Crude Oil Contracts: The "Message from Markets"

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Professor Ehud Ronn (standing), McCombs School of Business, University of Texas at Austin, in discussion with Professor Vince Kaminski, Rice University, at the September 30, 2016 JPMCC Research Council meeting. Both are members of the JPMCC's Research Council.

Overview

One of the most oft-cited, and frequently hotly debated, questions in financial markets pertains to the question of what it is markets are "telling us": What is it about the level of prices, and their volatility, that conveys the message of the current state of the oil markets.

To address the "Message from Markets," this paper considers two important indicators:

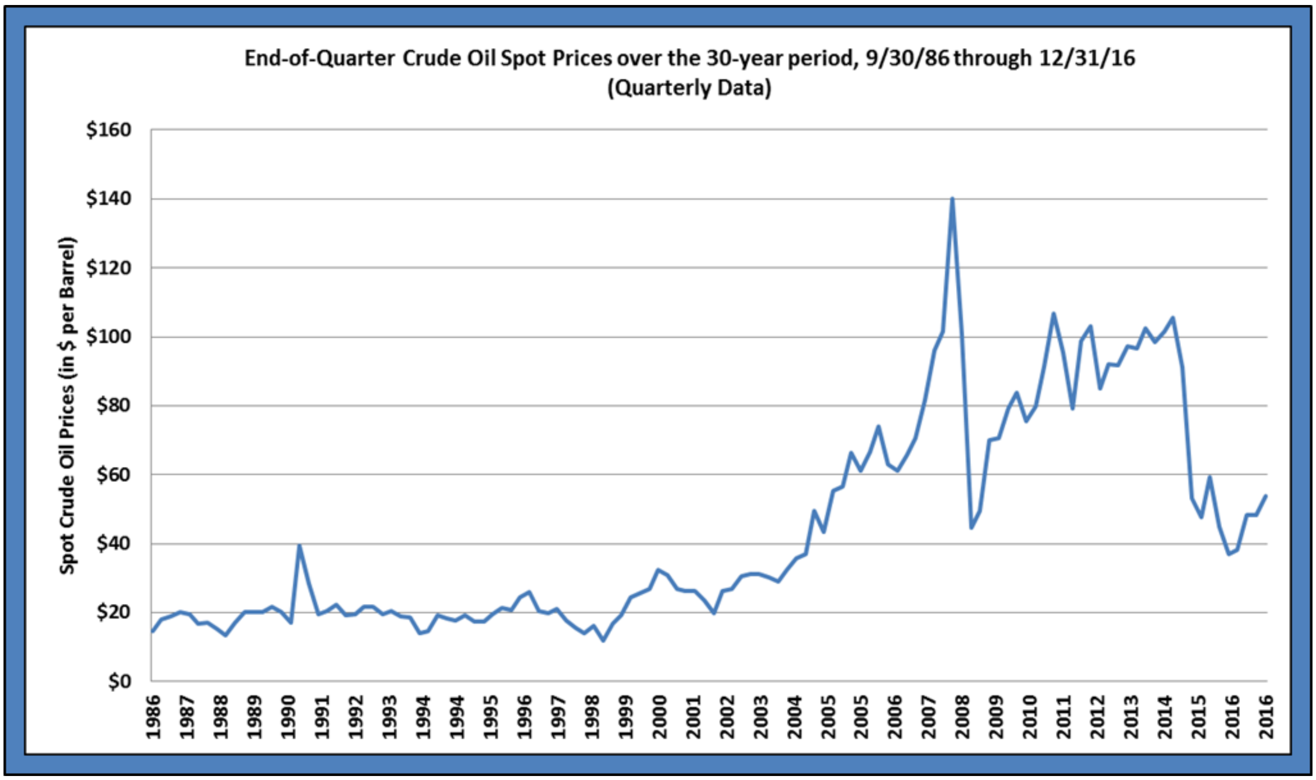
1. The *Level* of Crude Oil Spot prices (a.k.a., the crude oil "prompt-month" prices), and

2. *Volatility* — not the historical, but rather the "priced," or so-called "implied," volatility — of Crude Oil Futures Prices.

