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# VOLATILITY SPILLOVER BETWEEN COMMODITIES AND BRIC STOCK MARKETS DURING COVID-19 OUTBREAK

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**ABSTRACT**
The spread of coronavirus has adversely affected the world health and economic conditions. Consistent with this purview, this research attempts to examine the volatility spillover dynamics between oil, gold and stock markets of BRIC economies during the COVID-19. We employ bivariate BEKK-GARCH and DCC-GARCH models for analyzing the volatility spillover from November 17, 2019 to December 31, 2020. The sample comprises of two oil importing countries namely India and China along with two oil exporting one, Russia and Brazil. We find no volatility spillover evidence between oil and stock market of Brazil; however, oil and Russian stock market show the persistence of volatility spillover that is bi-directional. There is uni-directional volatility spillover from Indian and Chinese stock market to oil. Further, we find no evidence of volatility spillover between gold and stock market of Brazil, whereas in Russia and China there is persistence of bidirectional volatility spillover. Finally, unidirectional spillover between gold and Indian stock market is observed. The findings of the study present useful insight for policy makers as these can be used to ascertain the direction of spillover among the integrated economies. Moreover, the same can be used by the portfolio investors to allocate the weights to different asset classes while making the investment decisions.
**Keywords:** Covid-19, Volatility spillover, BRIC stock markets, BEKK-GARCH, DCC-GARCH

## 1. Introduction

Covid-19 has adversely hit nearly all walks of life. It resulted in lower consumer demand and also posed serious threats to stock markets. Similarly, oil prices face historic collapse when the prices turn into negative for the very first time in history. The producers are left with no space for the storage as a result of rapid decrease in demand (Shi, 2021). Another commodity that is considered volatile during pandemic is gold. According to Zhang and Hamori (2021), oil and gold are the most volatile commodities, and investors are of keen interest in commodity assets class during the pandemic times, Therefore, volatility spillover estimation among most volatile commodities and stock markets is of utmost importance in such a pandemic. Moreover, volatility spillover facilitates in decisions of hedging, portfolio diversification, and thus facilitates the investors in generating profits.

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Volatility spillover nomenclature explains the transmission of volatility from one market to another one. For example, presence of jolts in one gold and oil markets are transferred to stock markets and vice versa. Extensive literature is available for analyzing the spillover dynamics between group of commodities and stock markets during period of financial crisis and tranquil periods. Yu et al. (2020), Belhassine (2020), Sarwar et al. (2018), Akok and Civcir (2019) investigate the spillover between different sets of commodities and stock markets during financial crisis. Further, during financial crisis, markets show rise in spillover and volatility in other markets (Aslam et al., 2021). Similar situation has been observed during COVID-19. Stock markets faced great decline during this pandemic. Further, there has been a sharp increase in volatility of stock market during COVID-19 (Ali et al., 2020). Stock markets are witnessing high uncertainty and declines during pandemic times (Lyocsa et al., 2020). laborda & Olmo (2021) investigate the dynamics of volatility spillover between different sectors of economy in period of financial crises and COVID-19 period. Shahzad et al. (2021) analyses asymmetric volatility spillover trends in Chinese stock markets. Corbet et al. (2021) find volatility spillover dynamics from epicenter of China to financial markets in the pandemic period with a profound impact of directional spillover. Farid et al. (2021) investigate intraday volatility spillover patterns in the US stock market and commodities. Zhang and Hamori (2021) explain persistence of short- and long-term aspects of spillover dynamics between market of crude oil and US, Japan and Germany stock markets. Hanif et al. (2021) find asymmetric features of risk spillovers from stock market of US to Chinese stock markets.

Consistent with the above purview, we have analyzed for the first time the volatility transmission between pairs of Oil and BRIC stock markets and Gold and BRIC stock markets using bivariate models of BEKK-GARCH and DCC-GARCH. China and India are among the largest importers of oil but the pandemic has halted industrial activities (Shi, 2021). Russia and Brazil are oil exporting countries and the former is one of the top oil exporters (Jiang et al., 2019). Therefore, our study takes into consideration the volatility spillover in both oil importing and exporting countries in the time of pandemic. The research findings present useful insights for policy makers, investors, risk managers, and portfolio managers. The diversification benefits are pronounced in case of oil, gold and Brazilian markets. The strong spillover connections between oil and Russian stock market, gold and Russian stock market, gold and Chinese stock market highlight the need of policies that can protect the stock markets from oil and gold price fluctuations. Similarly, the investor can also minimize the risk by investing in the portfolio of oil and Brazilian stock market during tranquil period. Moreover, the same can be used by the portfolio investors to allocate the weights to different asset classes while making the investment decisions.

