2017-10-25

Volatility spillovers and cross-hedging between gold, oil and equities: Evidence from the Gulf Cooperation Council countries

Maghyereh, A

http://hdl.handle.net/10026.1/10126

10.1016/j.eneco.2017.10.025
Energy Economics
Elsevier

This paper has been accepted for publication in Energy Economics

The final publication is available at Elsevier via

https://doi.org/10.1016/j.eneco.2017.10.025

Volatility spillovers and cross-hedging between gold, oil and equities: evidence from the Gulf Cooperation Council countries

Aktham I. Maghyereh[a,*], Basel Awartani[b], Panagiotis Tziogkidis[c]

[a] Department of Economics and Finance, United Arab Emirates University, United Arab Emirates

[b] Westminster Business School, University of Westminster, Marylebone Road London NW1 5LS, UK

[c] Plymouth Business School, Plymouth University, Cookworthy Building, Drake Circus, Plymouth, Devon, PL4 8AA, UK

Abstract

The paper examines the return and volatility spillovers between crude oil, gold and equities, and investigates the usefulness of the two commodities in hedging equity portfolios. Using daily data from January 2004 to May 2016 for the Gulf Cooperation Council countries, a DCC-GARCH model is used to estimate dynamic correlations and hedge ratios. We find significant spillovers from oil to equities, highlighting the heavy dependence of the local economies on oil. Moreover, the spillovers of gold on the stock markets are insignificant, suggesting that gold price fluctuations do not necessarily influence equity investment decisions. In the opposite direction, we find that equities do not exert significant influence on the two commodities, which we attribute to the relatively small capitalisation of the exchanges. Our results reveal low dynamic correlations and hedge ratios, with a few spikes during crises, indicating that oil and gold are cheap hedges for stocks, albeit not good ones, while they could be considered as weak safe havens, but at a considerable cost.

Keywords*: Crude oil, Gold, Spillovers, hedging, dynamic correlation, Gulf Cooperation Council, portfolio*

JEL classification: G11, G15, Q02, C22

---

* Corresponding author. Tel.: +971 (03) 7135261

E-mail addresses: a.almaghaireh@uaeu.ac.ae (A.I. Maghyereh), B.Awartani@westminster.ac.uk (B. Awartani), panagiotis.tziogkidis@plymouth.ac.uk (P. Tziogkidis).

1. Introduction

There is an ongoing debate about the role of oil and gold in hedging equity portfolios, which has become topical since the financial crisis and the subsequent fluctuations in the prices of these assets. In the literature, the role of oil and gold as hedges is not universally accepted, and it seems to depend on geopolitical, economic, as well as other idiosyncratic factors. This topic is of particular interest for oil-exporting countries, which are usually rich in these assets. However, most of the literature has focused on developed countries (Baur and McDermott, 2010; Hood and Malik, 2013; Choi and Hammoudeh, 2010; Creti et al. 2013; Ciner, 2013), while developing countries have only recently started receiving further attention (Basher and Sadorsky, 2016). Using data from the Gulf Cooperation Council (GCC) countries[1] from January 2004 to May 2016, this paper employs a dynamic conditional correlation model (DCC-GARCH) to first examine the shock transmissions between the equity markets and the two commodities, and then evaluate the hedging opportunities arising from including crude oil and gold in equity portfolios. Our paper is the first to consider the dynamic relationships between oil, gold and equities in the GCC countries, therefore further contributing to the debate.

Examining the interconnectedness between oil, gold and equities is of great importance for GCC countries, as they are net exporters of oil, while they hold gold reserves to secure against US dollar fluctuations, which is the trading currency for both commodities. At the same time, GCC countries hold about 1.3% of the world's gold reserves, hence our study may also be of interest to local monetary authorities.[2] Finally, given the absence of a derivatives market for GCC stocks, traditionally used for hedging, it is important for GCC investors to find alternative risk management options.

[1] The Gulf Cooperation Council (GCC hereinafter) was established in Saudi Arabia in 1981 and it is an economic and political alliance between Bahrain, Oman, Kuwait, Qatar, Saudi Arabia and United Arabic Emirates.
[2] Valid as of October 2016, "World official gold holdings", *World Gold Council*.

In light of the above, this paper examines the interconnectedness between the GCC exchanges and oil and gold, as well as the usefulness of the two commodities in hedging GCC-based equity portfolios. The period considered, which spans from January 2004 to May 2016, is rich in events, as it begins with the post-Iraqi war era, and covers the financial crisis, the historic peak of gold prices in 2010 and the subsequent fall, as well as the recent oil crisis which began in June 2014. During the financial crisis, the price of oil fell significantly, but the rising price of gold balanced the negative effects of the crisis; in fact, the GCC countries experienced significant economic growth during that period, despite the slowdown in the global economy. The recent crises in the gold and oil markets, though, led to a substantial revenue slowdown for GCC oil exporters, while central bank reserves were also affected negatively. This adds to the on-going political turbulence in the Middle East, which creates more investment uncertainty, and therefore makes the topic in hand an interesting case to examine.

Our study contributes to the growing literature in energy finance, that includes studies such as Arouri and Nguyen (2010), Baur and McDermott (2010), Choi and Hammoudeh (2010), Filis et al. (2011), Arouri et al. (2012), Awartani and Maghyereh (2013), Awartani et al. (2013), Ciner et al. (2013), Creti et al. (2013), Guesmi and Fattoum (2014), Lean and Wong (2015), Basher and Sadorsky (2016). Most of these studies examine the dynamic correlations between oil and equities, while only a few studies consider additional commodities, such as Mensi et al. (2013, 2015).

We estimate return and volatility spillovers using the dynamic conditional correlation, general autoregressive conditional heteroscedasticity (DCC-GARCH) model of Engle (2002). For the returns equation, we use a VAR specification that endogenously accounts for structural breaks, while we follow the multivariate GARCH approach of Ling and McAleer (2003) to model volatility. The DCCs between GCC equities and the two commodities are then used to compute dynamic hedge ratios and portfolio weights.

Our results reveal significant return and volatility transmissions from oil to equities, highlighting the link between oil production and corporate cash flows in GCC economies, whereas the influence of gold on equities appears insignificant and negligible. In the opposite direction, we do not find convincing evidence that the GCC stock markets can influence the two commodity markets, which we attribute to the relatively small capitalisation of the exchanges. Our analysis of dynamic correlations and dynamic hedge ratios indicates that, although the two commodities are cheap hedges, and in contrast to previous studies, they cannot be considered as good ones due to their weak dynamic correlations with equities. We therefore conclude that oil and gold can instead be used for portfolio diversification, which is an important result for GCC equity holders, given that the local exchanges list relatively few corporations from a narrow selection of sectors.

The rest of this paper is structured as follows: section 2 provides a contextual background about the GCC stock markets; section 3 reviews the relevant literature; section 3 analyses the empirical methods followed; section 4 presents the data used in this study; section 5 discusses the empirical findings, while section 5 concludes the paper.

2. The GCC stock markets

The GCC was established on 11 November 1981, and it includes six countries: Bahrain, Kuwait, Oman, Qatar, Saudi Arabia, and the UAE. GCC countries are important players in the global oil market, as that they possess 47% of verified oil reserves and they produce 23.7% of crude oil. Saudi Arabia is the second largest crude oil producer in the world, producing on average 13% of crude oil. The contributions for the rest GCC countries are 3.6% for Kuwait, 1.3% for Oman, 1.9% for Qatar, and 3.9% for UAE. Bahrain is the smallest producer with an average output of 50 thousand barrels a day (0.06%).[3] As reported in Table 1, oil revenues contribute significantly to the economic and business activities of the region, as they range from 15% of GDP in Bahrain to 53% of GDP in Kuwait. Table 1 also shows that one of the main contributions of oil is through the trade balance, since fuel exports account from 42.5% of total merchandise value in UAE up to 89.1% in Kuwait.

These indicators suggest that corporate cash flows and economic output can be very sensitive to oil price fluctuations. Moreover, companies which are directly related to oil production, occupy a considerable proportion of the total capitalisation of the equity indices of the GCC stock exchanges, with the exception of the Kuwaiti market which is dominated by financial services. However, oil and gas in the bloc are produced by national companies and therefore the proportion of the energy sector that is represented in stock exchanges is not necessarily high. For instance, Saudi Arabia lists only four traded companies which comprise less than 2% of the total traded capital in the market.[4]

Corporate cash flows can be also indirectly related to oil price fluctuations, given the heavy dependence of the region on oil. Khandelwal et al. (2016) explain that this dependence may be channelled through the supply chain for companies for which oil comprises a significant proportion of their variable costs, or through the close links of financial services with the oil industry in the region. Moreover, given that oil revenues are the main source of government funding,[5] fiscal spending, which in turn is channelled to a great extent to the private sector, effectively depends on oil fluctuations.

[3] Source: Energy Information Administration (2016).
[4] For more information see Bloomberg for sectoral weights in GCC markets.
[5] Khandelwal et al. (2016) report that between 2011 and 2014, oil revenues comprise 87.2% of total fiscal revenues for Bahrain, 83.6% for Kuwait, 88.7% for Oman, 90.7% for Qatar, 90.3% for Saudi Arabia and 69.9% for UAE.

Saudi Arabia is the leading exchange in the bloc in terms of size, years of operation and liquidity, as implied by the turnover (Table 1). The smallest and least liquid market is Bahrain, while the Omani stock market is also relatively illiquid. Moreover, compared to other major emerging markets, GCC exchanges are small and less liquid, while their capitalisation accounts for 0.8% of global capitalization.

Despite the recent modernisation efforts, GCC stock markets suffer from several structural and regulatory deficiencies, which, combined with the political uncertainty in the area, create a challenging corporate environment. GCC markets are segmented with significant restrictions on capital mobility and foreign ownership (Table 1), especially when compared to other developed and emerging economies. Moreover, there are structural weaknesses in supervision, corporate governance, and reporting standards, creating issues in terms of the transparency and reliability of information. In addition to this, the participation of institutional investors is relatively small, which has been argued to be a contributing factor to noise trading. Finally, the number of listed companies and sectors is small, limiting the breadth of options for diversification (sector breadth).

[INSERT TABLE 1 HERE]

3. Literature Review

The literature on the links between oil, gold and equities is rich and offers various interpretations about the shock transmission mechanisms between these assets. Oil prices have been shown to have predictive power for stocks, especially in developed countries (Driesprong et al., 2008), while they are commonly cited in the literature to adversely influence stock prices. Oil price fluctuations alter production costs (Arouri and Nguyen, 2010), and they therefore affect corporate cash flows and firm profitability, which is then reflected on stock prices (Jones and

Kaul, 1996). Indirect effects are also important as oil prices traditionally correlate negatively with real economic activity (Mork, 1994), while empirical evidence seems to support this claim (Nandha and Faff, 2008).[6] For example, increasing oil prices can reduce disposable income, increase precautionary savings, and, therefore, reduce consumption demand overall (Edelstein and Kilian, 2009). At the same time, due to the fact that oil and capital are complements, the rising production costs can also lead to reduced output and cost-push inflation (Berndt and Wood, 1979). In addition, oil price volatility can introduce uncertainty in all sectors of the economy (Ferderer, 1996), negatively affecting firm investments (Henriques and Sadorsky, 2011). Finally, reallocation effects can also explain the negative correlation between the two assets, as capital and labour may migrate to sectors that are less exposed to a crisis (Hamilton 1988). In fact, the indirect effects can be severe if the economy depends heavily on oil, as Khandelwal et al., (2016) show for GCC countries. However, oil prices can be also driven by aggregate demand factors during the expansion phase of the business cycle, and therefore a positive association may be observed with stock prices as firms enjoy greater profitability and growth (Park and Ratti, 2008).[7]

The nature of the relationship of equities with gold is quite different compared to oil, as gold is a competing asset for stocks, given that a fraction of total demand for gold relates to investments. Gold, being a precious metal, is a store of value, therefore serving as a hedge against inflation (Jastram, 1977; Jaffe, 1989; Ghosh et al., 2004). In fact, in the presence of structural breaks, the role of gold as an inflation hedge appears more significant (Worthington

[6] An in-depth review on the theory and evidence on the relationship between energy prices and aggregate economic activity can be found in Brown and Yücel (2002).

