

Background of Surging Oil Prices and Market Expectation Seen in Options¹

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Summary

The crude oil prices (WTI futures) has been in an uptrend and has recorded the highest in a row in the first half of March 2008 hitting \$111 per barrel in 13th March. It shows about \$23 rise in the last one month.

In this period, OPEC decided that it maintain the production ceiling. However, it is considered that this rapid rise in the oil prices is caused mainly by the inflow of funds into the oil market and the sharp decline of the dollar, etc. These factors are side-effects of actions for the financial crisis caused by the subprime lending problem, and hard to be resolved radically in the short term. For the time being, the trend in the financial market may affect the oil prices significantly.

It, however, seems that expectation of the market is not in a complete bullish position if we look at the analysis of probability distribution of future prices estimated by option premium. Such expectation of the market is due to resurgence of actual demand decline brought about by recession and concern about too rapid price rise.

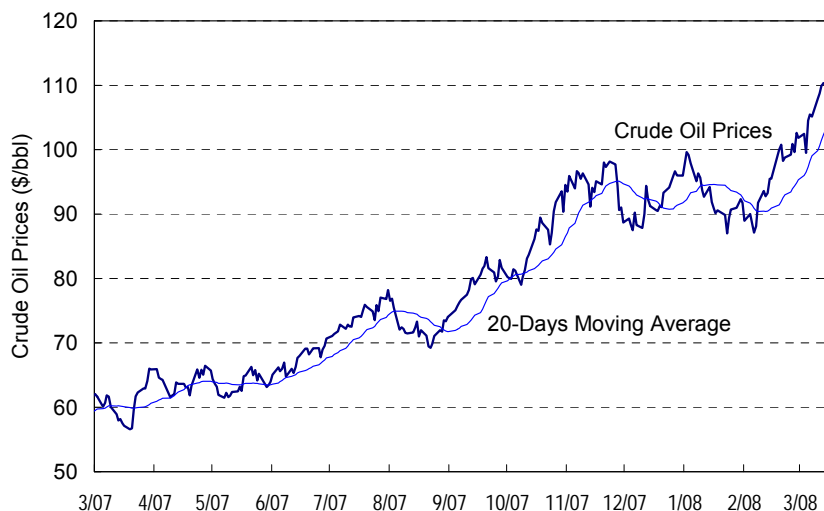
1. Background of sharp rise of oil prices

(1) Surging oil prices

In the second week of March 2008, the crude oil prices (WTI futures) soared following the surge in the previous week. It recorded historic high price six trading days in a row from 5th March and hit \$110.20 per barrel in 12th March. As to the closing price, it recorded historic high price four days in a row from 10th March and hit \$110.33 in 13th March. In 14th March, the price hit \$110.92 then closed at \$110.21 declining by \$0.12 from the previous day.

The oil prices (closing price, the same hereafter) increased by \$23 compared to the \$87.14 in 6th February, or \$5 in the last five trading days. This is sharper surge than that was seen in October and November 2007 when it tried \$100.

Figure 1-1 WTI prices



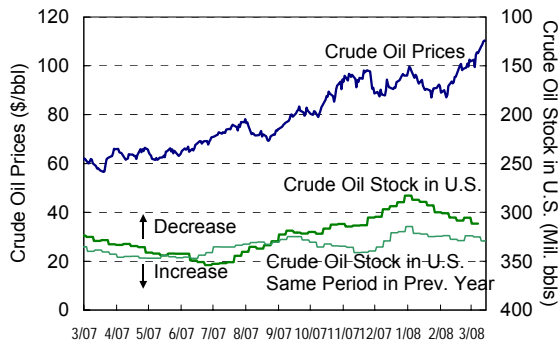
Source: New York Mercantile Exchange

¹ This paper is based on information by 16th March 2008.