## Review of Literature on Volatility Spillovers

Mean and volatility spillover is one of the most researched topics in finance. For instance, Wang & Wang (2019) explore the volatility spillovers linkages between sectoral equity

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markets and crude oil in China. The results indicate that spillovers in short term are the major cause of total volatility spillover, and the oil markets depict positive net spillover. The spillover is negative during the 2015 financial crisis of China. Belhassine (2020) analyzes spillovers in volatility Eurozone sectors and oil prices by investigating the phenomenon in two instable periods namely debt crisis of Euro and global financial crisis. The study employs VAR-BEKK-GARCH for analyzing volatility spillover. The results indicate the time varying relationship between Eurozone sectors and oil prices. In a recent study, Sarwar et al. (2020) highlight the dynamics of volatility spillovers between returns of stock market and oil by employing bivariate BEKK-GARCH model. The results explain two-way spillover in stock market of Karachi, mixed results in Bombay stock exchange, and unidirectional in Shanghai market. The results of spillover are not different in before crisis and after tranquil period, however the results are different on the basis of daily, weekly, and monthly frequencies. Moreover, Mensi et al. (2019) explains the spillovers between commodity markets, conventional and Islamic bank stock indices of five Gulf countries. The results show risk spillovers between commodity market, and Gulf countries bank indices. Zhang et al. (2020) investigate volatility spillovers spatial correlation across the stock market of G20 and find that during turbulent period volatility spillover in developed markets is more dominant than emerging markets. Therefore, we can say that volatility spillover is more prevalent in chaotic times, which sheds the light on understanding the dynamics of volatility spillover in pandemic times.

Wang & Wu (2018) investigate the asymmetric spillovers of volatility between international stocks to oil market. The results find that in the period of 2006 to mid-2009, there is domination of oil markets positive spillovers, but after mid-2009 reversed. Yu et al. (2020) analyzes the multidimensional linkage between oil and US and Chinese stock markets. The results show that dynamics of volatility spillovers and dependence are much stronger for oil-US as compared to Oil-China. Akok and Civcir (2019) explore the linkage between stock markets and strategic commodities and reveal enhanced price of oil and gold have negative repercussions on stock markets. Aromi & Clements (2019) examine spillover between oil sector and the Standard & Poor's 500, and reveal how the propagation of information or news impacts the volatility spillovers. Wen et al. (2019) explore the spillovers from oil to stock markets and show that asymmetrical spillover effect is more pronounced at upward quantiles, but not at downward quantiles. Jiang et al. (2019) analyze the portfolio management and dynamics of risk spillovers in BRICS economies and precious metals. The findings of the study outline negative dynamic conditional correlation in some periods of sample, facilitating the investor to hedge the risk from diversified portfolio. Shahzad et al. (2018) find the risk spillovers and extreme dependency between oil market and Islamic stock markets.

Boubaker and Raza (2017) show the evidence of volatilities that are time varying in nature in all the BRICS stock markets. Kumar et al. (2019) analyze volatility spillovers and correlations with and without asymmetry between group of stock prices, oil and natural gas. The results reveal absence of long run co-integrations. Pal and Mitra (2020) posit

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that spillover is prominent in lower frequency or longer band from oil to food crops and feed stocks, and spillover is more pronounced in the period of food and energy crises. Li et al. (2020) document volatility spillovers spatial linkages across interregional stock markets of China. Sarwar et al. (2018) elucidate the volatility spillover features and hedging strategies in top oil importing countries of Asia. Morema and Bonga (2020) show the volatility spillover persistence between oil, gold and equity market of South Africa.

Literature confirms that volatility spillover between different asset classes differ during normal and turbulent periods. Numerous researches are available in examining the volatility spillover. However, our study examines the volatility spillover among oil, gold and stock markets of BRIC economies during pandemic for the first time. Furthermore, the sample of the study constitutes of two oil importing countries that are China and India, and two oil exporting countries namely Brazil and Russia.

## 3. Data & Methodology

We use the data set of WTI crude oil prices, gold prices, Bovespa (Brazil), Nifty 50 (India), Moex (Russia), and Shangai stock market (China). The pandemic period is from November 17, 2019 to December 31, 2020. We collect the data of commodities and BRIC stock markets from investing.com. The returns of all the series namely stock markets, gold and crude oil are computed for examining the volatility spillover.

