THE IMPACT OF UTILITY DEREGULATION IN ARIZONA

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This analysis assesses Arizona's short-run price response to utility energy deregulation in the commercial and industrial sectors and the long-term response to deregulated industrial utility prices. Using a standard utility industry approach, ordinary least squares regression confirms commercial/industrial utility prices remain inelastic and Arizona's deregulation efforts have not effectively promoted short-run price competition. Moreover, widening differences in utility rates could be a response to a stronger long-run price elastic effect across states. The findings suggest states not aggressively deregulating utility price to narrow artificial comparative price advantages could be at a competitive disadvantage for interstate manufacturing investment. (*JEL* Q41, Q48, Q40)

I. INTRODUCTION

Whereas the Federal Energy Regulatory Commission began handing down rulings that relaxed *interstate* price controls in the early 1980s, it was not until the mid-1990s when various state regulatory commissions began actively pursuing *intrastate* utility price deregulation that was intended to increase price competition for natural gas and electricity.

This article explores the short-run impact that deregulation has had to date on commercial and industrial natural gas and electricity prices in Arizona as well as the long-run industrial response on the whole. While utility rate structures in the retail market were deregulated within Arizona in 2000, utility prices remain higher than those nationally and the evidence suggests that these deregulation policies have been largely ineffective to date in promoting price competition.

Nationally, although price restructuring and deregulation on the state level in the natural gas and electricity industry have generally been seen in the both retail and wholesale markets, there has only been partial deregulation in Arizona. In 1998, HB2663 was enacted allowing the Arizona Corporation Commission (ACC) to open service territories to competition. In 1999, the ACC approved R14-2-2 deregulating retail markets, which allowed residents and businesses to shop for their utility provider. However, electricity competitive conditions, as set forth in the Retail Competition Rules, have not occurred as anticipated and competition has not materialized for Arizona's small customers. For the most part, this is attributed to continued wholesale regulation as well as legislation that imposed a nonbypassable system benefits charge on direct access customers.[1] Since 2000, Arizona has continued to work toward a competitive retail electricity market; however, it is contingent upon competitive wholesale market conditions. In 2004, the ACC Administrative Law Division issued a ruling stating that the "... wholesale market does not appear workably competitive ..." and therefore may not create an ideal environment for overall competitive change (Arizona Corporation Commission, Docket No. CV1997-03748). As such, the traditional utilities are still basically the only provider of service within their franchised areas in the state and there appears to be little if any price competition. Meanwhile, in the natural gas market, the ACC only enacted open-access

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1. U.S. Department of Health and Human Services (2004).

ABBREVIATIONS

ACC: Arizona Corporation Commission
BEA: Bureau of Economic Analysis
BTU: British Thermal Unit
EIA: Energy Information Administration
GSP: Gross State Product
NOAA: National Oceanic and Atmospheric Administration

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provisions for large volume commercial and industrial customers. Thus, small business customers are unable to take advantage of unbundled services, and there are no provisions for residential customer choice. Moreover, even the eligible large industrial customers seemingly prefer the existing favorable interruptible status as opposed to transportation bypass.

This all has consequences. Intuitively, the regional cost of energy has always been an important industrial location factor (Blair and Premus, 1987). As such, given the obvious significance of differing utility energy costs, deregulation presents a new wrinkle that could potentially affect interstate competition for industry.[2] States that have not fully promoted the deregulation of utility rates may be at a competitive disadvantage that could negatively affect economic development. It is therefore appropriate to ask how much more competitive (i.e., elastic) commercial and industrial utility energy prices are apt to be in a deregulated environment. The existing (and somewhat dated) body of energy elasticity evidence neither tests this proposition directly nor even makes it explicit. Moreover, in the past, the focus is generally directed toward total energy demand. In instances where analysis is conducted by energy type, far greater attention is often given to the residential sector and less consideration is given toward the commercial or industrial sectors. In addition, more recent literature devotes little attention to price elasticity after deregulation. Given the intuitive importance of energy cost as an economic development location factor, it is surprising that there has been little discussion as to how commercial/industrial utility rates are affected by deregulation policies in practice.

The general hypothesis tested herein is that Arizona's deregulation has not effectively promoted short-run price competition for natural gas and electricity, and given that energy cost is a component of location decisions, the long-run impact of deregulation in the industrial sector could have negative economic development consequences for the state.

The next section explains the formation and specification of the short-run commercial and industrial demand models for Arizona, including a discussion of the elasticity results and a comparison of the results with those of similar studies. This is followed, in Section III, by national and state long-run industrial demand elasticity estimates.

II. SHORT-RUN COMMERCIAL AND INDUSTRIAL DEMAND IN ARIZONA

A. Introduction

Although numerous regional factors interact with commercial and industrial energy consumption, one cannot overlook the obvious role of the regulated prices for natural gas and electricity. Historically, more than 70% of net energy requirements for these two sectors in Arizona were from both of these fuel sources. By accounting for the implementation of deregulation, it is possible to estimate the impact (if any) deregulation has on the price elasticity of demand.

To examine the price sensitivity of utility energy, it is necessary to isolate major demand characteristics. In addition to rate structure, conventional usage analysis in the utility industry has long established that natural gas and electricity load requirements are a derived demand generally depending on weather (Macfie et al., 1995), end-use determinants (Gellings et al., 1992), and economic activity (Bradley, 1978; Donnelly, 1987; Nguyen, 1994). The Energy Information Administration (EIA) publishes annual state energy consumption and price data by sector since 1960. The five sectors are disaggregated as residential, transportation, commercial, industrial, and electric power. Each sector is further disaggregated by major fuel type (i.e., coal, natural gas, petroleum, electricity, wood, solar, and other renewable).[3]

The standard utility industry methodology to estimate regional natural gas and electricity consumption, as set forth by the American Gas Association (Macfie et al., 1995), Electric Power Research Institute (Gellings et al., 1992), and others (such as Beierlein, Dunn, and McConnon, 1981; Bunn and Farmer, 1985; Donnelly, 1987; Olsen, 1988; Rose,

2. As an example, according to the U.S. Department of Energy, it is estimated that natural gas and electricity expenditures account for about one-fourth of all manufacturing operating expenses. See Energy Information Administration (EIA)—2005 Annual Energy Review.

3. Petroleum includes gasoline, diesel, aviation fuel, distillate fuel liquid petroleum gas, residential petroleum, and kerosene. Electricity includes nuclear, biomass, wind, hydropower, geothermal, and photovoltaic.

