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Shale Game:

Market Dynamics in North American Natural Gas

SINCE 2002, our firm has had a group dedicated to energy trading, with approximately 15 investment professionals currently operating from New York and Kansas City. That group trades in a number of markets globally, including power, coal, oil, oil products, and weather. The group's primary focus, however, is North American natural gas, which currently represents approximately half of its risk capital. The firm's energy group typically adopts a relative-value approach, aiming to identify anomalies across instruments rather than making concentrated one-sided bets on market movements.

Because natural gas (NG) trading is our energy group's major focus and the NG market can be opaque to non-specialists, we thought it might be illuminating to summarize some of our views on how that market has evolved over the last six or seven years. Although the emergence of large-scale shale gas production in the United States has greatly expanded NG supply and generally moderated long-term volatility, we argue that the impact of shale gas on the NG market has been less uniform and more complicated than might be suggested from readings of the popular press. In particular, although expanded NG supply has generally reduced overall NG volatility, specific features of shale production, in tandem with weather events, may contribute to *short-term* volatility.

D E Shaw & Co

Emergence of Shale Gas

Let's begin with some history. Before the advent of shale gas as a significant source of supply, natural gas generally traded above the price of coal and below the price of fuel oil (in energy-equivalent terms).[1] During that period, the ability of some power producers to substitute their input commodities generally caused the prices of coal and fuel oil to act as an effective floor and cap, respectively, on the price of natural gas. (We'll talk more about substitution dynamics in a bit.) If NG prices remained below coal for extended periods, gas-fired power plants would become more competitive relative to coal-burning plants, stimulating NG demand and therefore raising prices. Similarly, if NG prices rallied above the price of fuel oil, oil-fired power plants would increase production, which would put downward pressure on NG prices.

As illustrated by Figure 1, shale gas began to emerge as a significant source of supply of natural gas in North American markets around 2007. By mid-2014, U.S. shale gas production exceeded 35 billion cubic feet per day, a nearly ten-fold increase over the mid-2006 level. Shale gas now accounts for more than half of total U.S. NG production, and U.S. shale gas has become the third largest source of natural gas in the world.[2]

