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Time-varying transmission between oil and equities in the MENA region: New evidence from DCC-MIDAS analyses

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Abstract

In this paper we use the DCC-MIDAS (Dynamic Conditional Correlation-Mixed Data Sampling) model to infer the association between oil and equities in five MENA countries between February 2006 and April 2017. The model indicates that higher oil returns tends to reduce the long-term risk of the Saudi market, but to increase it in other markets. The risk transfer from oil to MENA equities is found to be weak. The dynamic conditional correlation between oil and equities is not always positive and it unexpectedly changes sign during the sample period. However, the association always strengthens when there is a large draw down in oil prices as well as during periods of high volatility. Finally, we find that short term association occasionally breaks from the longer-term correlation particularly in Egypt and Turkey. These patterns of influence and associations are unique, and have important implications for equity portfolio managers who are interested in investing in energy and MENA equities.

JEL classifications: G11; G12; G15

Keywords: GARCH-MIDAS; DCC-MIDAS; Risk transfer; Oil; MENA Equities

1. Introduction

It is widely believed that Middle East and North Africa (henceforth, MENA) economies are oil economies and that higher oil prices are good for equity markets' performance. In this paper we revisit the relationship between oil and equities in the MENA region using a recent sample and we show that the linkages between oil and equity returns occasionally breaks and even turns negative during certain time periods. This is unexpected particularly in oil producer countries where growth, spending and budgets are heavily dependent on oil. However, market inefficiency and underrepresentation of the energy sector in these countries' markets may provide a suitable explanation.

The recent booms and busts in the oil market has brought into the question of how the oil market information influence equities of both oil producers and non-oil producer countries. Theoretically, the transmission of influence between oil and equities may run in many directions. For instance, the rise in oil prices may affect company profit margins, cash flows, growth and risk depending on whether the company is a net producer or a net consumer of oil.[1] Oil prices may also affect inflation, inflation expectations, monetary policy and discount rates with direct implications on the cost of capital and company values. They also determine household disposable available to spend on non-energy items and in that sense, they affect company sales, cash flows and values. For all these reasons, a negative/positive oil supply shock is considered as bad/good news and is expected to reduce the value of equities, thus introducing a negative correlation between oil and equities in general.[2]

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[1] It also depends on whether the company can pass the oil price increase to the final consumer and on the competitiveness of the industry in which the company operates.

[2] If you are an oil producer, a negative shock means higher prices, profit margins and cash flows and hence correlation is expected to be positive.

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On the other side, global economic cycles influence the demand for oil and hence its prices and returns. During economic expansion/recession demand and prices of both oil and equities increases/decreases. The cyclicality of the value of both leads to positive association between oil and equity. Therefore, the direction of the linkages between oil and equities is not certain depending on whether oil prices are driven by a demand or a supply shock.

These interrelationships between oil and equities are also reflected in the varying empirical evidence recorded in the literature. For instance, the empirical evidence provided by Basher and Sadorsky (2006) in emerging markets and by Choi and Hammoudeh (2010a, 2010b) in the US markets show that oil and equities are positively correlated. On the other hand, Chen et al. (1986) find that the equity market is independent of the oil market. The studies by Kling (1985), Jones and Kaul (1996) and Huang et al. (1996) show that equities are negatively associated with oil.

To check the influence of oil on industry demand and supply Lee and Ni (2002) use a VAR model and find that a rise in the oil prices reduces the demand for cars and reduces the supply of refinery and petrochemical products. They conclude that the direction of association depends on the industry.[3] The global influence of oil on equities is examined by Driesprong et al. (2008) who find a negative association between oil prices and future equity returns in developed and emerging countries. They conclude that investors underestimate the influence of oil particularly in vertain sensitive sectors and oil related industries. The extend of return variation that can be explained by oil shocks is studies by Kilian and Park (2009) who find that a round 22% of the change in the US equity returns from 1975 to 2006 can be attributed to oil.

The literature on oil and equities also focus on risk transfer. The uncertainty in the oil market makes it difficult to predict company cash flows introducing uncertainty in equity values and markets. Hence, the oil-equity research also assesses volatility transmission and risk transfer between oil and equities. For instance, Malik and Ewing (2009) show that there is significant risk transfer from oil to equities in the financials, industrial consumer services, and health care and technology sectors in the US markets. Similarly, Arouri et al. (2011) find significant volatility cross over from oil to equities in Europe and the US. In their study, the transmission of risk from equities to oil is found to be minor and insignificant. Similarly, Vo (2011) finds significant volatility spillover from oil to equities. A long the same line Park and Ratti (2008) and Arouri et al. (2012) show that the risk transfer from the oil market to the equity markets to be asymmetric across economic sectors. The weaker transfer is found to be in less competitive sectors, in sectors that are less energy dependant and in sectors that can pass any price increases to final consumers.

In the MENA region, Malik and Hammoudeh (2007) report significant transmissions of oil volatility to equity volatilities. Similarly, Awartani and Maghyereh (2013), Awartani et al. (2013) and Maghyereh et al. (2015) show that volatility connections and news transmission have intensified following the global financial crisis in 2008. They also show that cross overs of volatility information from MENA equities to the oil market is weak and insignificant.

The methodologies used in these studies are numerous and vary from using multivariate GARCH models to the use of variance decomposition models as in Diebold and Yilmaz (2009).[4] In these specifications the volatility process is modelled as one short term component and mostly at the daily or weekly frequency. Therefore, these models fail to differentiate between the myopic short-term risk and association that depends on short lived market fluctuations and the longer-term fundamental risk and correlation which is determined by the macroeconomic fundamentals of the economies and the markets involved.

