COVID-19 and Energy

Hourly Oil Price Volatility: The Role of COVID-19

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In this paper, we study the evolution of hourly oil price volatility. Using multiple measures of oil price volatility, we conclude that volatility increased following the onset of COVID-19. After controlling for conventional predictors of oil price volatility, we show that COVID-19 cases and deaths led to an increase in daily oil price volatility by between 8% and 22%. Our results pass a battery of robustness tests.

I. Introduction

Research on crude oil price volatility occupies significant interests in both energy economics and financial economics (see, inter alia, Narayan & Narayan, 2007; Salisu & Fasanya, 2013).[1] In energy economics, one research topic has been oil price and its volatility forecasting (see Herrera et al., 2018; Narayan, 2019). In financial economics, oil price volatility has been shown to influence firm profitability (see Alaali, 2020) and stock market returns (see Phan et al., 2016 and Diaz et al., 2016). In the macroeconomics literature, oil price volatility has been shown to negatively affect global industrial production (see Jo, 2014).

Given the importance of crude oil price volatility, understanding its evolution, particularly at a time when it reached its lowest point in history, is imperative. Crude oil recorded negative prices for the first time in history. On April 20, 2020, the price of the West Texas Intermediate (WTI) crude plummeted to US$37 per barrel, marking an unprecedented 300% drop in price. Two factors are potentially responsible for this decline: the Russia and Saudi Arabia price war and the COVID-19 pandemic. The pandemic halted global economic activities. The post-April 2020 period, despite seeing price recovery, represents one of the most volatile phases experienced by the oil market. This story inspires our inquiry. Our hypothesis is that the onset of the COVID-19 pandemic resulted in the most volatile period observed in the oil market and COVID-19 cases and deaths contributed to this volatility. We argue that COVID-19 and oil market activities—both price and price volatility—are directly related. The reason is simple. COVID-19 brought about three specific government responses—namely, lockdown, travel ban, and stimulus package; for a complete discussion, see Phan and Narayan (2020). Of these three policy responses, two (lockdown and travel ban) halted economic activity, including international travel, thus reducing the demand for oil. WTO (2020) argues that trade in 2020, as a result of COVID-19, is expected to decline by between 13% and 32%.[2] In short, global demand for oil has fallen impacting both the oil price and uncertainty surrounding it, which we argue will be reflected in oil price volatility.

Our analysis of the evolution of oil price volatility makes use of hourly time-series data. We document that oil price was ten times more volatile during the onset of the COVID-19 pandemic compared to the pre-COVID-19 phase. We investigate the role of COVID-19 specifically in shaping oil price volatility. After controlling for oil market factors (trading volume, price returns, and liquidity), we discover that a one standard deviation increase in COVID-19 cases (which is 2,578) and deaths (which is 157) results in an increase in daily oil price volatility by between 8.6% and 22%. We construct three different measures of oil price volatility. All measures provide conclusive and robust evidence of: (a) oil price volatility rising during the COVID-19 period; and (b) COVID-19 cases and deaths contributing economically meaningfully to oil price volatility.

Our contribution to the literature alluded to above is new. Our study represents the first attempt at establishing the connection between oil price volatility and COVID-19. While the potential positive effect of COVID-19 on oil price volatility is rather obvious, what is not so obvious is the precise contribution of COVID-19 to volatility. We show using hourly data that as much as 22% of daily oil price volatility during COVID-19 was a result of the pandemic. By discovering this evidence, our study sets the foundation for future research on this subject.

II. Data and results

A. A note on data

We have hourly data on the oil market, which includes high price (*HP*), low price (*LP*), closing price (*CP*), opening price (*OP*), bid price, ask price, and trading volume.[3] We build a dataset of oil market price variables with global COVID-19 cases and deaths.[4] The hourly data cover the time 1:00am to 5:00pm, culminating into 17 hourly observations per day. Data start from 1:00 am July 01, 2019 and conclude

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2 See https://www.wto.org/english/news_e/pres20_e/pr855_e.htm; downloaded on July 6, 2020.

