

Natural Gas Pricing: Do Oil Prices Still Matter?

For a number of years, natural gas and refined petroleum products have been used as close substitutes in U.S. industry and electric power generation. Industry and electric power generators have switched back and forth between natural gas and residual fuel oil, preferring to use whichever energy source was less expensive. Consequently, movements of natural gas prices in the United States have generally tracked those of crude oil. Most often, crude oil prices are shaped by world oil market conditions, and natural gas prices adjust to oil prices.

Over the past 10 years, however, the number of facilities able to switch between natural gas and residual fuel oil has declined. And in the most recent five years, natural gas prices seemed to move somewhat independently of oil prices. Natural gas prices rose above what was seen as their historical relationship with crude oil prices in 2000, 2002 and 2003. In the first half of 2005, natural gas prices seemed to fall below this historical relationship.

Consequently, many may wonder whether oil price movements still shape those of natural gas and whether the old rules of thumb for relating natural gas prices to those of crude are still useful. The analysis presented here shows oil prices do still matter for natural gas prices, but the old rules of thumb relating natural gas prices to those for oil are of limited usefulness.

Two Simple Rules of Thumb

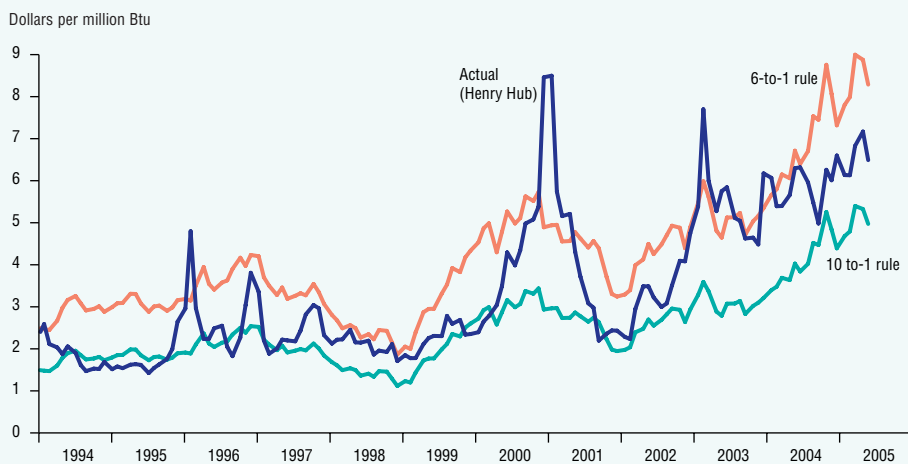
One commonly used rule of thumb relating natural gas prices to crude oil is the 10-to-1 rule, in which the price of natural gas is one-tenth the crude oil price:

$$P_{NG} = .1 \times P_{WTI},$$

where P_{NG} is the Henry Hub price of natural gas in dollars per million Btu and P_{WTI} is the price of West Texas Intermediate (WTI) crude oil in dollars per barrel. Under this rule of thumb, a WTI price of \$20 per barrel would mean a

Chart 1

Actual and Implied Natural Gas Prices Using 10-to-1 and 6-to-1 Rules of Thumb



SOURCES: New York Mercantile Exchange; author's calculations.

natural gas price of \$2 per million Btu at Henry Hub, and \$50 oil would mean \$5 natural gas.

Some energy analysts have argued that natural gas really ought to trade at the same price per million Btu as crude oil. Because a barrel of WTI contains 5.825 million Btu, those analysts have used a 6-to-1 rule, in which the natural gas price ought to be roughly one-sixth the crude oil price:

$$P_{NG} = .1667 \times P_{WTI}.$$

Under this rule of thumb, a WTI price of \$20 per barrel would mean a natural gas price of \$3.33 per million Btu at Henry Hub, and \$50 oil would mean \$8.33 natural gas.

When used to assess the relationship between U.S. natural gas prices and WTI, neither the 10-to-1 nor the 6-to-1 rule of thumb seems to perform well (*Chart 1*). The 10-to-1 rule consistently underforecasts natural gas prices, and the 6-to-1 rule generally overforecasts them. Moreover, as oil and natural gas prices have risen, they seem to be making a transi-

tion from the 10-to-1 rule to the 6-to-1 rule.