1987), is a single linear equation comprising demand determinants that account for utility price, economic conditions, market size, building characteristics, and environmental factors. Many regulatory commissions prefer this approach to complex econometric models of demand and supply for a number of reasons.

First, given that customer usage in most temperature sensitive applications are predominately linear throughout the duration of the load curve (i.e., the shape of the so-called inverted hockey stick), utility regulators often prefer such linear or log-linear models as they are easier to understand and replicate. Second, the consumption and price data published by the EIA already reflect market equilibrium. Thus, to estimate short-run elasticity using simultaneous demand and supply equations would be inconsistent. Last, in practice, distribution companies (i.e., public utilities) as a rule generally consider the supply curve (for natural gas and electricity) to be (theoretically) fixed as a horizontal price ceiling in any given year as rates are set and all utility tariffs are mandated to provide adequate (uninterrupted and safe) service (Crew and Kleindorfer, 1979; Crew and Kleindorfer, 1986; Viscusi, Vernon, and Harrington, 1995). Moreover, even in the event of a producer or pipeline transmission price increase, it ultimately results in a distribution company pass through to the consumers as a fuel adjustment clause.[4]

To observe the impact of deregulation in Arizona, four short-run ordinary least squares equations are estimated to quantify the demand elasticities. Since energy is typically measured in dissimilar physical units (e.g., natural gas in cubic feet, electricity in kilowatts, and petroleum in barrels), all sources are converted to a common measure of energy output (i.e., trillions of British thermal units [BTUs]) to control for different heat content of various fuels. Using a modified approach similar to Beierlein, Dunn, and McConnon (1981), two equations each are estimated for natural gas and electricity in the commercial sector and industrial sector using 1960–2004 data.[5] The derived demand determinants of consumption are outlined in Appendix A. Given that the analysis is concerned with the elasticities for price and determinants of demand other than sheer economic growth, the size of the two sectors are controlled for by converting consumption to a per-unit (i.e., per firm) basis.

B. Short-Run Commercial Model and Results

To control for the overall size in this sector, the dependent variable is measured as BTU usage per retail establishment. Commercial natural gas (or electricity) demand is assumed inversely related to the real price of natural gas (or electricity), negatively related to firm size, and positively related to seasonal weather, real retail output, and real alternative fuel price.

Seasonal weather data (i.e., heating and cooling degree-days) are available from National Oceanic and Atmospheric Administration (NOAA).[6] Natural gas demand is expected to respond positively to heating degree-days, and electricity demand can respond positively to both heating and cooling degree-days.[7]

To account for real economic output in the commercial sector, retail gross state product (GSP) data from Bureau of Economic Analysis (BEA) is used as a proxy. As a component of GSP, these data are now available from BEA and a time series of real retail GSP

4. Historically, natural gas and electricity prices have not been determined by competing interests of consumers and suppliers in open markets. Rather, state regulators have traditionally set utility rates by reviewing the average cost of service incurred by the utilities under their jurisdiction, using normative equity and economic efficiency criteria, to determine how costs should be allocated among the various classes of customers. Moreover, some utility economists describe this as a vertical supply curve at the fixed regulated price ceiling. Thus, price and quantity supplied remain the same even as demand increases. See Viscusi, Vernon, and Harrington (1995). Further descriptions of horizontal supply are also discussed in Crew and Kleindorfer (1979, 1986).

5. The residential sector, transportation sector, and electric power sector are excluded from this analysis. The residential sector is excluded as the natural gas market remains highly regulated in Arizona. Transportation is excluded as its dominant fuel source (i.e., gasoline) is already market driven. Electric power is excluded because it is predominately comprising consumers in the residential as well as the commercial sector. In addition, this sector's role as a dual producer and consumer of energy makes the disaggregation of consumption difficult at best.

6. Heating and cooling degree-days are measured as an annual weighted average for Phoenix (70%), Tucson (25%), Flagstaff (2.5%), and Yuma (2.5%).

7. Using average annual temperature alone in electricity demand is complicated by the fact that consumption often exhibits a twin winter/summer peak, depending on the predominance of electric heating.

(output) can be constructed to 1958.[8] All dollars are adjusted to the 2004 gross domestic product implicit price deflator.

The number of retail establishments and employees are available from Bureau of Census (County Business Patterns). Among other things, these data are used to capture the impact of individual firm size. In the utility industry, it is a generally accepted principal that larger (commercial) firms tend to use less energy per square foot, as they are more likely to take advantage of energy-saving technology. While the EIA does not report square footage data consistent with consumption and prices by sector, employees per firm provides a reasonable proxy of firm size.

To account for a structural shift in energy usage patterns that occur in the early 1980s, as identified by Rose (1987), Broehl and Faruqui (1987), and Hawdon (1992), a shift dummy variable is included in the model. This variable should be negatively related to consumption and for the most part accounts for conservation not related to changes in current price.

Finally, a (utility price) slope dummy variable is included to account for any impact of deregulation might have on utility prices. This variable is central in substantiating the original hypothesis that retail deregulation in Arizona has largely been ineffective in promoting price competition in natural gas and electricity. As such, it is a variable of significant interest in the model and should be negative in the event that deregulation policies are effective. The 5-yr period used here should be a sufficient amount of time to capture the impact of deregulation as open-access policy effects have been observed in other states, such as Texas, Illinois, New York, New Jersey, and Maryland, during this same period (U.S. Department of Energy, Energy Information Administration, 2006).

Consistent with traditional industry standards found in Beierlein, Dunn, and McConnon (1981) and others (such as Bunn and Farmer, 1985; Donnelly, 1987; Gellings et al., 1992; Macfie et al., 1995; Olsen, 1988; Rose, 1987), the equation is written as a linear function but estimated using a double log format to reflect demand elasticites. The general commercial demand specification is shown in Equation (1). The results for natural gas appear in Table 1A and 1B, and the results for electricity appear in Table 2A and 2B. In each case, the transition from table A to B separately tests the deregulation slope dummy (λ_7) for own price and alternative fuel price.[9]

$$\begin{aligned}(1)\quad & \ln \mathrm{COMMERCIALUSAGE}_t \\ &= \lambda_0 + \lambda_1 \ln \mathrm{HDD}_t + \lambda_2 \ln \mathrm{CDD}_t \\ &\quad + \lambda_3 \ln \mathrm{Output}_t + \lambda_4 \ln \mathrm{FirmSize}_t \\ &\quad + \lambda_5 \mathrm{StructureDummy}_t \\ &\quad + \lambda_6 \ln \mathrm{OwnPrice}_t + \lambda_7 \mathrm{PriceDummy}_t \\ &\quad + \lambda_8 \ln \mathrm{AltPrice}_t\end{aligned}$$

As expected, the short-run own-price elasticity coefficient (from Table 1A and 1B) for natural gas is negative ($\lambda_6 = -0.43$) and statistically significant at the 5% level. This is consistent with earlier estimates of [−0.38] by Taylor (1975), [−0.37] by Bohi and Zimmerman (1984), and [−0.16 to −0.37] by Dahl (1993). While the cross-price coefficient ($\lambda_8 = 0.42$) for the natural gas consumption response to electricity price had the correct sign (for a substitute good), it was statistically insignificant and suggests that commercial firms do little if any short-run natural gas to electricity fuel switching. This is consistent with that found by Beierlein, Dunn, and McConnon (1981), Dahl (1993), and Wade (1998).