U.S. Shale and Non-Shale Dry Gas Production, January 2000 – July 2014

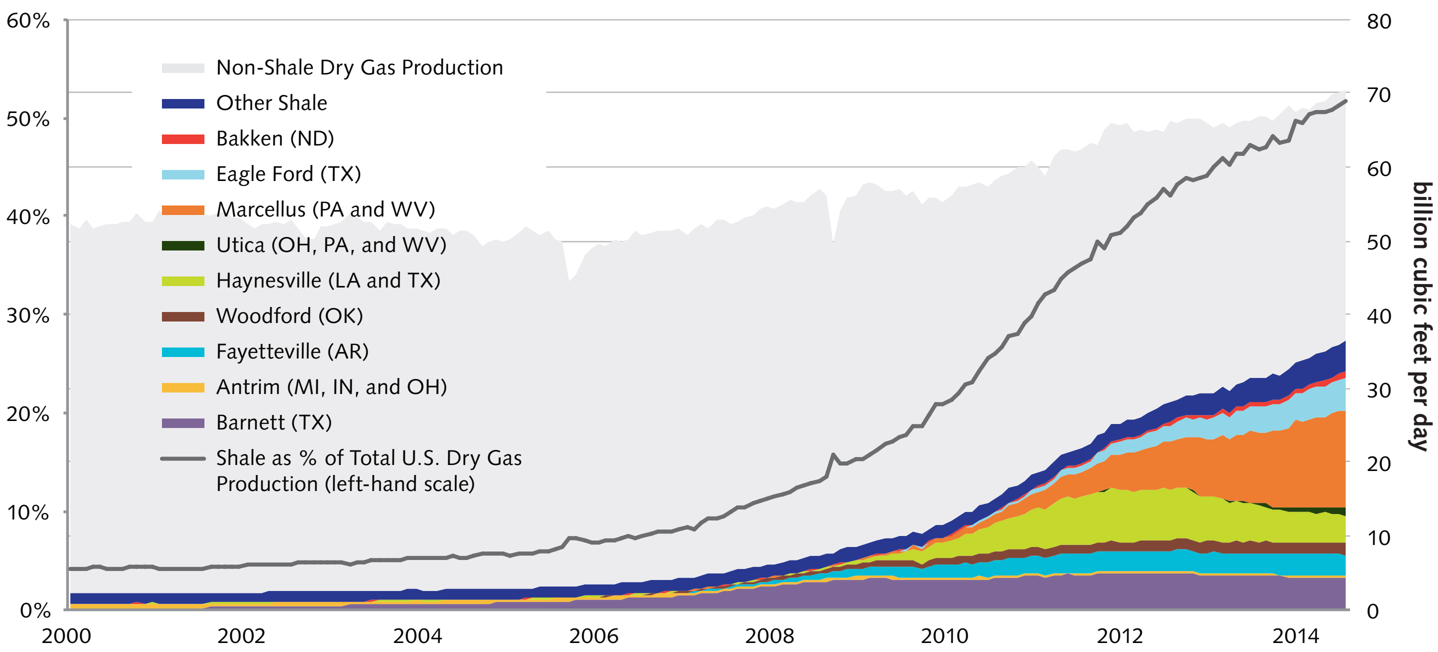

Figure 1

To understand the importance of this new source of natural gas, it's helpful to compare pre-shale conventional gas exploration and modern shale gas development. Conventional exploration techniques center on discrete reservoirs or pockets of rock formations that could hold natural gas. Flowing gas from conventional NG wells relies, in part, on the natural pressure of permeable reservoirs to bring gas to the surface. That flow may be enhanced by pumping pressurized water and other substances into a well. By comparison, shale deposits have a broad geographic extent, often covering hundreds of square miles, but limited capacity to flow gas. The challenge of extracting gas from shale was less in locating formations rich in natural gas and more in developing mechanisms to enhance the flow of that gas to the surface. Unlike conventional wells, extracting shale gas is predicated on using explosive charges to perforate relatively impermeable geological formations and

1 British thermal units (BTUs) are used as a standardized measure of energy output across fuel sources.

2 In 2012, the United States led the world in (dry) NG production, ahead of Russia's aggregate NG production. When broken out separately, U.S. non-shale and shale gas production ranked second and third, respectively, after Russia's aggregate production.

then pumping in a highly pressurized mixture of fluids and particulates to "fracture" those formations and release trapped gas ("fracking").

Initial testing of the Barnett Shale in Texas, the first major shale formation developed in the United States, began in 1981, but it wasn't until the early 2000s that a combination of horizontal drilling and multi-stage hydraulic fracturing consistently produced economic flow rates across a broad region. By the mid-2000s, exploration companies began to look at other shale formations, attempting to recreate the success of the Barnett. During this period, multiple new shale plays emerged across the United States, with NG production from the Haynesville and Marcellus shales surpassing that of the Barnett.

A Primer on Seasonality

Before we go further, it's helpful to give some context around seasonal dynamics in the gas markets. NG demand increases substantially in winter months given heating consumption. Consequently, a consistent feature of this market is that gas is injected into storage facilities from April to October (in "summer") and drawn down from November to March (in "winter"). By contrast, NG production is generally less seasonal. Price action in the NG market is in part driven by the "stock-out" risk of exhausting stored NG if the winter is colder than expected. This creates a premium in the price of winter gas relative to summer gas. The spread between NG futures contracts for delivery in March and delivery in April is often treated as a proxy for the likelihood that markets will run out of natural gas over the course of the winter (with higher spreads signaling greater likelihood) because March typically is the last month during which gas is drawn from storage. That stock-out fear also creates high call skew in the options market (*i.e.,* out of-the-money options trade with a higher implied volatility than at-the-money options).

Price volatility in the NG market is also sensitive throughout the year to extreme weather events that can reduce supply. Historically, hurricanes have been the most impactful of these weather events. Prior to the emergence of sizable shale production, North American NG production was heavily concentrated in the Gulf of Mexico. Offshore platforms and rigs were often evacuated in advance of a storm as a precautionary measure, which temporarily reduced supply. A strong storm could damage rigs and materially reduce NG supply for extended periods. For example, a year after Hurricanes Katrina and Rita successively struck the Gulf Coast in mid-2005, Gulf of Mexico NG production remained 20% below its pre-Katrina level.

