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Futures-based commodity ETFs when storage is constrained

Key takeaways

- *Exchange-traded funds (ETFs) that hold futures contracts on commodities are an important link between commodity markets and financial markets.*
- *When commodity storage capacity is constrained, investor flows into ETFs holding futures can lower, instead of raise, commodity prices due to potentially high costs of physical storage.*
- *April 2020 briefly witnessed negative prices for the nearest-maturity futures contract on WTI oil, possibly due to such a combination of storage constraints and investor flows into ETFs.*

Financial products that reflect commodity prices have broadened the set of choices available to investors. Instruments like commodity futures can help market participants diversify their portfolios, hedge risks, and express views on economic developments. The rising popularity of futures-based exchange-traded funds (ETFs) is a key element of this trend.[1] Such ETFs buy and sell futures contracts, just as more traditional funds trade in stocks or bonds, and give investors, including smaller ones, the ability to easily change their exposure to commodities. Holding futures is a common strategy for ETFs that track the value of assets with relatively high storage costs, including energy or industrial metals.

This note reviews the market-functioning implications of wider access to commodity trading through futures-based ETFs. In general, ETFs enhance liquidity by attracting new investors, but they can affect price formation (Todorov (2019)). Our focus is on how ETFs can allow market participants to pursue strategies that, in some instances, may lead to unusual price movements for commodities with costly storage. Specifically, we consider the case of small investors using ETFs to bet on price reversals after rapid declines. Normally, large flows into ETFs raise futures prices, since ETFs buy futures in response. In certain cases, however, inflows could *lower* prices and even push them below zero. Since they are wrappers for the underlying assets, ETFs could also, in theory, see negative net asset values.

These counterintuitive dynamics are more likely to arise under three conditions. First, the futures purchased by ETFs are settled through physical delivery of the commodity and storage capacity at the delivery point is constrained. Second, ETFs hold a significant share of the futures market. Third, investors expect that large commodity price declines will be reversed in the future, so that unusually low prices attract large flows into ETFs. When all three conditions are met, ETF inflows may not lead to the usual price appreciation. Instead, these flows can raise storage costs at the physical delivery point enough to offset the typical demand-driven appreciation, possibly even leading to negative commodity prices.

The fall of some oil futures prices into negative territory on 20 April 2020 is a useful case study. Flows into futures-based ETFs tracking the price of West Texas Intermediate crude oil (WTI) accelerated in March

[1] In line with common practice, we use the term "ETFs" to refer to both investment vehicles holding actual securities and those structured as obligations of the issuer (exchange-traded notes). See Blackrock (2020) for a proposed classification taxonomy.

and April, just as available storage capacity at the futures delivery point became scarcer and costlier. High-frequency data suggests that strong demand by relatively small investors contributed to large inflows, which exacerbated the fall in WTI prices during the early afternoon of 20 April. Other major international oil benchmarks and US energy commodities were broadly unaffected, indicating that the price drop reflected issues specific to short-maturity WTI futures. As a result, this note mostly focuses on US ETFs that invest in physically settled WTI futures traded on the New York Mercantile Exchange.[2]

High storage costs and, more generally, problems with the physical-delivery procedure of futures contracts are known to affect prices. The events of April 2020 were unusual due to the stark fall in oil prices and the role of ETFs, but the impact of bottlenecks in the settlement process has been highlighted by past episodes in other futures markets. For example, the divergence of cash and futures wheat prices in the late 2000s originated, in part, from the exchange-mandated schedule of storage fees at the delivery point. Further back in time, in 1926, the US Federal Trade Commission worried about the fragility of the wheat-futures physical delivery process. Grains had to be delivered to Chicago although the city was not the main location for the physical handling of wheat (Irwin, Garcia, Good and Kunda (2009) and references therein). In addition, negative prices can occur in electricity markets, because storage is often impractical (Zhou, Scheller-Wolf, Secomandi and Smith (2015)).

The link between commodity ETFs and futures markets

The use of futures brought a number of changes to commodity markets. In particular, the landscape of investors changed and currently comprises a more substantial portion of financial institutions. Between 2010 and 2020, net open interest of oil futures used to hedge industrial business contracted sharply, while the amount held by certain delegated money managers, including hedge funds, increased steadily (Graph 1, left-hand panel). The expanded footprint of swap dealers also indicates that futures are increasingly used to hedge risks taken by financial intermediaries rather than those faced by industrial companies.

