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The Pricing of Natural Gas in U.S. Markets

Recent patterns in natural gas prices have raised public concern about the pricing of natural gas in U.S. markets (Johnson 1992). In recent years, prices paid by industrial and electrical end users have fallen more than wellhead prices, while residential and commercial prices have fallen less than wellhead prices (Yücel 1991).[1]

The lack of uniform changes in natural gas prices may arise from differences in end users and the market institutions that serve them. Industrial and electrical users of natural gas can switch easily between oil products and natural gas, while residential and commercial users cannot. Industrial and electrical users generally bypass local distribution companies (LDCs), relying heavily on spot supplies in a competitive market served by brokers and pipeline companies. In contrast, residential and commercial users typically purchase their gas from LDCs, which earn a regulated rate of return and obtain their supplies under long-term contracts.

These observations about U.S. natural gas markets lead us to ask two questions. Do differing characteristics in end users and the market institutions serving them lead to differences in pricing behavior? Are changes in natural gas prices uneven in the long run, or is popular concern about natural gas prices unwarranted? To answer these questions, we examined econometrically how price shocks are transmitted across various markets for natural gas.

Natural Gas Markets and Prices

As natural gas journeys downstream from the wellhead, it travels through collection systems, pipelines, and local distribution systems before it reaches its consumers. Natural gas prices are observed in six separate markets. Prices in these markets include wellhead, city gate, and four end-use prices. End-use prices are identified by the characteristics of the final customer—that is, as residential, commercial, industrial, and electrical prices for natural gas.

Natural gas is first sold at the wellhead, where it is produced. Both pipeline companies and brokers use the collection and pipeline systems to transport gas from the field to their customers, with brokers using the pipelines as contract carriers. Pipeline companies and brokers sell their natural gas directly to some end users and to LDCs, which pay the city gate price. In turn, the LDCs distribute gas throughout localities and sell it to additional end users.

When comparing end-use markets for natural gas, several differences stand out. Industrial and electrical users of natural gas generally can switch easily between fuels to seek the lowest cost energy source. As a consequence, most of these end users rely heavily on spot supplies purchased directly from pipeline companies and brokers. For the most part, these suppliers seem to behave competitively in serving this market (Brown and Yücel 1993). In contrast, most residential and commercial consumers are tied to a single fuel. These end users purchase their natural gas from LDCs, which

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[1] *Electrical utilities use natural gas to generate electricity.*

earn a regulated rate of return and obtain much of their gas under long-term contract. (For a discussion of why electrical and industrial end users rely more heavily on spot markets for natural gas than commercial and residential customers, see the box titled “Development of a Spot Market for Natural Gas.”)

To some extent, differing reliance on spot and contract supplies may account for the long-term difference in the way price shocks are transmitted through the market for natural gas. When average wellhead prices change, spot prices generally change more than those specified in long-term contracts. Thus, when average wellhead prices fall, as has been the trend since 1985, spot prices generally fall more than those specified in long-term contracts.

The extent to which the supply in a market comprises spot gas determines how responsive its prices are to changes in the average wellhead price. With a greater than average reliance on spot supplies, electrical and industrial customers stand to see a change in their gas prices that is greater than the market average. With a less than average reliance on spot supplies, commercial and residential customers stand to see a change in their gas prices that is less than the market average.

Empirical Analysis of Natural Gas Pricing

The institutional arrangements in natural gas markets suggest that seven pairs of natural gas prices have an upstream–downstream relationship. These are the wellhead price with electrical, industrial, city gate, commercial, and residential prices, and the city gate price with commercial and residential prices. For each pair of upstream and downstream prices, we conceptualize the long-run relationship as a simple markup model of natural gas prices in which price shocks are transmitted:

$$PD_t = a + \beta PU_t, \quad (1)$$

where *PD* is a downstream price for natural gas, and *PU* is an upstream price for natural gas.

To examine how changes in price are transmitted across the markets for natural gas, we utilize time-series methods. In the absence of a specific theory to be tested, we use the statistical tests, together with identifying assumptions, to assess in which markets shocks to natural gas prices originate and how they are transmitted across natural gas markets.

