1.41
P^{oil}_{it}	3.28	3.32
%Coal	0.49	0.50
%Gas	0.13	0.13
%Oil	0.08	0.07
$\%Hydro_{it}$	0.06	0.05
$\%Nuke_{it}$	0.12	0.11
$PeakStdDev_{it}$	477.44	425.90
$\%Res_{it}$	0.34	0.33
$\%Ind_{it}$	0.34	0.33
$\%Com_{it}$	0.29	0.31
$Total\ Output_{it}$	18,288,300	15,199,900
$PopDensityt_{it}$	204.97	203.57
$Income_{it}$ (1989\$1000 *s*)	25,820	26,046
N	442	275

TABLE V
NATURAL GAS COST AND DEMAND CHARACTERISTICS BY MARKET STRUCTURE

Variable	Single-Product Mean	Dual-Product Mean
AvgRev for NatGas (\$/*BTUs*)	3.77	3.61
$P^{citygate}_{it}$	2.15	2.15
$\%Res_{it}$	0.51	0.54
$\%Ind_{it}$	0.29	0.26
$\%Com_{it}$	0.20	0.19
$TotVol_{it}$	24,822,500	35,086,600
$PopDensity_{it}$	214.63	184.91
$Income_{it}$ (1989\$1000 *s*)	25927	26116
N	968	392

V(ii). *Empirical Model*

I estimate reduced form equilibrium price equations for both electricity and natural gas firms, letting the equilibrium prices vary by market structure.[16] In particular let:

$$
(7)\qquad
\begin{aligned}
P^{e}_{it} &= f^{1}(X^{e}_{it},\ W^{e}_{it} Market\ Structure_i, \varepsilon^{e}_{it}, v^{e}_{i}) \\
P^{ng}_{it} &= f^{2}(X^{ng}_{it},\ W^{ng}_{it} Market\ Structure_i, \varepsilon^{ng}_{it}, v^{ng}_{i})
\end{aligned}
$$

where, for market *i* and time *t*, P^{e}_{it} is the price of electricity, P^{ng}_{it} is the price of natural gas, X^{k}_{it} is a matrix of demand determinants for firm *i* at time *t*, W^{k}_{it} is a matrix of cost determinants, ε^{k}_{it} is a mean zero error term with a common

[16] This is similar to Shepard [1991] which analyzes price discrimination in retail gasoline markets by leveraging the fact that certain gas stations provide both self and full-service.

distribution across all firms, and v_i^k is a firms specific effect (k = electricity and natural gas).

Electricity Equation

Dependent Variable: The dependent variable for the electricity equation is the average revenue from electricity sales, measured in dollars per megawatt hour.

Independent Variables

Market Structure: The market structure is measured as an indicator variable, D_i, equal to one if the electricity firm also sells natural gas.

Cost Determinants: Electricity firms have a choice of a wide-array of generation technologies and fuel sources for those technologies. For example, if a firm chooses to build a steam generator, i.e., one that uses steam to turn the generation turbine, the fuel source may be either natural gas, coal, oil or nuclear. A firm's costs will, in part, depend on the cost of the associated fuels, as well as the amount of generation the firm employs that uses the particular fuel. For example, changes in the price of coal should not affect a firm's electricity price if the firm does not use coal generation. To account for this, I include the following variables: $\%Gas \times P_{it}^g$, $\%Coal \times P_{it}^{coal}$ and $\%Oil \times P^{oil}$, which are the regional price of input k interacted with the percentage of the firm's generation that uses the fuel k.[17] Because changes in the regional price of natural gas may affect a dual-product firm differently, I also include the variable: $\%Gas \times P_{it}^g D_i$. In addition, because of environmental regulations, California IOUs are not able to build coal generation facilities inside California.[18] To control for possible differences in the sensitivity to coal price changes for firms that operate within California, I also include a variable that interacts $\%Coal \times P_{it}^{coal}$ with a California state dummy, denoted as $\%Coal_{it}P_{it}^{coal}I(i \in CA)$.

While the relative use of most generation technologies is a firm's choice variable, the availability of hydroelectric resources is largely exogenous, driven instead by the availability of water resources in the operating area. Because the marginal cost of hydroelectric generation is lower than that of other technologies, we would expect the availability of hydro resources to have a negative impact on price of electricity. Therefore, I include the percentage of electricity that was produced using hydroelectric resources, $\%Hydro_{it}$.