The Level of Crude Oil Spot Prices

The "spot price of crude" is defined to be the price of the "prompt-month" futures contract, that is, the futures contract closest to maturity. As the nearby contract matures and ceases trading, on or about the third week of the calendar month,[1] the next maturity futures contract takes over the role of the prompt-month contract. When we splice together the prices of these prompt-month contracts, we obtain Figure 1, which depicts end-of-quarter crude oil spot prices over the 30-year period, 9/30/86 through 12/31/16.[2] Over the first part of this period, through 2002, prices remained remarkably stable in the \$20 ± \$5/barrel range — the exception being the price spike to circa-\$40 surrounding "Persian Gulf I" in the Aug. 1990 – Feb. 1991 period.[3]

Figure 1



Source of Data: The Bloomberg.

Beginning in 2002, prices began a dramatic increase, driven primarily by the voracious demand of the developing economies such as China and India. This particular run reached its apogee as prices rose to the \$140-level at the beginning of July 2008. Then, with the onset of the worldwide recession, prices collapsed to the mid-\$30 range. Subsequent to the 2009 end of the "Great Recession," prices recovered to the \$100 mark before the precipitous decline in 2014 to sub-\$30 levels before then appreciating again to their current \$50s.

As important, if not more so, than the demand side, oil prices are dramatically impacted by supply-side concerns, geopolitical and meteorological in nature. The geopolitical concerns are found in several regions of global unrest. As is well-known, geopolitical uncertainty in at least three distinct areas of the Middle East evokes supply concerns: the eastern Mediterranean, Iraq and Iran. Outside the Middle East, supply concerns arise due to domestic unrest in the oil-producing areas of Nigeria. Finally, current relations between the United States and one of its Latin American providers, Venezuela, are occasionally sources of concern.

With the growing importance of onshore oil production using hydraulic fracturing ("fracking") in the continental U.S., the importance of meteorological phenomena such as hurricanes in the Gulf of Mexico (and, for that matter, El Niño in the Pacific Ocean) may have diminished in its ability to impact crude oil prices.

Crude Oil Futures Options' Implied Volatilities

One of the most interesting message-from-markets indicators is that of a metric inferred from option prices — the implied volatility that can be extracted from option prices using the famed Black-Scholes (1973) and Black (1976) option pricing models. After defining implied volatility, to lend perspective to the analysis we will first consider implied volatility ("implied vol") in the equity market, then make the transition to the crude oil futures market.

Definition of Implied Volatility

The key to the seminal contribution of the Black-Scholes-Merton option pricing model is the identification of the parameters which determine option prices.[4] Specifically, for an option on a stock index or a futures contract such as crude oil futures, the Black futures-option model (the latter is a variant of the stock-based Black-Scholes model) provides the value of an option (c) given the inputs of: futures contract price (F), strike price (K), risk-free rate (r), time to expiration (T) and prospective volatility (σ) over the remaining time to the option's expiration. It is important to note that of all these parameters, all are observable (the time to expiration and the strike price are *contractual*) save the future volatility σ.

Econometricians have devised numerous ways of estimating prospective volatility using recently-observed returns on the underlying asset (stock or futures). These volatilities are then substituted into the Black-Scholes model to obtain the option's fair market value.

In contrast to using such historically-based volatility estimates, implied vol changes the question: instead of asking,

> "What is the value of the option?"

the question posed is:

> "Given the option's observable market price, and assuming the market is using the Black-Scholes model to price options, what volatility number is the 'market' using?"

Table 1 provides a useful contrast of implied vol relative to its better-known historical-volatility counterpart:

Table 1
Contrasting Implied vs. Historical Volatilities

Descriptor	Historical	Implied
Method of Calculation	Standard Deviation of Rates of Return	Inferred from Option Prices using the Black-Scholes Model
Data Period for Calculation	*Past* History [−t, 0]	*Forward*- Looking [0, T], where T is the maturity date of the option
Bias, due to a Risk Premium, as a measure of volatility	None	Typically perceived as an *upward* -biased measure of future volatility

