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The financial interconnectedness between global equity markets and crude oil: evidence from the GCC

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ABSTRACT

This paper investigates the interconnectedness between the GCC region, crude oil prices, and global equity markets of the US, Europe, and China. We use DCC-GARCH models and the Diebold and Yilmaz (2012) approach to examine the dynamic connectedness and the net directional flow of spillovers. Consistent with previous studies, we find that the US and European markets are net global contributors of return and volatility shocks, whilst the Chinese equity markets are gradually becoming influential. Meanwhile, the GCC equity markets have been anet recipient of shocks from oil prices. Our empirical results provide some important insights. Firstly, the net transmission of shocks from oil prices to the GCC markets has been reducing over time. Secondly, the total connectedness nearly doubled in response to the global pandemic. Thirdly, the Chinese stock markets are gradually transforming into net transmitters of spillovers to other global equity markets.

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Financial markets; connectedness; GCC; crude oil; spillovers; financial integration

1. Introduction

Financial markets are connected beyond simple correlations. Certain markets play a relatively dominant role in creating spillover effects that impact returns and volatilities of other markets. On the other hand, some markets are rather vulnerable as net recipients of shocks from others. The interconnectedness of financial markets could also vary over time and may exhibit anomalies during major geopolitical and economic events. The dynamic connectedness and integration across financial markets can be explored using econometric techniques such as the GARCH models or the Demirer, Gokcen, and Yilmaz (2019) approach. Our study particularly examines the financial connectedness of the Gulf Cooperation Council (GCC) countries, with the global equity markets and crude oil prices. The GCC comprises of six nations in the Middle East, which collectively form an economic bloc with a distinguished geopolitical environment. The GCC alone, accounts for nearly 56% of all the oil production by member states of the Organization of the Petroleum Exporting Countries (OPEC), and has therefore, been heavily reliant on oil exports (OPEC, 2019).[1]

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Nonetheless, the GCC countries have been committed to diversifying into non-oil sectors, such as tourism and real estate. Therefore, it is important to evaluate the intertemporal connectedness of the GCC equity markets with oil prices to observe if there has been a reduction in the net spillovers from oil prices. Our study covers the past decade, which has experienced several events both globally and regionally within the Middle East that have vastly affected the geopolitical and socioeconomic environment. Some of these events include the Arab Spring, the global oil price crash of mid 2010s, the regional Qatar Diplomatic Crisis, and the recent COVID-19 outbreak.[2] Recent events such as the global pandemic have created a demand for further research into the connectedness of regional financial markets with the global markets. Prior literature has shown that oil prices have been a significant contributor of return and volatility shocks, especially for oil exporting countries (Awartani and Maghyereh 2013; Maghyereh, Awartani, and Bouri 2016; Schmidbauer and Roesch 2013; Zhang 2017). Therefore, the crude oil market cannot be isolated from a connectedness study on the GCC region. Furthermore, prior studies show that the financial connectedness levels intensify during crises events (Mensi et al. 2018; Yoon et al. 2019). Hence, it would be reasonable to expect that the recent COVID-19 outbreak could increase the level of financial connectedness. Our study would also explore if this is the case, whilst examining the intensity of this effect.

Our research aims to explore the interconnectedness of GCC equity markets with global equity markets and crude oil prices, and doing so, we explore the connectedness for all GCC countries collectively, as well as for each GCC country separately. Our overall research objectives can be classified into three parts. Firstly, we are interested in examining the dynamic connectedness between GCC equity markets and oil prices, to assess if there has been a reduction in the directional spillovers from oil prices to the GCC equity markets. Secondly, we examine the net flow of directional spillovers from three global equity market indexes of the US, Europe and China to the GCC. Lastly, we are interested in learning about impacts of the recent COVID-19 outbreak on the financial integration levels. Pursuing our research objectives, the following questions would be answered. Have the regional crises events caused a dynamic shift in the region's financial connectedness with the rest of the world? Have the diversification strategies of the GCC countries reduced their dependence on oil? What is the new role of China, when it comes to the global financial connectedness of stock markets? Lastly, how has the connectedness of GCC financial markets with the rest of the world responded to the COVID-19 outbreak?

To answer these questions, we use two methods. First, we use VAR models to empirically examine the interactions between the GCC stock markets and three global equity market indexes as well as the crude oil prices. Here, the Diebold and Yılmaz (2014) approach is adopted, which uses forecast error variance decompositions to establish a matrix of directional spillovers amongst each possible pair of variables examined. This helps identify which of the markets are the largest contributors in terms of spillover shocks to others, and which of the markets are net recipients of shocks from others. Furthermore, we adopt a rolling-window to construct sub-samples of the data series to examine the time-varying spillovers and the dynamic relationship amongst the equity market indexes and the crude oil prices. Second, we use the DCC-GARCH approach to compute the dynamic conditional correlations between every pair of markets examined, to explore the pairwise financial integration levels between the GCC and global markets.

We use both approaches to evaluate the connectedness using the MSCI GCC regional index. Then, we repeat each analysis for the individual GCC countries using the country-wise MSCI equity indexes.

Our findings can contribute to the existing literature by providing insights on the source of global spillovers into the GCC equity markets. These results can help macroprudential policymakers and international investors. Policymakers could predict the directional future flow of a spillovers resulting from an external shock, and accordingly, use macroprudential policies to mitigate the impact of a financial contagion. International investors could learn about certain regional markets that are least correlated with the global markets, to devise optimal hedging and diversification strategies. Furthermore, we analyze how the equity markets' dynamic connectedness levels have been affected by the global pandemic. In addition to benefiting policymakers in crises handling situations and investors in diversification, our study also contributes to a growing literature on international finance.

The following parts of this paper are structured as follows: Section 2 provides a concise review of existing literature that is relevant to this research. Section 3 provides a discussion on the methodologies applied in this research. Section 4 provides further details regarding the data used for this research and the sample period that has been chosen. Section 5 illustrates the empirical findings of this research and lastly, Section 6 concludes this paper by providing the practical implications and policy recommendations drawn from the empirical findings of this research.

2. Literature review

Historically, the six GCC countries have been heavily dependent on oil. The GCC countries are often sought as diverse markets for international investors that not only provide an opportunity to invest into growing and high-growth sectors, but also provide hedging opportunities due to their differing geopolitical characteristics. For example, plummeting oil prices could be good news for most developed economies that are net importers of crude oil. However, any drastic reductions in global oil prices negatively impact the GCC economies and vice versa (Arouri and Rault 2012). Therefore, economic diversification strategies, which reduce their level of dependence on black gold would ultimately reduce the amount of spillovers these economies receive due to the volatilities and uncertainties in the global oil market. Over the past decade, the GCC countries have introduced many reforms to diversify their economies away from their overdependence on black gold. These include improvements in domestic infrastructure, education, business climate, tourism and the financial sector. Despite these efforts, the GCC countries continue to heavily rely on oil exports and it is unclear whether these strategies have resulted in reducing the amount of return and volatility spillovers from the global oil market. Prior literature has examined whether oil exporting countries are affected by shocks to oil prices and provided evidence for the existence of these spillovers. Awartani and Maghyereh (2013) examined this issue for the GCC and claimed that the global oil market is a net transmitter of shocks to the GCC equity markets. Arouri, Lahiani, and Nguyen (2011) and Jouini and Harrathi (2014) also concluded that there are substantial return and volatility spillovers between the global oil prices and the GCC equity markets.

Prior literature on regional and global spillovers to the GCC equity markets also includes an IMF Working paper by Saadi-Sedik and Williams (2011) who use GARCH models and find that the GCC equity markets are vulnerable to both intra-regional and extra-regional spillovers. They use the S&P 500 index as a proxy for global spillovers, whilst other developed equity markets are excluded from the analysis. Their findings suggest that the inflow of shocks for the GCC markets peaked during the global financial crisis of 2007–2008. However, the time frame examined does not include major regional and global crises events that occurred over the past decade, including the Arab Spring of early 2010s, the oil price crash of mid 2010s, the Qatar diplomatic crisis of 2017 and the global pandemic of 2020. This creates a gap in the literature that needs to explore the dynamic flow of connectedness and spillovers over the past decade. Furthermore, recent diversification strategies of GCC countries and an overall increase in the level of global financial integration may have cause significant changes to the connectedness dynamics and inferences from historic findings could be questionable. This provides us an opportunity to explore the issues in further detail with the most recently available datasets. Moreover, we could apply a wider variety of methods in addition to GARCH models, such as the recent econometric methods suggested by Diebold and Yılmaz (2014) to obtain further insights on the directional flow of spillovers amongst the equity indexes of our study.