In unusually cold weather, "freeze-offs" may also temporarily reduce supply. In the process of flowing gas from a well, hydrates (water or its elements, hydrogen and oxygen) are usually also extracted through the wellhead. If temperatures fall far enough for long enough, those hydrates may freeze and halt the flow of gas.

With production shifting to onshore shale fields, we have seen the risk of hurricane-related production disruption and related price shocks diminish over time. However, because many shale fields are located farther north (relative to the Gulf) and hold wetter gas, the risk of freeze-offs has perhaps intensified. For example, during the extremely cold winter of 2013–2014, freeze-offs caused a significant number of onshore wells to temporarily shut down.

The Impact of Shale Gas on Energy Markets

The substantial addition to NG supply from shale plays has influenced U.S. energy markets—including natural gas, coal, and oil—in a number of important ways. As a general matter, we believe the impact of shale gas on the market is more nuanced than one might initially expect.

NG Supply

Recent developments in credit and equity markets were important to the expansion of NG supply. When credit markets unseized after the 2008 crisis, equity markets appeared to begin pricing the shares of energy companies in proportion to the expected rate at which they could grow NG production. We believe this stemmed from a combination of high prices along the NG forward curve, which created possibilities for attractive returns on capital for drilling, and a view in the market that the companies with the greatest potential to increase production were the best shale gas drillers and thus more likely to be acquired by larger firms seeking to enter the space. Firms were therefore strongly incented to increase their production capacity, and by early 2010, these market dynamics created a structural oversupply in the NG market.

Substitution Effects

One way of gauging the impact of the increased NG supply is to consider how price has influenced demand among users that can substitute different forms of energy in their production processes. Perhaps the most important of such users, in terms of the scale of their demand, are producers of electricity. The dramatic production growth brought on by shale gas was so overwhelming that by 2011, the price of natural gas began trading below more expensive grades of coal, which stimulated NG demand in the power sector. As a result, lower NG pricing prompted power producers to substitute natural gas for coal, which then put downward pressure on coal demand and prices. While a substitution effect between coal and natural gas has long been a feature of the market, historically natural gas rarely substituted for the least expensive grades of coals. By 2012, when natural gas traded as low as $2 per thousand cubic feet, weather-normalized NG demand increased significantly to partially substitute for Powder River Basin coal, the cheapest coal in the country.

Price Volatility

We can also assess the effects of expanded NG supply brought about by shale gas by looking at price volatility.

Volatility is much lower in the current oversupplied NG market today than it was five or ten years ago. Figure 2 traces the implied volatility of the October NG futures contract from 2003 through 2015. The implied volatility of the October contract approximates the volatility of summer gas. Figure 2 generally shows that the contracts for years after 2009 exhibited lower implied volatility on average than in prior years.

At-the-Money Implied Volatility of October NYMEX Natural Gas Futures Contract, 2003 – 2015