The short-run own-price elasticity coefficient for electricity (from Table 2A and 2B) was also less than proportional ($\lambda_6 = -0.34$) and statistically significant at the 5% level. Although earlier estimates widely fluctuate, this is more or less consistent with that of [−0.24 to −0.55] by Taylor (1975), and to an extent [−0.17 to −1.18] by Bohi (1981) and [−0.82] by Dahl (1993). The statistical insignificance of the cross-price coefficient ($\lambda_8 = 0.14$ in Table 2A and 2B) for the electricity consumption response to natural gas price is

8. To measure output, economic development analysts sometimes use retail sales from the Survey of Buying Power or Census of Retail Trade for the commercial sector and value added for the manufacturing sector. However, retail sales are not available for all years in the study period. Moreover, for the "consistent" data that is available, the simple correlation coefficient is about $r = .98$ with retail GSP. Manufacturing GSP is used for the industrial sector to be consistent with that done in the commercial sector and also has a very high correlation with value added.

9. While is would be desirable to test both dummy coefficients simultaneously, the obvious presence of multicollinearity makes this impractical. In addition, although the Durbin-Watson autocorrelation test for the commercial sector in both Tables 1 and 2 proved inconclusive, a first differences procedure did not significantly alter the coefficients.

TABLE 1
Commercial Sector for Natural Gas

(A)

Regression statistics		
R^2		95.3%
Adjusted R^2		86.2%
Durbin-Watson		1.68
F statistic		63.2
Observations		45
	Coefficients	***p* Value**
λ_0 intercept	−3.585	.146
λ_1 heating degree-days	.0664	.038
λ_2 cooling degree-days	.3048	.264
λ_3 retail GSP per firm	.6005	.000
λ_4 firm size	−.4887	.000
λ_5 structural shift	−.2069	.004
λ_6 natural gas price	−.4349	.019
λ_7 natural gas price dummy	.0088	.843
λ_8 electric price	.4221	.571

(B)

Regression statistics		
R^2		95.3%
Adjusted R^2		86.2%
Durbin-Watson		1.68
F statistic		63.1
Observations		45
	Coefficients	***p* Value**
λ_0 intercept	−3.604	.143
λ_1 heating degree-days	.0665	.038
λ_2 cooling degree-days	.3125	.248
λ_3 retail GSP per firm	.5994	.000
λ_4 firm size	−.4904	.000
λ_5 structural shift	−.2083	.003
λ_6 natural gas price	−.4303	.018
λ_7 electric price dummy	.0042	.884
λ_8 electric price	.4121	.575

TABLE 2
Commercial Sector for Electricity

(A)

Regression statistics		
R^2		98.6%
Adjusted R^2		86.2%
Durbin-Watson		1.64
F statistic		228.1
Observations		45
	Coefficients	***p* Value**
λ_0 intercept	−8.898	.001
λ_1 heating degree-days	−.0021	.966
λ_2 cooling degree-days	.1766	.068
λ_3 retail GSP per firm	.9614	.000
λ_4 firm size	−.1488	.010
λ_5 structural shift	−.0285	.056
λ_6 electric price	−.3416	.049
λ_7 electric price dummy	.0165	.526
λ_8 natural gas price	.1368	.242

(B)

Regression statistics		
R^2		98.7%
Adjusted R^2		86.2%
Durbin-Watson		1.65
F statistic		228.4
Observations		45
	Coefficients	***p* Value**
λ_0 intercept	−8.900	.001
λ_1 heating degree-days	−.0021	.966
λ_2 cooling degree-days	.1769	.063
λ_3 retail GSP per firm	.9605	.000
λ_4 firm size	−.1490	.009
λ_5 structural shift	−.0282	.057
λ_6 electric price	−.3410	.045
λ_7 natural gas price dummy	.0111	.514
λ_8 natural gas price	.1352	.240

consistent with that found in past studies such as Beierlein, Dunn, and McConnon (1981), Dahl (1993), and Wade (1998). Interestingly, while the adjustment for the cross-price elasticity of electricity to natural gas was not statistically significant, it was stronger than that of the natural gas response to the electricity cross-price elasticity. This can be explained by the presence of backup gas cooler condensing units found at large commercial establishments statewide. No cross-price estimate is calculated for petroleum as few utility analysts would agree that commercial firms have dual fuel capability and switch between natural gas/electricity and oil (Huntington and Soffer, 1982).

One possible explanation for the less than proportional own-price elasticities for natural gas and electricity (λ_6) is that commercial establishments in Arizona have few alternatives for other fuel sources (evidenced by the insignificant cross-price elasticities). Another possibility is that firms may have some ability to pass along increasing energy costs to consumers. Although energy consumption is measured here as a derived demand, the inelastic own-price coefficient could suggest that commercial establishments are relatively unresponsive to increases in utility energy rates because they have the ability to pass some costs along. If this is so, by conjecture the interaction between real retail GSP and consumption should also be less than proportional as there should be some downward influence on retail sales (as a result of higher energy prices). This partially appears to be the case as the quantity of utility energy demanded to retail output is no better than unity (λ_3 is about 0.60 for natural gas and 0.96 for electricity, respectively) and statistically significant at 1% level. This energy-to-output ratio suggests that an increase in economic growth can be accommodated by a less than proportional response for natural gas and a unitary response for electricity. Other factors, of course, impact these coefficients including interactions with other economic variables. As an example, the attraction of agglomerated markets may appeal to consumers and could result in transportation energy economies as store-to-store driving is curtailed. However, a factor that might discount this somewhat could be the number of tenants who have little control over their energy use and the wide-scale development of climate-controlled shopping malls that consume relatively large quantities of energy relative to output.

