



Volatility connectedness of GCC stock markets: how global oil price volatility drives volatility spillover in GCC stock markets?

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Abstracts

The study investigated the volatility connectedness of GCC stock market return and S&P global oil index returns using Diebold and Yilmaz (2012) method. The current study has also analyzed the possible impact of oil price volatility on net volatility spillover in GCC stock market returns pre- and post-COVID-19 period. The current study results suggest that the GCC stock markets have volatility connectedness with S&P Global Oil Index returns' volatility and across GCC stock markets. The GCC stock markets have greater volatility in their stock markets than volatility spillover from other GCC countries. Further investigation also suggests that global oil price volatility has a divergent causal impact on net spillover in GCC stock markets. Such results would enhance the understanding of GCC stock market connection, spillover, and economic channels through which GCC markets are connected.

Keywords Volatility connectedness · Volatility spillover · Stock prices · Oil prices · Pandemic-induced crises

Introduction

The oil-stock nexus has been investigated extensively by various scholars due to its vital implication for the real economy see, e.g., (Fasanya et al. 2021; Naeem et al. 2022). Similarly, financial analysts, policy-makers, energy portfolio managers, government, and investors also keep eye on oil and stock price movements (Narayan and Narayan 2017; Salisu and Isah 2017). Recently, greater instability in global oil prices (Narayan and Narayan 2017; Raheem 2017; Shahzad et al. 2021) created greater turbulence in oil supply and demand (Salisu and Isah 2017). Disequilibrium was observed in the supply and demand of oil which resulted in co-movements in oil prices and stock markets (Narayan and Narayan 2017; Raheem 2017; Shahzad et al. 2021). Such co-movement

urged energy portfolio managers, investors, and governments in oil-rich countries to plan public spending and individual investors to proceed with caution (Hussain et al. 2017; Narayan and Narayan 2017; Naeem et al. 2022).

The Gulf Cooperation Council (GCC) plays a vital role in oil production (Hung 2021). GCC contributes 40% to global oil production (Ziadat et al. 2020; Hung 2021). The brief statistics of GCC's contribution to oil production are given in Table 1 which clearly shows the importance of GCC in global oil production. It is evident from Table 1 that Kuwait has produced 103.1 million tons, Oman 46.1, Qatar 75.9, Saudi Arabia 519.6, and United Arab Emirates 165.6 in the year 2020. GCC being a major oil producer, the fluctuation of oil prices will directly affect GCC countries stock markets and economy (Fasanya et al. 2021). As result, companies, businesses, governments, and individuals would suffer (Fasanya et al. 2021). Similarly, the GCC economies have gone through liberalization in recent decades which might have a connection with global economies (Hung 2021). Such association might appeal to the international investor who seeks diversification in global financial markets.

Theoretically, the oil-stock nexus has established a negative relationship in many studies. Still, the oil-stock nexus is unresolved. The famous Jones and Kaul (1996) cash flow hypothesis suggests that oil price has two obvious effects on the stock price. First, the direct effect suggests that an

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Table 1 Production in million tons (MT)

	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Kuwait	123.4	140.9	154	151.4	150.2	148.2	152.7	145	146.8	143.4	130.1
Oman	42.2	43.2	45	46.1	46.2	48	49.3	47.6	47.8	47.3	46.1
Qatar	70.9	77.7	82.2	84.2	83.5	81.2	81.6	79.1	79.5	77.7	75.9
Saudi Arabia	463.3	522.7	549.2	538.4	543.8	568	586.7	559.3	576.8	556.6	519.6
United Arab Emirates	135.2	150.5	156.2	162.8	163.4	176.1	182.4	176.2	176.7	180.5	165.6

Source: (Dale 2021)

increase in oil price increases the cost of production and hence reduces earnings, dividends, future cash flow, and stock prices (Basher et al. 2012; Rafailidis and Katrakilidis 2014). Second, the indirect effect of oil prices on stock prices also called the interest rate channel suggests that higher oil prices increase inflation and nominal interest rate. The interest rate channel works on basic valuation theory where the relevant cash flow is discounted by a relevant discount factor. Higher nominal rates mean a higher discount factor which results in depressing stock prices (Basher et al. 2012; Rafailidis and Katrakilidis 2014). Contrary to this argument, Kilian (2008) reported convincing empirical evidence that stresses the importance of the segregation of demand and supply shocks. The oil-stock relationship can go either way, positive or negative. The oil-stock relationship depends on supply or demand shocks, i.e., whether the oil price is driven by supply or demand (Kilian 2008). Following Kilian and Park (2009), many studies have applied such an approach to investigate the oil-stock nexus, see, e.g., Basher et al. 2012; Wang et al. 2013).