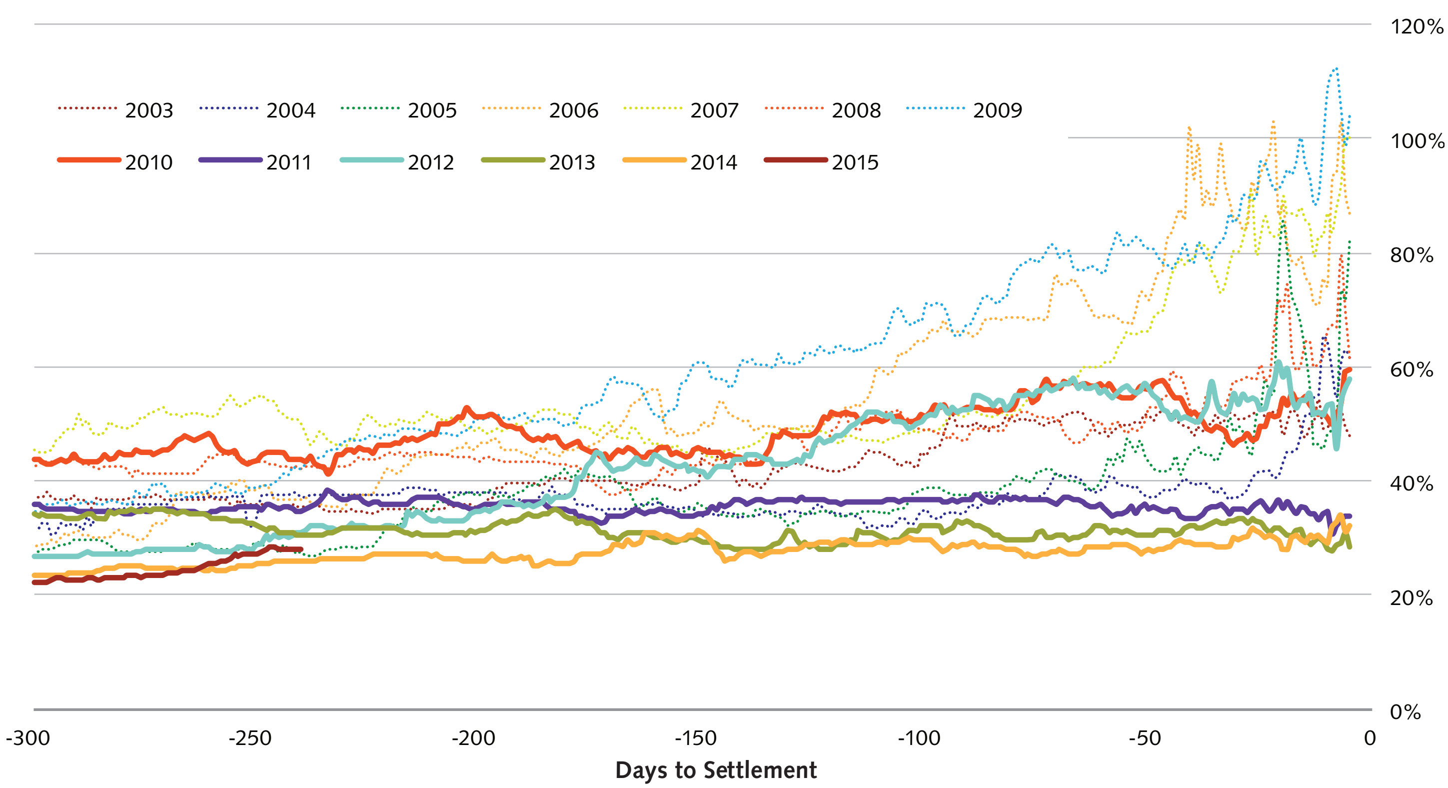

Figure 2

Figure 3 shows the implied volatility of the contract for the month after a "prompt" month (the prompt-month contract being the one closest to expiration) and the trend line over the 2003–2014 period. The data clearly indicate the downward pressure on price movements.

At-the-Money Implied Volatility of Month after Prompt-Month NYMEX Natural Gas Futures Contract, January 2003 – September 2014

