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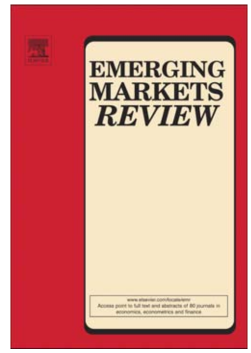

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New evidence on hedges and safe havens for Gulf Stock markets using the wavelet-based quantile

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Abstract

This paper examines the dynamic tail dependence structure for the Gulf equity indices, using the Dow Jones Islamic world emerging equity index and four macroeconomics factors (the three-month U.S. Treasury bill rate, the VIX index, gold prices and oil prices) under different market conditions and scale or time horizons. We find little or insignificant dependence at the short investment horizon but strong asymmetric dependence at middle and long investment horizons. Gold is a strong hedge and a safe haven at the short, middle and long run horizons for all Gulf markets.

JEL classification:
Keywords: GCC markets, Islamic equity index, Macroeconomics factors, Quantile, Wavelet.

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1. Introduction

Modeling and understanding the degree and the structure of dependence across financial asset classes serving as return enhancers and/or portfolio diversifiers is of great relevance to speculators, traders and investors, particularly during bear and bull markets which characterize extreme market conditions. The dynamic dependence, especially during extreme market movements, is one of the main concerns of market participants for at least two main reasons. First, the portfolio strategies are strongly sensitive to the correlation structure between financial assets, principally when the correlations evolve in a certain direction over time, underlying a special trend. Second, given information spillovers across asset classes, financial decisions will likely have cross-market influences, which are of interest to decision makers who must reckon with the full impacts of their actions (Ciner et al., 2013).

The 2008–2009 global financial crisis (GFC), which was sparked by the U.S. subprime and the banking defaults that took place in July 2007, had caused severe damages to different international stock markets and harmed global economic growth. However, during this turmoil period, safe haven assets were widely sought after by most investors since stock asset prices plummeted as they faced a systematic risk. Both investors and portfolio managers had rushed into buying safe assets including the U.S. Treasury bills, bonds, gold among others (Baur and Lucey, 2010; Baur and McDermott, 2010). The "flight to quality" phenomenon had materialized and the prices of these safer assets surged (Caballero and Krishnamurthy, 2008).

Concurrently, the products of Islamic finance that have different characteristics from their conventional counterparts have become considerably more known to investors and traders as a result of the recent economic and financial turmoil episodes. The spectacular growth and the interest in the Islamic financial assets have motivated us to examine the usefulness of these safe asset candidates and other relevant assets during downturn periods and across different time horizons. The Islamic finance investments are well-developed in certain global financial markets including those of the Gulf Cooperation Council (GCC) countries: Bahrain, Kuwait, Oman, Qatar, Saudi Arabia and United Arab Emirates (UAE). One should also note that the literature on the linkages between Islamic and conventional indexes is also growing (see, for example, Hammoudeh et al., 2014).

The main purpose of this paper is to assess the dynamic asymmetric linkages of the six GCC stock indexes with other relevant stock markets and major macroeconomic variables during different market conditions and during different investment horizons. This objective fits within the market heterogeneity hypothesis that conjectures the presence of short-term and long-term investors in the markets, acting as speculators (e.g., hedge funds and market makers), arbitrageurs, and long term institutional investors (e.g., institutional investors and bankers) under different market conditions. The variables include the faith-based Dow Jones Islamic World Emerging equity (DJIWEM) index, the three-month U.S. Treasury bill rate (T-bills), CBOE volatility (VIX) index, gold prices and Europe Brent oil prices. Given the GCC markets' oversensitivity to faith-based investments and regional and global political and financial risks, we seek to discern which of the considered markets can provide more protection to GCC portfolios and which macroeconomics factors have considerable impacts on those portfolios under different market conditions and diverse investment horizons.

The investigation is conducted by using a quantile regression approach (QRA) and a wavelet decomposition analysis. On one hand, the quantile analysis enables one to examine dependence under different market circumstances including states of downturn (lower quantiles), normality (intermediate quantiles) and upturn (upper quantiles) markets. This method generally provides information on the asymmetric effects of conditional variables on the dependent variables. On the other hand, the wavelet analysis allows one to test the dynamic dependence at different scales or horizons. Therefore, by applying a QRA approach combined with the different scales, obtained through the wavelet decomposition, we deepen the investigation of the strength of the co-movement and dependency among the GCC stock markets and the other variables in terms of specific scales or investment horizons.

A wavelet-based quantile methodology provides useful new insights into the current study. The wavelet approach decomposes the time–scale relationships between the GCC stock markets and the macroeconomic variables, while the quantile regression analysis allows to examine the changes in different degrees of market dependence. The advantage of merging both approaches is to investigate the sensitivity of the asymmetric tail dependence under both the extreme market conditions and the time-scale domain (short, medium, long run investment horizons).

This paper differs from and adds to the related literature on GCC stock market co-movements and negative and positive dependence in several ways. First, we investigate the degree and structure of dependence between the individual GCC stock indexes with the Islamic emerging market equity index (DJIWEM) and the relationship with several major macroeconomics factors as specified above. Second, several reasons have motivated us to focus on the cash- and oil-rich GCC stock markets. The GCC countries are awash with foreign reserves and dominate the oil market. While they share several common financial and economic characteristics, they also differ in the degree of their openness to foreign ownership and the government involvement in supporting their own markets (Balcilar et al., 2015). The regulations of the GCC stock markets restrict investments by non-GCC citizens, although those measures are changing rapidly and the recent collapse in oil prices is transforming their debt markets to be more integrated with the world market. The stock markets of Saudi Arabia and

Abu Dhabi in UAE are still closed to direct investment by non-GCC nationals, but their country funds have been open for foreign investors since 1997 (Yu and Hassan, 2008). On the other hand, the Bahrain stock exchange has stipulated that non-resident foreigners are allowed to buy up to 24% of the shares of companies listed on their exchanges. Concerning the Oman market, foreigners are able to invest in the local stock market. Among the GCC markets, the UAE (Dubai) has the highest degree of foreign participation, while Saudi Arabia has the least but now is increasingly opening up to foreign investors through institutional funds. The GCC stock markets also differ widely from those of both developed and major emerging stock markets. In fact, the GCC markets are highly segmented markets, seemingly isolated from the international markets and are overly sensitive to regional political events.

Third, this study provides further evidence on the time-varying dependence at different time horizons among the considered markets, which we address through the use of the novel wavelet-based quantile methodology. The time-scale domain analysis distinguishes between the short and long-term investors where the former is interested in dependence at lower scales (or short-term dependencies), while the latter focuses on the relationship at higher scales (or long-term dependencies).

Fourth, the above methods are crucial to detect the market where the co-movements among the variables are higher or lower over quantiles. This is of striking importance to investors and portfolio managers to identify hedge/safe haven assets during financial stress periods and achieve portfolio diversification benefits during normal periods.

Finally, the examination of the strength of the co-movements and how they evolve over time takes into account the distinction between short and long term investors. The short-term investors (e.g., speculators, market makers and hedge funds) are interested in the co-movements at lower scales (short-term variations), while the long term investors (e.g., mutual funds and institutional investors) are keen on identifying the linkages at higher scales (long-term variations). Thus, motivated by the heterogeneous market hypothesis of stock markets and the diversity of short, medium and long run factors that drive cyclical variations, we apply the wavelet approach. Wavelets are considered as a powerful mathematical tool for signal processing, and can provide fruitful insights into the co-movements at different scales among the financial markets under consideration via a decomposition of the time series into their time-scale components. More importantly, the decomposition into sub-time series and the localization of the interdependence between international financial markets are the two most widely considered areas of the wavelet approach in finance. The wavelet analysis is however able to decompose the data into several time-scales. It serves the quantification of co-movement among GCC markets with Islamic stock index and macroeconomics factors at the scale level, such analysis disregards the potential evolution of the co-movement over time (Rua, 2010). Furthermore, this approach is able to handle non-stationary data and localization in time. Also, the short-run as well as long-run co-movements among the considered markets are clearly established through the wavelet time-scales, which provide us a holistic picture on the entire relationship (Durai and Bhaduri, 2009). Since the dependence structure is crucial in understanding the portfolio diversification benefits in the oil-rich region, we dub this as "hedging" relations between the GCC stock markets and the Dow Jones Islamic World Emerging equity index (DJIWEM) while accounting for the macroeconomic variables.

Using a QRA, the empirical results support the presence of significant positive dependence between the GCC stock markets and oil prices but negative dependence with gold and under the seven market conditions. Three out of the six GCC markets (UAE, Saudi Arabia and Qatar) are negatively dependent with the VIX index in bearish and bullish markets, indicating that the VIX product is a safe haven asset. The Dow Jones Islamic index (DJIWEM) is negatively linked in downturn markets for only Qatar and Saudi Arabia markets and the relationship is positive for the other Gulf markets under the different markets conditions. The T-bills rate exhibits negative lower tail dependence with both Oman, Qatar and Saudi Arabia, indicating their ability as a safe haven asset. However, by using a wavelet-based quantile methodology, the results underscore the presence of strong negative dependences between the GCC stock and gold markets at the short-, intermediate- and long-investment horizons in bear, normal and bull markets), underlying the importance of gold as a hedge and a safe haven for investors dealing with the GCC stock markets. Oil is positively dependent with GCC markets for the seven market conditions and at different time investment horizons, indicating that the GCC stock and oil markets tend to co-move closely in times of extreme events and negating their ability to be refuge assets.

Concerning the Islamic equity index (DJIWEM), T-bills and VIX index, these variables show a little or insignificant dependence structure at the short investment horizons (or lower scale levels), negating the importance of the hedge and safe haven variables for the GCC stock markets. Further, the dependence structure varies on the scale or horizon levels. More interestingly, the Islamic index (DJIWEM), the U.S. T-bills and VIX can be beneficial for GCC-based investors during financial stress periods especially at the intermediate and long run horizons in terms of portfolio risk management and international diversification strategies.

The remainder of this article is structured as follows. Section 2 presents the methodology. Section 3 describes the data and descriptive statistics. Section 4 presents the empirical results. Section 5 concludes the paper and discusses the implications of the findings.

2. Methodology

2.1. Quantile regression analysis

A more sophisticated tool than the linear correlation is needed in order to capture the complex dependence between financial time series under different market conditions and at different investment horizons. In addition to the copula functions, QRA since its introduction by Koenker and Bassett (1978) has become a common tool in modeling the degree and the structure of dependence since it involves the consideration of a set of regression curves that differ across different quantiles of the conditional distribution of the dependent variable. Compared to a classical linear correlation, the quantile functions provide a more precise and accurate result of the impact of conditional variables on the dependent variable (see, Koenker, 2005). Similarly to the copula functions, QRA gives information on the average dependence as well as the extreme tail dependence (i.e., upper and lower tails). However, according to Baur (2013) and Mensi et al. (2014), QRA differs from the copula functions in that it directly relates the quantile of the dependent variable with the conditioning variables, while the copulas relate the quantiles of both the dependent and the conditioning variables.

Let *y* be a dependent variable that is assumed to be linearly dependent on *x*. The τ^{th} conditional quantile function of *y* is thus specified as follows:

$$Q_y(\tau|x) = inf\{b|F_y(b|x) \geq \tau\} = \sum_k \beta_k(\tau)x_k = x'\beta(\tau) \quad (1)$$

where *b* is an element of the conditional distribution function of *y* given *x*, $F_y(b|x)$ is the conditional distribution function of *y* given *x*, and the quantile regression (QR) coefficient $\beta(\tau)$ determines the dependence relationship between vector *x* and the τ^{th} conditional quantile of *y*. Dependence is unconditional if no exogenous variables are included in *x*, while is conditional if exogenous variables are added to *x*. The values of $\beta(\tau)$ for $\tau \in [0,1]$ determine the complete dependence structure of *y*. The dependence of *y* based on a specific explanatory variable in vector *x* could be: (a) constant where the values of $\beta(\tau)$ do not change for different values of τ; (b) monotonically increasing (decreasing) where the values of $\beta(\tau)$ increase (decrease) with the value of τ*;* and (c) symmetric (asymmetric) where the values of $\beta(\tau)$ are similar (dissimilar) for the low and high quantiles.

The coefficients $\beta(\tau)$ for a given τ are estimated by minimizing the weighted absolute deviations between *y* and *x*:

$$\hat{\beta}(\tau) = \arg\min \sum_{t=1}^{T} \left(\tau - 1_{\{y_t < x_t' \beta(\tau)\}}\right) |y_t - x_t' \beta(\tau)| \tag{2}$$

where $1_{\{y_t < x_t' \beta(\tau)\}}$ is the usual indicator function. The solution to this problem is obtained using the linear programming algorithm suggested by Koenker and D'Orey (1987). The standard errors for the estimated coefficients can be obtained using the pair bootstrapping procedure proposed by Buchinsky (1995) since this procedure provides standard errors that are asymptotically valid under the heteroscedasticity and misspecifications of the QR function.

2.2. Wavelet approach

To overcome the limitations of the Fourier transform, the wavelet analysis came into existence. For example, the Fourier transform requires that the time series under study must be periodic and assumes that scales do not evolve in time, etc. In the wavelet transform, its window is adjusted routinely for the high or low scale. This is because it uses short window for the low scale and the long window at high scales by utilizing time compression rather than a variation of frequency in the modulated signal which is achieved by separating the time axis into a sequence of successively smaller segments.

Basic wavelets in any wavelet family are defined by father wavelets ϕ and mother wavelet ψ as:

Father wavelets $\int \phi(t)dt = 1$, and

Mother wavelets $\int \psi(t)dt = 0$.

The father wavelets are used to calculate the trend components, while the mother wavelets are used for all the deviations from trend. A sequential pattern of mother wavelets is used to represent a function and only one father wavelet is used to represent a function. In the up-to-date wavelet literature, a number of wavelet families have been introduced. However, in the empirical literature, the majority of the literature concentrates on using the orthogonal wavelets such as the Haar, Daublets, Symmlets and coiflets. A time series, say $f(t)$, can be decomposed by the wavelet transformation, which can be expressed as follows:

$$f(t) = \sum_k s_{J,k}\phi_{J,k}(t) + \sum_k d_{J,k}\psi_{J,k}(t) + \sum_k d_{J-1,k}\psi_{J-1,k}(t) + ... + \sum_k d_{1,k}\psi_{1,k}(t) \quad (3)$$

where J is the number of multiresolution levels, and k ranges from 1 to the number of coefficients in each level. The wavelet coefficients $s_{J,k}, d_{J,k}, \ldots, d_{1,k}$ are the wavelet transform coefficients and $\phi_{J,k}(t)$ and $\psi_{j,k}(t)$ represent the approximating wavelet functions. The wavelet transformations can be expressed as

$$s_{J,k} = \int \phi_{J,k}(t) f(t)dt \quad (4)$$

$$d_{j,k} = \int \psi_{j,k}(t) f(t)dt, \text{ for } j=1,2,\ldots\ldots J. \quad (5)$$

where J is the maximum integer such that 2^J takes a value less than the number of observations.