3 Oil hourly data are from "DATASCOPE" database (https://www.refinitiv.com/en).

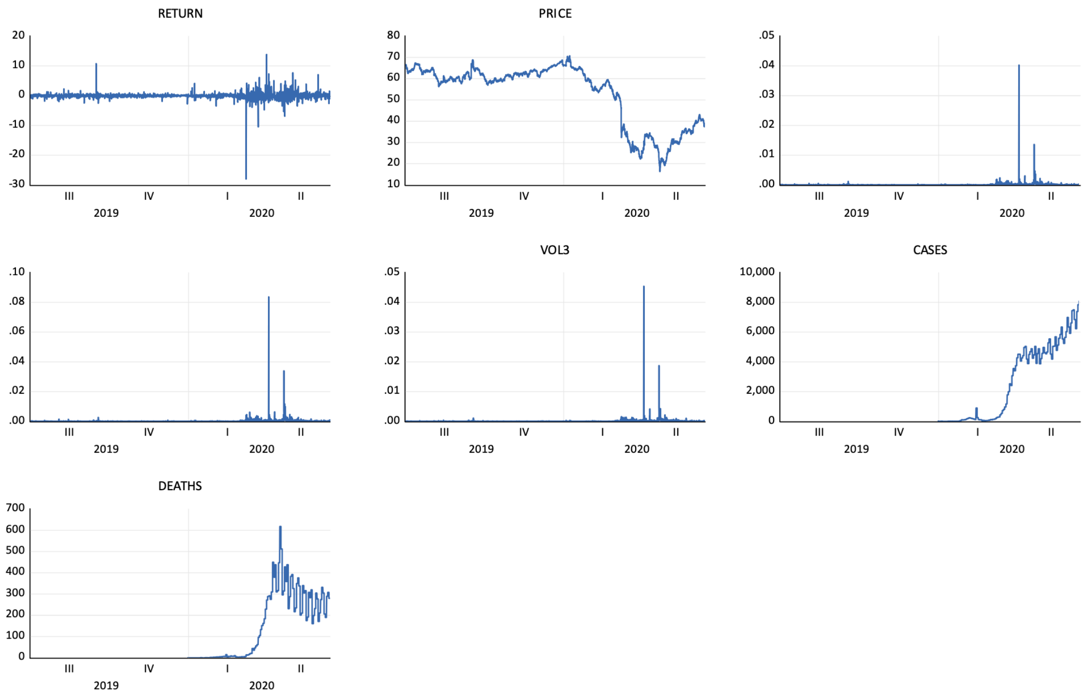

Figure 1: Oil price returns and volatility

The plot contains seven series—the stock price (US$), the stock price logarithmic percentage returns, the three measures of oil price volatility (*VOL1*, *VOL2*, and *VOL3*) and the number of global COVID-19 cases and deaths. The data are hourly and for the period 7/01/2019 01:00 to 6/12/2020 17:000 except for COVID-19 for which data start from 12/31/2019 01:00.

on June 12, 2020. This amounts to an hourly data sample of 4,250 observations. To convert COVID-19 daily data into hourly, we simply divide each day's COVID-19 cases and deaths by 17.[5] The COVID-19 related data start from 1:00 am December 31, 2019 and conclude at 5:00 pm June 12, 2020.

Figure 1 plots the key data series—namely, oil price, its return, and the three measures of volatility. We compute the WTI oil price as the average of the opening bid, opening ask, closing bid and closing ask prices. Price returns are computed as the log of current hourly price scaled by previous hourly price multiplied by 100. The three measures of volatility (namely, *VOL1*, *VOL2* and *VOL3*) are as follows. *VOL1* follows Parkinson (1980) and is one without drift in prices and assumes a geometric Brownian motion. Its specification is: $0.361 * \left[\frac{\ln(HP)}{\ln(LP)}\right]^2$. *VOL2* is a measure proposed by Rogers and Satchell (1991):

$$[\ln(HP) - ln(OP)] * [\ln(HP) - ln(CP)] + [\ln(LP) - ln(OP)] * [\ln(LP) - ln(CP)]\,.$$

The third measure, *VOL3*, is based on the work of Garman and Klass (1980):

$$0.5 * [\ln(HP) - ln(LP)]^2 - [2ln2 - 1] * [\ln(CP) - ln(OP)]^2$$

where all variables are as defined earlier.

