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# The bubble contagion effect of COVID-19 outbreak: Evidence from crude oil and gold markets

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## ABSTRACT

This paper examines the causal relationship between crude oil and gold spot prices to assess how the economic impact of COVID-19 has affected them. We analyze West Texas Light crude oil (WTI) and gold prices from January 4, 2010, to May 4, 2020. We detect common periods of mild explosivity in WTI and gold markets. More importantly, we find a bilateral contagion effect of bubbles in oil and gold markets during the recent COVID-19 outbreak.

## 1. Introduction

The price of WTI crude oil dropped into a negative level on April 2020. This severe collapse is a direct result of a fall in demand caused by the economic slowdown generated by Coronavirus pandemic and failed negotiations between Russia and OPEC (Organization of the Petroleum Exporting Countries) to reduce daily barrel production. The financial markets have reacted to this oil price crash and the global panic with large drops. The important uncertainty in markets all over the world has created a risk-averse environment that has driven investors toward safe-haven assets, notably gold. Previous studies such as Hillier *et al.* (2006) and Kaul and Sapp (2006) document that the correlations between gold and other assets are weak or negative. Baur and McDermott (2010) and Baur and Lucey (2010) show that gold serves as a hedge and a safe haven for the US, the UK, and German stocks or bonds. This property can be a priori seen in the recent evolution of gold price. Indeed, despite the mid-March decrease, the gold price has been on a new upward course since March 19, 2020.

As oil and gold are the most commonly traded commodities in the world and lead economic variables, their price movements have important implications for the world economy and the financial markets. It is therefore of crucial practical significance to analyze their co-movement and causality. Although there is a vast body of literature on the prices relationship between gold and oil (Bedoui *et al.*, 2019; Ewing and Malik, 2013; Narayan *et al.*, 2010; Soytaş *et al.*, 2009; Zhang and Wei, 2010), the economic impact of the COVID-19

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pandemic on the dependence structure between oil and gold prices has not yet been analyzed. Our study fills this gap in the literature and provides three contributions. First, we assess how the recent health and economic crisis has affected the relationship between oil and gold. This allows us to assess to which extent gold can act as a hedge, a safe haven and/or a diversifier against oil price movements during the period of COVID-19 outbreak. Second, our long analysis period (January 4, 2010, to May 4, 2020) enables us to examine how the relationship between oil and gold has progressed and to analyze the dependence and risk contagion between oil and gold. Third, in addition to the previous empirical contributions, our study presents a third methodological novelty. Indeed, various techniques are applied to capture the co-movement of both commodities during the period of COVID-19 outbreak. We use rolling window of the linear correlation between gold and crude oil prices and find that the dependence between WTI and gold varies across time due to the presence of bubbles and crises. Therefore, we employ the [Phillips and Shi \(2018\)](#) technique to identify a common bubble for both commodities during the period of COVID-19 pandemic. Then, we employ the linear [Granger \(1969\)](#) and the non-parametric nonlinear version of the Granger non-causality test of [Diks and Panchenko \(2005, 2006\)](#) for causality analysis. To identify changes in the causal relationship, we complete our causality analysis via time-varying Granger causality tests of [Thoma \(1994\)](#), [Swanson \(1998\)](#) and [Shi et al. \(2018\)](#). Identifying changes in the causal relationship allows to detect and to date the causality between gold and oil markets. To the best of our knowledge there are no studies, using time-varying Granger causality tests, to identify changes in the causal relationship between gold and WTI.

Overall, our study of how gold price co-moves with the oil price fluctuations will contribute to our understanding both of how COVID-19 is impacting the price of the most important commodities; as well as how gold might act as a hedge or safe haven during this period.

## 2. Econometric methodology

### 2.1. Testing for crisis identification of Phillips and Shi (2018)

The Phillips and Shi (2018) procedure is based on the recursive rolling window of [Phillips et al. \(PSY; 2015a, b\)](#), which is more efficient particularly if multiple bubbles are present in the sample period.

The PSY test can be conducted for each observation of interest ranging from  $r_0$  to 1. The recommended setting of  $r_0 = 0.01 + 1.8 / \sqrt{T}$  with T the sample length. Suppose the observation of interest is  $r$ . The PSY calculates the ADF statistic respectively from a backward expanding sample sequence. Let  $r_1$  and  $r_2$  be the start and end points of the regression sample. The ADF statistic calculated from this sample is  $ADF_{r_1}^{r_2}$ . We fix the end point of all samples on the observation of interest such that  $r_2 = r$  and allow the start point  $r_1$  to vary within the range  $[0, r - r_0]$ .