Finally, I include the percentage of generation capacity that utilizes nuclear fuel, $\%Nuke_{it}$. Although nuclear generation units have a low marginal cost, they also have high sunk costs. While efficient pricing would dictate that these sunk costs not affect electricity rates, this has not been the case, as public utility commissions have incorporated these sunk costs into rates. Therefore, we would expect markets that rely more heavily on nuclear power to have higher rates.

[17] Input price data were collected from the Natural Gas Institute and are split into 12 regions.

[18] Southern California Edison has a 1702 MW of coal burning capacity, which operates outside of California.

Demand Determinants: Electricity IOUs service a wide-array of consumer types with different demand elasticities. To account for this, regulators set different prices for three main consumer class: residential, commercial and industrial consumers. Since the dependent variable is the average price paid by all consumers, it will be a function of the relative quantities purchased by the different groups.[19] Therefore, I include the percentage of electricity that was purchased by residential consumers and the percentage that was purchased by industrial consumers.[20] In addition to demand considerations, the relative mixture of consumers is also likely to affect the cost of electricity generation. Because the variability of industrial demand is less than that of residential consumers, the increased predictability of demand reduces the need for generation units that operate infrequently, thereby reducing the costs of generation. Furthermore, industrial and some commercial consumers require less voltage regulation, thereby reducing costs.

The average price of electricity across a year will also be a function of the intertemporal nature of demand. Variation in demand has both an intra-day and a seasonal component; this variation affects generation costs. Although an obvious control for this would be the variance of demand within a given year, these data are not available. Instead, I included the variable $PeakStdDev_{it}$, defined as the standard deviations of the monthly peak demand levels.

A major determinant of the distribution costs for electricity is the population density of the customer base. *Ceteris paribus*, the more dense the population, the shorter the electricity has to travel, requiring less distribution and transmission infrastructure. While data that report the population density of the firm's service area are not available, I include the population density of the state in which the firm operates.

Finally, to control for changes in residential demand, the average yearly personal income for the state in which the firm operates is also included. This variable is included for two reasons. For one, although in the long-run the level of demand should not affect price, since the capacity of the system would be built to cater to a particular level of demand, short term fluctuations in demand caused by changes in the average income may affect price. Secondly, it could be argued that more wealthy customers demand higher quality electricity service than less wealthy consumers, either through lower levels of interruptions or better billing services. These considerations would tend to increase the average price of electricity.

[19] Bypassing the IOU is only economical for consumers who purchase a large amount of electricity, thus industrial demand is largely considered more elastic than residential and commercial demand. In addition, regulatory restrictions often make bypass for residential consumers illegal.

[20] Sales are divided into 4 categories: residential, commerical, industrial and the utilities' own consumption. Because the sum of the percentage from residential, commercial and industrial consumers is near one, the percentage consumed by both commercial consumers and the IOU are omitted.

Long Run Determinants: To control for demand and cost determinants that vary across region, but are not captured by the above variables, I include 12 regional indicator variables.[21, 22]

Natural Gas Equation

Dependent Variable: The dependent variable for the natural gas equation is the average revenue from natural gas sales, measured in dollars per million British Thermal Units (BTUs).

Independent Variables

Market Structure: The market structure is measured as an indicator variable, D_i, equal to one if the natural gas firm also sells electricity.

Cost Determinants: Given the ability to store natural gas, controlling for the costs of providing natural gas is more straightforward than controlling for the costs of providing electricity. The natural gas industry consists of production (exploration and extraction), transmission and distribution. To control for production costs, I include the yearly average city-gate price at the state level.[23] As with electricity, a major determinant of distribution costs is the population density of the customers. Therefore, I include the population density of the state in which the firm operates.

Demand Determinants: As with the electricity equation, I include the average annual income at the state level, as well as the percentage of natural gas consumed by residential and industrial consumers.

Long Run Determinants: As with the electricity pricing equation, I include 12 regional indicator variables.