The detail coefficients, $d_{J,k}, \ldots.., d_{1,k}$, represent increasing finer scale deviations from the smooth trend and $s_{J,k}$ which represents the smooth coefficient capture the trend. Hence, the wavelet series approximation of the original series $f(t)$ can be expressed follows:

$$f(t) = S_{J,k}(t) + D_{J,k}(t) + D_{J-1,k}(t) + ... + D_1(t). \qquad (6)$$

where $S_{J,k}$ is the smooth signal and $D_{J,k}$, $D_{J-1,k}$, $D_{J-2,k} \ldots D_{1,k}$ are the detailed signals. These smooth and detailed signals are expressed as follows:

$$S_{J,k} = \sum_k s_{J,k}\phi_{J,k}(t), \text{ and } D_{J,k} = \sum_k d_{J,k}\psi_{J,k}(t), \quad j = 1,2,....,J-1 \qquad (7)$$

2.2.1 Discrete wavelet transform

If $h_1 = (h_{1,0},...h_{1,L-1},0,...,0)^T$ represents the wavelet filter coefficients of a Daubechies compactly supported wavelet for unit scale Daubichies (1992), zero padded to length N by defining $h_{1,j} = 0 \; for \; l > L$, certain properties must be satisfied by a wavelet filter which can be found in Tiwari et al. (2013).

Let $g_1 = (g_{1,0},...g_{1,L-1},0,...,0)^T$ be zero padded scaling filter coefficients, defined through $g_{1,l} = (-1)^{l+1} h_{1,L-1-1}$ and also let $x_0,...,x_{N-1}$ be a time series. For scales having, $N \geq L_j$, where $L_j = (2^j - 1)(L-1) + 1$, the time series can be filtered using h_j to obtain the wavelet coefficients.

$$W_{j,t} = 2^{j/2}\tilde{W}_{j,2^j(t+1)+1}, \quad \left[(L-2)\left(1 - \frac{1}{2^j}\right)\right] \leq t \leq \left[\frac{N}{2^j} - 1\right], \qquad (8)$$

where

$$\tilde{W}_{j,t} = \frac{1}{2^{j/2}} \sum_{2^{j/2}}^{L_j - 1} h_{j,l} x_{t-1}, \qquad t = L_j - 1, \ldots\ldots N-1$$

The $\tilde{W}_{j,t}$ coefficients which are associated with changes on a scale of length $\tau_j = 2^{j-1}$ are obtained by sub sampling every $2^j th$ of the $\tilde{W}_{j,t}$ coefficients.

2.2.2 Maximal overlap DWT (MODWT)

Given the limitations of the orthogonal discrete wavelet transform (DWT), an alternative MODWT can be useful. This is because it does not require the dyadic length requirement (i.e., a sample size divisible by 2^J), and the fact that the wavelet and scaling coefficients are not shift-invariant due to their sensitivity to circular shifts because of the decimation operation.

We therefore present an alternative called MODWT. Wavelet coefficients, $\tilde{w}_{j,t}$ and scaling coefficients $\tilde{V}_{j,t}$ at levels $j;\, j = 1, \ldots, J$, in MODWT can be obtained as:

$$\tilde{W}_{j,t} = \sum_{l=0}^{L-1} \tilde{g}_l \tilde{v}_{j-1,t-1 \bmod N} \;\; and \;\; \tilde{v}_{j,t} = \sum_{l=0}^{L-1} \tilde{h}_l \tilde{v}_{j-1,t-1 \bmod N} \tag{9}$$

The wavelet and scaling filters, $\tilde{g}_l, \tilde{h}_l$ are rescaled as $\tilde{g}_j = g_j / 2^{j/2}$, $\tilde{h}_j = h_j / 2^{j/2}$. The non-decimated wavelet coefficients represent differences between generalized averages of the data on a scale $\tau = 2^{j-1}$.

As the DWT can only be applied to sample sizes that are multiples of 2, we use the modified overlap discrete wavelet transform (MODWT) in this study. The MODWT, besides providing all the functions of DWT, comes with extra benefits as it can handle any sample size, it does not introduce phase-shifts which would change the location of events in time, and it is translation-invariant as a shift in the signal does not change the pattern of wavelet transform coefficients.

3. Sample data and preliminary statistics

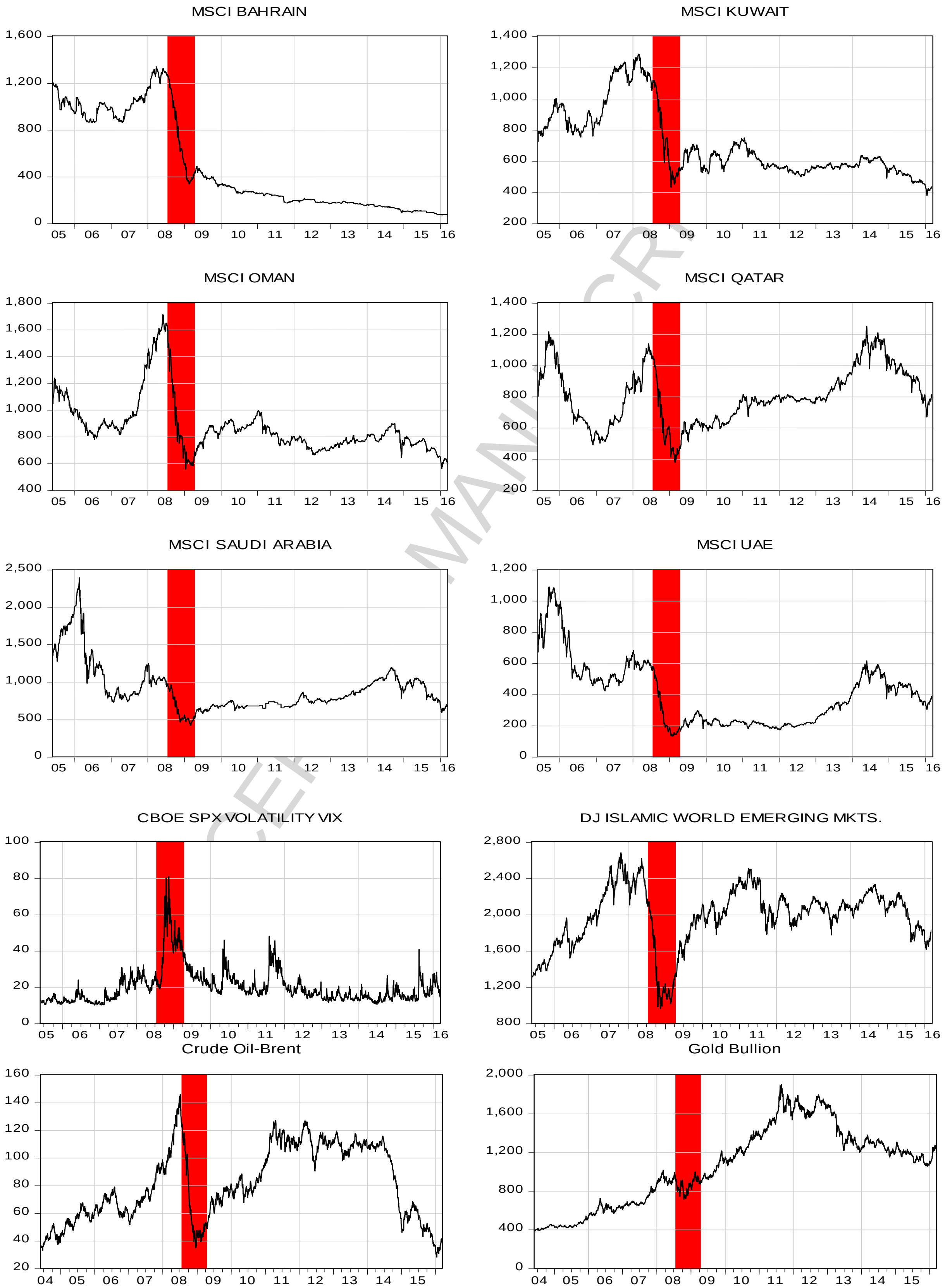
3.1. Sample data

This study employs daily closing stock price indexes for the GCC markets, specifically the MSCI Saudi Arabia, the MSCI UAE, the MSCI Bahrain, the MSCI Kuwait, the MSCI Oman and the MSCI Qatar. Additionally, we consider the Dow Jones Islamic world emerging equity index (DJIWEM), the three-month U.S. Treasury bills, the U.S. stock market volatility or fear (CBOE volatility Index or VIX), gold prices (expressed in U.S. dollars per ounce), and Europe Brent oil prices (expressed in U.S. dollars per barrel) which is the reference for the North Sea oil. The choice of the global macroeconomic factors is motivated by their strong links to the GCC economies.

The daily sample spans the period from June 03, 2005 to March 18, 2016, totaling 2816 daily observations. It is worth noting that June 03, 2005 is the inception date of the MSCI time series for the GCC market, and thus the data series are not available before that date. One should also note that the GCC markets follow different trading days from Western markets, observe different weekends among themselves and are dissimilar to those of the major markets. For instance, Fridays and maybe Thursdays are part of the weekends of the GCC countries and therefore their markets are closed on those days. To avoid the time-zone bias (i.e., the weekend effects in the sets of markets), we utilize daily data for three-trading days a week (Monday-Wednesday) when the GCC and the global markets are commonly open. The period under study has been marked by high levels of volatility and an upward trend in prices.

It also includes several global and regional marked events such as the recent global financial crisis, the euro-zone sovereign debt crisis, the slow recovery of the global market in 2010 and the 2014 oil price decline, among others. The GCC indices, the Islamic equity index (DJIWEM), the CBOE volatility index, the gold price, and the oil price data are sourced from DataStream, while the three-month U.S. Treasury bill rate data is compiled from the Federal Reserve Bank of St. Louis.

Fig. 1 plots the time-paths of the daily indices under consideration. As clearly shown in this figure, all series of the indices exhibit significant long-swing movements over the considered period. More precisely, the red-shaded regions for the GCC indices, Islamic equity index (DJIWEM), oil prices and the three-month U.S. Treasury bill rate display a significant sharp drop between July 2008 and March 2009, which corresponds to the 2008-2009 GFC period. Conversely, the VIX index and gold prices show an increase for the same period, underlying the important roles played by these assets in market stress periods. It is also worth noting that the T-bills rates exhibit a constant evolution between mid-2009 and 2016. The oil price drops significantly from the first quarter of 2014 to reach $US30 per barrel by the end of 2015. The Bahrain stock market displays a decline after the GFC period until 2016. The trajectories of the daily dynamic returns of the GCC stock indices, the DJIWEM index and the macroeconomic factors show volatility clustering (the figures are not reported here but are available upon request).


MSCI BAHRAIN
1,600
1,200
800
400
0
05 06 07 08 09 10 11 12 13 14 15 16
MSCI KUWAIT
1,400
1,200
1,000
800
600
400
200
05 06 07 08 09 10 11 12 13 14 15 16
MSCI OMAN
1,800
1,600
1,400
1,200
1,000
800
600
400
05 06 07 08 09 10 11 12 13 14 15 16
MSCI QATAR
1,400
1,200
1,000
800
600
400
200
05 06 07 08 09 10 11 12 13 14 15 16
MSCI SAUDI ARABIA
2,500
2,000
1,500
1,000
500
0
05 06 07 08 09 10 11 12 13 14 15 16
MSCI UAE
1,200
1,000
800
600
400
200
0
05 06 07 08 09 10 11 12 13 14 15 16
CBOE SPX VOLATILITY VIX
100
80
60
40
20
0
05 06 07 08 09 10 11 12 13 14 15 16
DJ ISLAMIC WORLD EMERGING MKTS.
2,800
2,400
2,000
1,600
1,200
800
05 06 07 08 09 10 11 12 13 14 15 16
Crude Oil-Brent
160
140
120
100
80
60
40
20
04 05 06 07 08 09 10 11 12 13 14 15
Gold Bullion
2,000
1,600
1,200
800
400
0
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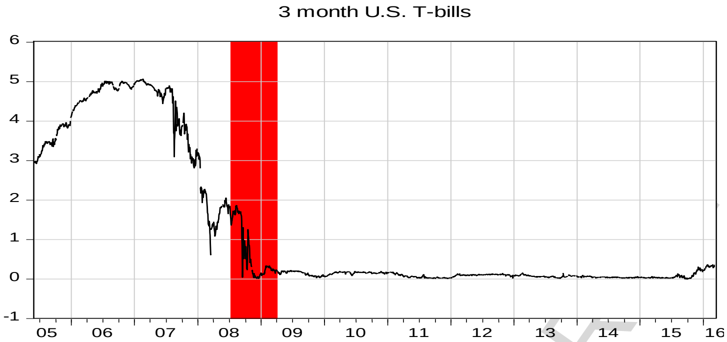

Fig. 1. The time evolution of the daily GCC and other stock indices and macroeconomic factors.

Note: the red lines refer to the crisis period between July 2008 and March 2009.

3.2. Statistic and stochastic properties of the data

Table 1 presents the stochastic properties for the daily level series under study for both the raw data and at each wavelet scale. As shown in Panel A, among the GCC markets, Bahrain market is the most volatile whereas the Qatar market is the less volatile. The average stock indexes, commodity prices and T-bill rates of wavelet time series (*D1*, . . . , *D8*) are close to zero. The unconditional volatility as measured by the standard deviation increases across the scales. This result can be explained by the extreme losses that were reported in the aftermath of the GFC. As expected, all wavelet series are skewed and exhibit high excess kurtosis, implying the presence of high peaks and fat tails. Therefore, the Jarque-Bera test strongly rejects the normality of the unconditional distributions for all the eleven series. Interestingly, we check the serial residual autocorrelation and the Ljung-Box statistic for autocorrelation up to the 20th order and the result reveals non-linear temporal dependency in the price indexes for all cases. Finally, we test the null hypothesis of a unit root, using the conventional augmented Dickey and Fuller (1979) and Phillips and Perron (1988) statistics, and the stationarity property under the null using the Kwiatkowski et al. (1992) test. The results reported in Panel A of Table 1 indicate that all level series are not stationary.

Table 2 reports the Spearman correlations of the level series among the GCC, DJI-

WEM index, T-bills rate, gold prices, oil prices and VIX index. We find significant correlations among the GCC stock markets, underlying the short-run integration of these markets. The UAE is highly correlated with the rest of the GCC markets especially the Kuwait, Saudi Arabia and Oman markets. As for the Islamic equity index (DJIWEM), the results show positive and significant correlations with the GCC stock markets, with the exception of the Bahrain stock market.