[7] In the opposite direction, we did not find any papers theorising that stocks can influence oil returns or volatility. The main reason is that oil has well-defined fundamentals, which explain a significant proportion of the fluctuations in its price. However, the common dependence of the two assets through demand factors, could allow for the possibility of feedback loops. For example, a demand-driven global recession, apart from corporate earnings, may also affect the demand for oil through a substitution effect towards more efficient energy sources.

and Pahlavani, 2007). However, Hoang et al. (2016) find that gold is an inflation hedge in the short run for the UK, USA and India, but not for China, Japan and France.[8] Gold has been also thought traditionally to serve as a hedge against stock price fluctuations during crisis periods (that is, a safe haven), a finding which is mostly confirmed for developed countries. Baur and McDermott (2010) investigate this relationship from 1979 to 2009 and find that gold is both a hedge and a safe haven for European and with the US dollar, but not for Australia, Canada, Japan and BRICS countries. Chua et al. (1990) and Baur and Lucey (2010) provide further supporting evidence on the safe haven status of gold. Hood and Malik (2013), on the contrary, find evidence that gold can serve as a hedge in the US stock market, but its performance as a safe haven is weak.[9]

Oil and gold are also cited to be positively correlated, as they are both traded in US dollars. In particular, a falling dollar would lead to an increase in the nominal dollar price of oil and gold (to maintain their real value), which has been confirmed by Capie et al. (2005) and Reboredo (2013b) for gold. Zhang and Wei (2010) and Reboredo (2013a) find a positive link between the two commodities which they attribute to their common dependency with the US dollar; however, Reboredo (2013a) also finds that gold can act as a safe haven against oil price fluctuations.

---

[8] Although GCC countries are relatively small countries, they are pegged to the US dollar and, in fact, the falling value of the dollar of the dollar in the last decade, due to the crisis and the expansionary US monetary policy, imported inflation into these countries. The only exception is the Kuwaiti Dinar which is marked to a portfolio of currencies dominated by the dollar.

[9] We would like to thank one of the anonymous reviewers who indicated that, due to the small capitalization of the GCC countries, it would be unlikely to evidence significant spillovers from equities to gold. Indeed, there is little or non-existing evidence in the literature that stock market fluctuations could have an impact on the gold market, especially if the focus is on small exchanges, such as in GCC countries. Two exceptions that we found concern large exchanges. For example, Myazaki and Hamori (2013) observe return spillovers from US stocks to gold after the financial crisis, which they describe as a "flight-to-quality" effect. Similar results are reported by Choudry et al. (2015) who applied nonlinear causality tests to the UK, US and Japanese stock exchanges and found bidirectional causality in returns and volatility between equities and gold. However, it is also interesting to note that Bekaert et al. (2014) show that the country origin of the financial crisis did not play an important role in the contagion of the crisis to other countries. Instead, they found evidence in support of the "wake-up call" hypothesis, according to which crises induce investors to reconsider their investment positions and risk exposures, even in the absence of trade and banking links. The implication is that, even though GCC countries hold a small fraction of global stock capitalisation, it would be unwise to exclude the possibility of contagion to other markets, originating from GCC.

Hammoudeh and Yuan (2008), find that past positive oil shocks tend to reduce current gold volatility, therefore having a calming effect on gold, which appears significant in oil producing countries.

Apart from the return and volatility spillovers between oil, gold and equities, the literature has also examined dynamic correlations and hedging opportunities. Filis et al. (2011), consider both oil-importing and oil-exporting countries and find that dynamic correlations between oil and equities increase with demand-side shocks, while they do not find evidence that oil can serve as a safe haven. Choi and Hammoudeh (2010), who examine the dynamic correlations between Brent oil, West Texas Intermediate (WTI) oil, copper, gold, silver and the S&P 500 index, find increasing correlations between WTI oil and gold since 2003, but decreasing correlations between S&P 500 returns and all commodities. Creti et al. (2013) find increasing, and more volatile dynamic correlations between the S&P 500 returns and 25 commodities after the financial crisis, except for gold, which appears negatively correlated with the stock market. Ciner et al. (2013), who focus on stocks, bonds, gold, oil and exchange rates in the US and the UK during the period 1990 to 2010, find weak dependency between oil and stocks, with the exception of crisis periods, where this relationship becomes negative. They also find a weak relationship between gold and stocks, which they attribute to the increasing instrumentation of gold through Exchange-Traded Funds (ETFs), and, hence, the re-evaluation of the role of gold as a safe haven by investors.

The studies which are closest to ours are by Mensi et al. (2015) and Basher and Sadorsky (2016). Mensi et al. (2015) find a positive association between Saudi equities and oil, and a negative association with gold; however, only tail dependence is considered, rather than dynamic correlations and volatility transmissions across GCC markets. Basher and Sadorsky (2016) examine the links between oil and gold and emerging country equities, represented by the MSCI emerging market index.[10] Their results indicate that oil is the best asset to hedge emerging market stock prices.[11] However, no safe conclusions can be drawn about individual countries in the area due to aggregation in to a single market index. In light of the above, there is a gap in the literature in examining the dynamic correlations and dynamic hedge ratios between oil, gold and equities of GCC countries.

4. Methodology

This section presents the modelling approach used in our paper. We first provide details about the dynamic conditional correlation (DCC) GARCH model that estimates volatility spillovers and conditional correlations, which we use to examine for interdependencies among GCC stock markets, oil and gold. Then, we show how hedge ratios and optimal weights can be calculated for two-asset portfolios, using the results from DCC-GARCH.

Since the seminal works of Engle (1982) and Bollerslev (1986), there is a voluminous literature that models the volatility of univariate financial time series with the (G)ARCH family of models. To account for interlinkages and spillovers between financial assets or markets, multivariate GARCH models have been proposed, where the conditional mean equation is modelled through a vector autoregressive (VAR) process and the covariance matrix has a dynamic structure. The challenge with MGARCH lies in modelling the time-varying conditional covariance matrix and therefore various parametrisations have been proposed. In the generalised VEC formulation, outlined in Bollerslev et al. (1988), the conditional volatility is parametrized as a linear function of lagged squared errors and cross products of errors and lagged values of conditional variances. To guarantee positive definiteness of the covariance matrix, Engle and

[10] They also include bonds and the VIX index.
[11] In the MSCI index two of the GCC countries are included: Qatar and the UAE.

Kroner (1995) propose the BEKK model which is a special case of the VEC model. The difficulty with these models lies in the large number of parameters to be estimated even after the imposition of restrictions, explaining why these models are rarely used when the number of series exceeds three. Factor models, proposed by Engle et al. (1990) and Bollerslev and Engle (1993), have been employed to circumvent this difficulty, though by assuming the same dynamic structure on all the elements of the conditional variance matrix, hence reducing the number of estimated parameters.

Another group of models that that is useful in the context of information transmission is the conditional correlation models. The individual conditional variance in these models is first estimated and then the conditional correlation matrix is built on the basis of the chosen specification. The constant conditional correlation model of Bollerslev (1990), known as CCC-GARCH, assumes that the conditional correlations are time invariant. The DCC-GARCH by Engle (2002) is an extension that allows for the conditional correlation matrix to be time-varying and therefore allows for past innovations in one market to influence the conditional volatility in other markets.[12]

In this paper, we estimate volatility transmission and dynamic correlations using a DCC-GARCH (1,1) specification. For the returns equation, we use a VAR model that endogenously accounts for structural breaks, while we follow the multivariate GARCH approach of Ling and McAleer (2003) in modelling the volatility equation, the difference of which with the model of Engle (2002) is explained below. This multivariate GARCH specifications with a dynamic

[12] The model by Christodoulakis and Satchell (2002) also accommodates for dynamic correlations, using the Fisher transformation of the correlation coefficient. Correlation is specified as the ratio of the cross product of residuals, divided by the product of conditional GARCH volatilities. Also, dynamic correlations exist in the Tse and Tsui (2002) model where the conditional correlation is specified as a weighted sum of past correlations.

conditional correlation framework allows us to model the (conditional) volatility dynamics and conditional correlations between GCC equities and the two commodities.

The DCCs between GCC equities and the two commodities are subsequently used to compute the dynamic hedge ratios and the optimal portfolio weights. This approach is applied by, among others, Sadorsky (2012, 2014) and Basher and Sadorsky (2016) to study the volatility dynamics between emerging market stock prices and commodity prices, and appears to be flexible and efficient in studying time-varying correlations and volatility spillover effects.

Let $r_t = \left(r_t^s, r_t^o, r_t^g\right)'$ be a $k{\times}1$ vector containing the returns at time t on $k = 3$ assets, and in particular the stock market (r_t^s), crude oil (r_t^o) and gold $\left(r_t^g\right)$. The conditional mean equation is specified by the following VAR model:

$$\begin{cases} r_t = c + \Psi r_{t-1} + \Xi b_t + \varepsilon_t \\ \varepsilon_t = H_t^{1/2} v_t\,, \quad v_t \sim N(0,1) \end{cases} \tag{1}$$

where $c = (c^s, c^o, c^g)'$ is a $k{\times}1$ vector of constant terms; Ψ and Ξ are time-invariant $k{\times}k$ matrices of coefficients with elements $[\Psi]_{ij} = \psi_{ij}$, $[\Xi]_{ij} = \xi_{ij}$, where $i, j = \{s, o, g\}$; $b_t = \left(b_t^s, b_t^o, b_t^g\right)'$ is a $k{\times}1$ vector of dummy variables that take the value 1 for $t \geq t_{break}$; $\varepsilon_t = \left(\varepsilon_t^s, \varepsilon_t^o, \varepsilon_t^g\right)'$ is a $k{\times}1$ vector of error terms; $v_t = \left(v_t^s, v_t^o, v_t^g\right)'$ is a $k{\times}1$ vector of independently and identically distributed errors. From the above specification, testing for return spillovers is equivalent to testing $\psi_{ij} = 0,\ \forall\, i \neq j$.

In the volatility specification, H_t is a symmetric $k{\times}k$ conditional variance-covariance matrix, which includes the time-varying conditional volatilities on the main diagonal, $[H_t]_{i=j} = h_{ii,t}$, and the time-varying conditional covariances on the off-diagonal elements, $[H_t]_{i\neq j} = h_{ij,t}$. Following Engle (2002), H_t can be written as $H_t = D_t R_t D_t$, where $D_t = diag\left\{\sqrt{h_{ii,t}}\right\}$ is a diagonal $k\times k$ matrix of time-varying conditional volatilities, R_t is a symmetric $k\times k$ matrix of time-varying conditional correlations with elements $[R_t]_{ij} = \rho_{ij,t}$, so that $h_{ij,t} = \sqrt{h_{ii,t}h_{jj,t}}\rho_{ij,t}$.