Under the null hypotheses of  $\rho = 0$ , estimate the following equation:

$$\Delta y_t = \mu + \rho y_{t-1} + \sum_{j=1}^p \phi_j \Delta y_{t-j} + \gamma_t \tag{1}$$

The PSY statistics are the ultimate values of all ADF statistics expressed as follows:

$$PSY_r(r_0) = \sup_{r_1 \in [0, r - r_0], r_2 = r} \{ADF_{r_1}^{r_2}\} \tag{2}$$

The *exuberance* date is assumed to be where the PSY test statistic first exceeds its critical value — the first time it has stopped for this episode. Similarly, the *collapse* date is considered to be when the supremum test statistic consequently falls below its essential values—a second stopping period for this episode. Suppose there is only one episode of the sample originating from  $r_e$  to  $r_f$ . According to Phillips and Shi (2018), estimated periods and termination dates are given by the [Eqs. \(3\) and \(4\)](#):

$$\hat{r}_e = \inf_{r \in [r_0, 1]} \{r : PSY_r(r_0) > cv_r(\beta_T)\} \tag{3}$$

$$\hat{r}_f = \inf_{r \in [\hat{r}_e, 1]} \{r : PSY_r(r_0) < cv_r(\beta_T)\} \tag{4}$$

where  $cv_r(\beta_T)$  the quantile of the distribution of the  $PSY_r(r_0)$  of [Eq. \(2\)](#).

### 2.2. Identifying changes in causal relationships between gold and WTI

In this paper, we use three tests of time-varying Granger causality of [Thoma \(1994\)](#), [Swanson \(1998\)](#) and [Shi et al. \(2018\)](#). [Thoma \(1994\)](#) and [Swanson \(1998\)](#) suggested using forward expanding and rolling window Wald tests, respectively, to detect changes in causal relationships. In contrast, the test of [Shi et al. \(2018\)](#) is based on the recursive rolling window, or evolving procedures of [PSY \(2015 a, b\)](#). The process of the corrective bootstrap algorithm is detailed below:

Step 1: We estimate the VAR(1) model under the null hypothesis of no Granger causality: in the first step from  $y_{1t}$  (WTI return) to  $y_{2t}$  (gold return) and in the second step from  $y_{2t}$  (gold return) to  $y_{1t}$  (WTI return).

Step 2: For data size, we run a bootstrap sample calculated as follows:

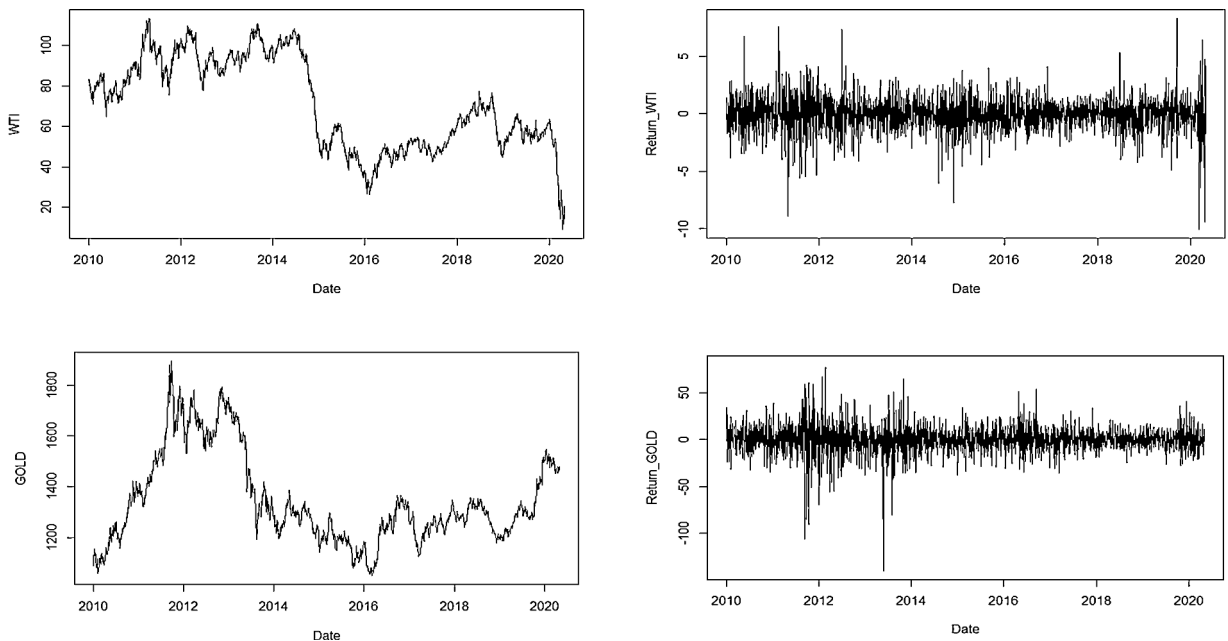
**Table 1**  
Summary statistics

	Prices		Returns	
	WTI	Gold	WTI	Gold
Min.	8.91	1049.4	-10.09	-140.5
Max.	113.39	1895	8.34000	80.35
Mean	71.37	1355.053	-0.02350789	0.222
St. dev.	22.62385	182.5971	1.424845	14.066
Kurtosis	-1.182962	-0.3524728	4.639625	9.472
Skewness	-0.02285266	0.793256	-0.3557669	-0.66722
Jarque-Bera	151.35	2677.6	2390.1	10296
ADF	-2.2344	-1.7865	-13.519	-13.708

**Notes:** Summary statistics for daily WTI and gold prices and returns respectively from January 4, 2010, to May 4, 2020.

Jarque–Bera statistic tests for the null hypothesis of Gaussian distribution.

ADF denotes the statistics of the augmented Dickey and Fuller test.



**Fig. 1.** Evolution of WTI and Gold prices and returns

**Notes:** The first, second rows show daily WTI and gold prices and returns respectively from January 4, 2010, to May 4, 2020.

$$\begin{pmatrix} y_{1t} \\ y_{2t} \end{pmatrix} = \begin{pmatrix} \hat{\varphi}_{11} & 0 \\ \hat{\varphi}_{12} & \hat{\varphi}_{22} \end{pmatrix} \begin{pmatrix} y_{1t-1} \\ y_{2t-2} \end{pmatrix} + \begin{pmatrix} \varepsilon_{1t} \\ \varepsilon_{2t} \end{pmatrix}$$

where  $\varepsilon_{1t}$  and  $\varepsilon_{2t}$  are the residuals of the VAR(1) model.

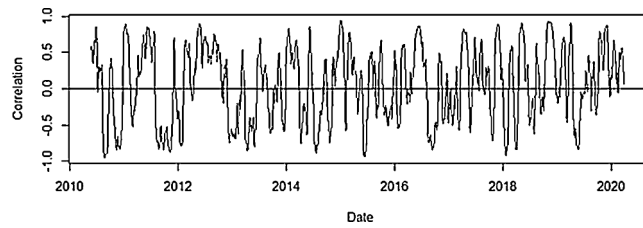
Step 3: Calculate the statistic sequences for the forward, rolling and recursive evolution by bootstrapped series. The statistic sequences for each test is expressed as follows:

- **Thoma (1994)** test based on the forward procedure:

$$M_{1,t}^b = \max_{t \in [\tau_0, \tau_0 + \tau b - 1]} (W_{1,t}^b)$$

- **Swanson (1998)** test based on the rolling procedure:

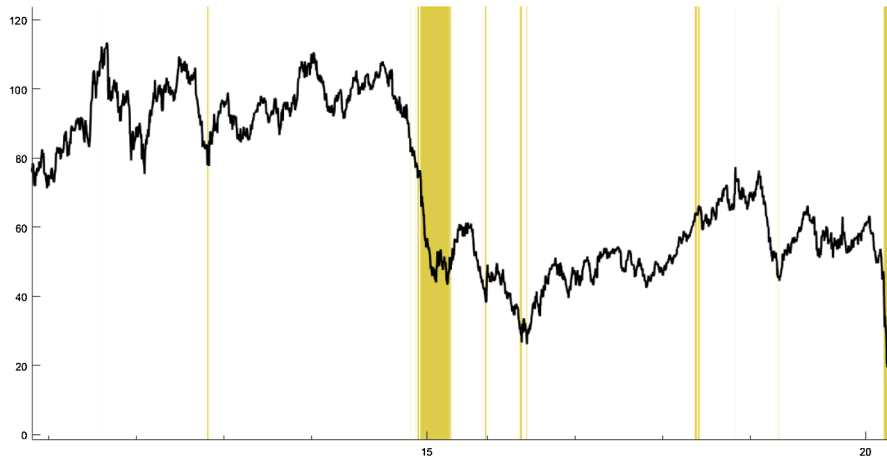
$$M_{t-\tau_0+1,t}^b = \max_{t \in [\tau_0, \tau_0 + \tau b - 1]} (W_{t-\tau_0+1,t}^b)$$