On the other hand, we find a negative correlation between the DJIWEM index and VIX, which is a standard result for the correlation of VIX with the U.S. stock market. This result is also similar with those of Mensi et al. (2014). The T-bill rates have significant and positive correlations with the GCC stock markets, with the exception of the Qatar market which presents negative correlations. The VIX index has also a negative correlation with the GCC markets (except for Bahrain), which implies that market fear for Bahrain is not the same as for the United States' market. This result indicates that investors in most GCC markets can be mindful of VIX in periods of high stress periods when it comes to diversification benefits and downside risk reductions. The gold prices exhibit negative and significant correlations with all GCC markets with the exception of the Qatari market, indicating potential diversification benefits for the other GCC markets. The Qatari market is supported by the Qatari Investment Authority. The oil market is strongly correlated with the GCC stock markets as expected, except with the Bahrain and Qatar markets. The Bahrain market is a negligible oil producer, widely open to international investors and relatively strongly connected to major global stock markets. Qatar, on the other hand, is a major natural gas exporter and is the only GCC country that exports natural gas. Furthermore, as indicated the Qatar Investment Authority frequently intervenes in the Qatar stock market which helps to un-synchronize its stock market from the oil market.

Table 1: Descriptive statistics and unit root test results.

	Bahrain	Kuwait	Oman	Qatar	S. Arabia	UAE	DJIWEM	T-bills	Gold	CBOEVIX	Oil
Panel A: Level series											
Mean	479.54	703.56	873.55	799.84	897.50	398.81	1975.44	1.21	1050.63	19.98	80.43
Max.	1338.17	1284.93	1710.85	1248.91	2388.81	1087.51	2678.87	5.05	1898.25	80.86	145.61
Min.	68.62	377.43	554.36	375.29	416.50	130.244	959.12	-0.02	384.75	9.89	27.82
Std. dev.	399.75	217.22	208.99	181.12	317.89	206.68	324.33	1.81	403.26	9.64	26.75
Skewness	0.741	1.100	1.916	0.239	1.915	1.066	-0.79	1.17	-0.002	2.33	0.083
Kurtosis	1.888	3.107	6.798	2.404	7.150	3.947	3.52	2.61	1.93	10.22	1.75
J-B	403.10***	570.12***	3416.93***	68.49***	3742.92***	638.94***	327.81***	635.30***	145.95***	8691.36***	203.33***
Q(20)	55382***	54914***	53820***	53667***	53276***	54390***	51937***	53610***	60474***	45909***	58534***
ADF	-2.91	-1.98	-1.02	-0.386	-1.27	-1.37	-0.05	-1.35	0.52	-1.95**	-0.45
PP	-3.09	-2.14	-0.98	-0.389	-1.22	-1.22	0.006	-1.33	0.52	-2.07**	-0.45
KPSS	116.22***	7.40***	44.43***	31.18***	33.70***	45.70***	15.10***	93***	115***	14.52***	37.23***
Panel B: Wavelet series											
D1											
Mean	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Std. dev.	0.023	0.007	0.006	0.006	0.009	0.009	0.005	0.030	0.010	0.031	0.008
Skewness	11.782	0.691	2.577	-0.170	2.103	0.572	-1.651	4.087	-8.527	0.322	0.292
Kurtosis	1229.216	164.469	237.129	12.580	163.796	72.490	98.452	326.537	728.602	6.307	9.391
J-B	176000000***	3059364***	6434890***	10783***	3035765***	566743***	1070306***	12289880***	61809867***	1331***	4833***
D2											
Mean	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Std. dev.	0.027	0.008	0.008	0.007	0.010	0.011	0.007	0.040	0.012	0.034	0.010
Skewness	6.255	1.365	0.979	-0.399	1.374	0.564	-0.557	1.468	-3.765	0.347	0.052
Kurtosis	616.530	108.828	114.169	9.676	95.154	44.355	30.824	129.502	378.368	6.132	6.751
J-B	44184801***	1314962***	1450515***	5305***	997333***	200819***	90983***	1878670***	16539028***	1208***	1652***
D3											
Mean	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Std. dev.	0.036	0.012	0.012	0.011	0.015	0.016	0.011	0.050	0.016	0.045	0.014
Skewness	3.559	0.312	-0.074	-0.482	0.192	-0.248	-0.676	0.493	-2.846	0.383	0.024
Kurtosis	305.657	58.739	49.539	12.288	46.106	24.690	18.303	85.320	183.670	5.617	7.396
J-B	10753829***	364581***	254136***	10232***	218036***	55229***	27692***	795224***	3833736***	872***	2268***
D4											
Mean	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Std. dev.	0.051	0.016	0.016	0.015	0.020	0.023	0.015	0.064	0.022	0.053	0.019

Skewness	2.306	0.597	-0.273	-0.246	0.399	-0.279	0.099	0.644	-1.931	0.392	-0.198
Kurtosis	154.966	34.662	30.369	6.382	22.662	10.304	10.740	51.699	95.291	4.417	5.559
J-B	2712132***	117790***	87927***	1371***	45435***	6295***	7034***	278466***	1001148***	308***	787***
D5											
Mean	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Std. dev.	0.071	0.023	0.021	0.021	0.031	0.034	0.020	0.085	0.032	0.069	0.026
Skewness	1.776	0.803	1.081	-0.064	0.752	0.606	-0.139	0.464	-0.685	0.196	0.002
Kurtosis	76.895	15.889	29.306	6.318	14.955	12.299	5.447	27.313	42.468	4.160	4.193
J-B	642170***	19795***	81747***	1294***	17034***	10318***	711***	69459***	182991***	176***	167***
D6											
Mean	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Std. dev.	0.104	0.033	0.031	0.028	0.046	0.045	0.027	0.116	0.045	0.093	0.040
Skewness	1.522	-0.043	0.561	0.012	-0.272	0.408	-0.390	0.225	-0.294	0.295	-0.525
Kurtosis	37.231	10.297	15.394	4.455	8.122	7.555	4.419	17.334	26.390	4.140	4.258
J-B	138576***	6249***	18173***	249***	3113***	2512***	308***	24131***	64234***	193***	315***
D7											
Mean	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Std. dev.	0.150	0.051	0.051	0.045	0.064	0.078	0.043	0.171	0.056	0.107	0.081
Skewness	0.506	-0.578	0.229	0.264	-0.409	-0.624	-0.318	0.262	-0.976	0.418	-0.264
Kurtosis	16.912	4.863	6.668	4.806	4.857	4.995	4.840	9.302	15.125	3.706	4.814
J-B	22830***	564***	1603***	415***	483***	650***	444***	4692***	17696***	141***	419***
D8											
Mean	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Std. dev.	0.205	0.086	0.100	0.091	0.119	0.152	0.078	0.220	0.080	0.135	0.120
Skewness	0.538	-0.118	-0.002	-0.100	0.026	-0.052	-1.225	-0.438	-0.988	0.484	-0.545
Kurtosis	8.391	3.950	4.735	4.373	4.142	4.247	6.825	6.422	7.443	3.098	5.173
J-B	3546***	112***	353***	226***	153***	184***	2421***	1464***	2774***	111***	694***
S8											
Mean	5.798	6.514	6.749	6.658	6.750	5.862	7.573	1.214	6.947	2.911	4.376
Std. dev.	0.831	0.258	0.168	0.204	0.261	0.467	0.156	1.788	0.355	0.315	0.293
Skewness	0.187	0.963	1.405	-0.166	0.859	0.092	-0.737	1.182	-0.355	0.664	-0.234
Kurtosis	1.765	2.952	4.625	2.102	3.427	1.564	2.690	2.741	1.894	2.565	1.698
J-B	195***	436***	1236***	107***	368***	246***	266***	664***	203***	229***	225***

Notes: J-B and Q(20) refer to the empirical statistics of the Jarque-Bera test for normality and the Ljung-Box test for autocorrelation, respectively. ADF, PP and KPSS are the empirical statistics of the Augmented Dickey and Fuller (1979), and the Phillips and Perron (1988) unit root tests, and the Kwiatkowski et al. (1992) stationarity test, respectively. The asterisks ***, ** and * denote the rejection of the null hypotheses of normality, no autocorrelation, unit root, non-stationarity, and conditional homoscedasticity at the 1%, 5% and 10% significance levels, respectively.

Table 2: Spearman correlations of sample returns.

	Bahrain	Kuwait	Oman	Qatar	S. Arabia	UAE	DJIWEM	T-bills	Gold	CBOEVIX	Oil
Bahrain	1										
Kuwait	0,885***	1									
Oman	0,711***	0,838**	1								
Qatar	-0,25***	0,014	0,304***	1							
S. Arabia	0,346***	0,439***	0,467***	0,614***	1						
UAE	0,436***	0,585***	0,558***	0,542***	0,877***	1					
DJIWEM	-0,202***	0,160***	0,249***	0,347***	0,034*	0,046**	1				
T-bills	0,784***	0,741***	0,429***	-0,165***	0,557***	0,654***	-0,106***	1			
Gold	-0,783***	-0,660***	-0,464***	0,128***	-0,548***	-0,692***	0,446***	-0,838***	1		
CBOEVIX	0,054***	-0,075***	-0,057***	-0,422***	-0,615***	-0,541***	-0,351***	-0,351***	0,169***	1	
Oil	-0,065***	0,094***	0,250***	0,335***	-0,003	-0,180***	0,617***	-0,266***	0,535***	-0,114***	1

Notes: The asterisks ***, ** and * denote the rejection of the null hypotheses at the 1%, 5% and 10% significance levels, respectively.

4. Empirical results

To model the dependence structure, we first apply the QRA to the level series.[1] Second, to get further evidence, we consider the wavelet decomposition method in order to have a richer picture of the degree and structure of dependence for the GCC markets in terms of time investment horizons using a wavelet-based quantile methodology. To do this, we follow Tiwari et al. (2013) to decompose the time series into different scales using the Daublets basis which is orthogonal, near symmetric, and has compact support and good smoothness properties, thus suits the objectives of this study.[2] Specifically, we carry out the wavelet decomposition of the GCC stock markets, the Islamic stock index (DJIWEM) and the macroeconomic factors time series into a set of eight orthogonal components ranging from *D1* to *D8* (lowest to highest scales).[3] This decomposition represents different scale components of the original series in details and a trend/smoothed component (*S8*) in the level series.[4]

The Multi-Resolution Analysis (MRA), which is the design method of most of the practically relevant modified discrete wavelet transforms (MODWT) of order $J=8$ for the level series of the GCC markets is reported in Fig. 2 (see Appendix A) and for the Sharia-compliant stock index and the macroeconomic factors in Fig. 3.[5] Specifically, we carry out the wavelet decomposition of each level time series into a set of 8 orthogonal components (*D1* until *D8* deviations) that represent different scale components of the original series in the details (ranging from the lowest to the highest scale) and a trend/smoothed component (*S8*) in the level series. This decomposition allows for a time-scale domain representation of the orig-

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[1] "raw" refers to the original return series before the decomposition of the series into different scales.

[2] Daublets wavelets are constructed by and named after Ingrid Daubechies who is one of the pioneers of wavelet researchers. They are the first orthogonal wavelets with compact support (zero outside a finite interval). They are near symmetric and have varying widths. They are also chosen for the suitability of their properties to the data and the objectives of the paper. The increasing finer scale deviations from the smooth trend are the details coefficients (Ds).

[3] Eight is realized since this exhausts all the data points. At the 8th component, we have 256-512 days, whereas the total observations are 2816 days only. Thus, any more decomposition than this would become meaningless.

[4] The details or components represent the fluctuations around the trend.

[5] $j=8$ is the maximum possible feasible decomposition level.

inal series.

Table 3 reports MRA of order *J=8* for the level series. Scale *Dl* represents the lowest scale that occurs at the 2–4 day scale, and *D2* stands for the next finest level in the series and represents the 4–8 day scale, etc. One can see from these figures that for all variables, there is a high volatility for the first three scales (i.e., Scales *D1-D3* are relevant for low scale speculative traders), while for Scales D4-D5 the volatility is reduced considerably. Finally, from Scale *D6* onwards the scales become smoother for all variables.

Table 3: Scale interpretation of the MRA scale levels.

Scale	daily scale
D1	2 ~ 4 days
D2	4 ~ 8 days
D3	8 ~ 16 days
D4	16 ~ 32 days
D5	32 ~ 64 days
D6	64 ~ 128 days
D7	128 ~ 256 days
D8	256 ~ 512 days

Note: MRA is the multi-resolution analysis. *D1-D3* represent a daily scale which can then be interpreted as low scales, whereas scales higher than *D3* (maybe until *D6*) can be interpreted as intermediate scales. Scales Higher than *D6* represent high scale data.

In the following subsections of this section, we provide an analysis of the dependence of the GCC markets with different subsets of the independent variables. We start first with dependence with the commodity markets.

4.1. Co-movements between GCC stock and commodity markets

To honor space, we provide selected tables which are Tables 4 and 5 to report the estimates of the quantile regression (QR) results under the wavelet decomposition for the Saudi Arabia and UAE stock markets, respectively, with each of the commodity markets as well as with the Islamic equity index (DJIWEM), VIX and T-bill rate.[6] As standard in the quantile regression literature, we show the numerical results for the seven quantiles from 0.05 to 0.95

[6]The full results for all GCC markets can be obtained from the authors upon request.

(i.e., the most severe financial stress period to the highest quantile or the highest bull market), with the consideration of the other markets and the global macroeconomics variables. As shown in Panel A of Table 4 for Saudi Arabia, the results for the raw series and for the seven markets support strong evidence of average and extreme dependence between the Saudi stock index and the oil and gold returns. More precisely, we find strong positive average and tail dependence between the oil price and the Saudi stock index, indicating that both oil prices and the Saudi stock index co-move in the same sense during the bear, normal and bull markets. This result is not surprising for an economy based on oil revenues.

The dependence structure between oil and stock markets is similar for all GCC markets. Looking at the gold-Saudi pairing, the results exhibit a negative dependence with the Tadawul index during downturns, average and upturns periods. This result underlines the crucial role played by gold as a good protection against losses in the Saudi market. The gold asset offers Saudi investors greater compensation for their stock market losses during turmoil periods. For all GCC stock markets, the gold asset is negatively dependent with stock markets across all quantiles, supporting their role as a hedge and a safe haven asset for investors dealing with Gulf markets.

As shown in Panel B of Tables 4-5, we find asymmetric tail dependence between the gold and GCC stock markets at different investment horizons. More precisely, we find negative lower dependence for the short term, middle-term and long-term investment horizons, making this precious metal a good hedge and a safe haven for the GCC markets in the longer run as well as at shorter-run horizons. It highlights the diversification importance of the shiny metal for short-term (traders and speculators) and long-term investors (institutional investors and central banks) involved in the GCC markets. More interestingly, this yellow metal is known as a refuge asset in the different time horizons for market participants interested in short-term and long-term fluctuations.