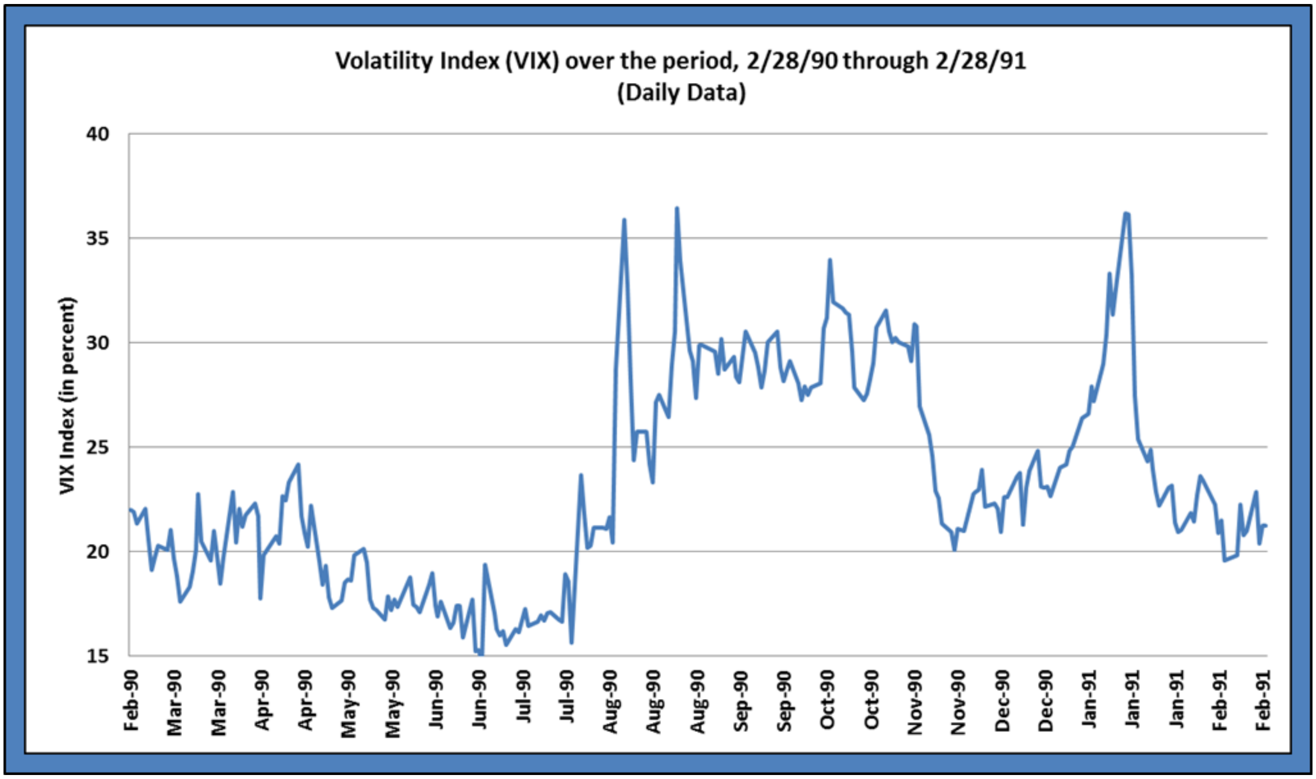
VIX — The Implied Volatility of the S&P 500 Index

The time-series of VIX, the 30-day implied volatility of the S&P 500 Index, is a subject which also fully merits an in-depth analysis of its own. Our purpose here, however, is simply to describe VIX, interpret its value and exemplify its application. Consider the following quotes from the CBOE’s http://www.cboe.com/micro/vix/faq.aspx#1:

> “1. What exactly is VIX?
>
> In 1993, the Chicago Board Options Exchange (CBOE) introduced the CBOE Volatility Index, VIX, and it quickly became the benchmark for stock market volatility. It is widely followed and has been cited in hundreds of news articles in the *Wall Street Journal*, *Barron’s* and other leading financial publications. Since volatility often signifies financial turmoil, VIX is often referred to as the ‘investor fear gauge’. VIX measures market expectation of near term volatility conveyed by stock index option prices.
>
> 2. Why is VIX called the ‘investor fear gauge’?
>
> VIX is based on real-time option prices, which reflect investors’ consensus view of future expected stock market volatility. Historically, during periods of financial stress, which are often accompanied by steep market declines, option prices — and VIX — tend to rise. The greater the fear, the higher the VIX level. As investor fear subsides, option prices tend to decline, which in turn causes VIX to decline.”