Maghyereh, Awartani, and Bouri (2016) conducted a volatility connectedness study between the crude oil market and 11 global equity markets. Their study ultimately showed that the connectedness between crude oil and stock markets is predominantly unidirectional, running from the crude oil price to stock market indexes across all major equity markets. Another study by Jouini (2013) investigated the links between GCC stock markets and oil prices with the inclusion of the MSCI world index and the US interest rate. They also found that the GCC equity markets were being affected by global oil prices and had a significantly positive correlation as it would be expected for oil exporting countries. Jouini also claimed that there have been regime-shifts throughout the time series, and there have been structural breaks that must be accounted for. This can be achieved through a dynamic time varying analysis over an extended time frame. Furthermore, whilst it is helpful to include a single global index to examine the spillover effects from the rest of the world, it might be of greater interest to include specific globally dominant stock indexes instead.

Our choice of the US, Europe and Chinese equity indexes is motivated by the following. Tsai (2017) examined the impact of economic policy uncertainties of the US, Europe, Japan and China; on the rest of the world. They concluded that the Chinese and European policy uncertainties had a highly significant impact on the economic policy uncertainties of countries in the Asian continent. Moreover, the study concluded that China was the most influential transmitter of uncertainties in economic policies, whilst the US was also a significant contributor. Zhang et al. (2019) constructed a time-series model following the Diebold and Yılmaz (2014) approach and found out that whilst China has been increasingly becoming a key player in shaping the global world order, the US's dominant position still holds across all markets examined; oil, equity, credit and non-energy markets. From these two different viewpoints, it is beneficial for any further research to include, each of the US, European and Chinese stock markets when examining the influence of global stock markets on the GCC.

One of the most widely used methods to examine spillovers across the various financial markets has been introduced by Diebold and Yilmaz (2009), Diebold and Yılmaz (2014) and it will be later discussed in the methodology section. Diebold and Yilmaz (2009) examined the case for 19 global equity markets and analyzed the connectedness of their returns and volatilities. They used vector auto-regression (VAR) models to extract forecast errors that could be divided into two parts; Errors explainable by shocks to other data series, and errors due to un-explained idiosyncratic factors. Through this formulation, it is possible to determine what proportion of shocks to a particular data series could be explained due to spillovers from others. For instance, Diebold and Yilmaz (2009) found that the US equity market had a high level of connectedness with other markets and was a net contributor of return and volatility shocks to other countries. Meanwhile, Japan had a relatively lower level of connectedness and was a net recipient of volatility of shocks from other economies. By using a generalized VAR framework, Diebold and Yilmaz (2010) estimated the volatility spillovers amongst four various US financial markets; equity, bonds, foreign exchange and commodities. They concluded that inter-market volatility connectedness was at lower levels until the global financial crisis, which intensified the transmission of spillovers across these markets.

The application of their method can be extended to various inter-market and inter-regional studies by exploring the connectedness between various markets within a country, or the connectedness of a particular market type across various countries. The connectedness methodology suggested by Diebold and Yilmaz has been subsequently adopted by many researchers in the fields of macroeconomics and finance. Various researchers have studied clusters of representative countries to examine the regional connectedness of their equity markets. These include studies conducted on East Asia (Guimaraes-Filho and Hong 2016), Africa (Fowowe and Shuaibu 2016), Europe (Mensi et al. 2018), United States (Demirer, Gokcen, and Yilmaz 2019), Morocco (Belcaid and El Ghini 2019), Asia (Chow 2017; Hsu and Lee 2019; Yoon et al. 2019), Russia (Schmidbauer et al. 2016) and a global sample of emerging markets (Yarovaya, Brzeszczyński, and Lau 2016). Whilst these researchers have specifically studied the equity markets, many authors have also examined the interconnectedness between equity markets and crude oil (Awartani and Maghyereh 2013; Husain et al. 2019; Maghyereh, Awartani, and Bouri 2016; Schmidbauer and Roesch 2013; Zhang 2017). However, the interconnectedness and spillovers from crude oil markets to stock markets in the GCC especially after considering the economic diversification strategies, remains an unsettled debate. Our study would examine this effect for the GCC, and also examine the spillovers received from global equity markets; for the US, Europe and China.

GARCH models are amongst the most popular tools used by researchers exploring financial interconnectedness. These models are popular due to their simplicity in application, ability to control for conditional heteroscedasticities, flexibility to choose between various extensions, and capacity to conduct a dynamic study to explore the time varying flow of financial integration. Worthington and Higgs (2004), Wang and Wang (2010) and Li and Giles (2015) are some of the many researchers that have used different forms of multivariate GARCH models in their analysis. GARCH models are favored due to their simplicity in application and their ability to control for heteroskedasticity. For these reasons, GARCH models have been widely adapted by researchers, especially for studies on stock market volatilities. Meanwhile, many other researchers such as Schmidbauer and

Roesch (2013), Yarovaya, Brzeszczyński, and Lau (2016), Zhang (2017) and Yoon et al. (2019) have preferred to apply the generalized VAR framework suggested by Dielbold and Yilmaz (2014). In this research, we shall apply both methods to compare and contrast the results for robustness. Furthermore, using the Diebold and Yılmaz (2014) approach, we would also be able to explore the dynamic connectedness in further detail by examining the net directional flow of spillovers.

3. Methodology

For the analysis of spillovers in this study, two different econometric methods would be used that would fulfil the objectives of our study. First, we will use the generalized VAR framework suggested by Diebold and Yilmaz (2014). This method involves rolling window estimations of forecast error variance decompositions that would help explore the net direction of spillovers for each of the GCC countries, as well as the magnitude of these spillovers, which could be compared across each of the countries in the cluster. Second, we construct DCC-GARCH models separately for each of the individual GCC countries and the collective GCC region. The DCC-GARCH approach is preferred for its flexibility of univariate GARCH models along with parsimonious parametric models for correlations. This would provide the time varying conditional correlations that indicate the financial integration levels between the GCC and the global markets. By separately applying the same methods for each of the GCC countries' equity indexes over the same time horizon, we could compare the reactions of these individual markets identifying how differently (or similarly) do these respond to shocks from oil prices and global equity markets of the US, Europe, and China.

The Diebold and Yılmaz (2014) approach, adopts VAR models with a moving average (MA) component that helps capture the persistence of shocks. This MA component is given by $X_t = \varphi(L) * \varepsilon_t$, where $\varphi(L) = (I - AL)^{-1}$. Furthermore, we denote the unique lower triangular Cholesky factor of the covariance matrix of ε_t by ${Q_t}^{-1}$. Based on these formulations, we can rewrite the above equation as $X_t = \varphi(L){Q_t}^{-1} * Q_t\varepsilon_t$. By introducing $K(L) = \varphi(L){Q_t}^{-1}$ and $u_t = Q_t\varepsilon_t$, the above can be rewritten as follows $X_t = K(L) * u_t$. Now, considering a one-step ahead forecast for a vector of N variables represented by $\hat{X}_{t+1} = A * X_t$. The forecast error of the above, is given by $\in_{t+1} = X_{t-1} - \hat{X}_{t+1}$

$$\in_{t+1,t} = K_0 * u_{t+1} = \begin{bmatrix} a_{1,1} & \cdots & a_{1,N} \\ \vdots & \ddots & \vdots \\ a_{N,1} & \cdots & a_{N,N} \end{bmatrix}_0 \begin{bmatrix} u_{1,t+1} \\ \vdots \\ u_{2,t+1} \end{bmatrix} \tag{1}$$

The non-diagonal coefficients $a_{i,j}$ (where $i \neq j$) can explain the extent to which the errors are explainable by shocks occurring to other variables, whilst the diagonal coefficients $a_{i,j}$ (where $i = j$) explain the proportion of idiosyncratic shocks. Furthermore, since

$E(u_t u'_t) = I$, the covariance matrix of $\in_{t+1,t}$ is given by $E\left(\in_{t+1,t} \in'_{t+1,t}\right) = K_0 K'_0$ and therefore, the sum of elements in the coefficients matrix K_0, equal $trace(K_0 K'_0)$. Hence, the H-step ahead total spillover index is given by:

$$TotalSpilloverIndex = \frac{\sum_{h=0}^{H-1}\left(\sum_{i,j=1}^{N} a_{h,ij}\right)}{\sum_{h=0}^{H-1} trace(K_h K'_h)} * 100, where i \neq j \quad (2)$$

The financial connectedness is a dynamic concept that is expected to vary over time and be affected due to major global and regional events. Therefore, the coefficients $a_{i,j}$ representing the directional flow of spillovers, and the total spillover index could be estimated repeatedly for rolling samples of a specific sample window length to examine the dynamic connectedness over an extended time frame. These sample windows can also be perceived as several overlapping subsets of the overall time series data with equal number of observations. The rolling window method can be illustrated using the following diagram (Figure 1):

The rolling sample method uses a specific sample window size, which in the above diagram(Figure 1) could be denoted from the interval between the start of the sample until time '*t*'. This fixed interval is re-estimated with lags of '*H*', which is the forecast horizon. This is called an *H-step* ahead forecast, and is repeatedly estimated for equal sample window lengths, which are chosen at a specified lag '*H*'.