Although Kilian and Park (2009) argument was convincing, the applicability of such an approach has been criticized in the literature (Naeem et al. 2022). For example, Degiannakis et al. (2018) and Naeem et al. (2022) criticized the decomposition process of oil demand and supply shocks. For correct estimation of oil demand and supply shock, a proper decomposition process is vital and current oil prices must correlate with future prices in structural vector autoregression (SVAR) (Degiannakis et al. 2018; Naeem et al. 2022). Such condition makes it challenging to segregate the oil demand and supply shock (Han et al. 2016; Clements et al. 2019). Similarly, the estimation of oil supply and demand shock becomes problematic due to a slow increase in oil prices (Anand and Paul 2021). Furthermore, the Kilian and Park (2009) approach is well suited to macro-economic variables where monthly, quarterly, and annual data is used. However, this approach may not be well suited for equity markets where daily data is used (Degiannakis et al. 2018; Naeem et al. 2022). Finally, the financial analyst, portfolio managers, individual investors, and day traders analyze the market on daily basis due to daily changes in market expectations (Degiannakis et al. 2018; Mokni and Youssef 2019; Naeem et al. 2022).

Oil-stock nexus in the GCC context is also explored in a few studies using different methods, see, e.g., Alqahtani et al. (2019) and Cheikh et al. (2021). We have reported some recent studies to compare our study with the rest of the literature based on the methods applied. For example, Hamdi et al. (2019) examined the oil-stock nexus using the nonlinear wavelet demonized-based quantile and granger causality method. Hamdi et al. (2019) report that almost all sectors of the GCC economy are dependent on oil price volatility except the banking, insurance, and transport sector. Fasanya et al. (2021) investigated the oil-stock nexus using non-linear ARDL to find the significance of asymmetries and structural breaks in the oil-stock nexus. Wong and El Massah (2018) investigated the effect of oil price changes on stock price volatility using granger causality and impulse response function. More diversification is required at the country level due to high volatility in GCC during the period of high oil price changes (Wong and El Massah 2018). Similarly, Alqahtani et al. (2019) have examined the possible impact of oil price volatility on stock returns using dynamic conditional correlation (DCC) and found a negative association of GCC stock returns with oil price uncertainty. Mokni and Youssef (2019) used a copula approach and reported contradictory evidence to Alqahtani et al. (2019) and report a positive association of oil-stock nexus in GCC. Siddiqui et al. (2020) examined the oil-stock nexus in the 2014–2016 oil slump using non-linear ARDL and concluded asymmetric effects persist in the pre- and post-slump period. The negative oil price changes have more pronounced effects on stock returns in oil exporting countries whereas positive oil price changes have stronger effects on equity returns in oil-importing countries. Furthermore, Cheikh et al. (2021) examined the asymmetric relationship between oil prices and stock returns using a nonlinear transition regression method. Cheikh et al. (2021) have found asymmetric relationship between oil and stock nexus in GCC. Finally, Al Refai et al. (2022) investigated oil-stock nexus and possible impact of COVID-19 and concluded that COVID-19 has no meaningful effect on oil-stock nexus in GCC.

After a careful review of current literature related to GCC, we depart from existing literature and contribute to the existing literature by applying novel methods. First, our focus is on volatility connectedness and spillover. We first extracted

volatility using the Generalized Autoregressive Conditional Heteroscedasticity (GARCH) model for each stock market in GCC and oil prices. Then, we find the volatility connectedness using Diebold and Yilmaz (2012)'s method. Diebold and Yilmaz (2012)'s method has advantages compared to existing studies. The current study method measures pairwise connectedness of time series variables on different time scales which might not be possible in traditional methods of causality and correlation (Inekwe 2020). The method also quantifies the volatility of "receiver" and "giver." The current study method is also capable of quantifying volatility connectedness and spillover across the markets in different countries (Diebold and Yilmaz 2012; Inekwe 2020). It is worth mentioning that we found one similar study in the method applied, i.e., Hung (2021). Hung (2021) has investigated stock market connectedness in GCC using Diebold and Yilmaz (2012)'s method. Hung (2021) has investigated stock market connectedness in GCC, and our study investigated several differences compared to Hung (2021)'s study. First, our study investigated S&P Global Oil Index returns' volatility connectedness with GCC stock market returns. Hung (2021) has investigated connectedness across GCC stock markets. Hung (2021) does not analyze S&P Global Oil Index returns' volatility and GCC stock market return volatilities. Similarly, our study also investigated the impact of global oil price volatility on net volatility spillover in GCC but Hung (2021) lacks such analysis. Furthermore, the current study analysis is extended to examine the behavior of global oil price volatility and net volatility spillover pre-COVID-19 and during COVID-19. Such analysis has not been conducted by Hung (2021) might also fill the gap in growing literature related to pandemic-induced crises and financial markets.

The rest of the paper has three sections. Section 2 contains a brief literature review, followed by Section 3 which contains the research methodology and result and Section 4 which contains the conclusion.

Literature review

Decades-old oil-stock nexus has been investigated by various studies. The literature is very extensive and may not be possible to cover all aspects of the empirical studies conducted in the oil-stock nexus. The current study reviews a brief of the current studies in oil-stock nexus related to GCC, especially, the methods applied.