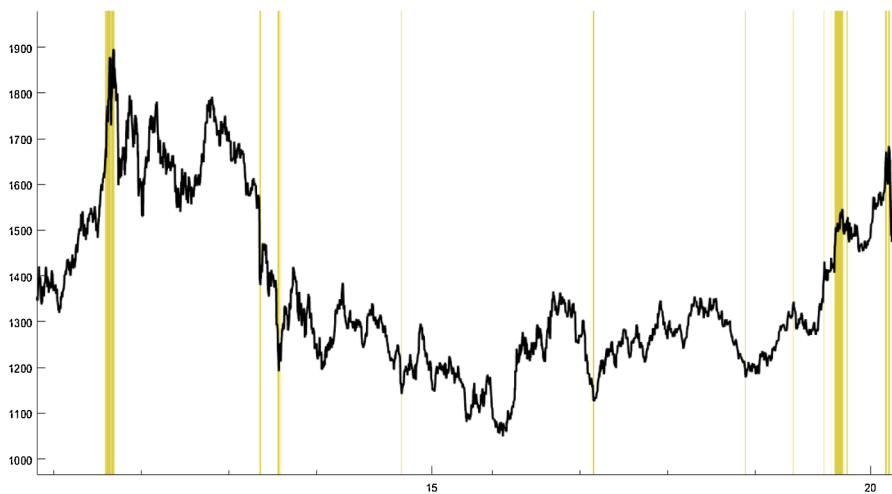
**Fig. 2.** Overlapping Rolling Windows correlation between Gold and WTI

**Notes:** The rolling windows bivariate correlation between daily WTI and gold prices from January 4, 2010, to May 4, 2020

### WTI



### GOLD



**Fig. 3.** Bubbles and Crisis in WTI and Gold Markets

**Notes:** The solid line is the price of WTI (Panel A) and Gold (Panel B) respectively. The daily WTI and gold prices are from January 4, 2010, to May 4, 2020. The shaded areas are the bubble/crisis period when the periods where the PSY statistic exceeds its 95% bootstrapped critical value.

**Table 2**  
Date stamping of crises and bubbles in WTI and gold prices

WTI			Gold		
Exuberance date	Collapse date	Duration	Exuberance date	Collapse date	Duration
04/08/2011	04/08/2011	1	04/04/2011	04/05/2011	2
06/21/2012	06/25/2012	5	04/07/2011	04/26/2011	20
06/28/2012	06/28/2012	1	04/28/2011	05/09/2011	12
10/14/2014	10/14/2014	1	05/11/2011	05/12/2011	2
11/25/2014	03/25/2015	121	01/04/2013	01/10/2013	7
03/27/2015	03/31/2015	5	03/20/2013	03/28/2013	9
04/02/2015	04/02/2015	1	04/02/2013	04/03/2013	2
08/21/2015	08/26/2015	6	08/18/2014	8/18/2014	1
01/12/2016	01/13/2016	2	10/12/2016	10/12/2016	1
01/15/2016	01/21/2016	7	10/24/2016	11/27/2016	35
02/09/2016	02/11/2016	3	07/18/2018	07/20/2018	3
01/10/2018	01/18/2018	9	02/04/2019	02/04/2019	1
01/23/2018	01/28/2018	6	06/11/2019	06/12/2019	2
02/01/2018	02/01/2018	1	07/10/2019	07/10/2019	1
06/27/2018	06/27/2018	1	07/25/2019	08/29/2019	36
12/18/2018	12/18/2018	1	09/04/2019	09/04/2019	1
12/27/2018	12/27/2018	1	09/13/2019	09/17/2019	5
03/06/2020	04/01/2020	27	02/20/2020	02/27/2020	8
04/14/2020	04/29/2020	16	03/04/2020	03/11/2020	8
			04/15/2020	04/15/2020	1
			04/17/2020	04/17/2020	1
			04/24/2020	04/24/2020	1

**Notes:** following to PWY (2011), we only consider explosive bubbles if the duration of explosive behavior more than 11 days ( $\log(T)$ ). T is equal to 2598 is the number of observations for daily WTI and gold prices from January 4, 2010, to May 4, 2020

- Shi et al. (2018) test based on the recursive rolling window (i.e. evolving) procedure:

$$SM_t^b(\tau_0) = \max_{t \in [\tau_0, \tau_0 + tB - 1]} (SM_t^b(\tau_0))$$

Step 4: For  $B = 1, \dots, 499$ , repeat Steps 2 and 3.

Step 5: The forward, rolling and recursive processes are now provided by the 95% percentile of the  $\{M_{1,t}^b\}_{b=1}^B$ ,  $\{M_{t-\tau_0+1,t}^b\}_{b=1}^B$ , and  $\{SM_t^b(\tau_0)\}_{b=1}^B$ , respectively.

### 3. Data and preliminary analysis

#### 3.1. Data

We analyze the daily WTI and gold prices from January 4, 2010, to May 4, 2020. The nominal WTI price is provided by the U.S. Energy Information Administration (EIA) and the gold price by [www.gold.org](http://www.gold.org).