(2) Impact of actual supply and demand balance

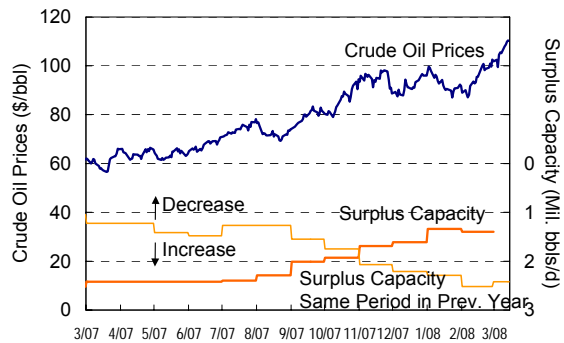
Crude oil stock in the United States excluding SPR and surplus crude oil production capacity of OPEC, etc. show that the actual supply and demand balance of crude oil is more tightened than the same period of the previous year. The actual supply and demand balance pressure, however, seems not strong as price hike pressure. In fact, an increase of 6.20 million barrels, which was unexpectedly strong, from the previous week of crude oil stock released in 12th March was accepted as bearish factor in the market. The OPEC’s decision of maintaining the production ceiling (29.67 million barrels per day of 12 countries excluding Iraq) in 5th March did not support the oil prices much because the decision had been expected.

Figure 1-2 Crude oil stock in United States excluding SPR and oil prices



Source: U.S. Department of Energy, etc.

Figure 1-3 Surplus crude oil production capacity of OPEC and oil prices

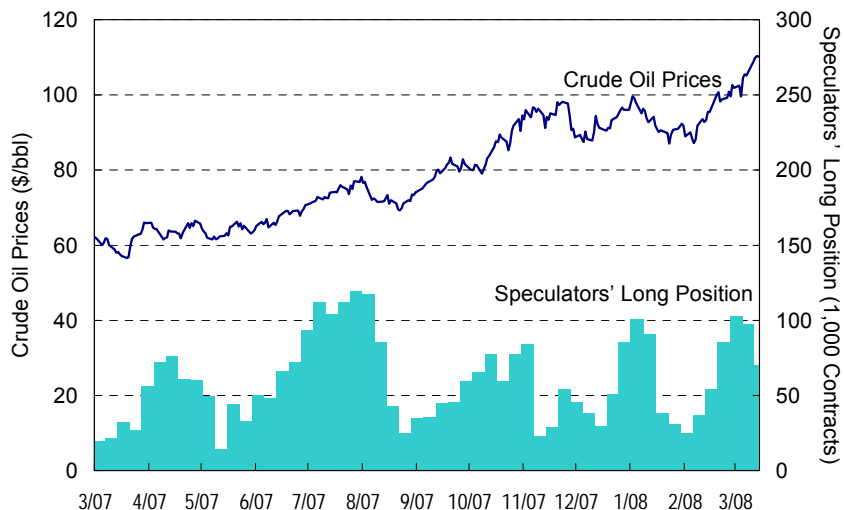


Source: U.S. Department of Energy, etc.

(3) Trend of speculators

Current sharp rise of the oil prices is affected much by inflow of funds from the stock market to the commodity markets like crude oil and gold, reflecting the worsening subprime lending problem. In the crude oil market, speculators, who once decreased the long position after the peak of the oil prices in the early January, turned to net buying since February.

Figure 1-4 Speculators’ long position in WTI futures and oil prices



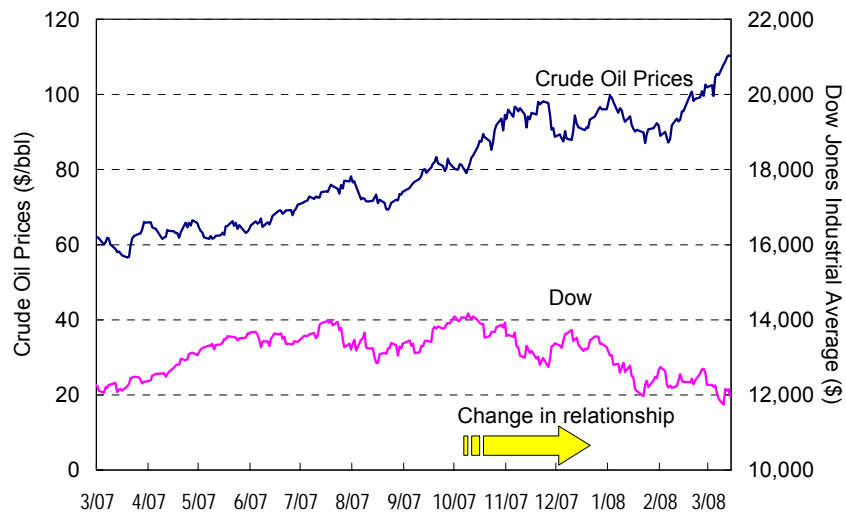
Note: Speculators refer non-commercial and non-reportable
 Source: Computed from U.S. Commodity Futures Trading Commission data, etc.

