U.S. Energy Information Administration

January 2010

Short-Term Energy Outlook
Energy Price Volatility and Forecast Uncertainty[1]

January 12, 2010 Release

Crude Oil Prices. West Texas Intermediate (WTI) crude oil spot prices averaged $74.50 per barrel in December 2009, about $3.50 per barrel lower than the prior month's average. The WTI spot price fell from $78 to $70 during the first 2 weeks of December, but colder-than-normal weather and U.S. crude oil and product inventory draws that exceeded the December 5-year averages helped push it back up to $79 per barrel by the end of the month. EIA forecasts that WTI spot prices will weaken over the next few months, averaging $76 per barrel in March, before rising to about $82 per barrel in the late spring and to $85 by late next year (West Texas Intermediate (WTI) Crude Oil Price Chart).

Expected WTI price volatility continued to edge lower at the start of the new year. Crude oil futures market participants were pricing March 2010 options at an implied volatility slightly below 40 percent per annum at the beginning of December 2009, and the level dropped to an average of 34 percent over the 5 days ending on January 7, 2010. March 2010 WTI futures averaged $82 per barrel over that same 5-day window. Thus, the lower and upper limits of the 95-percent confidence interval for the March 2010 futures price were $66 per barrel and $102 per barrel, respectively (see Energy Price Volatility and Forecast Uncertainty documentation).

During the same period last year, market participants were pricing March-delivered WTI into Cushing, Oklahoma, at $50 per barrel. However, at that time the implied volatility of 87 percent was more than twice the current level, resulting in lower and upper limits of $29 and $87 per barrel, respectively, for the 95-percent confidence interval. Global oil markets still were adjusting to highly uncertain conditions following a price collapse from all-time highs for WTI futures in mid-2008.

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[1] This is a regular monthly supplement to the EIA *Short-Term Energy Outlook*. (http://www.eia.doe.gov/emeu/steo/pub/contents.html)
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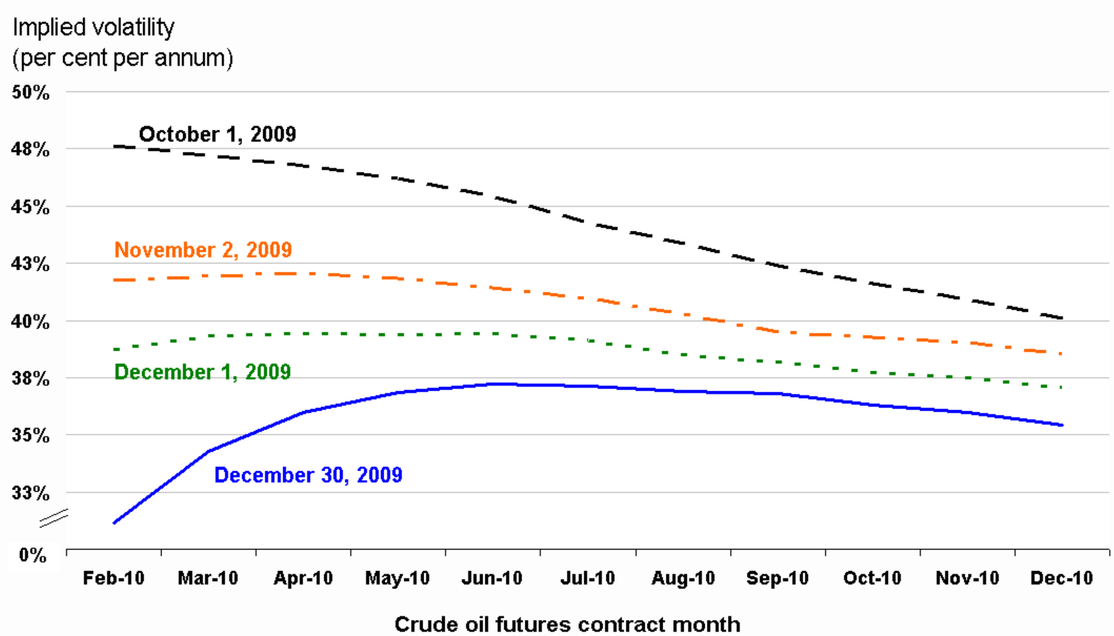
In addition to a steady decline in realized volatility in WTI futures prices and implied volatility derived from options prices, the options market saw a rare inversion in the New York Mercantile Exchange (NYMEX) implied-volatility term structure during the fourth quarter of 2009. Figure 1 shows the implied volatilities for options on 2010 WTI futures contracts, measured at different times during the fourth quarter of 2009 (i.e., October 1, November 2, December 1, and December 30, 2009). By December 30, when the February 2010 contract had 10 trading days left to expiry, prompt NYMEX WTI implied volatility was the lowest of the monthly implied volatilities for all 2010 options contracts (solid blue line in Figure 1).[2]