The inclusion of these variables implies:

(8)

$$
\begin{aligned}
& f^1(Di, \%Gas_{it}P^g_{it}, \%Gas_{it}P^g_{it}D_i, \%Coal_{it}P^{coal}_{it}, \%Coal_{it}P^{coal}_{it}I)(i = CA) \\
P^e_{it} &= \%Oil_{it}P^{oil}_{it}, \%Hydro_{it}, \%Nuke, PeakStdDev_{it}, PopDensity^{state}_{it}, \\
& \%Res_{it}, \%Ind_{it}, Income_{it}, \{Reg_1, \ldots, Reg_{12}\}, \varepsilon^e_{it}, v^e_i \\
P^{ng}_{it} &= f^2(D_i, P^{citygate}_{it}, PopDensity^{state}_{it}, \%Res_{it}, \%Ind_{it}, Income_{it}, \\
& \{Reg_1, , \ldots, Reg_{12}\}, \varepsilon^{ng}_{it}, v^{ng}_i)
\end{aligned}
$$

Tables II and III reports the summary statistics for the data.

[21] These regional variables will also capture other variables that vary by region, *e.g.* weather conditions, and are not included on the right hand side.

[22] The regions are the same as those defined by the American Gas Association in reporting natural gas prices. Region 1 is defined as; CT, MA, ME,, NH, RI, VT, Region 2; NJ, NY, PA, Region 3; DC, DE, FL, GA, MD, NC, SC, VA, WV, Region 4; IL, IN, MI, OH, WI, Region 5; IA, KS, MN, MO, ND, NE, SD, Region 6; AL, KY, MS, TN, Region 7; AR, LA, OK, TX, Region 8; CO, ID, MT, UT, WY, Region 9; AZ, NM, NV, Region 10; OR, WA, CA. State dummies were also included, but did not qualitatively change the results.

[23] The city-gate price is the price charged by the transmission companies, reflecting both the spot price and the costs of tranmission to the state.

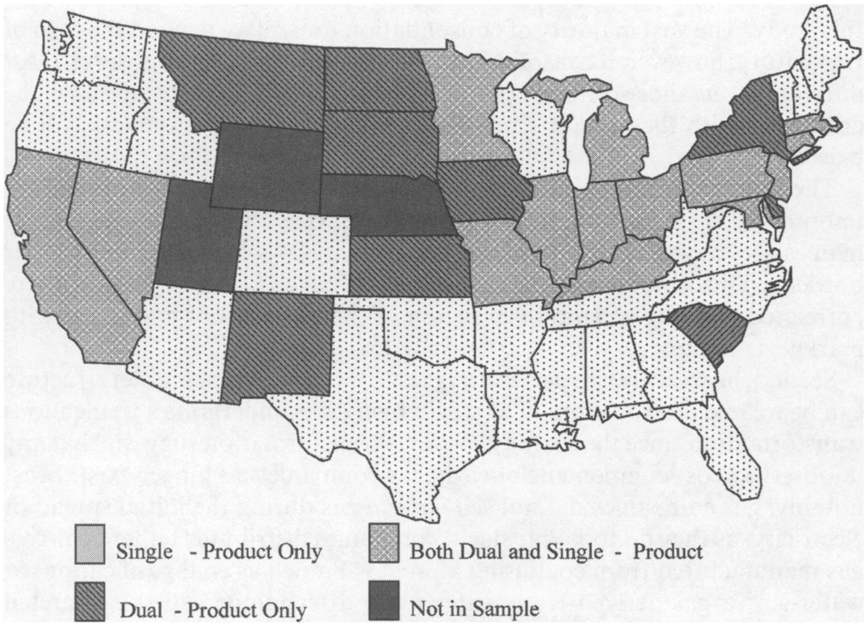

Figure 1
Distribution of Single and Dual-product Electricity Monopolies

I estimate two functional forms, a linear model and a log-linear model. Under the log-linear model, the logarithm of the variables in percentage terms are not taken for two reasons. First, because these variables can take on the value of zero, numerical problems arise when the logarithm is taken. Second, one of the appeals of the log-linear form is that the parameter estimates are elasticities; however the elasticity of price with respect to a variable measured in percentage terms makes little sense. Therefore, only the logarithm of the prices (electricity, natural gas, coal and oil), the standard deviation of the monthly peaks, the income level and population density are taken.

Finally, I employ a random effects model to capture the serial correlation within a firm.