#### 3.2. Statistical properties

Table 1 shows the statistical properties of the oil and gold market used in this study. The skewness indicates that oil prices are skewed negatively while gold prices are positively skewed. The kurtosis of returns is greater than 3, indicating that oil and gold returns are leptokurtic. Both the prices and returns have a not-normal distribution. As expected, the Jarque-Bera test rejects the null hypothesis for the Gaussian distribution at a significance level of 5%. The price series are nonstationary, as confirmed by Fig. 1. In contrast, the return series are stationary, indicating the presence of volatility clustering. As anticipated, the augmented Dickey–Fuller test rejects the null hypothesis of nonstationarity.

The ADF test results in Table 1 show that the crude oil and gold prices have the same order one I(1) process. Hence there may be a cointegration relationship or a long-term relationship between the two sequences. Based on modeling needs, to eliminate seasonal factors in the crude oil and gold prices, we use the first-differencing of log time series i.e., return series as in Ding et al. (2017) and Holmes et al. (2020).

#### 3.3. Correlation analysis of gold and WTI

We use a 30-day window to estimate the linear correlation of Pearson. Specifically, we use the overlapping rolling window to move

**Table 3**  
Linear and non-linear Granger causality

	Linear test	Non linear test
WTI running to Gold	0.3674	0.08763**
Gold running to WTI	0.8051	0.17711

**Notes:** Linear and non-linear Granger causality tests applied the the daily WTI and gold returns from January 4, 2010, to May 4, 2020

\*\*\*, \*\*, \* indicate statistical significance at the 10%, 5% and 1% levels respectively.

Linear Test: *p*-value linear causality test of Granger (1969). Non Linear Test: *p*-value of Non linear and non parametric test of Diks and Panchenko (2005, 2006).

forward one-day observations. Fig. 2 reports the overlapping rolling windows of the linear correlation between gold and WTI prices. The changing correlations between crude oil and gold price vary between a positive and a negative value. As can be seen, some strong changes in the dependence between WTI and gold vary across time due to the presence of bubbles and crises in WTI and gold markets. However, linear correlation may be inadequate to fully reflect the dependence between WTI and gold.

## 4. Results and discussion

### 4.1. Testing for crisis identification

Fig. 3 and Table 2 report the results of crisis identification with 95% critical values obtained by the bootstrap procedure of Phillips and Shi (2018). We date a negative mildly explosive episode between late November 2014 and late March 2015 in WTI nominal price. Our results are in line with Fantazzini (2016), Su et al. (2017) and Zaho et al. (2020). This negative financial bubble is explained by the excess capacity in the oil market (Baumeister and Kilian, 2016), the increased leverage of oil firms (Domanski et al., 2015; Tokic, 2015) and the increase in non-OPEC oil exports (Sharm and Escobari, 2018). Su et al. (2017) show that crude oil prices also react to non-fundamental factors (e.g., speculation, geopolitics, USD exchange rates). We also date two short-lived bubbles at the beginning of 2016 and 2018 in WTI nominal price.

Moreover, our empirical results indicate two short, mildly explosive episodes in 2020: the first between March 6 and April 1, 2020, and the second from 14 to 29 April 2020 in WTI. These falling oil prices are explained by a combination of supply and demand issues as well as uncertainty about the future. Indeed, COVID-19 outbreak has had a negative impact on the world economy (Yilmazkuday, 2020; Majjama'a et al., 2020; Aloui et al., 2020) and specifically on oil demand because of border closures. In addition, the Russia–Saudi Arabia oil price war of 2020 and the insufficient storage capacity also contributed to the oil price crash. As a consequence, on April 21, 2020, the price of WTI dropped below zero for the first time in recorded history (-\$39).

In the gold market, we detect a positive, mildly explosive episode in July–August 2019 due to the collapse of the U.S. dollar. This can be explained by the safe-haven properties of gold.<sup>1</sup> Beckman et al. (2015) showed that gold serves as both a hedge and a safe haven in times of market stress or turmoil. As mentioned by Su et al. (2017), when investors anticipate the depreciation of the U.S. dollar, they tend to move away from the dollar and buy commodities (i.e., crude oil or gold). Furthermore, we also detect two short, mildly explosive episodes in gold prices in 2020: from February 20 to 27, 2020, and from March 4 to 11, 2020. This larger increase in the price of gold in late February could be explained by the oil price fall and decline in global stock markets. Due to the global spread of COVID-19 and oil price collapse, stock markets all over the world have responded in terms of growing risks and decline of stock prices U.S.<sup>2</sup>, European and Asian stock market indices<sup>3</sup> reported their largest single-week declines since the 2008 financial crisis. Recently, Corbet et al. (2020) show a positive and significant relationship between WTI and Chinese stock markets. Sharif et al. (2020) have found that oil prices were leading the US market at both low and high frequencies in the period from January, 21st 2020 to March, 30, 2020. Since gold is considered to be a safe asset, investors shift over to this investment. Traditionally, gold (Baur and Lucey, 2010; Baur and McDermott, 2010), is considered as a safe-haven investment during times of financial turmoil.

