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Oil Prices: Backward to the Future?

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Bad as the economic consequences of higher oil prices might be, the fog surrounding their future path only makes things worse. People wonder, can they go higher? Will they fall? To gain some clarity, many observers have looked to oil futures prices as a quick and easy means to forecast the direction of oil prices. After all, that is the market where experts trade contracts for the future delivery of oil. Unfortunately, futures prices do not predict well. A close examination of the futures market may help us understand the forces affecting oil prices, but won't tell us much about where those prices are headed.

This *Economic Commentary* explains the basic workings of the oil futures market and the economic forces that set the spot and futures prices of oil.

Crude Oil Futures

Until the late 1970s, oil prices were primarily determined by long-term contracts between oil producers and international oil companies. OPEC produced 67 percent of the free world's crude oil, allowing it to dominate the price and quantity of oil sold. Prices fluctuated when these long-term contracts were revised, but prices were not otherwise particularly responsive to market conditions. Spot markets—markets for immediate delivery—were relatively unimportant, and accounted for only 10 percent of internationally traded crude oil.

However, the oil market began to change as non-OPEC countries surpassed OPEC oil production for the first time in 1982. Owners of the newer oil, from areas such as the North Sea, lacked the typical long-term contracts with buyers, forcing them to find other ways to build market share. They were able to achieve this objective on the spot markets by undercutting OPEC. Buyers were attracted by prices that could range as much as $8 per barrel below long-term contract prices. The strategy worked, and a fundamental change took place in the oil market. By the end of 1982, almost half of all internationally traded oil was traded on the spot market instead of through long-term contracts. Even the world's largest oil companies began turning from long-term contracts, replacing them with market-determined price agreements. With prices now determined on a very-short-term basis, daily fluctuations in the price of oil became the norm. In order to hedge against daily fluctuations in the oil market, participants began purchasing oil futures.

With an oil future, a buyer agrees to purchase oil at a prespecified price and quantity on a certain date in the future, the expiration date. The agreement is made today, but the oil and the payment are delivered in the future. This contract eliminates the uncertainty and price risk for both the buyer and seller. This insurance comes at a cost, however. If the actual spot price on the expiration date differs from the futures price, one party will regret signing the contract. This party has an incentive to default on the agreement, because he either purchased oil for higher than the prevailing market price, or sold oil for lower than the spot price. In order to reduce the credit risk, futures contracts are marked to market daily using the closing futures price. This means that whenever the closing futures price goes up or down, the gain is credited to—or the loss is debited from—the appropriate party's margin account. Participants must maintain a specified amount of funds (the margin requirement) in this account.

A useful first guess about the future spot price of a commodity is usually found in its current futures price. But it doesn't work that way when the commodity in question is oil. This *Commentary* explains why the characteristics of oil, particularly the value it can offer its owner by remaining in the ground, cloud the information that oil futures prices give about future oil prices.

By marking to market daily and making sure participants maintain margin requirements, credit risk is lower than it would be if gains and losses were not settled until the expiration date. For some commodities, the credit risk is further lowered by setting a cap on the amount prices can change in any one day, limiting a trader's immediate losses. This is not the case for oil, though; trading is halted for five minutes whenever a contract is traded, bid, or offered for $10 above or below the initial price.

Although crude oil futures began trading on the New York Mercantile Exchange (NYMEX) in 1983, trading was relatively limited until 1985. Today, oil is the world's most heavily exchanged commodity, with "light, sweet" crude the most heavily traded of over 161 different types. Oil that is "light" has a low density, and "sweet" means a low sulfur content. These determine the quality of the oil, or how much of the oil can be refined into gasoline. West Texas Intermediate (WTI) is a very high quality crude oil, and therefore its price is usually higher than other blends, such as

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Brent Blend, which is less sweet and not as light. WTI is the crude benchmark in the Americas because of its high quality and because most WTI is refined in the United States, where most gasoline is consumed.

When most major U.S. newspapers report the spot price of oil, they are referring to the one-month NYMEX futures price. A NYMEX crude oil future is a contract for 1,000 barrels of domestic light, sweet crude oil. To be included in the contract, the oil must meet specifications on sulfur content and density. Because WTI meets these standards, it is often traded in NYMEX contracts. Therefore, the one-month NYMEX crude oil futures price and WTI spot price are nearly identical. An exception to this is at the end of the month, when the NYMEX futures contract expires three days before the WTI spot contract. The futures contracts are traded for 30 consecutive months, plus longer-term contracts of 36, 48, 60, 72, and 84 months prior to delivery.

Figure 1 shows the spot and 12-month futures prices since 1989.

Will Oil Prices Fall?

A glance at figure 1 reveals several characteristics of oil prices. One is, with apologies to the great stock speculator Bernard Baruch, that they fluctuate. The second is the large (if not steady) increase since 1999. The third pattern is a bit more subtle, but equally important: Spot prices are usually above futures prices. In futures market jargon, this is known as backwardation, and the oil market is in backwardation more than two-thirds of the time. What does this tell us about the oil market?