Whist, the Diebold and Yılmaz (2014) approach is methodologically equipped to examine the connectedness and spillovers between a network of financial markets, variants of the GARCH models have also been a popular choice amongst researchers modeling volatilities, as the GARCH models are known for their ease of application, adaptability to examine a large dynamically changing dataset and control for conditional heteroscedasticities. Out of the class of different multivariate GARCH models, we adopt the DCC-GARCH model, which is best suited to help us explore the dynamic conditional correlations between pairs of markets in a network of multiple variables that are

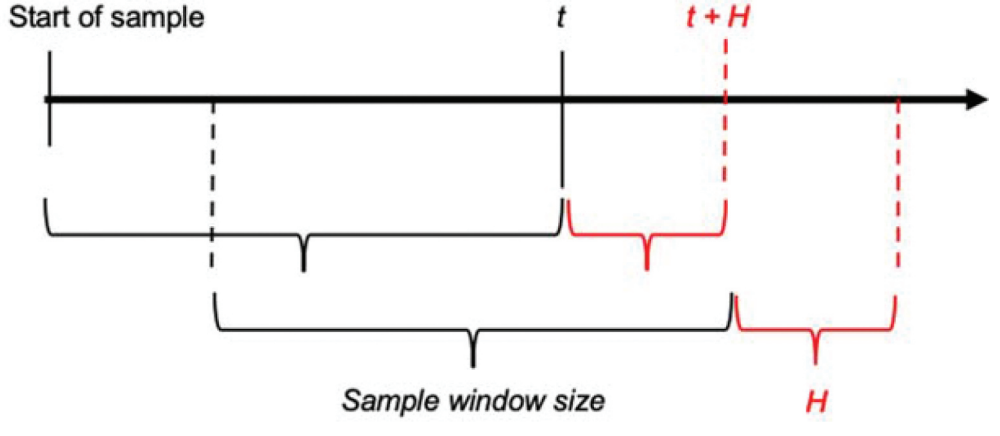

Figure 1. An illustration of rolling sample analysis. The rolling sample method is used to repeatedly estimate the Generalized VAR models at every fixed interval 'H', for a sub-sample (window size) 't'. This allows us to explore the dynamic connectedness and flow of spillovers over time.

dynamically correlated with each other. Results from the DCC-GARCH models would provide further insights for our analyses of each individual GCC countries, as well as serve as a robustness measure to verify if our conclusions from the two different approaches are found congruent or contradictory.

The DCC-GARCH model was introduced by Engle (2002), and has since, been widely adopted by researchers as a tool to measure time varying conditional correlations amongst stock market indexes, as discussed in the literature review section. The DCC-GARCH model is a one of the many multivariate GARCH models, specified as follows:

$$R_t = \mu + \gamma R_{t-1} + \in_t \tag{3}$$

$$\in_t = {H_t}^{1/2} z_t \tag{4}$$

where R_t is the $N \times 1$ vector of returns of N financial indexes at time t, μ is an $N \times 1$ vector of the expected value of the conditional R_t, γ is the $N \times 1$ vector of the autoregressive coefficients, whilst $\in_t$ is an $N \times 1$ vector of the error terms defined in (4). H_t is an $N \times N$ matrix of conditional variances and covariances. Lastly, z_t is an $N \times 1$ vector of independent random variables satisfying the conditions of zero mean and unit variance. There are various classes of multivariate GARCH models that differ in their specification of the conditional covariance matrix H_t. For our research, we will apply the DCC-GARCH model due its ability to model time varying conditional correlations, which would allow us to explore the dynamic flow of volatility spillovers. The DCC-GARCH model specifies H_t as follows:

$$H_t = {D_t}^{1/2} R_t {D_t}^{1/2} \tag{5}$$

$$R_t = diag\left({Q_t}^{-\frac{1}{2}}\right) Q_t diag\left({Q_t}^{-1/2}\right) \tag{6}$$

$$Q_t = (1 - \alpha - \beta)\bar{Q} + \alpha \in_{t-1} \in'_{t-1} + \beta Q_{t-1} \tag{7}$$

whereby, D_t is the diagonal matrix of conditional variances, represented by the diagonal elements of H_t, whilst R_t is the positive definite quasi correlation matrix with diagonal elements equating to 1, and Q_t is the conditional covariance matrix of the error terms, with $\bar{Q}$, representing the unconditional covariance matrix. α and β are non-negative scalar parameters with the restriction that $(\alpha + \beta) < 1$. If $\alpha = \beta = 0$, then $Q_t = \bar{Q}$, and therefore, a constant conditional correlation model, would be sufficient to estimate the correlation matrix. If $\alpha + \beta$ is closer to 1, the model would indicate high persistence in the conditional variance.

4. Data description

The data for the GCC region, used in our research represents the six GCC equity markets, which account for nearly 56% of all the oil production of OPEC Countries (refer to Figure 2). Therefore, the results from this research would not only significantly contribute to the Middle Eastern studies, but also represent a large proportion of the largest oil exporting economies in the world. Moreover, the timespan over this study, covers major crises events, such as the Global Financial Crisis of 2007–2008, the Arab Spring events of

early 2010s, the oil price crash of mid-2010s, and the COVID-19 outbreak of 2020. These events have drastically impacted the equity market behaviour of the GCC and could be expected to alter the connectedness dynamics as well. To review the timeline of these major global and regional events, these events are indicated along the MSCI GCC regional index in Figure 3.2019

Time-series data of daily frequencies has been used in our research for three global stock market indexes; the MSCI US country index, MSCI Europe regional index and the MSCI China country index. For the GCC equity markets, we include a representative index generated by the MSCI that includes 67 constituents that represent about 85% of market capitalization in each country across all the six GCC countries. We also include the MSCI country-level indexes for each of the GCC countries; UAE, KSA, Qatar, Kuwait, Bahrain, Oman. Finally, we include the Dow Jones Brent crude oil futures price index.

All data series have been indexed at 100 on their starting date, which is 31 May 2005. The resultant indexed series for the global markets, oil prices and the GCC's regional index, are plotted in Figure 4. We have used the time-series data for an approximate duration of over 15 years, until 31 December 2020 (summarized in Table 1). We compute the stock market returns for each of these series by taking the log deviation between every consecutive observation. The daily returns are found stationary and represent the growth rate of each series for every stock market working day; Saturdays and Sundays are excluded. These stationary plots for log-deviations of the indexes, are illustrated in Figure 5.

We use the above data to conduct the empirical analysis in two parts. First, we use the Diebold and Yılmaz (2014) approach, as explained in the methodology section. Second, we apply the DCC-GARCH approach to compute the dynamic conditional correlations between the markets examined. Each of these methods are first used to explore the GCC's

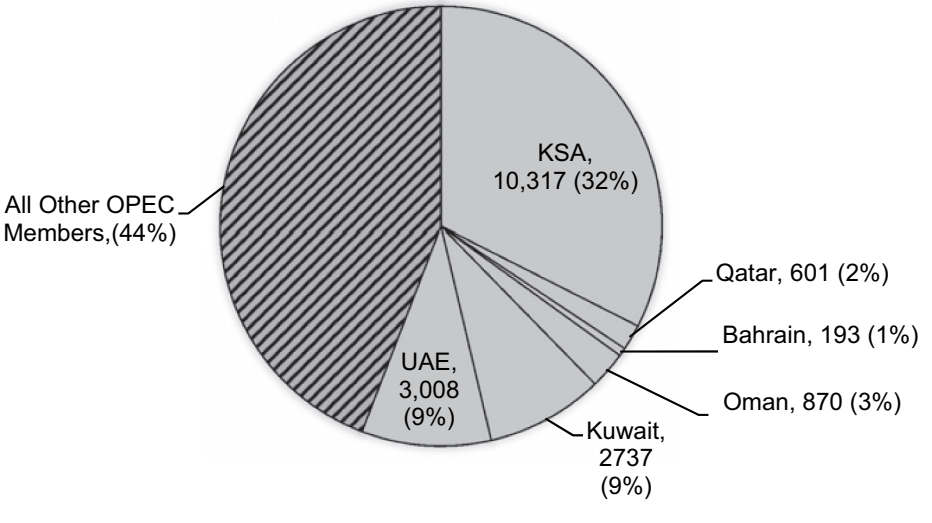

Figure 2. GCC's oil production in barrels per day amongst OPEC members. The Gulf Cooperation Council (GCC) countries represent more than half of all the entire oil production of OPEC countries, with the Kingdom of Saudi Arabia (KSA) being the largest producer and exporter of oil (OPEC).

