CARR FUTURES

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Tracking and Trading Nat Gas Vols

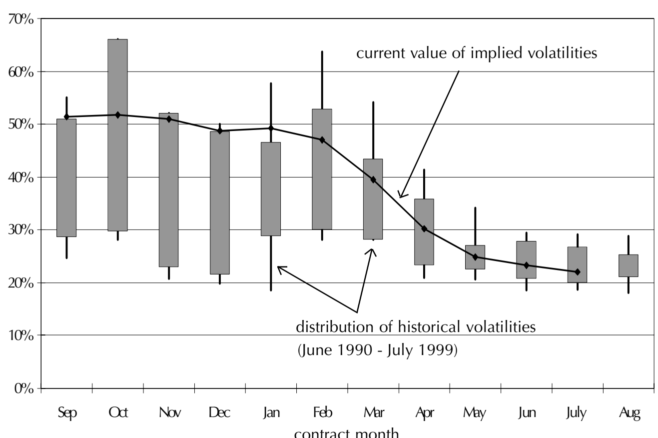
research *note*

GALEN BURGHARDT • GEORGE PANOS

An option is rich if the volatility implied by the price of the option can be expected to exceed the realized volatility of the underlying over the option's remaining life. Judging the richness or cheapness of an option on natural gas futures is complicated by two things. First, some months – the winter months in particular – are more volatile than other months. Second, the volatility of the underlying futures contract tends to rise as the contract approaches expiration. A correct assessment of an option's richness or cheapness requires, as a result, correct treatments of both seasonality and of time remaining to expiration.

This note introduces the idea of volatility candlesticks, which capture both influences (seasonality and time) quite handily and which allow one to tell at a glance whether options on a particular natural gas futures contract are rich or cheap, either outright or relative to the options on neighboring contracts.

Exhibit 1
Volatility candelsticks for natural gas futures (August 6, 1999)



Volatility candlesticks

Exhibit 1 uses a charting method that is more commonly used in technical analysis to show how the current values of implied volatility stack up against the past eight years of volatility history. Each candlestick in this chart summarizes the distribution of historical volatilities for a particular contract given its remaining time to expiration as of August 6. On that day, options on the Sep '99 contract had 15 business days remaining to expiration. Options on the February contract had six months remaining to expiration.

To construct the candlestick for the September futures contract, for example, we calculated the realized volatility of the September contract over the last month of its life for each of the past eight years. The top wick shows the highest of these eight volatilities, while the bottom wick shows the lowest. And, in this construction, the top of the body represents the next highest of the 8 volatilities (that is, we threw out the highest), while the bottom of the body represents the next to lowest volatility.

We then repeated this exercise for each of the rest of the contracts, estimating remaining life volatilities for October futures contracts (which had about 2 months to expiration) through the following August (which had a remaining life of about 12 months).

Attractive trading opportunities

When we look at implied natural gas volatilities this way, we find interesting trading opportunities. For one thing, in light of the past eight years of experience, options on the Sep '99, Nov '99, Dec '99, and Jan '00 futures contracts appear to be rich outright. In all three cases, the volatilities implied by these options are at the upper end of the ranges of their respective historical volatility distributions.

We also find interesting spread trades. For example, implied volatility for the September option is roughly the same as it is for the October option even though October is a considerably more volatile month. Notice, too, that implied volatility for the February option is slightly lower than it is for the January option even though the February contract tends to be considerably more volatile than the January contract. Thus, Sep '99 options seem rich relative to Oct '99 options and Jan '00 options seem rich relative to Feb '00 options.

CARR FUTURES
Research Department
150 S. WACKER DRIVE
15TH FLOOR
CHICAGO, IL 60606
(312) 984-4345