Also as anticipated, to an extent natural gas and electricity consumption in the commercial sector was sensitive to weather, evidenced by the statistical significance of natural gas consumption to heating degree-days and electricity consumption to cooling degree-days. However, given that heating degree-days are not statistically significant for electricity suggests that the commercial sector does not rely on electric heating. With regard to the relative size of firms (as expected), consumption responds to establishment size as the coefficients had the correct signs (λ_4 is -0.49 for natural gas and -0.15 for electricity) and are statistically significant.

Finally, for the policy variables of central importance to the hypothesis of this article, the deregulation price slope dummy coefficient (λ_7) for both commercial natural gas and electricity had the incorrect sign and were not statistically significant (ρ value$_{\text{natural gas}} = .84$ and ρ value$_{\text{electricity}} = .53$, respectively). This strongly suggests that deregulation efforts starting in 2000 have no appreciable short-run impact on own-price elasticity. Thus, the statistical evidence reveals that retail deregulation in Arizona has largely been ineffective so far in promoting increased price competition among commercial utility prices.

C. Short-Run Industrial Model and Results

Since the size and composition of the industrial sector has changed over the 45-yr sample period, this sector is standardized similar to the commercial sector by measuring per firm usage. Industrial utility energy demand per firm is traditionally assumed to be inverse with industrial utility price, positively related to real output (i.e., manufacturing GSP), positively related to alternative fuel prices, and positively or negatively related to real wages per production worker (available from Bureau of Census). Other usage characteristics captured are seasonal weather, the structural shift occurring in the early 1980s, and deregulation policy.

The real wage relationship requires further explanation. Assuming technological progress leads to a more efficient use of energy, this leads to higher labor productivity and higher real wages. This effect will have a negative correlation between real wages and energy intensity. Thus, if labor and energy are complement goods, the negative trend will be reinforced by the complementary effect. If, in contrast, labor and energy are substitutes, real wages will be positively correlated with energy use per dollar of output, offsetting the negative effect (Denny, Fuss, and Waverman, 1981; Jorgensen, 1995). The net impact depends on which effect is stronger.[10]

The generally accepted industrial demand specification is shown in Equation (2). The natural gas results appear in Table 3A and 3B, and the results for electricity are in Table 4A and 4B.

$$
\begin{aligned}
(2)\quad \ln \text{INDUSTRIALUSAGE}_t &= \psi_0 + \psi_1 \ln \text{HDD}_t + \psi_2 \ln \text{CDD}_t \\
&\quad + \psi_3 \ln \text{Output}_t + \psi_4 \ln \text{Wages}_t \\
&\quad + \psi_5 \text{StructureDummy}_t \\
&\quad + \psi_6 \ln \text{OwnPrice}_t + \psi_7 \text{PriceDummy}_t \\
&\quad + \psi_8 \ln \text{AltPrice}_t + \psi_9 \ln \text{OilPrice}_t
\end{aligned}
$$

10. In a published collection of works by Dale Jorgensen, the author cites a 1979 study that found employment could be a substitute for energy when all sectors of the economy are aggregated. In particular, the labor for energy substitution effect appears to cushion the effects of rising energy prices in the long run. See Jorgensen (1995).

TABLE 3
Industrial Sector for Natural Gas

(A)

Regression statistics		
R^2		97.2%
Adjusted R^2		96.1%
Durbin-Watson		2.03
F statistic		91.1
Observations		45

	Coefficients	***p* Value**
ψ_0 intercept	−8.860	.504
ψ_1 heating degree-days	.3668	.072
ψ_2 cooling degree-days	1.1227	.069
ψ_3 manufacturing GSP	.3991	.049
Ψ_4 wages	−.0017	.042
ψ_5 structural shift	−1.1431	.000
ψ_6 natural gas price	−.7207	.000
ψ_7 natural gas price dummy	−.0150	.734
ψ_8 electric price	−.0438	.939
ψ_9 oil price	.2390	.062

(B)

Regression statistics		
R^2		97.2%
Adjusted R^2		96.1%
Durbin-Watson		2.03
F statistic		91.1
Observations		45

	Coefficients	***p* Value**
Ψ_0 intercept	−8.832	.506
Ψ_1 heating degree-days	.3669	.073
Ψ_2 cooling degree-days	1.1217	.070
ψ_3 manufacturing GSP	.4044	.044
Ψ_4 wages	−.0017	.034
Ψ_5 structural shift	−1.1405	.000
Ψ_6 natural gas price	−.7265	.000
ψ_7 electric price dummy	−.0326	.747
Ψ_8 electric price	−.0259	.964
Ψ_9 oil price	.2395	.063

TABLE 4
Industrial Sector for Electricity

(A)

Regression statistics		
R^2		87.9%
Adjusted R^2		81.1%
Durbin-Watson		1.96
F statistic		13.7
Observations		45

	Coefficients	***p* Value**
ψ_0 intercept	−3.646	.518
ψ_1 heating degree-days	.0757	.374
ψ_2 cooling degree-days	.1014	.092
ψ_3 manufacturing GSP	.2302	.025
ψ_4 wages	−.0003	.069
ψ_5 structural shift	−.1697	.002
ψ_6 electric price	−.6017	.005
ψ_7 electric price dummy	−.0293	.612
ψ_8 natural gas price	.2512	.073
ψ_9 oil price	.2386	.441

(B)

Regression statistics		
R^2		87.9%
Adjusted R^2		81.2%
Durbin-Watson		1.96
F statistic		13.7
Observations		45

	Coefficients	***p* Value**
ψ_0 intercept	−3.580	.525
ψ_1 heating degree-days	.0778	.362
ψ_2 cooling degree-days	.0928	.067
ψ_3 manufacturing GSP	.2242	.035
ψ_4 wages	−.0002	.087
ψ_5 structural shift	−.1707	.002
ψ_6 electric price	−.6550	.002
ψ_7 natural gas price dummy	−.0124	.637
ψ_8 natural gas price	.2479	.073
ψ_9 oil price	.2349	.444

The estimate of industrial natural gas own-price elasticity suggests that the Arizona short-run demand is inelastic (ψ_6 ranges between −0.72 and −0.73) and statistically significant at the 1% level. This is comparable to other short-run estimates of [−0.68 to −1.09] by Halvorsen (1977), [−0.71] by Denny, Fuss, and Waverman (1981), and [−0.58] by Faruqui (1986). Consistent with Beierlein, Dunn, and McConnon (1981), while the cross-price coefficient for the natural gas response to electricity price was not significant (and negative), this was not totally unexpected as electricity is not generally considered an alternative fuel for natural gas in industrial processing.