We use the bivariate BEKK-GARCH model put forward by Engle and Kroner (1995) for analyzing volatility spillover linkages. Equations 1 & 2 explain the bivariate BEKK-GARCH (1,1) model,

$$R_t = H_t^{1/2} e_t \quad (1)$$

$$H_t = C + A'_1 r'_{t-1} A_1 + G'_1 H_{t-1} G_1 \quad (2)$$

In the equation 1 described above $\mathbf{R_t}$ is the returns vector at time t. In equation 2 $\mathbf{H_t}$ depicts the $\mathbf{R_t}$ conditional covariance matrix whereas $\mathbf{H_t^{1/2}}$ explains the square root of $\boldsymbol{H_t}$ and $\boldsymbol{e_t}$ shows the bivariate normal distribution and is an innovation at time t. Hence in bivariate BEKK-GARCH there are 11 parameters that are *C (1,1) C(2,1) C(2,2), A(1,1), A(1,2), A(2,1), A(2,2), B(1,1), B(1,2), B(2,1), B(2,2).*

We also employ DCC GARCH model put forward by Engle (2002) for estimating spillover dynamics between gold, oil and BRIC economies stock market. The DCC GARCH model is specified below as variance-covariance matrix as shown in equation 3.

$$H_t = D_t A_t D_t \quad (3)$$

$W_{io}$ specifies the constant term and $A_{ii}$, $B_{ii}$ are ARCH and GARCH estimated coefficients, whereas short term persistence is measured by ARCH effects and long-term persistence is measured by GARCH effects. The parameters $\sigma_1$measures the impact of on present dynamic conditional correlation of lagged shocks, and $\sigma_2$ estimates the impact on the present dynamic conditional correlation of past dynamic conditional correlation.

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## 4. Results and Interpretation

Table 1 reports the descriptive statistics of BRIC stock markets returns, gold returns and oil returns.

**Table 1. Descriptive statistics**

| | ***Oil*** | ***Gold*** | ***Brazil*** | ***Russia*** | ***India*** | ***China*** |
|---|---|---|---|---|---|---|
| **Mean** | -0.0251 | 0.0010 | -0.0002 | -0.0002 | -0.0009 | 0.0002 |
| **Min** | -3.0596 | -0.0463 | -0.1478 | -0.0828 | -0.1460 | -0.0772 |
| **Max** | 0.3766 | 0.0576 | 0.1391 | 0.0772 | 0.0953 | 0.0315 |
| **Stdev** | 0.2803 | 0.0141 | 0.0340 | 0.0192 | 0.0263 | 0.0125 |
| **Skew** | -9.1718 | 0.4281 | -0.8609 | -0.5816 | -1.2338 | -1.8711 |

Note: Min = Minimum values, Max = Maximum values, Stdev = Standard deviation, Skew = Skewness

The outcomes show that the Chinese stock market has highest return, whereas the average returns of Brazil, Russia and India are negative. The Indian stock market has the minimum return. The skewness result revealed negative results that is an indication of extreme losses in stock markets of BRIC economies and oil markets. Only the gold market shows the positive results.

**Table 2. BEKK-GARCH (Oil-BRIC Sample)**

| | ***Oil-Brazil (OB)*** | ***Oil-Russia (OR)*** | ***Oil-India (OI)*** | ***Oil-China (OC)*** |
|---|---|---|---|---|
| C (1,1) | 0.0024*<br>(0.0114) | 0.0001<br>(0.9856) | 0.0027*<br>(0.0112) | 0.0030*<br>(0.0025) |
| C (2,1) | -0.0003<br>(0.7353) | 0.0021*<br>(0.0006) | 0.0005*<br>(0.0003) | 0.0007*<br>(0.0001) |
| C (2,2) | 0.00002<br>(0.5798) | 0.0001<br>(0.9568) | 0.0041<br>(0.6299) | 0.0018<br>(0.8591) |
| A (1,1) | 0.1272*<br>(0.0001) | 1.4796*<br>(0.0049) | 0.9058<br>(0.0051) * | 0.2402*<br>(0.0011) |
| A (1,2) | -0.0984* | 0.0666* | -0.0936* | -0.0769* |