Our econometric work involves a number of steps. We check whether the price series are stationary and find that all of them have stochastic trends (or are integrated). For each of the seven pairs of prices, we then test for cointegration and use a series of reduced-form vector-error-correction models to test for causality and adjustment to equilibrium error. We then identify the sources of long-run price shocks and calculate their persistence. Estimation and testing uses monthly data from January 1984 through March 1992.[2]

Integration. As an initial step in our econometric work, we check whether our price series are integrated or stationary. A time series that is integrated is said to have a stochastic trend (or unit root). Identifying a series as an integrated, nonstationary series means that any shock to the series will have permanent effects on it. Unlike a stationary series, which reverts to its mean after a shock, an integrated time series does not revert to its preshock level.

Applying conventional econometric techniques to an integrated time series can give rise to misleading results.[3] Therefore, we use both augmented Dickey–Fuller and Phillips–Perron tests to test for

[2] *During the estimation period, there were extensive changes in federal regulation of the natural gas pipeline industry. These changes raise concern about estimating stable relationships between the wellhead price and the electrical, industrial, and city gate prices. Because we do find cointegrating relationships in all cases, we treat the regulatory changes as primarily endogenous or irrelevant to the transmission of price shocks.*

Monthly data for average wellhead, city gate, electrical, industrial, commercial, and residential prices were obtained from the U.S. Department of Energy. The price series were deflated with a monthly GNP deflator series and then seasonally adjusted with the X–11 procedure in SAS.

The monthly GNP deflator was obtained by using the Chow–Linn procedure on quarterly data. The consumer price and producer price indexes were used as monthly reference series in the Chow–Linn procedure.

[3] *See Balke (1991), Sims, Stock, and Watson (1990), and Stock and Watson (1988).*

Development of a Spot Market for Natural Gas

As consumers of large quantities of energy, industry and electrical utilities have found it attractive to invest in the ability to switch between residual fuel oil and natural gas. This ability may have contributed to the development of spot markets for natural gas. Without the ability to switch fuels, an electrical or industrial user would find it undesirable to rely on spot supplies because the pipeline company or LDC providing connections to the natural gas transportation and distribution system could appropriate the end user's capital investment.

Energy consumption involves relatively high capital costs. After an end user makes a capital investment that is specific to natural gas consumption, the pipeline company or LDC providing the connection could exploit monopoly power over the end user's capital investment. Government regulation and long-term supply contracts negotiated before the investment is made are two ways to protect a capital investment that has a specific use. Competition among suppliers also protects the energy user's capital investment and allows the user to rely on spot supplies (Ellig and High 1992).

A spot market for natural gas may not provide enough competition to protect the capital investment of its end users.[1] End users must still rely on a specific LDC or pipeline company for a hookup to the natural gas transportation and distribution system. The ability to switch fuels provides end users with competitive energy supplies, allowing them to rely on spot supplies of natural gas.

In contrast, most commercial and residential customers find it too expensive to invest in the ability to switch fuels, given their relatively small consumption of energy. Their low levels of consumption combined with their inability to switch fuels reduces the attractiveness of relying heavily on spot supplies of natural gas. In that sense, LDCs protect their customers from potential upstream monopolies by obtaining a greater share of their natural gas supplies under long-term contract. In turn, state governments regulate LDCs, giving them a regulated rate of return and preventing them from exercising monopoly power over their customers. Combined with the regulators' concern for security of supply, however, this regulated rate of return may induce LDCs to overcommit to long-term contracts (Lyon 1990).

[1] The spot market for gas creates a competitive demand for the transportation and distribution of natural gas, protecting the capital investments of the pipeline and LDCs involved in contract carriage.

stochastic trends. We find that all price series are integrated of order one—that is, the first differences of all series are stationary.[4]

Cointegration. After determining that each price series is integrated of order one, we test each of the seven pairs of natural gas prices described above for cointegration. Two integrated time series are cointegrated if they move together in the long run. Cointegration implies a stationary long-run relationship between the two series. As such, the cointegrating term provides information about the long-run relationship.