We follow Ling and McAleer (2003) and obtain the elements of D_t from a multivariate GARCH specification. Their approach to modelling the conditional variances allows for measuring the volatility spillovers between assets. Define as h_t the vector of conditional volatilities included in the principal diagonal of H_t. The conditional variances are specified as follows:

$$h_t = \gamma + A\varepsilon_{t-1}^2 + Bh_{t-1} \tag{2}$$

where $\gamma = (\gamma^s, \gamma^o, \gamma^g)$ is a $k\times 1$ vector of constant terms; A and B are $k\times k$ matrices of estimated ARCH and GARCH coefficients, respectively, with elements $[A]_{ij} = \alpha_{ij}, [B]_{ij} = \beta_{ij}$, where $i, j = \{s, o, g\}$.[13] For $i = j$, α_{ij} represent own conditional ARCH effects which measure short-term persistence, whereas β_{ij} represent own GARCH effects which measure long-term persistence or volatility clustering. The mean reverting condition, $0 < \alpha_{ij} + \beta_{ij} < 1$, for $i = j$ is required to ensure that a long run equilibrium in conditional volatility is established. For $i \neq j$, the α_{ij} and β_{ij} coefficients capture volatility spillovers between assets. In particular, α_{ij} measures the shock spillovers from asset j on the conditional volatility of asset i, while β_{ij} measures past volatility spillovers from asset j on the conditional volatility of asset i.

Given the conditional variances in Eq (2), the time-varying conditional correlation matrix R_t in the DCC model takes the following form:

$$R_t = \left(diag\ (Q_t)\right)^{-1/2} Q_t \left(diag\ (Q_t)\right)^{-1/2} \tag{3}$$

where Q_t is a $k\times k$ symmetric positive-definite matrix, given by:

---

[13] Note that Eq. (2) is not extended to take into account asymmetric responses, because sign and size bias tests (as in Engle and Ng, 1993) produced no evidence of asymmetry for all variables under consideration. Results are available upon request by the authors.

$$Q_t = (1 - \theta_1 - \theta_2)\overline{Q} + \theta_1 \varepsilon_{t-1}\varepsilon'_{t-1} + \theta_2 Q_{t-1} \quad (4)$$

where $\overline{Q}$ is the unconditional covariance matrix of the standardized residuals ε_t, θ_1 and θ_2 are nonnegative scalar coefficients with a sum of less than unity that account for past influences on the current conditional covariances, while the elements of $[Q_t]_{ij} = q_{ij,t}$ can be interpreted as the dynamic conditional covariances between assets i and j. The parameters of the DCC model are obtained using the quasi-maximum likelihood (QML) algorithm of Bollerslev and Wooldridge (1992).[14]

The conditional correlation coefficient $\rho_{ij,t}$ can be then computed as follows:

$$\rho_{ij,t} = \frac{q_t^{ij}}{\sqrt{q_t^{ii} q_t^{jj}}}, \forall\, i \neq j \quad (5)$$

The conditional volatility estimates are then used to compute *optimal hedge ratios*, which can be considered as the proportion of risk of asset i that can be hedged away by taking a short position in instrument (asset) j, while minimising the variance of the formed portfolio.[15] Following Kroner and Sultan (1993), the hedge ratio between asset i (long position) and asset j (short position), can be computed as:[16]

$$\beta^*_{ij,t} = \frac{Cov(r_{it}, r_{jt})}{var(r_{jt})} = \frac{h_{ij,t}}{h_{jj,t}} \quad (6)$$

To obtain dynamic hedge ratios, we follow Sadorsky (2012, 2014) and Basher and Sadorsky (2016) who employ a rolling window analysis with out-of-sample forecasts. The hedge ratios are commonly interpreted as the dollar amount of the short position that needs to be taken in the

---

[14] We use the quasi-Newton algorithm of Broyden, Fletcher, Goldfarb, and Shanno (BFGS), with a convergence criterion of 0.00001. We estimated the DCC model with WinRats 9.0 using a code provided by Sadorsky (2012), which we modified for our purposes.

[15] More information can be found in Lindahl (1992) and Moosa (2003).

[16] Alternatively, the hedge ratio between two assets can be given from $\beta^*_{ij,t} = corr(r_{it}, r_{jt})\frac{sd(r_{it})}{sd(r_{jt})} = \rho_{ij,t}\sqrt{\frac{h_{ii,t}}{h_{jj,t}}}$

hedge to cover one dollar of the short position in the asset under consideration. Hence, an instrument is a *cheap hedge* for another asset when the associated hedge ratio is close to zero.[17] Following the definitions in Baur and Dermott (2010), we also characterise an asset as a *strong* (*weak*) *hedge*, if it is negatively correlated (uncorrelated) with another asset. Similarly, the status of *strong* (*weak*) *safe haven* can be given to an asset when negative (low) correlations are observed only during financial crises. We therefore define an instrument as a *good hedge*, if is both a cheap and strong hedge, while a *bad hedge* is an instrument that is an expensive and weak hedge.

Similarly, the conditional volatilities from the model can be used to construct optimal portfolio weights as in Kroner and Ng (1998):

$$w_{ij,t}^{*} = \frac{h_{jj,t} - h_{ij,t}}{h_{ii,t} - 2h_{ij,t} + h_{jj,t}}, \qquad \text{with } w_{ij,t}^{*} = \begin{cases} 0, & if \quad w_{ij,t}^{*} < 0 \\ w_{ij,t}^{*}, & if \quad 0 \leq w_{ij,t}^{*} \leq 1 \\ 1, & if \quad w_{ij,t}^{*} > 1 \end{cases} \tag{7}$$

where $w_{ij,t}^{*}$ is the weight of asset i in a one-dollar portfolio at time t, while the weight of asset *j* in is computed as $1 - w_{ij,t}^{*}$.

5. Data description and preliminary statistics

We use daily data on GCC stock market indices, Brent crude oil prices (dollars per barrel) and gold prices (dollars per ounce) from 2nd January 2004 to 31st May 2016, obtained from Thomson Reuters Datastream (a total of 3239 daily observations). Daily returns are used to capture the short-lived effects of volatility spillovers which would otherwise appear weak in

[17] Negative values are also possible, indicating that investors should instead take a short position in asset i and a long position in asset j.

longer horizons (Kim et al. 2005).[18] Daily frequency is therefore more suitable for estimating volatility spillovers (Mensi et al. 2015), while it is often preferred in similar recent studies (Mollick and Assefa, 2013; Nazlioglu et al. 2013; Basher and Sardosky, 2016). Stock returns are calculated using the log ratio of the closing prices as $r_t = \ln(p_t/p_{t-1})$.

Figure 1 presents the price-return plots for oil, gold and the GCC stock indices. The primary axes correspond to the price levels and the secondary axes to returns, while the titles above each graph are self-explanatory. We observe that all assets have an increasing trend during the first year of the study, reaching a peak in 2007, after which a sharp decline is observed as the effects of the financial crisis have started showing up. Apart from the fast declining oil and stock prices, volatility was also high during that period as can be seen from the returns graph. However, Saudi Arabia had just exited a stock exchange crisis in 2006 and the negative effects were moderate during the financial crisis compared to the other GCC countries.

After 2009 a tranquil period follows which is interrupted by the recent decline in oil prices, accompanied by high volatility in oil returns indicating strong asymmetry, which was also manifested across the GCC stock exchanges to a varying degree. The momentum of gold prices is maintained throughout the financial crisis, consistent with the view that gold can serve as a safe haven in volatile periods. The continuous price increase of gold stops in 2011, while a moderate leverage effect is also observed. The volatility spike in 2013, when the price of gold sharply declined in one week, does not link to any abnormal price variation in oil or equities, though. The oil crisis has been reflected in stock price variations to varying degrees in the GCC stock exchanges, though this is not true for gold.

[INSERT FIGURE 1 HERE]

[18] As an additional exercise, we have performed our analysis using weekly data (Wednesday to Wednesday). We do not find any significant differences, while the additional results are available upon request.

The descriptive statistics of the return series for the stock indices and the two commodities are presented in Table 2. Gold exhibits the highest average daily returns of 0.032%, while oil is the riskiest asset in terms of standard deviation. The risk and return relationships seems to differ across exchanges and commodities, indicating the varying degrees of relative risk and indicating a potential for risk reduction by combining the various assets in portfolios. All asset returns are non-normal and have shapes which differ to some extent. It seems, though, that the returns for all assets have negative skewness with the exception of oil returns that do not seem to be skewed. An interesting observation is that the Qatari stock exchange exhibits positive skewness, which suggests a considerably different behaviour than the neighbouring exchanges. Moreover, the fact that all distributions are leptokurtic, with the exception of oil (3.550), indicates that the distributions have fat tails, pointing to the existence of conditional heteroscedasticity. The table also reports the Ljung–Box portmanteau statistic for a 20-day period and we find evidence of serial correlation for all assets.

Table 2 also reports the correlation coefficients for each exchange with oil and gold, as well as the correlation coefficient between the two commodities. The low correlation, on average, between stock exchange returns and the commodities implies that hedging opportunities may be limited, though diversification opportunities may be available during certain times. However, the simple correlation analysis cannot be safely utilised, given the time varying nature of volatilities and covariances of asset returns, which is dealt with in the next section.

[INSERT TABLE 2 HERE]

In order to test for structural breaks we conduct a unit root test that accounts for multiple breaks in the series as in Lee and Strazicich (2003) and Lee et al. (2012), and report our findings in Table 3. We find breaks for the stock exchanges and oil around the peak of the international financial crisis in the end of 2008, with the exception of Saudi Arabia which lags behind by a quarter, presumably due the fact that Saudi Arabia had just exited another financial crisis. On the contrary, the structural break for gold is manifested in late September 2011, which coincides with the reversal of the price momentum of gold, which ended up in a steady decline of its price until the beginning of 2016. Although it is difficult to pin down the underlying causes of this reversal, as gold has no well-defined fundamental value, it could be speculated that this is related to the declining uncertainty in financial markets as the effects of the financial crisis had been fading away. Moreover, the reversal coincides with the gold sell-out by the Central Bank of Cyprus to deal with its financial crisis, the bearish Goldman-Sachs prediction of the gold prices, and the algorithmic trading against gold by many commodity ETFs. These primary observations are indications that oil and GCC equities react to similar events whereas gold does not follow these patterns.

[INSERT TABLE 3 HERE]

6. Empirical results

This section discusses the empirical results of our study. We first present the results from the DCC-GARCH models and then we compute hedge ratios and optimal weights resulting from including oil and gold in the GCC equity portfolios.

6.1 Return and volatility spillovers

The results of the multivariate DCC-GARCH model for all GCC countries are presented in Table 4 below. Panel A reveals moderate, though significant, positive autocorrelations for all indices (ψ_{ss}), positive but insignificant autocorrelations for oil (ψ_{oo}), with two exceptions at the 10% level, while for gold the influence of past returns seem to have a negative but insignificant effect on current returns (ψ_{gg}). As expected, oil returns have positive spillovers on stock indices (ψ_{so}), supporting the view that corporate cash flows are directly or indirectly affected by oil prices (Jones and Kaul, 1996; Arouri and Nguyen, 2010). Moreover, the effect of past gold returns on current stock returns appear marginally negative, though insignificant, indicating that investors do not necessarily consider gold price fluctuations when investing on GCC equities. In the opposite direction, we found insignificant spillovers of past stock returns on the returns of oil (ψ_{os}) and gold (ψ_{gs}). This suggests that past financial shocks in the GCC stock markets do not influence the investment behaviour of commodity traders, which can be justified by the relatively small proportion of GCC stock markets in the global capitalisation (0.8% for all indices).