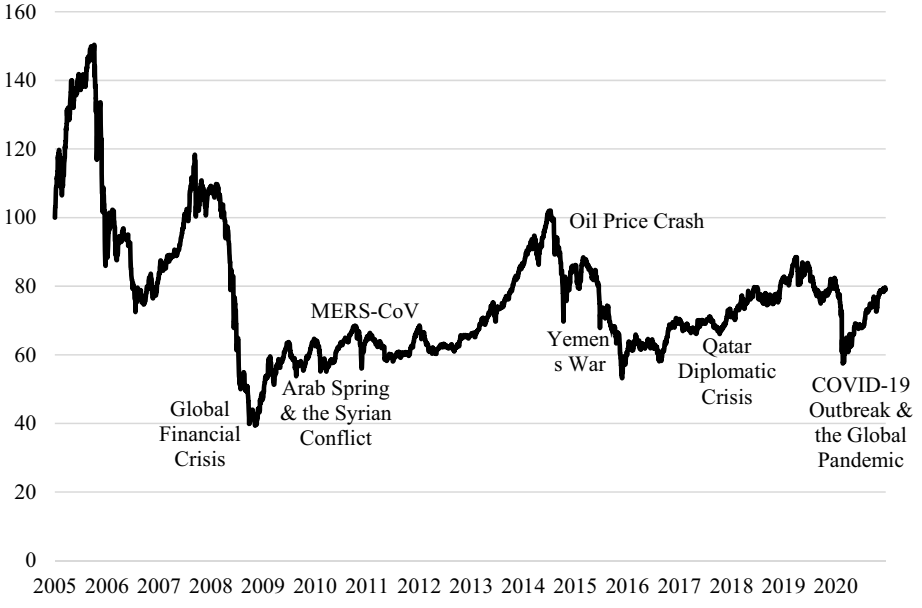

Figure 3. Major crises events along the GCC regional equity index. Major global and regional crises events have impacted the GCC equity market index over the 2005–2020 period. The above diagram is indexed to 100 at the start of the data series, on 31 May 2005.

connectedness with global markets as a region, following by a repetition of these methods, applied on each individual GCC country, to explore any idiosyncrasies between specific GCC countries and the global markets examined.

5. Empirical results and discussion

5.1 Empirical findings from the Diebold and Yılmaz (2014) *connectedness approach*

For the decade examined in our study, the US stock markets have been the largest net contributors of shocks to others, followed by Europe. Interestingly, China has been a net recipient of shocks from others. As it would be expected from the size and influence of the regions involved in this study, the GCC region has also been a net recipient of shocks from others. Most of these shocks are transmitted from the US financial markets, followed by Europe and then the global oil prices. The average net connectedness over the time frame could be summarized using a network topological diagram (Figure 6) that reveals the direction of net spillovers amongst the four equity markets and the global oil market. This diagram is generated from the connectedness table, by taking the difference between the net shocks to and from another market, therefore, illustrated the overall net directional flow of spillovers.

So far, we have noticed that the global oil prices have significantly influenced the GCC stock markets over the decade. However, we only examined the static average for the entire decade. Hence, for further insights, we analyze the dynamic connectedness over time, using a rolling sample window approach. This would help us observe any trends and

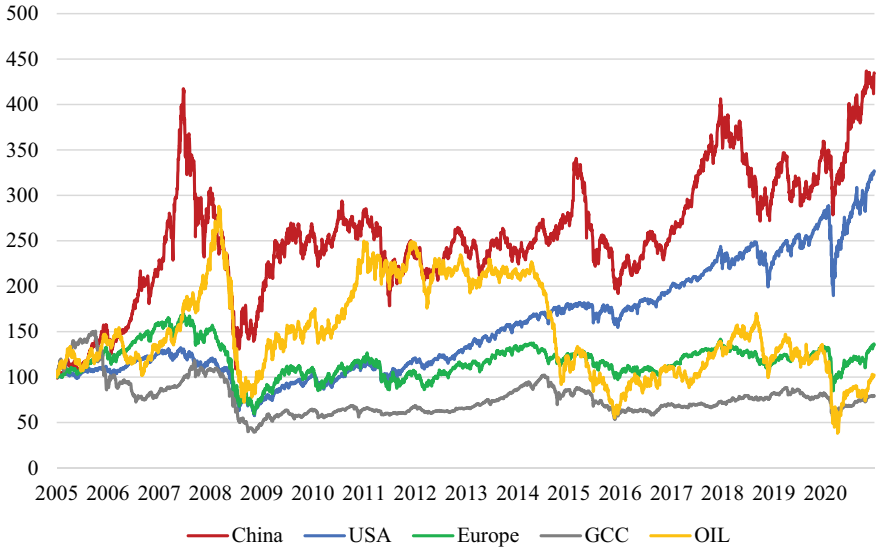

Figure 4. Indexed series for oil prices and the US, Europe, China and GCC equity markets. The MSCI GCC regional index is plotted alongside the MSCI Indexes for global markets of the US, Europe and China, as well as the oil prices for the 2005–2020 period. All the series are indexed to 100 at the start of the data series, on 31 May 2005.

Table 1. Descriptive statistics.

	UAE	KSA	QAT	KWT	OMN	BAH
Mean	−0.0001	0.0003	0.0001	0.0004	0.0000	−0.0002
Median	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Maximum	0.1833	0.1623	0.1127	0.0875	0.1087	0.1150
Minimum	−0.1640	−0.1700	−0.1337	−0.2292	−0.1765	−0.1799
Std. Dev.	0.0168	0.0154	0.0138	0.0130	0.0114	0.0126
Skewness	−0.7321	−1.3956	−0.8606	−2.2490	−1.5836	−1.9629
Kurtosis	18.5090	23.5592	17.9661	38.3517	37.3695	34.0455
	GCC	USA	EUR	CHINA	OIL	
Mean	−0.0001	0.0003	0.0001	0.0004	0.0000	
Median	0.0000	0.0004	0.0004	0.0001	0.0004	
Maximum	0.1165	0.1104	0.1078	0.1404	0.1908	
Minimum	−0.1703	−0.1292	−0.1402	−0.1284	−0.2798	
Std. Dev.	0.0117	0.0124	0.0139	0.0165	0.0230	
Skewness	−2.0700	−0.6047	−0.4505	−0.0639	−0.6644	
Kurtosis	30.4369	17.5784	13.3411	10.5592	17.9951	

The descriptive statistics are shown above, as the mean, median, maximum, minimum, standard deviation, skewness and kurtosis of returns (computed as the log deviations) for each of the MSCI country-level indexes for each of the GCC countries, the MSCI GCC regional index, the MSCI Indexes for the US, Europe, China, and the BRENT Crude Oil Futures Price Index.

infer whether the interconnectedness of stock market returns and oil prices have changed over time. Eventually, this would help us answer our research questions, including whether the spillovers from the global oil market to the GCC have increased or decreased over time. Also, we could examine the extent to which the COVID-19 outbreak has affected the connectedness levels.