If cointegration is not accounted for, any model involving the two cointegrated variables could be misspecified, and/or the parameter estimates could be inefficiently estimated.[5] Therefore, we employ the Johansen procedure to estimate

[4] *In other words, shocks to first differences of all series are not permanent.*

[5] *See Engle and Yoo (1987).*

Table 1
Cointegration of Upstream and Downstream Prices

Price pairs		Cointegrating relationship	Significance (β 1)
Upstream	Downstream		
Wellhead	Electrical	1.401	.002
Wellhead	Industrial	1.453	.000
Wellhead	City Gate	1.186	.000
Wellhead	Commercial	1.294	.003
Wellhead	Residential	1.148	.120
City Gate	Commercial	1.079	.282
City Gate	Residential	.938	.447

the cointegrating relationship between pairs of upstream and downstream prices.[6] We find a linear cointegrating relationship (of the form $PD = \beta PU$) between all seven pairs of prices considered.

Because each estimated cointegrating relationship is stationary, the cointegrating terms provide an efficient estimate of the long-run relationships between upstream and downstream prices. If a one-unit change in the upstream price occurs over the long run, it will be met by a β change in the downstream price over the long run. Conversely, if a one-unit change occurs in the downstream price over the long run, it will be met by a $1/\beta$ change in the upstream price.

As Table 1 shows, the estimated βs are unequal, signifying that a one-unit change in an upstream price affects some downstream prices more than others. It is not possible, however, to directly test whether the differences between the βs are statistically significant. To assess whether the estimated βs differ significantly from each other, we use an indirect test for which we estimate cointegrating relationships between all possible price pairs. With these additional estimates, we judge which βs are or are not equal to each other. For example, to assess whether the β in the wellhead–electrical price pair (β_{WE}) is different from the β in the wellhead–residential price pair (β_{WR}), we estimate a cointegrating relationship between the electrical–residential price pair (β_{ER}) and check to see whether it has a value equal to one. A value of one for β_{ER} would imply $\beta_{WE} = \beta_{WR}$. A nonunitary value would imply β_{WE} β_{WR}.[7]

We find the βs between the wellhead price and the electrical and industrial prices are the same as each other but greater than the β between the wellhead price and the city gate price. We also find that the βs between the wellhead price and the commercial and residential prices are equal to each other but less than the βs between the wellhead price and the electrical and industrial prices.

At best, the estimated βs only partially support public concerns about uneven changes in natural gas prices. Differences in the estimated βs do show that uneven changes in natural gas prices are maintained in the long run. Specifically, a per-

[6] *The Johansen procedure is a maximum likelihood method. We chose it over several other procedures because it provides the most efficient estimates of the cointegrating relationships. In addition, it provides estimates of the number of cointegrating relationships.*

[7] *Let $P_E = \beta_{WE} P_W$, $P_R = \beta_{WR} P_W$, and $P_R = \beta_{ER} P_E$. Then $P_R = (\beta_{WR}/\beta_{WE})P_E$, and $\beta_{ER} = \beta_{WR}/\beta_{WE}$. It follows that a value of one for β_{ER} implies $\beta_{WE} = \beta_{WR}$. A nonunitary value for β_{ER} implies β_{WE} β_{WR}.*

manent change in the wellhead price is accompanied by more extreme changes in the electrical and industrial prices for natural gas than in the commercial and residential prices for natural gas. Nonetheless, our estimates suggest that the recent pattern, in which residential and commercial prices for natural gas have fallen less than the wellhead price, is unlikely to persist. The βs between the wellhead price and the commercial and residential prices are estimated at greater than or equal to one, indicating that residential and commercial prices for natural gas change by at least as much as the average wellhead price in the long run.