One of the first guesses about why the current spot price is above the futures price is that prices are expected to fall. In other words, the futures price is the expected future spot price. After all, if you think the spot price in six months will be higher than the six-month futures price, there's a profit to be made: You can buy the futures and in six months turn around and sell the oil at the higher spot price. People doing this should bid up the futures price until there is no more profit to be made. Conversely, if you see the futures price higher than you think the spot will be, sell the futures, which will drive down the futures price.

This reasoning is almost seductive in its simplicity, but it is wrong. As we explain below, it neglects some vital elements of this particular market, such as interest rates and the costs of storage, but the most telling criticism is factual. On the face of it, futures prices do not appear to be the expected spot price. One bit of evidence is the preponderance of backwardation: The oil market shows backwardation, with spot prices exceeding futures prices, 70 percent of the time. If futures predict spot prices, then spot prices should fall quite often. But oil prices do not fall anywhere near 70 percent of the time. Indeed, as figure 1 shows, the futures market has been "predicting" a fall since 2002, as oil prices more than doubled to record levels.

A closer look at the predictive ability of the futures price bears this out. Perhaps the simplest way of assessing a predictor's quality is to calculate the average difference between the predicted and actual value. In fact, the average error using oil futures prices is larger than the average error using the spot price. Errors using futures prices get worse relative to errors using spot prices the further out one forecasts. On average, you'd do better guessing that next year's oil price will be the same as today's than using the 12-month futures price (not that you'd do well).

Of course, average forecast error is not necessarily the only way to assess a predictor's quality. But more sophisticated approaches, such as using mean squared error or a linear regression to account for bias, do not find much predictive ability in oil futures.

One still might suspect that if we accounted for the average amount of backwardation, we could get good predictions. Removing the average backwardation helps little. The correlation between the adjusted futures price and the actual future spot is still about the same as the correlation between the current spot and actual future spot. This is true even for varying time lengths although, not surprisingly, the correlations go down the further out in time one goes.

So it seems that futures prices are, in general, no better a forecaster of future oil prices than the spot price. The enthusiast of making oil price forecasts using futures might wonder if futures prices add information about future oil prices that spot oil prices do not. Alternatively stated, are forecasts that use both futures prices and spot prices better than forecasts that use only the spot price? Even in this case, the futures price adds little.

Theory of Storage and Arbitrage

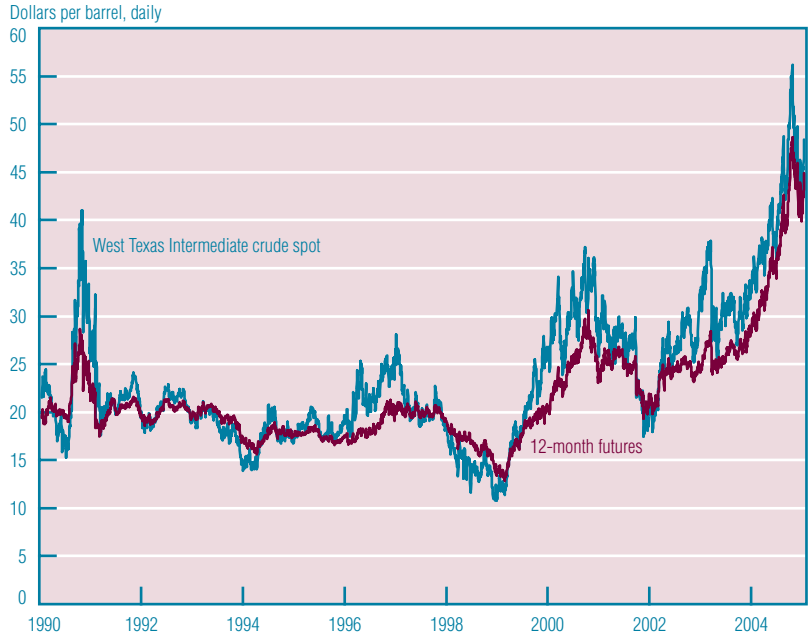
The failure of the "futures equals expected future spot" theory of futures prices is far from a recent phenomenon. Many famous economists in the 1930s and 1940s, such as John Maynard Keynes, Sir John Hicks, and Holbrook Working, noted its problems, at least for "full-carry" markets, that is, markets where extensive storage took place. These economists were the first to realize that a closer look at the costs and benefits of storage might give a better explanation of futures prices.

In one sense, the flaw in the "expectations" approach to futures prices was that it ignored uncertainty. You might think prices were going to rise, but if you weren't certain, playing your hunch left you open to a lot of risk. A high futures price is then less like a sure thing and more like a bet, and this affects the price because there is risk associated with the reward. Thinking about the problem from the perspective of storage, however, shows how analyzing profitable opportunities can tie down the futures price.

