The Volatility of Market Returns: A Comparative Study of GCC Markets, Oil, UK & USA

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Abstract

This paper will examine the volatility of markets returns, dynamic conditional covariance and dynamic conditional correlation between the equity markets of developed countries (US and UK), the equity markets of developing countries in the Gulf Cooperation Council (GCC) - Kuwait, Oman, Qatar, Bahrain and United Arab Emirates - and the international prices of oil - Europe Brent Spot Price. A multivariate generalized autoregressive conditional heteroskedasticity (MGARCH) model will be used to identify the source and magnitude of volatility. The results will show the relation between the global mature market of (USA and the UK) and International oil prices on the emerging markets of the GCC countries.

Introduction

Stock market volatility has grown rapidly with the general observation that stock markets around the world are becoming strongly interrelated and more interdependent. The interest in stock market volatility has extended beyond developed markets to emerging markets because the emerging markets are now considered an investment alternative to developed markets as reflected by the increasing share of the world's capital markets invested in emerging markets (see Hartmann and Khambata (1993). In addition the emerging markets exhibit greater volatility than developed capital markets, emerging capital markets also have differing characteristics such as higher average returns, lower correlations than developed markets, and more predictable returns, Bekaert, G. & Harvey, C. (1997), each of these characteristics has made the volatility of emerging markets an interesting topic.

Like their Asian counterparts, the six countries in Arabian Gulf Cooperation council (AGCC) have become the latest "emerging markets" in the Middle East. The decision by the AGCC leaders of states to reach a common currency in 2010 has widened the target of integration of AGCC countries. In a short span of five years, the market capitalization of AGCC countries have grown from US$112 billion at the end of 2000 to approximately US$1,061 billion at the end of October 2005. in accordance with the latest figures, the combined stock markets of the AGCC region is larger than the Hong Kong stock exchange and nearly 1/3 the size of the London stock exchange HSBC on 2005, Rao, A. (2008).

Literature Review

The stock markets of the GCC countries are relatively new compared to the advanced markets. The oldest regulated market in the Gulf area is the Kuwait stock market, commenced operations in 1983, followed by the Saudi market in 1984, while the UAE market was officially launched in 2000. These governments desire to integrate their markets into the emerging system of global governance for instance Hanelt, (2002) has observed these countries are also keen to adapt best international practice within the limits imposed by some special cultural behavior of the countries in question.

Ewing, Malik and Ozfidan, (2002), examined the volatility spillovers between the oil and natural gas markets using daily returns data. They found indication of volatility persistence in both markets. They showed that volatility in natural gas returns is more persistent than volatility in oil returns. They also found that current oil volatility depends on past volatility and not so much on specific events or economic news. In contrast, natural gas return volatility reacts more to unanticipated events (e.g. supply interruptions, changes in reserves and stocks, etc.) regardless of which market they originated in. Assaf, (2003) examined the dynamic interactions among stock market returns of six (GCC) countries (Bahrain, Kuwait, Oman, Qatar, Saudi Arabia and United Arab Emirates). His empirical findings suggest that there is substantial evidence of interdependence effects among GCC stock markets. He found that Saudi Arabia market was slow in responding to shocks initiated in other markets and that markets are not completely efficient in responding to regional news, providing an opportunity for portfolio diversification at the regional level.

Oil price shocks can affect corporate cash flow since oil is an input in production and because oil price changes can influence the demand for output at industry and national levels. Figure 1 shows how are the stock markets in the GCC countries and oil prices are interrelated with analogous trend. It also noticeable from Figure 1 that there is a positive relation with analogous trend between stock markets in the GCC countries and international oil prices.

Malik and Hammodeh, S. (2005), examined the spillover effects of volatility in oil prices on equity markets for the US, Saudi Arabia, Kuwait and Bahrain by applying MGARCH models. The findings confirm that in all cases the three Gulf equity markets were affected by the volatility experienced in oil markets. This study also found significant volatility spillover's from the US equity markets to the three Gulf equity markets. Abu Zarour, B. (2006), applied the Vector Auto-regression model to investigate the relation between oil prices and five stock markets in Gulf Countries during the period between May, 2001 and May 2005. This study found that the response of these markets to shocks in oil prices has increased and became faster during the raise in oil prices, while both the Saudi and Omani markets only have the power to predict oil prices.