(4) Impact of financial situation

Recession of U.S. economy is regarded as bearish factor so far because it leads the decline of actual oil demand. Current situation, however, under the financial crisis and recession caused by the subprime lending problem, is different from the past. For example, the relation between the stock

quotation, which is the leading indicator, and the oil prices has been changed since last autumn. The relation has no connection to theory in actual supply and demand: falling in the stock quotation leads to rise of oil prices.

Figure 1-5 Dow Jones industrial average and oil prices

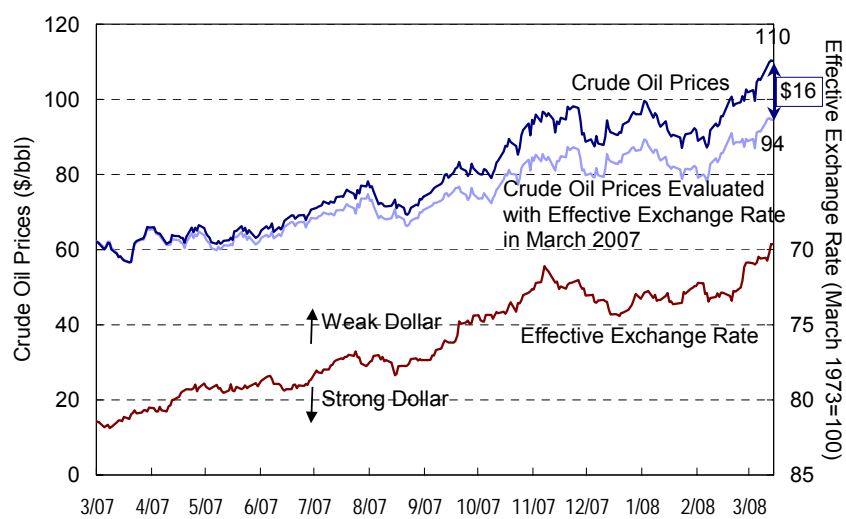


Source: New York Stock Exchange, etc.

The Federal Reserve Board, or FRB, supplies easy money to the financial market as actions for the current financial crisis. The huge supply of the dollar, however, results in upward pressure in commodity markets such as crude oil and gold, etc. combined with funds from the stock market avoiding risk of falling stock prices.

In parallel, supply of easy money, reduction in interest and recession of the U.S. economy lead to the decline of the dollar. In addition to acceleration of decline of the dollar against major currencies like the Euro since last summer, rapid decline of the dollar against Yen, which is apart from the other major currency, is proceeding recently. This situation results in the decline of nominal effective exchange rate of the dollar against major currencies²: decline of more than 10% in the last one year, or nosedive of more than 40% p.a. in the last one month. This leads that the oil prices seems to be undervalued and triggers the upward pressure for the oil price.

Figure 1-6 Nominal effective exchange rate of dollar and oil prices



Source: Estimated from Federal Reserve Board data, etc.

² Currency weights since 2007: Euro 34%, Canadian Dollar 32%, Japanese Yen 18%, U.K. Pound 9%, Swiss Franc 3%, Australian Dollar 2% and Swedish Krona 2%.

It is estimated that the decline of the dollar in the last one year pushes up the oil prices by \$16 if the effective exchange rate were maintained at the level of March 2007³.

2. Market expectation of oil prices seen in options

(1) Analysis of market expectation using option premium

Option is the right to purchase or sell an underlying asset at a specified price (“strike price”) in future. “Call options” provide the holder the right to purchase the underlying asset and “put options” provide the holder the right to sell the underlying asset. Moreover, “European style options” allow the holder to exercise the right only on the expiration date and “American style options” allow the holder to exercise the right at any time up to the expiration date. Options are economically valuable and the value is called “option premium”. In New York Mercantile Exchange, or NYMEX, options which underlying asset are WTI futures, are listed.

While futures prices provide information of average of expected future prices, option premiums provide information of distribution of expected future prices. Typically, “implied volatility”, variation of expected future prices estimated from European call option premium in the market applying the Black-Scholes equation is well known. Implied volatility is the theoretical standard deviation and obtained by back calculation of the Black-Scholes equation assuming rational pricing in the market, or the premium reflecting the market expectation of true volatility.