For instance, in the context of these models it is not possible to measure the influence of the oil factor returns and volatility on the long-term volatility of equity markets. In the same way, the models will not be able to differentiate between short and long-term linkages that rest on the economics of oil and equities. This is important information as portfolio managers have varying investment horizons and would like to assess long and short-term diversification of portfolios that are composed of oil and equities.

Therefore, in this paper we contribute to the literature on oil equity relationship by using a mixed data sampling approaches that differentiate between the short term and long-term components of volatilities and correlations. Specifically, we use a GARCH-MIDAS (Mixed Data Sampling) model introduced by Engle et al. (2013) in which daily volatility is specified as a short term and a long-term component whereby the long-term component depends oil and oil volatility. From this model it is possible to infer the influence of oil and oil volatility on the risk of equity markets.[5] Then, we use a Mixed Data Sampling Dynamic Conditional Correlation (DCC-MIDAS) model introduced by Colacito et al. (2011) to investigate long and short term dynamic correlations between oil and equities and our contribution here is to provide the first evidence on long and short-term links between oil and equities in five MENA countries.

The estimated models show some interesting results on the association of oil and equities in the MENA region. The GARCH-MIDAS model shows that oil returns tend to reduce the long-term volatility of Saudi equities and to increase it in other countries. It also shows that risk transfer from oil to equities is weak. The volatility in the oil market is not an important determinant of the volatility in MENA equities. The DCC-MIDAS model's dynamic conditional correlations indicate that long and short-term correlations between oil and equities in the MENA

[3] Similarly, many studies have reported that the influence is not uniform and different industries shows different sensitivity to oil. For example, see Hamilton (1988), Dhawan and Jeske (2008) and Edelstein and Kilian (2007, 2009).

[4] Choi and Hammoudeh (2010a, 2010b) have used various switching volatility regime process and dynamic conditional correlations to make their inference.

[5] The oil factor here is used as a proxy of the economic activity in oil producing countries and the MENA region in general. In that sense it stands for GDP.

regions are relatively strong and mainly positive. However, this is not uniform across the whole sample period and there are periods when correlation weakens and eventually become negative. Moreover, short term association occasionally breaks and deviate substantially from the longer-term association. Finally, we find that the dynamic correlations eventually strengthen and reach high levels right after big drawdowns in oil prices.

The rest of the paper is organized as follows: in Section 2 we discuss the GARCH-MIDAS and DCC-MIDAS methodologies that are used to infer the association between oil and equities. Section 3 contains a description of the data set and some preliminary statistics of time series of returns included in the study. Also, in this section we discuss and explain the empirical findings of the models. Finally, in Section 4 we write some concluding remarks.

2. Methodology

2.1. GARCH-MIDAS

We study the two-component volatility and pairwise correlation patterns between MENA stock markets and oil market using two component GARCH-MIDAS and DCC-MIDAS models. To setup notations, assume log returns on all price series (stock or oil) on day i in month t are $r_{i,t} = \mu_i + \sqrt{\tau_t g_{i,t}}\varepsilon_{i,t}$ where $\varepsilon_{i,t}|\Phi_{i,t-1} \sim N(0, 1)$ and $\Phi_{i,t-1}$ is the information filtration until day $i-1$ in period t. GARCH-MIDAS decomposes asset's total variance into a short-run component $g_{i,t}$ and a long-run component τ_t as described in Engle et al. (2013): $\sigma^2 = \tau_t g_{i,t}$.

In their model, short run volatility component follows a unit GARCH process:

$$g_{i,t} = (1-\alpha-\beta) + \alpha\frac{\left(r_{i-1,t}-\mu_i\right)^2}{\tau_t} + \beta g_{i-1,t} \quad (1)$$

where $\alpha > 0$, $\beta \geq 0$ and $\alpha + \beta < 1$.

The trend/secular variance component is the smoothed realised volatility in a MIDAS regression:

$$\log(\tau_t) = \theta_0 + \theta_1 \sum_{k=1}^{K_v} \phi_k(\omega_1, \omega_2)\, RV_{t-k} \quad (2)$$

where $RV_t = \sum_{i=1}^{N} r_i^2$, $N = 22$ to approximate monthly realised volatility, and K_v lags are kept to 12 months in our estimations.[6] We employ fixed span monthly realised volatility, RV_t, in the estimation of long run volatility component, which keeps secular component unchanged during month t. We adopt log specifications ensuring the non-negativity of the conditional variances across all models.

The long-term volatility of daily returns in Eq. (2) is expressed as a weighted average of lower-frequency financial and/or macroeconomic variables using the flexible beta smoothing function. We utilise different MIDAS lag years to span MIDAS polynomial specification for the long run variance component i.e. τ_t and reported estimations use one year MIDAS lag to impute monthly trend component.[7] This beta-polynomial in MIDAS filter is specified:

$$\phi_k(\omega_1, \omega_2) = \frac{(k/K_v)^{\omega_1-1}(1-k/K_v)^{\omega_2-1}}{\sum_{j=1}^{K_v}(j/K_v)^{\omega_1-1}(1-j/K_v)^{\omega_2-1}} \quad (3)$$

On the properties of the chosen beta-polynomial structure, we refer interested reader to Ghysels et al. (2005).

In our estimations following Engle et al. (2013) and Conrad and Loch (2015), we fix the weight ω_1 to one. This results in a restricted version of above weighting function: $\phi_k(\omega_2) = \frac{\left(1-k/K\right)^{\omega_2-1}}{\sum_{j=1}^{K}\left(1-j/K\right)^{\omega_2-1}}$. Conrad et al. (2014) report that restricted smoothing scheme is more flexible than unrestricted version and allows for hump-shaped decaying pattern. For all estimated values for $\omega_2 > 1$, wesighting scheme ensures a decaying pattern whereas size of ω_2 determines speed of decay: large (small) values of ω_2 generate an accelerating (decelerating) decaying pattern.