In such a case, investors can hedge their positions by taking a long position in GCC equity indexes and a short position in the gold market. This precious metal is a safe haven asset in turbulent market periods. This result is consistent with Mensi et al. (2014) for the BRICS stock markets, given the onset of the GFC as well as for Mensi et al. (2015) for the GCC stock markets using vine copula approach.

Turning now to the crude oil market effects and looking first at the behavior of the co-movement for the oil-Tadawul pairing for the wavelet series, the dependence is strongly positive for the long investment horizons under all quantiles of the distribution (lower, middle and upper tails). The long-run positive co-movement does not make oil a good hedge for the Saudi market and indicates that no benefits can be reaped from portfolio diversification when it comes to risk management under all quantiles in the longer time horizons. This result also indicates that both the oil price and the Tadawul index co-move in the same direction, whatever the market circumstances or conditions are. More specifically, both markets are more positively integrated in bull markets. However, the rise in oil prices still improves the Saudi stock market performance. Looking at the short and middle investment horizons, the results also show positive average and tail dependence between the largest oil exporter's stock market and the oil market but the level of significance of the results is sensitive to the bear, tranquil and bull (except q=0.95) market conditions. The Saudi government may use its cash cushion during bear oil markets. These results hold for all GCC stock markets. Indeed, the dependence structure is positive and asymmetric between the crude oil and GCC stock markets across all quantiles and for middle and long investment horizons, meaning that the oil and GCC markets are co-dependent during the seven markets conditions in the middle- and long-term run horizons. The result underscores the importance of the presence of oil for investors dealing with the GCC markets who seek to make earnings by diversifying their portfolios. In the short investment horizons, the oil and GCC stock markets are positively dependent, except for the lowest Scale *D1* (2~4 days) for Bahrain, Kuwait, Oman and Qatar, and *D2* (4~8 days) for both Bahrain and Qatar which we find independence between the oil and stock markets across all quantiles. It is worth noting that in the short run the Qatar stock market is managed by Qatar's sovereign wealth fund. Bahrain is a minor oil producer and is highly connected with the international markets through its offshore banking system. Qatar is also a major natural gas exporter and is the only GCC country that exports natural gas.

These findings imply that the oil and GCC stock markets are particularly integrated at times of extreme negative events. Thus, when the GCC markets are in a bearish environment, the diversification benefits generated by portfolios composed of the GCC stocks and the oil commodity may potentially decrease as oil co-crash with the GCC stocks. It is also worth noting that oil plays a fundamental role in the oil/stock portfolio designs and asset allocations for the GCC investors. More interestingly, these investors would be able to anticipate changes in their portfolio values due to oil and stock price shocks and to build an accurate asset pricing process.

4.2. Co-movements between GCC stock markets and Islamic stock index

For the raw series, the Islamic stock index is positively co-dependent with the Bahraini market for bull markets. As for Kuwait and Oman, the dependence is also positive for the seven markets conditions. The UAE, Qatar and Saudi Arabia stock markets and the Islamic stock market (DJIWEM) are positively dependent during both bull and normal markets, highlighting the importance of this Islamic asset for designing diversification strategies. More interestingly, we find negative dependence between the DJIWEM index and both Saudi Arabia and Qatar during highly stressed markets, underscoring the role plays by this index as a safe haven during financial stress periods.

The results for the wavelet series and for the short investment horizons fail to provide evidence of tail dependence between the Islamic stock index (DJIWEM) and the Bahrain market. Furthermore, we show on the whole evidence of average and extreme dependences between the three out of six GCC markets (UAE, Qatar and Saudi Arabia) and the faith-based Islamic stock market index, negating their role as a hedge and a safe haven in the short run horizon. As for Kuwait and Oman, we find an average dependence and an extreme dependence with the Islamic stock market index (DJIWEM), implying that diversification with those assets does not realize portfolio benefits during tranquil markets and for short run horizons.

For the middle-run investment horizons, the GCC stock markets and the Islamic stock index (DJIWEM) are strongly co-dependent across all quantiles, suggesting a contagion effect between those markets during bearish and average markets at relatively intermediate time horizons. This means “co-faithing” in Islamic markets does not bring diversification benefits in the short-run. This relationship is also maintained at the intermediate Scale *D6* and for all quantiles (low, middle and high tails), except for the Bahraini stock market that exhibits negative lower tail dependence with the Islamic stock market index ((DJIWEM), underlying the importance of this Islamic financial asset as a refuge asset during extreme negative stock market movements. At the long investment horizons, we find generally significant positive average and tail dependence between almost all GCC stock markets and Islamic stock market index (DJIWEM), implying that both markets evolve in the same way and are particularly more integrated during bearish markets, indicating poor mutual performance under bad markets. In contrast, for example, for Bahrain and Saudi Arabia, the Islamic equity index (DJI-

WEM) can be included in portfolios in order to minimize risks during crisis market periods and also to improve portfolio performance during upturn periods. For the UAE and Qatar markets, at Scale *S8* the results exhibit negative dependence between the UAE and Islamic markets for all quantiles or mutual performance.

Table 4: Estimates for a quantile regressions under the wavelet decomposition for Saudi Arabia.

Scale	Variables	q0.05	q0.1	q0.25	q0.5	q0.75	q0.9	q0.95
Panel A : Raw series								
Raw	DJIWEM	-0.116**	-0.143***	-0.077***	0.073**	0.226***	0.272***	0.817***
	T-bills	-0.032***	-0.026***	-0.026***	-0.02***	0.0006	0.046***	0.061***
	Gold	-0.428***	-0.449***	-0.498***	-0.57***	-0.6303***	-0.507***	-0.703***
	Oil	0.3984***	0.461***	0.446***	0.24***	0.143***	0.065***	0.098***
	CBOEVIX	-0.361***	-0.327***	-0.287***	-0.406***	-0.371***	-0.32***	-0.18***
	c	9.705***	9.709***	9.571***	10.302***	9.998***	9.029***	5.758***
	Pseudo R2	0.4829	0.4059	0.3439	0.375	0.45***	0.557	0.5819
Panel B : Wavelet series								
D1								
	DJIWEMd1	0.073	0.127*	0 .073*	0.050*	0.111***	0.183**	0 .165
	T-billsd1	0.004	0.005	0.002	0.007	0.017	0.018	0 .014
	Goldd1	-0.534***	0.336***	-0.155***	-0.089***	-0.203***	-0.392***	-0.546***
	Oild1	0.204***	0.183***	0.105***	0.062***	0.093***	0.176***	0.184***
	CBOEVIXd1	-0.0008	-0.003	0.0009	0.003**	0.007	0.0125	0.029
	c	-0.0105***	-0.006***	-0.002***	8.15e-06	0.002***	.006***	0.010***
	Pseudo R2	0.0758	0.0506	0.0242	0.0108	0.0265	0.0508	0.0821
D2								
	DJIWEMd2	0.155**	0.174**	0.133***	0.127***	0.0138***	0.018	0.044
	T-billsd2	0.034*	0.031**	0.0296**	0.024**	0.019	0.013	0.002
	Goldd2	-0.478***	-0.461***	-0.223***	-0.14***	-0.236***	-0.42***	-0.535***
	Oild2	0.226***	0.169***	0.12***	0.078***	0.102***	0.156***	0.177***
	CBOEVIXd2	0.017	0.012	0.013**	0.016***	0.018***	0.007	0.026**
	c	-0.012***	-0.008***	-0.003***	-0.0001	0.003***	0.008***	0.012***
	Pseudo R2	0.1247	0.0752	0.0342	0.0195	0.0377	0.0644	0.1114
D3								
	DJIWEMd3	0.266***	0.12	0.043	0.118***	0.167***	0.112	0.383***
	T-billsd3	0.039**	0.04***	0.034***	0.022**	0.022	0.028**	0.023
	Goldd3	-0.559***	-0.461***	-0.241***	-0.197***	-0.307***	-0.503***	-0.61***
	Oild3	0.192***	0.2***	0.186***	0.121***	0.145***	0.178***	0.164***
	CBOEVIXd3	-0.033*	-0.033**	-0.034***	-0.008	-0.005	-0.012	-0.0163
	c	-0.018***	-0.01***	-0.0048***	0.0002	0.004***	0.011***	0.018***
	Pseudo R2	0.1861	0.1237	0.0670	0.0435	0.0575	0.1070	0.1808
D4								
	DJIWEMd4	0.439***	0.39***	0.289***	0.275***	0.204***	0.327***	0.38***
	T-billsd4	0.031**	0.027**	0.038**	0.04*	0.034**	0.03	0.047**
	Goldd4	-0.557***	-0.54***	-0.319***	-0.331***	-0.322***	-0.479***	-0.492***
	Oild4	0.366***	0.278***	0.18***	0.171***	0.218***	0.225***	0.087
	CBOEVIXd4	0.017	-0.2*	-0.039***	-0.032***	-0.04***	-0.019	-0.047*
	c	-0.027***	-0.017***	-0.007***	0.0002	0.007***	0.016***	0.026***
	Pseudo R2	0.1815	0.1462	0.1179	0.0963	0.1244	0.1601	0.2082
D5								
	DJIWEMd5	0.55***	0.464***	0.326***	0.151***	0.04	0.164**	0.411***
	T-billsd5	0.023	0.019	0.037***	0.066***	0.076***	0.08***	0.067***

	Goldd5	-0.908***	-0.737***	-0.524***	-0.394***	-0.404***	-0.523***	-0.659***
	Oild5	0.338***	0.334***	0.252***	0.182***	0.222***	0.107**	0.038
	CBOEVIXd5	0.063***	0.04*	0.005	-0.018*	-0.014	0.023**	0.084***
	c	-0.04***	-0.027***	-0.011***	0.0001	0.011***	0.025***	0.036***
	Pseudo R2	0.2993	0.2388	0.1647	0.1386	0.1601	0.2322	0.3162
D6								
	DJIWEMd6	0.31***	0.314***	0.467***	0.435***	0.545***	0.646***	0.714***
	T-billsd6	0.055**	-0.002	0.0247**	0.047***	0.071***	0.09***	0.126***
	Goldd6	-0.632***	-0.665***	-0.586***	-0.495***	-0.551***	-0.703***	-0.746***
	Oild6	0.102*	0.264***	0.403***	0.42***	0.344***	0.117***	-0.064
	CBOEVIXd6	0.028	0.03	0.068***	0.068***	0.091***	0.107***	0.184***
	c	-0.053***	-0.036***	-0.016***	-0.0005***	0.0155***	0.041***	0.059***
	Pseudo R2	0.3417	0.2869	0.2679	0.2470	0.2613	0.2764	0.3201
D7								
	DJIWEMd7	-0.068	-0.07	-0.219***	-0.096	-0.025	-0.244***	-0.532***
	T-billsd7	-0.058***	-0.027***	-0.011	-0.006	0.013	-0.002	0.07***
	Goldd7	-0.604***	-0.457***	-0.279***	-0.274***	-0.194***	-0.118**	0.165***
	Oild7	0.291***	0.344***	0.53***	0.504***	0.434***	0.332***	0.181***
	CBOEVIXd7	-0.197***	-0.156***	-0.085***	-0.072***	-0.106***	-0.234***	-0.442***
	c	-0.055***	-0.043***	-0.021***	-0.003***	0.019***	0.046***	0.072***
	Pseudo R2	0.4914	0.4899	0.4376	0.3872	0.3912	0.3246	0.3249
D8								
	DJIWEMd8	0.175***	0.279***	0.259***	0.292***	0.79***	1.241***	2.504***
	T-billsd8	0.035***	0.02*	0.127***	0.148***	-0.047	-0.141***	-0.068**
	Goldd8	-0.428***	-0.518***	-0.397***	-0.429***	-1.035***	-1.495***	-1.928***
	Oild8	0.673***	0.677***	0.151***	0.562***	0.462***	0.626***	0.23
	CBOEVIXd8	0.019	0.025	-0.03***	0.111***	0.179***	0.542***	0.949***
	c	-0.09***	-0.075***	-0.03***	-0.066***	0.032***	0.072***	0.129***
	Pseudo R2	0.6547	0.6081	0.5474	0.4842	0.4568	0.4737	0.4809
S8								
	DJIWEMs8	0.145***	0.129***	0.048**	0.062	0.104***	0.05***	0.05***
	T-billss8	-0.067***	-0.066***	-0.07***	-0.092***	-0.056***	-0.03***	-0.036***
	Golds8	-0.872***	-0.856***	-0.846***	-0.975***	-0.831***	-0.746***	-0.736***
	Oils8	0.616***	0.598***	0.498***	0.332***	0.347***	0.334***	0.342***
	CBOEVIXs8	-0.32***	-0.335***	-0.459***	-0.631***	-0.604***	-0.63***	-0.641***
	c	9.866***	10.003***	11.385***	13.55***	12.153***	12.057***	12.059***
	Pseudo R2	0.6034	0.5572	0.4712	0.4894	0.5845	0.7188	0.7540

Notes: The Pseudo *R2* estimates indicate that both the Islamic index (DJIWEM) and macroeconomics factors are able to explain a larger fraction of changes in the GCC stock markets in the lower tails than in the upper tails. The DJIWEM, T-bills and CBOEVIX are the Dow Jones Islamic World Emerging market index, the three-month U.S. Treasury bills and the VIX index, respectively. q= 0.05 means lowest quantile (the most severe financial stress period), while q= 0.95 refers to the highest quantile (the highest bull market period). ***. **. * denote significance at the 1%. 5% and 1% levels, respectively.

Table 5: Estimates for a quantile regression under the wavelet decomposition for UAE.