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| | | | | |
|---|---|---|---|---|
| | (0.0550) | (0.0084) | (0.0012) | (0.0022) |
| A (2,1) | 0.6091*<br>(0.0001) | 0.5435*<br>(0.0356) | 0.2496*<br>(0.0071) | -0.8243*<br>(0.0187) |
| A (2,2) | 0.6131*<br>(0.0105) | 0.4551*<br>(0.0001) | 0.3720*<br>(0.0005) | -0.4769*<br>(0.0004) |
| B (1,1) | 0.1730*<br>(0.0103) | -0.0740*<br>(0.0041) | 0.3474*<br>(0.0017) | -0.2417*<br>(0.0109) |
| B (1,2) | -0.0718<br>(0.0940) | 0.0312*<br>(0.0075) | -0.4130*<br>(0.00151) | 0.0909*<br>(0.0202) |
| B (2,1) | 0.2691<br>(0.4329) | 0.9890*<br>(0.0000) | -0.7749*<br>(0.8853) | -0.3725<br>(0.9876) |
| B (2,2) | -0.8445*<br>(0.0802) | -0.8648*<br>(0.0041) | -0.9196*<br>(0.0001) | 0.8928*<br>(0.0016) |

Note: A(1,1) is ARCH effect coefficient for crude oil market, A(2,2) is the coefficient ARCH effect for stock markets, B(1,1) is GARCH effect coefficient for oil market, B(2,2) is coefficient of GARCH effect for BRIC economies stock markets, A(1,2) shows the transmission of shock from oil to BRIC economies, A(2,1) shows the shock transmission from stock markets of BRIC to oil, B(1,2) shows the volatility spillover from oil to BRIC economies, B(2,1) shows the spillover from stock market of BRIC economies to oil. P-values are shown in parentheses.

Table 2 and 3 show that GARCH and ARCH effects are significant in oil and BRIC stock markets. The contemporary volatility of Brazil and Chinese stock markets is affected by their own volatilities, whereas the Russia and Indian markets are influenced by their own lag shocks, and not their lagged volatility. The oil market is affected by the lagged volatilities of the stock market. The results of shock dependence reveal that there is a significant positive impact on returns of stock market in Brazil and China because of positive news in the past. The results show the presence of bivariate shock dependence between oil and Brazilian stock market persistence of volatility spillover in case of oil-Brazil stock markets.

The results of oil-Russia market show the bidirectional shock and volatility spillover and highlight significant outcomes. The findings reveal that oil market affects the Russian market positively and positive volatility spillover from stock market to oil. The results are consistent with study of Zhang et al. (2020), Wang & Wu (2018) and Yu et al. (2020). The

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findings of Oil-India stock markets highlight the bidirectional shock transmission between oil and Indian stock market and vice versa. There is also volatility spillover from Indian stock market to oil whereas there is no volatility spillover from oil to Indian stock market. The results of Oil-China stock market reveal the bidirectional presence of shock dependence, which shows that oil market is negatively affected by shocks in stock markets and vice versa. The volatility spillover results show unidirectional spillover from oil to stock markets, and a significant positive spillover. The results endorse the findings of Belhassine (2020) and Sarwar et al. (2020).

The results show past shocks impact on the own market is more persistent in case of Brazil and China. There is variation in volatility spillover between oil and BRIC economies. Oil-Brazil stock market shows no persistence of spillover, whereas the Oil-Russian stock market depicts bi-directional volatility spillover. Further, in Oil-India pair, there is indication of uni-directional volatility spillover from Indian stock market to oil. The results of China reveal the aspect of volatility spillover from oil market to stock market. Brazil, Russia, and India shows the evidence that current volatility is negatively affected by the past volatilities of stock markets, whereas China shows positive impact of past volatilities on the current volatilities of stock market. The results are endorsing the previous studies of Aromi & Clements (2019), Wen et al. (2019).

**Table 3. BEKK-GARCH (Gold-BRIC Sample)**

| | ***Gold-Brazil*** | ***Gold-Russia*** | ***Gold-India*** | ***Gold-China*** |
|---|---|---|---|---|
| C (1,1) | 0.0051<br>(0.9285) | 0.0081<br>(0.9981) | 0.0062<br>(0.9962 | 0.0088<br>(0.9975) |
| C (2,1) | 0.0002<br>(0.6911) | -0.0084<br>(0.8837) | -0.0025<br>(0.6399) | -0.0724<br>(0.2276) |
| C (2,2) | 0.1808<br>(0.5046) | 0.0754<br>(0.1277) | 0.0951<br>(0.9381) | 0.0774*<br>(0.0203) |
| A (1,1) | -0.1433<br>(0.5711) | 0.2750*<br>(0.0640) | 0.2973*<br>(0.0568) | 0.3701*<br>(0.0018) |
| A (1,2) | -0.5426<br>(0.8912) | -0.5699*<br>(0.0503) | -0.4295<br>(0.4911) | 0.5299<br>0.4811 |
| A (2,1) | 0.5930<br>(0.2978) | -0.9910<br>(0.1110) | 0.8842*<br>(0.0024) | -0.5257<br>(0.5670) |
| A (2,2) | 0.8953*<br>(0.0024) | 0.6554*<br>(0.0037) | 0.4688*<br>(0.0071) | 0.5565*<br>(0.0052) |