Also as anticipated, the short-run own-price elasticity coefficient for industrial electricity demand shown in Table 4A and 4B is inelastic (ψ_6 ranges between −0.60 and −0.65) and statistically significant at the 1% level. Both the natural gas and the electricity elasticities for the industrial sector are more elastic than those estimated for the commercial sector. This higher price responsiveness can probably be attributed to the fact that industrial energy prices in this period (1960–2004) have exhibited less relative increase and variation as manufacturers often possess the technology to switch fuels as prices change and thus have the ability to lower their utility energy bills by taking advantage of interruptible service. This may additionally reflect some changes in Arizona's industrial mix during the 1960–2004 study period, which may have altered the demand for energy in relation to the composition of manufactured goods (Macfie, 2006).[11]

The statistically significant cross-price elasticity of the electricity response to the natural gas price ($\psi_8 = 0.25$) suggests that electricity to natural gas fuel switching is apparent. Given that cooling degree-days are also statistically significant for electricity consumption, the cross-price elasticity likely reflects the use of natural gas air-conditioning condensing units. Moreover, the cross-price elasticity of petroleum is shown to be statistically significant for natural gas (but not electricity) at the 10% level. This likely reflects industrial firms with interruptible dual fuel capability.

The coefficient for real wages per production worker is negative (ψ_4 is -0.0017 for natural gas and about -0.0003 for electric) and statistically significant. Although the coefficients indicate that wages have a small impact on energy consumption, these finding differ from that of Jorgensen (1995) where real wages and energy intensity are substitute inputs of production. Jorgensen's conclusion, however, was based on an analysis for total energy requirements as he aggregated all sectors of the economy and thus eliminated competition between fuels.

Finally, similar to that concluded for the commercial sector, the most illuminating policy aspect of these results reveal that the statistical insignificance of deregulation price slope dummy variable (ψ_7) for both industrial commercial natural gas price (ρ value$_{\text{natural gas}}$ = .73) and electricity price (ρ value$_{\text{electricity}}$ = .61) strongly suggests that deregulation efforts starting in 2000 have yet to have any appreciable impact on the responsiveness to industrial prices. Thus, the retail market deregulation enacted in Arizona appears to have no appreciable effect to date on own-price elasticity or promoting price competition within industrial natural gas and electricity.

11. For a further discussion of Arizona manufacturing employment (and service), see Macfie (2006).

III. LONG-RUN INDUSTRIAL PRICE ELASTICITY

A. Introduction

Conventional economic logic suggests that industrial establishments tend to react more strongly to broader regional location incentives than commercial establishments. Commercial firms are more highly correlated to local economic development variables, such as population or income, and less likely to respond to regional factors between states, such as wages, cost of substitute and complementary input resources, or productivity (Blair and Premus, 1993; Justman, 1994). As a location incentive, while energy prices play a central role in site location decisions for both the commercial and the industrial sectors, common (economic) sense suggests that energy cost plays a greater role in long-run regional industrial development (Galambos and Schreiber, 1978; Martinek and Orlando, 2002). In addition, the industrial sector tends to *be more* energy intensive and considerably more price elastic than the commercial sector in the short run (i.e., λ_6 vs. ψ_6). Given the obvious importance of the manufacturing jobs to the overall health of the state economy, it is useful to assess the long-run energy demand behavior of this sector over time.

From an economic development perspective, energy prices have historically been lower relative to those of other inputs of production and consequently played a central part in the development of the United States. When energy was abundant and cheap, many major industrial complexes developed that were far removed from energy sources. Some industry was attracted to sources of cheap energy, but by and large manufacturers located in response to other market factors. Recently, however, the level of utility prices now differ more substantially from state to state and these differing levels can have an effect on future industrial development. As discussed in Bernstein et al. (2003) and Bernstein and Griffin (2005), there exist a myriad of explanations for the variation in state energy prices including state taxes levied on intrastate energy sales, geography, sources of fuel, and the mix and cost of fuels. However, one cannot overlook the role of price competition resulting from utility deregulation.

B. Long-Run Industrial Model and Data

Using a modified model originally developed by Halvorsen (1978) and later employed by Donnelly (1987), long-run utility price elasticity is estimated with 2004 cross-sectional data for the lower coterminous 48 states. This approach allows for long-run adjustments to interstate differences in natural gas and electricity prices. One example of a long-run adjustment might be the relocation of a manufacturing firm to a state with comparative cost advantages. As utility prices rise (relative to other input costs), it becomes a more important location determinant (Blair and Premus, 1987). The model has been modified to account for seasonal weather, firm size, an industry mix proxy, and deregulation policy.

Applying the modified Halvorsen (1978) and Donnelly (1987) specification for industrial natural gas and electricity demand and output, the format are the double log functions in Equations (3) and (4). The empirical results for demand function, Equation (3), appear in Tables 5 and 6. The results for output function, Equation (4), appear in Table 7.

$$
\begin{aligned}
(3)\quad \ln \mathrm{INDENERGYUSAGE}_i &= A_0 + A_1 \ln \mathrm{Output}_i \\
&\quad + A_2 \ln \mathrm{MineralValue}_i + A_3 \ln \mathrm{Wages}_i \\
&\quad + A_4 \ln \mathrm{HDD}_i + A_5 \ln \mathrm{CDD}_i \\
&\quad + A_6 \ln \mathrm{FirmSize}_i + \ln A_7 \mathrm{IndustrialMix}_i \\
&\quad + A_8 \ln \mathrm{OwnPrice}_i + A_9 \ln \mathrm{AltPrice}_i \\
&\quad + A_{10} \ln \mathrm{OilPrice}_i + A_{11} \mathrm{Dereg}P_i
\end{aligned}
$$

$$
\begin{aligned}
(4)\quad \ln\ \mathrm{OUTPUT}_i &= B_0 + B_1 \ln\ \mathrm{EnergyPrice}_i \\
&\quad + B_2 \ln\ \mathrm{Wage}_i \\
&\quad + B_3 \ln\ \mathrm{CapitalAssets}_i \\
&\quad + B_4 \ln\ \mathrm{EnergyProductivity}_i \\
&\quad + B_5 \ln\ \mathrm{LaborProductivity}_i \\
&\quad + B_6 \ln\ \mathrm{Density}_i + B_7 \ln\ \mathrm{Income}_i
\end{aligned}
$$

Industrial utility energy consumption (Equation 3) is assumed to be a function of output, the cost of substitute and complementary resources (i.e., energy prices, wages, mineral production) and climate. The demand and output variables to capture these effects are outlined below and shown in Appendix B. An adjustment to consumption (using Equation 4) is necessary as energy demand is