Scale	Variables	q0.05	q0.1	q0.25	q0.5	q0.75	q0.9	q0.95
Panel A : Raw series								
Raw	DJIWEM	0.049	0.053	0.334***	1.053***	1.224***	1.236***	1.265***
	T-bills	0.035***	0.018***	-0.034***	-0.133***	-0.1655***	-0.169***	-0.1609***
	Gold	-0.938***	-1.078***	-1.306***	-1.675***	-1.894***	-1.859***	-1.821***
	Oil	0.485***	0.541***	0.505***	0.098***	0.0749**	0.043*	0.034**
	CBOEVIX	-0.376***	-0.403***	-0.464***	-0.485***	-0.292***	-0.294***	-0.28***
	c	10.561***	11.401***	11.372***	10.678***	10.675***	10.627***	10.183***
	Pseudo R2	0.4821	0.4636	0.48	0.5206	0.4862	0.532	0.5674
Panel B : Wavelet series								
D1								

	DJIWEMd1	0.383***	0.473***	0.436***	0.374***	0.384***	0.331***	0.318***
	T-billsd1	0.016	0.012	0.015	0.006	0.020	0 .031	0.017
	Goldd1	-0.370***	-0.324*	-0.171***	-0.132***	-0.175***	-0.311***	-0.450***
	Oild1	0.125**	0 .061	0.032	0.0181***	0.046*	0.091*	0 .154***
	CBOEVIXd1	-0.003	0.019**	0.015***	0.018	0.019***	0.017**	0.028**
	c	-0.011***	-0.007***	-0.003***	0.000	0.003***	0.007***	0.011***
	Pseudo R2	0.0775	0.0534	0.0432	0.0432	0.0395	0.0483	0.0843
D2								
	DJIWEMd2	0.0402**	0.462***	0.437***	0.039***	0.396***	0.411***	0.414***
	T-billsd2	0.025	0.028	0.009	0.011	0.016	0.017	0.023
	Goldd2	-0.49***	-0.484***	-0.247***	-0.264***	-0.263***	-0.411***	-0.49***
	Oild2	0.157**	0.156***	0.073**	0.057***	0.089**	0.141**	0.098*
	CBOEVIXd2	-0.003	0.11	0.14***	0.1**	0.015**	0.024**	0.002
	c	-0.136***	-0.009***	-0.003***	0.0002	0.004***	0.009***	0.014***
	Pseudo R2	0.1230	0.0936	0.0656	0.0588	0.0573	0.0717	0.1097
D3								
	DJIWEMd3	0.435***	0.349***	0.333***	0.282***	0.235***	0.308***	0.346***
	T-billsd3	0.055***	0.058***	0.053***	0.044***	0.054***	0.049***	0.048***
	Goldd3	-0.482***	-0.467***	-0.372***	-0.285***	-0.356***	-0.435***	-0.447***
	Oild3	0.22***	0.217***	0.177***	0.12***	0.162***	0.183***	0.162***
	CBOEVIXd3	0.007	-0.008	-0.009	-0.017**	-0.006	-0.003	-0.013
	c	-0.02***	-0.014***	-0.006***	0.0002	0.007***	0.014***	0.019***
	Pseudo R2	0.1638	0.1329	0.0937	0.0758	0.0744	0.1205	0.1674
D4								
	DJIWEMd4	0.388***	0.314***	0.229***	0.209***	0.234***	0.24***	0.254***
	T-billsd4	0.081***	0.072***	0.062***	0.068***	0.084***	0.089***	0.077***
	Goldd4	-0.357***	-0.345***	-0.28***	-0.15***	-0.177***	-0.192***	-0.213***
	Oild4	0.352***	0.37***	0.0279***	0.229***	0.256***	0.369***	0.3333***
	CBOEVIXd4	-0.021	-0.023	-0.036***	-0.034***	-0.022*	-0.006	-0.01
	c	-0.03***	-0.022***	-0.01***	0.0002	0.01***	0.022***	0.03***
	Pseudo R2	0.2219	0.1782	0.1073	0.0866	0.0911	0.1307	0.1690
D5								
	DJIWEMd5	0.923***	0.75***	0.619***	0.454***	0.368***	0.481***	0.46***
	T-billsd5	0.038**	0.041***	0.04***	0.045***	0.053***	0.064***	0.07***
	Goldd5	-0.846***	-0.702***	-0.592***	-0.469***	-0.463***	-0.581***	-0.59***
	Oild5	0.208***	0.266***	0.229***	0.19***	0.219***	0.25***	0.347***
	CBOEVIXd5	0.038**	0.038***	0.043**	-0.0008	0.008	0.031***	0.045***
	c	-0.043***	-0.033***	-0.015***	0.001***	0.016***	0.03***	0.04***
	Pseudo R2	0.2682	0.2177	0.1448	0.1267	0.1405	0.2161	0.3049
D6								
	DJIWEMd6	0.7***	0.629***	0.634***	0.402***	0.406***	0.586***	0.769***
	T-billsd6	0.028**	0.043***	0.025***	0.075***	0.081***	0.004	-0.0146
	Goldd6	-0.614***	-0.56***	-0.529***	-0.365***	-0.423***	-0.723***	-0.864***
	Oild6	-0.132***	-0.05	0.245***	0.291***	0.336***	0.179***	0.111***
	CBOEVIXd6	0.001	0.011	0.048**	0.001	0.01	0.006	0.033*
	c	-0.053***	-0.045***	-0.022***	0.0007	0.021***	0.045***	0.056***
	Pseudo R2	0.3230	0.2625	0.2032	0.1841	0.2035	0.2644	0.3614
D7								
	DJIWEMd7	0.666***	0.563***	0.248***	0.381***	0.13	0.62***	0.815***
	T-billsd7	-0.017	-0.023*	0.023*	0.065***	0.12***	0.163***	0.071**
	Goldd7	-0.856***	-0.768***	-0.481***	-0.507***	-0.32***	-0.252***	-0.394***
	Oild7	0.378***	0.438***	0.525***	0.366***	0.223***	0.092*	0.159**
	CBOEVIXd7	0.01	-0.006	0.035	0.06***	-0.044*	0.173***	0.164***
	c	-0.081***	-0.07***	-0.033***	0.0006	0.034***	0.065***	0.085***
	Pseudo R2	0.5914	0.4669	0.3475	0.3221	0.2942	0.3454	0.4194
D8								
	DJIWEMd8	0.102***	0.959***	0.638***	0.807***	0.776***	1.083***	1.31***
	T-billsd8	-0.148***	-0.173***	-0.127***	-0.001	-0.046***	-0.097***	-0.132***
	Goldd8	-1.228***	-1.309***	-1.23***	-1.029***	-1.193***	1.489***	-1.71***

	Oild8	0.486***	0.543***	0.805***	0.71***	0.813***	0.771***	0.728***
	CBOEVIXd8	0.027*	-0.014	0.022	0.115***	0.1***	0.122***	0.168***
	c	-0.089***	-0.074***	-0.036***	0.005***	0.033***	0.072***	0.084***
	Pseudo R2	0.7473	0.7009	0.6123	0.6141	0.6685	0.7054	0.7281
S8								
	DJIWEMs8	-0.15***	-0.137***	-0.045**	1.402***	1.548***	1.487***	1.463***
	T-billss8	-0.064***	-0.066***	-0.084***	-0.258***	-0.248***	-0.252***	-0.256***
	Golds8	-1.765***	-1.791***	-1.921***	-2.3343***	-2.337***	-2.355***	-2.368***
	Oils8	1.21***	1.224***	1.258***	0.226***	0.258***	0.29***	0.303***
	CBOEVIXs8	-0.519***	-0.519***	-0.527***	-0.734***	-0.583***	-0.574***	-0.582***
	c	155.349***	15.374***	15.495***	13.03***	11.394***	11.836***	12.079***
	Pseudo R2	0.6628	0.6538	0.6332	0.6738	0.7150	0.7662	0.7865

Notes: See the notes of Table 4.

4.3. Co-movements among GCC stock markets and U.S. T-bill rate

The average and tail dependencies between the T-bills and both the Bahrain and Kuwait stock markets are positive, while these dependencies are negative for Oman and Qatar for the seven market conditions (from q=0.05 to q=0.95). This result negates the role of this asset as a good protector for investors in Bahrain and Kuwait but it is useful for the Omani and Qatari investors. Turning now to the Saudi market, the result shows negative dependence with the U.S. T-bills during bear and normal markets, indicating that those T-bills are a strong hedge and a safe haven for Saudi investors.

For the lower scales (*D1* and *D2*), we fail to provide significant evidence of average and tail dependences between the GCC markets and the T-bills. As indicated earlier, the GCC countries are engaged in monetary control to determine their domestic credit policy and perform sterilization of foreign reserves, making the GCC assets and the T-bills imperfect assets. On the other hand, we find positive and tail and average dependence between the T-bills and the Saudi Arabian markets at Scale *D3* (8~16 days). The Saudi central bank (SAMA) invests sizable amounts of its foreign reserves in the U.S. T-bills because of their short maturity and risk-free nature. This positive average and tail dependence is maintained at the middle investment horizons for different market episodes, while the dependence structure among both assets becomes negative during downturns and upturns periods for the higher scale (long-term horizons). This important result suggests that the Saudi stock market performance mirrors the T-bill market in the short-run, which in essence negates the need for the T-bills to be a refuge asset for Saudi equity investors in this time framework. However, this situation changes in the long-term horizon where the co-dependency becomes negative. In this case, the T-bill can be a safe refuge for the Saudi market. These results should be important for SAMA that invests most of its foreign assets in the U.S. T bills. They indicate that the T-bills protect investors' wealth in the Saudi market in the event of negative economic conditions. This finding is consistent with those of Chan et al. (2011) and Flavin et al. (2014) who also find evidence of decoupling between the U.S. stock and Treasury bond markets.

The results are similar for all other GCC markets during the three time investment horizons and across different markets conditions. More precisely, we show positive tail dependence between the U.S. T-bills and the GCC markets only at Scale *D3*. This result indicates that short-term investors cannot consider the T-bills as a protector asset during bear markets. Interestingly, we find a positive dependence between the T-bills and the GCC market at middle investment horizons, regardless of the selected quantiles. However, this relationship becomes negative for long term investment horizons. Thus, the T-bill asset can be applied as a refuge asset. This result is of great importance for investors and portfolio managers during stress periods in terms of best assessing the risks of their portfolios.

The GCC investors and central bank can include this asset in their portfolios during extreme market movements to deal with their portfolio risk, reallocate the assets and rebalance their portfolios. Further, the result reveals asymmetric tail dependencies between the T-bills and the Oman market, suggesting that this risk-free asset can be a candidate acting as a protector in the turmoil periods, thereby reducing losses in times of extremely negative shocks to the Oman stock market.

To sum up, we can conclude that the T-bills asset is of great significance for portfolio designs and asset allocations for all GCC-based investors at long investment horizons.

4.4. Co-movements between GCC stock markets and VIX

Concerning the VIX index-GCC market pairing using QRA, the dependence structure between three GCC stock e markets - namely Bahrain, Kuwait and Oman- and the U.S. equity VIX index (which measures fear in the U.S. stock market) is positive and asymmetric, while the dependence for the UAE, Saudi Arabia and Qatar stock markets is negative and asymmetric across different market conditions. These findings underscore the important role of the VIX index for the UAE, Saudi Arabia and Qatar, serving as an asset protector during periods of high stress.

At short investment horizons and precisely at Scale *D2*, we find positive dependence between the Saudi Arabian stock markets and the VIX index at normal and bull markets. This means that investors in the Saudi market, which is the largest, most active and utmost liquid market in the GCC region and the MENA area, cannot consider contracts based on VIX as a precursor of fear in the Saudi counterpart. Similar results are also detected for all GCC markets. Conversely, at Scale D3 and in a bearish market, VIX is negatively related to the Saudi market which is also the case for the U.S. market. This result reveals that contracts based on this volatility index can offer investment opportunities in periods of market stress for Saudi investors as part of their diversification strategies. The dependence structure also persists between VIX and the Oman market at Scale D3 for the seven markets conditions. In tranquil markets and short investment horizons (i.e., at Scale D3), the Qatar market is negatively dependent with VIX index. These findings underscore the important role of VIX at the short investment horizons (8~16 days), serving as an asset protector during periods of high stress.

Turning now to middle investment horizons, a positive dependence for the VIX-GCC market pairs is obtained for the Bahrain market for different market conditions negating the role of this asset as a protector. The same dependence is detected for UAE, Qatar and Saudi Arabia. In contrast, we find negative lower and average dependence at time scales D4 and D5 for Oman. Similarly, we obtain a negative lower dependence between the pair VIX index-Saudi Arabian market at Scale *D4* as well as between the pair VIX index-Qatar market at Scale D6. VIX is also negatively correlated with the Kuwait stock market at Scale *D5* for intermediate quantiles. This result shows that VIX-based contracts can be a strong safe haven during turmoil periods. It is consistent with that of Hood and Malik (2013) for the U.S. stock market. More precisely, those authors show that VIX is a superior hedging tool and serves as a better safe haven than gold for the U.S. stock market.

Concerning long investment horizons, for most GCC markets, this volatility index is negatively linked to their stock markets except those for Kuwait and UAE, indicating that this asset may serve as a good protector against extreme stock markets' co-movements prevailing in the short run. It is also worth noting that VIX-based contracts are important for portfolio designs and asset allocations.

4.5. Robustness

For robustness, we check for the stability of the "scale-by-scale" results over time by applying nonparametric regression analysis. More concretely, we carry out the Wald robustness test (for further details, see Koenker and Bassett, 1982) which allows one to check all parameter heterogeneity across any two quantiles. Specifically, we test the null hypothesis that the coefficients for each quantile have the same slope against the alternative hypothesis that the coefficients for each quantile are significantly different. Table 6 presents the results of these heterogeneity tests across the quantiles. In the current analysis, we only report the empirical results for the lowest quantile (q=0.05) against the highest quantile (q=0.95), and the medium quantile (q=0.5) versus the highest quantile (q=0.95).[7] As shown in this table, the slope equality tests of the coefficients between the quantiles reject the null of parameter homogeneity across quantiles, indicating that the estimated coefficients are time-varying, confirming changes in the dependence structure. This implies that the status of dependency between the GCC markets and their hedge/safe haven assets changes under different market conditions for each investment horizon.

[7] Full results of the Wald tests are available upon request from the authors.

Table 6: Heterogeneity tests (Wald tests) for equality of slopes.

	Bahrain		Kuwait		Oman		UAE		Saudi Arabia		Qatar	
	Test statistic	p-value	Test statistic	p-value	Test statistic	p-value	Test statistic	p-value	Test statistic	p-value	Test statistic	p-value
tau1=c(0.05.0.95)												
raw	1.783	0.113	1.706	0.130	1.750	0.120	1.710	0.129	2.799	0.016	0.669	0.647
d1	0.862	0.506	1.703	0.130	0.601	0.700	1.017	0.406	0.553	0.736	0.460	0.807
d2	0.455	0.810	1.785	0.112	0.430	0.828	0.106	0.991	2.174	0.054	1.511	0.183
d3	0.566	0.726	1.500	0.186	2.099	0.063	0.452	0.812	0.358	0.877	1.549	0.171
d4	1.276	0.271	4.186***	0.001	1.715	0.128	2.010	0.074	3.996***	0.001	4.392***	0.001
d5	0.506	0.772	4.987***	0.000	6.096***	0.000	6.977***	0.000	10.629***	0.000	9.003***	0.000
d6	18.148***	0.000	26.27***	0.000	18.097***	0.000	21.434***	0.000	4.971***	0.000	22.009***	0.000
d7	522.15**	0.000	149.78***	0.000	150.11***	0.000	693.43***	0.000	86.737***	0.000	120.06***	0.000
d8	2092.2***	0.000	362.40***	0.000	178.37***	0.000	1257***	0.000	251.73***	0.000	469.09***	0.000
s8	9609.6***	0.000	8090.3***	0.000	29052***	0.000	237719***	0.000	12027***	0.000	53854***	0.000
Tau2=c(0.5.0.95)												
raw	NA	NA	NA	NA	NA	NA	4.6167***	0.000	NA	NA	6.62***	3.74E-06
d1	4.589***	0.000	4.238***	0.001	2.927**	0.012	3.379***	0.005	6.521***	0.000	4.657***	0.000
d2	2.906**	0.013	3.349***	0.005	5.969***	0.000	1.283	0.268	16.784***	0.000	5.129***	0.000
d3	3.558***	0.003	16.66***	0.000	20.387***	0.000	5.6***	0.000	48.231***	0.000	4.695***	0.000
d4	11.278***	0.000	77.949***	0.000	8.815***	0.000	1.615	0.152	3.142***	0.008	12.497***	0.000
d5	6.967***	0.000	16.083***	0.000	12.829***	0.000	8.685***	0.000	25.145***	0.000	12.772***	0.000
d6	114.79***	0.000	26.18***	0.000	2.059*	0.067	52.92***	0.000	34.896***	0.000	94.101***	0.000
d7	245.76***	0.000	123.77***	0.000	175.46***	0.000	158.3***	0.000	86.249***	0.000	88.622***	0.000
d8	1626.4***	0.000	124.62***	0.000	254.63***	0.000	113.48***	0.000	195.49***	0.000	138.26***	0.000
s8	21633***	0.000	364.55***	0.000	443.26***	0.000	22.806***	0.000	39.877***	0.000	141.66***	0.000

Notes: This table presents the estimate results of the Wald test for equality of slopes (0.05 against each of 0.5 and 0.95 quantiles). The asterisks *, ** and *** denote statistical significance at the 0%, 5% and 1% levels, respectively.