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| | | | | |
|---|---|---|---|---|
| B (1,1) | -0.9897*<br>(0.0008) | 0.2030<br>(0.9139) | -0.5620*<br>(0.0461) | 0.8592*<br>0.0001 |
| B (1,2) | 0.2711<br>(0.9419) | 0.8266*<br>(0.0001) | -0.0263<br>0.5402 | -0.1132*<br>0.00488 |
| B (2,1) | -0.1245<br>(0.2362) | 0.7516*<br>(0.0001) | 0.4552*<br>(0.0012) | 0.2855*<br>0.0001 |
| B (2,2) | 0.6127*<br>(0.0627) | 0.1862<br>(0.4674) | 0.8990*<br>(0.0271) | 0.7284*<br>0.0021 |

Note: A(1,1) is ARCH effect coefficient for gold market, A(2,2) is the ARCH effect coefficient for BRIC stock markets,B(1,1) is GARCH effect coefficient for gold market,B(2,2) is GARCH effect coefficient for BRIC stock markets, A(1,2) shows the transmission of shocks from gold to BRIC stock markets, A(2,1) shows the shock transmission from BRIC stock markets to gold, B(1,2) shows the dynamics of volatility spillover from gold to BRIC stock markets, B(2,1) shows the aspect of volatility spillover from BRIC stock markets to gold, p-values are shown in parentheses

Table 3 shows that the Brazilian stock market is influenced by the past shocks, whereas gold is not. The results of shock dependence from Gold to stock markets of Brazil and from Brazilian stock market to Gold are insignificant. The volatility spillover results from Gold to Brazil and from Brazil to Gold are insignificant explaining no indication of volatility spillover dynamics between gold market and Brazilian stock markets. The Gold-Russia stock market nexus show gold market and stock markets in Russia are influenced by their lag shocks whereas gold market is affected positively by the lag shocks. However, stock market is negatively affected by lag shocks. The results highlight that there lagged volatiles impact have no impact on Gold-Russia stock market pair. There is a unidirectional shock dependence of gold market to stock market and has negative repercussion on stock market, whereas there is no sign of shock dependence from stock market to gold. There is a significant volatility spillover impact of from gold market to Russian stock market and vice versa and there is a significant positive impact. The results are reliable and are consistent with Mensi et al. (2013), Akok & Civcir(2019).

The BEKK-GARCH parameter estimates show there is dependence of gold and stock markets on their lag shocks in case of India, and there is a significant positive impact. The volatility spillover results show that the past volatilities influence the current volatility of gold and Indian stock market. Moreover, past volatility of gold (stock market) has negative (positive) influence on current volatility. The shock dependence results are unidirectional from stock markets to gold, and there is a significant positive impact, whereas from gold to stock market there is no volatility spillover. The Gold-China stock market pair is influenced by past shocks the volatility spillover results show that gold and Chinese

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market are influenced by the past volatilities. There is volatility spillover from gold to stock market, and there is a significant and negative impact, whereas there is no volatility spillover persistence from stock market to gold, and there is significant positive impact. The results are in line with Jiang et al. (2019) and Ahmed and Huo (2020).

Overall, the results indicate that the influence of past shocks is more persistent in stock markets of India and China. In case of gold and stock markets there is no sign of shock dependence in gold and stock markets and vice versa in scenario of China and Brazil, whereas in Russia and India there is the evidence of shock dependence. There is negative shock dependence from gold to stock market in Russia whereas in India there is the positive shock dependence from stock market to gold. The volatility spillover results of Gold-Brazil show insignificant results. The Gold-India stock markets nexus show the unidirectional spillover from gold market to stock market.