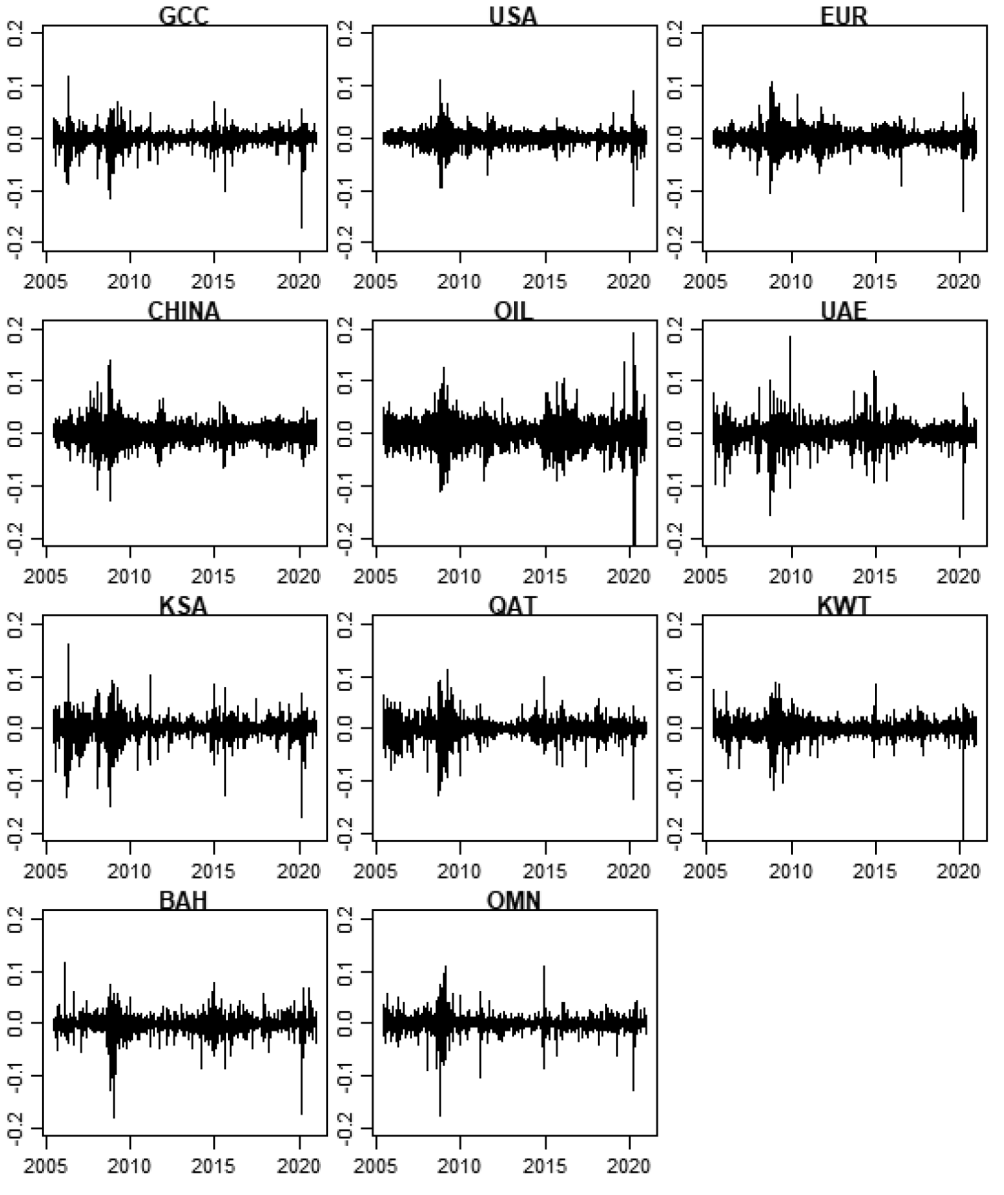

Figure 5. Stationary series. Returns for each of the financial indexes are computed by taking the log deviation of the index series, and after conducting the Dickey–Fuller tests, the series are found stationary.

Various connectedness studies have shown that the spillovers between financial markets intensify during times of financial crises (Diebold and Yilmaz 2009; Mensi et al. 2018; Yoon et al. 2019). When there are greater levels of uncertainties due to such events, stock markets tend to follow each other for a sense of overall direction. As a result, there are higher spillovers between these financial markets and the total dynamic connectedness index increases. Therefore, based on these predictions, it is reasonable to expect that

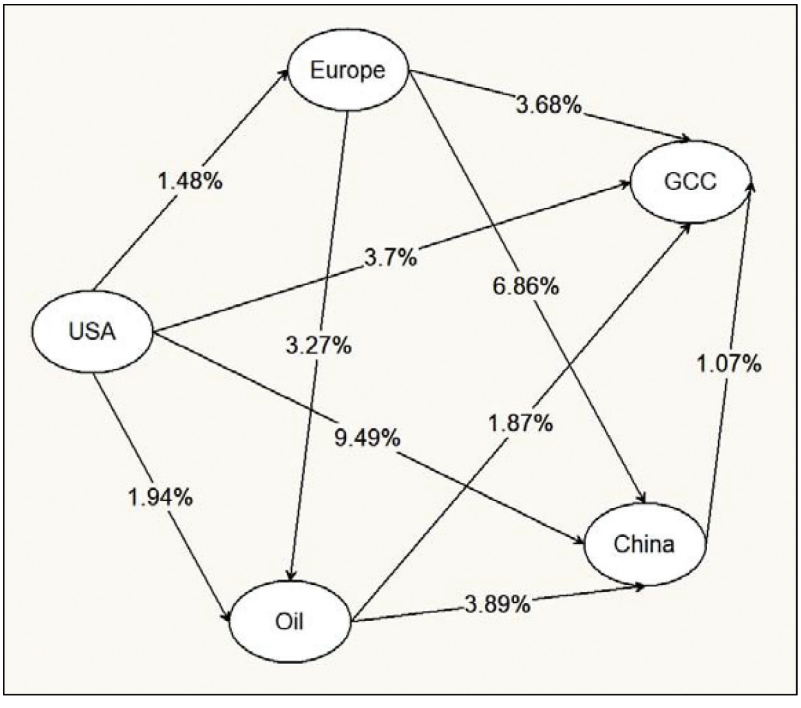

Figure 6. Connectedness network diagram. Above diagram represents the overall net direction of spillovers across the GCC and global markets examined. Arrows indicate the net flow of spillovers and the amount (in percentage) is the net transfer of spillovers computed as the difference between the pairwise outflow and inflow of spillovers for each possible pair of markets examined.

the total connectedness index would increase as a response to the COVID-19 outbreak. However, the extent of this increase could be evaluated by comparing the current spike with previous spikes in the total dynamic connectedness index (illustrated in Figure 7).

From Figure 7, it is evident that the past decade has exhibited waves of uncertainties that can be attributed to several regional and global events, such as the Arab Spring of early 2010s or the plummeting oil prices of mid-2010s. However, neither of these spikes are as significant as the rise that was followed by the COVID-19 outbreak. The connectedness index, as a result of the outbreak nearly doubled abruptly, whilst the equity markets crashed. As this incident was followed by and accompanied with a financial crisis, a global financial contagion emerged simultaneously.

Over the span of a decade, it is possible for the direction and intensity of spillovers to shift drastically. Therefore, individual dynamic plots of net total directional connectedness have been drawn in Figure 8. These plots provide the total net connectedness of each market with others. When the series is above zero, the market under consideration is a net transmitter of shocks to others, whilst when the series is below zero, the specific market is a net recipient of shocks from others, for that period. For the most parts of the decade, the US and European stock markets have transmitted net positive spillovers to others. Especially for the case of the US stock markets, which only fell below zero for a slight period of time, during the COVID-19 outbreak towards the end of the series. China and the GCC on the other hand, have been the net recipients of shocks from others. Furthermore,

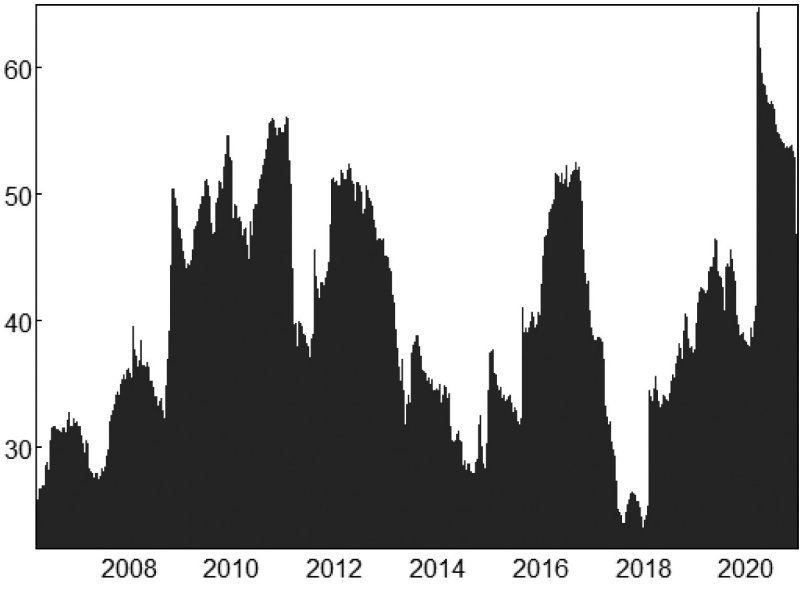

Figure 7. Total dynamic connectedness. The above plot represents the total dynamic connectedness across the GCC region, global markets and oil prices, computed based on the Diebold and Yılmaz (2014) approach. The amounts could be interpreted as the percentage of shocks to markets within the cluster of indexes examined, that could be explained by spillovers from other markets within the cluster, hence representing the level of financial integration.

the net spillovers to China have been decreasing gradually as its net dynamic connectedness plot approaches zero. This signals a possibility that China could eventually become a net contributor of spillovers, though this is not yet the case.

An examination of the net dynamic spillovers for the global oil prices has provided some further insights. At the beginning of the decade, oil prices had a near zero net contribution of shocks to the stock markets, on average. This suggests that the amount of shocks transmitted to others, almost equated to the amount of shocks received from others. However, the series spiked when the oil prices plummeted in the mid 2010s. In addition to affecting the oil exporting economy of the GCC, this event also impacted the oil importing economies, who treat oil as a major input. In recent years, the series has mostly stayed below zero, suggesting that the global oil price has become a net recipient of shocks from the global stock markets. However, these figures of net connectedness represent the transmission of shocks from all other markets, whilst pairwise net connectedness is especially important to determine the net transmission of shocks amongst specific stock markets.