Figure 1. Evolution of WTI implied volatility term structure



Source: CME Group, Light Sweet Crude Oil futures and options contracts (http://www.cmegroup.com/)

The implied volatility term structure normally is backwardated (i.e., prompt implied volatility is higher than deferred volatility). Volatility in the near-month futures contract typically is higher than volatility in longer-term futures contracts because supply and demand are, for all intents and purposes, price-inelastic when commodities are trading spot, i.e., when they are in or near actual physical delivery. Therefore, with the arrival of new information – such as a shock affecting supply,

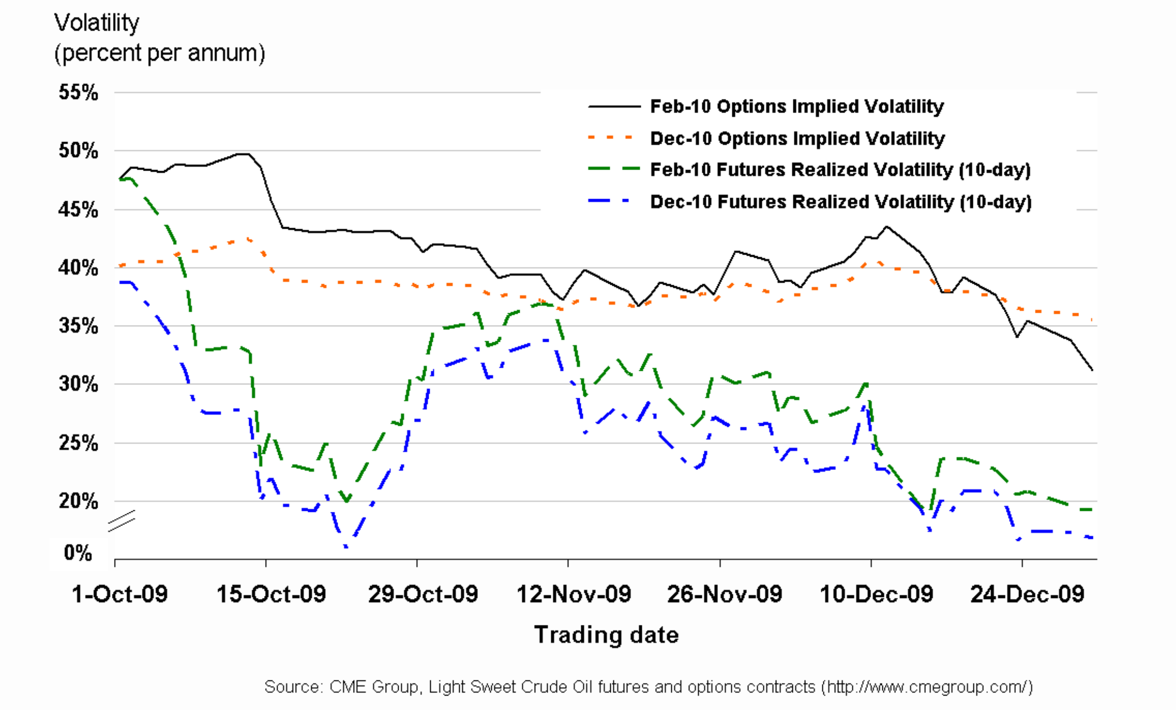
[2] EIA rolls to the next option contract when the prompt contract has less than 10 days to expiry, to avoid over-estimating implied volatility in the Black model due to the shortened life of the option.

demand or both – price must quickly go to the level where immediately available supply clears immediate demand. Supply and demand typically are more price-elastic over longer timeframes. Thus, longer-term futures prices are less volatile as a result. This is the well-known Samuelson effect (1965), which asserts futures prices should be more volatile as they approach delivery because of "real-life complications" associated with trading many commodities (e.g., inventory outages and ruptured pipelines), and the convergence with cash-market prices.[3]

The inversion observed at the end of the fourth quarter 2009 was associated with a decline in realized futures volatility over the October – December 2009 period (the dashed lines in Figure 2. These realized futures volatilities are rolling 10-day annualized standard deviations of daily log returns.) Even so, the term structure of realized futures volatility during this time retained a "backwardation," i.e., prompt realized volatility exceeded that of the deferred futures contracts (the green dashed line lies above the blue dashed line throughout the period). In contrast, the implied volatility term structure flipped in the middle of December. Prior to that, the market maintained a "normal" backwardated term structure for implied volatility.