### 4.2. Causality analysis of gold and WTI

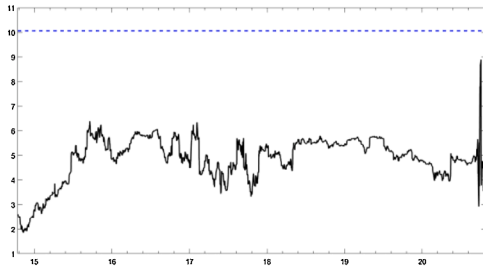
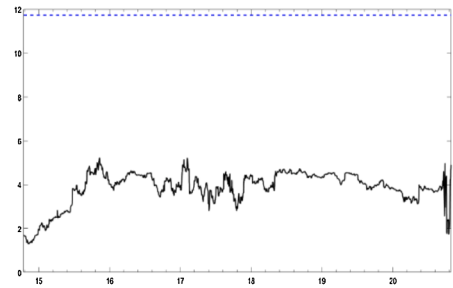
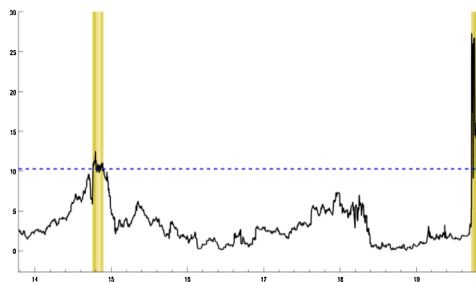
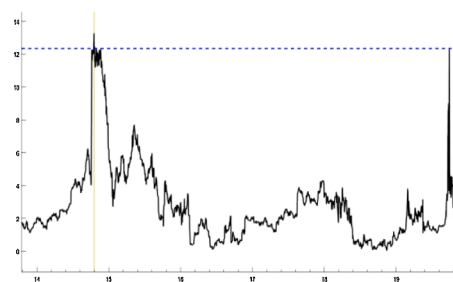
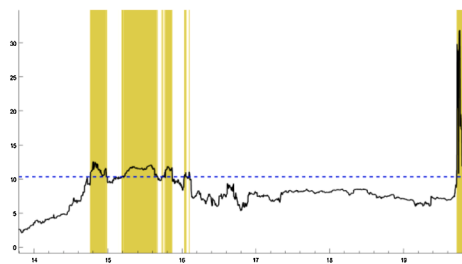
#### 4.2.1. Linear and nonlinear causality analysis

For a complete analysis of WTI and gold price interactions, we use causality tests to test the WTI versus gold returns and vice versa. We apply the linear non-Granger test (1969) and the nonparametric-nonlinear version of the Granger non-causality test of Diks and Panchenko (2005, 2006).

<sup>1</sup> Baur and McDermott (2010) explained that an asset is a safe haven if it is uncorrelated or negatively correlated with another asset in times of market stress or turmoil.

<sup>2</sup> On 27 February 2020, U.S. stock market indices (NASDAQ-100, the S&P 500 Index, and the Dow Jones Industrial Average) have experienced their sharpest falls since 2008 (World Economic Forum, 2020).

<sup>3</sup> Parallel to the U.S crash, stock markets in Europe and Asia have also plunged. FTSE, the UK's main index, dropped more than 10% from Black Monday I (9 March 2020) to Black Thursday (12 March, 2020), in its worst day since 1987.

(a) **Forward-Homoskedasticity**(b) **Forward-Heteroskedasticity**(c) **Rolling-Homoskedasticity**(d) **Rolling-Heteroskedasticity**(e) **Recursive Evolving-Homoskedasticity**(f) **Recursive Evolving-Heteroskedasticity****Fig. 4.** Tests for Granger causality running from WTI to Gold

**Notes:** Tests for Granger causality running from daily WTI to gold returns are from January 4, 2010, to May 4, 2020.

The solid line is the test statistic sequence. The blue discontinue line is the 5% critical value sequence.

The shaded areas are the causality episode i.e. the periods where the test statistic exceeds its 95% bootstraped critical value.