In the Black-Scholes model, however, only implied volatility is available as information on distribution of expected future prices because it is assumed beforehand that the underlying asset prices follow log normal distribution. No additional information such as whether distribution of expected future prices is asymmetric or not, fat tail or not, is available. Therefore, I tried to estimate the distribution itself from option premium and strike price and to analyze market expectation from the estimated distribution.

(2) Estimation of distribution of expected future prices

In this paper, risk⁴ neutral implied probability distribution is estimated as distribution of expected future prices by finite difference method⁵. Finite difference method is a numerical approximate solution to the differential equation. Shiratsuka and Nakamura (1998) provides application method of finite difference method for option premium in detail.

As a rough outline of the method, cumulative distribution of expected future prices is estimated firstly, then probability density is obtained from the cumulative distribution.

For call options, the cumulative distribution where expected future price of the underlying asset F is equal or less than strike price K_i is obtained as

$$\Pr\{F \leq K_i\} \approx 1 - \frac{C_{i-1} - C_{i+1}}{K_{i+1} - K_{i-1}}$$

where $\dots < K_{i-2} < K_{i-1} < K_i < K_{i+1} < K_{i+2} < \dots$

C_i is call option premium for strike price K_i . Then the probability density is

³ Reference: Exchange rate in March 2007: USD 1.00 = EUR 0.7552, USD 1.00 = JPY 117.28. In 14th March 2008: USD 1.00 = EUR 0.6409, USD 1.00 = JPY 100.20.

⁴ Risk in the financial engineering is variation of expected rate of return in general. It is different from “risk” in “risk of oil disruption” or “geopolitical risk”, etc.

⁵ Estimation of implied probability distribution by finite difference method should be applied for European options intrinsically as the Black-Scholes equation. In this paper, however, estimation was using American options data for following reasons. (1) In case of call options without dividend like WTI, American option premium is equal European option premium theoretically. (2) As actual value, European option premium and American option premium are not much differ for WTI. (3) American options are traded more than European options and American options data are reliable.

$$\begin{aligned} \Pr\{K_i < F \leq K_{i+1}\} &= \Pr\{F \leq K_{i+1}\} - \Pr\{F \leq K_i\} \\ &\approx \left(1 - \frac{C_i - C_{i+2}}{K_{i+2} - K_i}\right) - \left(1 - \frac{C_{i-1} - C_{i+1}}{K_{i+1} - K_{i-1}}\right) \\ &= \frac{C_{i-1} - C_{i+1}}{K_{i+1} - K_{i-1}} - \frac{C_i - C_{i+2}}{K_{i+2} - K_i} \end{aligned}$$

For put options, in a similar way, the cumulative distribution and the probability density are available using put option premium P_i with strike price K_i as follows:

$$\begin{aligned} \Pr\{F \leq K_i\} &\approx \frac{P_{i+1} - P_{i-1}}{K_{i+1} - K_{i-1}} \\ \Pr\{K_i < F \leq K_{i+1}\} &= \Pr\{F \leq K_{i+1}\} - \Pr\{F \leq K_i\} \\ &\approx \frac{P_{i+2} - P_i}{K_{i+2} - K_i} - \frac{P_{i+1} - P_{i-1}}{K_{i+1} - K_{i-1}} \end{aligned}$$

Premium pricing can be irrational for “in the money”⁶ options. Therefore probability distribution is estimated by composition that obtained from “out of the money” call option and that from out of the money put option.

(3) Market expectation for front month seen in options

The crude oil market is affected by trend in the financial market rather than actual supply and demand balance. It, however, seems that expectation of the market is not in a complete bullish position if we look at the probability distribution of future prices estimated by option premium (left of Figure 2-1). Compared with one year ago (right of Figure 2-1),