Maghyereh, A. & AL-Kandari, A. (2007), found that oil price impacts the stock price indices in GCC countries in a nonlinear fashion and they supported the statistical analysis of a nonlinear modeling relationship between oil and the economy, which is consistent with some authors, such as Mork et al. (1994), and Hamilton (2000).

In case of the effect of oil price shocks on stock market returns for the advanced countries, Jones and Kaul (1996), Sadorsky (1999) and Ciner (2001) report a significant negative connection, while Chen *et al.* (1986) and Huang *et al.* (1996) do not. A negative association between oil price shocks and stock market returns has been reported in several recent papers. Nandha and Faff (2008) find oil prices rises have a detrimental effect on stock returns in all sectors except mining, oil and gas industries, O'Neil *et al.* (2008) find that oil price increases lead to reduced stock returns in the United States, the United Kingdom and France, and Park and Ratti (2008) report that oil price shocks have a statistically significant negative impact on real stock returns in the U.S. and 12 European oil importing countries.

Again, Miller, I. & Ratti, R. (2009), analyzed the long-run relationship between the world price of crude oil and international stock markets for six OECD countries over the period from January 1971 to March 2008. They found negative relation between them; this means stock market prices increase as the oil price decreases or decrease as the oil price increases, over the long-run. Haque, Hassan, Maroney & Sackley, (2004), studied volatility, time varying risk premiums and persistence of shocks to volatility in ten Middle Eastern and African emerging stock markets. Their findings indicate that in eight out of the ten markets there was evidence of volatility clustering and the presence of a nonlinear relationship between oil and the economy. In contrast the work by Ewing, Malik and Ozfidan (2002) and Maghyereh and AL-Kandari (2007), found the relationship between oil and stock priced in GCC countries was represented by a linear relationship.

In a study by Bley, J. & Chen, K. (2006), a low correlation was found between GCC market returns and US markets which reveals diversification opportunities for international investors. Co-integration revealed an increase in the number of co-integrating vectors across. This is likely to be the indication of ongoing attempts to coordinate market economies in preparation for an economic union and eventually the introduction of a single currency. AL-Deehani, T. & Moosa, I. (2006), explored volatility spillovers in three regional Gulf emerging markets (Kuwait, Bahrain & Saudi Arabia) by estimating a SUTSE (Seemingly Unrelated Time Series Equation) model. In their research volatility in each market is described by volatility in the other two markets and by other variables represented by a time-varying trend, findings may be concluded as the Kuwait market exerts strong volatility spillover in the other two markets while the Saudi market exercises strong spillovers effect on the Kuwait market with no effect on the Bahrain market. The Bahrain market has a positive effect on the Kuwait market but not on the Saudi market. Finally, volatility in each of these markets can be explained by global effect rather than regional effect only. Rao, A. (2008), concluded that, emerging markets in AGCC gain more of their volatility persistence from the domestic market. So that, international investors could increased diversification in the AGCC markets and utilize opportunities for high returns due to higher risk-return trade off.

Table 1 shows some key financial indicators for the GCC economies. The contributions of oil to GDP range from 22% in Bahrain to 44% in Saudi Arabia. The GCC markets are important for several reasons.

Hammoudeh, S. & Yuan, Y. M., M. (2009), estimated own market volatility, shocks and persistence volatility and volatility spillovers in three equity sectors of four Gulf Cooperation Council (GCC). The conclusion suggested that past own volatility and not past shocks is the stronger force in determining future volatility for the GCC stock markets. Recently Fayyad & Daly (2010) found that the volatility for the emerging markets of Kuwait and UAE are more volatile than the advanced markets of USA and UK. Also they found that the GCC Countries have higher correlation across the region than globally.

The Methodology and Model

Data

The daily data employed in this study is drawn from the weighted equity market indices of seven major markets and oil (Europe Brent Spot Price): named Kuwait, Oman, United Arab Emirates (UAE), Bahrain, Qatar, United Kingdom (UK) and United States of America (USA). Daily data employed for the period between 21/09/2005-12/02/2010; the stock market data obtained from *MSCI Barra* while the daily data for crude oil price came from U.S Department of Energy, Energy Information Administration (EIA). All indices based on USA Dollar and do not include dividends, also the indices include small, medium and large caps. The return for each market plus oil is expressed in percentage computed by multiplying the first difference of the logarithm of stock market by 100. $\Delta P_i = LOG(P_{it} / P_{it-1}) \times 100$ Where ΔP_i denotes the rate of change of P_i.