For the three pairs of prices involving wellhead price with electrical, industrial, and city gate prices, the βs are greater than one. These βs mean that the markups over the wellhead price taken by the pipeline companies on electrical, industrial, and city gate prices increase as natural gas prices rise and decrease as natural gas prices fall. These βs can be consistent with either normal responses to shocks in demand, or shocks to supply coupled with increasing returns to scale.

Because price shocks can arise from either shocks to supply or demand, further interpretation of the βs requires additional information. For natural gas, demand shocks can originate in factors such as changing oil prices, economic activity, weather, technology, and government regulation of energy consumption. Supply shocks can originate in factors such as changing production technology, geophysical knowledge, and government policy. Using this information for the period of analysis, we view changes in demand to be a more important source of initial shocks to natural gas markets than changes in supply (Brown and Yücel 1993). Given our view, demand shocks account for long-run movements in natural gas prices (see "Long-Run Sources of Variance," below).

As such, the estimated βs between the wellhead price and the electrical, industrial, and city gate prices are consistent with a normal response to shocks in end-use demand. As end-use demand is increased, the pipeline companies experience rising costs and/or are able to increase profits. As end-use demand is decreased, the pipeline companies experience falling costs and/or are forced to reduce profits.

The likelihood of variable profitability is consistent with the fact that pipeline companies purchase more gas under long-term contract than they sell under long-term contract. Given the existing contracts, prices at which pipelines sell natural gas would vary more in the face of fluctuating demand than the prices they pay for natural gas. Data for the estimation period generally show falling natural gas prices and declining profitability for pipeline companies.[8]

The differences we see in the βs most likely reflect how spot and contract prices respond to changing market conditions. Spot prices adjust more readily, and industrial users rely more heavily on spot supplies than do LDCs. Differences in the βs also may reflect a lack of incentive for LDCs to pursue the cheapest sources of gas as prices are falling because their rate of return is regulated, and their customers cannot easily switch fuels.

The βs between the city gate price and the commercial and residential prices for natural gas are not significantly different from unity. These estimates probably reflect a regulated rate of return for LDCs and a direct pass-through of gas price changes.

Causality. A causal relationship between two variables implies that changes in one variable lead to changes in the other. To test for a predictive relationship between the variables, we perform Granger causality tests on each of the seven pairs of upstream and downstream prices.

Because all our price series are cointegrated, we account for cointegration by specifying an error-correction model in which changes in the dependent variable are expressed as changes in both the independent variable and dependent variable, plus an error-correction term. For cointegrated variables, the error-correction term is the deviations from the long-run cointegrating relationship between the variables. The coefficient on the equilibrium error reflects the extent to which

[8] An alternative explanation for declining pipeline profitability is structural change. Since 1985, the Federal Energy Regulatory Commission has changed the role of pipelines toward one of open access and contract carriage. These changes helped foster the development of a spot market for natural gas served by brokers and the pipeline companies. This explanation is inconsistent with finding cointegration unless one can view the structural change as endogenous to market pressure brought to bear by falling demand.

Table 2
Causality and Adjustment to Equilibrium Error (Significance)

Price Pairs		Causality		Adjusts to error*	
Upstream	Downstream	*PU* to *PD*	*PD* to *PU*	*PU*	*PD*
Wellhead	Electrical	.025	.000	.014	.542
Wellhead	Industrial	.007	.000	.001	.285
Wellhead	City Gate	.005	.000	.000	.783
Wellhead	Commercial	.000	.166	.082	.001
Wellhead	Residential	.002	.320	.155	.002
City Gate	Commercial	.000	.758	.457	.006
City Gate	Residential	.005	.600	.570	.011

* The significance of errors in the cointegrating relationship in the respective upstream and downstream price equations indicates adjustment to the equilibrium error.

the dependent variable adjusts during a given period to deviations from the cointegrating relationship that occurred in the previous period.[9]