Considering the relationship between the two commodities, we find significant return spillovers in both directions, which is attributed in the literature to their common dependence on the US dollar (Capie et al., 2005; Reboredo, 2013b; Zhang and Wei, 2010). A surprising finding is that, although the effect of past oil returns on gold (ψ_{go}) is positive and significant, the sign is negative in the opposite direction (ψ_{og}). One possible explanation is that gold has served as a hedge against inflation and as a safe haven for developed countries during the financial crisis (Baur and McDermott, 2010; Hoang et al., 2016). Moreover, the halt in momentum of gold price was not necessarily related to the oil market, and therefore the estimated parameters ψ_{go} and ψ_{og} may have been picking up different impacts. Our structural break tests provide support for the latter explanation, as the break in oil returns had no significant impact on gold (ξ_{go}), whereas the structural break for gold, apart from the negative effects on its own returns (ξ_{gg}), had also had a negative and significant influence on oil returns (ξ_{og}), implying a change in the relationship between the two assets.

Regarding other structural breaks, we find that the financial crisis has had a significant negative impact on stock returns (ξ_{ss}), but a significant positive impact on oil returns (ξ_{oo}), indicating that there may be hedging opportunities for investors. This is also supported by the negative and significant influence of the structural break of oil on equities (ξ_{so}), which was more pronounced for Saudi Arabia and the UAE as being the two major oil producers in the area. On the contrary, the crisis in the gold market does not exhibit a particular pattern of influence on equities (ξ_{sg}), as it has a marginally significant effect on two out of the six exchanges in GCC. Finally, it would be hard to extract any conclusions about the effect of the structural break of equities on the two commodities (ξ_{os}, ξ_{gs}), as the financial crisis was imported from the US, while GCC equities occupy a small fraction of the global capitalisation.

The estimation output for the variance equations (Panel B) indicates that there is significant long term persistence (β_{ss}) in the volatility of GCC equity markets, which is more pronounced than the short-term persistence (α_{ss}). This implies that shocks in the GCC markets impose risk which influences the volatility in the following period (α_{ss}), but which mainly builds into the market risk and takes time to fade away (β_{ss}). In the two commodity markets, we find slightly different results as short term persistence is quite small $(\alpha_{oo}, \alpha_{gg})$, while long-term persistence is much more substantial (β_{oo}, β_{gg}) and shocks have a longer lasting effect on risk. Long term effects also dominate when considering volatility spillovers from the oil market to GCC stocks (β_{so}), compared to short-term spillovers (α_{so}), since oil price fluctuations are likely to have a lagged and persisting impact on the riskiness of corporate cash flows, and therefore on the volatility of stock prices.[19] It is interesting to note that the long-term effects are particularly strong for Kuwait, which has been argued to be dominated by banking (Arouri et al., 2011),

[19] Bahrain is an exception which can be justified by the fact that it is relatively less dependent on oil compared to the other countries, as indicated in the contribution of oil revenues on GDP in Table 1.

providing further support for the close dependence of financial services in the region with oil production (Khandelwal et al., 2016). On the contrary, gold returns do not affect the level of risk in GCC exchanges, neither in the short-run (α_{sg}) nor in the long-run (β_{sg}), suggesting that equity investors are not affected by the riskiness in the gold market.

Regarding the volatility spillovers of equities on the two commodities, we find insignificant results for oil $(\alpha_{os}, \beta_{os})$, which we attribute to the fact that the cash flows of the GCC listed companies are dependent on oil production, whereas the opposite cannot be true. Finally, we find that gold has a volatility calming effect on oil in the short run (α_{og}), which is in line with Hammoudeh and Yuan (2008), though in the long run the effects are positive in both directions (β_{og}, β_{go}). The strong link in the volatility of the two commodities is not surprising as their price volatility is affected to some extent by their common dependence on the US dollar. A surprising observation is that the long-term spillovers from stocks to gold (β_{gs}) are significant. However, they are small and have mixed signs, while a joint Wald test of significance does not reveal any spillovers overall.[20]

[INSERT TABLE 4 HERE]

6.2 Dynamic correlations and hedge ratios

Table 4 also reports the expected values for the dynamic conditional correlations between the assets considered. Equities exhibit insubstantial correlations with the two commodities, which are positive and significant, in principle, with respect to oil (ρ_{so}) and insignificant with respect to gold (ρ_{sg}). Gold and oil have positive significant correlations (ρ_{go}), though of a relatively

[20] To complement our analysis of volatility transmissions, we also examine for causality in volatility using a Wald test of joint significance with the null hypothesis $H_0: \alpha_{ij} = \beta_{ij} = 0, \forall\, i \neq j$. We find similar evidence compared to the DCC-GARCH: oil volatility influences equity volatilities but there are no significant influences in the opposite direction, there is no causality in volatility between oil and gold, and, finally, we find two-way causality between the two commodities. The results are available upon request by the authors.

small magnitude. These preliminary results indicate that the two commodities may not be good hedging instruments against GCC equity fluctuations, but they may provide adequate hedging to each other. Moreover, considering conditional covariances, we find that they depend heavily on their past values (θ_2), which can be considered as evidence of covariance persistence, while the dependence on lagged innovations (θ_1) is small but significant. Finally, we find that the dynamic conditional correlations are mean reverting, while diagnostic tests of the model's standardized residuals, presented in Table 5, do not reject uncorrelated residuals, indicating that the fit of the model is good.

[INSERT TABLE 5 HERE]

The evolution of the dynamic conditional correlations between the three assets is presented in Figure 2. The correlations between equities and the two commodities are relatively volatile during the beginning of the study period, undergo a period of more intense fluctuations during the 2007-2008 financial crisis, whereas they become less vivid after 2010.[21] The implication is that investors' preferences have been continuously changing over the study period, requiring frequent portfolio rebalancing. This is, also, partially in line with Creti et al. (2013), who attribute the increasing correlations to the financialisation of commodity markets.

We find that, most of the time, the correlations between oil and equities are positive, which is in line with Arouri et al. (2011), Filis et al. (2011), Awartani and Maghyereh (2013), among others. However, their magnitude remains low during the study period, with the most substantial peak observed during the 2008-2009 financial crisis, and with the highest value recorded for Oman (almost 0.5). The dynamic correlations between GCC stocks and gold exhibit similar fluctuations, but smaller in magnitude, hence limiting the potential of using gold as a hedging

[21] We would like to thank one of the anonymous reviewers for bringing the volatility of dynamic correlations to our attention.

instrument against GCC equities, while during the financial crisis we find that the correlations are small and negative. This provides further support to Ciner et al. (2013), who find a weak relationship between stocks and gold, and to Baur and Dermott (2010), who conclude that the safe haven status of gold is stronger in the US and European stock markets. Finally, we find that the correlation between oil and gold is consistently positive, which is in line with Reboredo (2013a) and Choi and Hammoudeh (2010), among others. Since the dynamic correlations between GCC stocks and the two commodities remain low, with the exception of a moderate peak during the financial crisis, we conclude that oil and gold are weak hedges and weak safe heavens.

[INSERT FIGURE 2 HERE]

To further evaluate the benefits of including oil or gold in equity portfolios, we calculate optimal hedge ratios in Table 6 along with the associated optimal portfolio weights. On average, both oil and gold are cheap hedges, with gold providing the cheaper hedging opportunities. For example, a $1 investment on the Saudi index can be hedged by taking a short position of 9.3 cents on oil and with the optimal (minimum variance) weights being 28.6% on the index and the rest on oil. Similarly, a $1 short position on the Saudi index can be hedged by purchasing 0.4 pence in gold, in a portfolio that includes 53.4% equities.[22]

[INSERT TABLE 6 HERE]

From the time-varying hedge ratios in Figure 3, we also observe that oil is a cheap hedge in all periods, except during the financial crisis, suggesting that the weak safe haven attribute of gold comes at a cost. For Saudi Arabia, the biggest oil producer in the region, the hedge ratios for oil have a second peak during the oil crisis that started in 2014, highlighting the dependence

[22] Regarding hedging opportunities between the two commodities, we find that, on average, a $1 position in gold can be hedged with a short position of 16 cents in oil.

of the economy on the commodity. The relative price of gold as a hedge for equities also fluctuates, though to a smaller extent, peaking for most exchanges during the financial crisis, with the exception of Saudi Arabia where the hedge ratios fluctuate more widely during the Saudi crisis in 2006. What is interesting, though, is that the gold crisis did not have any noticeable effects on the hedge ratios, indicating that GCC equity holders did not necessarily incorporate the falling price of gold in their portfolio management decisions.[23]

Despite the fact that the two commodities are cheap hedges during non-crisis periods, they cannot be considered overall as good hedges due to the very low dynamic correlations that they exhibit with equities. However, they could be considered as relatively good safe havens for most countries, but at a relatively higher cost compared to tranquil periods. Given the above, oil and gold would be better suited as instruments for portfolio diversification rather than hedging. We argue that any hedging opportunities are weak and short lived, while their effectiveness during crises is limited due to the relatively higher costs. Our results are not in line with previous evidence that including commodities in a well-diversified equity portfolio provides good hedging opportunities [for example, Mensi et al. (2013) for the US and Arouri et al. (2011) for GCC countries], hence adding more evidence to the ongoing debate.

When considering the relationship between the two commodities, our results indicate that gold could be a better hedge for oil than equities, and vice versa. The dynamic correlations between oil and gold fluctuate between relatively moderate values, while the hedge ratios are substantial, especially during the financial crisis. Hence, although not cheap, gold can be a more reliable hedge for oil than stocks. Since GCC countries are significant oil exporters, this

[23] Another potential interpretation could be related to the increasingly heavier instrumentation of gold through ETFs. However, this argument would require more formal investigation since the price behaviour of ETFs should rationally follow closely the price fluctuations of gold.

implication may not only be of interest to GCC equity holders, but also to oil producers and traders, including the GCC governments.

[INSERT FIGURE 3 HERE]

7. Conclusions

This paper examines the return and volatility spillovers between equities, oil and gold in the GCC region and explores for hedging opportunities during the period from 2004 to mid-2016. The local markets comprise an interesting case as the GCC economies depend heavily on oil, while the political instability of the region creates more uncertainty. At the same time, hedging opportunities are limited due to the absence of a derivatives market, while portfolio diversification is challenging due to the relatively small number of listed companies and sectors.

A multivariate DCC-GARCH model is used to estimate the return and volatility spillovers, and then to extract the dynamic correlations and optimal hedge ratios between the assets considered. We take care to evaluate hedging opportunities by considering both their relative prices, through dynamic hedge ratios, and their quality, assessed by the strength of the dynamic correlations.

Our results reveal interesting patterns about the information transmissions among the three markets. In particular, we find positive and significant return and volatility spillovers from oil to equity returns, with the greatest magnitude observed for Saudi Arabia and the UAE; the biggest oil producers in the region. This highlights the important influence that oil exerts on corporate cash flows (direct or indirect), which is reflected on the GCC equity indices and has been confirmed in the literature. On the contrary, we do not find significant spillovers from gold to GCC equities, indicating that gold price fluctuations do not necessarily inform GCC equity investment decisions. In the opposite direction, the influence of the GCC stock markets on commodities appears small and insignificant, which can be attributed to the relatively small capitalisation of the exchanges of the region. However, we observe that there is weak significance in the long-term volatility spillovers on the gold market, which are, though, of mixed sign and could be justified by the common dependence of oil and gold through the US dollar. Indeed, we find that the two commodities exhibit significant return and volatility spillovers between them in both directions, validating our previous point.

The analysis of dynamic correlations indicates positive, but weak linkages between oil and equities, as well as between oil and gold, with only a few exceptions. The correlations between equities and gold, though, fluctuate about zero at moderate levels throughout the study period. Both correlations and the dynamic hedge ratios peak during the financial crisis, in general, as well as during the recent oil crisis, for oil and stocks. We argue that oil and gold, despite being cheap hedges, they cannot be considered as good ones due to the weak correlations they exhibit with equities, contradicting the findings in some of the previous studies. Although the two commodities are stronger safe havens than hedges, when considering the relatively higher hedge ratios during crises, the benefits are not necessarily adequate to counterbalance the costs.