To examine the pairwise relationship between the variables examined, we construct the dynamic net pairwise connectedness plots for each of the 10 possible pairs of our 5 time-series variables (refer to Figure 9). One of our major inferences from these is regarding the pairwise connectedness of the US and China. Although China has largely been a net recipient of shocks from the US, the series has been trending towards zero, suggesting that the Chinese stock markets could possibly become net contributors of shocks in the future. Furthermore, the Chinese stock markets have shifted from being

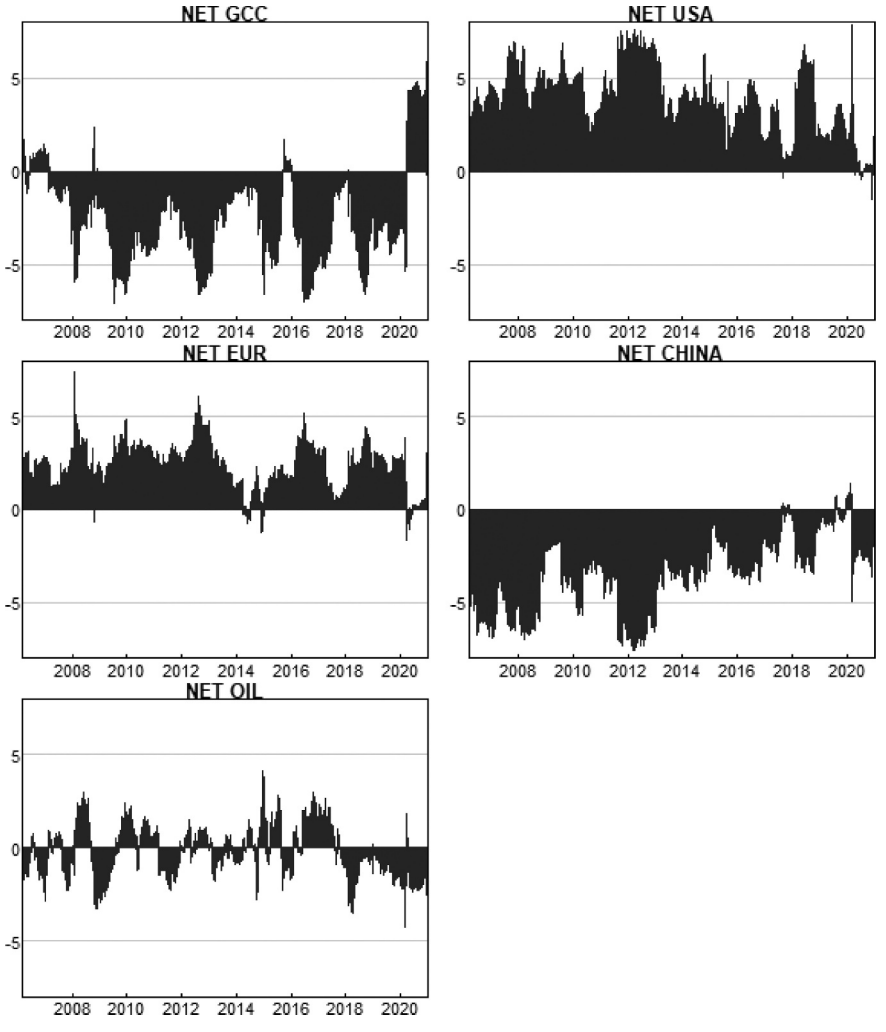

Figure 8. Net dynamic connectedness. The above figure represents the net dynamic connectedness for each of the financial indexes examined. The amounts on the y-axis are computed as the difference between the percentage of total spillovers transmitted to other markets and the percentage of total spillovers received from other markets. Therefore, for time periods when the net dynamic connectedness is above zero, the corresponding market is a net transmitter of shocks, and vice versa.

the net recipients of shocks from the global crude oil market, to a net transmitter of shocks to global oil prices. As for the GCC, oil prices have historically played a significant role as a net transmitter of shocks, although this has changed. The pairwise connectedness series between the GCC stock markets and oil prices has nearly approached zero, which could potentially be a result of recent economic diversification strategies into non-oil sectors.

Subsequently, we conduct the analysis six more times for each of the six GCC countries, separately. The net pairwise connectedness plots for each of the GCC countries, against the spillovers from USA, Europe, China, and the crude oil markets, are plotted in Figure 10, where each row represents a different country of the GCC region.

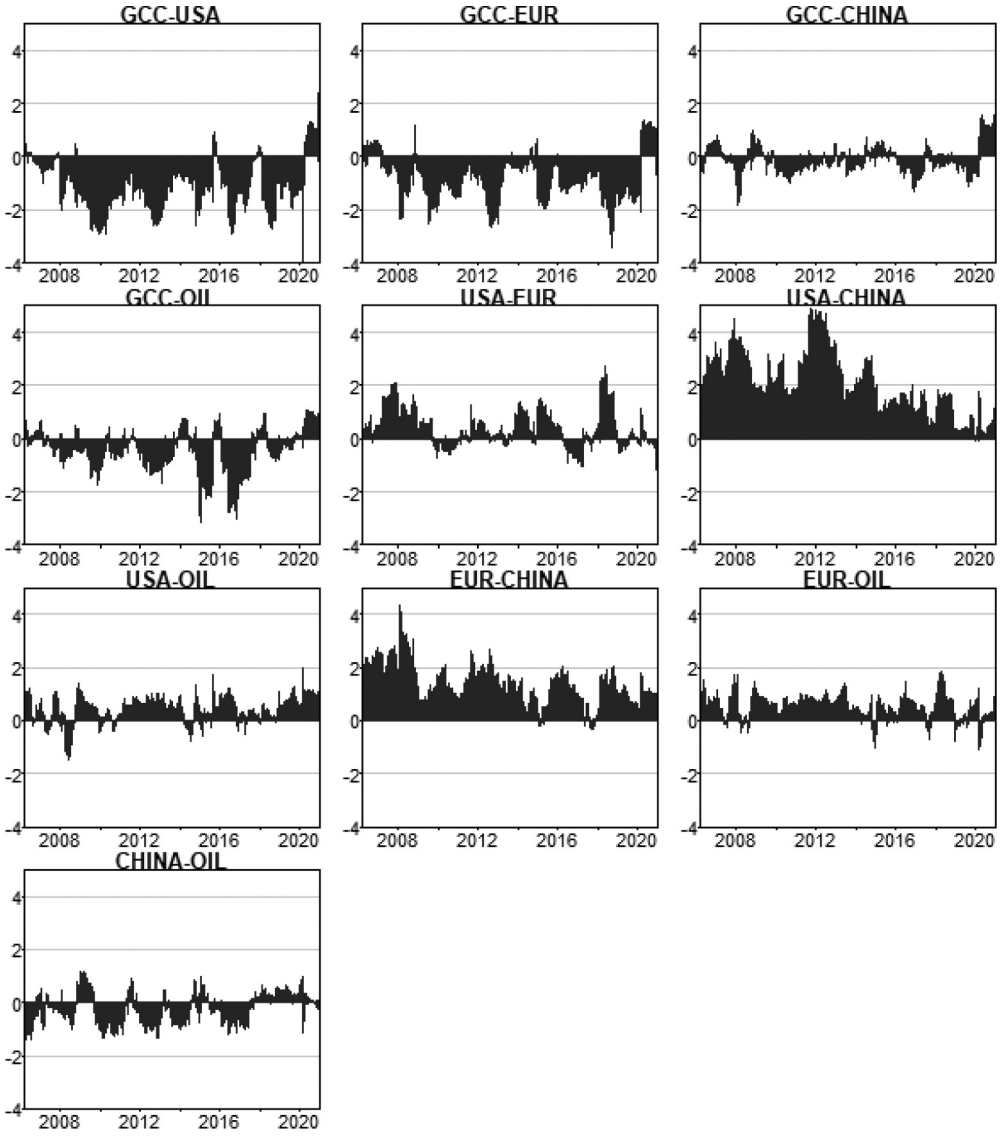

Figure 9. Net pairwise dynamic connectedness. The above figure represents the net pairwise dynamic connectedness between each of the 10 possible pair of financial indexes examined. The amounts on the y-axis are computed as the difference between the percentage of spillovers transmitted to and the percentage of spillovers received from the other market.

Interestingly, despite having many cultural and geopolitical similarities, the GCC countries differ in the extent to which they receive spillovers from the global markets. Interestingly, the UAE and Qatar, receive the largest proportion of spillovers from the US and European equity markets, compared the inflow of spillovers for the rest of the GCC countries. This could be due to the large proportion of trade that these two countries have, with the rest of the world, outside of the GCC. On the other hand, Bahrain, despite being the smallest country in the GCC, shows little spillovers from