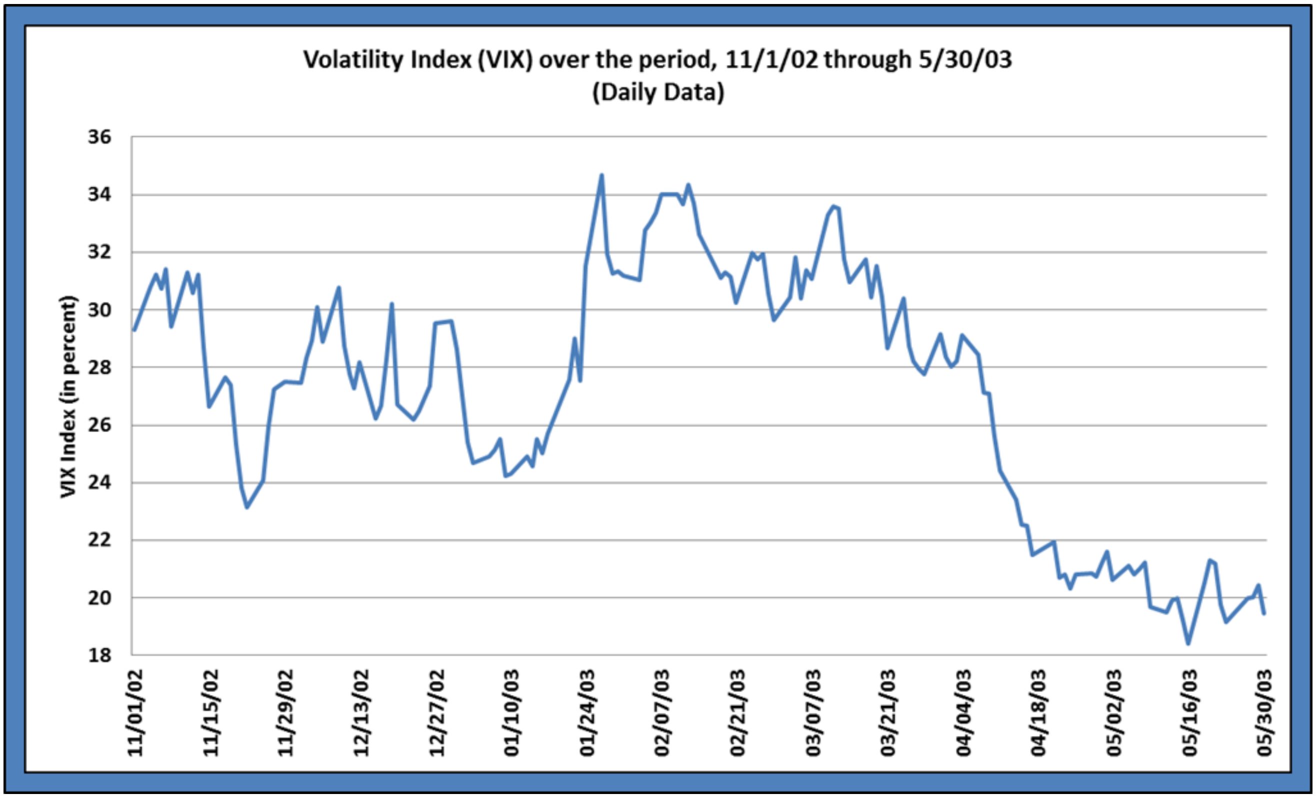
Figures 2 and 3 graph VIX over the two periods, 2/28/90 – 2/28/91 and 11/1/02 – 5/30/03, which span the two Persian Gulf conflicts.[5] VIX’s high-water marks in these two periods are 36.47% on 8/23/90 and 34.69% on 1/27/03. Using VIX as the measure of investor uncertainty/nervousness, investors (through VIX) assessed both conflicts as presenting equal risks to the U. S. economy. Although political scientists may take issue with this characterization, I thus infer from VIX a quantitative measure by which to measure any crisis, be it geopolitical, economic or financial.