Given that, most of the time, correlations and hedge ratios are low, we conclude that the two commodities could be used for portfolio diversification instead, which is of value for GCC equity investors, portfolio managers and oil producers. Our findings provide further evidence about the usefulness of oil and gold as hedging instruments, hence contributing to the ongoing debate.

Acknowledgements

The authors would like to thank two anonymous referees for their in-depth reviews and valuable comments, which significantly enhanced our paper. Any remaining errors are the authors' responsibility.

References

Arouri, M.E.H., Jouini, J., Nguyen, D.K, 2012. On the impacts of oil price fluctuations on European equity markets: Volatility spillover and hedging effectiveness. Energy Economics 34(2), 611–617.

Arouri, M.E.H., Lahiani, A., Nguyen, D.K., 2011. Return and volatility transmission between world oil prices and stock markets of the GCC countries. Economic Modelling 28, 1815–1825.

Arouri, M.E.H., Nguyen, D.K., 2010. Oil prices, stock markets and portfolio investment: Evidence from sector analysis in Europe over the last decade. Energy Policy 38, 4528–4539.

Awartani, B., Maghyereh, A.I. 2013. Dynamic spillovers between oil and stock markets in the Gulf Cooperation Council Countries. Energy Economics 36, 28-42.

Awartani, B., Maghyereh, A.I., Al Shiab, M. 2013. Directional spillovers from the US and the Saudi market to equities in the Gulf Cooperation Council countries. Journal of International Financial Markets, Institutions and Money 27, 224-242.

Balcilar, M., Demirer, R., and Hammoudeh, S. (2015). Regional and global spillovers and diversification opportunities in the GCC equity sectors. Emerging Markets Review 24, 160–187.

Basher, S.A., Sadorsky, P., 2016. Hedging emerging market stock prices with oil, gold, VIX, and bonds: A comparison between DCC, ADCC and GO-GARCH. Energy Economics 54, 235–247

Baur, D.G., Lucey, B.M., 2010. Is gold a hedge or a safe haven? An analysis of stocks, bonds and gold. Financial Review 45, 217–229.

Baur, D.G., McDermott, T.K., 2010. Is gold a safe haven? International evidence. Journal of Banking and Finance 34, 1886–1898.

Bekaert G., Ehrmann M., Fratzscher M., Mehl A., 2014. The global crisis and equity market contagion. Journal of Finance 69(6), 2597-2649.

Berndt, E.R., and Wood O.D., 1979. Engineering and econometric interpretations of energy-capital complementarity. American Economic Review 69(3), 342-54

Bollerslev T. 1986. Generalized autoregressive conditional heteroskedasticity. Journal of Econometrics, 31 307–327.

Bollerslev T. 1990. Modeling the coherence in short-run nominal exchange rates: a multivariate generalized ARCH model. Review of Economics and Statistics 72, 498–505.

Bollerslev T, Engle RF. 1993. Common persistence in conditional variances. Econometrica, (61), 167–186.

Bollerslev, T., Wooldridge, J. 1992. Quasi-maximum likelihood estimation and inference in dynamic models with time varying covariances. Econometric Reviews 11, 143–172.

Brown P.A.S., Yücel K.M., 2002. Energy prices and aggregate economic activity: an interpretative survey. Quarterly Review of Economics and Finance 42(2), 93-208.

Capie, F., Mills, T.C., Wood, G., 2005. Gold as a hedge against the dollar. Journal of International Financial Markets, Institutions and Money 15, 343–352.

Choi, K., Hammoudeh, S., 2010. Volatility behavior of oil, industrial commodity and stock markets in a regime-switching environment. Energy Policy 38, 4388–4399.

Choudry T., Hassan S.S., Shabi S., 2015. Relationship between gold and stock markets during the global financial crisis: Evidence from nonlinear causality tests. International Review of Financial Analysis 41, 247-256.

Chua, J.H., Sick, G.S., Woodward, R., 1990. Diversifying with gold stocks. Financial Analysts Journal 46(4), 76–79.

Christodoulakis GA, Satchell SE., 2002. Correlated ARCH: modelling the time-varying correlation between financial asset returns. European Journal of Operations Research 139: 351–370.

Ciner, C., Gurdgiev, C., Lucey, B.M., 2013. Hedges and safe havens: An examination of stocks, bonds, gold, oil and exchange rates. International Review of Financial Analysis 29, 202–211.

Creti, A., Joëts, M., Mignon, V., 2013. On the links between stock and commodity markets' volatility. Energy Economics 37, 16–28.

Demirer, R., 2013. Can advanced markets help diversify risks in frontier stock markets? Evidence from Gulf Arab stock markets. Research in International Business and Finance 29, 77–98.

Driesprong, G., Jacobsen, B., Maat, B., 2008. Striking oil: Another puzzle? Journal of Financial Economics 89 (2), 307–327.

Edelstein P., Kilian L., 2009. How sensitive are consumer expenditures to retail energy prices? Journal of Monetary Economics 56, 766-779

Engle, R., 2002. Dynamic conditional correlation: A simple class of multivariate generalized autoregressive conditional heteroskedasticity models. Journal of Business and Economic Statistics 20(3), 339-350.

Engle R., Kroner F.K., 1995. Multivariate simultaneous generalized ARCH. Econometric Theory 11, 122–150.

Engle, R.F., Ng, V., 1993. Measuring and testing the impact of news on volatility. Journal of

Finance 48, 1749–1778.

Ferderer P., 1996. Oil price volatility and the macroeconomy. Journal of Macroeconomics 18(1), 1-26.

Filis, G., Degiannakis, S., Floros, C., 2011. Dynamic correlation between stock market and oil prices: The case of oil-importing and oil-exporting countries. International Review of Financial Analysis 20, 152–164.

Ghosh, D., Levin, E.J., Macmillan, P., Wright, R.E., 2004. Gold as an inflation hedge? Studies in Economics and Finance 22, 1–25.

Guesmi, K., Fattoum, S., 2014. Return and volatility transmission between oil prices and oil-exporting and oil-importing countries. Economics Modelling 38, 305–310.

Hamilton, J.D., 1988. A neoclassical model of unemployment and the business cycle. Journal of Political Economy 96, 593–617.

Hammoudeh, S., Yuan, Y., 2008. Metal volatility in presence of oil and interest rate shocks. Energy Economics 30, 606–620.

Henriques I., Sadorsky P., 2011. The effect of oil price volatility on strategic investment. Energy Economics 33(1), 79-87.

Hoang, T.H. Van, Lahiani, A., Heller, D., 2016. Is gold a hedge against inflation? New evidence from a nonlinear ARDL approach. Economic Modelling 54, 54–66.

Hood, M., Malik, F., 2013. Is gold the best hedge and a safe haven under changing stock market volatility? Review of Financial Economics 22, 47–52.

Jaffe, J.F., 1989. Gold and gold stocks as investments for institutional portfolios. Financial Analysts Journal 45, 53–59.

Jastram, R.W., 1977. The golden constant: The English and American experience. John Wiley & Sons, New York.

Jones, C.M., Kaul, G., 1996. Oil and the stock markets. Journal of Finance 51, 463–491.

Khandelwal P., Miyajima K., Santos A., 2016. The impact of oil prices on the banking system in the GCC. IMF Working Papers 16/161

Kim, S.J., Moshirian, F., Wu, E., 2005. Dynamic stock market integration driven by the European Monetary Union: an empirical analysis. Journal of Banking and Finance 29, 2475–2502.

Kroner, K.F., Ng, V.K., 1998. Modeling asymmetric movements of asset prices. Review of Financial Studies 11, 844–871.

Kroner, K.F., Sultan, J., 1993. Time-varying distributions and dynamic hedging with foreign currency futures. Journal of Financial and Quantitative Analysis 28, 535–551.

Lee, J., Strazicich, M.C., 2003. Minimum Lagrange multiplier unit root test with two structural breaks. Review of Economics and Statistics 85(4), 1082-1089.

Lee, J., Strazicich, M.C., Meng, M., 2012. Two-step LM unit root tests with trend-breaks. Journal of Statistical and Econometric Methods 1(2), 81-107.

Lindahl. M., 1992. Minimum variance hedge ratios for stock index futures: duration and expiration effects. Journal of Futures Markets 12(1), 33-53.

Ling, S., McAleer, M., 2003. Asymptotic theory for a vector ARMA-GARCH model. Econometric Theory 19, 278–308.

Miyazaki T., Hamori S., 2013. Testing for causality between the gold return and stock market performance: evidence for ‘gold investment in case of emergency’. Applied Financial Economics 23(1), 27-40.

Mensi, W., Beljid, M., Boubaker, A., Managi, S., 2013. Correlations and volatility spillovers across commodity and stock markets: Linking energies, food, and gold. Economic Modelling 32, 15–22.

Mensi, W., Hammoudeh, S., Kang, S.H., 2015. Precious metals, cereal, oil and stock market linkages and portfolio risk management: Evidence from Saudi Arabia. Economic Modelling 51, 340–358.

Mollick V.A., Assefa A.T., 2013. U.S. stock returns and oil prices: The tale from daily data and the 2008–2009 financial crisis. Energy Economics 36, 1-18.

Moosa, I., 2003. The sensitivity of optimal hedge ratio to model specification. Finance Letters 1, 15-20.

Mork, K., Olsen, Ø, & Mysen, H., 1994. Macroeconomic Responses to Oil Price Increases and Decreases in Seven OECD Countries. The Energy Journal 15(4), 19-35.

Nandha M., Faff R., 2008. Does oil move equity prices? A global view. Energy Economics 30(3), 986-997.

Nazlioglu S., Erdem C., Soytas U., 2013. Volatility spillover between oil and agricultural commodity markets. Energy Economics 36, 658-665.

Park, J., Ratti, R.A., 2008. Oil price shocks and stock markets in the U.S. and 13 European countries. Energy Economics 30, 2587–2608.

Reboredo, J.C., 2013a. Is gold a hedge or safe haven against oil price movements? Resources Policy 38, 130–137.

Reboredo, J.C., 2013b. Is gold a safe haven or a hedge for the US dollar? Implications for risk management. Journal of Banking and Finance 37, 2665–2676.

Sadorsky, P., 2012. Correlations and volatility spillovers between oil prices and the stock prices of clean energy and technology companies. Energy Economics 34, 248–255.

Sadorsky, P., 2014. Modeling volatility and correlations between emerging market stock prices and the prices of copper, oil and wheat. Energy Economics 43, 72–81.

Tse Y.K., Tsui A.K.C., 2002. A multivariate GARCH model with time-varying correlations. Journal of Business and Economic Statistics 20, 351–362.

Worthington, A.C., Pahlavani, M., 2007. Gold investment as an inflationary hedge: cointegration evidence with allowance for endogenous structural breaks. Applied Financial Economics Letters 3, 259–262.

Zhang, Y.J., Wei, Y.M., 2010. The crude oil market and the gold market: Evidence for cointegration, causality and price discovery. Resources Policy 35, 168–177.