Following, Hamilton (1983)'s numerous studies have investigated the oil-stock nexus in oil-importing and exporting countries (Maghyereh and Al-Kandari 2007; Narayan and Narayan 2010; Jammazi 2012). Jones and Kaul (1996)'s cash flow hypothesis provides theoretical justification oil-stock nexus. Oil price fluctuation can have either direct or

indirect effects. The direct effects of oil prices can change the production cost of corporations. Such effects affect income, expenses, dividends, expected future cash flows, and stock prices (Basher et al. 2012; Rafailidis and Katakilidis 2014). The indirect effect of oil price changes on stock price suggests that higher oil price affects inflation and nominal interest rates. Once nominal interest is affected, the stock price will also change. Stock valuation theory suggests that the higher the nominal rates (discount rates) lower will be the stock price.

Beyond the negative link between the oil-stock nexus, Kilian (2008) and Kilian and Park (2009) suggest that it is important to segregate the oil demand and supply shocks to determine which shock is driving oil prices. Following Kilian and Park (2009), many studies have applied such an approach to investigate the oil-stock nexus, see, e.g., Apergis and Miller (2009), Miller and Ratti (2009), Filis et al. (2011), Basher et al. (2012), and Wang et al. (2013). Although Kilian and Park (2009)'s argument was convincing, the applicability of such an approach has been criticized in the literature see, e.g., Naeem et al. (2022).

Recent studies (other than GCC) have also applied various methods to explore the oil-stock nexus (Zhou et al. 2019; Mokni et al. 2020; Wang and Xu 2022). Kumar et al. (2021) investigated the oil-stock nexus in oil-importing and exporting countries using the CQ method. The result reported an asymmetric response of stock price to oil prices. Maghyereh and Abdoh (2021) investigated the oil-stock nexus using the BK-QCSD method to segregate the oil demand and supply shock and oil shocks affect stock returns directly. The short-run and long impacts of oil shocks are different on stock prices. Shahzad et al. (2021) studied the oil-stock nexus in BRICS using TVOC and concluded that oil-exporting countries are more effective by oil price shocks than oil-importing countries.

Similarly, various studies have been conducted on the oil-stock nexus in the GCC context. For example, Maghyereh and Al-Kandari (2007), Narayan and Narayan (2010), Arouri et al. (2011), Fayyad and Daly (2011), Mohanty et al. (2011), and Jouini and Harrathi (2014) have investigated the oil-stock nexus in GCC using various methods. Maghyereh and Al-Kandari (2007) studied the non-linear relationship between oil and stock prices. Similarly, Fayyad and Daly (2011) applied a vector autoregressive model (VAR) to find the possible linkage between oil prices and stock prices. Adding on, Mohanty et al. (2011) investigated the oil-stock nexus using the panel Granger causality test. Similarly, Jouini (2013) used panel OLS to account for cross-country heterogeneity in GCC, and Jouini and Harrathi (2014) applied BEKK-GARCH to find out the volatility linkages in GCC oil-stock nexus. Khalifa et al. (2017) investigated oil-stock nexus using spillover asymmetric multiplicative error modeling whereas Nusair (2016) used NARDL to find

out the possible non-linearity in oil-stock nexus in GCC. All studies mentioned above have used other methods to explore the oil-stock nexus in GCC. For example, Hamdi et al. (2019) investigated the oil-stock nexus using the wavelet method. Fasanya et al. (2021) investigated the oil-stock nexus using non-linear ARDL. Finally, some recent studies see, e.g., Ziadat and McMillan (2021), Al Refai et al. (2022), and Tien and Hung (2022), have also investigated the topic under discussion. Ziadat and AlKhouri (2022) decomposed oil price shock into supply and demand shock using Ready (2018)'s method using monthly data. Monthly data usage has been criticized in literature as the financial analyst, portfolio managers, and individual investors, and day traders analyze the market on daily basis due to daily changes in market expectation (Degiannakis et al. 2018; Mokni and Youssef 2019; Naeem et al. 2022). Similarly, Tien and Hung (2022) have used dynamic conditional correlation (DCC) to explore the topic under discussion. Tien and Hung (2022) found that negative oil price shocks have pronounced effects than positive shocks on conditional correlation among oil price and stock price. Umar et al. (2021) examined the topic under discussion by decomposing oil shocks (supply, demand, and risk shocks) and concluded that demand and risk shocks are prominent contributors to volatility connectedness.

A careful review of the literature enabled us to highlight the important contribution to existing literature. To the best of our knowledge, the current is the first to use Diebold and Yilmaz (2012)'s method with one exception, i.e., Hung (2021). Hung (2021) investigated the stock market connectedness in GCC, our study investigated several differences compared to Hung (2021)'s study. First, our study investigated S&P Global Oil Index returns' volatility connectedness with GCC stock market returns. Hung (2021) has investigated connectedness across GCC stock markets. Hung (2021) does not analyze S&P Global Oil Index return volatility and GCC stock market return volatilities. Similarly, our study also investigated the impact of global oil price volatility on net volatility spillover in GCC but Hung (2021) lacks such analysis. Furthermore, the current study analysis is extended to examine the behavior of global oil price volatility and net volatility spillover

pre-COVID-19 and during COVID-19. Such analysis might also fill the gap in growing literature related to pandemic-induced crises and financial markets.