Figure 2



Source of Data: The Bloomberg.

Figure 3



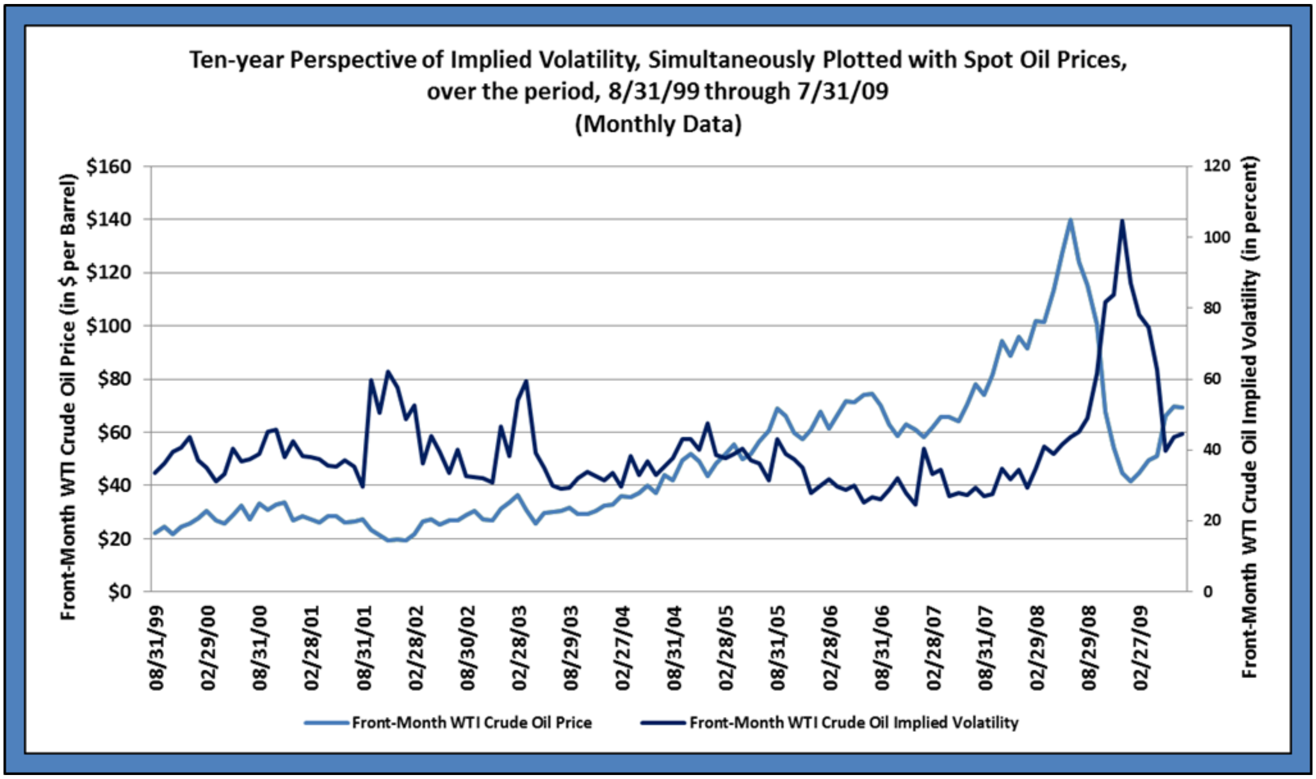
Source of Data: The Bloomberg.

<u>Implied Volatility on Crude Oil Futures Contracts</u>

In light of the previously-described stock market-based VIX, and its interpretation in terms of an intertemporally-comparable measure of nervousness and uncertainty, consider now the implied volatility on crude oil futures contracts. Analogous to VIX, we will in the following graphs for the most part focus on the short-term implied vol, that inferred from the option on the prompt-month crude oil futures contract:

1. Figure 4 presents a 10-year perspective (8/31/99 – 7/31/09) of implied vol simultaneously plotted with spot oil prices. The price series is depicted in dollars/barrel along the left axis; the implied vol is graphed in percentage points on the right axis. In general, non-crisis vols are in the admittedly-wide range of 20% to 40%, with recognizable crises taking the vol into higher, occasionally significantly higher, ranges.