V(iii). *Econometric Issues*

The most obvious econometric issue is whether the market structure variable can be treated as exogenous.[24] Figure 1 illustrates the distribution of single- and dual-product electricity firms for the IOUs in the data used for

[24] This is consistent with the previous literature. Owen [1970] and Landon [1973] both treat market structure as exogenous. In addition, a number of papers have studied the cost functions of single and dual-product electricity firms, treating market structure as exogenous (see Stevenson [1982], Mayo [1984] and Sing [1987]).

this study. The vast majority of consolidation took place around the turn of the century; however, if consolidation took place because of unobserved cost differences *and* those differences still exist today, then the error term will be correlated with the market structure variable, and the parameters will be biased.

The market structure variable is unlikely to be correlated with current unobserved costs for a number of reasons. For one, Figure 1 illustrates that many states have both single- and dual-product IOUs operating within their borders. This would suggest that unobserved cost differences that are correlated with the geographical region of the firm are not correlated with market structure.

Second, historical evidence also suggests that the current market structure can be treated as exogenous. The gas industry has undergone a tremendous transformation since the early 1900s. This transformation suggests that any unobserved cost components of early gas companies no longer exist. Most notably, gas companies did not sell *natural* gas during the initial spread of electricity, as they do today. Instead, companies distributed either coal-gas, gas manufactured from coal using a process known as coal gasification, or water-gas, a gas derived from water using a technique called carbureted water-gas. *Natural* gas was not used on a widespread basis until World War II (Tussig and Barlow [1984]). Therefore, any unobserved cost components on the manufacturing side of gas during this period are not likely to exist today, since gas companies use an entirely different product. In addition, during this period, gas distribution was generally limited to municipal areas and these original distribution systems no longer exist. Large-scale distribution and pipeline systems did not exist until the late 1920s, when advances in pipeline technology made it possible (Tussig and Barlow [1984]). Today, pipelines connect all parts of the United States with the longest stretching from northern Alaska to Indiana. With the new pipeline technology, a nationwide network of natural gas pipelines and the discovery of natural gas reservs in the north (most notably Alaska), any unobserved cost components originating from gas distribution that might have existed in the early 1900s are not likely to remain.

Finally, a number of studies have suggested that merger activity between electricity and gas companies and the creation of dual-product firms was not cost driven. Passer [1953] suggests that integration of gas and electricity companies had more to do with the existing gas companies' willingness to accept the merits of electricity lighting. Many gas firms were reluctant to offer electricity because they engaged in a propaganda war against the use electricity. As electricity expanded, a number of gas companies created state level gas associations to devise ways to counteract the expansion. Coleman [1952] reports that the Pacific Gas Association, created in 1893, initially sought to defeat the spread of electricity, but later pushed for a plan of embracing and joining the expansion of electricity.

A second econometric issue deals with whether the regional price of natural gas paid by electricity firms is endogenous. Although the price is measured at the regional level, given the size of electricity IOUs it is likely they have some influence on this price. Therefore, I instrument for this price using the city-gate prices from the natural gas specification. The city-gate price is the price paid by all natural gas purchasers within the region. The city-gate price can safely be treated as exogenous since electricity IOUs are a smaller proportion of the entire demand for natural gas at the regional level.

VI. RESULTS

The results from the linear and log-linear specifications are reported in Table VI.

The results for linear specification suggest that dual-product firms have electricity rates that are \$.21 per megawatt hour higher than the rates of single-product electricity firms. This implies that the electricity rates of dual-product firms are 4.3 percent higher than their single-product counterparts, when evaluated at the mean price. Similarly, the log-linear specification suggests that electricity rates are 4.3 percent higher when serviced by a dual-product firm. Both are significant at the 1% level.

The results of the natural gas equation are less clear. The parameter estimates in both the linear and log-linear specifications are negative; however the estimate is only marginally significant in the linear specification. The linear model suggests that the dual-product natural gas firms price 5.4 percent lower than single-product firms, while the log-linear model suggests that dual-product prices are 1.6 percent lower and is significant at the 5% level.

Combined, these results are most consistent with the interest group explanation for price differences between single- and dual-product firms.

The parameter estimates with respect to the control variables are largely consistent with economic intuition. The estimates with respect to $\%Gas_{it}P^{g}_{it}$ imply that increases in the price of natural gas lead to increases in the price of electricity. For the linear specification, a 10 percent increase in the real price of delivered natural implies is associated with a 1.4 percent increase in the price of electricity, for a single-product firms at the mean level of natural gas generation (13.0%).[25] This result is robust to changes in the functional form. For the log-linear specification, a 10 percent increase in the price of delivered natural gas for single-product firms at the mean share of natural gas generation is associated with a 1.8 percent increase in the price of electricity.