Methodology

Data

The current study has used daily data from March 2012 to May 2022. Three variables, GCC Stock Indexes, S&P Global Oil Index, and World Crude Oil (WTI), are applied in the analysis. We have calculated stock returns for all countries in our sample by using the first difference. Similarly, the S&P Global Oil Index returns were calculated. The detail of GCC Stock Indexes, S&P Global Oil index, and World Crude Oil (WTI) data sources are given in Table 2.

Method

Before applying Diebold and Yilmaz (2012)'s method, first, we extracted the volatilities of GCC Stock Index returns by applying the Generalized Autoregressive Conditional Heteroscedasticity (GARCH). Similarly, the S&P Global Oil Index returns' volatilities were estimated. Furthermore, the volatilities were also extracted from global oil prices (WTI). Then, we applied Diebold and Yilmaz (2012)'s cross-country connectedness of the following:

- I. Stock market volatility connectedness and spillover across GCC countries
- II. S&P Global Index volatility connectedness with GCC stock returns' volatilities.

Furthermore, the oil price volatilities were regressed on net volatility spillover to check the possible impact of oil price volatilities on net volatility spillover in GCC stock returns using Newey regression.

Table 2 Data source

Country	Stock market index	Data source	Other variables	Data source
Kuwait	Premier Market Index (PR) (BKP)	Investing. Com	World Crude Oil (WTI)	Federal Reserve Bank of St. Louis
Saudi Arabia	Tadawul (traded) All Share Index (TASI)	Investing. Com	S&P Global Oil Index	www.spglobal.com
Qatar	QE Index (GNRI)	Investing. Com		
UAE	Abu Dhabi General Index (ADI)	Investing. Com		
Bahrain	Bahrain All Share Index (BSEX)	Investing. Com		
Oman	MSX 30 Index (MSX30)	Investing. Com		

Extracting volatilities

As mentioned earlier, the volatilities are extracted using GARCH the model. The following GARCH (1,1) variance equation (01) was estimated. All preliminary tests were conducted to apply GARCH. For example, the BDS and Ramsey’s RESET test to check for possible nonlinearities. We also tested expected ARCH effects (not reported for sake of brevity).

$$\delta_t^2 = \alpha_0 + \alpha_1 \mu^2_{t-1} + \beta \delta^2_{t-1} \tag{1}$$

Volatilities extracted were stored to check the connectedness and spillover of a variable of interest in this study using Diebold and Yilmaz (2012)’s method.

Volatility connectedness and spillover

Diebold and Yilmaz (2012)’s method is based on the vector auto-regression (VAR) model with “P” lag and “N” variables. Diebold and Yilmaz (2012)’s specification of VAR for a variable of interest can be written as follows:

$$x_t = \sum_{i=1}^p \phi_i X_{t-i} + \varepsilon_t \tag{2}$$

$\varepsilon_t \sim (0, \Sigma)$ is a white noise error term that is identically and independently distributed. The intercept of the autoregressive (AR) process can be obtained as given as follows:

$$x_t = \sum_{i=0}^{\infty} A_i \varepsilon_{t-i} - 1 \tag{3}$$

where recursive substitution $A_i = \phi 1A_{i-1} + \phi pA_{i-2} + \dots + \phi pA_{i-p}$ with $A_0 = I_n$ can be used to estimate $N \times N$ coefficient matrix A_i and $A_i = 0$ for $i < 0$. Diebold and Yilmaz (2012) studied the specification of moving average (MA) to obtain the forecasted value of H-step ahead. This generalized H-step ahead statistics is named as Generalized Spillover Index (GSI). Diebold and Yilmaz (2012) specified GSI as follows:

$$\theta_{ij}(H) = \frac{\sigma_{ij}^{-1} \sum_{h=0}^{H-1} (e'_i A_h \Sigma_{\varepsilon} e_j)}{\sum_{h=0}^{H-1} (e'_i A_h \Sigma_{\varepsilon} A'_h e_i)} \tag{4}$$

Similarly, the normalized variance decomposition matrix (normalized by row sum) is given in Eq. (5) and the Total Volatility Spillover Index (TVSI) can be specified as given in Eq. (6).

$$\tilde{\theta}_{ij}(H) = \frac{\tilde{\theta}_{ij}(H)}{\sum_{j=1}^N \theta_{ij}(H)} \tag{5}$$

$$C(H) = \frac{\sum_{i,j=1, i \neq j}^N \tilde{\theta}_{ij}(H)}{\sum_{i,j=1}^N \tilde{\theta}_{ij}(H)} \times 100 = \frac{\sum_{i,j=1, i \neq j}^N \tilde{\theta}_{ij}(H)}{N} \times 100 \tag{6}$$

Furthermore, Diebold and Yilmaz (2012) specified the directional spillover from one market to another (market i to market j) and the directional volatility spillover from market j to market i are given in Eqs. 7 and 8, respectively.

$$C_{i \rightarrow j}(H) = \frac{\sum_{j=1, i \neq j}^N \tilde{\theta}_{ji}(H)}{N} \times 100 \tag{7}$$

$$C_{i \leftarrow j}(H) = \frac{\sum_{j=1, i \neq j}^N \tilde{\theta}_{ij}(H)}{N} \times 100 \tag{8}$$