Table 1: Macroeconomic and stock market characteristics of GCC countries

	Bahrain	Kuwait	Oman	Qatar	Saudi Arabia	UAE
Stock market indicators						
Start of trading	1987	1952	1989	1997	1935	1988
Start of electronic trading	1989	1995	1998	2002	1988	2000
Number of listed companies	50	204	141	44	175	150
Market capitalization (US $ bn)	19.3	87.8	41.1	142.6	421.1	195.9
Market capitalization (% of GDP)	61.8	86.6	58.9	86.6	65.2	52.9
Stocks traded, total value (% of GDP)	2.0	17.3	7.1	17.5	67.6	15.6
Turnover ratio (%)	1.8	3.0	8.66	16.97	77.5	23.2
Max. of foreign investment (%)*	100	49	25-100	25	0	49
Foreign investment through mutual funds*	Yes	Yes	Yes	Yes	Yes	Yes
Macroeconomic indicators						
GDP (current US $ bn)	31.13	114.04	69.83	164.64	654.27	357.95
GDP per capita (current US $)	22,689	28,975	16,627	66,347	20,733	39,102
Oil revenue (% of GDP)	15.27	53.04	27.97	19.50	38.71	18.98
Fuel exports (% of merchandise exports)	50.4	89.1	62	82.8	78.4	42.5
FDI net inflows (% of GDP)	-4.7	0.2	-3.9	0.7	1.2	2.5
FDI net outflows (% of GDP)	1.6	4.8	0.4	2.4	0.8	2.96

Notes: This table presents some stock market and macroeconomic indicators for the GCC countries. Due to missing data and to ensure consistency we present 2015 indicators. Data were obtained from multiple sources including the Arab Monetary Fund, World Bank, the International Finance Corporation, the Institute of International Finance.

* Data partially replicated from Table 1 in Demirer (2013), and Balcilar et al., (2015; p.162). Note that the maximum foreign ownership in an Omani can range up to 100% in the free zones. Foreign ownership in certain countries, such as Saudi Arabia, is restricted to GCC nationals.

Table 2: Descriptive statistics

	Bahrain	Oman	Kuwait	Qatar	Saudi Arabia	UAE	Oil	Gold
Mean (%)	-0.005	0.023	0.003	0.027	0.011	0.027	0.015	0.032
Median (%)	0.000	0.000	0.000	0.004	0.070	0.001	0.025	0.035
Maximum (%)	3.613	8.038	6.303	14.196	16.399	9.818	13.687	6.86
Minimum (%)	-4.919	-8.698	-9.334	-9.853	-11.681	-9.492	-13.024	-10.16
Std.Dev. (%)	0.566	1.024	0.865	1.448	1.645	1.567	2.102	1.200
Skewness	-0.463	-0.914	-0.929	0.029	-0.596	-0.694	0.015	-0.488
Kurtosis	6.744	16.572	15.134	7.965	11.194	9.267	3.701	5.069
JB	6252.2**	37507.7**	31369.9***	8560.4***	17098.3***	12228.5***	1850.6***	3595.4***
$Q(20)$	462.4**	547.1***	225.8***	282.2***	231.932***	307.7***	171.5***	170.4***
Corr. Oil	0.038	0.120	0.069	0.060	0.139	0.092	1.000	0.242
Corr. Gold	-0.013	0.010	-0.002	0.002	0.000	0.013	0.242	1.000

Notes: The table presents descriptive statistics for the returns of the GCC stock market index returns, as well as the oil and gold returns. JB is the value of the Jarque–Bera statistic, testing for normality. Q(20) is the Ljung and Box (1978) test for serial correlation with 20 lag lengths. Corr. denotes the correlation coefficients.

*** Statistical significance at 1% level.

** Statistical significance at 5% level.

* Statistical significance at 10% level.

Table 3: Unit root with structural break

	Break dates	t-statistics
Bahrain Stock	18/11/2008	-38.507
Oman Stock	17/10/2008	-37.708
Kuwait Stock	04/10/2008	-31.092
Qatar Stock	06/11/2008	-33.339
Saudi Arabia Stock	25/03/2009	-11.223
UAE	17/09/2008	-22.519
Oil	22/09/2008	-47.809
Gold	20/09/2011	-13.940

Notes: This table presents the result for the structural breaks tests in Lee and Strazicich (2003). The second column reports the estimated structural break date, while the third column reports the associated t-statistics. Critical values of the endogenous break LM unit-root test at 10%, 5% and 1% level of significance are -3.504, -3.842 and -4.545 respectively.

Table 4: Multivariate DCC-GARCH estimation results

	Bahrain		Oman		Kuwait		Qatar		Saudi Arabia		UAE	
	Coeff	*p*-value	Coeff	*p*-value	Coeff	*p*-value	Coeff	*p*-value	Coeff	*p*-value	Coeff	*p*-value
Panel A: Mean equation												
c^s	0.027***	(0.022)	0.052**	(0.020)	0.083***	(0.000)	0.066**	(0.030)	0.189**	(0.000)	0.062***	(0.005)
ψ_{ss}	0.115***	(0.000)	0.249***	(0.000)	0.122***	(0.000)	0.119***	(0.000)	0.065***	(0.000)	0.177***	(0.000)
ψ_{so}	0.014***	(0.045)	0.027***	(0.000)	0.016***	(0.000)	0.047***	(0.000)	0.032***	(0.001)	0.042***	(0.000)
ψ_{sg}	-0.001	(0.925)	-0.005	(0.572)	-0.000	(0.910)	-0.008	(0.456)	-0.016	(0.353)	-0.006	(0.558)
ξ_{ss}	-0.146**	(0.033)	0.065***	(0.006)	-0.002	(0.605)	0.240	(0.200)	-0.334***	(0.010)	-0.126*	(0.052)
ξ_{so}	0.078	(0.264)	-0.107***	(0.000)	0.075***	(0.000)	0.003	(0.932)	-0.195***	(0.005)	-0.188**	(0.012)
ξ_{sg}	0.033*	(0.079)	0.008	(0.498)	0.011	(0.117)	-0.039	(0.313)	0.040	(0.389)	0.049*	(0.083)
c^o	0.110**	(0.040)	0.084***	(0.000)	0.140***	(0.000)	0.105**	(0.021)	0.115**	(0.034)	0.109**	(0.012)
ψ_{os}	0.008	(0.858)	0.027	(0.463)	-0.034	(0.373)	0.048**	(0.050)	0.016	(0.279)	0.003	(0.874)
ψ_{oo}	0.007	(0.686)	0.013	(0.455)	0.028*	(0.069)	0.012	(0.459)	0.008*	(0.070)	0.026	(0.118)
ψ_{og}	-0.006**	(0.050)	-0.012**	(0.050)	-0.030**	(0.012)	-0.008**	(0.026)	-0.005*	(0.093)	-0.013*	(0.063)
ξ_{os}	-0.007	(0.877)	-0.006	(0.921)	0.179	(0.209)	0.029	(0.845)	-0.199	(0.268)	-0.113*	(0.052)
ξ_{oo}	0.021**	(0.019)	0.059	(0.305)	-0.191***	(0.000)	0.117**	(0.040)	0.220**	(0.020)	0.148**	(0.043)
ξ_{og}	-0.168**	(0.023)	-0.182***	(0.000)	-0.191***	(0.000)	-0.174**	(0.046)	-0.170**	(0.017)	-0.185***	(0.004)
c^g	0.050**	(0.036)	0.036***	(0.007)	0.060***	(0.000)	0.040	(0.107)	0.049*	(0.077)	0.042*	(0.070)
ψ_{gs}	0.059	(0.113)	0.035	(0.145)	-0.052	(0.129)	0.008	(0.562)	-0.027	(0.118)	-0.016	(0.195)
ψ_{go}	0.027**	(0.010)	0.028***	(0.001)	0.030***	(0.000)	0.029***	(0.000)	0.031***	(0.000)	0.027***	(0.001)
ψ_{gg}	-0.017	(0.327)	-0.021	(0.236)	-0.022	(0.149)	-0.022	(0.179)	-0.018	(0.415)	-0.012	(0.479)
ξ_{gs}	0.068	(0.351)	0.058**	(0.044)	0.043**	(0.019)	0.022	(0.781)	0.018	(0.704)	0.091*	(0.130)
ξ_{go}	-0.018	(0.815)	-0.004	(0.986)	-0.019	(0.432)	-0.062	(0.243)	-0.011	(0.711)	-0.038	(0.558)
ξ_{gg}	-0.125***	(0.007)	-0.121***	(0.000)	-0.125***	(0.003)	-0.134**	(0.015)	-0.120***	(0.000)	-0.117***	(0.001)
Panel B: Variance equation												
γ^s	0.025*	(0.055)	0.015***	(0.000)	0.007***	(0.000)	0.004	(0.257)	0.035***	(0.000)	0.032***	(0.005)
α_{ss}	0.148***	(0.000)	0.114***	(0.000)	0.149***	(0.000)	0.117***	(0.000)	0.134***	(0.000)	0.224***	(0.000)
a_{so}	0.021	(0.576)	0.042**	(0.026)	0.041***	(0.004)	0.015*	(0.084)	0.013**	(0.044)	0.027**	(0.037)
a_{sg}	-0.009	(0.481)	-0.021	(0.487)	-0.021	(0.528)	-0.014	(0.366)	-0.027	(0.356)	-0.014	(0.620)
β_{ss}	0.755***	(0.000)	0.817***	(0.000)	0.818***	(0.000)	0.894***	(0.000)	0.855***	(0.000)	0.752***	(0.000)
β_{so}	0.049	(0.627)	0.231**	(0.039)	0.703***	(0.000)	0.049*	(0.095)	0.055***	(0.004)	0.026**	(0.034)
β_{sg}	-0.057	(0.598)	0.001	(0.961)	-0.021	(0.540)	0.259	(0.116)	0.345	(0.104)	0.125	(0.609)
γ^o	0.005	(0.323)	0.009*	(0.062)	0.005**	(0.014)	0.004	(0.457)	0.006	(0.363)	0.005	(0.465)
a_{os}	-0.000	(0.972)	-0.010	(0.219)	0.001	(0.404)	-0.008	(0.249)	0.003	(0.836)	0.015	(0.443)
a_{oo}	0.043***	(0.000)	0.039***	(0.000)	0.048***	(0.000)	0.042***	(0.000)	0.040***	(0.000)	0.041***	(0.000)
a_{og}	-0.025***	(0.010)	-0.022**	(0.025)	-0.022***	(0.002)	-0.030***	(0.006)	-0.027**	(0.033)	-0.019***	(0.001)
β_{os}	0.139	(0.105)	-0.020	(0.447)	0.317	(0.262)	0.007	(0.882)	0.018	(0.567)	0.300	(0.348)
β_{oo}	0.949***	(0.000)	0.950***	(0.000)	0.930***	(0.000)	0.944***	(0.000)	0.943***	(0.000)	0.948***	(0.000)
β_{og}	0.070***	(0.007)	0.063***	(0.010)	0.036**	(0.029)	0.093**	(0.040)	0.087***	(0.006)	0.075***	(0.002)
γ^g	0.015*	(0.082)	0.016**	(0.045)	0.027**	(0.000)	0.017**	(0.029)	0.016*	(0.063)	0.015***	(0.007)
a_{gs}	-0.023	(0.581)	0.002	(0.829)	-0.027	(0.271)	0.017	(0.197)	-0.004	(0.561)	-0.030***	(0.000)
a_{go}	-0.005	(0.319)	-0.007	(0.111)	-0.004	(0.598)	-0.007	(0.390)	-0.002	(0.672)	0.002	(0.534)
a_{gg}	0.044**	(0.019)	0.045***	(0.000)	0.058***	(0.000)	0.047***	(0.000)	0.041***	(0.002)	0.040***	(0.000)
β_{gs}	0.163*	(0.079)	-0.051*	(0.079)	0.080***	(0.000)	-0.078*	(0.068)	-0.019*	(0.058)	0.018	(0.661)
β_{go}	0.039**	(0.039)	0.036***	(0.005)	0.344***	(0.008)	0.037**	(0.031)	0.036**	(0.026)	0.035**	(0.040)
β_{gg}	0.931***	(0.000)	0.931***	(0.000)	0.909***	(0.000)	0.930***	(0.000)	0.931***	(0.000)	0.949***	(0.000)
ρ_{so}	0.029	(0.193)	0.077***	(0.000)	0.046***	(0.000)	0.110***	(0.000)	0.134***	(0.000)	0.061***	(0.000)
ρ_{sg}	-0.015	(0.480)	-0.001	(0.961)	-0.024***	(0.000)	0.010	(0.316)	0.000	(0.682)	0.000	(0.185)
ρ_{go}	0.241***	(0.000)	0.258****	(0.000)	0.237***	(0.000)	0.251***	(0.000)	0.258***	(0.000)	0.260***	(0.000)
θ_1	0.013***	(0.000)	0.015***	(0.000)	0.008***	(0.001)	0.022***	(0.005)	0.012***	(0.000)	0.025***	(0.008)
θ_2	0.973***	(0.000)	0.973***	(0.000)	0.994***	(0.000)	0.937***	(0.000)	0.977***	(0.000)	0.780***	(0.000)
LL	-13801.55		-14762.35		-14742.19		-16211.06		-16514.95		-16008.31	