The tests involve estimating a reduced-form vector-error-correction model comprising the following set of equations for each pair of prices:

$$(2)\ \Delta PU_t = \sum_{i=1}^{n} a_i \Delta PD_{t-i} + \sum_{j=1}^{n} b_j \Delta PU_{t-j} + \alpha_1 CI_{t-n-1} + \mu_{1t},$$

$$(3)\ \Delta PD_t = \sum_{i=1}^{n} c_i \Delta PU_{t-i} + \sum_{j-1}^{n} d_j \Delta PD_{t-j} + \alpha_2 CI_{t-n-1} + \mu_{2t},$$

where *PU* is the upstream price, *PD* is the downstream price for natural gas, *CI* is the errors in the cointegrating relationship $(PD_t - \beta PU_t)$,[10] a_i, b_j, c_i, d_j, α_1, α_2 are parameters to be estimated, and μ_{1t} and μ_{2t} are white noise residuals.[11] The coefficients α_1 and α_2 represent the adjustment to equilibrium error.

Causality runs from the downstream price to the upstream price if α_1 and the a_i jointly are statistically different from zero. Similarly, causality runs from the upstream price to the downstream price if α_2 and the c_i are jointly statistically differ-ent from zero. If both sets of coefficients are significantly different from zero, causality is bidirectional.

As shown in Table 2, shocks in the wellhead, electrical, industrial, and city gate prices cause shocks in all other prices with which they are paired. If we abstract from shocks that might be initiated by pipeline companies or LDCs, shocks originating in electrical and industrial prices most likely reflect changes in the prices of competing fuels. Shocks originating in the city gate price may reflect the LDCs' response to quantity shocks in their end-use markets. For any particular downstream price, shocks to the wellhead price may reflect changes in drilling technology, changes in reserve estimates, contracts fixed to oil prices, and changes in demand by other downstream buyers.

[9] See Engle and Granger (1987).

[10] The error-correction term is included because all pairs of upstream and downstream prices are cointegrated with each other.

[11] The value of n was set in the Johansen procedure to assure white noise in the residuals.

Price shocks in commercial and residential prices do not cause shocks in other prices. This finding most likely reflects how LDCs administer natural gas prices for commercial and residential users. In response to changing weather, fluctuating economic activity, or changing prices for competing fuels, the customers adjust their consumption of natural gas.[12] Changes in consumption prompt LDCs to seek smaller supplies at lower prices or greater supplies at higher prices. Only as the city gate price paid by LDCs is changed, however, are price changes passed on to end users.

Adjustment to Equilibrium Error. If two variables are cointegrated, any movement away from the long-run cointegrating relationship will eventually be corrected, and the variables will move back into their long-run relationship. The adjustment could be through one or both of the variables. Which variable adjusts to the equilibrium error depends on many factors, including elasticities and market structure.

In a cointegrated system (such as represented by equations 2 and 3), the presence of an error-correction term implies that the dependent variable adjusts to the equilibrium error. The coefficient on the equilibrium error, α, reflects the extent to which a given price variable reacts in the short run to deviations from its long-run relationship with another price variable. In the equations where α is significant, the dependent variable adjusts to deviations from the cointegrating relationship. In equations where α is not significant, the dependent variable does not adjust to deviations from the cointegrating relationship.

As shown in Table 2, the electrical and industrial prices do not adjust to errors in their equilibrium relationship with the wellhead price. Instead, the wellhead price adjusts. These findings are consistent with electrical and industrial demand being more elastic in the short run than is the supply of natural gas. A high short-run elasticity of demand reflects these end users' ability to switch fuels.

Similarly, the wellhead price adjusts to errors in its equilibrium relationship with the city gate price, but the city gate price does not adjust. The resistance of the city gate price may indicate some ability of commercial and residential customers to switch fuels, the ability of LDCs to foster competition between suppliers, or an inelastic supply of gas at the wellhead.

From our institutional knowledge of the natural gas market, we can make a compelling case for a very inelastic supply of natural gas in the short run. Producers hesitate to vary production because doing so could disturb pressure in the well, which could reduce its eventual output or make production from it more costly.

The adjustment of commercial and residential prices to errors in their equilibrium relationships with upstream prices is consistent with administered prices.