TABLE 5
Long-Run Industrial Sector Natural Gas Consumption

(A)

Regression statistics		
R^2		77.8%
Adjusted R^2		71.0%
Durbin-Watson		2.04
F statistic		11.5
Observations		48

	Coefficients	***p* Value**
A_0 intercept	−11.255	.152
A_1 manufacturing GSP	.7607	.000
A_2 mineral value	.1239	.056
A_3 wages	1.8905	.200
A_4 heating degree-days	.5166	.124
A_5 cooling degree-days	.3142	.271
A_6 firm size	−.3584	.537
A_7 industrial mix	−.1579	.488
A_8 natural gas price	−1.9643	.056
A_9 electric price	1.2418	.133
A_{10} oil price	1.1922	.082
A_{11} natural gas price dummy	−.1485	.057

(B)

Regression statistics		
R^2		77.4%
Adjusted R^2		71.0%
Durbin-Watson		2.04
F statistic		11.5
Observations		48

	Coefficients	***p* Value**
A_0 intercept	−9.573	.234
A_1 manufacturing GSP	.7378	.000
A_2 mineral Value	.1330	.053
A_3 wages	1.6192	.270
A_4 heating degree-days	.5552	.106
A_5 cooling degree-days	.3732	.252
A_6 firm size	−.2644	.652
A_7 industrial mix	−.1466	.524
A_8 natural gas price	−2.0133	.064
A_9 electric price	1.2003	.052
A_{10} oil price	1.1017	.071
A_{11} electric price dummy	−.0451	.683

TABLE 6
Long-Run Industrial Sector Electricity Consumption

(A)

Regression statistics		
R^2		89.6%
Adjusted R^2		86.4%
Durbin-Watson		2.19
F statistic		28.1
Observations		48
	Coefficients	***p* Value**
A_0 intercept	−5.646	.163
A_1 manufacturing GSP	.6557	.000
A_2 mineral value	.0522	.017
A_3 wages	1.2929	.283
A_4 heating degree-days	.5927	.119
A_5 cooling degree-days	.3962	.081
A_6 firm size	−.2030	.491
A_7 industrial mix	−.2268	.455
A_8 electric price	−1.6778	.000
A_9 natural gas price	.8950	.065
A_{10} oil price	.3126	.531
A_{11} electric price dummy	−.0155	.030

(B)

Regression statistics		
R^2		89.6%
Adjusted R^2		86.4%
Durbin-Watson		2.16
F statistic		28.1
Observations		48
	Coefficients	***p* Value**
A_0 intercept	−5.530	.164
A_1 manufacturing GSP	.6526	.000
A_2 mineral value	.0534	.017
A_3 wages	1.2638	.293
A_4 heating degree-days	−.5918	.117
A_5 cooling degree-days	−.3999	.075
A_6 firm size	−.1949	.507
A_7 industrial mix	−.2256	.456
A_8 electric price	−1.6577	.000
A_9 natural gas price	.8858	.067
A_{10} oil price	.2941	.557
A_{11} natural gas price dummy	.0300	.712

dependent on output and energy price affects firm location decisions.[12]

12. Since the economy is dependent on energy and the consumption of energy in turn depends on the level of economic activity, this adjustment is necessary and is performed in the next section. For further discussion, see Halvorsen (1978).

TABLE 7
Long-Run Industrial Sector Manufacturing GSP

Regression statistics		
R^2		98.1%
Adjusted R^2		97.8%
Durbin-Watson		2.28
F statistic		294.9
Observations		48
	Coefficients	***p* Value**
Intercept	−2.342	.390
B_1 energy price	−.283	.052
B_2 wages	−1.239	.001
B_3 capital assets	1.073	.000
B_4 energy productivity	.167	.000
B_5 labor productivity	.602	.003
B_6 population density	−.080	.031
B_7 per capita income	.598	.027

For Equation (3), energy price (i.e., natural gas, electricity, and petroleum) and consumption data (i.e., natural gas and electricity) by state for 2004 are available from EIA. GSP for manufacturing and mining in 2004 are derived from BEA and wages per production worker are available from County Business Patterns. To measure output, some analysts prefer using value added for manufacturing from the Census (or survey) of Manufactures and value added of mineral production from the Census of Mining. However, the economic censuses are only published every 5 yr, and as suggested earlier, GSP provides a reasonable proxy of economic activity and would also be consistent with the short-run industrial estimates provided previously. Wages, as already discussed, can be negative or positive.

Seasonal weather data are expected to have a positive relationship on consumption and is available by state from NOAA. For each state, the data for the capitol and/or largest city was used. As before, natural gas demand is expected to respond positively to heating degree-days, and electricity demand can respond positively to both heating and cooling degree-days.

The number of firms and workers are available from County Business Patterns. These data are used to capture the impact of firm size and industry mix (ratio of durable-to-nondurable goods employment). As suggested earlier, firm size may have a negative effect on usage. As discussed in Fuss (1977) and Casler

(1992), it is also possible that the mix of industry could have a negative or positive effect on energy usage depending on the distribution of employment.[13]

Finally, a (utility price) slope dummy variable (A_{11}) is included to account for the impact of deregulation on utility energy prices for states with active programs (as reported by the U.S. Department of Energy–EIA, 2007a, 2007b).[14] A value of 1 is assigned to states that have active programs in place in 2004. If deregulation programs across states are effective, this important policy variable should be negative and statistically significant. This would suggest a more elastic own-price coefficient implying increased utility price competition.

For Equation (4), industrial output is negatively affected by utility prices and wages and positively related to market variables. It is expected that manufacturers will be more responsive to long-run increases in utility prices because, in addition to energy conservation, some firms will leave high-price energy states and relocate in states where utility costs are less. Therefore, state price elasticity must incorporate both the influence of price on energy use and the influence of energy price on the location of industrial output among states. Wages can be positive or negative depending on whether they are substitutes or complements in production (Jorgensen, 1995).

The other output market variables can have varying degrees of effect on production. Population density can be either negative or positive depending on any existing economies of scale.[15] In addition, it is expected that capital assets, energy productivity (output per BTU), labor productivity (GSP per worker), and per capita income (from BEA) should all have a positive relationship (Bernanke, 1983; Halvorsen, 1978; Thompson and Taylor, 1995). To approximate 2004 capital stock by state, it was necessary to estimate a reasonable proxy using the total depreciable assets from the 2002 Census of Manufactures adjusted for capital expenditures and retirements (from the Annual Survey of Manufactures) in 2003 and 2004.