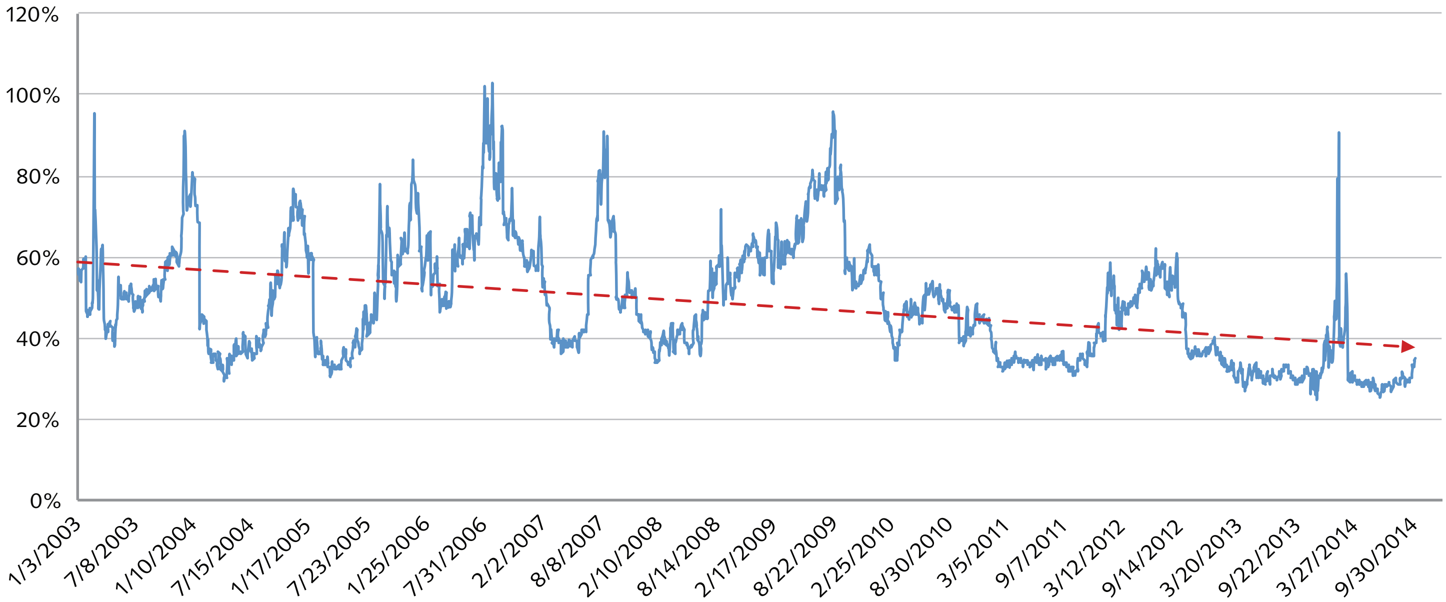

Figure 3

As long as natural gas is priced within the coal stack (which represents various grades of coal), the elasticity of NG demand tends to keep NG prices somewhat bounded. The shift to shale production from conventional exploration, which required lengthy periods to identify and tap new sources of supply, means that new supply can be delivered to the market much more quickly. In the current environment, if prices rally substantially, the relative abundance of shale gas means that producers can increase drilling rates and bring on more supply in as little as three months.

However, at the front end of the curve, short-term prices remain prone to spikes. The relatively stable prices across much of the curve can snap higher during periods of peak demand. The extremely cold winter of 2013–2014 precipitated one such spike in NG prices, which is clearly visible in the right-hand portion of Figure 3. The sudden increase in demand for heat (brought about by what we estimate was the second coldest winter in the United States in the past 25 years) caused the price of the March 2014 contract to jump dramatically. Meeting such short-term spikes in demand will likely always prove challenging. With temperatures remaining unusually low for considerable periods at the end of 2013 and beginning of 2014, NG wellheads and gathering systems froze, creating bottlenecks in supply. The implications for pricing were obvious. Thus, although longer-term price volatility has been dampened by the successful development of large shale gas fields, meaningful volatility remains a fact of life in this market at the front end of the curve.

Infrastructure

The advent of shale gas has transformed incentives in a number of areas related to NG infrastructure, including storage, pipelines, and export/import facilities.

Prior to the advent of increased supply stemming from shale gas production, there was a significant incentive to build gas storage facilities. Investments in such facilities were the result of the persistent wide discount in the price of summer gas relative to that for the following winter. That spread was the arbitrage that storage players collected. Increased gas supply resulting from the development of shale has generally compressed the premium paid for winter gas over summer gas. With the tighter spreads reflected across much of the curve due to the abundance of shale gas, incentives to build out more gas storage have materially diminished.

Similarly, the wide differentials in NG pricing across different geographic locations in the United States in the 1990s and early 2000s incentivized a substantial build-out of pipeline infrastructure. In certain regions, such as the west and southwest, that infrastructure has generally rendered the price of domestic natural gas much more uniform. However, the shift in production to the northeast with the development of shale gas has created new regional imbalances. For example, trading locations like TGP Z4 Marcellus now trade at a material discount to surrounding regions.