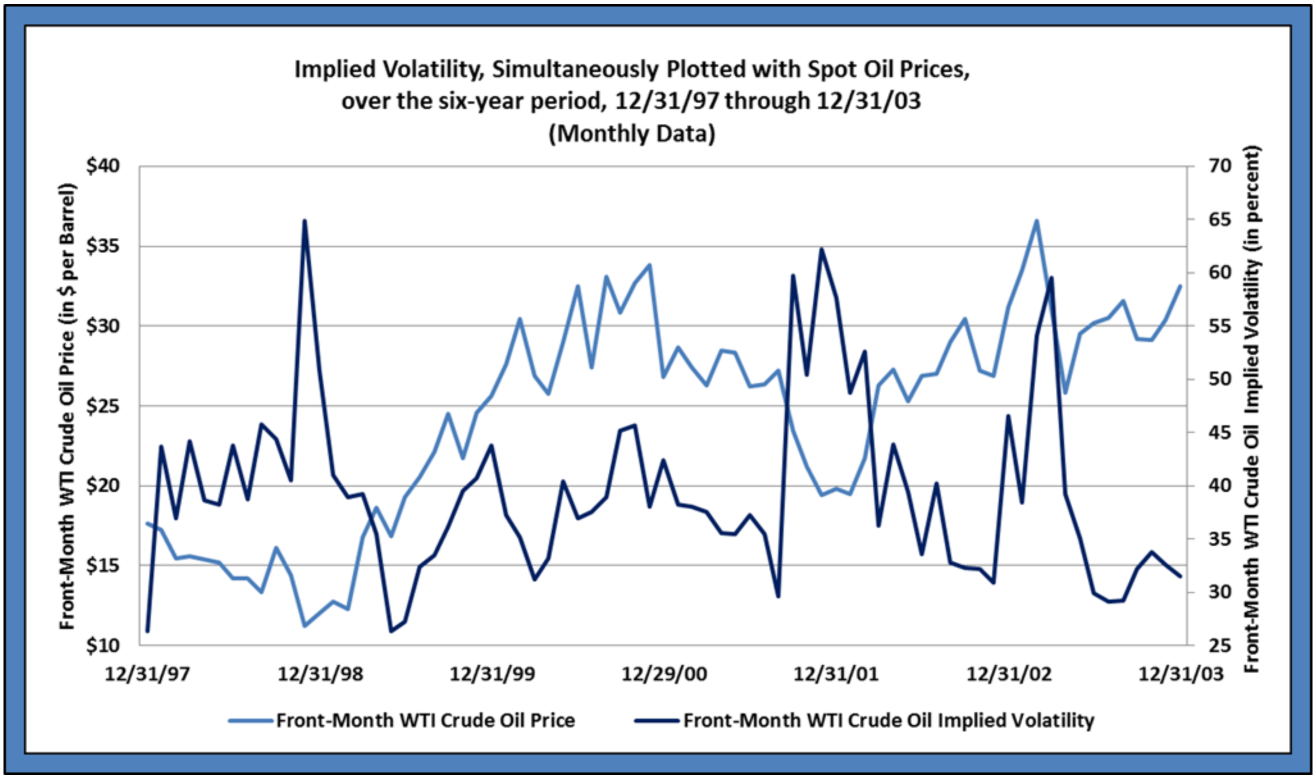
Figure 4



Source of Data: The Bloomberg.

2. Figure 5 considers these two price series over the six-year period, 12/31/97 – 12/31/03. We discern three major crisis periods over this time: the aftermath of the Asian financial crisis in 1998, the period of 9/11/01, and "Persian Gulf II" in the spring of 2003. The early and late-1970s accustomed us to thinking of oil-related crises as primarily *supply-driven*, wherein the correlation between increasing prices and higher implied vols is positive.[6] In fact, we see that two of the three most-recent episodes were in fact demand-driven: the 1998 episode is the aftermath of the Asian financial crisis, which reduced Far Eastern oil demand. In the immediate aftermath of 9/11, markets were concerned the U.S. economy would be pushed into recession or depression. In these two events, the correlation between prices and vols is negative.