4.6. Summary of the main results

Tables 7-8 summarize the main empirical results for the six GCC stock markets as discussed in this section earlier. Based on these empirical results, the following remarks can be made for each GCC stock market.

i. There are significant evolving relationships among each of the GCC stock markets and the Sharia-compliant stock index (DJIWEM), and the four major global macroeconomic factors when applying QRA by itself[8]. This finding underscores the importance of combining the different market conditions accounted for by QRA with the different investment horizons underpinned by the wavelet approach and emphasizes the importance of market participants' heterogeneity in forming dependencies.

ii. The heterogeneous market hypothesis categorizes traders in terms of their time horizons (level scales). Among the different scale traders, the institutional investors and central banks are high scale or long horizon traders, whereas speculators and market makers are classified as low scale or short-run horizon traders. These diverse market participants differ in terms of their expectations, beliefs, risk profiles, informational sets and many others aspects. Motivated by the heterogeneous market hypothesis, we consider the wavelet decomposition method to have new insights into the reactions of short- and long-term investors in terms of dependence between the considered market level series, taking into account the different market conditions (bull, tranquil and bear markets) and the diverse interests of the different traders and investors. In sum, the results exhibit positive (negative) dependence among the GCC markets and the oil (gold) variables for all investment horizons and across the quantiles (lower, middle and upper tails).

[8] The QRA results are not reported in Table 6 to save space but are available upon request.

iii. The dependence between almost all GCC stock markets and both Islamic stock market index and macroeconomic factors is stronger at the high scale (long run investments) than at the low scale (short run investments).

iv. For each GCC country, each time scale has a specific dependence between the GCC stock markets and both the Islamic stock market and the macroeconomic factors.

v. Further, gold is a strong hedge in normal market conditions and a safe haven in extreme negative market conditions for all GCC markets at short, middle and long investment horizons. Thus, this characteristic of gold goes across markets.

vi. On the whole, we find positive average and tail dependence between the oil-rich GCC markets and the oil market for the seven market conditions and at three different investment horizons, making oil neither a good hedge nor a safe haven for GCC stock returns. This is not surprising because the economies of these countries are based on oil.

vii. Finally, the U.S. T-bills, DJIWEM and VIX-based products can be suitable candidate assets for risk-averse GCC-based investors as well as for portfolio managers interested in the GCC stock markets during high stress market periods and, especially at the long investment horizons.

Table 7: Hedge and/or safe haven assets for GCC markets.

Stock markets	Variables	D1	D2	D3	D4	D5	D6	D7	D8	S8
		Short investment horizons			Medium investments horizons			Long investment horizons		
	DJIWEM	No	No	No	No	No	**SH**	**H&SH**	**H & SH**	**H & SH**
	T-bills	No	No	No	No	No	No	No	No	No
Bahrain	Gold	No	**H & SH**	**H & SH**	**H & SH**	**H & SH**	**H & SH**	**H & SH**	**H & SH**	**H & SH**
	Oil	No	No	No	No	No	No	No	No	No
	CBOEVIX	No	No	No	No	No	No	**H & SH**	**H & SH**	No
	DJIWEM	No	No	No	No	No	No	No	No	No
	T-bills	No	No	No	No	No	No	**H&SH**	No	No
Kuwait	Gold	**H & SH**	**H & SH**	**H & SH**	**H & SH**	**H & SH**	**H & SH**	**H & SH**	**H & SH**	**H & SH**
	Oil	No	No	No	No	No	No	No	No	No
	CBOEVIX	No	No	H	H	No	No	No	No	No
	DJIWEM	No	No	No	No	No	No	No	No	No
	T-bills	No	No	No	No	No	No	**SH**	**H & SH**	**H & SH**
Oman	Gold	**H & SH**	**H & SH**	**H & SH**	**H & SH**	**H & SH**	**H & SH**	**H & SH**	**H & SH**	**H & SH**
	Oil	No	No	No	No	No	No	No	No	No
	CBOEVIX	No	No	**H&SH**	**H & SH**	**H&SH**	No	**H & SH**	H & SH	No
	DJIWEM	No	No	No	No	No	No	No	No	**H & SH**
	T-bills	No	No	No	No	No	No	No	**H & SH**	**H & SH**
UAE	Gold	**H & SH**	**H & SH**	**H & SH**	**H & SH**	**H & SH**	**H & SH**	**H & SH**	**H & SH**	**H & SH**
	Oil	No	No	No	No	No	No	No	No	No
	CBOEVIX	No	No	H	H	No	No	No	No	**H & SH**
	DJIWEM	No	No	No	No	No	No	H&SH	No	No
	T-bills	No	No	No	No	No	No	H	No	**H & SH**
S. Arabia	Gold	**H & SH**	**H & SH**	**H & SH**	**H & SH**	**H & SH**	**H & SH**	**H & SH**	**H & SH**	**H & SH**
	Oil	No	No	No	No	No	No	No	No	No
	CBOEVIX	No	No	**H & SH**	**H**	No	No	H & SH	No	**H & SH**
	DJIWEM	No	No	No	No	No	No	No	No	SH
	T-bills	No	No	No	No	No	No	**H&SH**	**H&SH**	**H & SH**
Qatar	Gold	**H & SH**	**H & SH**	**H & SH**	**H & SH**	**H & SH**	**H & SH**	**H & SH**	**H & SH**	**H & SH**
	Oil	No	No	No	No	No	No	No	No	No
	CBOEVIX	No	No	**H**	No	**H**	**H & SH**	No	No	**H & SH**

Notes; The table summarizes the roles of Islamic index, gold, T-bills, oil and VIX index serving as a hedge and/or a safe haven asset for the six GCC stock markets. H and HS denote hedge and safe haven asset, respectively.

Table 7: Summary of empirical results of a wavelet-based quantile methodology.

Stock markets	Investment horizons	DJIWEM			T-bills			Gold			Oil			CBOEVIX		
		Quantile level			Quantile level			Quantile level			Quantile level			Quantile level		
		L	I	H	L	I	H	L	I	H	L	I	H	L	I	H
Bahrain	Short term investments				+			–	–	–	+	+	+			+
	Medium term investments		+	+	+	+	+	–	–	–	+	+	+		+	+
	Long term investments	–	–	+a	+	+	+a	–	–	–	+	+	+	–	–	
Kuwait	Short term investments	+	+		+			–	–	–	+	+	+		+	+
	Medium term investments	+	+	+	+	+	+	–	–	–	+	+	+	+	–	+b
	Long term investments	+	+	+	+a	+a	+a	–	–	–	+	+	+	+	+	+
Oman	Short term investments		+		+	+	+	–	–	–	+	+	+	c	+c	+c
	Medium term investments	+	+	+	+	+	+	–	–	–	+	+	+	–	–	–
	Long term investments	+	+	+	–	–d	–	–	–	–	+	+	+	–	–	–d
UAE	Short term investments	+	+	+	+	+	+	–	–	–	+	+	+		+	+
	Medium term investments	+	+	+	+	+	+	–	–	–	+	+	+	+	+	+
	Long term investments		+	+	–c	–c	–	–	–	–	+	+	+	+	+	+
Saudi Arabia	Short term investments	+	+	+	+	+		–	–	–	+	+	+	c	+	+
	Medium term investments	+	+	+	+	+	+	–	–	–	+	+	+		–e	+
	Long term investments	+	+	+a	–d	+	–	–	–	–	+	+	+	–	–f	–f
Qatar	Short term investments	+	+	+	+		+	–	–	–		+			+	+
	Medium term investments	+	+	+	+	+	+	–	–f	–	+b	+	+	+a	+a	+
	Long term investments	+	+	+	–d	–d	–	–	–	–	+	+	+	+	+	+a

Note This table provides a summary of the empirical results discussed in Section 4. L, I and H refer to low (or bear markets), intermediate (or normal markets) and high quantiles (or bull markets), respectively. The symbols + and – denote positive and negative dependence between the relevant variables, respectively. The symbols a, b and c (d, e and f) indicate that there is a negative (positive) sign at the scales *D7*, *D6* and *D3* (*D7*, *D8* and *D6*), respectively.

5. Discussions and conclusions

Sound asset allocations and prudent portfolio risk management require modelling of dependence structure in both bear and bull market conditions. Market participants are marked by their heterogeneity in terms of expectations, beliefs, time horizons and risk profiles, and thus they hold different informational sets. Thus, this characteristic leads to different reactions from those participants to the same news in the same market, which implies that market heterogeneity leads to the presence of different dealings under time horizons. Therefore, each market participant has its own reaction time to information, which is related to its time horizons and dealing scale characteristics.

This paper examines the dependencies between the six GCC stock markets on one hand, and possible safe haven candidates and major global factors on the other hand, using the combined framework of the quantile regression analysis and the wavelet approach. The safe haven candidates include gold, U.S. T bills and the Islamic world emerging stock market index (DJIWEM), while the global factors consist of oil prices and VIX.

Our empirical evidence show significant average and tail dependence structure between the GCC stock markets, and the DJIWEM index and the global macroeconomic factors (gold, oil, T-bills and VIX), using the quantile regression analysis alone. For the seven markets conditions, the GCC stock markets are negatively dependent with gold markets, underscoring their important role as a hedge and a safe haven asset. In contrast, GCC is positively dependent with oil prices for the lower, normal and upper quantiles since they are important oil-exporting countries. Three out of the six GCC markets namely UAE, Qatar and Saudi Arabia are also negatively linked to the VIX index under different markets conditions, indicating the ability of this index to serve as a hedge in tranquil periods and a safe haven in extreme markets periods. The Islamic index (DJIWEM) is a safe haven for Saudi Arabian and

Qatar. Furthermore, the T-bills play a role of a hedge and a safe haven for all GCC markets except Bahrain and Kuwait.

Based on the heterogeneous market hypothesis of stock markets and the diversity of the short, medium and long run factors that drive cyclical variations, we decompose the original (raw) log-level series into lower, intermediate and higher time-scales via the wavelet approach. Overall, we find that the GCC stock markets, the Islamic equity index (DJIWEM) and the global factors are scale or investment horizon co-dependent. At the short investment horizons, the results show little dependence between them, but at the medium and long investment horizons we find a stronger dependence structure among the considered markets and factors. This dependence structure varies strongly across the quantiles (bear, normal and bull markets).

Consistent with the previous literature for gold, this study finds gold to be a strong hedge (negatively correlated with stocks in normal periods) and a safe haven (has a negative correlation with GCC stocks during extreme stock market declines) for the GCC stock markets in both short, middle and long investment horizons. Interestingly, three candidate assets such as the Islamic equity index, the T-bills and the VIX-based products may serve as suitable hedges during average periods and safe havens for the GCC markets in times of market turmoil (high volatility period) especially at long run horizons. It is worth noting that Whaley (2009), the founder of VIX, argues that a part of VIX can even serve as a hedge to stock investing. This revolutionary volatility product represents investors' expectations of future market volatility and can offer effective ways to help manage risk, leverage volatility and diversify a portfolio.

Several important policy and economic implications can be drawn from the empirical results of this study. Investors dealing with the GCC markets can seize the information on dependence with global factors to gain large diversification benefits and improve the performance of investment portfolios investing in different asset classes. The cognizance of the presence of dependence structure between the GCC stock markets and the oil market is useful for portfolio managers and policy makers. In fact, portfolio managers can tap our empirical results by combining oil as a commodity and stocks in the GCC regions in order to hold different optimal portfolio weights and hedge ratios in different time-scales and in different market episodes. The regulation of stock markets at home by GCC policy makers and their management of the oil price at OPEC, where they are also decision makers, can be done based on sound decisions. As OPEC policy-makers, they should be prudent in discerning the effects of oil price changes on their corresponding economies and equity markets by their understanding of the oil supply/demand factors. They can also take advantage of the information related to gold, Islamic equity market, volatility in the U.S. equity markets and changes in the U.S. Treasury bill rate in their risk management and portfolio diversification.

Overall, the evidence of dependence across the GCC stock markets with the Islamic equity index and the major macroeconomic factors provides meaningful insights pertinent to international asset pricing, and the dynamic interactions in the global economy as well as risk management. Risk management in the literature is a function of the level and dependence between the Islamic and conventional GCC stock markets. In this research, the DJIWEM index may serve as a financial tool to hedge against extreme movements in the GCC stock markets. In contrast to previous studies, the results for the co-dependence provide evidence that the Islamic stock market universe is immune against global shocks common to the world financial system as well as to contagion risks in the case of financial crises.