B. Results

We start results with a descriptive story of the data, summarized in Table 1. We divide the data into two samples, pre-COVID-19 (7/01/2019 01:00 to 12/30/2019 17:00) and a COVID-19 period (12/31/2019 01:00 to 6/12/2020 17:00). The latter period's start date is identified by the first global COVID-19 case. This data split is important because it not only tells how the oil market has changed so dramatically in the COVID-19 period compared to pre-COVID-19 period but also provides a motivation for our hypothesis test.

The first point of note is that that the mean hourly oil price in the pre-COVID-19 period was US$62.26 which fell by 31.4% to US$42.72 in the COVID-19 period. During this period, there was a six-fold rise in volatility as measured by the standard deviation of oil price. Hourly oil price returns were 0.0017% (6.9% per annum) in the pre-COVID period which declined to -0.028% per hour (or -114.24% per annum). Return skewness in the pre-COVID period was 8.67 becoming -4.77 in the COVID-19 period. The mean of each volatility series saw dramatic rises; *VOL1*, *VOL2* and *VOL3* increased tenfold in the COVID-19 period compared to the pre-COVID-19 period (see Table 1). In unreported results, we also performed the Narayan and Popp (2010, 2013) structural break unit root test and found all variables to be stationary.

These statistics imply that a lot has gone wrong (statistically speaking at least) in the oil market from the time the COVID-19 pandemic took effect. A significant decline in oil price returns implies ineffectiveness of extant trading strategies to deliver profits; extraordinary rise in volatility implies not only greater uncertainty in the oil market but the need to re-balance investor portfolios that have oil as

4 https://ourworldindata.org/grapher/daily-covid-cases-deaths.

5 This approach is motivated by Narayan et al. (2018).

Table 1: Descriptive statistics of oil price and volatility data

	A: Pre-COVID period: 7/01/2019 01:00- 12/30/2019 17:00			B: COVID period: 12/31/2019 0:100 – 6/12/2020 17:00		
	Mean	SD	Skewness	Mean	SD	Skewness
Oil Price	62.26	2.68	0.1900	42.72	15.06	0.273
Returns	0.0017	0.40	8.697	-0.028	1.24	-4.771
VOL1	0.0016	0.0040	15.49	0.0167	0.1001	33.340
VOL2	0.0037	0.0094	14.64	0.0388	0.2151	31.025
VOL3	1.58E-05	3.66E-05	15.45	0.00017	0.0011	33.040

This table reports selected descriptive statistics (namely, mean, standard deviation (SD) and skewness) for oil price, its percentage returns, and the three measures of volatility (*VOL1*, *VOL2*, and *VOL3*). The data are split into two samples: Panel A denotes the pre-COVID-19 sample period while the COVID-19 sample period is in Panel B.

an investment asset in them; and negative skewness implies the chances of making losses have increased. While all these aspects of the data point to different questions to be addressed by future research, our goal is to test the role of COVID-19 in oil price volatility. We turn to exploring this next.

Table 2 has results. These results are based on an ordinary least squares regression model that corrects for heteroskedasticity using the Newey and West (1987) approach where optimal lag lengths are selected using the Schwarz information criteria beginning with a maximum of 12 lags. The model has the following specification:

$$Volatility_t = \alpha + \alpha_1 COVID_{t-1} + \alpha_2 Returns_{t-1} + \alpha_3 Spread_{t-1} + \alpha_4 Volume_{t-1} + \varepsilon_t \quad (1)$$

In this regression, *Volatility* is one of the three proxies of oil price volatility as described earlier (*VOL1*, *VOL2*, and *VOL3*); *COVID* represents either *COVID-19* cases or deaths; *Returns* are the oil price returns; *Spread* is the bid-ask spread; *Volume* is the trading volume of oil; and the error term is standard normal.

We estimate two models for each measure of volatility—one that includes no controls, where we simply regress the one period lagged *Cases* and *Deaths* on volatility while in the other model, we include three control variables as specified in Equation (1). The results are robust to the inclusion of control variables. We will, therefore, focus the discussion on the control variable-based models.