For keeping a restricted version of beta weighting scheme, parameter space $\Theta = \{\mu, \alpha, \beta, \theta_0, \theta_1, \omega_2\}$ for Eq. (2) represents the baseline GARCH-MIDAS model in our work. The baseline MIDAS framework filters a fixed RV for the Saudi stock or oil market to estimate long run variance. As we expand the GARCH-MIDAS model with the level and variance of oil market in the estimation of two-component volatility for Saudi stock market, the parameter space changes accordingly. For example, as we include oil returns in the MIDAS component the parameter space become $\Theta = \{\mu, \alpha, \beta, \theta_0, \theta_1, \theta_2, \omega_2\}$, where θ_2 is coefficient estimate on oil returns. Analogously any additional variables will expand the parameter space through the long-run component in our estimations.

Using estimated decay pattern through estimated ω_2 input variables are filtered to yield long run variance component.

2.2. DCC-MIDAS

Consider a return vector compricing n assets i.e. $\boldsymbol{r_t} = \left[r_{1,t}, r_{2,t}, \ldots, r_{n,t}\right]$ which follows the process: $\boldsymbol{r_t} \sim N(\mu, H_t)$. The conditional covariance matric of the n assets is specified $\mathrm{H_t} \equiv \mathrm{D_t} R_t \mathrm{D_t}$ where $\mathrm{D_t}$ is a diagonal matrix with the conditional volatilities and R_t is the conditional correlation matrix of the standardized return residuals $\xi_{Saudi,k}$ and $\xi_{Oil,k}$ retrieved from GARCH-MIDAS specifications for return series of stock market and oil market.

In order to compute short run and long run correlatin components of stock market and oil market in the spirit of Colacito et al. (2011) DCC-MIDAS model, we use the above noted standardised residuals to estimate Q_t component of the correlation

[6] Our results for GARCH-MIDAS specification are insensitive to selection of 12, 24 or 36 months for K_v lags. However, to have larger time-series predictions, we report results using 12 lags.

[7] MIDAS variance smoothing filter can be applied to more than one input variable (see Engle et al. 2013; Virk and Javed, 2017; among others).

matrix. In this step, we estimate conditional correlation matrix applying Qt: $R_t = diag(Q_t)^{-1/2} Q_t diag(Q_t)^{-1/2}$.

Keeping intact with our GARCH-MIDAS setup, where long run variance component only changes at low frequency and stays constant at daily frequency, transitory correlation component in the DCC-MIDAS also moves around the secular correlation component:

$$q_{i,t} = \bar{\rho}_{i,t}(1 - a - b) + a\xi_{Saudi,i-1}\xi_{Oil,i-1} + bq_{i-1,t} \quad (4)$$

where $\bar{\rho}_{i,t}$ is the slow moving secular correlation component given by DCC-MIDAS framework of Colacito et al. (2011). To maintain distinction, the DCC-MIDAS weighting scheme is referred by $\delta_k(\omega_1, \omega_2)$ which maintains the same smoothing structure as we have in equation (3). The long run correlation component $\bar{\rho}_{i,t}$, using the restricted $\delta_k(1, \omega_2)$ smoothing structure, is a weighted average of K_l past realised correlations c_{t-l}:

$$\bar{\rho}_{i,t} = \sum_{l=1}^{K_c} \delta_k(1, \omega_2) c_{t-l} \quad (5)$$

and

$$c_t = \frac{\sum_{k=t-N_c}^{t} \xi_{Saudi,k}\xi_{Oil,k}}{\sum_{k=t-N_c}^{t} \xi^2_{Saudi,k} \sum_{k=t-N_c}^{t} \xi^2_{Oil,k}} \quad (6)$$

3. Data set and empirical results

3.1. Data set

To investigate the linkages between oil and MENA equities, we use daily data on WTI crude oil prices and the equity market indexes of five MENA countries. These countries are Saudi Arabia, the Emirate of Abu Dhabi, Oman, Egypt and Turkey. All indexes are value weighted and all data is retrieved from Thomson Reuters DataStream. The sample covers the period that extends from the 1st of April 2006 to the 24th of May 2017 for a total of 1995 trading days. From the original data set, we get the continuously compounded returns by taking the logarithmic first differences of each series. From the high frequency we draw monthly oil returns computed from the 15th of each month to the 15th of the following month to be used in the long-term variance equation of the GARCH-MIDASX model. This has resulted in 169 monthly oil returns observations.

Table 1 reports the summary statistics of the indexes and the oil returns time series. The table shows that all markets including the oil market have not grown and that the average continuously compounded returns is around zero in all markets. Following the big rally in oil prices from 2006 to 2008, crude oil prices has reverted to its initial level over the sample period. There is a slight drop in the price of oil, the Saudi market index and the Abu Dhabi market index while there is a tiny increase in the prices of Omani, Egyptian and Turkish equities. The Standard deviations reflect a higher volatility in the oil market compared to the rest of markets which exhibits lower levels of risk. The volatility of the oil market is 140 basis points higher than the Omani market and it is 80 basis point higher than the Saudi and Egyptian markets. The volatilities in the various equity markets are similar except for the Omani market which is relatively less volatile. The market has also shown less range of returns at around 16%. The daily rallies and drawdowns is highest in the Abu Dhabi equity market with daily ups and downs of 39% and 36% respectively.

As expected all equity markets have shown negative skewness thus indicating that the volatility during the drop of the market is greater than during its rise.[8] The skewness of the oil market is positive which implies that the oil market is more exposed to positive surprises than its exposure to negative shocks. This may reflect the supply shocks to the oil market due to new technologies and the geopolitical circumstances in the Middle East during the sample period.[9] There is excess kurtosis in all return series. The skewness and the excess kurtosis have led to non-normal returns and hence, the Jarque-Bera statistics rejects the hypothesis of normal returns at conventional levels.