**Table 4. DCC-GARCH (Oil-BRIC Sample)**

| | ***Oil-Brazil (OB)*** | ***Oil-Russia (OR)*** | ***Oil-India (OI)*** | ***Oil-China(OC)*** |
|---|---|---|---|---|
| $W_1$ | 0.1095<br>(0.8115) | 0.0186<br>(0.9223) | 0.2844<br>(0.6841) | 0.2678<br>(0.4880) |
| $W_2$ | 0.1529<br>(0.9762) | 0.1324<br>(0.9744) | 0.0945<br>(0.2951) | 0.5731<br>(0.1953) |
| $\mathbf{A_{11}}$ | 0.1967*<br>(0.0783) | 0.4224<br>(0.1483) | 0.4185<br>(0.1401) | 0.6258<br>(0.1873) |
| $\mathbf{A_{22}}$ | 0.1179*<br>(0.0511) | 0.34693*<br>(0.0021) | 0.38136*<br>(0.0024) | 0.45164*<br>(0.0054) |
| $\mathbf{B_{11}}$ | 0.0661<br>(0.9884) | -0.1472<br>(0.9688) | -0.3216<br>(0.9194) | -0.8775<br>(0.7134) |
| $\mathbf{B_{22}}$ | 0.1544<br>(0.5276) | 0.3552*<br>(0.0048) | 0.6725*<br>(0.0001) | 0.2878<br>(0.1545) |
| $\boldsymbol{\sigma_1}$ | 0.6799*<br>(0.0354) | 0.7255*<br>(0.0160) | 0.0683*<br>(0.0028) | 0.17478*<br>(0.0063) |
| $\boldsymbol{\sigma_2}$ | 0.1933<br>(0.4435) | 0.4465<br>(0.2951) | 0.8451<br>(0.7884) | 0.6725<br>(0.2152) |

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Note: The table specifies the parameter of DCC-GARCH model. $W_1$, $W_2$ specifies the constant term and $A_{11}$, $A_{22}$ are estimated coefficients of ARCH effects, $B_{11}$, $B_{22}$ are estimated coefficients of GARCH effects, $\sigma_1$measures the impact on present dynamic conditional correlation of lagged shocks, and $\sigma_2$ estimates the impact of past dynamic conditional correlation on present dynamic conditional correlation, p-values are shown in parentheses

Table 4 shows DCC-GARCH model estimates for the pair of BRIC stock markets and oil. The ARCH effects show that previous shocks in Brazilian, Indian, Chinese and Russian stock market lead to contemporaneous volatility. The findings highlight that current volatilities of BRIC stock markets are not influenced by influenced by the lagged volatilities. The results are consistent with Boubaker and Raza (2017) and Morema and Bonga (2020).

**Table 5. DCC-GARCH (Gold-BRIC Sample)**

| | **Gold-Brazil** | **Gold-Russia** | **Gold-India** | **Gold-China** |
|---|---|---|---|---|
| $W_1$ | 0.1556<br>(0.3615) | 0.5652<br>(0.2199) | 0.0511<br>(0.3552) | 0.5014<br>(0.1195) |
| $W_2$ | 0.3880<br>(0.5119) | 0.1149<br>(0.3401) | 0.2907<br>(0.4081) | 0.0166<br>(0.1723) |
| **$A_{11}$** | 0.2578*<br>(0.0015) | 0.21891*<br>(0.0031) | 0.07211*<br>(0.0210) | 0.05634*<br>(0.0312) |
| **$A_{22}$** | 0.24559*<br>(0.0017) | 0.21824*<br>(0.0056) | 0.17266*<br>(0.0057) | 0.13759*<br>(0.0043) |
| **$B_{11}$** | 0.49211<br>(0.2801) | 0.7829*<br>(0.5201) | 0.5238<br>(0.3511) | 0.0255<br>(0.1447) |
| **$B_{22}$** | 0.62689*<br>(0.0012) | 0.79857*<br>(0.0005) | 0.21405<br>(0.1525) | -0.02151<br>(0.8673) |
| **$\sigma_1$** | 0.0535<br>(0.4228) | 0.1851<br>(0.3622) | 0.1314<br>(0.242) | 0.0516<br>(0.3051) |
| **$\sigma_2$** | 0.1805<br>(0.9617) | 0.4258<br>(0.3925) | 0.00017*<br>(0.0347) | 0.0959<br>(0.7394) |

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Note: The table specifies the parameter of DCC-GARCH model. $W_1$, $W_2$ specifies the constant term and $A_{11}$, $A_{22}$ are estimated coefficients of ARCH effects, $B_{11}$ ,$B_{22}$ are estimated coefficients of GARCH effects , $\sigma_1$measures the impact of lagged shocks on present dynamic conditional correlation, and $\sigma_2$ estimates the impact on present dynamic conditional correlation of the past dynamic conditional correlation, p-values are shown in parentheses

Tale 5 shows DCC GARCH model results of gold and BRIC economies. The results explain that past shocks have linkage with current volatility in case of oil and BRIC stock markets. The results of Russia and Brazil show strong persistence with respect to the past and current shocks. In case of India and China the ARCH effect show significant results, outlining the linkage between current and past shocks whereas GARCH effect shows insignificant results. Overall the finding shows that current shocks are influenced by past shocks in the stock markets under consideration and the findings are in line with Akkok and Civcir (2019).