We see that the slope coefficients associated with *Cases* and *Deaths* are all statistically different from zero and in most cases at the 1% level of significance. In all cases, regardless of how we measure volatility, the effect is positive. This means that, as expected, COVID-19 increased oil price volatility. The question is: by how much? This is a question about economic significance, and we discuss this. Let us first examine the economic effect of *Cases*. Its sample standard deviation is 2,578. Given the slope coefficient of 3.28E-08 (*VOL1*), 7.45E-08 (*VOL2*) and 3.45E-08 (*VOL3*), a one standard deviation increase in *Cases* will increase *VOL1*, *VOL2*, and *VOL3* by 0.50%, 0.50% and 1% of their hourly sample means, respectively. On a daily basis, these effects translate to a rise in volatility by 8.56% (*VOL1*), 8.42% (*VOL2*) and 17.07% (*VOL3*). The corresponding daily effect from *Deaths* is a rise in volatility by 11.41%, 11.28% and 22.02% of the respective sample means.

III. Concluding remarks

This note was inspired by a sharp rise in volatility of oil prices particularly during the onset of the COVID-19 pandemic. Oil price volatility modelling is important not only for macroeconomic stability but also for investor portfolio creation and risk management. We propose the hypothesis that COVID-19 (both cases and deaths) contributed to oil price volatility. Using hourly time-series data for a sample containing over 4,000 observations (from July 2019 to June 2020), we show that COVID-19 cases and deaths have contributed between 8% to 22% to oil price volatility on a daily basis. Our results are robust to alternative measures of volatility and employment of controls for volatility. To close, we believe that our paper has opened directions for future research. One such area of research is to examine the effect of the price war between Russia and Saudi Arabia on oil price and its moments. We believe in order to accurately capture the effect of any such price wars on price moments will require much higher frequency data than the one we use.

Table 2: Empirical results of the effect of COVID-19 on oil price volatility

	VOL1		*VOL2*		*VOL3*	
	No control	control	No control	control	No control	control
$Cases_{t-1}$	2.73E-08*** (2.617)		6.22E-08** (2.507)		2.90E-08** (2.502)	
$Deaths_{t-1}$	7.00E-07*** (2.979)		1.61E-06*** (3.050)		7.28E-07*** (2.679)	
$Cases_{t-1}$		3.28E-08*** (3.122)		7.45E-08*** (3.221)		3.54E-08*** (2.979)
$Volume_{t-1}$		1.15E-08*** (2.919)		2.62E-08*** (3.009)		1.33E-08*** (2.624)
$Spread_{t-1}$		-0.004*** (-3.817)		-0.009*** (-3.919)		-0.004** (-2.492)
$Returns_{t-1}$		-5.27E-05 (-1.291)		-0.000 (-1.276)		-6.45E-05 (-1.369)
$Deaths_{t-1}$		7.18E-07*** (3.362)		1.64E-06*** (3.444)		7.50E-07*** (3.278)
$Volume_{t-1}$		1.12E-08*** (2.868)		2.53E-08*** (2.952)		1.29E-08** (2.575)
$Spread_{t-1}$		-0.003*** (-3.279)		-0.007*** (-3.418)		-0.004** (-2.089)
$Returns_{t-1}$		-5.35E-05 (-1.333)		-0.000 (-1.312)		-6.52E-05 (-1.412)

This table reports the effect of COVID-19 cases and deaths on *Volatility* (*VOL1*, *VOL2*, and *VOL3*) based on:

$$Volatility_t = \alpha + \alpha_1 COVID_{t-1} + \alpha_2 Returns_{t-1} + \alpha_3 SPREAD_{t-1} + \alpha_4 VOLUME_{t-1} + \varepsilon_t$$

COVID represents either *COVID-19* cases or deaths; *Returns* are the oil price returns; *Spread* is the bid-ask spread; *Volume* is the trading volume of oil; and the error term is standard normal. The model is estimated using OLS with standard errors corrected based on Newey-West procedure. Finally, * (**) *** denote statistical significance at the 10% (5%) 1% levels.

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