[25] Recall that the variables $\%Gas_{it}$, $\%Coal_{it}$, and $\%Oil_{it}$ measure the percentage of all generation capacity (*e.g.*, including hydroelectric resources) devoted to their respective technologies. The mean and standard deviation of $\%Gas_{it}$, $\%Coal_{it}$, and $\%Oil_{it}$ are 12.99 and 23.01; 48.80 and 31.15; and 8.06 and 16.22, respectively.

TABLE VI
THE IMPACT OF MARKET STRUCTURE ON PRICES

Variable	Linear Specification		Log-Linear Specification	
	Dependent Variable			
	P^{e}_{it}	P^{ng}_{it}	$\log P^{e}_{it}$	$\log P^{ng}_{it}$
Constant	5.89***	1.99***	1.69***	−0.49*
	(0.48)	(0.27)	(0.23)	(0.27)
β_{dual}	0.21***	−0.20*	0.04***	−0.02**
	(0.08)	(0.12)	(0.02)	(0.01)
$\%Gas_{it}P^{g}_{it}$	6.68***		1.53***	
	(1.23)		(0.19)	
$\%Gas_{it}P^{g}_{it}D_i$	0.14		0.40×10^{-2}	
	(0.13)		(0.24×10^{-1})	
$\%Coal_{it}P^{coal}_{it}$	0.04		0.07	
	(0.07)		(0.12)	
$\%Coal_{il}P^{coal}_{it}I(i = CA)$	4.11		0.82	
	(2.80)		(0.53)	
$\%Oil_{it}P^{oil}_{it}$	1.00***		0.17***	
	(0.09)		(0.02)	
$PeakStdDev_{it}$	0.24×10^{-4}		0.79×10^{-3}	
	(0.28×10^{-4})		(0.57×10^{-2})	
$\%Hydro_{it}$	−0.79***		−0.39***	
	(0.18)		(0.20)	
$\%Nuke_{it}$	1.96***		0.50***	
	(0.22)		(0.05)	
$\%Res_{it}$	1.69***	1.01***	0.33***	0.24***
	(0.56)	(0.13)	(0.11)	(0.03)
$\%Ind_{it}$	−1.15***	−1.39***	−0.26***	−0.46***
	(0.27)	(0.12)	(0.05)	(0.03)
$Income_{it}$ (1000 s)	−0.002	1.73***	−0.13	0.22***
	(0.001)	(.31)	(0.08)	(0.04)
$PopDensity^{state}_{it}$ (1000 s)	0.001***	−1.03***	0.02***	−0.06***
	(0.000)	(0.13)	(0.004)	(0.01)
P^{cityng}_{it}		0.59***		0.36***
		(0.08)		(0.04)
N	717	1360	717	1360

Random Effects Model assumed.
***significant at the .01 level,
**significant at the .05 level,
*significant at the .10 level.
Heteroskedastic-consistent errors in parentheses.
Regional effects not shown.

Surprisingly, the estimates with respect to $\%Gas_{it}P^{g}_{it}D_i$ suggest that increases in the price of natural gas do not affect dual-product firms differently from single-product firms. We would expect increases in the price of natural gas to affect dual-product firms less than single-product firms, since some of this price increase will be absorbed by the firm as a result of increases in the retail rate of natural gas.

The estimates imply that increases in the price of oil are associated with increases in the price of electricity, while the parameter estimates with respect to the price of coal are not significant. In particular, the linear specification implies that a 10 percent increase in the real price of oil is associated with a .19 percent increase in electricity prices for firms at the mean level of oil generation share, while this estimate is .13 percent in the log-linear specification.

The parameter estimates with respect to the percentage of electricity produced via hydroelectric resources suggest that greater hydroelectric resources are associated with lower rates. The linear specification implies that a one standard deviation increase in the hydroelectric capabilities results in a 1.4 percent decrease in the price of electricity; the log-linear specification implies that a one standard deviation increase in hydroelectric capabilities is associated with a 4.3 percent decrease in the price of electricity.

The results also confirm our expectations that, although the marginal cost of nuclear units is very low, their high sunk costs lead to higher rates. Specifically, a one standard deviation increase in the percentage of capacity devoted to nuclear fuel is associated with a 5.5 percent increase in rates, in the linear specification, and a 6.9 percent increase in the log-linear specification.