ETFs are important investment vehicles in commodity markets. Like mutual funds, ETFs hold portfolios of assets financed by issuing shares to investors. Unlike mutual funds, however, ETF shares can be bought and sold throughout the day on an exchange. As a result, ETFs provide individual and institutional investors with an efficient way to gain exposure to a variety of commodities, including agricultural products, energy, metals, or combinations thereof. Among single-commodity ETFs, the largest ones are those tracking precious metals, with US gold and silver ETFs managing about $130 billion in assets as of end-2020. Amid energy ETFs, those referencing oil and natural gas are most popular. Globally, such ETFs managed $10 billion in 2020 compared with only $1 billion in 2008. In the United States, they accounted for roughly 70% of the total (Graph 1, centre panel).

Oil ETFs can be large compared with the size of the underlying futures market. Between 2008 and 2020, assets of oil ETFs represented between 5 and 10% of the open interest for near-term futures, which are the contracts most often held by these funds. In periods of market stress, the ratio spiked to 40%, partly due to declining open interest (Graph 1, right-hand panel). ETFs also comprised a meaningful share of open interest for futures maturing within six months, especially during periods of falling oil prices.

Investor inflows into ETFs and price dynamics when storage is costly

Futures contracts can be settled in cash or by physical delivery. They are traded on exchanges and allow parties to buy or sell assets on a pre-determined future date and at a pre-specified price. Depending on contractual specifications, parties may exchange cash at maturity. Alternatively, commodity futures may

[2] In its interim report on the events of 20 April 2020, the US Commodity Futures Trading Commission (CFTC) noted that the exceptional decline occurred even as circuit breakers were triggered.

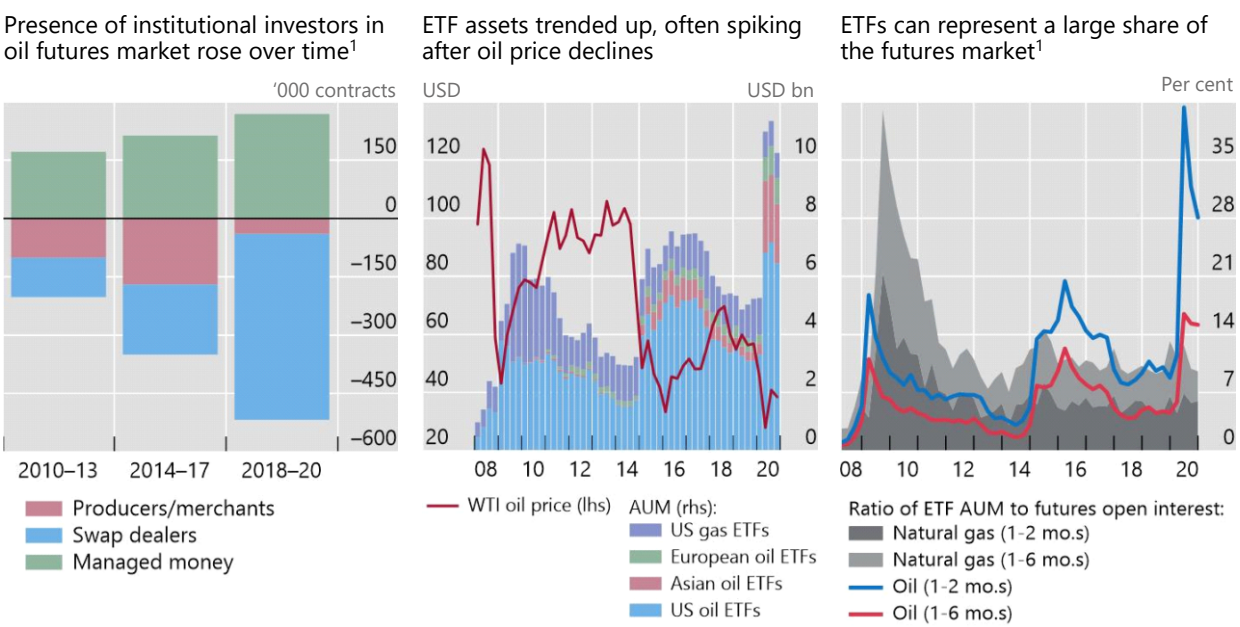
require physical delivery of the reference assets. Buyers cannot avoid taking delivery, lest being held liable for their obligations by the futures exchange. Among oil futures, those referencing Brent settle in cash. However, the main US-traded WTI contract settles with physical delivery in Cushing, Oklahoma, an early oil production hub.