Notes: This table presents the results of the DCC-GARCH model for all GCC countries. Panel A reports the return spillover parameters while Panel B reports the volatility transmission parameters between the three markets. The notation corresponds to the expositions in the method section. The subscript s denotes the stock market, o corresponds to the oil market and gold is represented by g; while $i, j = \{s, o, g\}$ is used to denote the direction of effects from one commodity to another and the case $i = j$ corresponds to own market mean (volatility) spillovers. In the mean equation $\forall i, j = \{s, o, g\}$, c^i are estimated constant terms, while ψ_{ij} is the estimated AR(1) coefficient that captures the return transmission from asset j to asset i. The ξ_{ij} parameters are the estimated coefficients of the structural-break-related dummy variables, and they reflect the contemporaneous effect of the break in asset j on the returns of asset i. In the variance equations in Panel B, γ^i represents constant terms, α_{ij} is the short-term volatility transmission from asset j to asset i for $i \neq j$ and own volatility effects that measure short-term persistence for $i = j$, while β_{ij} is the long-term volatility transmission from asset j to asset i for $i \neq j$ and own volatility effects that measure long-term persistence for $i = j$. Also ρ_{ij} is the expected value of the dynamic conditional correlations between asset i and j, while θ_1 and θ_2 examine the influences of last period's residuals and covariance on the current level of the covariance. The values in parentheses are p-values. The model is estimated by the quasi-maximum likelihood (QMLE) method which can be optimized by implementing the Broyden–Fletcher–Goldfarb–Shanno (BFGS) algorithm. LL is the log-likelihood function value.

*** Statistical significance at 1% level.

** Statistical significance at 5% level.

* Statistical significance at 10% level.

Table 5: Diagnostic tests on standardized residuals

	Bahrain		Oman		Kuwait		Qatar		Saudi Arabia		UAE	
	$Q(20)$	$Q^2(20)$	$Q(20)$	$Q^2(20)$	$Q(20)$	$Q^2(20)$	$Q(20)$	$Q^2(20)$	$Q(20)$	$Q^2(20)$	$Q(20)$	$Q^2(20)$
Stock	43.762***	16.283	32.248**	19.864	82.443***	12.126	75.257***	11.809	24.249	10.540	36.531**	9.161
	(0.001)	(0.698)	(0.040)	(0.466)	(0.000)	(0.911)	(0.000)	(0.922)	(0.231)	(0.957)	(0.013)	(0.980)
Oil	11.219	15.275	14.313	20.623	10.619	14.611	13.720	25.721	10.775	16.223	12.797	25.211
	(0.940)	(0.760)	(0.814)	(0.419)	(0.955)	(0.798)	(0.844)	(0.175)	(0.951)	(0.702)	(0.885)	(0.193)
Gold	18.902	15.926	18.986	22.896	18.522	10.230	18.970	18.307	18.342	19.567	19.479	21.135
	(0.528)	(0.721)	(0.522)	(0.293)	(0.553)	(0.963)	(0.523)	(0.567)	(0.564)	(0.485)	(0.490)	(0.389)

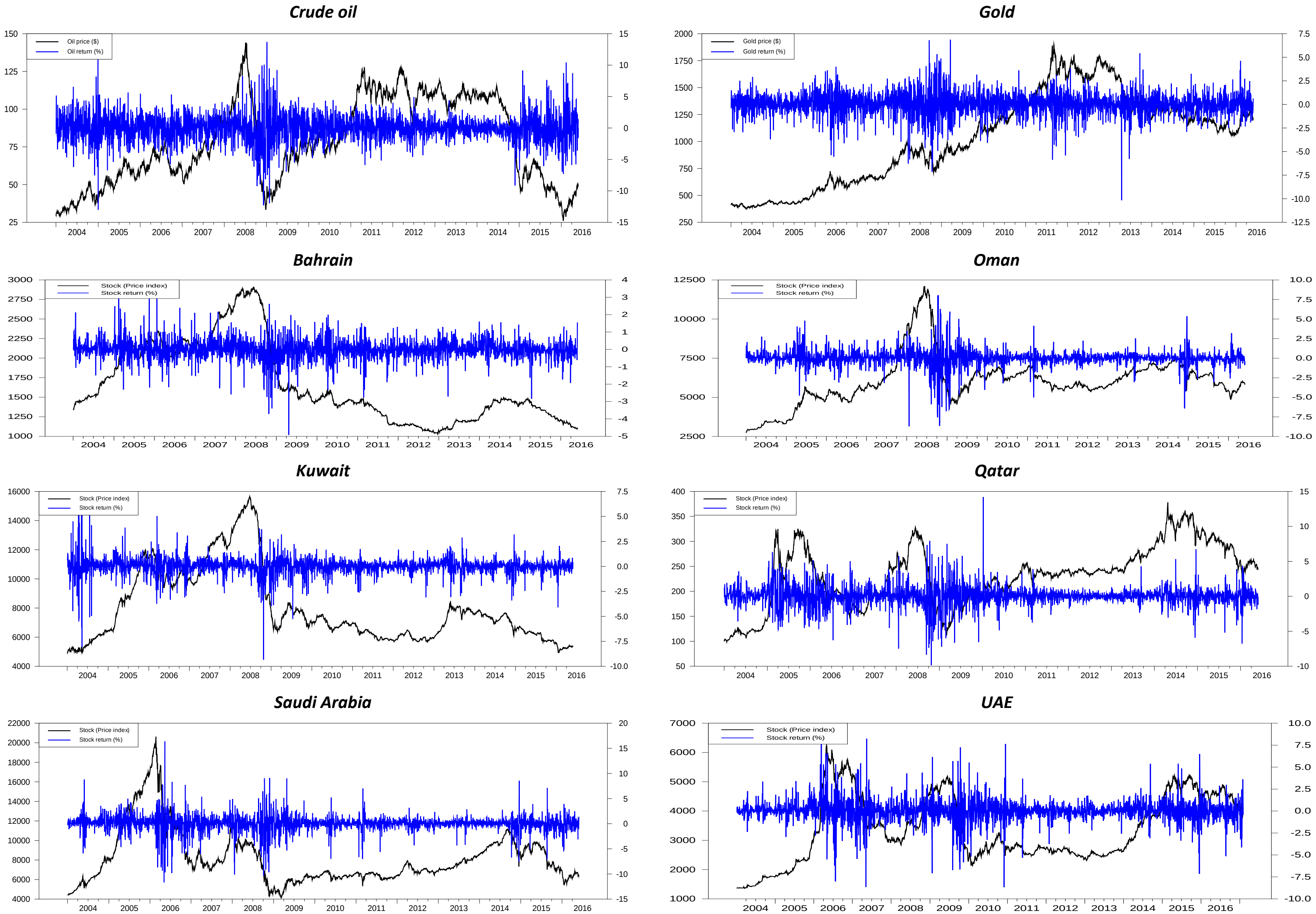
Notes: The table presents the $Q(20)$and $Q^2(20)$ Box-Pierce statistics for autocorrelations of the standardized residuals and the squared standardized residuals, respectively. The reported numbers in parentheses are *p*-values.
*** Statistical significance at 1% level.
** Statistical significance at 5% level.
* Statistical significance at 10% level.

Table 6: Hedge ratios and portfolio optimal weights

	Hedge Ratios		***Optimal Weights***	
	Stock/ Oil	Stock/ Gold	Stock/ Oil	Stock/ Gold
Bahrain	0.008	-0.007	0.079	0.202
Oman	0.043	0.005	0.130	0.310
Kuwait	0.018	-0.017	0.132	0.302
Qatar	0.064	0.017	0.274	0.493
Saudi Arabia	0.093	-0.004	0.286	0.534
UAE	0.060	0.021	0.242	0.435

Notes: This table presents the average hedge ratios and optimal portfolio weights between equities and the two commodities.

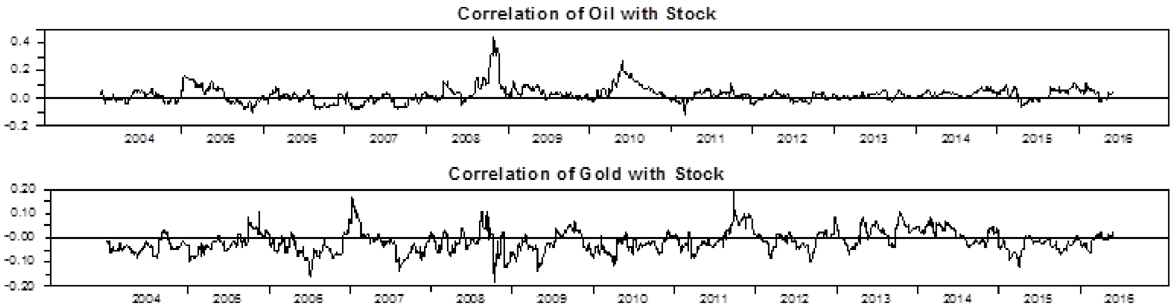
Figure 1: Time series plots of prices and returns



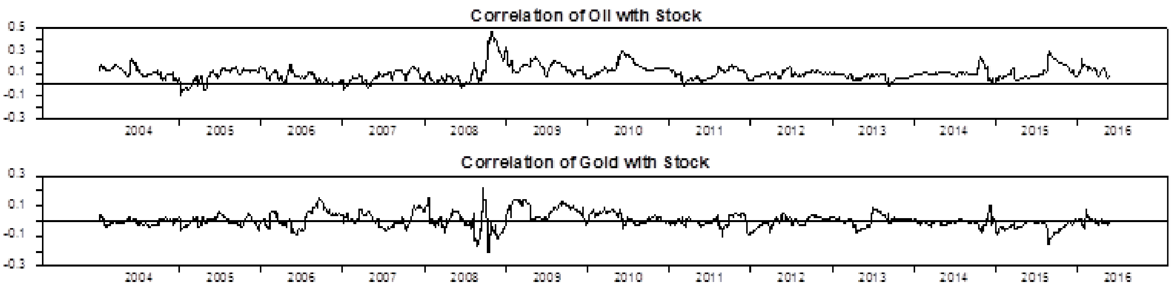
Notes: The figures plot the historical prices for the GCC stock indices and the oil and gold commodities (black lines), as well as the respective returns series (blue lines). Captions are self-explanative.