- bigger variation (bigger volatility): uncertain for future prices
- fat tail (bigger kurtosis⁷): recognizing possibility for big fluctuation of future prices

and

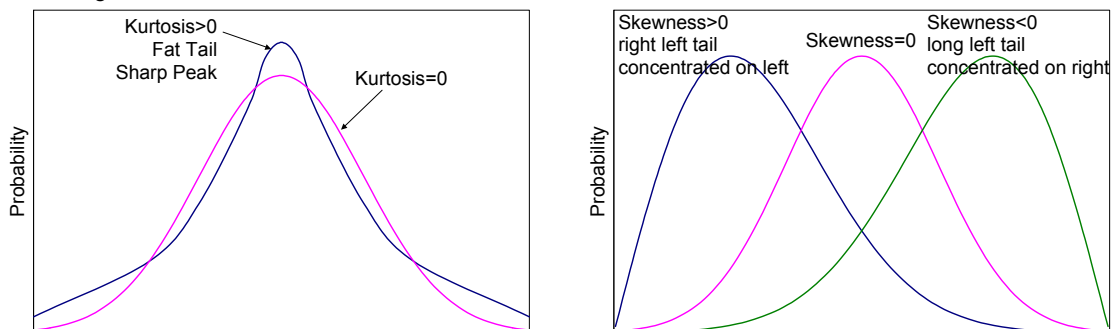
- concentration on left and longer right tail (positive skewness): conscious of price falling are recognized clearly^{8, 9}. As reason of such expectation of the market, resurgence of actual demand decline brought about by recession and concern about too rapid price rise are considerable.

⁶ In the money, out of the money and at the money: If options are exercised now and gain is available, it is called “in the money”. In case of loss, it is called “out of the money”. If the strike price is equal to the current underlying asset price, it is called “at the money”.

⁷ Kurtosis and skewness: kurtosis is a measure of the peakedness and fat tails of the probability distribution. Positive (excess) kurtosis means that the distribution has fat tail and sharp peak.

Skewness is a measure of the asymmetry of the probability distribution. Positive skewness means that the right tail is longer and the mass of the distribution is concentrated on the left.

Both skewness and kurtosis are zero for normal distribution. Many of financial data series have asymmetry and fat tail compared with log normal distribution.