The results with respect to the variability of demand suggest that the greater the variability of demand, the greater the average price; however this is not statistically significant.

The results also suggest that higher levels of demand from residential consumers, relative to commercial consumers, are associated with higher electricity rates, while higher levels of industrial consumers are associated with lower rates. These results are consistent with the observation that industrial demand is both more elastic and cheaper to service than that of other consumers, while residential demand is more inelastic relative to commercial demand and the cost of servicing residential consumers is greater.

The parameter estimates associated with the natural gas control variables are also consistent with our intuition. A greater proportion of residential consumers is associated with higher natural gas prices, while more industrial consumers is associated with lower rate levels. Higher levels of city gate prices translate to higher natural gas prices at the consumer level. The more dense the population, the lower are natural gas prices. Finally, income has a positive influence on natural gas prices.

VII. SEPARATING THE IMPACT BY CONSUMER GROUP

In this section, I analyze the impact of integration across three consumer groups: residential, commercial and industrial. The political economy literature implies that the impact of integration may differ across consumer groups. Returning to equation (6), we can write the difference in the price-cost margin faced by consumer group j for the product k from integration as:

$$\frac{p_{jk}^{d} - c_{jk}}{p_{jk}^{d}} - \frac{p_{jk}^{s} - c_{jk}}{p_{jk}^{s}} = \frac{\lambda^{d}\alpha_{jk}^{s} - \lambda^{s}\alpha_{jk}^{d}}{\varepsilon_{jk}\lambda^{d}\lambda^{s}} \tag{9}$$

where λ^s represents the Lagrangian associated with the single-product firm's profitability constraint ($s = e, ng$). Equation (9) implies that two factors will drive the relative magnitudes of price differences across consumer classes. The first is the relative elasticities. Thus, if $\lambda^e < \lambda^d$ (as suggested by the results above), *ceteris paribus*, we would expect residential electricity prices to increase by a greater amount, since residential demand is less elastic than commercial and industrial demand. The second is the difference in the weights regulators place on the consumer surpluses in a single- and dual-product setting. If, for example, regulators place the same weight on all consumers across fuels (*e.g.*, $\alpha_{jk} = .5$ for all j and k), then the elasticity is the only driving force behind price changes. Alternatively, if the relative weights differ in a dual-product setting then price differences may be disproportional to elasticities. For example, consider natural gas prices. Given equal weight to all consumers, we would expect residential natural gas consumers to gain the most from moving from a single-product to a dual-product setting.

This effect is mitigated if the relative consumer weights differ in a dual-product setting. One source for this difference maybe the existence of economies of scope in lobbying activity, as lobbying activity may be more effective when consumer groups are lobbying 'against' one firm, rather than two. There are a number of reasons why this may be the case. For one, much of the 'official' lobbying takes place in regulatory rate hearings; lobbying groups counter the utilities estimates of costs and the distribution of the costs with their own.[26] (Gormley [1983]) Berry [1984] posit that 'to a large extent, a group's influence is a function of its ability to provide the information as a basis for commission decisions.' In a dual-product setting, rate hearings often address rate changes for both electricity and natural gas; this is not the case for single-product firms.[27] Given some fixed costs associated with attending and preparing for a rate hearing, the ability of lobby groups to focus their efforts on a single rate hearing may increase their efficiency and effectiveness. In addition, the ability to focus on one firm may reduce the costs associated with cost estimation. Finally, Gormley [1983, page 42] finds that interest groups are more likely to take part in electricity rate cases than natural gas rate cases. Therefore, integration may have the largest effect on the regulators weights for natural gas consumers, since integration would lead to a larger increase in lobbying activity at the natural gas level.

If the degree of scope economies differs across consumer classes, then this will be another source for price differences across market structures. For example, if industrial consumers have greater scope economies compared to

[26] Not surprisingly, large consumer groups, such as industrial consumers, are more likely to take part in rate hearings.

[27] In conversations with a number state PUCs, they stated that rate cases are predominantly firm specific and that it was common for rate cases for dual-product firms to deal with both electricity and natural gas prices.

residential consumers, the relative weights will differ across market structures, implying $\alpha^s_{rg}\alpha^d_{rg}, \alpha^s_{ig} < \alpha^d_{ig}$ (again constraining the sum of the weights to remain the same), and industrial prices will be more negative than the simple elasticity effect would imply. Industrial electricity prices will not be as high in a dual-product setting and industrial natural gas prices will be even lower.