Figure 2: Dynamic conditional correlations from the DCC-GARCH model

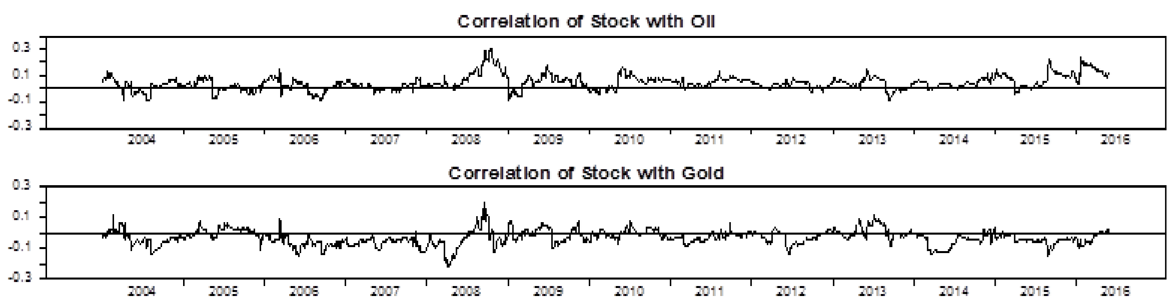
Bahrain



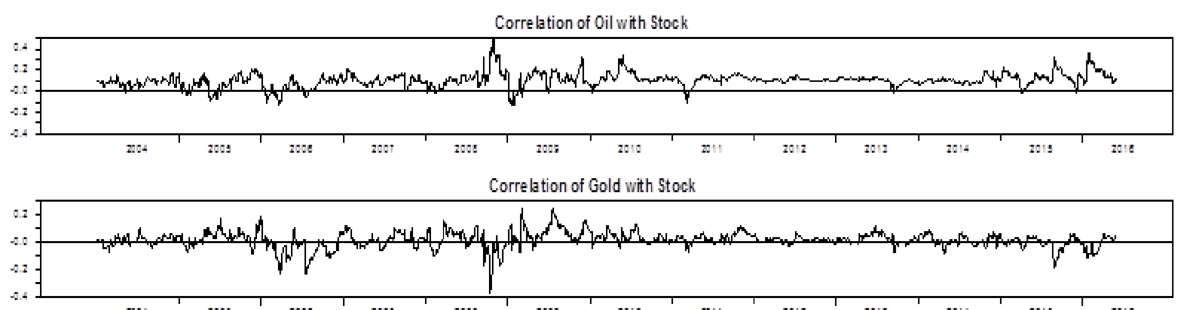
Oman



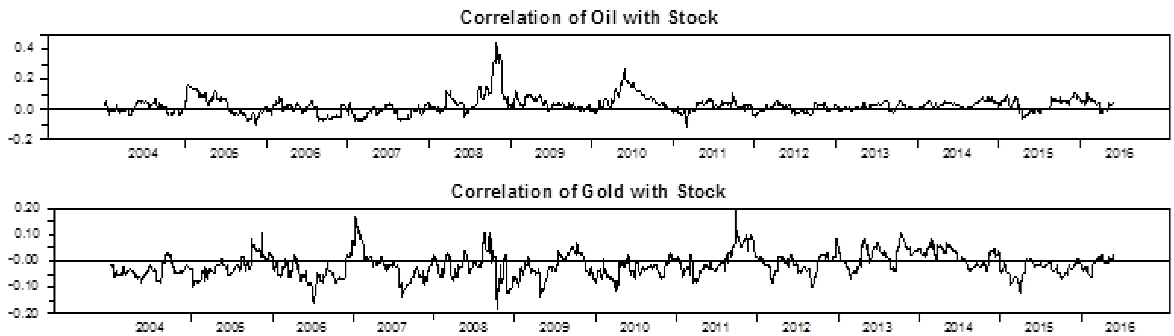
Kuwait



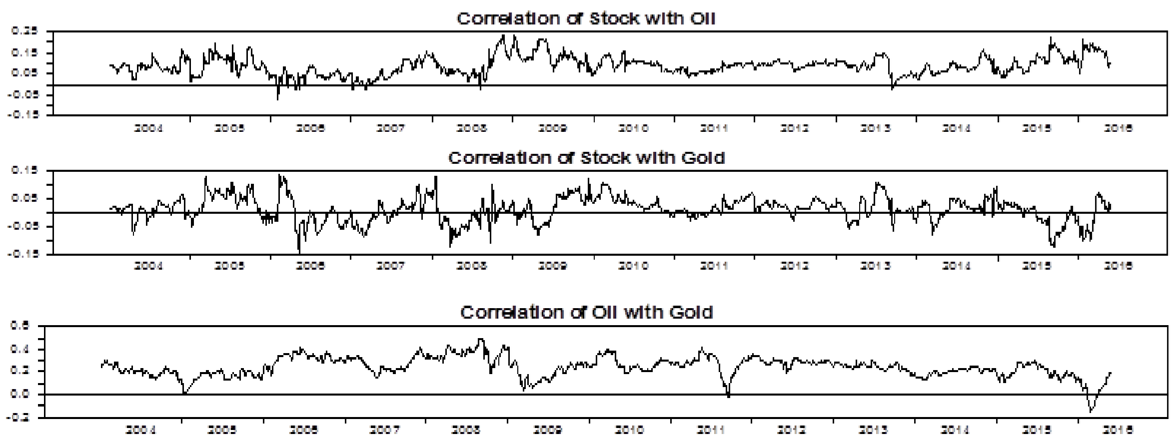
Qatar



Saudi Arabia



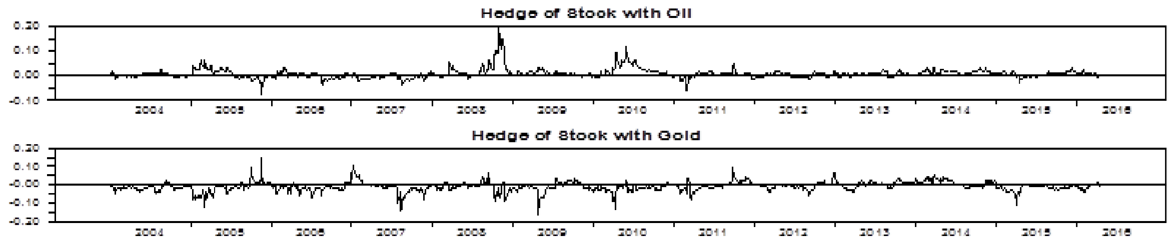
UAE



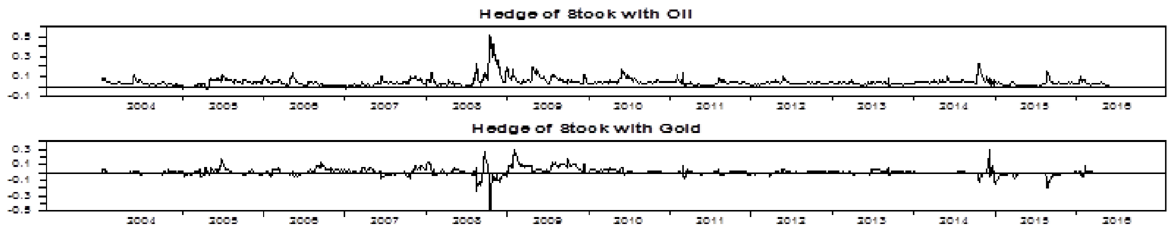
Notes: The figures plot the dynamic correlations between for the GCC stock indices and the oil and gold commodities, as well as the dynamic correlations between oil and gold..

Fig. 3: Time-varying hedge ratios

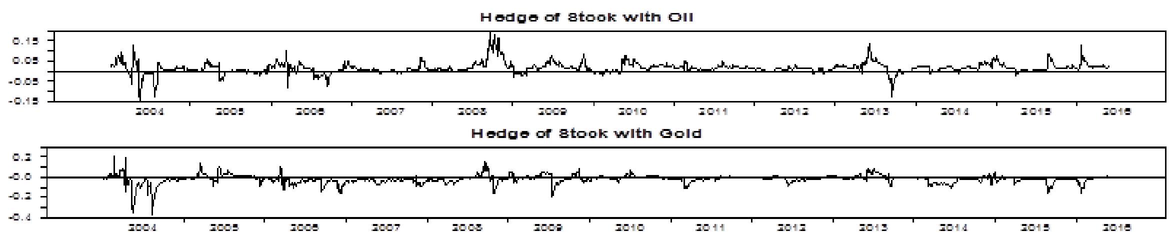
Bahrain



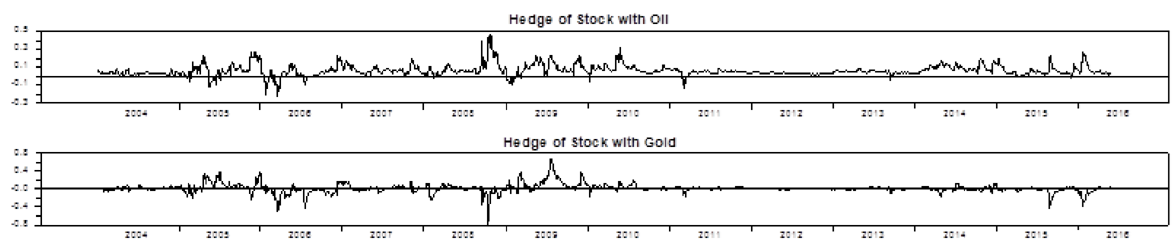
Oman



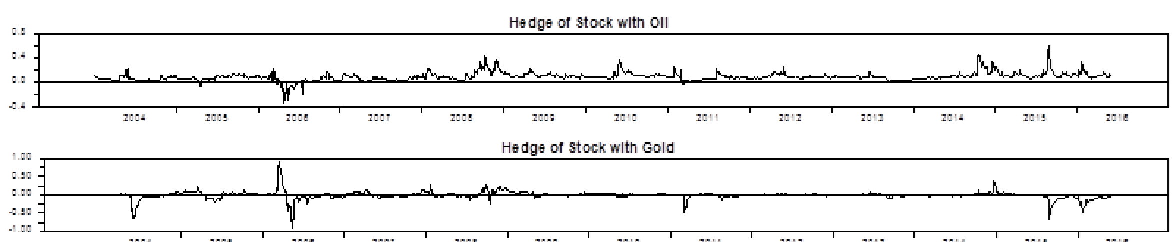
Kuwait



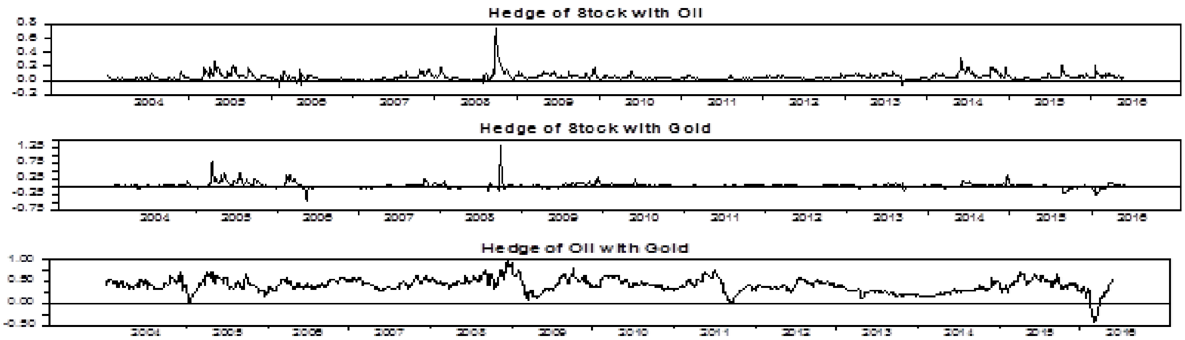
Qatar



Saudi Arabia



UAE



Notes: The figures plot the time-varying hedge ratios between for the GCC stock indices and the oil and gold commodities, as well as dynamic correlations between oil and gold.