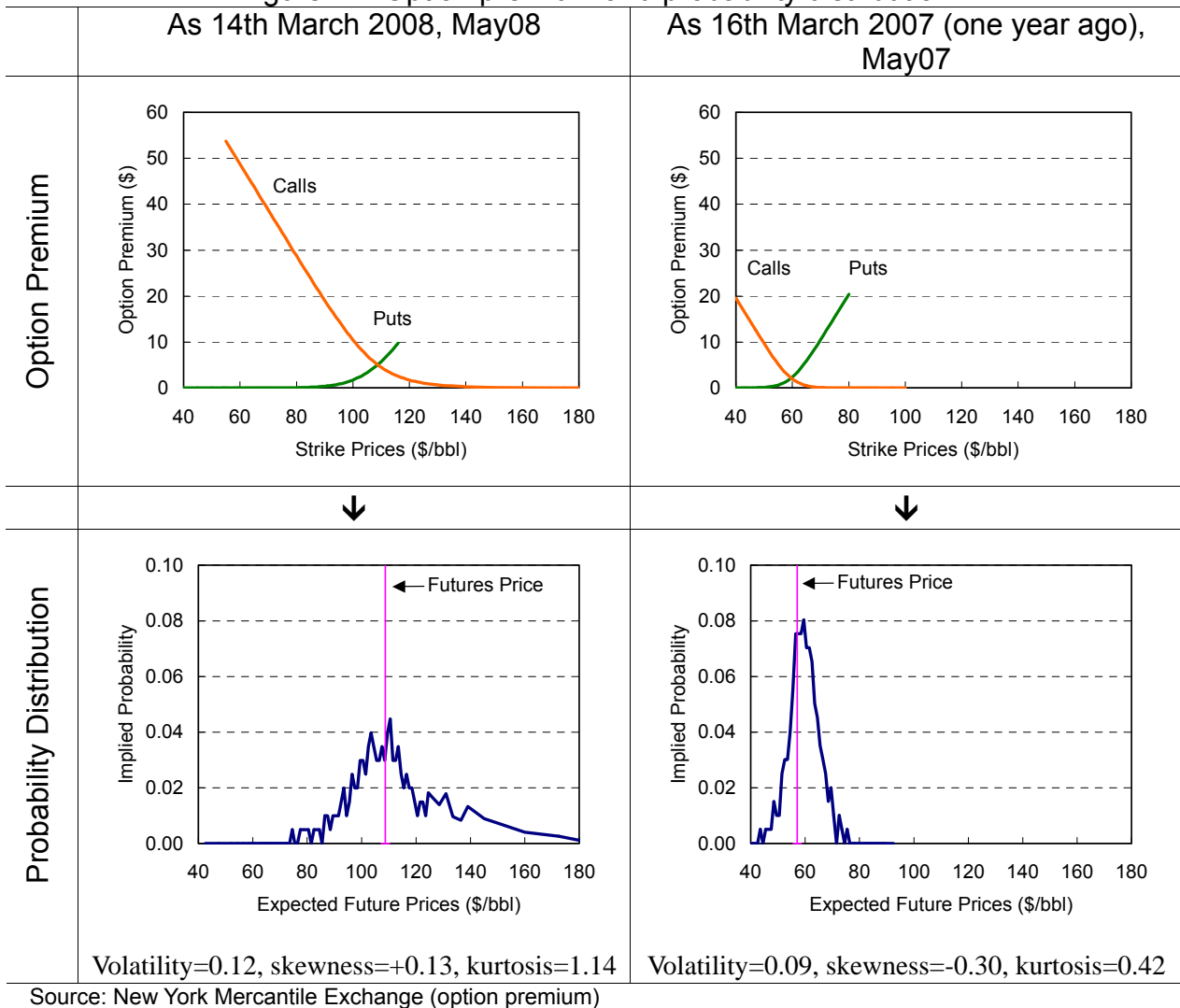


⁸ The following relation is addressed between statistics and prices:

Increase of both volatility and kurtosis, Increase (decrease) of skewness → growing expectation for rise (fall) in prices

⁹ In this paper, statistics (volatility, skewness and kurtosis) are calculated for logarithm of the intending prices following assumption in the Black-Sholes model, in which the underlying asset prices follow log normal distribution. Therefore, impression from anti-logarithm based figures can be unmatched from these statistics.

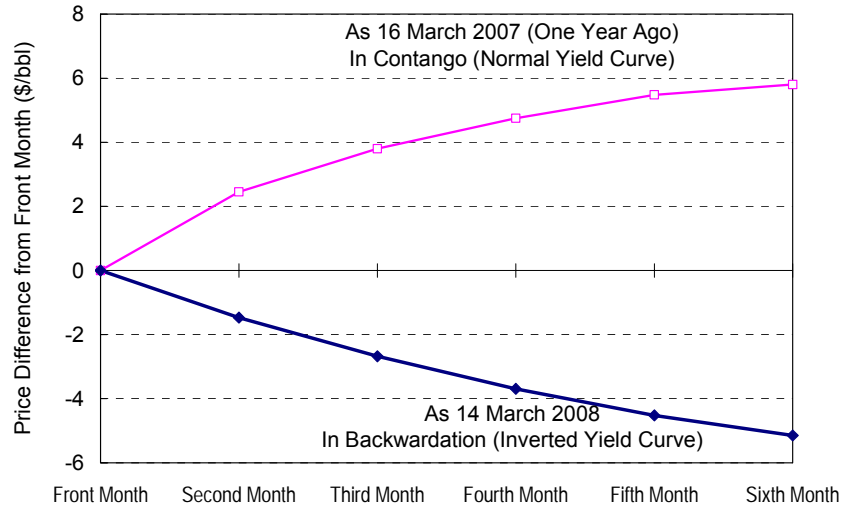
Figure 2-1 Option premium and probability distribution



(4) Market expectation for back months seen in options

To fathom market expectation for back months, forward curves are used often. “Contango” is a situation in which far future delivery prices are higher than nearer future delivery, or normal yield curve. “Backwardation” is a situation in which far future delivery prices are lower than nearer future delivery, or inverted yield curve. By judging the forward curves are whether in contango or in backwardation, people try to fathom market expectation for back months.

Figure 2-2 Crude oil forward curves



Source: Computed from New York Mercantile Exchange data

In WTI futures, however, backwardation is observed often. One of many aspects of backwardation is hedging pressure by commercial sellers is relatively strong.

Being in contango is tended to be regarded as situation that something is different from normal because backwardation is observed in general. For example, the latest contango, from 2005 to mid 2007, is generally regarded as a sign that the market was at a bullish position for future prices. In contrast, it is thought that unexpectedly deep price drop led to contango in 1998 and 1999.