Table 1 also reports the Ljung-Box portmanteau statistics for the last two and four weeks of returns. As can be seen in the table all indexes are serially correlated indicating the presence of temporal dependence in the return series. The results of the unit root test for the indexes are reported in the last two columns of Table 1. The null hypothesis of the ADF test is that there is a unit root in the variable. As can be seen in the table both the Dicky Fuller and Phillips Perron unit root tests show that oil and equities are all stationary at the 5% significance level.

Table 2 reports simple daily correlations between oil and equities. In panel A we report returns correlations and in Panel B we report volatility correlations.[10] As can be seen in the table the risk linkages between oil and equity markets are generally higher than return associations. In Panel A, the highest return correlation is 20% with Turkish equities. It is then followed by the correlation with Saudi equities at 10%. This can be explained by the fact that the Turkish economy is relatively large in the area and it is classified as one of the most energy intensified economies of the MENA region. Similarly, the Saudi Arabian economy is heavily dependent on oil but as a major oil producer rather than a consumer. Panel B shows that there is some risk association in all markets particularly in the Turkish and Saudi markets. But the highest risk correlation is with the Omani market where the correlation between oil volatility and Omani equity volatility is found to be around 22%.

3.2. Empirical results

As mentioned previously, the short-term component of volatility is estimated using Eq. (1), the long-term component is measured using (3) and the conditional volatility is the product of the two components.

[8] The exception is the Abu Dhabi equity market which exhibits positive skewness and a lot of kurtosis compared to the rest of markets.

[9] The sample period witnessed the Arab Spring. Moreover, it witnessed new technologies such as shale oil production and fracking.

[10] We measure volatilities simply by squared returns.

Table 1
Descriptive statistics.

	Oil	Saudi Arabia	Abu Dhabi	Oman	Egypt	Turkey
Mean	−0.0001	−0.0003	−0.000014	0.000009	0.000186	0.000236
Std. Dev.	0.024	0.016	0.015	0.010	0.015	0.016
Maximum	0.167	0.16	0.39	0.080	0.092344	0.12
Minimum	−0.12	−0.11	−0.36	−0.080	−0.171978	−0.11
Skewness	0.12	−0.64	1.22	−1.06	−1.075354	−0.28
Kurtosis	4.74	11.96	257.97	17.86	9.17	4.13
Jarque-Bera	2778***	17,569***	8,080,891***	39,322***	10793***	2110***
Q(10)	29.31***	51.56***	59.86***	163.62***	114.18***	18.22**
Q(20)	39.98***	76.89***	81.73***	232.48***	129.93***	32.30**
ADF	−55.61***	−49.67***	−61.28***	−43.45***	−45.43***	−53.01***
PP	−55.67***	−49.68***	−61.60***	−42.93***	−45.60***	−53.02***

Notes: Q(k) is the Ljung–Box statistics for serial correlation in the squared returns computed with k lags. ADF, and PP are the empirical statistics of the Augmented Dickey and Fuller and the Phillips and Perron unit root tests.
*** $p<0.01$.
** $p<0.05$.

Table 2
Correlation matrices.

	Oil	Saudi Arabia	Abu Dhabi	Oman	Egypt	Turkey
Panel A: returns correlations						
Oil	1.00					
Saudi Arabia	0.11	1.00				
Abu Dhabi	0.05	0.28	1.00			
Oman	0.09	0.21	0.31	1.00		
Egypt	0.09	0.23	0.22	0.24	1.00	
Turkey	0.20	0.17	0.11	0.12	0.20	1.00
Panel B: volatility correlations						
Oil	1.00					
Saudi Arabia	0.15	1.00				
Abu Dhabi	0.12	0.28	1.00			
Oman	0.22	0.30	0.25	1.00		
Egypt	0.12	0.21	0.17	0.23	1.00	
Turkey	0.14	0.17	0.13	0.17	0.18	1.00

In Table 3 we report the parameter estimates of the GARCH-MIDAS specification in the 5 MENA countries under investigation. The table reports the parameter estimates and the t statistics of three GARCH-MIDAS models. In the first model it is assumed that all the relevant macroeconomic information needed to measure the long-term variance is captured by realized volatility over the last three years and therefore the model includes only previous realized volatility. In the second model we include oil returns as an additional factor. The parameter associated with this factor is of interest to our study as we focus on how oil influence the long-term variance of equities in the MENA region. Finally, we estimate a model that includes oil returns and oil volatilities as explanatory variables. To get much of macroeconomic information the realized volatility used in the long-term variance equation is computed as the average of a 3-year rolling sample of monthly realized volatilities.

Model 1 in Table 3 reports parameter estimates when the oil information is not included in the determination of long term volatility. The parameters associated with realized volatility (θ_1) are positive and significant indicating that realized volatility influences the long-term variance of equities particularly in Saudi Arabia, Egypt and Turkey.[11] The level of the unconditional long-term variance (θ_0) is highest in Oman and Abu Dhabi and it is lowest in Turkey. The parameters of the long-term volatility process sum to more than 0.5 in all countries and thus the long-term risk is not mean reverting.

The short-term volatility process is persistent. The sum of $(\alpha+\beta)$ ranges from 91% in Turkey to 99% in Saudi Arabia. Furthermore, different countries require different weighting structure for the model to converge. The weights are relatively high in the oil importing countries compared to oil exporters. For instance, the weights for Egypt and Turkey are 1.37 and 2.83 while the weights are around 1 in Saudi Arabia, Oman and Abu Dhabi. All weights are significant at conventional levels.