Finally, the net spillover between one market and another (market i , market j) can be quantified as the difference between Eqs. 7 and 8. In the equation form, the difference can be specified as follows:

$$C_{i \rightarrow j}(H) - C_{i \leftarrow j}(H) \tag{9}$$

Global oil price volatility and GCC stock market net volatility spillover

As mentioned earlier, we have also checked the possible impact of global oil price volatility on net volatility spillover in GCC. We have examined such impact for the whole study period, during pre-COVID-19 and COVID-19. The following equation was estimated:

$$NVSO_t = \alpha + \beta OPV_t + \varepsilon_t \tag{10}$$

where NVSO is net volatility spillover and OPV is global oil price volatilities (WTI price volatilities extracted by GARCH).

Results and discussion

Tables 3, 4, and 5 report brief descriptive statistics of volatility connectedness and spillover, i.e., Table 3 (transmitter), Table 4 (receiver), and Table 5 (net spillover). As shown in Tables 3, 4, and 5, on average, the volatility spillover

Table 3 Descriptive statistics volatility spillover to (transmitter)

Variable	Obs	Mean	Std. Dev.	Min	Max
Kuwait	2268	6.294	2.912	.359	19.63
Bahrain	2268	6.11	3.676	.221	53.293
Oman	2268	6.404	4.233	.591	58.022
Qatar	2268	6.23	3.432	.149	46.255
Saudi Arab	2268	5.203	3.192	.45	50.474
Abu Dhabi	2268	5.536	3.401	.008	57.831
S&P Global Oil	2268	6.755	3.792	.118	67.018

Table 4 Descriptive statistics volatility spillover from (receiver)

Variable	Obs	Mean	Std. Dev.	Min	Max
Kuwait	2268	6.811	2.423	1.333	14.161
Bahrain	2268	5.883	1.893	1.486	14.184
Oman	2268	6.054	2.128	1.57	14.13
Qatar	2268	6.152	2.232	1.212	14.273
Saudi Arab	2268	5.404	1.872	1.193	14.242
Abu Dhabi	2268	5.92	2.067	1.171	14.284
S&P Global Oil	2268	6.308	2.157	1.844	14.266

Table 5 Descriptive statistics volatility spillover (net)

Variable	Obs	Mean	Std. Dev.	Min	Max
Kuwait	2268	-.517	3.749	-13.348	14.732
Bahrain	2268	.227	4.096	-13.508	48.042
Oman	2268	.35	4.545	-12.965	53.421
Qatar	2268	.078	3.912	-14.124	44.436
Saudi Arab	2268	-.202	3.545	-13.792	46.314
Abu Dhabi	2268	-.384	3.862	-14.275	53.621
S&P Global Oil	2268	.447	4.253	-14.138	64.239

of transmitters, receivers, and net spillover have interesting characteristics. It is evident from Table 3 that on average, volatility in S&P Global Oil returns is dominant in volatility transmission to GCC countries.

The second major transmitter is Oman which (on average) has the second contribution in volatility transmission to GCC countries. Similarly, the third, fourth, and fifth major volatilities transmitters are Qatar, Bahrain, and Abu Dhabi, respectively (kindly see Table 3). On the receiver end, S&P Global Oil returns are receiving the highest volatility from GCC countries. Kuwait is the second major volatility receiver, followed by Qatar, Oman, Abu Dhabi, Bahrain, and Saudi Arabia (kindly see Table 4). The ranks of transmitter and receiver are different; the net volatility spillover can give us a clear picture. As shown in Table 5, the positive net spillover represents the (net) transmitter and the negative denotes the (net) receiver. Interestingly, three countries (Kuwait, Saudi Arabia, and Abu Dhabi) have received more volatility than transmission. Kuwait has received the highest net volatility shock, followed by Abu Dhabi and Saudi Arabia. S&P Oil Index returns' volatility is the highest net transmitter to GCC countries.

Figure 1 show net volatility spillover on the different time scale in GCC stock markets. The Saudi Arabian stock market had a minor fluctuation in net volatility spillover in the first four years of the sample period. However, the positive net volatility spillover (transmitting) is dominant till the end of 2020. On a different time scale, the Qatar net volatility spillover is positive and more pronounced compared to

negative (positive net spillover indicates transmitter whereas negative means receiver). Similarly, the Oman stock market has transmitted more volatility than received in the sample period. Kuwait can be seen as a little different as the net volatility spillover does not have a clear pattern. The positive and negative volatility spillover is consistently changing over the study period. Bahrain's stock market is also following a random pattern in net volatility spillover; however, the magnitude of positive volatility spillover is more dominant during the study period. The same pattern can be seen in the Abu Dhabi stock market where the stock market has transmitted more volatility than receiving. Overall, the GCC stock markets have transmitted more volatility than receiving (see Fig. 1, overall net volatility spillover, the net volatility spillover has positive values).