The existence of both economies of scope and elasticity differences would imply that residential electricity price differences will be the largest and large consumer electricity prices (both commercial and industrial) may not be higher in a dual-product setting. In contrast, economies of scope would lead large consumer natural gas prices to be more negative in a dual-product setting, while the elasticity effect would lead to residential prices being more negative.

Comparing the mean level of prices in single- and dual-product settings across consumers foreshadows the regression results. As Tables VII and VIII indicate, the largest disparity between the mean electricity prices is for residential consumers (a 4.9 percent premium in the dual-product setting), while the premium is 2.3 percent for industrial consumers. On the other hand, industrial natural gas consumers appear to benefit the greatest from integration. The mean level of natural gas prices for industrial consumers is 9.0 percent lower in a dual-product setting versus the entire sample, while this difference is only 6.7 percent for residential consumers.

Tables IX and X report the results of regressions by consumer class. For brevity, only the coefficients associated with the dual-product indicator are shown. The results with respect to the other variables are similar to those reported in Table VI.

TABLE VII
SUMMARY STATISTICS FOR ELECTRICITY DATA BY CONSUMER CLASS

Variable		Mean	Std Dev	Min	Max	Count
AvgRev for *Elec*, Residential	Single-Product	5.89	1.60	3.05	9.79	442
	Dual-Product	6.18	1.71	3.27	11.14	275
AvgRev for *Elec*, Commercial	Single-Product	5.17	1.36	2.62	8.74	442
	Dual-Product	5.40	1.59	1.28	10.74	275
AvgRev for *Elec*, Industrial	Single-Product	3.74	1.12	1.67	7.43	442
	Dual-Product	3.80	1.48	2.02	12.09	275

TABLE VIII
SUMMARY STATISTICS FOR NATURAL GAS DATA BY CONSUMER CLASS

Variable		Mean	Std Dev	Min	Max	Count
AvgRev for *NatGas*, Residential	Single-Product	4.35	1.04	1.50	8.16	968
	Dual-Product	4.06	0.76	1.85	7.12	392
AvgRev for *NatGas*, Commercial	Single-Product	3.67	0.75	0.93	6.36	968
	Dual-Product	3.44	0.64	2.04	5.76	392
AvgRev for *NatGas*, Industrial	Single-Product	2.95	1.31	1.31	6.84	968
	Dual-Product	2.70	0.62	0.89	4.66	392

TABLE IX
MARKET STRUCTURE AND CONSUMER CLASS - LINEAR SPECIFICATION

	Dependent Variable					
	$P_{it}^{e,res}$	$P_{it}^{e,com}$	$P_{it}^{e,ind}$	$P_{it}^{ng,res}$	$P_{it}^{ng,com}$	$P_{it}^{ng,ind}$
β_{dual}	0.28***	0.15	0.06	−0.01	−0.03	−0.17***
	(0.01)	(0.09)	(0.08)	(0.04)	(0.04)	(0.05)
N	717	717	717	1360	1360	1360

Random Effects Model assumed.
***significant at the .01 level,
**significant at the .05 level,
*significant at the .10 level.
Heteroskedastic-consistent errors in parentheses.
Controls not shown.

TABLE X
MARKET STRUCTURE AND CONSUMER CLASS--LOG-LINEAR SPECIFICATION

	Dependent Variable					
	$\log P_{it}^{e,res}$	$\log P_{it}^{e,com}$	$\log P_{it}^{e,ind}$	$\log P_{it}^{ng,res}$	$\log P_{it}^{ng,com}$	$\log P_{it}^{ng,ind}$
β_{dual}	0.06***	0.02	0.02	0.01	−0.02*	−0.05***
	(0.02)	(0.02)	(0.02)	(0.01)	(0.01)	(0.02)
N	717	717	717	1360	1360	1360

Random Effects Model assumed.
***significant at the .01 level,
**significant at the .05 level,
*significant at the .10 level.
Heteroskedastic-consistent errors in parentheses.
Controls not shown.