The first, second and third rows show the sequences of test statistics obtained from the forward recursive test of [Thoma \(1994\)](#), rolling window test of [Swanson \(1998\)](#) and recursive evolving test of [Shi et al. \(2018\)](#) respectively. The columns of [Figs. 4](#) and [5](#) refer to the homoscedasticity and heteroskedasticity assumption of the residual of the VAR(1) model.

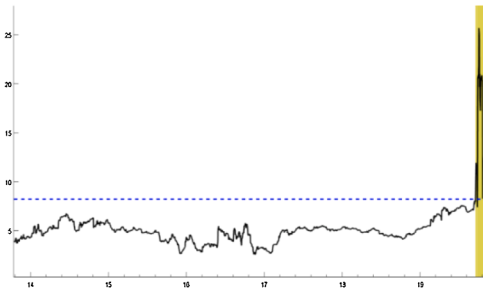
As shown in [Table 3](#), the results reveal the rejection a bi-directional causality between gold and WTI returns. Additionally, we observe a unidirectional nonlinear causality running only from the WTI returns to the gold returns at a significance level of 10%. More importantly, this rejection of causality may possibly be explained by the time-varying behavior on the dynamic correlations and the presence of explosive processes or bubbles in these markets.

#### 4.2.2. Identifying changes in causal relationships

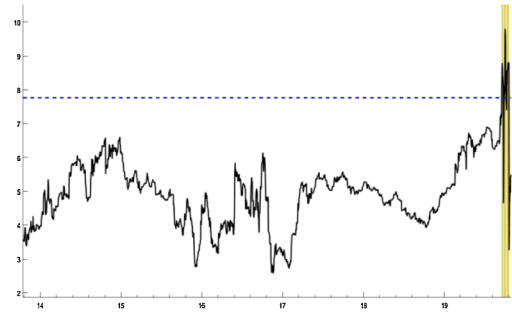
For implementing the time-varying Granger causality tests, the minimum window size is  $f_0 = 0.2$ , which contains 519 observations. The critical values are obtained from a bootstrapping procedure with 499 replications. The empirical size is 5% and is controlled over a three-year period. Following [Shi et al. \(2018\)](#), the three tests of time-varying Granger causality are run with the assumption of



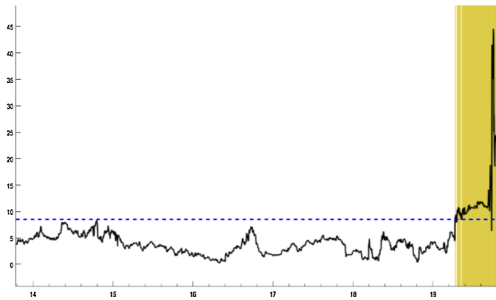
(a) **Forward-Homoskedasticity**



(b) **Forward-Heteroskedasticity**



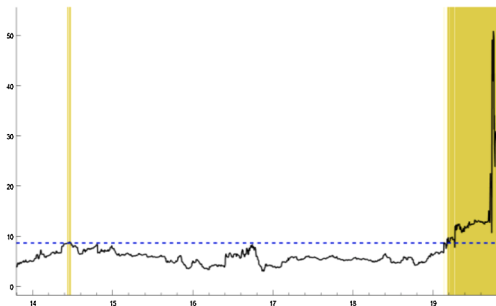
(c) **Rolling-Homoskedasticity**



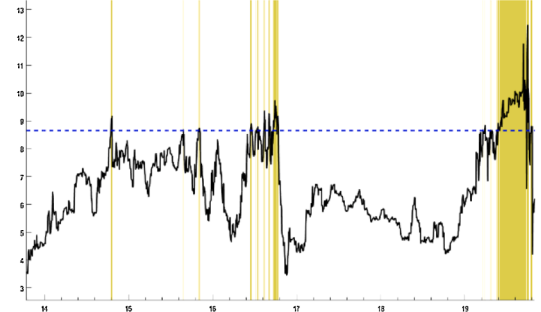
(d) **Rolling-Heteroskedasticity**



(e) **Recursive Evolving-Homoskedasticity**



(f) **Recursive Evolving-Heteroskedasticity**



**Fig. 5.** Tests for Granger causality running from GOLD to WTI

**Notes:** Tests for Granger causality running from daily gold to WTI returns are from January 4, 2010, to May 4, 2020.

The solid line is the test statistic sequence. The blue discontinue line is the 5% critical value sequence.

The shaded areas are the causality episode i.e. the periods where the test statistic exceeds its 95% bootstraped critical value.

The first, second and third rows show the sequences of test statistics obtained from the forward recursive test of [Thoma \(1994\)](#), rolling window test of [Swanson \(1998\)](#) and recursive evolving test of [Shi et al. \(2018\)](#) respectively. The columns of [Figs. 4](#) and [5](#) refer to the homoskedasticity and heteroskedasticity assumption of the residual of the VAR(1) model.

homoscedasticity/heteroscedasticity of the residual error term for the VAR(1).