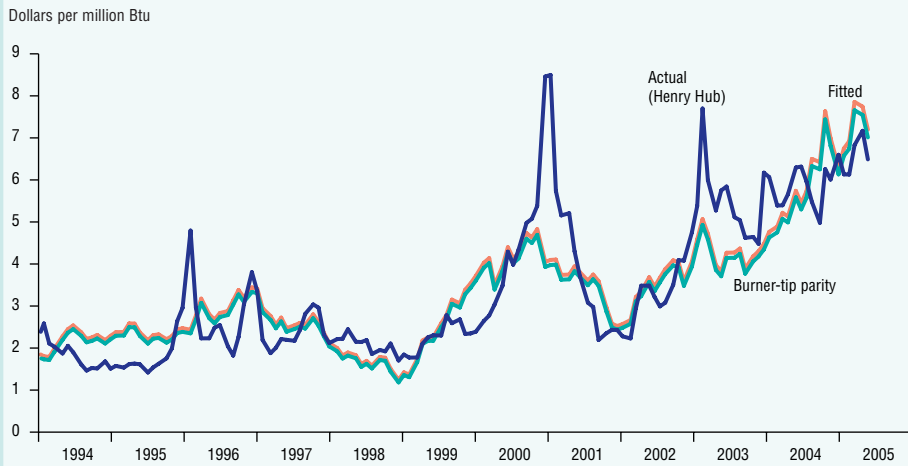
Burner-Tip Parity

A few analysts have interpreted the apparent transition from the 10-to-1 rule to the 6-to-1 rule as indicative of improving market conditions for natural gas. In fact, the seeming transition in pricing may reflect a more complex relationship between natural gas and oil prices. The competition between residual fuel oil and natural gas occurs where they are used—at the burner tip. Therefore, natural gas pricing should yield parity at the burner tip, and prices at the trading hubs should adjust to whatever is necessary to achieve burner-tip parity. In fact, residual fuel oil sells for less than WTI, and natural gas costs more to move to end users than residual fuel oil.

If we explicitly consider the historical relationship between prices for residual fuel oil and WTI, convert to million Btu and subtract the higher costs of transporting natural gas to market, we obtain a rule of thumb based on burner-tip parity:

Chart 2

Actual and Implied Natural Gas Prices Using Burner-Tip Parity and Fitted Values



SOURCES: New York Mercantile Exchange; author's calculations.

Hub, and \$50 WTI would mean \$7.24 natural gas. For these prices, a 150 percent increase in the oil price would mean a 177 percent increase in the natural gas price.

Fitted values from the regression analysis and those obtained through the burner-tip parity rule show that U.S. natural gas prices generally track those of WTI (Chart 2). Nonetheless, there appear to be a number of occasions when natural gas prices have decoupled from those of crude oil. In particular, natural gas prices seem to have pulled away from oil prices in 2000, 2002 and 2003 and then fallen behind in 2005.

Seasonality and Storage

Seasonality and the natural gas in storage also play a prominent role in natural gas prices. Because natural gas consumption is seasonal but production is not, natural gas inventories are built during the summer for use in the winter (Chart 3). This seasonality leads to higher winter prices and lower summer prices. In addition, inventories above the seasonal average depress prices, and inventories below the seasonal average boost prices. Taking these additional factors into account in a regression analysis using weekly data yields

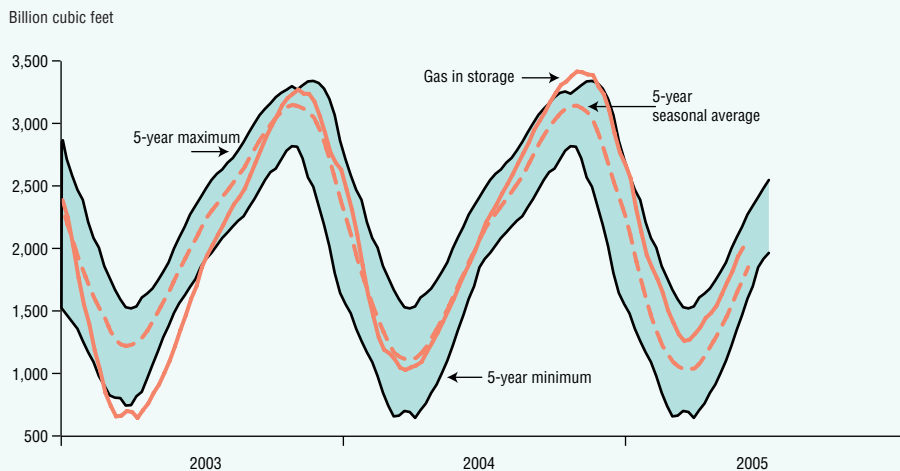
$$P_{NG} = -.3345 + WSF - .0265 \times ST + .1503 \times P_{WTI},$$

where *WSF* is a weekly seasonal addition to or subtraction from the price of natural gas and *ST* is the percent deviation of natural gas in storage from the weekly seasonal average for the previous five years. Seasonal factors affect the price of natural gas considerably—adding 94 cents per million Btu in the last week of the year and subtracting 55 cents per million Btu in the 38th week of the year (Table 1). Storage 10 percent below the weekly seasonal average adds 26 cents per million Btu.

These weekly seasonal factors and storage conditions allow for considerable variation in the price of natural gas for any given oil price. With natural gas 10 percent above the normal seasonal average, a \$20 per barrel price for WTI would imply a natural gas price of \$1.86 per million Btu at Henry Hub in the 38th week of the year. With natural gas 10

Chart 3

Natural Gas in Storage Above Seasonal Average



SOURCE: U.S. Information Administration, Department of Energy.

$$P_{NG} = -.5 + .1511 \times P_{WTI}.$$

Under this rule, a \$20 per barrel price for WTI would mean a natural gas price of \$2.52 per million Btu at Henry Hub, and \$50 WTI would mean \$7.06 natural gas. For these prices, a 150 percent increase in the oil price would mean a 180 percent increase in the natural gas price.