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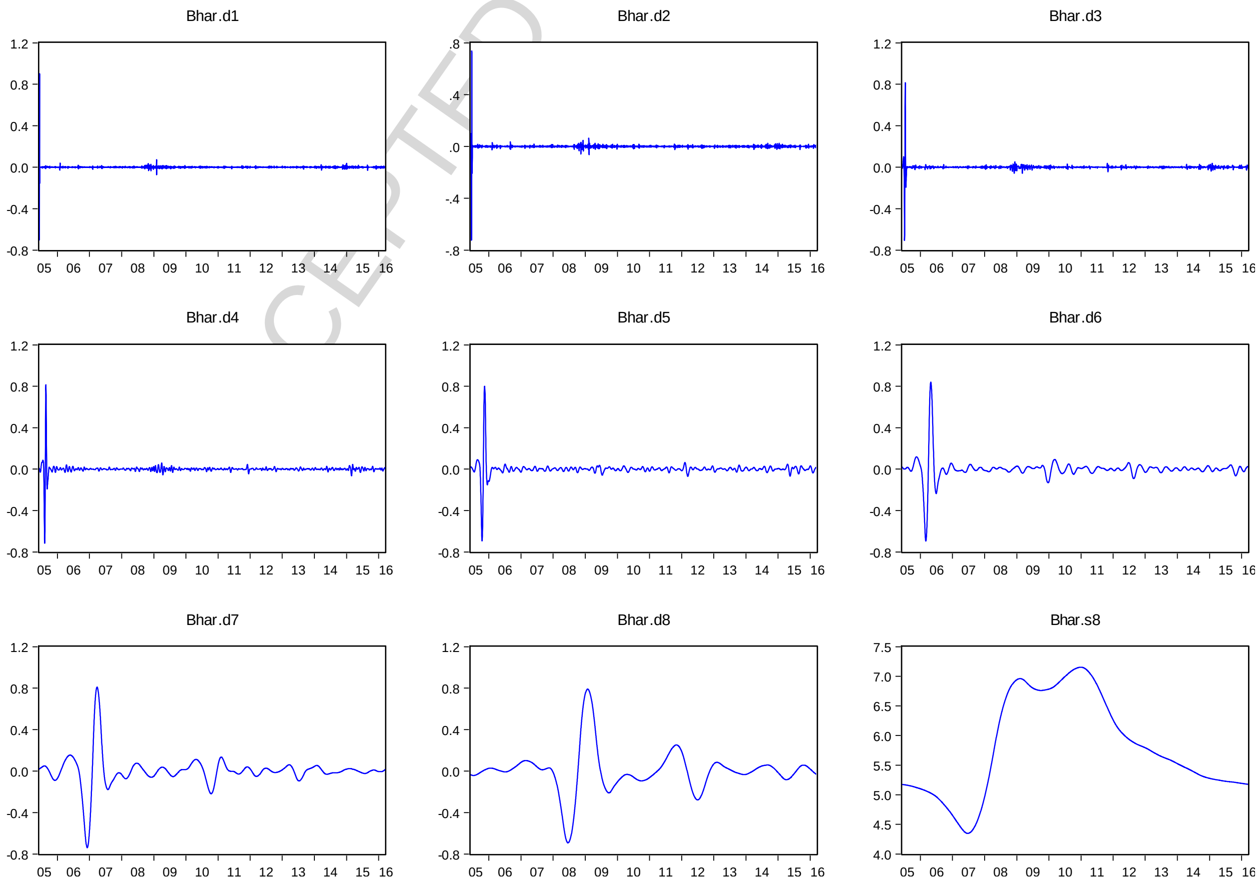
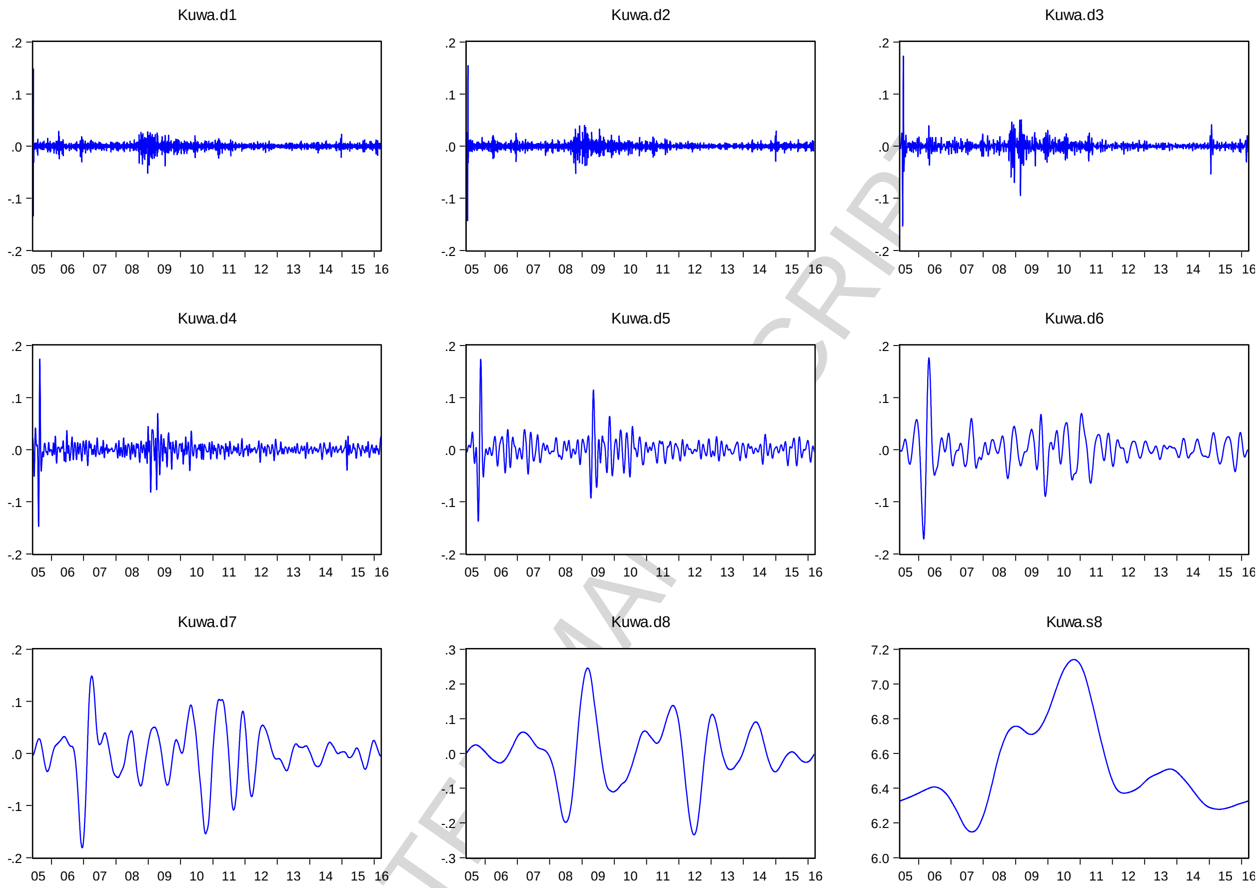
Appendix A

Plots of the wavelet decomposed results of the GCC stock markets, the Sharia-Compliant stock index and the global macroeconomics factors into different scale bands.

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Kuwa.d3
Kuwa.d4
Kuwa.d5
Kuwa.d6
Kuwa.d7
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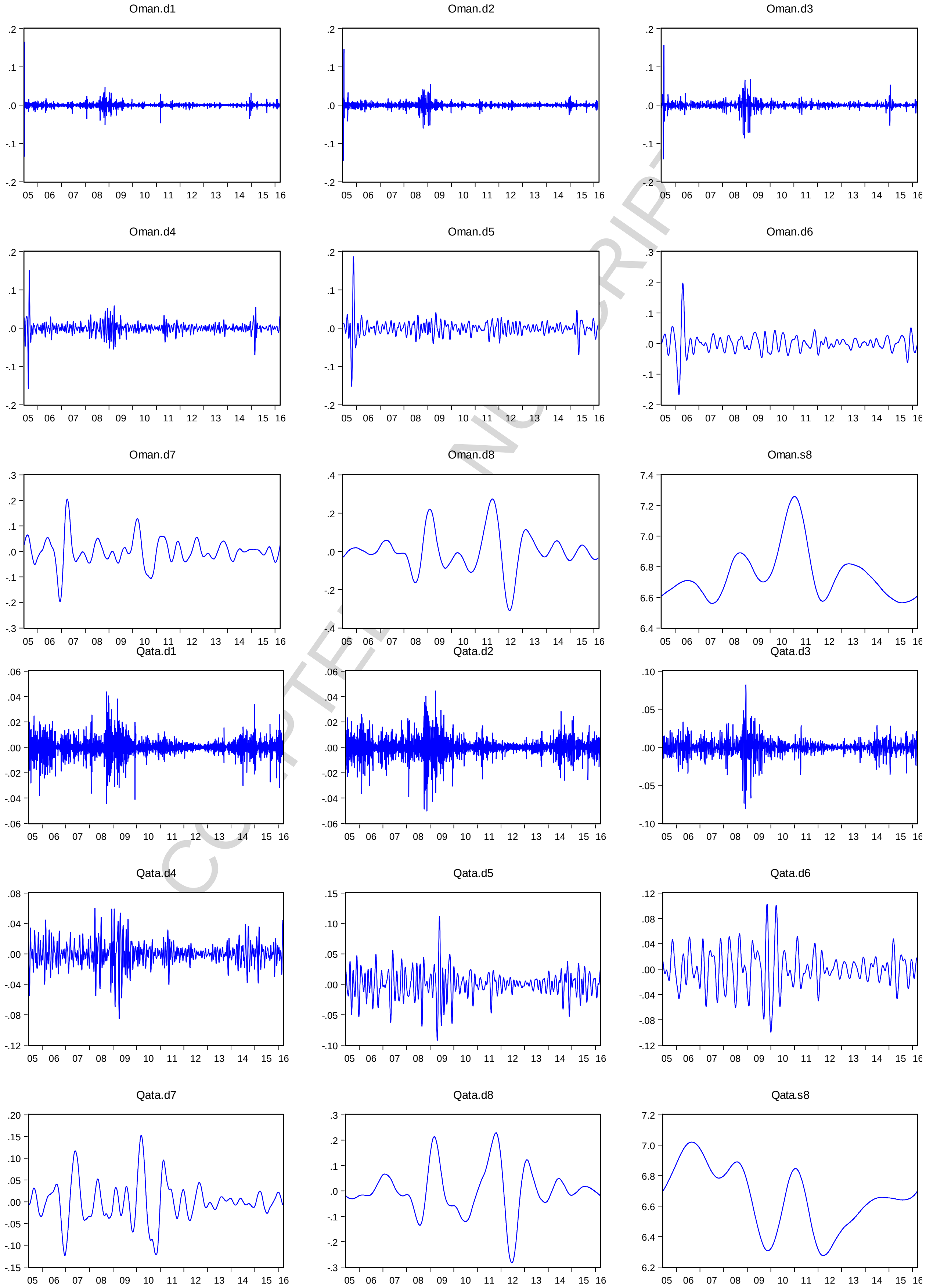
Kuwa.s8
05 06 07 08 09 10 11 12 13 14 15 16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Oman.d2
Oman.d3
Oman.d4
Oman.d5
Oman.d6
Oman.d7
Oman.d8
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Qata.d1
Qata.d2
Qata.d3
Qata.d4
Qata.d5
Qata.d6
Qata.d7
Qata.d8
Qata.s8
05 06 07 08 09 10 11 12 13 14 15 16
.2 .1 .0 -.1 -.2
.3 .2 .1 .0 -.1 -.2 -.3
.4 .2 .0 -.2 -.4
7.4 7.2 7.0 6.8 6.6 6.4
.06 .04 .02 .00 -.02 -.04 -.06
.10 .05 .00 -.05 -.10
.08 .04 .00 -.04 -.08 -.12
.15 .10 .05 .00 -.05 -.10
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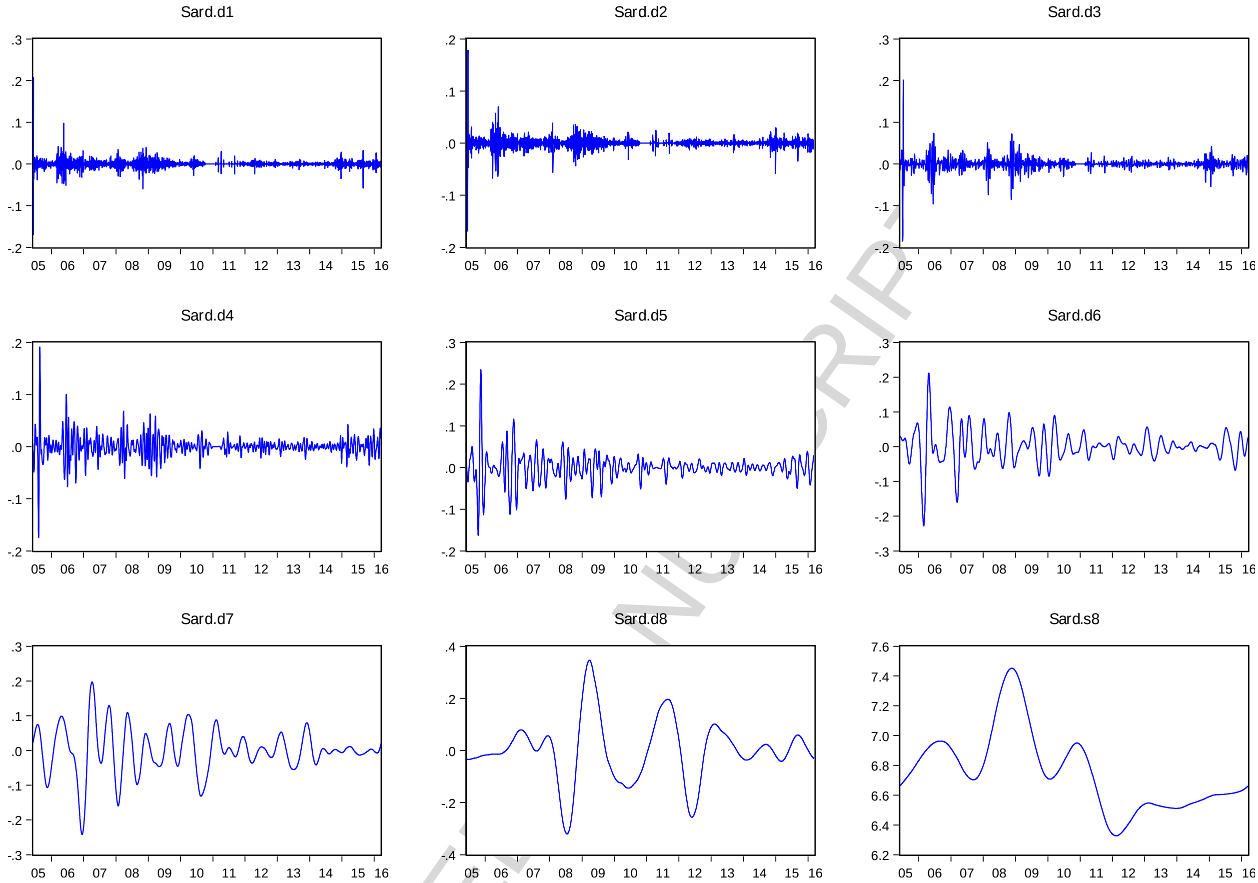
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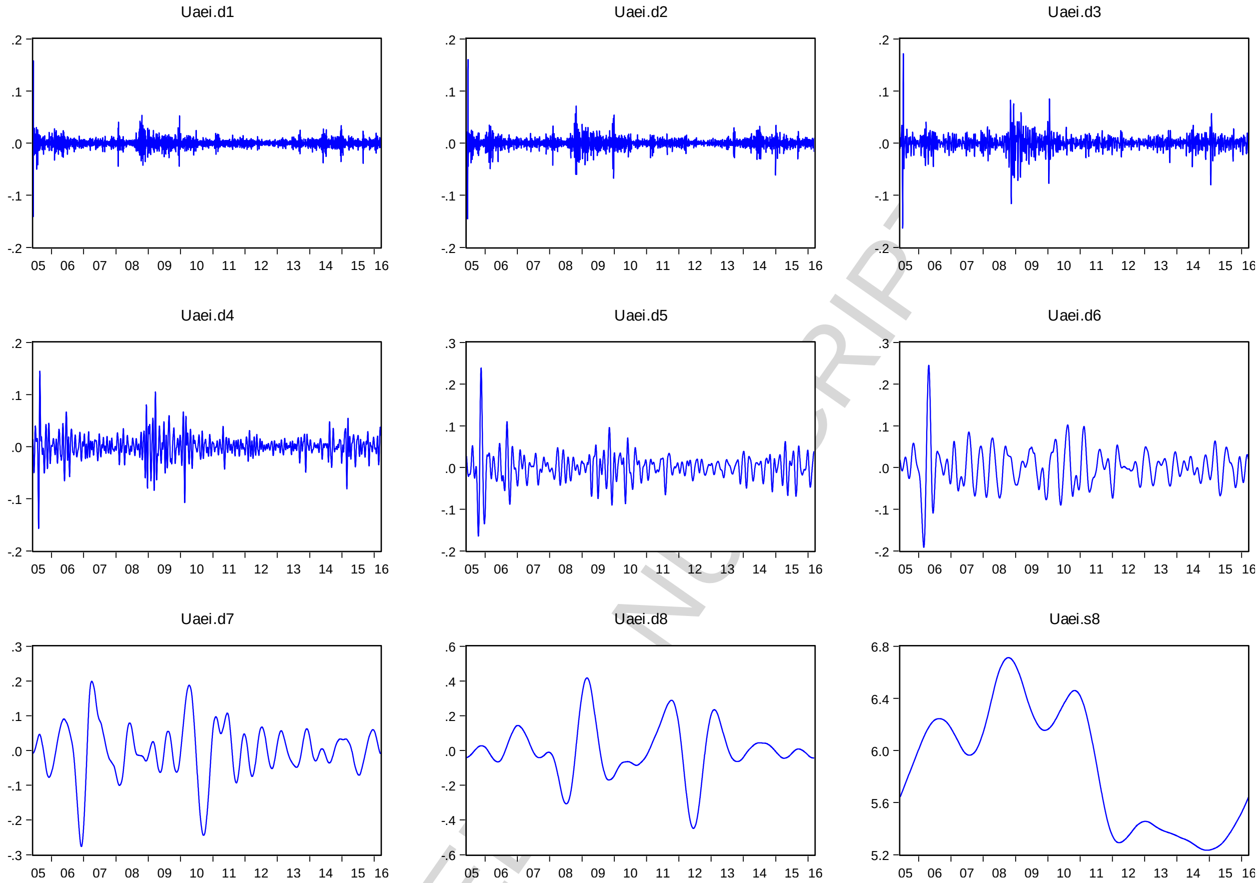
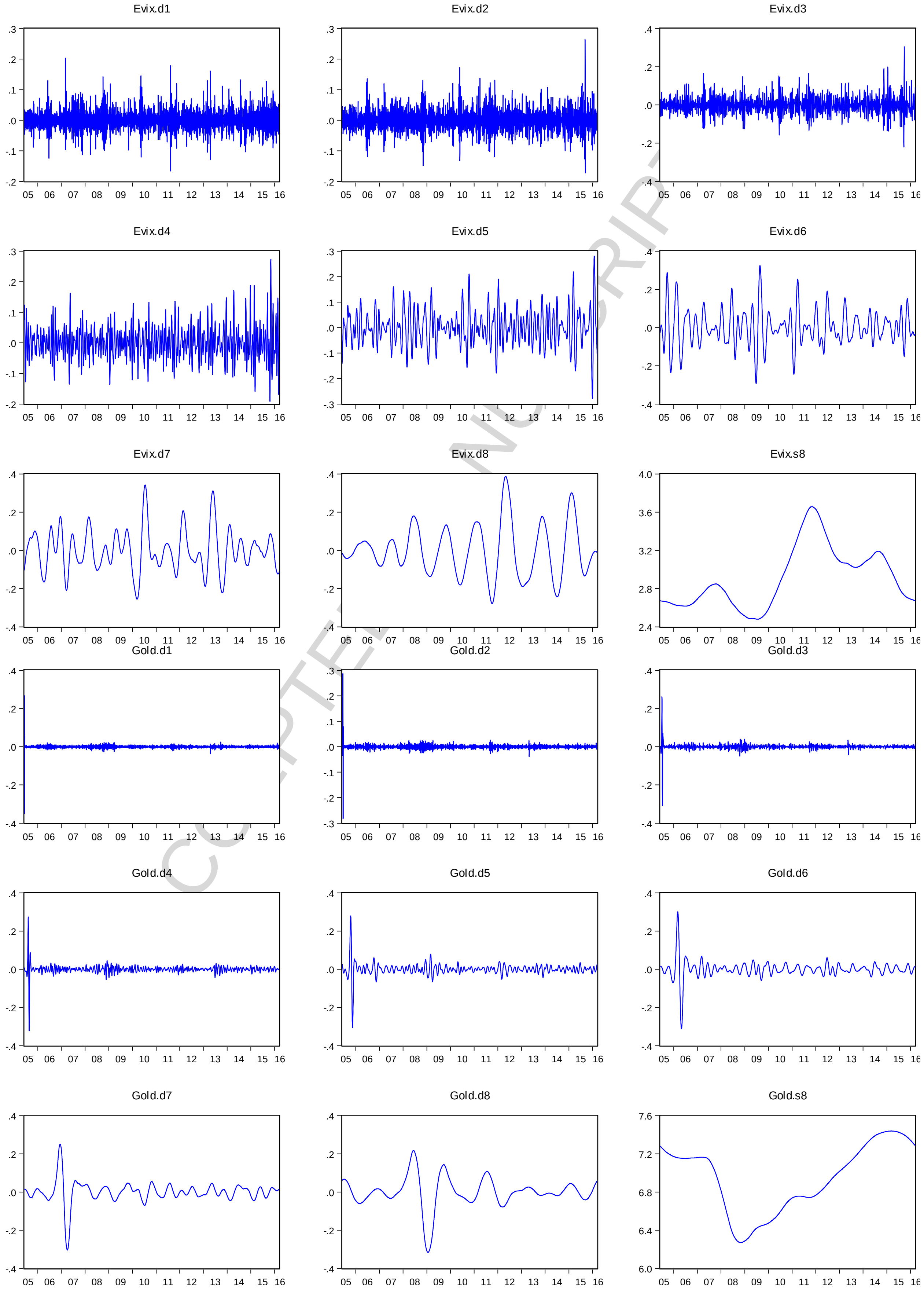