The prices of futures contracts are affected by commodity storage costs. By definition, the value of futures can be decomposed into the spot price and a residual, which includes the cost of storage until expiry. As maturity gets closer, the effect of storage costs becomes smaller and the price of the futures converges to the spot price. Upon maturity, storage costs in one specific location – namely, the futures delivery point that traders are required to use – can exert significant negative influence on the spot price. These costs are distinct from those incurred prior to futures expiry, since commodities can be held at different locations before being moved to the delivery point upon maturity, for instance with pipelines in the case of oil.

Limited storage capacity at the delivery point of physically settled futures could depress prices or even turn them negative. When the amount of the physical commodity to be delivered in fulfilment of the expiring futures contract is large relative to storage available at the delivery point, storage costs could soar. Accepting physical delivery would then turn into a costly obligation, pushing the spot price even below zero. If investors expected negative spot prices at expiry, the prices of futures contracts close to maturity would, in turn, also become negative. Put differently, investors with long futures positions could prefer to pay their counterparties in order to avoid taking physical delivery of costly-to-store commodities.

ETFs are an important instrument to gain commodity exposure

Graph 1



AUM = assets under management; ETF = exchange-traded fund; WTI = West Texas Intermediate.

[1] Average number of outstanding futures contracts.

Sources: Commodity Futures Trading Commission; Bloomberg; Refinitiv; BIS calculations.

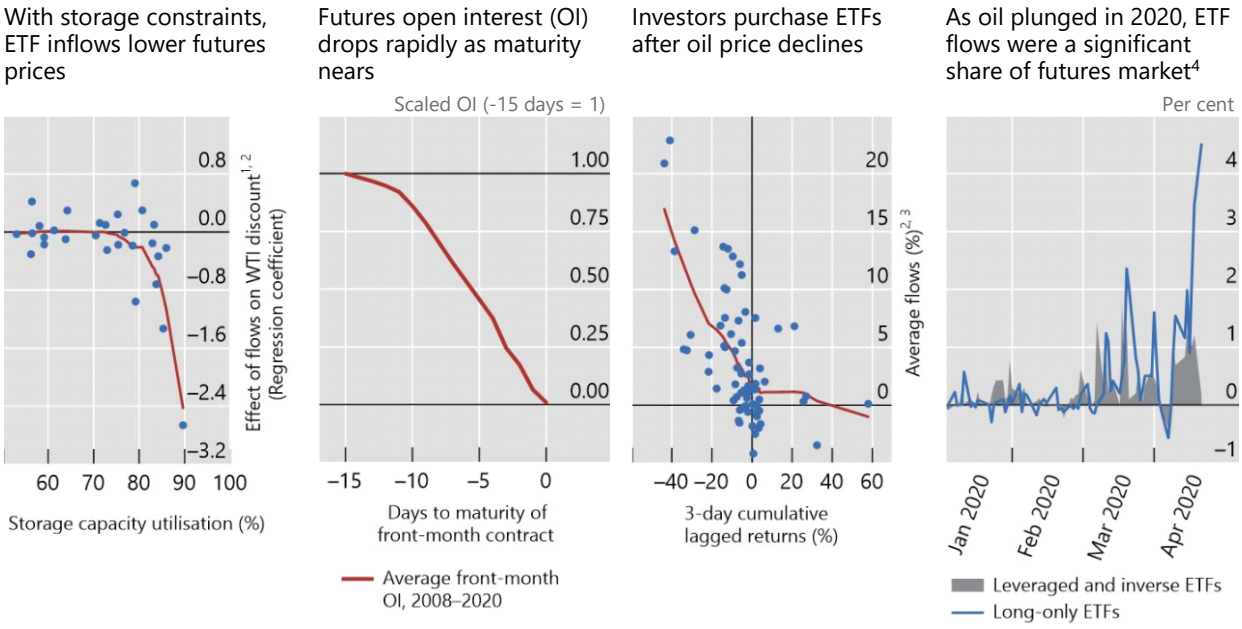
Empirical evidence is consistent with our key hypothesis that investor inflows into ETFs can depress futures prices if storage is constrained. We compare traded prices for one-month WTI futures with their "fair value". This number is computed from the historical relation between such futures and other oil contracts, including Brent futures and longer-dated WTI futures. The deviation of traded futures prices relative to fair values indicates whether the one-month WTI futures price appears expensive (at a premium) or cheap (at a discount). On the vast majority of days, the difference is virtually zero, but it can open in some instances. The first panel of Graph 2 shows that ETF inflows typically have little effect on the WTI