C. Long-Run National Industrial Elasticity Results

The results of the industrial natural gas demand function in Table 5A and 5B show the national long-run own-price elasticity ($A_8 = -2.0$) is statistically significant at the 10% level and considerably more elastic than the short-run from the previous section (where λ_6 ranges from -0.72 to -0.73). The long-run coefficient is interpreted to suggest that a 10% increase in national energy prices induces a 20% decline in natural gas consumption.

One of the main policy variables central to the hypothesis of this article is the deregulation price slope dummy coefficient. For natural gas, the coefficient (A_{11}) is about -0.15 and is statistically significant. This suggests that states with active deregulation programs tend to have greater levels of price competition, holding all else constant.[16]

The results of the industrial electricity demand function are shown below in Table 6A and 6B. The estimated national long-run price elasticity ($A_8 = -1.7$) is statistically significant and considerably larger than the short-run industrial elasticity in the previous section (where λ_6 ranges between -0.60 and -0.65). This suggests that a 10% increase in national electricity prices induces an approximate 17% decline in electricity consumption.

Again, of particular policy interest is the electricity deregulation price slope dummy variable (A_{11}) that confirms the hypothesis that states with active deregulation programs tend to have greater levels of price competition as the coefficient ($A_{11} = -0.02$) is statistically significant.

Although the ability of firms to "wheel" electricity across the grid has always been an important factor in determining industrial price concessions, this suggests that deregulation now accentuates this as there exists a wider array of transmission options for

13. Energy intensity differs by industry. Unfortunately, the EIA does not collect consumption or price data by specific North American Industry Classification System industry. Using the ratio of durable-to-nondurable employment serves as a proxy.

14. To assess whether a state has an active natural gas or electricity deregulation program in 2004, each state public utility regulatory authority was contacted to determine the existence of such programs for at least 2 yr. See http://www.eia.doe.gov/oil_gas/natural_gas/restructure/restructure.html and http://www.eia.doe.gov/cneaf/electricity/page/fact_sheets/restructuring.html

15. Halvorsen, Econometric Models of Energy Demand (1978), 59.

16. Although the capacity of industrial firms to switch between fuels (particularly natural gas to oil) existed prior to deregulation, this became especially prevalent after deregulation as the ability to "transport" natural gas that bypasses the distribution system (or to credibly threaten such bypass) is heightened.

industrial customers to shop for electricity. Interestingly, while the negative impact of rising energy prices would normally suggest that price serves as an effective mechanism to reduce energy demand and encourage conservation, for both natural gas and electricity, this is only apparent in the long run as the relatively inelastic short-run demand suggests that price may not be an effective way to encourage conservation and the energy savings attributed to a rising price may fall short of energy conservation priorities.

Although the academic literature offers virtually no estimates of industrial own-price elasticity for natural gas, there exists some estimates for bundled industrial elasticity estimates. For example, Halvorsen (1978) estimates the long-run industrial price elasticity to be about unity and Nagle (1980) estimates 0.92. Both are lower than that estimated here presumably due to energy source being treated as a homogeneous product (i.e., no substitution between fuels).

With regard to the other determinants for utility energy demand, most performed as anticipated and were consistent with that found by Halvorsen (1978) and Donnelly (1987). The output variables (i.e., manufacturing GSP and mining GSP output) are positive and statistically significant. The manufacturing GSP coefficient in particular provides some insight with regard to conservation as observed from the energy output elasticity (A_1 ranges between 0.65 and 0.76). This suggests a 10 increase in output can be achieved with an increase in energy consumption of approximately 7% and implies that energy intensity is significantly less than unity.[17] Consistent with Halvorsen (1978), the energy-to-output ratio indicates that long-term economic growth is possible with a less than proportionate increase in energy demand.

The energy labor cost coefficient is positive (A_3 ranges between 1.6 and 1.9 for natural gas and about 1.3 for electricity), indicating that overtime labor may be a substitute for energy as reported by Jorgensen (1995). However, this coefficient, as well as firm size, industrial mix, and the climate variables (except for cooling degree-days and electricity consumption) were insignificant. This may reflect a lack of wage variation between the states and the comparative lack of importance of weather and industry structure relative to other location variables.

Last, similar to that observed in the short run, the cross-price elasticities produce mixed results. Although the natural gas response to the cross-price coefficient for electricity was not significant, the long run does show a stronger relationship (than that seen in the short-run). As with the short run, the long-run electricity response to the natural gas cross-price elasticity ($A_9 = 0.9$) is statistically significant at the 10% level and suggests electricity to natural gas fuel switching takes place. Moreover, the cross-price elasticity of petroleum (A_{10}) is shown to be close to unity for natural gas and statistically significant at the 10% level (but not significant for electricity). Similar to that seen earlier for the short run, this instinctively makes sense as it reflects industrial firms that have dual fuel capability.

D. Long-Run State Industrial Price Elasticity

As just shown in the prior analysis, while the national long-run price elasticity for natural gas is about -2.0 and for electricity is approximately -1.7, to estimate the long-run price elasticity for states, it is necessary to also account for both the influence of price on energy consumption and the influence of energy price on the location of industrial output among states.[18] As shown in Table 7, the results of the output function (i.e., Equation (4)) confirm that output is negatively related to the prices of resource inputs. Utility energy price in particular is observed as having a negative influence on the level of industrial output ($B_1 = -0.283$). This can be interpreted to mean a 10% increase in energy price lowers output almost 3%.

17. In other words, since the respective standard errors for natural gas and electricity are 0.098 and 0.058, the calculations are $t = (0.76 - 1)/0.098 = -2.45$ and $t = (0.65 - 1)/0.058 = -6.03$.

18. The level of output is dependent on the price of energy because this also affects location decisions. The change in energy price in a state will affect the demand for energy (A_8) and through its effect on the location decisions of firms (A_1B_1). The average long-run state price elasticity will therefore be equal to $A_8 + A_1B_1$. The location effect is composed of the effect of the energy price effect on output (B_1), representing the changes in output due to industrial relocation induced by energy price changes and the effect of output on energy demand (A_1). This suggests that the estimate is not an appropriate measure of the response of demand to a national price change because a change affecting all states equally would not induce the relocation effect.

In addition, the coefficient for labor costs ($B_2 = -1.2$) is also negative and is significant at the 10% level. The productivity variables (i.e., energy and labor) were positively associated with increased industrial output, but the coefficients were less than unity. Also as anticipated, the coefficient for the capital stock was positive ($B_3 = 1.07$), per capita income was positively related to output ($B_7 = .0.6$), and population density ($B_6 = -0.08$) was negative. All coefficients were statistically significant as expected.