CHICAGO
Global Headquarters
(312) 441-4200

LONDON
(0171) 550 2424

MADRID
(1) 432 73 41

NEW YORK
(212) 392-8681

PARIS
(01) 44 82 86 86

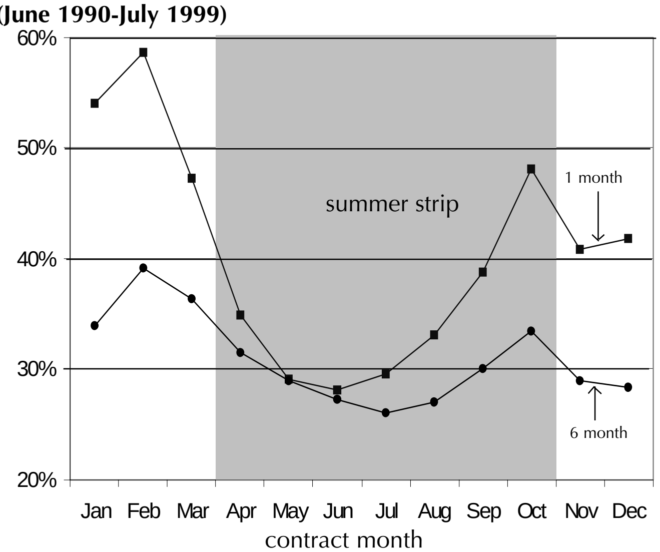
SINGAPORE
(65) 538 52 32

TOKYO
(03) 3261 4477

Seasonality

The two broad seasons in the natural gas market are winter and summer. The "winter strip" comprises November through March, while the "summer strip" comprises contract months from April through October. The seasonality of natural gas volatility is shown in Exhibit 2, which shows the average level of volatility during the last one month and the last six months of each of the twelve contract months over the past eight years. Winter months are clearly more volatile than summer months, and certain months – February in particular – are more volatile than the months around them.

Exhibit 2
Seasonality of historical volatilities
(June 1990-July 1999)

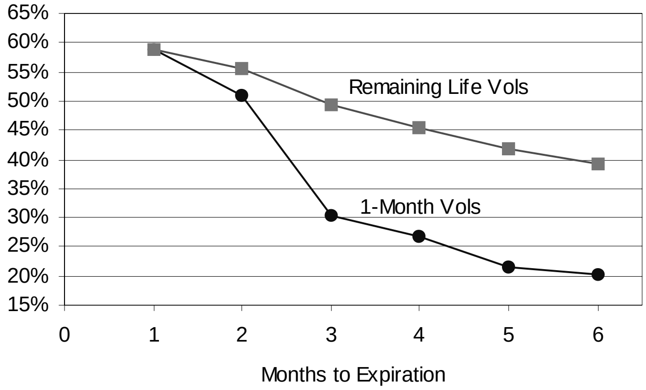


Time remaining to expiration

According to a long standing academic proposition, forward or futures prices should be less volatile than spot prices. People who trade options on financial products tend not to see this kind of behavior. For that matter, Eurodollar futures rates tend to be more volatile than spot deposit rates.

Natural gas futures, however, uphold this proposition with a vengeance. Exhibit 3 shows what happened on average to the volatility of the February contract over the past eight years. The lower line is an average of 1-month historical volatilities. The upper line is an average of realized remaining lifetime volatilities. In either case a futures contract volatility rises as the contract approaches expiration and the interval between the spot date and the forward date shrinks.

Exhibit 3
Average February contract historical volatilities
(1991-1999)



The relationship between the two measures of volatility merits a brief explanation. Consider the hypothetical volatilities shown in Exhibit 4. The middle column shows that 1-month volatilities for each of the last 3 months of the contract's life are 10%, 20%, and 30% respectively. That is, from the time the contract has 3 months remaining to expiration to the time it has 2 months remaining to expiration, the annualized standard deviation of relative price changes is 10%. From 2 months to 1 month, the volatility is 20%, and over the last month of the contract's life, volatility is 30%.

Exhibit 4
Futures volatility and time to expiration (hypothetical)

Months remaining to expiration	Volatility over the next month of trading	Volatility over the contract's remaining life
3	10%	21.6%
2	20%	25.5%
1	30%	30.0%

With this pattern of 1-month volatilities, the volatility of the futures contract over its remaining life reflects all of the remaining volatilities. Thus, with 3 months left to expiration, the volatility of the contract over its remaining life would be 21.6% $[=((.10^2+.20^2+.30^2)/3)^{½} \times 100\%]$. With 2 months left to expiration, the volatility of the contract over its remaining life would be 25.5% $[=((.20^2+.30^2)/2)^{½} \times 100\%]$. And, of course, over the last month of its life, its remaining lifetime volatility would be 30%. A fairly priced 3-month option in this case would be priced to imply 21.6% volatility. A fairly priced 2-month option would be priced to imply 25.5% volatility.

As a rule, then, if the volatility of a contract rises over time, its remaining life volatility will be greater than any shorter-term measure of its volatility. And the two measures converge when the contract's remaining life is just equal to the length of the shorter term.