Regression analysis using monthly data yields

$$P_{NG} = -.4744 + .1543 \times P_{WTI}.$$

With the relationship obtained through regression analysis, a \$20 per barrel price for WTI would imply a natural gas price of \$2.61 per million Btu at Henry

Table 1

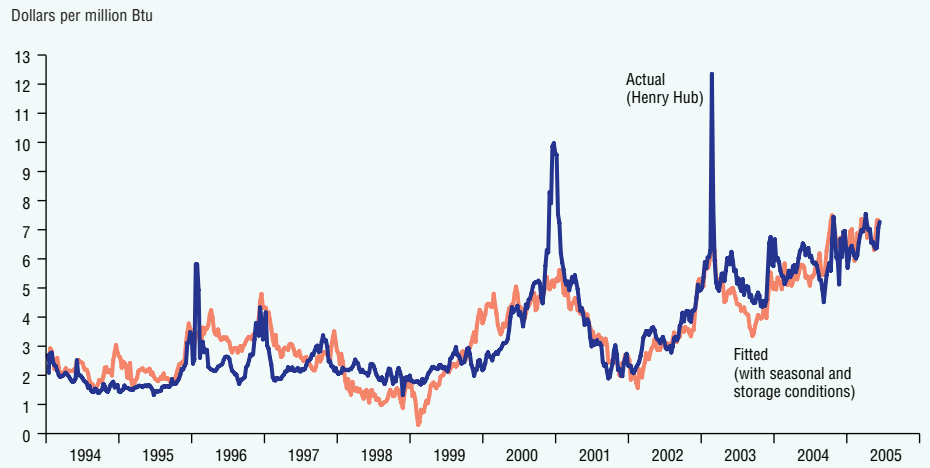
Estimated Weekly Seasonal Factors

| Week | Factor | Week | Factor |
|------|--------|------|--------|
| 1 | .7755 | 27 | -.0192 |
| 2 | .6901 | 28 | -.1600 |
| 3 | .6833 | 29 | -.1948 |
| 4 | .3790 | 30 | -.2917 |
| 5 | .6603 | 31 | -.3226 |
| 6 | .6289 | 32 | -.2775 |
| 7 | .4511 | 33 | -.3579 |
| 8 | .0766 | 34 | -.4062 |
| 9 | .0660 | 35 | -.4215 |
| 10 | .4768 | 36 | -.5056 |
| 11 | .0605 | 37 | -.5435 |
| 12 | -.1538 | 38 | -.5510 |
| 13 | -.0649 | 39 | -.5060 |
| 14 | -.0977 | 40 | -.4112 |
| 15 | -.0431 | 41 | -.3920 |
| 16 | .0545 | 42 | -.3888 |
| 17 | .0118 | 43 | -.2843 |
| 18 | -.0269 | 44 | -.1322 |
| 19 | -.0579 | 45 | -.0257 |
| 20 | -.1216 | 46 | -.0460 |
| 21 | -.0935 | 47 | -.0475 |
| 22 | -.0356 | 48 | -.0252 |
| 23 | -.0233 | 49 | -.0833 |
| 24 | .0060 | 50 | .4254 |
| 25 | -.0223 | 51 | .7122 |
| 26 | .0335 | 52 | .9427 |

NOTE: By construction, the weekly seasonal factors have a zero mean.

Chart 4

Actual and Implied Natural Gas Prices Incorporating Seasonal Factors and Storage Conditions



SOURCES: New York Mercantile Exchange; author's calculations.

A Relatively Stable and Complex Relationship

A number of common rules of thumb imply that the relationship between U.S. natural gas and crude oil prices has changed or that oil prices no longer affect natural gas prices. This view has been bolstered by the observation that industrial and electric power-generation facilities are less able to switch between natural gas and residual fuel oil than they were in the past. When we take into account the normal seasonal variation in natural gas prices and the amount of natural gas in storage, however, we find compelling evidence that U.S. natural gas prices continue to be related to those for crude oil. The relationship is relatively stable and complex.

—Stephen P. A. Brown

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Note

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percent below the normal seasonal average, a \$20 per barrel price for WTI would imply a natural gas price of \$3.88 per million Btu at Henry Hub in the last week of the year. Comparable figures for \$50 WTI are \$6.36 and \$8.39 per million Btu, respectively.

With variations in natural gas storage of ± 10 percent, a 150 percent gain in the crude oil price could result in the natural gas price rising by less than 65 percent or more than 350 percent. It's no wonder that analysis using rules of thumb to price natural gas suggests that the relationship between natural gas and crude oil prices has changed. In contrast, fitted values from the regression analysis with weekly seasonal factors and storage conditions taken into account show that U.S. natural gas prices track those of WTI quite well (*Chart 4*).