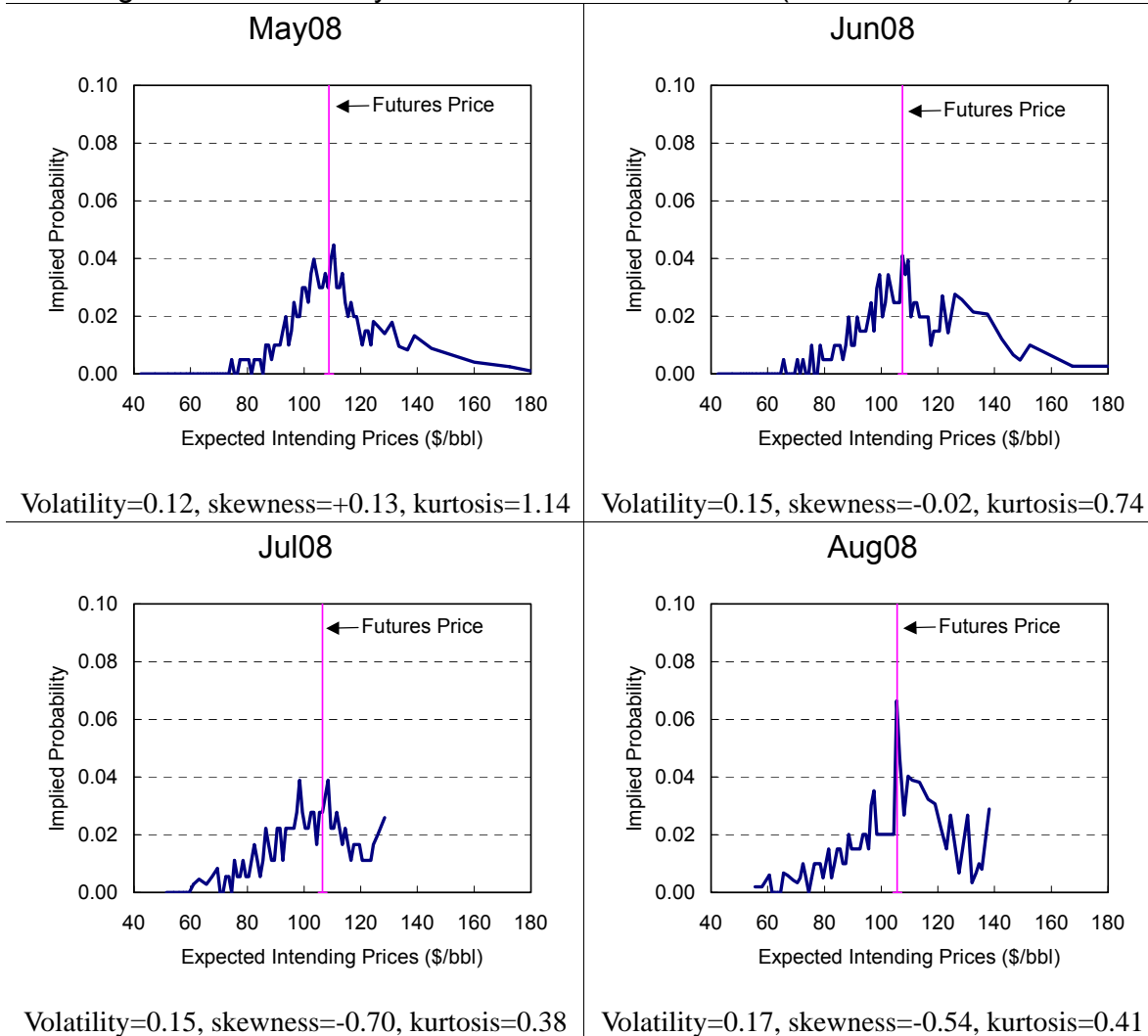
On the other hand, being in backwardation is uncertain as to whether or not market is in a bearish position. Oil price rise with backwardation is far from rare¹⁰.

In this chapter, to see market expectation for the far future, probability distribution for back months is estimated as in the previous chapter.