Volatility connectedness across GCC and S&P Global Oil Index returns

Table 6 reports pairwise volatility connectedness across GCC and S&P Global Oil Index returns. The extreme left column (contribution from) reports volatility "received" and the second last row (contribution to) highlights volatility "transmitted" to other countries in GCC. The S&P Global Oil Index has received 7% volatility from the GCC stock market. The S&P Global Index has a volatility of approximately 93.33%. If we see the volatility connection of the S&P Global Oil Index returns, the major contributors are Oman and Kuwait and S&P Global Oil Index returns have received 1.755% and 3.1434%, respectively. The rest of the countries in the GCC (Bahrain, Qatar, Saudi Arabia, and UAE) have a very small contribution to volatility transmission.

However, the volatility connectedness across GCC is a little different. For example, Kuwait has 90.31% of its market volatility and received 10% from the remaining GCC countries and S&P Global Oil Index. Interestingly, Kuwait has received 6.746% volatility from Bahrain. Similarly, Bahrain has 89.07% of its market volatility and received only 11% from GCC stock markets and S&P Global Oil Index. Bahrain has received 7.28% from Kuwait and 2.913% from Saudi Arabia. Oman has a strong volatility connection with S&P Global and Qatar. The Oman stock market volatility is 90.4%, and the total volatility received from GCC and S&P Global Oil Index is 10%. The Oman stock market has received major volatility from S&P Global (6.82%) and Qatar (2.35%). Similarly, the Qatar stock market has a volatility of approximately 96.88%. Volatility received from GCC stock markets and the S&P Global Oil Index is around 3%. Qatar has received 1.612% volatility from Abu Dhabi, and the rest of the GCC countries have little connectedness with Qatar. The Abu Dhabi stock market has volatility of around 98.67% and receives only 1% from GCC and S&P Global Oil index. Overall, the GCC stock markets have