Figure 5

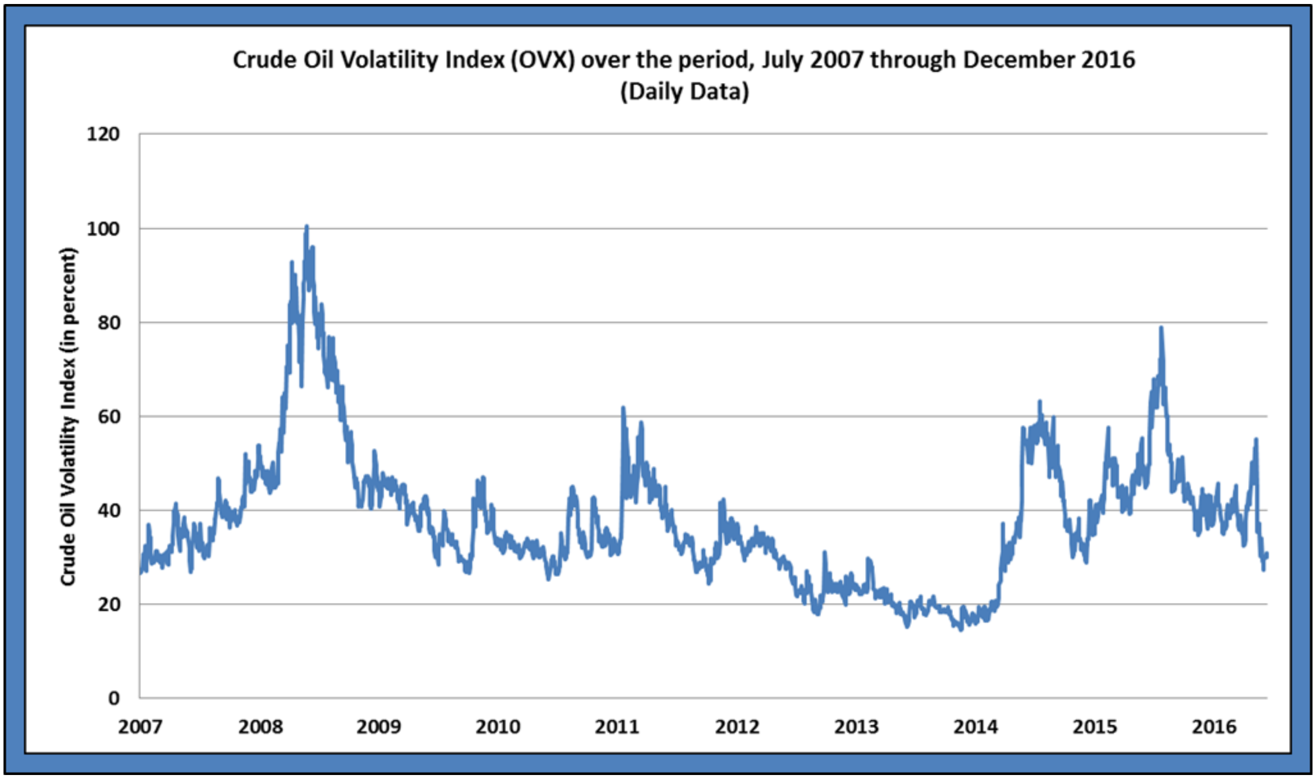


Source of Data: The Bloomberg.

The spring of 2003 is the traditional supply-driven crisis: "Persian Gulf II" raised concerns supplies of oil from the Persian Gulf would be curtailed, driving both prices and vols higher.

3. Figure 6 brings us to the present. Turning our attention to data frequency shorter than one-month, we can now use the available OVX index, initiated in May 2007, to graph the relevant crude oil implied vol on a daily, rather than monthly, granularity. As prices climbed ever-higher in June 2008 and the effects of the recession were becoming more apparent, oil vols exceeded the 40% level. As prices crashed and financial ramifications of the recession hit our financial markets, vols spiked to a peak over 100%. The observed negative correlation between prices and vols is, again, a manifestation of *demand-side* effects, clearly driven by recessionary conditions.

