One Potential Reason the Oil Market Broke

Jessica Chipera, MBA

On April 20, 2020, shortly before expiration, the May futures contract for West Texas Intermediate crude oil fell into negative prices. Speculation about how that could have happened ran rampant all-over financial news. With storage running out worldwide, nobody wanted to accept delivery of barrels of oil, so traders began dumping their oil futures at any price.

With everyone on the same side of the trade, the price quickly and not surprisingly crashed to $0.00. Amazingly, it fell lower than that. The moment the price became a negative number, something broke. Specifically, the Black Scholes Option Pricing Model. Some traders buy options on futures contracts because there are tax advantages to doing so. In other words, people who buy a call option on an oil futures contract buy the right to have an obligation to buy barrels of crude oil on a specific date. Traders who buy a put option on an oil futures contract are buying the right to have an obligation to sell barrels of crude oil on a specific date.

This trade becomes problematic now that the Chicago Mercantile Exchange is allowing negative prices to continue. While options prices are heavily influenced by supply and demand, their value is calculated mathematically, and this is where the trade breaks, particularly for traders who purchased the right to sell oil for a price above $0.00 (by buying put options on oil futures).

The Black Scholes Formula defines the price of a put option as:

$$P = Xe^{-rt}N(-d_2) - Se^{(b-r)t}N(-d_1)$$

Where:

X = Strike price of the option

r = Risk free rate of return (%)

t = Time to expiration, in years

S = Price of the underlying oil futures contract

b = Dividend yield of the underlying (%)

$$d_1 = \frac{Ln\left(\frac{S}{X}\right) + \left(b + \frac{\sigma^2}{2}\right)t}{\sigma\sqrt{t}}$$

$$d_2 = d_1 - \sigma\sqrt{t}$$

σ = Annualized standard deviation (%)

Assume that S = −$1.00 and X = $1.00

Therefore:

$$d_1 = \frac{Ln\left(\frac{-1}{1}\right) + \left(b + \frac{\sigma^2}{2}\right)t}{\sigma\sqrt{t}}$$

$$= \frac{\pi\, i + \left(b + \frac{\sigma^2}{2}\right)t}{\sigma\sqrt{t}}$$

$$d_2 = \pi\, i + \left(b + \frac{\sigma^2}{2}\right)t - 1$$

Note that both d_1 and d_2 are complex numbers because the log of a negative number is an imaginary number (i).

Therefore, the price of the put is also a complex number:

$$P = Xe^{-rt}N\left[-\pi\, i - \left(b + \frac{\sigma^2}{2}\right)t + 1\right] + e^{(b-r)t}N\left[-\frac{\pi\, i + \left(b + \frac{\sigma^2}{2}\right)t}{\sigma\sqrt{t}}\right]$$

Of course, if both the strike of the option and the price of the underlying are negative numbers, the resulting price of the option is indeed a real number. The math breaks every time the strike price of the option and the price of the underlying security are on opposite sides of $0.00.

Nobody has imaginary dollars to pay for a few thousand barrels of oil (except maybe the Federal Reserve). Therefore, the CME Group has decided to switch to the

Bachelier Options Pricing Model to determine the price of options on oil and other specific related commodities. This fixes the problem of complex numbers because Bachelier's model only requires that time and volatility be positive numbers.

However, regardless of the pricing model used, negative oil prices are still problematic.

What happens to the rights and responsibilities if the underlying security remains at a negative price? If a trader buys a negative strike call on an oil futures contract, does the trader then pay for the right to receive money to accept delivery of oil? If that sounds like printing money, what about selling a put contract on oil futures (receiving money to be obligated to receive money to accept delivery of oil)? Why would anyone buy a put (pay money for the right to pay someone else to accept delivery of oil)?

The market maker is obligated to buy puts if nobody else is willing to buy them from put sellers. In addition, the market maker would probably short oil futures so that they can remain delta-neutral and avoid taking delivery of oil they cannot store. Such an action then pushes the price of oil even more negative.

If oil futures remain negative, large funds that track the benchmark futures contract could blow up. While futures are now permitted to go negative, an exchange traded fund cannot have a negative net asset value. Technically, that would be insolvency.

This also raises the question: what other commodities will drop into negative territory? What does an economy with negative prices look like?

Jessica Chipera

6300 Riverside Plaza Dr. NW, Suite 100

Albuquerque, NM 87120

Legal Information and Disclosures

This white paper expresses the views of the author as of the date of its publication. Such views could change without notice. Companies with which she is affiliated have no connection to the white paper. This white paper is available for educational purposes only and should not be used for any other purpose. The information contained in the white paper should not be construed as an offering of advisory services or an offer to sell or solicitation to buy any securities or related instruments in any jurisdiction. Certain information contained in the white paper concerning economic performance are based on or derived from information provided by independent third-party sources which the author believes to be reliable; however, the author cannot guarantee the accuracy or completeness of such information. This white paper, including all information contained in it may not be copied, reproduced, republished, or posted in whole or in part, in any form without the prior written consent of the author.