The greatest burden is placed on residential electricity consumers, which is consistent with the elasticity effect and the existence of economies of scope within a political economy context. Residential electricity consumers pay 4.6 percent more in a dual-product setting in the linear specification, while the log-linear specification implies residential consumers pay 5.5 percent more. Commercial consumers pay 2.0 percent more in the log-linear specification (2.7 in the linear specification); however these are not significant at standard levels (the p-values are .27 and .13, respectively). Industrial consumers pay 1.5 percent more in the log-linear specification (1.5 in the linear specification). In addition, the statistical significance underlines these relationships. For the log-linear specification, the coefficient in the residential equation is statistical at the .001 level, for the commercial equations it is significant at the .27 level, while the p-value for the industrial consumers is .41.

The results for natural gas consumers suggest that large consumers have greater economies of scope in lobbying effort. The bulk of the inter-fuel subsidization goes to industrial natural gas consumers. Focusing on the log-linear specification, the results imply that residential consumers in a dual-product setting pay .8 percent more than their single-product counterparts;

TABLE XI
MARKET STRUCTURE AND CONSUMER CLASS--LOG-LINEAR SPECIFICATION CONTROLLING FOR ECONOMIES OF SCALE

	Dependent Variable		
	$\log P_{it}^{ng,res}$	$\log P_{it}^{ng,com}$	$\log P_{it}^{ng,ind}$
β_{dual}	0.01	−0.004	−0.05***
	(0.01)	(0.01)	(0.02)
N	1360	1360	1360

Random Effects Model assumed.
***significant at the .01 level,
**significant at the .05 level,
*significant at the .10 level.
Heteroskedastic-consistent errors in parentheses.
Controls not shown.

however this is not statistically significant. In contrast, industrial consumers pay 4.9 percent less in a dual-product setting. The impact on commercial consumers is −1.8 percent, between that of the residential and industrial consumers. The statistical significance is also consistent with the point estimates, as the industrial consumer coefficient is significant at the .001 level, the coefficient associated with commercial consumers is significant at the .10 level, while the residential consumers coefficient is not significant at conventional levels.

Finally, one possible explanation for the lower natural gas prices in a dual-product setting is that economies of scale exist and dual-product natural gas firms are larger, on average. The summary statistics on natural gas output, as well as the larger number of natural gas firms compared to electricity firms, suggests that dual-product natural gas firms are, on average, larger than single-product firms. As a robustness test, I included the level of output on the right hand side of the natural gas equations.[28] Table XI lists the results for the dual-product indicator variable. Including the level of output in the specification does not alter the conclusions from above.

VIII. CONCLUSIONS

I analyze the relative equilibrium prices of single- and dual-product electricity and natural gas firms. The results are consistent with the political

[28] Because the level of ouput might be endogenous, I instrument for output with the number of residential, commercial and industrial consumers in the combined specification, and the number of respective consumers in the consumer-class specifications.

It may also be the case that the number of industrial consumers, and to a lesser extent commercial consumers, is exogenous since large consumers are able to by-pass the local utility. I also instrumented using only the number of residential consumers and the results did not qualitatively change. Residential consumers are not able to by-pass the local utility and would be exogenous to price.

economy literature that suggests regulated prices will depend on the level of lobbying activity of interest groups, which in turn depends on the welfare gains from lobbying. Specifically, in a dual-product setting, the price markups of residential and commercial electricity consumers are used to subsidize the purchases of industrial natural gas consumers. This is in addition to the intra-firm cross-subsidization that is also present in both market structures.

The results have a number of policy implications. The most obvious is that regulators are likely to respond to interest group activity. Increases in the lobbying activity of one group will alter the regulators' relative weights assigned to different consumer classes. This suggests that an increase residential advocacy group participation will lead to lower residential rates and a lower amount of cross-fuel subsidization.

It is important to note that the policy implications in a restructured electricity market may be different. If market power exists in a restructured electricity market, it may be exacerbated by integration for two reasons. First, because of the substitution effect, in a restructured electricity market dual-product firms will have a heightened incentive, and ability, to bid higher in electricity generation auctions, because of the impact higher electricity prices have on the demand for natural gas. Secondly, in a restructured electricity market the dual-product firm will potentially be selling natural gas to entrants with power plants in their jurisdiction. Therefore, the incentives to 'raise your rivals' costs' will exist for both single and dual-product natural gas firms and may therefore reduce the ability of single-product electricity firms to bypass the local distribution company.

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