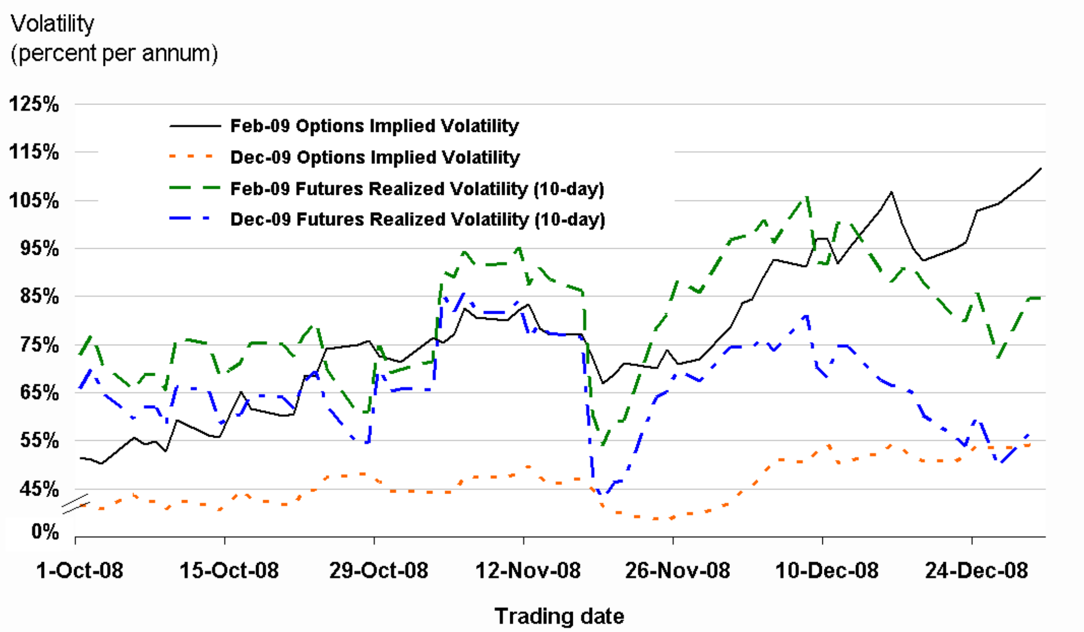
[3] See Samuelson, Paul A., "Proof that Properly Anticipated Prices Fluctuate Randomly," *Industrial Management Review*, Vol. 6 (1965), 41-49, particularly pp. 44 and 45, wherein he discusses the "well-known rule of thumb that nearness to expiration date involves greater variability or riskiness per hour or per day or per month than does farness." See Milonas, Nikolaos T., and Thomas Henker, "Price spread and convenience yield behaviour in the international oil market," *Applied Financial Economics*, Vol. 11 (2001), 23 – 36, particularly pp. 31 and 32, for a discussion germane to global oil markets. See also Lautier, Delphine, "Term Structure Models of Comodity Prices," Cahier de recherche du Cereg n °2003-9. Lautier notes (p. 7): "The movements in the prices of the prompt contracts are large and erratic, while the prices of long-term contracts are relatively still. This results in a decreasing pattern of volatilities along the prices curve. Indeed, the variance of futures prices, and the correlation between the nearest futures price and subsequent prices decline with the maturity. This phenomenon is usually called "the Samuelson effect". Intuitively, it happens because a shock affecting the nearby contract price has an impact on succeeding prices that decreases as maturity increases (Samuelson, 1965). Indeed, as futures contracts reach their expiration date, they react much stronger to information shocks, due to the ultimate convergence of futures prices to spot prices upon maturity. These price disturbances influencing mostly the short-term part of the curve are due to the physical market, and to demand and supply shocks."