premium/discount as long as storage capacity utilisation at the futures delivery point is below about 75%. However, as storage capacity becomes scarcer – particularly when the utilisation rate goes above roughly 85% – stronger ETF inflows increase the discount.

Even before storage constraints become binding, ETF inflows can contribute to WTI price declines. ETFs purchase futures according to inflows, which vary over time, but typically rebalance their portfolio in a relatively short time window. Rebalancing usually takes place 10 days before front-end contracts expire, and it entails selling expiring futures and purchasing those with longer maturity. At that time, open interest for these contracts is already declining rapidly, since the majority of futures investors roll out before expiration (Graph 2, second panel). In the presence of sustained strong flows into ETFs, the anticipation of sizable concentrated sales by ETFs when futures near expiration can lower current prices (Todorov (2019)).

Why would market participants purchase ETFs when storage is constrained, if doing so lowers the value of their investment? Small investors probably play a significant role. First, they are less likely than institutional investors, like hedge funds, to realise that large purchases of ETFs lead to strong demand for the underlying futures, which can rapidly increase storage costs and lead to falling prices. Second, these investors often buy assets that suffered large negative returns in the recent past, betting on price reversals (Kaniel, Saar and Titman (2008)). Indeed, early-2020 flows into oil ETFs were considerably larger after oil had dropped more steeply in the previous three days, and inflows represented an increasingly large fraction of futures open interest as oil prices fell progressively lower (Graph 2, third and fourth panels). Assets held by oil ETFs also tend to rise after steep declines in oil prices, further indicating that investors might use ETFs to speculate on price reversals (Graph 1, centre panel).

ETF inflows can lower futures prices if oil storage is limited — Graph 2



[1] WTI discount is the relative difference between the traded price of front-month WTI futures and its fair value calculated from the prices of WTI and Brent futures using rolling regressions. Each data point is a coefficient of within-quarter regressions of daily WTI discounts on relative oil ETF flows, in addition to control variables, from January 2009 to March 2020. [2] Red lines show fitted value with local regression smoothing. [3] ETF flows scaled by lagged AUM. The sample runs from 2 Jan 2020 to 20 Apr 2020. [4] ETF flows as a percentage of futures open interest.

Sources: US Energy Information Administration; Bloomberg; Refinitiv; BIS calculations.