In the study of Engle et al. (2013) it is reported that the long-term volatility may have multiple components and that the realized volatility component may needs to be supplemented by other macroeconomic information particularly those that are

[11] Realized volatility is insignificant in affecting long term risk in Oman and Abu Dhabi.

Table 3
Parameter estimates for the GARCH-MIDAS model (using one MIDAS lag year).

	Saudi Arabia	Abu Dhabi	Oman	Egypt	Turkey
Model 1					
μ	0.106	0.043	0.031	0.123	0.110
	(6.265)	(2.907)	(3.220)	(5.150)	(4.480)
α	0.144	0.212	0.173	0.111	0.104
	(12.284)	(13.060)	(13.10)	(10.72)	(8.056)
β	0.834	0.787	0.824	0.831	0.818
	(71.138)	(48.380)	(74.045)	(56.790)	(34.270)
θ_0	0.574	6.320	1.710	0.754	0.544
	(1.961)	(9.670)	(0.608)	(5.340)	(4.944)
θ_1	0.008	0.0011	0.006	0.0046	0.0068
	(6.240)	(0.764)	(1.560)	(2.540)	(4.850)
ω_2	1.068	1.0001	1.000	1.370	2.830
	(4.305)	(1.443)	(8.25E08)	(1.730)	(3.004)
Model 2					
μ	0.100	0.043	0.031	0.099	0.099
	(5.890)	(2.960)	(3.170)	(4.190)	(4.045)
α	0.146	0.207	0.170	0.112	0.104
	(12.227)	(11.500)	(12.830)	(10.760)	(8.028)
β	0.830	0.792	0.819	0.832	0.814
	(70.356)	(43.900)	(70.740)	(59.870)	(33.140)
θ_0	0.558	5.720	0.394	0.683	0.505
	(2.093)	(5.830)	(0.521)	(4.580)	(4.540)
θ_1	0.008	0.0021	0.0097	0.0057	0.007
	(6.470)	(1.140)	(2.680)	(2.860)	(5.070)
θ_2	−4.126	7.650	9.180	3.760	1.570
	(−1.921)	(2.460)	(3.640)	(2.211)	(1.590)
ω_2	1.274	1.000	1.000	1.160	3.400
	(6.408)	(8.25E08)	(8.25E08)	(2.670)	(2.680)
Model 3					
μ	0.100	0.044	0.0308	0.099	0.099
	(5.889)	(3.073)	(3.180)	(4.25)	(4.040)
α	0.145	0.211	0.170	0.115	0.104
	(12.156)	(13.530)	(12.890)	(10.150)	(8.010)
β	0.831	0.787	0.819	0.823	0.816
	(70.047)	(50.450)	(70.960)	(44.900)	(33.100)
θ_0	0.520	3.39	0.504	0.810	0.500
	(1.927)	(1.810)	(0.634)	(7.660)	(4.480)
θ_1	0.007	7.46E-08	0.0128	4.54E-09	0.006
	(4.684)	(5.42E-05)	(2.548)	(4.88E-06)	(4.490)
θ_2	−3.465	14.360	8.320	0.900	1.770
	(−1.507)	(5.130)	(3.050)	(2.230)	(1.740)
θ_3	6.918	69.880	−13.59	17.440	2.74
	(0.732)	(5.5400	(−0.873)	(6.720)	(0.579)
ω_2	1.312	1.000	1.000	89.94	3.320
	(6.101)	(8.25E08)	(8.25E08)	(0.433)	(2.670)

Notes: The numbers in the parenthesis are robust t-stats computed with HAC standard errors.

related to business cycles. As business booms and busts in the MENA region depend on oil we use the oil factor as a proxy for economic cycles. Model 2 in Table 3 reports the estimates of the GARCH-MIDAS when oil returns are included as an additional explanatory variable of long term volatility. The parameter associated with oil which shows its influence on the long-term variance is (θ_2) is found to be negative and significant in the Saudi market and positive and significant in the rest of markets. This indicates that the price of crude oil is an important component in the determination of the long-term volatility in MENA countries.

Specifically, the model shows that the long-term risk in the Saudi equity market tends to be higher/lower with poor/good performance of the oil market. This is intuitive for a major oil producer that produces and controls a relatively large proportion of global oil production and reserves such as Saudi Arabia. A good performance of oil will confirm company values and reduces uncertainty in the market.[12] The model also shows that oil market performance increases the long-term risks of the Egyptian and Turkish equity markets and this is also intuitive as

[12] In the sense of confirmed expenditures and company cash flows.

both countries are net importers of oil with Turkey being classified as an energy intensive economy.[13] There is more uncertainty regarding the future performance and values of companies in Egypt and Turkey when oil prices are high and this in turns raises the level of long term risk in these markets.

The two markets for which the results are quite puzzling are Abu Dhabi and Oman. In the two markets, the level of long term volatility is positively related to the oil price even though the two countries are oil producers and have economies that thrive and stagnate with oil. The estimates here are counter-intuitive as one would expect that oil booms will reduce the risks of investing in both markets. A potential explanation lies in the low level of liquidity and stale prices in these two markets particularly when oil prices are low. Hence, during periods of low oil prices, the volatility in these markets is downward biased due to the lack of trading. As the oil market booms liquidity and trading picks up as well as the volatility in these markets.[14]

Note that in Model 2 of Table 3 the realized volatility is positive and significant in almost all countries indicating a good capture of the macroeconomic environment. Similarly, all weights are significant and for the model to converge different weights are used to generate the long-term estimates of volatilities in different countries.