Figure 2. Prompt and deferred WTI volatility in 4Q 2009



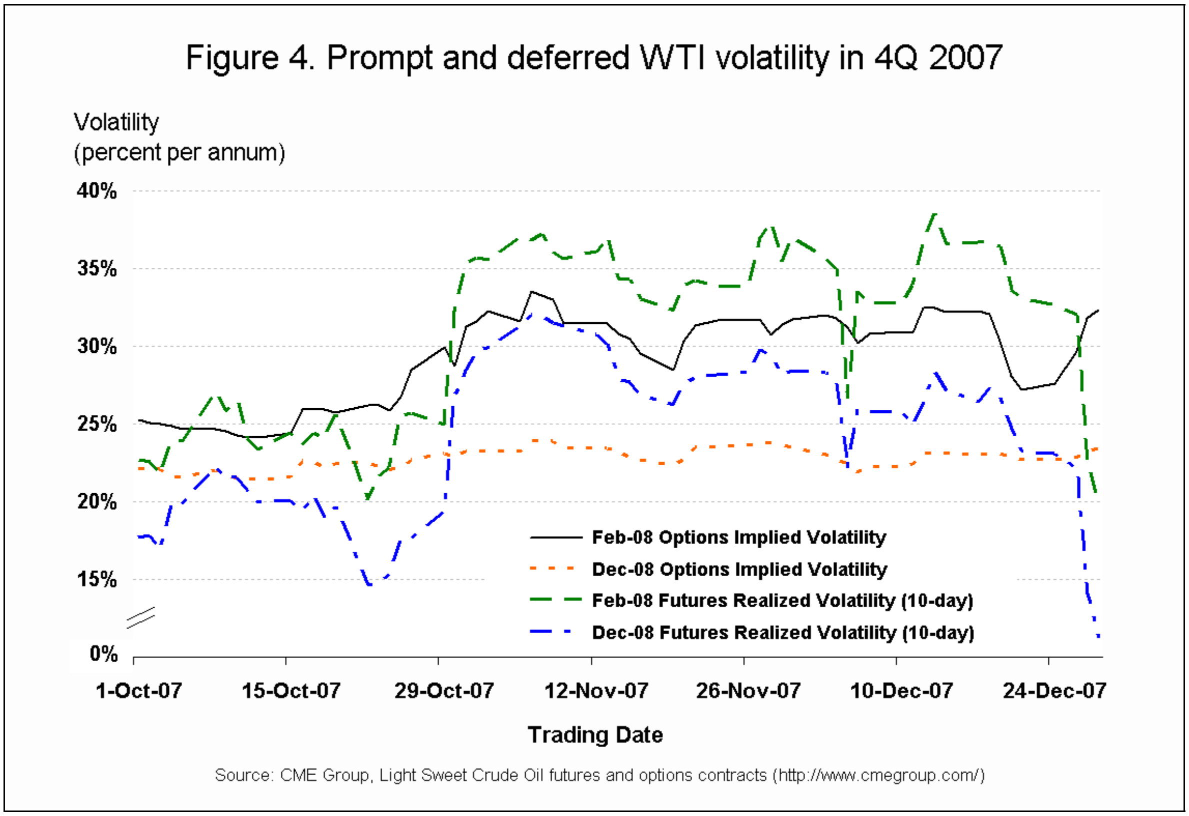
A "normal" backwardated term structure for WTI implied volatility also is shown in Figures 3 and 4 where prompt implied volatilities are higher than longer-dated implied volatilities. Figure 3 depicts implied volatility and realized futures volatility for February 2009 and December 2009 options and futures observed in the fourth quarter of 2008. While 2008 witnessed very high levels of implied and realized volatility, the volatility term structure retained its typical backwardated structure.

Figure 3. Prompt and deferred WTI volatility in 4Q 2008



Source: CME Group, Light Sweet Crude Oil futures and options contracts (http://www.cmegroup.com/)

The futures volatilities shown in Figures 3 and 4 (the dashed curves) illustrate why the implied volatilities typically are backwardated (i.e., the Samuelson effect described earlier). In Figure 3, the then-prompt February 2009 futures contract (green dashed curve in Figure 3) exhibited higher realized volatility than the December 2009 futures contract (blue dashed curve) as 2008 came to a close. Figure 4 shows the comparable 2007 period and the same effect.



U.S. Natural Gas Prices. The Henry Hub spot price averaged $5.50 per Mcf in December 2009, $1.73 per Mcf higher than the average spot price in November (Henry Hub Natural Gas Price Chart). Prices were affected by the colder-than-normal weather in December, which contributed to an increase of 2.2 Bcf/d in total consumption during December compared with the forecast in last month's *Short-Term Energy Outlook*. The Henry Hub spot price averaged $4.06 per Mcf in 2009, and the forecast price averages $5.36 per Mcf in 2010 and $6.12 per Mcf in 2011. Continued high storage levels combined with enhanced domestic production capabilities and slow consumption growth are expected to keep prices from rising dramatically through the forecast.

While natural gas inventories remain ample, implied volatility for the futures market in natural gas options moved slightly higher at the start of the new year. Natural gas for delivery in March 2010 at Henry Hub, Louisiana, was priced at $5.73 per million Btu (MMBtu) ($5.90 per Mcf) during the 5 days ending January 7, 2010. Implied volatility for options settling against March 2010 natural gas futures averaged just below 57 percent. Futures market participants, therefore, were pricing a 95-percent confidence interval with a lower limit of $3.88 and an upper limit of $8.47 per MMBtu for the March 2010 contract.

Last year at this time the picture looked very similar. Futures contracts on natural gas delivered to the Henry Hub during March 2009 traded at $5.90 per MMBtu. Implied volatility on the March 2009 natural gas options was at 59 percent; thus the lower and upper limits of the 95-percent confidence interval for natural gas prices were $3.94 and $8.84 per MMBtu, respectively.