Prior to the development of shale gas formations, the securing of supply was an important consideration in the U.S. market. As a result, a number of companies invested in liquefied natural gas (LNG) import facilities in the late 1970s and early 1980s. The supply growth brought about by shale gas undercut that investment thesis; utilization rates for those import terminals have been extremely low because U.S. NG prices are now among the lowest in the world. The current trend appears to be the inverse of that thesis, as U.S. regulators in 2012 began to approve the construction of a number of LNG *export* terminals that would allow U.S. firms to capture the arbitrage between low U.S. NG prices and higher global prices. Additionally, U.S. gas exports to Mexico are expanding and are expected to grow significantly, given excess supply in the United States and growing Mexican demand. The wide global price differential is fostering an industrial renaissance in the United States, as producers of products such as chemicals, fertilizers, and methanol take advantage of relatively low domestic energy prices.

Market Structure

Beyond the changing market dynamics brought about by shale, it would be useful to consider changes in the structure of the overall NG market during the period covered by this paper.

From the 1990s until it filed for bankruptcy in late 2001, Enron Corporation dominated trading in NG products. Enron leveraged the information gained from its physical asset holdings to build a competitive advantage in the analysis of market supply and demand dynamics. At that time, a substantial amount of energy trading was conducted bilaterally, and therefore a large number of market participants were heavily exposed to Enron's credit risk. Its bankruptcy unleashed a cascade of insolvencies and near insolvencies among energy trading firms. In the aftermath of that market upheaval, risk-taking in energy trading migrated to some banks and hedge funds (including our firm) that hired veteran traders to build out newly formed energy trading teams.

When we established our energy group in 2002, we entered the North American NG market primarily because market dislocations had created opportunities for hedge fund managers and investment talent had become available. To that mix we added our firm's expertise in the areas of data gathering and analysis. In particular, we accessed a significant amount of data on storage and inventories—much of which had to be tediously gathered from a variety of sources and then cleaned and standardized—and deployed a number of then-proprietary inventory level metrics that provided what we considered a significant competitive advantage in our analysis of supply and demand dynamics. The market we entered in 2002 was much less liquid than the one prevailing before Enron's bankruptcy. Liquidity began to improve around 2004, once trading generally shifted from OTC markets to exchanges.

Positioning of Our Firm in the Current Market

Since entering the NG market more than ten years ago, our firm's energy group has seen and adapted to a number of changes, including increased supply brought about by shale gas. In particular, we've shifted from longer-horizon trades—which were predicated on structural demand for liquidity—to a more opportunistic approach. We believe that in the current environment we enjoy several advantages relative to other players in the market. First, the multi-strategy structure of our investment platform may permit us to consider a broader set of opportunities and have more concentrated exposure to individual bets than may be possible for standalone energy hedge funds that do not benefit from the diversification afforded by other investment activities. This is particularly important in natural gas, as weather disruptions or other short-term events often create mispricings driven by fear rather than fundamentals. We think this can be a material benefit in giving us flexibility when seeking to exploit inefficiencies or avoid costly forced liquidations.

Second, as banks have scaled back their proprietary trading businesses and focused more on wholesale customers and market making, and as the number of dedicated energy funds has decreased in recent years, more flow-driven pricing anomalies on shorter timescales have arisen. This presents both heightened risk—the market can move much more abruptly than it might have in days when well-capitalized prop desks would step in to correct a fundamental distortion—but also additional opportunity. Producers and end users, whose trading activities are driven by economic considerations different from our own, now have a larger impact on the market, thus creating potential trading opportunities.

Finally, our expertise across related energy markets such as power, coal, and oil is conducive to identifying trends that may not be apparent when focusing solely on the NG market. Indeed, as we've noted in a previous *Market Insights* piece, one of the compelling features of the energy complex more generally is its fragmentation, which can create tradable anomalies. The relative diversity of our trading activities in energy markets enables us to structure trades in a number of ways in an effort to capture various inefficiencies, whether through calendar spreads, volatility positions, location basis spreads, or cross-commodity spreads.