Model 3 of Table 3 adds the oil returns and oil volatility as additional variables in the GARCH-MIDAS model to see if there is a long-term risk transfer from the oil market to equity markets. The parameter θ3 is associated with the oil volatility and it is not significant in all countries except in Abu Dhabi and Egypt that exhibit significant risk transfer from oil to equities. This indicates weak long-term risk transfer from oil to equities. While the long-term volatility of equities in the MENA region depends on the oil market performance, they are largely independent from the long-term oil volatility. The result here is on the opposite side of many studies that have shown volatility transmission from oil to equities.[15] However, these studies are only concerned with short term transmission of information and volatility at the daily level and our result concern the longer-term risk transfer from oil to equities. In that respect we provide another perspective on the risk transfer from the oil market to equity markets.

The standardized residuals of Model 1 which only uses realized volatility are carried forward to the DCC-MIDAS model that is subsequently employed to generate short term and long term dynamic conditional correlations between oil returns and equity returns. The estimated parameters of the model are reported in Table 4. As can be seen in the table all parameters including the weights that are required to achieve convergence are significant at conventional levels. The short-term correlation estimates are highly persistent across all markets. The value of $a+b$ is around 1 in all markets except the Omani market which shows the least persistence.

Table 4
Parameter estimates for the DCC-MIDAS model (with 2-MIDAS lag years).

	Saudi Arabia	Abu Dhabi	Oman	Egypt	Turkey
a	0.010	0.005	0.024	0.0143	0.022
	(12.070)	(1.040)	(3.780)	(3.490)	(4.075)
b	0.989	0.994	0.796	0.979	0.966
	(1858.590)	(381.130)	(11.830)	(108.000)	(75.330)
ω_2	6.030	4.400	2.089	1.050	2.310
	(5.96E06)	(4.63E05)	(10.440)	(1.560)	(1.710)

Notes: The numbers in the parenthesis are robust t-stats computed with HAC standard errors.

To depict the short term and long-term integration of MENA markets with the oil market we graph estimated short and long-term correlations during the sample period in Fig. 1. As can be seen in the figure, countries on average exhibit a positive association with oil in the short as well as in the long run. The correlation is highest in the largest three economies of Saudi Arabia, Turkey and Egypt and it is lowest in Abu Dhabi and Oman. The linkages have fluctuated heavily during the sample period with episodes of strong and weak correlations. The pattern of association is similar in all sample countries. For instance, in the run up to the financial crisis the markets are negatively correlated with oil. However, these linkages strengthen and become positive during and after the global financial crisis in 2008 and it stayed positive till the start of the global recovery in 2013. Thereafter linkages weaken to strengthen back with the bust in the oil market in 2014 and till the end of the sample in 2017. The pattern is uniform across all countries in the sample.

The main evidence to carry from these graphs is that linkages with oil is changing and can be negative even for oil producing countries such as Saudi Arabia, Abu Dhabi and Oman. A possible explanation lies in the quick response of the oil market to the economic fundamentals of the global economy and the lag of response of equity markets. Moreover, the nature of association does not differentiate between oil importers such as Turkey and/or oil exporters such as Saudi Arabia. The oil importer countries are also positively related to oil.

The graph also shows that the short-term linkages occasionally deviate from the long-term association particularly in oil importer countries.[16] For instance, the association graphs of Turkey and Egypt display a break of short term correlation from the long-term association during 2008, 2010 and 2013. Simply, the short-term association vanishes, and it becomes even negative during these time periods despite the longer term positive correlation.

[13] The Turkish economy consumption of oil per unit of output is among the highest in the MENA region. For more information, see Yalcin et al. (2014).

[14] Note also that the energy sector in both countries is not traded as it is publicly owned by the government and this weakens the linkages with oil. Moreover, equity trading depends on institutional investors with increased presence during oil booms.

[15] See for instance, Malik and Hammoudeh (2007), Maghyereh et al. (2015), Malik and Ewing (2009) and Arouri et al. (2011) among many others.

[16] This is reflected in higher equilibrium weights in GARCH-MIDAS model of these countries as mentioned previously.