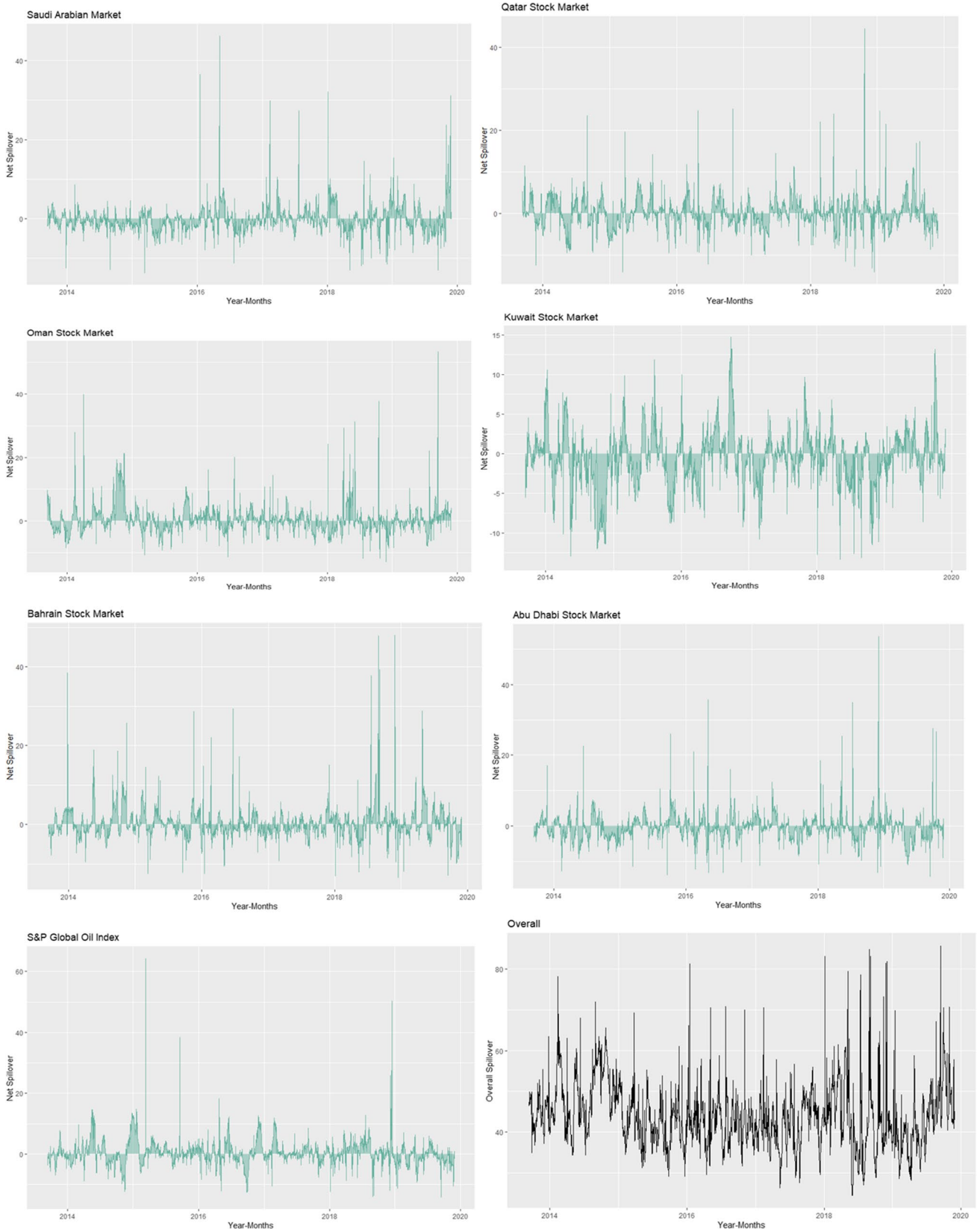


Fig. 1 Net volatility spillover in GCC

volatile markets due to their volatility. Some countries in GCC have volatility connectedness with the S&P Global Oil index and across GCC. As far as the volatility contribution to others is concerned, the S&P has transmitted 9% volatility to GCC countries. Kuwait and Bahrain are equal in volatility transmission (approximately 10% each) to the remaining countries in GCC. Similarly, the second-highest contributor in Oman and Qatar which have transmitted 5% volatility to the remaining countries in GCC. Finally, Saudi

Arabia and Abu Dhabi are the least volatile contributor to the remaining GCC countries (3% Saudi Arabia and 2% Abu Dhabi, respectively).

Impact of oil price volatility on net volatility spillover in GCC

Tables 7, 8, and 9 present the impact of oil price volatility on net volatility spillover in GCC. Table 7 reports the

Table 6 Volatility connectedness across GCC and S&P Global Oil Index returns

	S&P Global Oil	Kuwait	Bahrain	Oman	Qatar	Saudi Arab	Abu Dhabi	Contribution From
S&P Global Oil	0.933851	0.01755	0.007545	0.031434	0.007528	0.00004	0.002046	0.07
Kuwait	0.013937	0.903158	0.06746	0.001822	0.011313	0.000839	0.001472	0.10
Bahrain	0.005039	0.072871	0.890775	0.000466	0.001643	0.02913	0.00007	0.11
Oman	0.068245	0.000664	0.000994	0.904015	0.023542	6.60E-05	0.002475	0.10
Qatar	0.001783	0.002052	0.002464	0.007766	0.968864	0.000944	0.016127	0.03
Saudi Arab	0.00003	0.000319	0.017711	0.000376	0.001329	0.980196	0.00003	0.02
Abu Dhabi	0.003811	0.002827	0.000444	0.003354	0.002806	0.00003	0.986735	0.01
Contribution to other	0.09	0.10	0.10	0.05	0.05	0.03	0.02	
Including own contribution	1.03	1.00	0.99	0.95	1.02	1.01	1.01	

Table 7 Newey regression oil price volatility and net volatility spillover in GCC (full sample)

	Kuwait net spillover	Bahrain net spillover	Oman net spillover	Qatar net spillover	Saudi Arabia's net spillover	Abu Dhabi net spillover
Oil price volatility	-.151 (.127)	-.201 (.166)	-.527*** (.148)	.477*** (.182)	.326** (.152)	.115 (.173)
_cons	-1.876* (1.129)	-1.584 (1.511)	-4.395*** (1.309)	4.371*** (1.648)	2.73** (1.377)	.649 (1.558)
Observations	2268	2268	2268	2268	2268	2268
Pvalue	0.23	0.22	0.000	0.001	0.03	0.55

Standard errors are in parentheses: *** $p < .01$, ** $p < .05$, and * $p < .1$

Table 8 Newey regression oil price volatility and net volatility spillover in GCC (pre-COVID)

	Kuwait net Spillover	Bahrain net Spillover	Oman net Spillover	Qatar net Spillover	Saudi Arabia's net Spillover	Abu Dhabi net Spillover
Oil price volatility	-.135 (.137)	-.213 (.168)	-.634*** (.16)	.287* (.154)	.318** (.148)	.061 (.186)
_cons	-1.933 (1.235)	-1.722 (1.531)	-5.409*** (1.434)	2.631* (1.403)	2.575* (1.344)	.295 (1.672)
Observations	1936	1936	1936	1936	1936	1936
Pseudo- R^2	0.32	0.20	0.000	0.06	0.03	0.74

Standard errors are in parentheses: *** $p < .01$, ** $p < .05$, and * $p < .1$

Table 9 Newey regression oil price volatility and net volatility spillover in GCC (during-COVID)

	Kuwait net spillover	Bahrain net Spillover	Oman net spillover	Qatar net spillover	Saudi Arabia's net spillover	Abu Dhabi net spillover
Oil price volatility	−.575*** (.214)	−.224 (.326)	−.28 (.23)	1.04** (.481)	.177 (.343)	.536** (.262)
_cons	−4.481** (1.862)	−1.601 (2.878)	−1.906 (1.937)	9.515** (4.321)	1.946 (3.007)	3.616 (2.336)
Observations	332	332	332	332	332	332
Pseudo-R ²	0.007	0.49	0.22	0.03	0.66	0.04

Standard errors are in parentheses: *** $p < .01$, ** $p < .05$, and * $p < .1$

oil price volatility and net volatility spillover for the whole sample. We have divided the sample into two halves. First, pre-COVID-19 analysis and results are reported in Table 8. Second, Table 9 presents the possible impact of COVID-19.