## 5. Conclusion

The study aims at examining the volatility spillover and shock dependence between pairs of BRIC-Oil and BRIC-Gold during COVID-19 outbreak. We find no indication of volatility transmission between oil market and stock market of Brazil, whereas oil market and stock markets of Russia show the two-way volatility spillover. In case of India, there is presence of uni-directional volatility spillover from stock market to oil. The results of China show the presence of volatility spillover from oil market to stock market, whereas the results of gold and stock market reveal no evidence of shock dependence in gold and stock markets in case of Brazil and China whereas in Russia and India there is the evidence of the same. There is negative shock dependence from gold to Russian stock market, whereas in India there is the positive shock dependence from stock market to gold. The volatility spillover results of Gold-Brazil depict insignificant results, whereas in Russia and China there is volatility spillover that is bidirectional in nature. The results in case of India show the unidirectional spillover from gold to Indian stock market. The research findings present useful insights for policy makers, investors, risk managers, and portfolio managers. The diversification benefits are pronounced in case of oil, gold and Brazilian markets whereas the strong spillover connections between oil market, and Russian stock market, gold and Russian stock market, gold and Chinese stock market assist policy makers to devise policies for protecting the stock markets from oil and gold price fluctuations Investor can minimize the risk by investing in the portfolio of oil and Brazilian stock market during tranquil period. The scope of study is limited to BRIC economies. Future research can be done by taking into consideration a set of global stock markets due to increasing effects of COVID-19 pandemic on global stock markets.

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## References

1. Akkoc, U., & Civcir, I. (2019). Dynamic linkages between strategic commodities and stock market in Turkey: Evidence from SVAR-DCC-GARCH model. *Resource Policy, 62*, 231-239.
2. Aromi, G., & Clements, A. (2019). Spillovers between oil sector and S&P 500: The impact of information flow about crude oil. *Energy Economics*, *81,*187-196.
3. Al-Yahyaee, H. K., Rehman, M., Al-Jarrah, W. M. I., Mensi, W., & Vo, V. Z. (2020). Co-movements and spillovers between prices of precious metals and non-ferrous metals: A multiscale analysis. *Resource Policy*, *67,* 101680.
4. Ali, M., Alam, N., & Rizvi, S. A. R. (2020). Coronavirus (COVID-19)—An epidemic or pandemic for financial markets. *Journal of Behavioral and Experimental Finance*, *27,* 100341.
5. Aslam, F., Ferreira, P., Mughal, K. S., & Bashir, B. (2021). Intraday Volatility Spillovers among European Financial Markets during COVID-19. *International Journal of Financial Studies, 9*(1), 5.
6. Belhassine, O. (2020). Volatility spillovers and hedging effectiveness between the oil market and Eurozone sectors: A tale of two crises. *Research in International Business and Finance*, *53,* 101195.
7. Boga, B.L & Morema, K. (2020). The impact of oil and gold price fluctuations on the South African equity market: Volatility spillovers and financial policy implications. *Resource Policy*, *68.*
8. Boubeker, H., & Raza, A. S. (2017). A wavelet analysis of mean and volatility spillover between oil and BRICS stock markets. *Energy Economics*, *64,*105-117.
9. Corbert, S., Hou, Y., Hu, Y., Oxley, L., & Xu, D. (2021). Pandemic-related financial market volatility spillovers: Evidence from the Chinese COVID-19 epicenter. *International Review of Economics and Finance, 71,* 55-81.
10. Engle, R. F., & Kroner, K. F. (1995). Multivariate simultaneous generalized arch. *Economic Theory*, *11,* 122–150.
11. Engle, (2002). Dynamic Conditional Correlation: a simple class of multivariate generalized autoregressive conditional heteroskedasticity models. *Journal of Business Economics and Statistics, 20* (3), 339–350
12. Farid, S., Kayani, M. G., Naeem, A. M & Shazad, H. J. S. (2021). Intraday volatility transmission among precious metals, energy and stocks during the COVID-19 pandemic. *Resources Policy*, *72,* 102101
13. Jiang, Y., Fu, Y., & Ruan, W. (2019). Risk spillovers and portfolio management between precious metal and BRICS stock markets. *Physica A: Statistical Mechanics and its Applications, 534,* 120993.
14. Hanif, W., Mensi, W., & VO, V. X. (2021). Impact of Covid-19 outbreak on the spillovers between US and Chinese stock sectors. *Finance Research Letters*, *40,* 101922.
15. Huo, R., & Ahmed, D. A. (2020). Volatility transmission across international oil market, commodity futures and stock markets. *Energy Economics, 93,* 104741.
16. Kumar, S., Pradhan, K. A., Tiwari, K. A., & Kang, H. S. (2019). Correlations and volatility spillovers between oil, natural gas and stock prices in India. *Resource Policy*, *62,* 282-291.
17. Li, Y., Zhuang, X., Wang, J., & Dong, Z. (2020). Spatial linkage of volatility spillovers and its explanation across China's interregional stock markets: a network approach. *Applied Economics Letters, 28*(8), 668-674.
18. Lyocsa, S., Baumohl, E., Vyrost, T., & Molnar, P. (2020). Fear of the coronavirus and the stock markets. *Finance Research Letters, 36,* 101735
19. Labordo,R & Olmo,J.(2021). Volatility spillover between economic sectors in financial crisis prediction: Evidence spanning the great financial crisis and Covid-19 pandemic. *Research in International Business and Finance, 57,* 101402.
20. Mensi, W., Hammoudeh, S., Al-Jarrah, W. M. I., Al-Yahyaee, H. K., & Kang, H. S. (2019). Risk Spillover and hedging effectiveness between major commodities,and Islamic and conventional GCC banks .*Journal of International Financial Institiutions, Market and Money*, 60, 68-88.