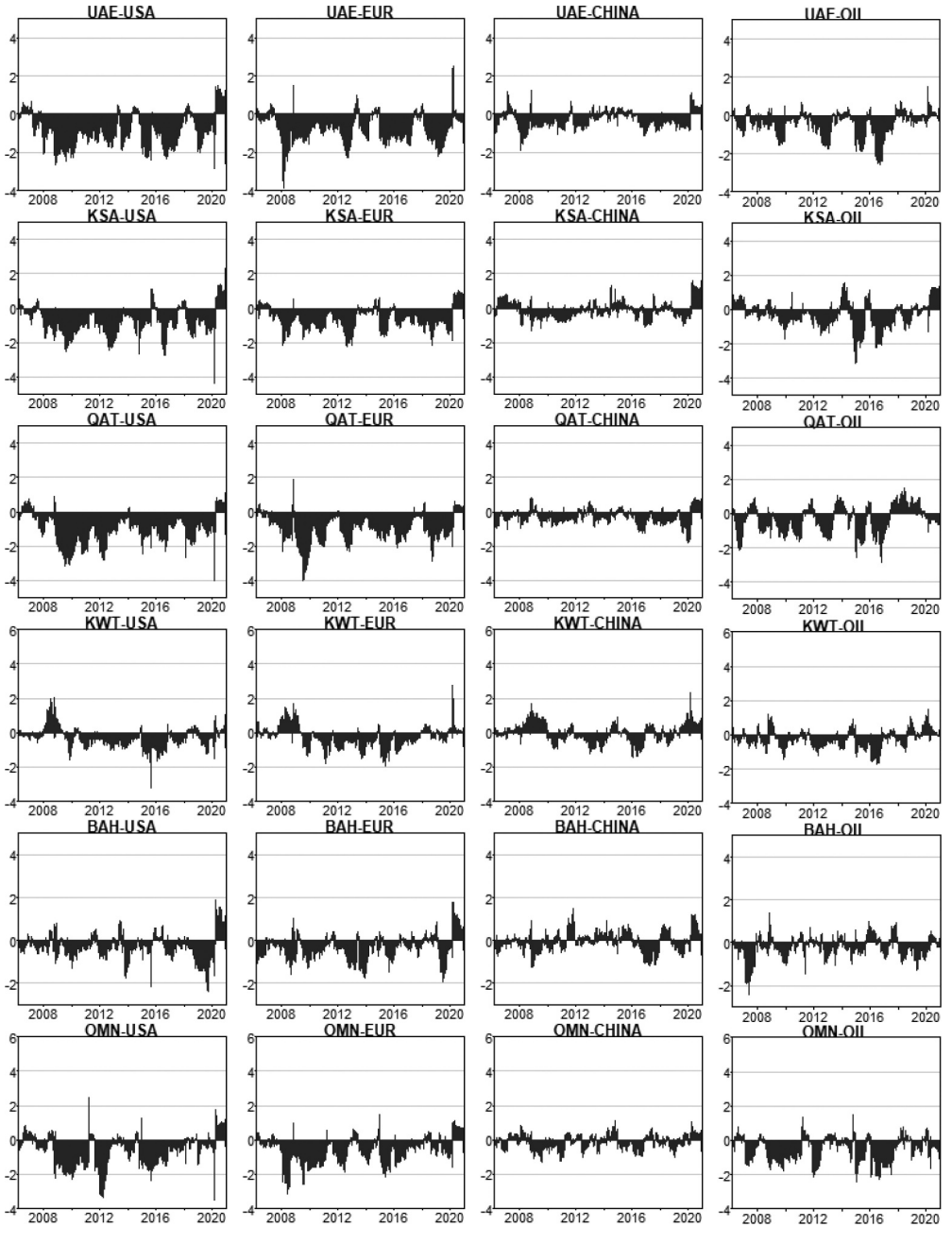

Figure 10. Net pairwise connectedness for individual GCC countries with global markets. The above figure represents the results for six individual studies conducted for the individual GCC countries. Each row represents the net pairwise connectedness for a different GCC country against the global markets and crude oil prices. The four columns represent markets of the US, Europe, China and crude oil, in order. The amounts on the y-axis for each plot, are computed as the difference between the percentage of spillovers transmitted to and the percentage of spillovers received from the global markets.

global markets, suggesting that it may be largely affected by spillovers from other countries within the region. Each of the GCC countries receive an inconsiderable amount of spillovers from China, with the exception of the UAE, which has consistently received spillovers from China, over the past decade, although the magnitude of these spillovers has been significantly lower, compared to the inflow of spillovers from the US and Europe.

As for the connectedness between the individual GCC countries and the oil market, certain patterns emerge across all countries. First, the oil prices have been a net contributor of shocks to the GCC during the Arab Spring of early 2010s. Subsequently, there is a sharp increase in the net spillovers from oil markets to all GCC countries except for Bahrain, during the oil price crash of mid 2010s. Towards the end of the decade, the net connectedness between GCC countries and oil prices has averaged to near zero, suggesting that the amount of spillovers transmitted, nearly equate the amount of spillovers received. Therefore, considering the recent data used in our study, the findings suggest that oil prices no longer dictate the equity market behaviour of GCC countries. For the GCC economies, this seems to be a desirable outcome as these countries have been increasing emphasizing on economic diversification into non-oil sectors, since the past decade. The GCC countries' sustainable initiatives include the UAE's Vision 2021, KSA's Vision 2030, Qatar's Vision 2030, Bahrain Economic Vision 2030, Kuwait Vision 2035, and the Oman Vision 2040.

5.2 Empirical findings from the DCC-GARCH models

Results from the DCC-GARCH Models are discussed in this section. The dynamic conditional correlations across the timeline of our study, for each of the 10 possible pairs between the five financial data series examined, are illustrated in Figure 11.

By examining the dynamic conditional correlations, interesting insights regarding the financial integration between the GCC and global markets could be found. Initially, the correlation between the GCC and global markets has been low. However, an upward trend could be found between the regional market's integration level with the US, Europe and China. Moreover, the correlation between Chinese and GCC equity markets has remained relatively high (exceeding 20% on average) over the past decade. This could reflect some of the common factors that most GCC countries and China have, such as being classified as emerging markets and experiencing rapid economic growth. Interestingly, the dynamic conditional correlations of the US equity market, is found to be significantly lower for the GCC, when compared to Europe and China. Whilst the conditional correlations between the US and Europe average at nearly 60% and between the US and China, average at nearly 30%, the dynamic conditional correlations between the US and GCC equity markets remains below 20% for the most of our time frame of study. This could be due to the gap between these markets as trade and cross-regional equity investments are more popular between the US and Europe, compared to the GCC and China, hence, strictly limiting arbitrage opportunities and hindering diversification due to the high correlation across these two global markets. Therefore, the findings of this research, provide econometric evidence in favor of the financial diversification opportunities that the GCC region offers to international investors.

As for the dynamic conditional correlations between the GCC and oil prices, the corresponding plot mostly remained below 20%, except for the oil price crashes of mid-2010s and 2020. During these times, a decline in oil prices could be strongly associated with a sharp drop in the GCC equity market returns, although the opposite was found for the correlation between oil prices and the global equity markets of the US, Europe and China, as these are net importers of oil. This is illustrated by the dynamic conditional correlation plots between oil prices, and the US, European and Chinese equity markets in Figure 11, which illustrate very similar trends.

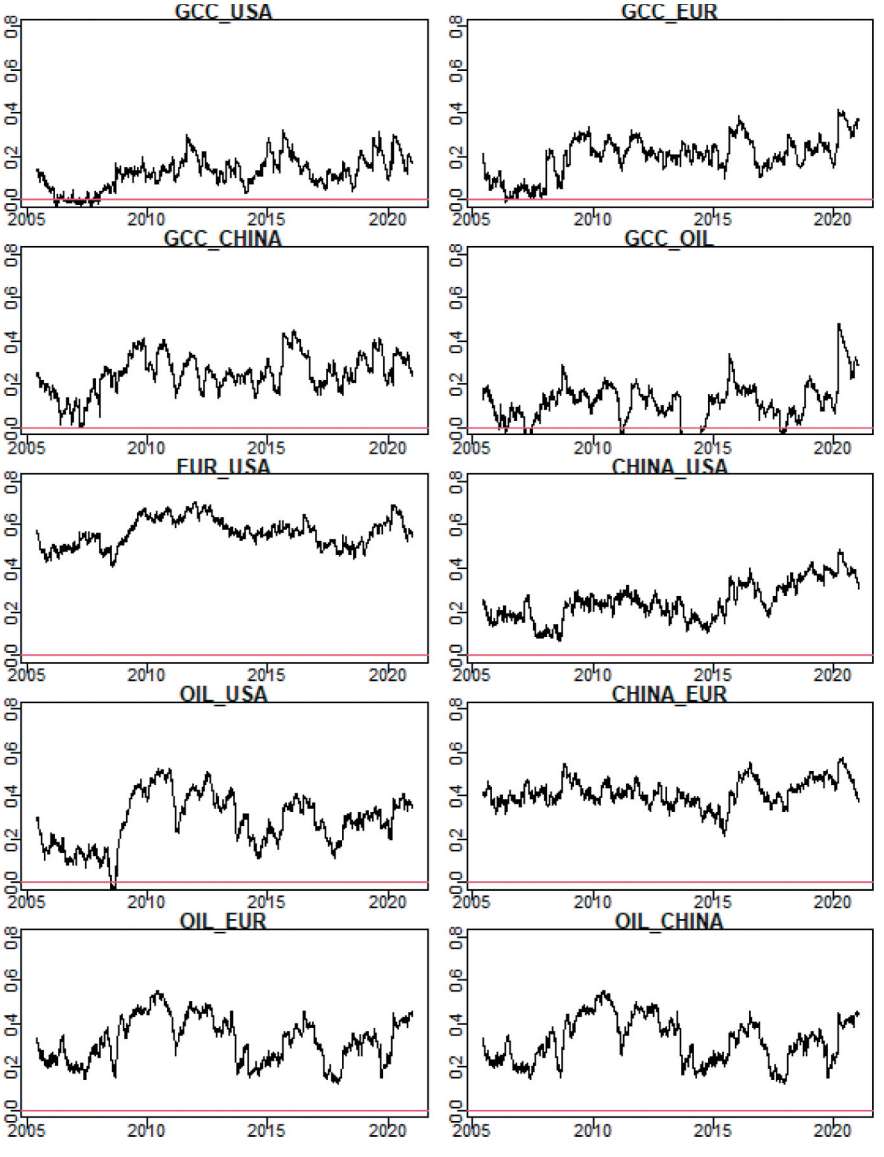

Figure 11. DCC-GARCH model results for the GCC region. The above plots represent pairwise dynamic conditional correlations between each of the 10 possible pairs of the financial indexes examined. High values indicate high financial integration between the markets, and vice versa.