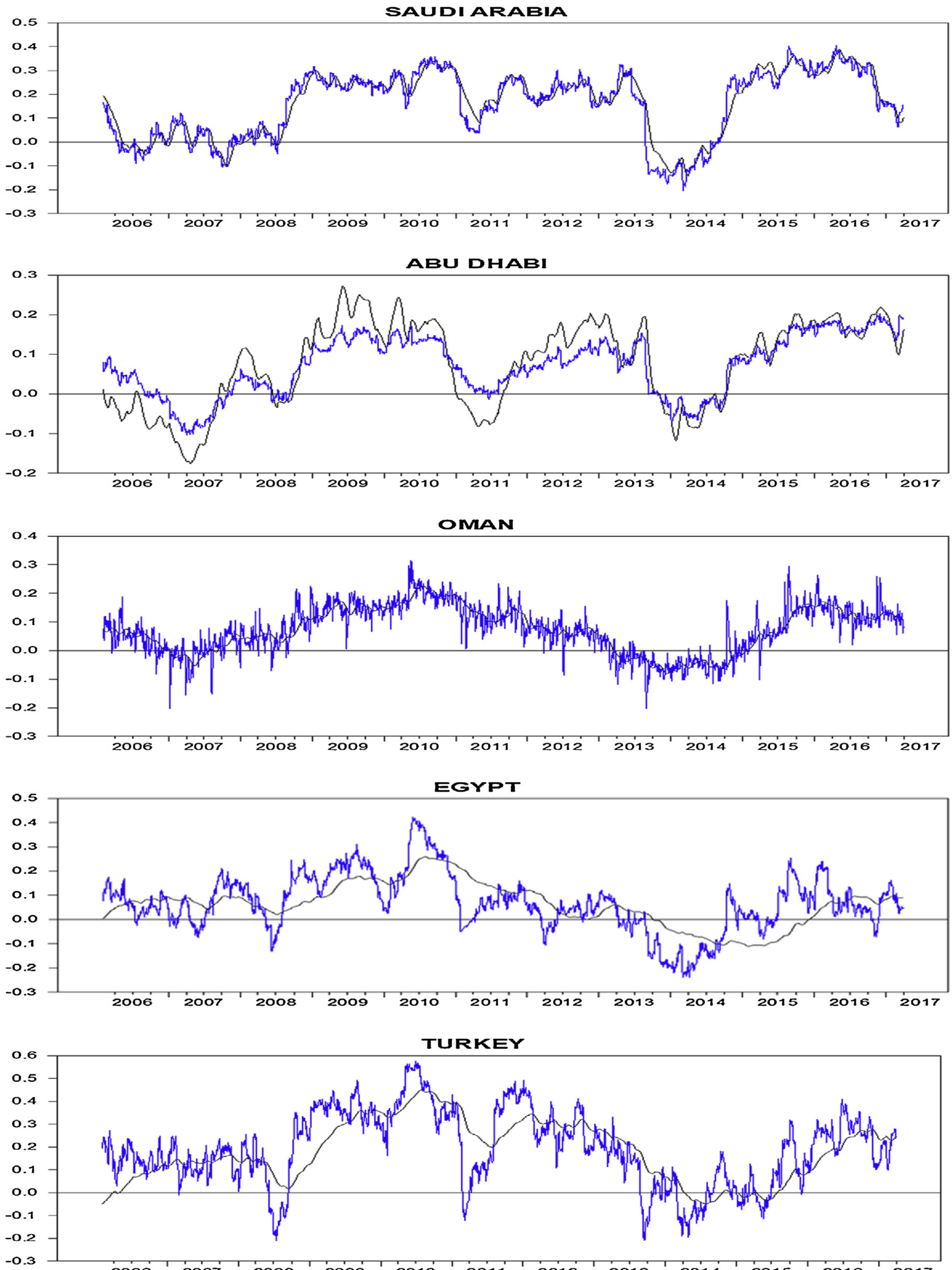

Fig. 1. Estimated short and long-term correlations of crude oil prices and equities in the MENA Region.
Notes: The blue line refers to the long-term correlations, while the black line represents short-term association.

To see how association changes with the oil prices, we graph a polygon of correlations against crude oil prices in Fig. 2. The left scale represents the crude oil price while the right scale measures the dynamic conditional correlations. The blue polygon is the long-term correlations, while the black is the short-term association. During the big rally of oil prices right before the global meltdown in 2008 the correlations between oil and equities are tiny and positive but tend to change sign in the three

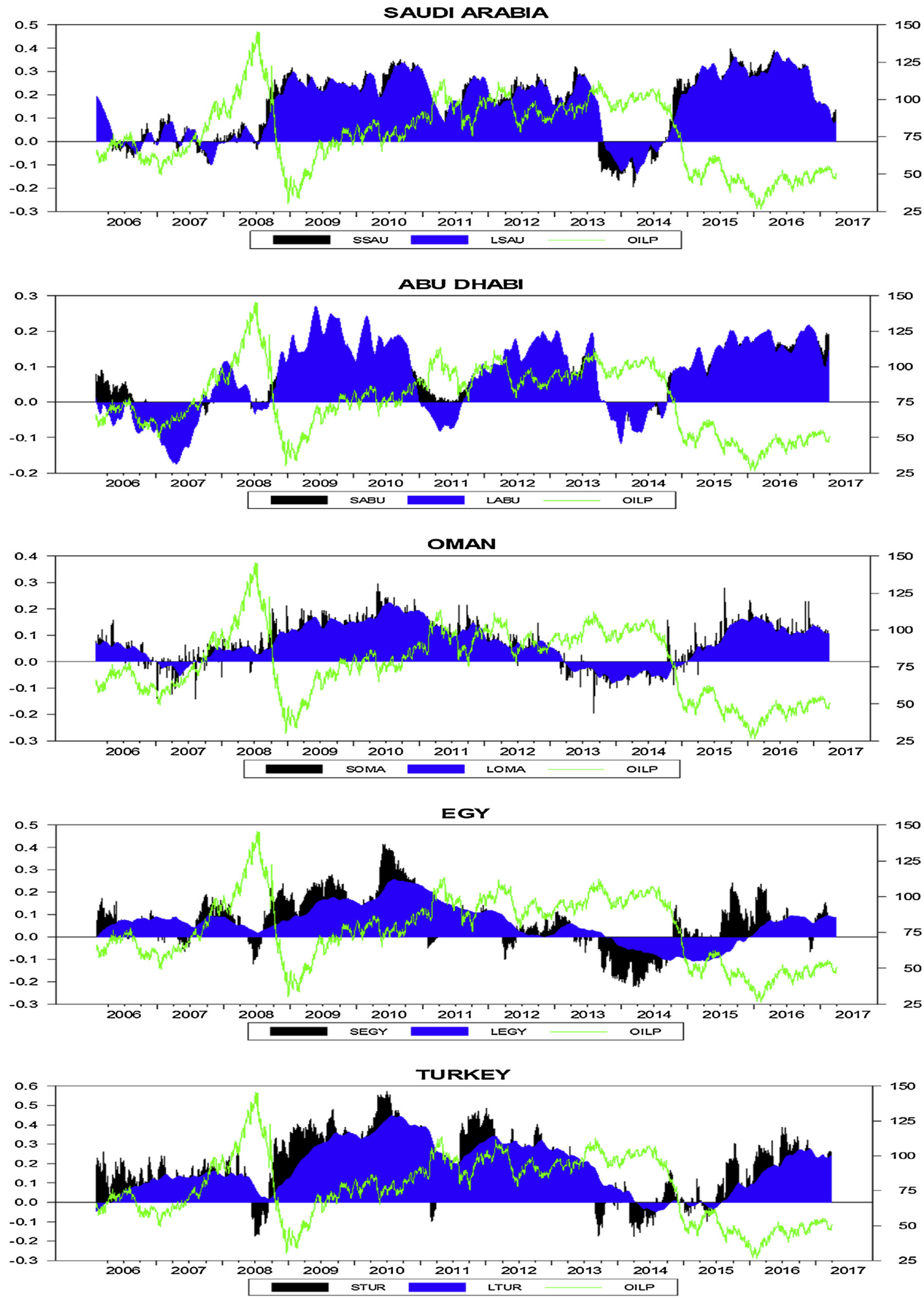

Fig. 2. Polygon of correlations against crude oil prices.