Case study: ETF demand pressure and negative oil prices

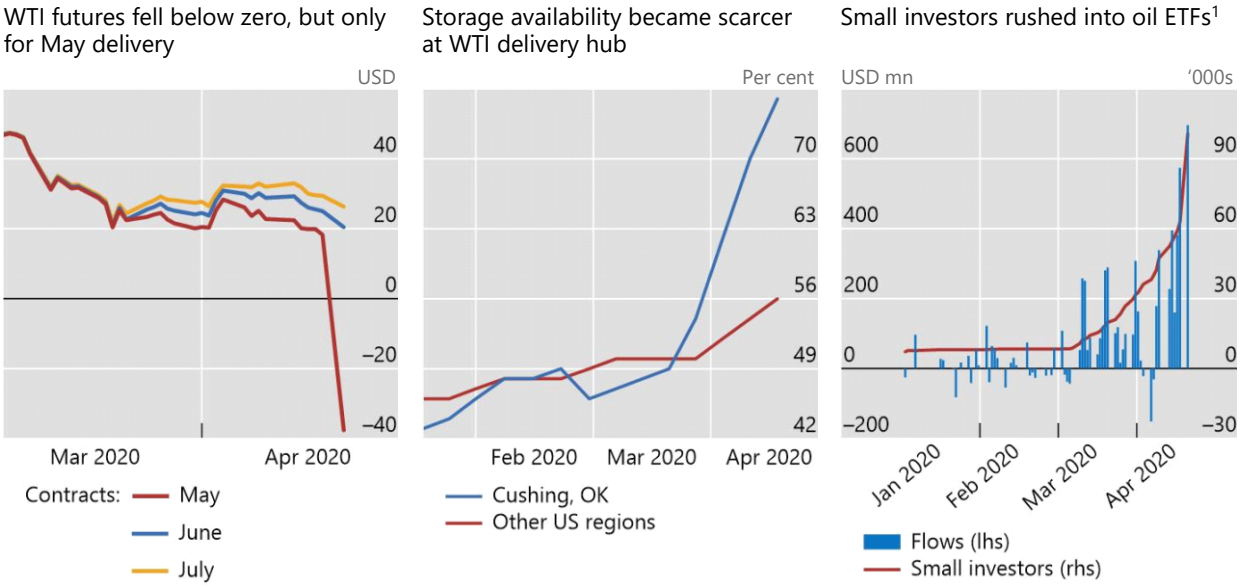
As oil supply outstripped demand in the first months of 2020, prices fell and storage became increasingly scarce. Futures on WTI, the main US benchmark, dropped by nearly 50% in the first three weeks of March.

On 20 April, the nearest-maturity futures experienced a very rapid decline into negative territory, closing at minus $37 (Graph 3, left-hand panel). The more moderate drop of the June and July contracts underscored that factors specific to the May futures played a key role. Most likely, limited storage capacity at the WTI futures delivery point in Cushing, Oklahoma (centre panel), compelled investors without storage access to pay buyers to avoid taking physical delivery.

Declining oil prices attracted rising investor interest. Long US oil ETFs saw large inflows on the day oil prices turned negative, and the number of small investors holding these ETFs also spiked (Graph 3, right-hand panel). In addition, the largest long oil ETF became substantially more expensive relative to its main holding (the June 2020 WTI futures) at the start of trading on 20 April. This valuation gap opened soon after the May 2020 contract – whose price tracked the headline WTI value reported by the financial press – lost 36% overnight (Graph 4, left-hand panel). The gap widened further when the May futures price dropped below $10 and, again, when it fell below $5 (centre panel). Such progression is consistent with the gap measuring demand pressure from reversal bets placed by less sophisticated traders, who often use round prices (like $10 and $5) for limit orders (Kandel, Sarig and Wohl (2001)). Small investors' appetite for ETFs probably supported the create-to-lend activity in which hedge funds were reportedly involved (Kaminska (2020)). With this strategy, dealers create ETF shares and immediately lend them to hedge funds, who in turn sell them in the secondary market (including to small investors) to take short WTI positions.

Before WTI prices plunged, storage was constrained and ETF inflows were rising

Graph 3



[1] The number of small investors indicates how many accounts in the Robinhood brokerage held long oil ETFs.