Figure 6



Source of Data: The Bloomberg.

Crude oil vols spiked both in 2011 — with the onset of the so-called "Arab Spring" — as well as in 2014 with the sharp decline in oil prices. As we close out this report at the end of 2016, OVX has subsided to a reasonably-moderate level of 30% (the equity VIX is at 14%).

Informationally-Efficient Financial Markets

In their well-known textbook, Principles of Corporate Finance, Brealey, Myers and Allen write:

> "If [financial markets are] efficient, prices impound all available information. Therefore, if we can only learn to read the entrails, security prices can tell us a lot about the future."

Financial markets in general, and energy finance markets in particular, are highly informative. The challenge is always in what the three authors termed "reading the entrails" — that is, what is the "Message from the Markets"? In this paper, we have attempted to address that question by considering crude oil commodity markets, specifically, the level of spot prices and the implied volatility of crude oil futures prices.

Endnotes

1 Per NYMEX specifications,"[t]rading terminates at the close of business on the third business day prior to the 25th calendar day of the month preceding the delivery month."

2 The frequency, or "granularity," of the data is not a matter of indifference. When plotting quarterly data, intra-quarter monthly, weekly, daily and intra-daily prices are lost. These latter prices will of course portray higher highs and lower lows than the end-of-quarter prices.

3 I have used the terms, "Persian Gulf I" and "Persian Gulf II," as shorthand for periods of hostilities in and around Iraq. To clarify, "Persian Gulf I" refers to Operations Desert Shield/Desert Storm (1990 – 1991), whereas "Persian Gulf II" refers to Operation Iraqi Freedom (2003).

4 The pioneers of the option pricing model were awarded the Nobel Prize in Economic Science in 1997.

5 I submit the term "investor nervousness/uncertainty index" is more appropriate, as "fear" may denote an element of irrationality.

6 Econometricians might challenge the implicit assumption of oil prices as log-normally distributed. (To explain, saying that oil prices follow the log-normal distribution is another way of saying that oil-price *returns* follow the normal distribution.) In my view, the observed volatility changes are too large to be driven by purely statistical effects.

References

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Author Biography

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Ehud I. Ronn is a Professor of Finance at the McCombs School of Business, University of Texas at Austin.

Dr. Ronn obtained his B.Sc. and M.Sc. in Economics at the Technion, the Israel Institute of Technology, and his Ph.D. in Finance from Stanford University. He has published articles on investments, interest rate-sensitive instruments and energy derivatives in the academic and practitioner literature. He is the editor of Real Options and Energy Management: Using Options Methodology to Enhance Capital Budgeting Decisions, which was published in 2002 by Risk Books, London.

Prior to joining the University of Texas in July 1988, Dr. Ronn was a faculty member at the University of California, Berkeley, and the University of Chicago. Dr. Ronn was the founding director of the University of Texas at Austin's Center for Energy Finance Education and Research over the years 1997 – 2009. In Fall 2011, Dr. Ronn was a visiting professor of finance at Dartmouth College and Fordham University.

During 1991 – '93, Dr. Ronn served as Vice President, Trading Research Group at Merrill Lynch & Co. From January 2010 to February 2011, Dr. Ronn served as Commodity Market Modeling practice area manager at Morgan Stanley & Co.

From May 1998 to June 2001, Dr. Ronn was a principal of the Law and Economics Consulting Group. From June 2001 to July 2002, Dr. Ronn was appointed Senior Advisor at PA Consulting Group. Since 1993, he has served as a consultant to government agencies, an insurance company, investment banks, risk advisory firms and energy-derivative software vendors in the interest-rate and energy-commodity arenas.

In November 2004, Dr. Ronn was selected by *Energy Risk* to be included in the "Energy Risk Hall of Fame."

Dr. Ronn is also a member of the J.P. Morgan Center for Commodities' Research Council at the University of Colorado Denver Business School.