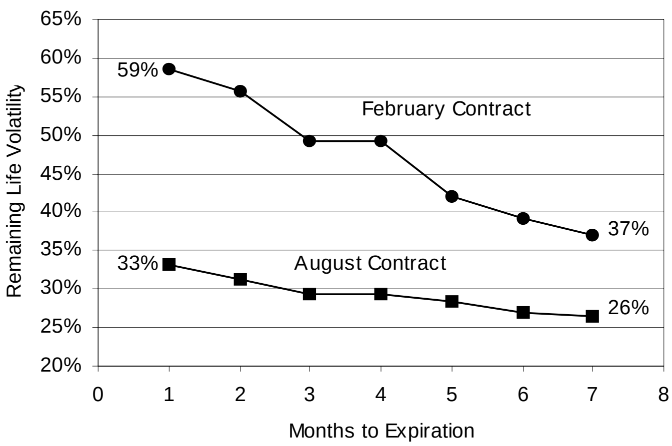
Understanding the term structure of implied nat gas vols

Taken together, the two forces that influence natural gas volatilities – seasonality and time to expiration – produce term structures of volatility that vary systematically throughout the course of the year. Exhibit 5, which provides remaining life historical volatilities for a summer contract (August) and a winter contract (February), allows us to see how these two forces interact.

Suppose, first, that it is the beginning of July, when the August contract has about 1 month left to expiration, while the February contract (which expires at the end of January) has about 7 months to expiration. Given the data provided in Exhibit 5, the remaining life volatility of the August contract would be about 33%, while the remaining life volatility of the February contract would be about 37%. The resulting implied volatility structure would be comparatively flat because the effect of extra time to expiration tends to offset the higher seasonal volatility of the February contract.

Now suppose instead that it is the beginning of January. The February contract has one month left to expiration, and the

Exhibit 5
Remaining life volatilities
(Aug: 1990-1998, Feb: 1991-1999)



August contract has seven months to expiration. In this case the remaining life volatility of the February option would be about 59%, while the remaining life volatility of the August option would be about 26%. The two forces that influence volatility would tend to reinforce rather than offset one another. And, as a result, the pattern of implied volatilities would be sharply downward sloping. The higher volatility implied by the February option would reflect two facts: first February is a more volatile month than August; second, the February option has less time to expiration. The lower volatility implied by the price of the August option reflects both the fact that August is a less volatile month than February and that the August option is on a longer-dated futures contract.

The year at a glance

The exhibit on the back page provides a bird's eye view of how natural gas volatilities behave over the course of a year. Seeing the 12 months side by side helps to drive home the importance of treating seasonality and time to expiration carefully.

Notice that the pattern of volatilities as of the beginning of January, when the February option has just under one month to expiration, is steeply downward sloping. Notice also that the range of realized 1-month volatilities for the February contract is very wide, while the range of realized 7-month volatilities for the August contract is quite narrow.

As the year progresses, the summer months become the shorter-dated options and the winter months become the longer-dated options. As a result, the implied volatility pattern tends to flatten out. The profiles for March (when April is the lead contract) through July (when August is the lead contract) are almost perfectly flat. Then, in late summer, with the winter months becoming the shorter-dated options and the summer months becoming the longer-dated options, the implied volatility pattern begins to steepen again.

A word about contract expirations

To read natural gas volatilities correctly, one must know that a NYMEX futures contract expires 3 business days before the beginning of the month for which the contract is named and during which gas deliveries are made. The option on the contract expires one day before this. Thus, the October '99 futures contract expires on Tuesday, September 28. The option on the October '99 futures contract expires on Monday, September 27.

As a result, the last month of trading in the October futures contract falls mainly in September. The last month of trading in the February contract falls mainly in January. Thus, the blip in volatility that we observe for the October contract may well reflect the market's reaction to the end of the hurricane season, which falls roughly at the end of September. Similarly, the extraordinary volatility of the February contract suggests that uncertainty about natural gas prices reaches its peak in January.

(Our thanks to Robert Johnson, a Northwestern student who worked with us as an intern this summer. He did an excellent job of organizing and analyzing a huge amount of futures data for this project and laid the groundwork for the ongoing production of natural gas volatility candlestick charts.)

The Nat Gas Volatility Year at a Glance

(Candelsticks for June 1990 through July 1999. Implied vols for dates shown.)

Explanation: The candlesticks in these charts show the distribution of remaining life historical volatilities for each contract from the reference date (e.g. January 4, 1999) to the contract's expiration date (e.g. January 27, 1999 for the Feb '99 contract, or Feb 24, 1999 for the March '99 contract). Overlaid on the candlesticks is the term structure of implied volatilities as of the close of business on the reference date.