As noted above, the market seems to be in a bearish position for May08 because of probability distribution with bigger kurtosis and positive skewness. For Jun08 though \$120 - 130 is relatively strong, it is seemed that bullish and bearish position is counterbalanced because of almost zero skewness. For Jul08 and Aug08, it is hard to judge the market expectation from statistics because of less accuracy for the highest price range led by limitation of strike prices and insufficient contract volume. According to impression of big picture of the probability distribution, it is seemed that the market is in neutral position or uncertain.

¹⁰ There are two cases for such situation. One is that the oil prices rise with backwardation though the market expects price rise. Another is that the oil prices rise despite bearish expectation in the market.

Figure 2-3 Probability distribution of back months (as 14th March 2008)



Note: For Jul08 and Aug08, accuracy for the highest price range is less because of limitation of strike prices, and insufficient contract volume.

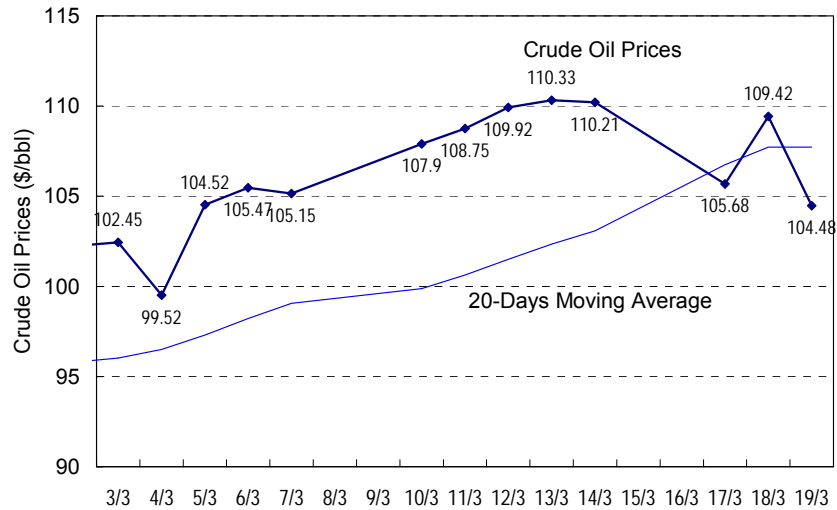
Of course, the market expectation is not realized as the actual price at all time. However, there is a possibility that the oil prices will not rise monotonically because the market expectation is not in a complete bullish position.

3. Postscript¹¹

This small postscript was added because the oil prices had fluctuated after finishing writing.

In 17th March, the beginning of the week, the oil prices dropped \$4.53, to finish \$105.68, the lowest level in 10 days. Although it rebounded sharply in 18th March, it plunged again to \$104.48 in 19th March. A drop of \$4.94 in a day is the first time in 17 1/2 years since 22nd October 1990 when it plunged \$5.41 — although the oil prices at that time was less than \$30.

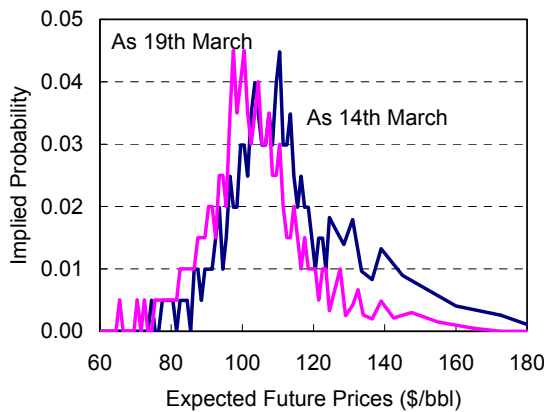
Figure 3-1 WTI prices



Source: New York Mercantile Exchange

The probability distribution in 19th March shifted to left from that of the 14th March in concert with the plunge of the oil prices. Additionally, conscious for around \$130 was grossly weakened. Moreover, it is noted that skewness turned to negative for the first time in a month.

Figure 3-2 Probability distribution (May08, as 14th March and 19th March)



As 19th March:
 Volatility=0.13,
 Skewness=-0.22,
 Kurtosis=0.95

As 14th March:
 Volatility=0.12,
 Skewness=+0.13,
 Kurtosis=1.14

It is not clear from only data of 19th March that this shows sign of change of the market expectation or delay of expectation adjustment for the plunge because of rollover, etc.

At any rate, the oil prices are affected largely by the financial market for the time being and cynosure of all eyes.

¹¹ This chapter is based on information by 20th March 2008.

References

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