As shown in Table 8, a divergent causal impact of oil price volatility on net spillover can be observed. The net volatility spillover behaves differently in GCC. For example, the result shows a negative significant impact of oil price volatility on net volatility spillover in Oman; however, net volatility spillover in Qatar and Saudi Arabia is affected positively. The impact of oil price volatility on net volatility spillover in the rest of the countries in the GCC is insignificant. The same result can be found in the pre-COVID-19 analysis (Table 8). The analysis during COVID-19 has little change as the sign and significance of the coefficient changed during COVID-19 (see Table 9). Table 9 shows that oil price volatility on net volatility spillover in Kuwait is negative and significant. However, a positive significant relationship can be found between oil price volatility and net volatility spillover in Qatar and Abu Dhabi stock markets. The divergent causal impact is not surprising in GCC due to the unique country's laws, reforms, risk, and strong oil dependence see, e.g., Alqahtani et al. (2019) and Al Refai et al. (2022). Alqahtani et al. (2019) report a negative and significant effect of oil price uncertainty on stock returns, Mohanty et al. (2011) report positive, and Al Refai et al. (2022) provide mixed evidence. GCC contributes 40% to global oil production (Ziadat et al. 2020; Hung 2021), and GCC countries have strong oil dependence. GCC countries' foreign earnings, government revenue, and expenditures are mainly driven by oil exports which are considered as main components of aggregate demand in GCC. These components of aggregate demand effects corporate output and prices which eventually affects corporate earnings. Due to high dependence on oil, GCC stock prices might be positively affected by an increase in oil prices. So we can expect a positive relationship. Conversely, one can expect a negative effect due to high inflation, interest rate, and discount rate which might decrease revenues, cash flows, and earnings, hence reducing stock prices.

Policy implications

The study results imply optimal portfolio strategy, reducing portfolio risk and diversification. Interestingly, the result of volatility connectedness across GCC differs and we can group GCC countries that have less volatility connectedness while assigning optimal portfolio weights. Similarly, the result can also help to identify GCC countries that are highly connected. High turbulence in one market may create high turmoil in highly connected markets which might increase portfolio risk. As shown in the result, the Oman stock market has received major volatility from Qatar. Similarly, Kuwait has received major volatility spillover from Bahrain and Bahrain is receiving major volatility from Kuwait. Qatar is a major volatility receiver from Abu Dhabi. The Saudi Arabian market has received a major volatility spillover from Bahrain. Such grouping is essential for investor fund allocation, portfolio construction, and diversification of portfolio risk. Apart from volatility connection across GCC stock markets, this study has also found volatility connection of GCC stock market with S&P Global Oil Index returns. Similarly, the GCC stock has also high volatility in its markets as well. The investor can consider such factors in optimal portfolio allocation strategies and portfolio weights. Furthermore, the COVID-19 impact reported in this study has given new insight related to investment decisions. Investors usually ignore infectious diseases while considering investment decisions. However, this study has shown significant effects of COVID-19 on net volatility spillover in GCC stock markets. Such a result argues that it is essential to consider infectious diseases while considering investment returns.

Conclusion

The study has investigated GCC stock market return volatility connectedness across markets. The study also shed light on stock return volatility connectedness and S&P Global Oil Index returns. Adding to stock market net volatility spillover determinants, we have also investigated the possible impact of global oil price volatility on net

volatility spillover in GCC. We have also extended the analysis to pre- and post-COVID-19 scenarios.

The result of stock market connectedness in GCC has diversity across stock markets. The stock markets have both stock market-to-market connections in GCC and stock market to S&P Global Oil Index returns. Although the GCC stock markets have greater volatility in their market, the volatility spillover from other GCC countries and S&P global oil index has been observed in the results. For example, among GCC stock markets, the Oman stock market has a strong volatility connection with S&P Global Oil Index returns. Similarly, the Oman stock market has received major volatility from Qatar. Similarly, Kuwait has received major volatility spillover from Bahrain and Bahrain is receiving major volatility from Kuwait. Qatar is a major volatility receiver from Abu Dhabi. The Saudi Arabian market has received a major volatility spillover from Bahrain. The analysis also finds the impact of global oil price volatility on net volatility spillover in GCC. In this regard, the results suggest the divergent causal impact of oil price volatility on net volatility spillover in GCC stock markets.

The investor, policymaker, and portfolio manager can benefit from such results in portfolio diversification and predicting the possible changes in stock returns in GCC stock markets. The outcome of the study has identified the “receiver” and “giver” and the magnitude of spillover across the market. So the portfolio manager and investors should contract the portfolio with caution and allocate the funds in less volatile markets.

Author contributions MH: writing—original draft, data collection, conceptualization, and supervision; RR: data analysis. Both authors read and approved the final manuscript.

Data availability The data is publically available, and all source of data used in this research is given in the manuscript.

Declarations

Ethics approval We declare that current research fully abides by both local and international guidelines of ethical research regulations.

Consent to participate Not applicable

Consent for publication All authors have explicit consent to publish this article submitted to ESPR.

Conflict of interest The authors declare no competing interests.

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