Impulse Response. To examine the dynamic properties of shocks to the price variables, we calculate impulse response functions. The impulse response function traces the effects and persistence of a shock on both the upstream and downstream prices. The persistence of a shock tells us how fast the system adjusts back to equilibrium. The faster a shock dampens, the quicker the adjustment.

We use the Choleski decomposition to calculate impulse response functions for each of the seven reduced-form vector-error-correction models.[13] For each model, we analyze the effects of a one-time, standard deviation shock to the first difference of each price in the pair.[14] We trace the effects of this impulse on the equilibrium error and the upstream and downstream prices.

We find that the maximum impact generally occurs within one to three months of the shock.

[12] *Econometric evidence suggests that residential and commercial natural gas consumption do respond to changes in the prices of competing fuels (Bohi 1981). The response is not through fuel switching in the existing energy-using capital stock, however. The response comes through long-term changes in the energy-using capital stock.*

[13] *The Choleski decomposition decomposes the residuals μ_{1t} and μ_{2t} into two sets of impulses that are orthogonal to each other. Orthogonalization allows one to take covariance between the residuals into account.*

The Choleski decomposition imposes a recursive structure on the system in which the ordering of the dependent variables is specified. If the covariance between the residuals is sufficiently high, the ordering can affect the results. We experimented using both changes in the upstream price and changes in the downstream prices first in the ordering.

[14] *This implies a permanent shock to the price.*

Table 3

Impulse Responses in Upstream and Downstream Prices (Based on Choleski decomposition)

Price Pairs		Month in which shock dampens to 5 percent of maximum			
		ΔPU first shock to		ΔPD first shock to	
Upstream	Downstream	ΔPU	ΔPD	ΔPU	ΔPD
Wellhead	Electrical	8	19	16	20
Wellhead	Industrial	19	16	17	17
Wellhead	City Gate	*	*	*	*
Wellhead	Commercial	11	11	11	9
Wellhead	Residential	10	10	10	10
City Gate	Commercial	24	26	24	27
City Gate	Residential	14	16	15	16

* Shocks do not dampen.

In six cases, deviations from the long-run equilibrium relationship between the prices dampen below 5 percent of their peak value within eight to twenty-seven months after a shock, as shown in Table 3.[15]

In four cases, shocks dampen in about one and a half to two years. Deviations from the equilibrium relationships between wellhead price and commercial and residential prices appear to dampen in less than a year. This quick dampening appears somewhat anomalous given the slower adjustment to equilibrium in the relationships between city gate price and commercial and residential prices. Nonetheless, the quick adjustment is reasonable because in the long run, wellhead, commercial, and residential prices adjust to shocks originating in city gate prices.[16]

Long-Run Sources of Variance. To find out which price shocks are the most likely sources of variance, we use the Choleski decomposition to calculate the variance decomposition. For given time horizons, the variance decomposition apportions the stochastic variability in a given price to shocks in itself and the price with which it is paired. Given our impulse response analysis, we use sixty months to represent the long run.

As shown in Table 4, the calculated source of variance is generally invariant to the ordering of the variables in the Choleski decomposition.[17] The two models in which the wellhead price is matched with electrical and industrial prices are an exception. If the change in wellhead price is placed first, both shocks to the wellhead price and the end-use prices are equal sources of variability. If either the change in electrical or industrial prices is placed first, shocks to the end-use price account for more than 90 percent of the variance.

In these cases, we prefer the ordering in which innovations in the end-use price are placed first. This ordering presumes that shocks are most likely to originate in the end-use prices, which fits our view that changes in demand were a more important source of shocks than changes in supply

[15] *In one case, the wellhead price-city gate price relationship, the shocks did not dampen.*

[16] *See "Long-Run Sources of Variance," below.*

[17] *See footnote 13.*

Table 4
Long-Run Sources of Variance in Upstream and Downstream Prices (Based on Choleski decomposition)