Panels (a) and (b) of Fig. 4 indicate that the test statistics of the forward causality of Thoma (1994) are always below their critical values over the whole sample period. Consequently, the null hypothesis of no Granger causality from oil price to gold over the whole sample period cannot be rejected. Under the homoscedastic assumption, and based on the rolling test of Swanson (1998) (panel (c) of Fig. 4), we find an episode of causality running from oil to gold from May 24 to August 2, 2013. After this date, we detect multiple causality periods from oil to gold: from March 11 to 19, 2020; from March 23 to April 13, 2020; and the last from April 17 to 20, 2020. In contrast, under the heteroscedastic assumption (panel (d) of Fig. 4), we cannot reject the null hypothesis of no Granger causality from oil price to gold over the whole sample period. This result highlights the danger of inattention of the homoscedasticity/heteroscedasticity in financial time series analysis. Under the homoscedastic assumption and with the consistent recursive evolving algorithm of Shi et al. (2018) (panel (e) of Fig. 4), we plot many episodes of causality running from oil to gold during the 2014–2015 oil crash (from October 16, 2014, to March 27, 2015) and from March 9 to May 4, 2020. In contrast, the heteroscedastic-consistent recursive evolving algorithm (panel (f) of Fig. 4) detects only the last 2014 episode and April 19, 2020.

Fig. 5 shows the time-varying Wald test statistics for causal effects running from gold to oil returns. The first interesting feature of the results is that the Thoma test (1994) based on the entire sample would suggest evidence of causality from gold to WTI for the episodes from March 5 to March 13, 2020, and from March 17 to May 4, 2020 (panel (a) of Fig. 5). In contrast, under the heteroscedastic assumption (panel (b) of Fig. 5), we paint only three episodes: from March 5 to 13, 2020; from March 20, 2020 to April 1, 2020; and the last episode from April 6 to 17, 2020.

By applying the rolling test of Swanson (1998) under the heteroscedastic assumption (panel (c) of Fig. 5), we find a longer episode of causality running from gold to oil from September 11, 2019, to March 13, 2020. We also detect two short causality episodes from March 17 to April 17, 2020, and from April 22 to May 4, 2020. In contrast, under the heteroscedastic assumption (panel (d) of Fig. 5), we paint two short periods from December 18, 2019, to January 2, 2020. After this date, we detect multiple shorter periods: from January 6 to 21, 2020, and from February 21 to 26, 2020. We also find three short episodes in March 2020 (March 6, from March 19 to 24, and from March 26 to 27). Under the homoscedastic assumption and the consistent recursive evolving algorithm of Shi et al. (2018) (panel (e) of Fig. 5), we plot a longer episode of causality running from gold to oil during the period from July 31, 2019, to May 4, 2020. In contrast, under the heteroscedastic assumption (panel (f) of Fig. 5), we refer to a longer episode of causality from October 9, 2019, to March 13, 2020, and two shorter episodes from March 19 to 27, 2020, and April 9 to 17, 2020. Our results are in line with the findings of Shi et al. (2018). The recursive evolving approach of Shi et al. (2018) offers the best finite sample performance, followed by the rolling window algorithm of Swanson (1998).

## 5. Conclusion

In this study, we used the bootstrap technique of Phillips and Shi (2018) to identify the bubbles in the crude oil and gold markets from January 2010 to May 2020. Our results indicate that there are common bubbles in the WTI oil and gold markets in March 2020 and April 2020. The dates of the 2020 crash correspond to the global COVID-19 outbreak. To investigate the causal relationships between WTI oil and gold markets, we used three tests of time-varying Granger causality. We detect a bilateral contagion effect of bubbles in oil and gold markets during the COVID-19 pandemic.

Our findings have practical implications. They are instructive for policy-makers who have to make decisions on financial stability measures. Indeed, the identification of explosive behavior and bubbles is of great importance in light of the links between oil prices and the overall economic activity, including other commodities prices. They are also relevant for different market participants (predictions of price changes, portfolio diversification, cross-hedging and cross-speculation).

## CRedit authorship contribution statement

**Cheima Gharib:** Conceptualization, Data curation, Methodology, Writing - review & editing, Software. **Salma Mefteh-Wali:** Investigation, Visualization, Writing - review & editing, Supervision. **Sami Ben Jabeur:** Writing - review & editing, Methodology, Resources.

## Supplementary materials

Supplementary material associated with this article can be found, in the online version, at [doi:10.1016/j.frl.2020.101703](https://doi.org/10.1016/j.frl.2020.101703).

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