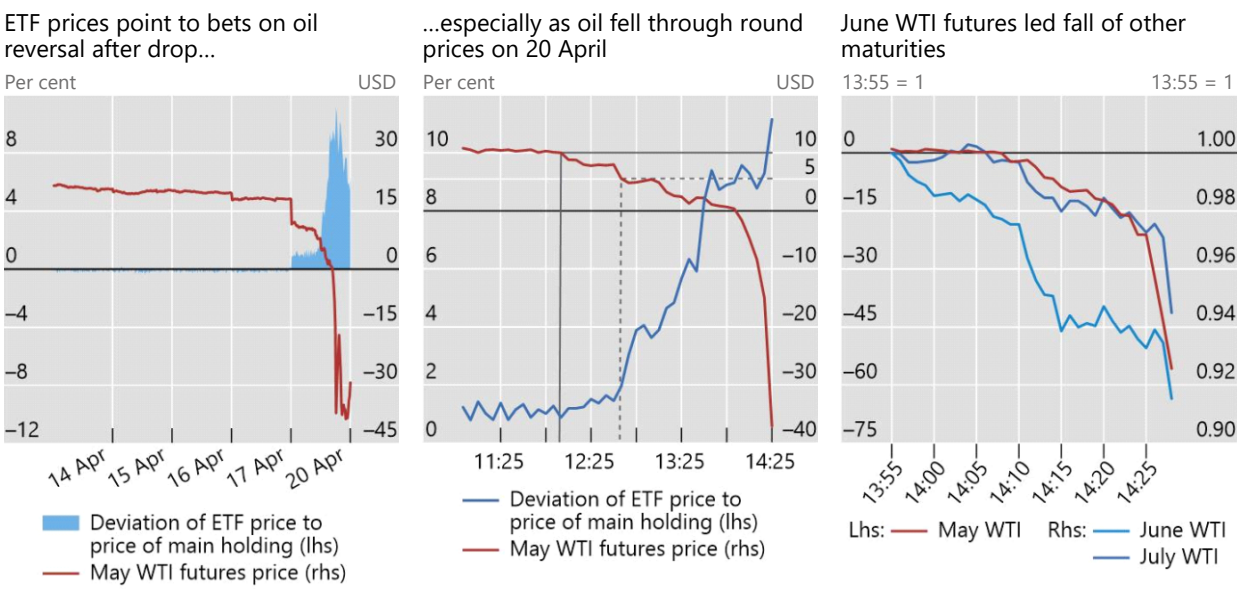
Sources: US Energy Information Administration; Bloomberg; Refinitiv; Robintrack; BIS calculations.

Large flows into ETFs likely saturated any remaining storage capacity, giving further impetus to the sharp drop in oil prices. On 20 April, investors poured about $565 million into the largest oil ETF alone, equivalent to about 4 million barrels of WTI crude per hour, or 20% of the theoretically available storage capacity. Most likely, inflows were concentrated in the 75 minutes during which the ETF valuation gap widened rapidly. In such case, the surge in oil deliverable to Cushing would have quickly increased storage costs, depressing June futures prices at first and eventually limiting investors' ability to roll over May futures. Due to its impending expiry, the May contract lost much more than the June and July contracts, but losses on all three followed a similar pattern after demand pressure peaked. Consistent with the hypothesis that large flows into the June contract contributed to oil market dislocations, June futures led losses on both May and July futures by about 20 minutes (Graph 4, right-hand panel). Of note, open

interest for low-strike options on WTI futures was limited, making dynamic hedging of options an unlikely culprit of WTI volatility.

The response of some ETFs to futures-market disruptions likely dampened volatility in oil prices. Commodity ETFs often invest in near-dated futures, regularly selling expiring contracts and buying longer-maturity ones. This strategy turned very costly as the term-structure of oil futures steepened, raising the risk of substantial capital erosion had oil markets remained unsettled. As a result, ETFs that normally invested in front-end contracts changed their strategy to buy a mix of longer-dated futures. By doing so, ETFs weakened the link between inflows and storage costs, reducing the risk of further price drops.

High-frequency prices indicate that pressure from ETF flows exacerbated oil drop — Graph 4



Sources: Refinitiv; BIS calculations.

References

Blackrock (2020): "Know what you own: advancing ETP classification".

CFTC (2020): "Trading in NYMEX WTI crude oil futures contract leading up to, on, and around April 20, 2020", *Commodity Futures Trading Commission Interim Staff Report*, 23 November.

Kaminska, I (2020): "How hedge fund shorting triggered the USO's epic AUM growth", *Financial Times*, 23 April.

Kandel, S, O Sarig and A Wohl (2001): "Do investors prefer round stock prices? Evidence from Israeli IPO auctions", *Journal of Banking and Finance*, vol 25, no 8, August.

Kaniel, R, G Saar and S Titman (2008): "Individual investor trading and stock returns", *Journal of Finance*, vol 63, no 1, February.

Irwin, S, P Garcia, D Good and E Kunda (2009): "Poor convergence performance of CBOT corn, soybean and wheat futures contracts: causes and solutions", *UIUC Marketing and Outlook Research Report*.

Todorov, K (2019): "Passive funds actively affect prices: evidence from the largest ETF Markets", *Working paper,* London School of Economics.

Zhou, Y, A Scheller-Wolf, N Secomandi and S Smith (2015): "Electricity trading and negative prices: storage vs. disposal", *Management Science*, vol 62, no 3, August.

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