Price Pairs		Sources of variance			
		ΔPU first		ΔPD first	
		ΔPU	ΔPD	ΔPU	ΔPD
Upstream	Downstream	(Percent)		(Percent)	
Wellhead		50	50	3	97
	Electrical	46	54	5	95
Wellhead		49	51	8	92
	Industrial	47	53	5	95
Wellhead		27	73	25	75
	City Gate	25	75	4	96
Wellhead		85	15	69	31
	Commercial	79	21	62	38
Wellhead		76	24	78	22
	Residential	66	34	67	33
City Gate		94	6	99	1
	Commercial	92	8	94	6
City Gate		96	4	100	0
	Residential	87	13	88	12

during our period of analysis (Brown and Yücel 1993). Shocks to demand may come from fluctuations in economic activity, changing oil prices, or other factors.

With our preferred ordering, we find shocks to electrical and industrial prices to be the primary sources of variance over the long run in their pairings with wellhead prices. Our findings are consistent with the long-run supply of gas at the wellhead being fairly inelastic, and the long-run demand for natural gas by industrial and electrical users being fairly elastic.

Shocks to commercial and residential prices are not the primary sources of variance in their pairings with the city gate price. We do find, however, that shocks to the city gate price are the primary source of variance over the long run in its pairing with the wellhead price. This finding suggests that LDCs drive city gate and wellhead prices in the face of fluctuating sales to end users and that the long-run supply of gas at the wellhead is fairly inelastic.

Our evidence is consistent with administered prices in the commercial and residential markets for natural gas. As consumers lower (increase) their consumption of natural gas, the LDCs pursue fewer (greater) natural gas supplies at lower (higher) prices. Only after the shock in the quantity of natural gas demanded is transmitted to the city gate price do commercial and residential prices for natural gas adjust to changes in the city gate price.

Summary and Conclusion

Our econometric evidence indicates that changes in natural gas prices are unequal in the long run. Nonetheless, all downstream prices change by at least as much as the average wellhead price. Statistically, residential and commercial prices change as much as the city gate price. In the face of persistent shocks, however, market institutions and market dynamics can lead to lengthy periods in which the residential and commercial prices of natural gas adjust less than the wellhead or city gate prices.

Electrical and industrial users of natural gas rely heavily on spot supplies and can switch fuels easily. Their ability to switch fuels may be related to the development of a spot market to serve them. Reliance on the spot market may explain why these end users have seen a greater reduction in natural gas prices than have the LDCs over the past seven years. The ability to switch fuels may account for electrical and industrial prices being the source of shocks in their relationships with the wellhead price. It also may explain why prices in these end-use markets are quick to adjust.

Commercial and residential customers cannot switch fuels easily and rely heavily on LDCs for their natural gas. The inability of these end users to switch fuels probably contributes to the reluctance of LDCs to purchase spot supplies of gas. Reliance on contract supplies may explain why the city gate price has not declined as much as electrical and industrial prices of natural gas over the past seven years.

Furthermore, the LDCs administer prices in the commercial and residential markets under state regulation. The administration of prices in these markets leads to slower adjustment in commercial and residential prices. Only after city gate prices can be reduced are commercial and residential prices for natural gas reduced.

Pipeline companies have been an integral part of the uneven change in natural gas prices. As natural gas prices have declined over the past seven years, electrical, industrial, and city gate prices have fallen more than the wellhead price, while pipeline profitability has been reduced. Our analysis suggests that the decline in pipeline profitability is associated with reduced demand for natural gas brought about by lower oil prices.

To summarize, public concern about recent movements in natural gas prices, in which residential and commercial prices have fallen less than wellhead prices, may be somewhat misplaced. Although uneven changes in natural gas prices are maintained in the long run, all downstream prices change by at least as much as the wellhead price. Uneven changes reflect differences in the end users and the market institutions that serve them. Our analysis indicates that if energy prices were to rise, pipeline profitability would rise, and commercial and residential end users would see smaller increases in natural gas prices than electrical and industrial end users. Compared with other natural gas prices, commercial and residential prices would be slow to rise.[18]

[18] Data limitations prevent us from testing for asymmetric relationships.

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