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21. Mensi, W., Beljid, M., Boubaker., A., & Managi, S. (2013). Correlations and volatility spillover across commodity and stock markets: Linking energies, food and gold. *Economic Modelling*, *32,* 15-23.
22. Pal,D.,& Mitra,K.S.(2020). Time-frequency dynamics of return spillover from crude oil to agricultural commodities. *Applied Economics, 52*(49), 5426-5445.
23. Sarwar, S., Tiwari, K.A., & Tingiu, C. (2020). Analyzing volatility spillovers between oil market and Asian stock markets. *Resource Policy, 66,* 101608.
24. Sarwar, S., Khalfoui, R., Waheed, R., Dastgerdi, G.H. (2018). Volatility spillovers and hedging: Evidence form Asian Oil importing countries. *Resource policy, 61,* 479-488.
25. Shahzad, H. J., Mensi, W., Hammoudeh, S., Rehman, M., & Yahyaee, H. K. (2018). Extreme dependence and risk spillovers between oil and Islamic stock markets. *Emerging Market Review*, *34,* 42-63.
26. Shahzad, H. J. S., Naeem, A. M., Peng, Z., & Bouri, E. (2021). Asymmetric volatility spillover among Chinese sectors during COVID-19. *International Review of Financial Analysis*. *75,* 101754.
27. Shi, K. (2021). Spillover of stock markets among the BRICS:New evidence in time and frequency domains before the outbreak of Covid-19 pandemic. *Journal of Risk and Financial Management, 14*(3), 112.
28. Wang, X & Wu, C. (2018). Asymmetric volatility spillovers between crude oil and international financial markets. *Energy Economics*, *74*, 592-604.
29. Wang, X & Wang, Y. (2019). Volatility spillover between crude oil and Chinses sectoral equity markets: Evidence from frequency dynamics perspective. *Energy Economics, 80,* 995-1009.
30. Wen, D., Weng, G.J., Ma, C., & Wang, Y. (2019). Risk spillovers between oil and stock markets: A VAR for VAR analysis. *Energy Economics, 80,* 524-535.
31. Yu, L., Zha, R., Stafylas, D., He Kaijian., & Liu, Ji.(2020).Dependences and volatility spillovers between oil and stock markets: New Evidence from copula and VAR-BEKK GARCH models. *International Review of Financial Analysis, 68,* 101280.
32. Zhang, W & Hamori, S. (2021). Crude oil market and stock markets during the COVID-19 pandemic: Evidence from the US, Japan, and Germany. *International Review of Financial Analysis*, *74,* 101702.
33. Zhang, W., Zhunag, X., Lu, Y., & Wang, J. (2020). Spatial linkage of volatility spillovers and its explanation across G20 stock markets:A network framework. *International Review of Financial Analysis*, *71,* 101454.