Consider once again that six-month oil futures contract. By taking it, you agree to deliver oil in six months, and in six months you get the agreed-upon price. If you're Shell Oil, or the Saudi royal family, you have oil to deliver, but if you're not, you can acquire it—at a cost. What does it cost to deliver the oil in six months? One strategy is to borrow money today to buy oil on the spot market, store it for six months, and then deliver it, get your payment, and pay back your loan. This puts a bound on the futures price: If the futures price is too high, it's worthwhile for market participants to buy oil and store it, driving the spot price up and the futures price down. Of course, the opposite strategy works if the futures price is too low, selling oil now and buying it on the futures market. (Since this may involve short selling, this case is a little trickier, but it works—see the recommended readings for carefully worked-out examples.)

This means that three things tie down the futures price: the spot price, the interest rate (borrowed money), and storage costs. Or, to turn things around,

FIGURE 1 CRUDE OIL SPOT AND 12-MONTH FUTURES PRICES, 1989–2004



SOURCES: New York Mercantile Exchange and Bloomberg Financial Information Services.

the futures price tells us about today's spot price, interest rates, and storage costs. Storage costs are generally pretty obvious, since many agricultural commodities spoil; even goods that don't, such as oil or gold, cost something to store. On average, then, this suggests that futures prices should be higher than spot prices because of interest charges and storage costs.

What then of backwardation, so common in the oil market, where the futures price is lower than the spot price? The crucial insight is that for some goods there are storage benefits as well as storage costs. If these benefits are large enough to balance storage costs and interest rates, backwardation can result. This storage benefit is referred to as the "convenience yield."

Storage benefits may sound strange, but the notion of a convenience yield is quite intuitive. A convenience yield is simply the benefit you get from owning an object. For instance, if you own a car, you get to drive it; if you own a house, you get to live in it; it has value beyond its worth as a financial asset. Another example would be art: You can admire your Duchamp as it hangs in your living room. A share of stock provides a less ethereal example; as it can pay you a dividend of cold hard cash, something you won't get if you merely have the right to buy it in the future.

How does this work out for oil? Well, for one thing, oil's explicit storage costs are quite small because it is naturally stored in the ground. Explaining backwardation, though, requires more than low storage costs, it requires convenience yield, and not even J.R. Ewing would think a barrel of oil in his sitting room had quite the charm of a Duchamp, Rodin, or Cassatt.

How, then, can oil have a convenience yield? First, it has a use option: If your refinery really needs input today, you can send it the oil you own. Having the inventory on hand is often easier, cheaper, and more convenient than going out and buying what you need, which may even be impossible on short notice. So, for example, if you promised gasoline to another company and face substantial penalties for delay, having oil you can deliver right now has its advantages. In other words, you have the option to stop speculating in oil and to start consuming it.

Owning oil has a related but more subtle benefit. Because oil is easy to store in the ground, there is a benefit to keeping it there. Not only is the future demand for oil—and thus its price—uncertain, but future supply costs are uncertain as well. Extraction costs (labor, drilling supplies, pipe costs) are uncertain, and so the profit from pumping oil six months from now is unknown. Keeping the oil in the ground today means that you can choose whether or not to pump it in six months. That is, if prices are high, pump out the oil; if they are low, leave it in the ground and wait for higher prices. Leaving the oil in the ground gives you the option to continue leaving it in the ground if prices don't shape up the way you want. (Pump it today and you are faced with high storage costs, risks of sabotage, or damaging oil spills.) But if everyone waits, there's no oil around today—so the price must rise to balance the two effects. The net result is backwardation: the price today is higher than the futures price to give an incentive to pump some oil now. The price today rises to offset the advantage of waiting to see the price before you pump.

■ Futures, Not Forecasts

The oil futures market is useful if you want to hedge, or speculate, on the price of oil, but it does not provide any easy way to predict where the price of oil is headed. When the good in question is easily stored, as is oil, the same supply and demand factors that would drive the futures price up would also drive up today's spot price. Storage costs, interest rates, and convenience yield then account for the difference between spot and futures prices. In particular, futures prices below today's spot price do not mean that oil prices are expected to decline. Nor is there anything special, or unusual, about such backwardation.

■ Recommended Reading

For a grand historical sweep of the role of oil in economics, politics, and the modern world in general, see:

Daniel Yergin, 1992. *The Prize: The Epic Quest for Oil, Money, and Power*. New York: Simon & Schuster.

A more sophisticated look at the ability of oil futures to predict spot prices can be found in:

Imad A. Moosa and Nabeel E. Al-Loughani, 1994. "Unbiasedness and Time-varying Risk Premia in the Crude Oil Futures Market," *Energy Economics* 16(2): 99–105.

Sergey V. Chernenko, Krista B. Schwarz, and Jonathan H. Wright, 2004. "The Information Content of Forward and Futures Prices: Market Expectations and Price of Risk," Board of Governors, International Finance Discussion Papers no. 808 (June).

The explanation of backwardation gets a more detailed (and technical) treatment in:

Robert Litzenberger and Nir Rabinowitz, 1995. "Backwardation in Oil Futures Markets: Theory and Empirical Evidence," *Journal of Finance* 50(5): 1517–45.

A good introduction to arbitrage in the futures market can be found in:

Ed Nosal, 2001. "How Well Does the Federal Funds Futures Rate Predict the Future Federal Funds Rate?" Federal Reserve Bank of Cleveland, *Economic Commentary*, (October 1).

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