Notes: The left scale represents the crude oil price while the right scale measures the dynamic conditional correlations. The blue polygon is the long-term correlations, while the black is the short-term association.

oil producing countries in the sample.[17] When the oil price collapsed in the wake of the financial crisis in 2008, correlations has increased substantially. The oil prices following crisis have compensated its losses due to the continued demand for oil from emerging economies that continue to grow such as China and the Middle East. During this period of oil price increases, the association with equities have stayed positive and strong. When the oil price reached around $100 per barrel in mid of 2013, correlations weaken, and it becomes even negative. The collapse of oil prices in 2014 has increased association one more time.

The main point here is that whenever there is a big draw down in the oil price association between equities and oil increases. The oil price busts in 2008, 2014 and 2016 have all triggered an increase in oil-equity association across various MENA countries. The implication of these findings is that during the run up of oil prices, oil is not only enhancing the returns of MENA equity portfolio but also it acts as a good diversifier. However, when oil prices collapse the portfolio will suffer the double whammy of oil losses and poor diversification.

The literature on oil equity relationship does not agree on the direction of oil equity association.[18] Hence positive and negative episodes of linkages between oil and equities in MENA countries conforms very well to the literature.[19] It is also consistent with the recent results by Mohaddes and Pesaran (2017) who record that the correlation of US equities with oil can be positive and negative depending on the period under investigation. In the language of Mohaddes and Pesaran, perverse correlations.

While the positive association of oil and equities in oil importing countries can be explained by the fact that high oil prices are good news for the MENA region which produces and controls large amount of oil and oil reserves, the negative dynamic correlations of oil and equities in oil exporter countries is unexpected.[20]

It is well known that equity markets in emerging countries including MENA countries are inefficient and that equity prices do not reflect the fundamentals of the economy. Therefore, these markets can be overbought or oversold during various time periods and the changes in prices may occasionally adjust for market inefficiency. These adjustments may be negative amid an increase in oil prices and hence, negative correlations are observed. Moreover, it should be noted here that the energy sector which creates the direct link with the oil market is owned by the government and this weakens the association between oil prices and equities in the MENA region.

[17] Right before the global financial meltdown in 2008, crude oil prices have reached unprecedented levels. The oil has traded in NYMEX at $ 145 per barrel.

[18] See Jones and Kaul (1996), Sadorsky (1999) and Wei (2003).

[19] The literature differentiates between linkages following a demand and/or a supply shock. Kilian and Park (2009) argue that demand shocks are relatively more important while Kang et al. (2016) support that both demand and supply shocks are equally important.

[20] The oil exporters have Sovereign wealth funds that invests in domestic equities. More funds are available for investment during oil booms. However, during oil busts, these funds tend to liquidate to support government budget. This style of managing funds supports the positive correlation between oil returns and domestic equity returns in oil exporting countries.

4. Conclusion

In this paper we revisit using a recent sample the long and short-term association of oil and equities in the MENA region by using a mixed data sampling approaches. A GARCH-MIDAS model is used to measure long and short-term volatility in three oil net producers and two oil net consumers' countries. The oil producers are: Saudi Arabia, Abu Dhabi and Oman and the oil consumers are Egypt and Turkey.

In the GARCH-MIDAS specification the long-term volatility is modelled as a function of the economic fundamentals. To capture the macroeconomic environment, we use realized volatilities over the last three years, oil monthly returns and oil volatility. This model is used to investigate the influence of oil and oil volatility on the long-term risk of equity returns. The standardized residuals from the GARCH-MIDAS model is used as inputs in a DCC-MIDAS specification to extract the long term and short-term association of oil and equities of the countries in the sample. Compared to the related literature which investigates only short-term linkages, our approach is novel and revealing of both short and long-term integration. Moreover, it incorporates the economic fundamentals by including realized volatility and the oil information in the determination of the long-term variance which in turn influence daily volatility.

Our results indicate that oil is an important factor that influence the long-term volatility of equities in the MENA region. It tends to reduce the long-term risk of net oil producer countries such as the Saudi market and to increase it in the net oil consumer countries such as Egypt and Turkey. The risk transfer from oil to equities is found to be weak.

The dynamic conditional correlations between oil and equities in the MENA region is positive and relatively higher in bigger economies such as Saudi Arabia, Egypt and Turkey. However, these correlations are occasionally tiny and negative. These are explained by the fact that markets in the MENA region are inefficient. Moreover, we find that correlations over the short term are likely to collapse and weaken particularly in oil importing countries. Finally, we find that the association of oil and equities increases to high levels following a large draw down in oil prices.

These results are important for portfolio managers who invest in oil and MENA equities. They indicate that oil not only increases portfolio performance in the run up of the oil market, but it also improves diversification and reduces portfolio volatility. However, when oil prices collapse portfolio risk increases as diversification disappears due to the increased association of MENA equities with the oil market. Moreover, short term diversification can occasionally improve due to the collapse of short term correlation particularly in oil importing countries.

Appendix A. Supplementary data

Supplementary data associated with this article can be found, in the online version, at https://doi.org/10.1016/j.rdf.2018.11.001.

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