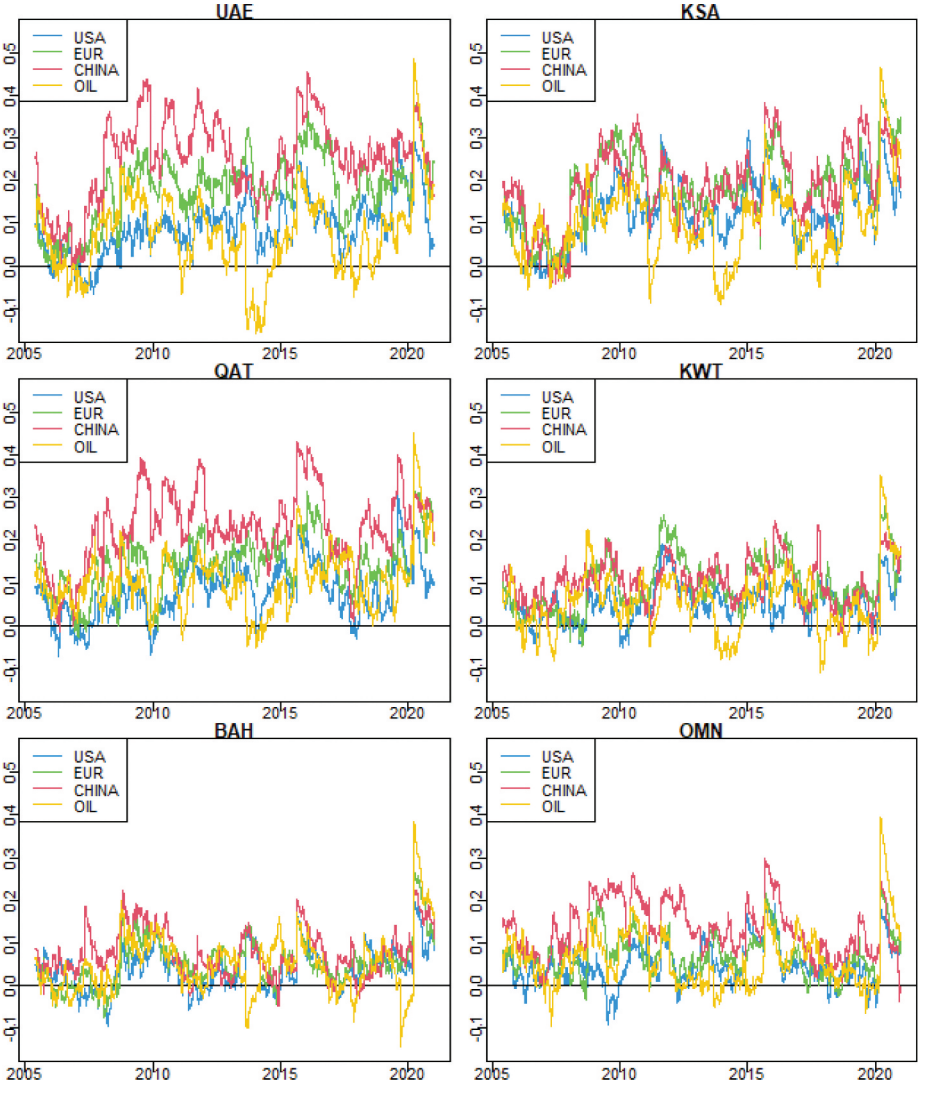

Figure 12. DCC-GARCH model results for individual GCC countries. The above plots represent pairwise dynamic conditional correlations computed and illustrated separately for each of the six regional countries, plotted against the global markets. High values indicate high financial integration between the markets, and vice versa.

Subsequently, we conduct the DCC-GARCH analysis for each of the six GCC countries, separately. The pairwise results for each of the GCC countries, plotting against the global markets, are illustrated in Figure 12. Consistent with the previous DCC-GARCH analysis for the GCC's regional index, individual GCC countries especially the UAE and Qatar, show high conditional correlation with the Chinese equity markets. The conditional correlations for Kuwait, Bahrain and Oman, show low levels of financial integration with the global markets, compared to the UAE, KSA and Qatar. The UAE and KSA are the largest trading partners for Oman, whilst the KSA is the largest trading partner for Kuwait and Bahrain. Therefore, it makes intuitional sense that much of the spillovers flowing into the smaller

countries in the GCC could be resulting from shocks occurring to other markets within the region. Meanwhile, the UAE and Qatar rank amongst the highest within the region, for their trade openness with the rest of the world, hence observable from our cross-country comparison using the DCC-GARCH models. To summarize, whilst the GCC as a region, provides diversification opportunities to the international investor, Kuwait, Bahrain and Oman, are the least correlated with global markets, making them attractive for the international investors, who are looking forward to diversifying their portfolios.

For policymakers of Kuwait, Bahrain and Oman, it would be helpful to study the regional flow of spillovers, as these countries could be more likely to be interconnected intra-regionally. As for the policymakers for the UAE, KSA and Qatar, our DCC-GARCH models show strong conditional correlations with global markets suggesting that there could be significant inflow of spillovers in case of a global financial contagion. Our results on the directional connectedness drawn by applying the Diebold and Yılmaz (2014) approach, have indicated precisely which of the global markets could these spillovers originate from. Hence, the results of this research could aid towards macroprudential policy making, by timely responding to shocks occurring to one of the global markets through predicting how these shocks could be transmitted to their domestic equity markets.

6. Conclusion

In conclusion, our research evaluated the connectedness of equity market returns for the GCC with three global financial market indexes; US, Europe and China, as well as the crude oil prices for the 2005–2020 period. The past decade has experienced some major changes in the connectedness of financial markets. Overall, US and European stock markets have been net transmitters of shocks whilst the Chinese and GCC stock markets were net recipients. The global crude oil market, however, has seen shifts in its net dynamic connectedness, becoming a major transmitter of shocks with the plummeting oil prices of mid-2010s and approaching near zero net connectedness towards the recent years. The GCC stock markets have historically been a significant recipient of shocks from oil prices, however this has been changing too. Over the recent years, net oil price shocks to the GCC stock markets have been approaching zero, suggesting that this could possibly be due to the region's diversification strategies into the non-oil sectors. This form of diversification not only helps portfolio managers in their hedging strategies, but also helps the GCC economies achieve their goal towards reducing their dependence on black gold. Furthermore, whilst the overall GCC region shows low correlation with the global markets, Kuwait, Bahrain and Oman are the least correlated, and could be considered as isolated markets that may provide excellent diversification opportunities for international investors.

The total dynamic connectedness index has shown that whilst there were different peaks during major global and regional crises events during the time frame of our study, the impact of COVID-19 outbreak on the level of financial connectedness was significantly greater. This suggests that during these crises events, stock markets look towards each other for a sense of direction more so, than they normally would. The COVID-19 outbreak was followed by a strong financial contagion and another wave of plummeting oil prices, intensified the spillovers further. Lastly, a major observation from the empirical findings showed that whilst the US continues to dominate global stock markets including that of

China, the net pairwise connectedness between the US and Chinese stock markets is trending towards zero. This indicates a future possibility where the Chinese stock markets could eventually become a net transmitter of return shocks to other markets.

Future research could examine the interconnectedness amongst the regional equity markets, especially between the GCC countries. This would be especially helpful for smaller equity markets that are more likely to receive intra-regional shocks, compared to the amount of direct spillovers from global markets. Researchers could also use similar econometric methods, such as the ones used in this paper, to compare the inflow of spillovers from global markets, against the spillovers from within the region, to explore the issue of financial integration and connectedness from a different perspective. Additionally, different domestic industries may respond to shocks from other markets differently, therefore, a cross-industry study would provide specific insights on which of the industries are most vulnerable to spillovers, as well as indicate which other markets are they most interconnected with.

Notes

1. Refer to Figure 2 for the relative composition of the GCC's oil production proportionate to the OPEC.
2. For a dynamic overview, major crises events are indicated along the MSCI GCC Index plotted in Figure 3.

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Disclosure statement

This is our independent piece of work, and where applicable, the scholarly works of preceding researchers, have been appropriately cited.

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