By using the output coefficient (B_1 of Equation 4), the long-run, state-level, own-price elasticity can be estimated. Given that the national price elasticity is A_8 (or -2.0 for natural gas and -1.7 for electricity), the estimated long-run state industrial price elasticity for natural gas and electricity is about -2.21 and -1.89, respectively.[19] As expected, this exceeds the national price elasticity estimates (A_8) because it includes the effect of price on the level of industrial output. This result reveals that state industrial prices for natural gas and electricity are relatively more elastic in the long run once the differential effects of industrial development are incorporated.

IV. SUMMARY AND CONCLUSIONS

From time-series data for Arizona, it was shown that for each 10% price increase to the commercial sector in the short run, consumption was reduced by 4.3% for natural gas and 3.4% for electricity. Moreover, for each 10% increase in price to the industrial sector, short-run quantity demanded was reduced by 7.2%–7.3% for natural gas and 6.0%–6.5% for electricity. The statistical results also suggest that Arizona's more restrictive deregulation polices (λ_7) did little thus far to encourage utility price competition.

Cross-section energy data were analyzed to provide estimates of the long-run response to changes in industrial energy price. As anticipated, the long run exhibited a considerably stronger effect because sufficient time was allotted for technological and locational changes. The empirical evidence additionally suggests that utility deregulation (A_{11}) increases price competition for natural gas and electricity in the long run.

After correcting for differences in interstate development and allowing for possible relocation of industrial firms to lower energy cost states, the average long-run state industrial price elasticity was found to be -2.21 for natural gas and -1.89 for electricity. This suggests that if the price of energy continues to rise faster than the price of other inputs, energy could become a more important factor in the location of industrial facilities. Long-run estimates also have important policy implications as some advocates suggest forsaking economic growth to conserve scarce energy resources (Gibbons and Chandler, 1981; Monnier et al., 1986; U.S. Department of Energy, Energy Information Administration, 2006). However, the data suggests that such an approach would probably fail as it is unrealistic to expect a decline in manufacturing output to have a proportional response in conservation as the long-run energy output elasticity ($A_1 = 0.76$ for natural gas and 0.66 for electricity) is less than unity, and thus, it is possible for the industrial sector to accommodate economic growth (in the long run) with a less than proportionate increase in energy intensity.

The long-run price effect of utility deregulation (A_{11}) is -0.15 for natural gas and -0.02 for electricity, and both are statistically significant. This suggests that states fully embracing open access and unbundled services tend to be more price competitive. However, in the short run for Arizona, the deregulation coefficient for both natural gas and electricity (λ_7) is statistically insignificant. Given the evidence that in the long run, deregulation is an effective mechanism to increase utility energy price competition and that deregulation policies in Arizona are thus far seemingly ineffective in the short run, Arizona should work for more aggressive deregulation of utility energy prices so as to not fall further behind. States such as Arizona that already have utility prices exceeding the national average may be at a disadvantage as differences in local utility rates diverge further from the states that become more price competitive. This could have deleterious economic development effects on high-utility energy cost states like Arizona. Only by convergence of interstate energy prices will the artificial comparative advantage now afforded in other states be reduced.

19. In other words, from Footnote 18, $-2.21 = [-2.0 + (0.76 \times -.283)]$ and $-1.89 = [-1.7 + (0.66 \times -0.283)]$.

APPENDIX A

Commercial and Industrial Short-Run Variables of Energy Demand in Arizona

Dependent variables	
COMMERCIALUSAGE	Annual commercial natural gas (or electricity) consumption per establishment for Arizona in trillions of BTU 1960–2004. This is available from USDA
INDUSTRIALUSAGE	Annual industrial natural gas (or electricity) consumption per establishment for Arizona in trillions of BTU 1960–2004. This is available from USDA
Independent variables	
Heating degree-days	Annual weighted heating degree-days for Arizona 1960–2004. This is available from NOAA
Cooling degree-days	Annual weighted cooling degree-days for Arizona 1960–2004. This is available from NOAA
Retail GSP	Annual real retail GSP for Arizona 1960–2004. This is available from BEA
Manufacturing GSP	Annual real manufacturing GSP for Arizona 1960–2004. This is available from BEA
Firm size	Annual number of employees per retail (or manufacturing) establishment for Arizona 1960–2004. This is available from the Bureau of Census
Wages	Annual real wages per production worker for Arizona 1960–2004. This is available from Bureau of Census
Structure shift	Shift dummy variable where 1960–1983 = 0 and 1984–2004 = 1
Natural gas price	Annual real commercial (or industrial) natural gas price per BTU for Arizona 1960–2004. This is available from USDOE
Electric price	Annual real commercial (or industrial) electricity price per BTU for Arizona from 1960 to 2004. This is available from USDOE
Oil price	Annual real industrial petroleum price per BTU for Arizona from 1960 to 2004. This is available from USDOE
Natural gas price dummy	Deregulation price slope dummy where 1960–1999 = 0 and 2000–2004 = 1
Electric price dummy	Deregulation price slope dummy where 1960–1999 = 0 and 2000–2004 = 1

USDA = U.S. Department of Energy; USDOE = Annual Energy Review.

APPENDIX B

Industrial Long-Run Variables of Energy Demand and Output

Dependent variables	
INDENERGYUSAGE	2004 industrial electricity or natural gas consumption in state "i" (trillions BTUs)
Output	2004 manufacturing output GSP in state "i" (millions of dollars)
Independent variables	
Price	2004 industrial electricity or natural gas price in state "i"
AltPrice	2004 alternative energy prices in state "i"
Output	2004 manufacturing GSP output in state "i"
Mineral value	2004 mining GSP output in state "i." This is available from BEA
Wages	2004 average hourly wages of production workers in state "i"
Heating degree-days	2004 heating degree-days by state (major station) in state "i"
Cooling degree-days	2004 cooling degree-days by state (major station) in state "i"
Firm size	2004 manufacturing employees per establishment in state "i"
Industrial mix	2004 ratio of durable goods manufacturing employment to nondurable goods manufacturing employment in state "i"
Capital assets	2002 total depreciable assets plus 2003–2004 capital expenditures less 2003–2004 retirements (millions of dollars) in state "i." This is available from Bureau of Census
Energy productivity	2004 energy productivity (manufacturing GSP per BTU) in state "i"
Labor productivity	2004 labor productivity (manufacturing GSP per production hour) in state "i"
Density	2004 population density (persons per square mile) in state "i." This is available from Bureau of Census
Income	2004 per capita personal income (in thousands) in state "i." This is available from BEA

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