Fig. 2. Plots of the wavelet decomposed results of GCC indexes into different scale bands (right).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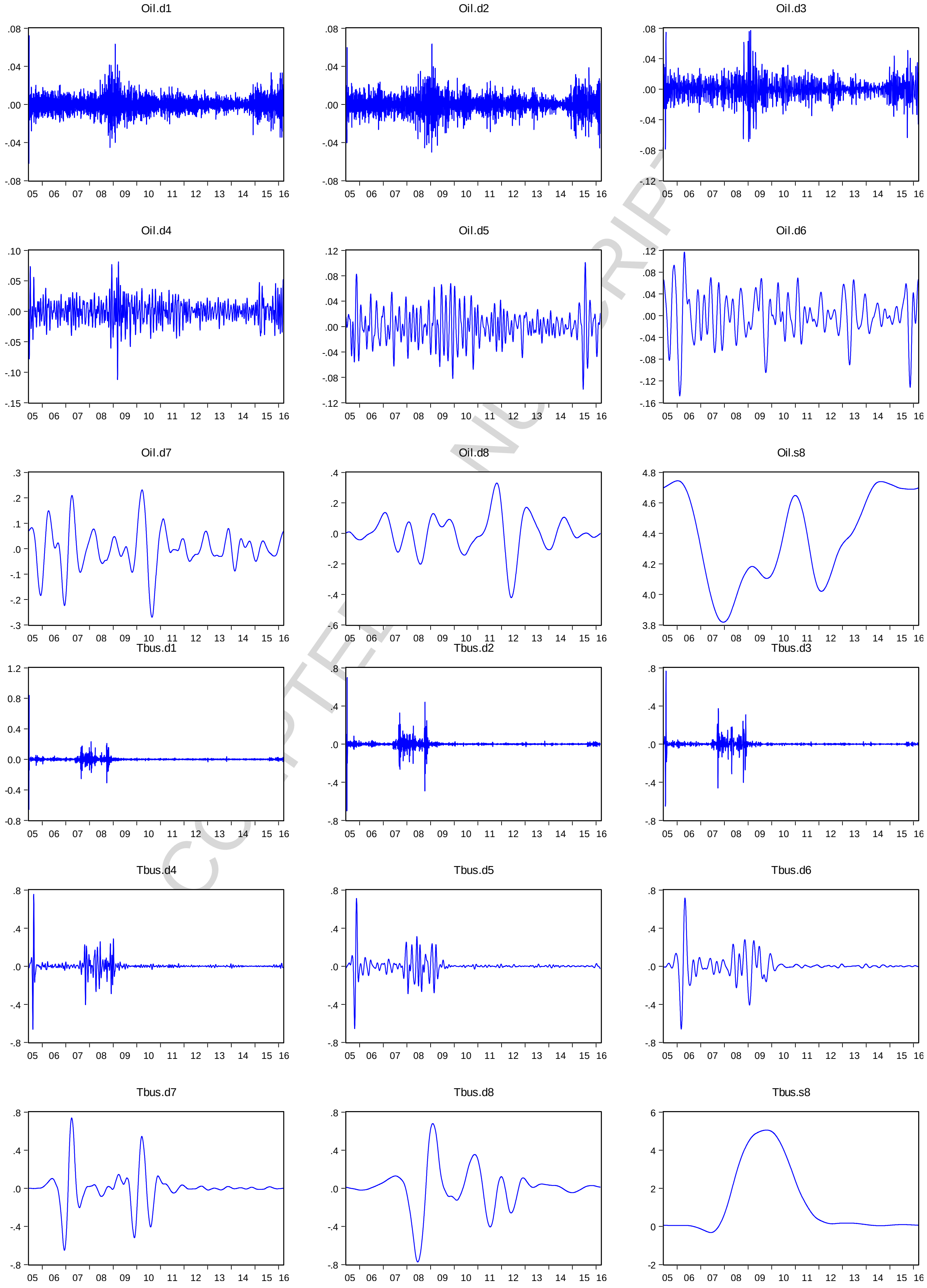
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Oil.d4
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Tbus.d1
Tbus.d2
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Tbus.d8
Tbus.s8
05 06 07 08 09 10 11 12 13 14 15 16

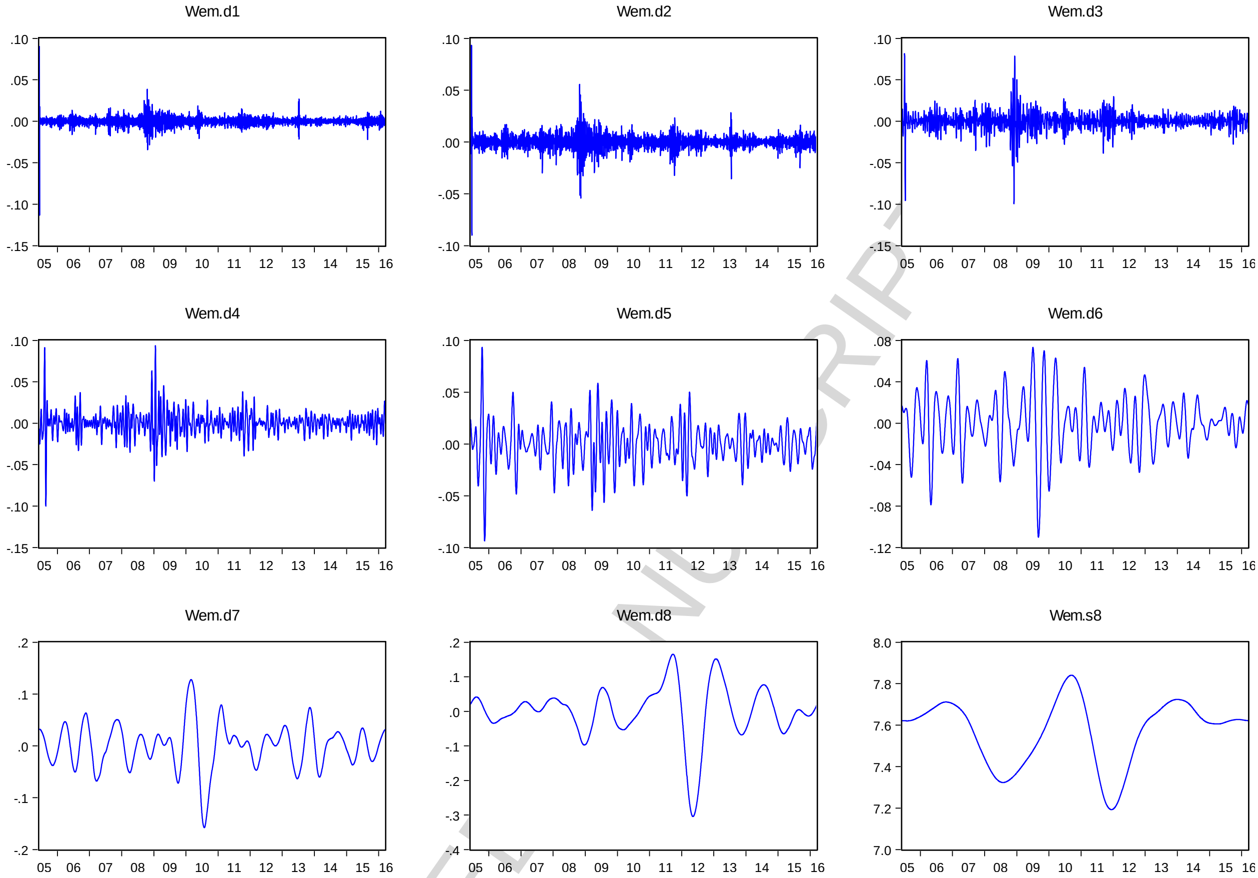

Fig. 3. Plots of the wavelet decomposed results of the Sharia-compliant stock index and the four global macroeconomic factors level series into different scale bands.