Table 2 presents descriptive statistics for each market return for the period between 21/09/2005-12/02/2010. Sample mean, medians, maximums, minimums, standard deviations, skewness, kurtosis and the Jarque-Bera statistics and P-value are reported for the daily dollar return. As appeared in Table 2 results the volatility (measured by standard deviation) for the oil market (2.4741) is higher than all other markets since oil tripled during the study period from minimum value of $49.95 to $143.95.

The distributional properties of the return series appear to be non-normal, since all the markets have negative skewness except for UAE. The kurtosis in all markets, both developed and emerging, exceeds three, indicating a leptokurtic distribution. The final statistics in Table 2 is the calculated Jarque-Bera statistics and corresponding used to test the null hypotheses that the daily distributions of returns are normally distributed. With all *p-values* equal to zero at four decimal places, Jarque-Bera statistics fail to reject the null hypotheses that the daily distributions of returns are normally distributed for all markets.

DVEC- MGARCH Model

VECH models allow for a quite flexible modeling of the conditional variance matrix. However, these models exhibit two demerits: First, it is not ensured that the estimated conditional variance matrices are positive definite. Second, the high estimated number of parameters. In 1988 Bollerslev, Engle, and Wooldridge have used the DVEC model in practice to overcome the disadvantages of VECH Model, since it is easy to parameterize admissible DVEC models and to check whether the stationary conditions hold or not.

Unit Root Testing: In order to run this model we require the data to be stationary, we test for unit roots for each series (1st difference of raw data). We test the null hypothesis of an existence of unit-root (non-stationary) against the alternative hypothesis of stationary variables using the Augmented Dickey-Fuller (ADF) statistic, Dickey, D.A., Fuller, W.A., 1981.We employ the Automatic selection of lags based on Schwarz (SIC); appendix (Table A.1) reports the results which shows the all series are stationary.

Market Returns: The following conditional expected return equation accommodates each market's own returns and the returns of other markets are lagged one period:

(1)

Where R_t is the n x 1 vector of daily return at time t for each market, is the innovation for each market at time t. Figure 2 shows the markets return for seven financial markets and oil.

DVEC Modellling:

In order to reduce the number of parameters, Bollerslev, Engle, and Wooldridge (1988) have proposed the diagonal VEC model. Below we apply the Diagonal VEC - MGARCH Model:

Definition (1) the vec operator for a matrix stacks the columns of $A_{n\times d} = [a_1, a_2, \ldots, a_d]$ sequentially, one upon another, to form a $nd \times 1$ vector a

$$a = vec(A) = \begin{bmatrix} a_1 \\ a_2 \\ . \\ . \\ . \\ a_d \end{bmatrix}$$, Timm, N. (2002).

Where, $\sum_t = \Omega^* + \sum_{i=1}^{p} A_i^* \otimes (\varepsilon_t - i\varepsilon'_{t-i}) + \sum_{j=1}^{q} B_j^* \otimes \sum_{t-j}$, (2)

Ω^* is an (n, n) positive definite and symmetric matrix (A is symmetric matrix if and only if (A Matrix transpose = A), and are (n, n) symmetric matrix, each element of the covariance matrix only depends on the corresponding past elements and and denotes the Hadamard product (where The hadamard product defines the element-wise product of two matrices so we have), Jondeau, E., Poon, S.-H. & Rockinger, M. (2007). The specification involves unknown parameters, so for, n = 2 time series & $p = q = 1 \Rightarrow$ total number of unknown parameter is 9. Example: In the case of $p = q = 1$ and $n = 2$ so this model will have 9 parameters.

(3)

Where, $\begin{pmatrix} \tilde{w}_{11} & \tilde{w}_{12} \\ \tilde{w}_{12} & \tilde{w}_{22} \end{pmatrix}$ is a constant (n x n) positive definite symmetric matrix.

Where, $\sum_t = \begin{pmatrix} \sigma_{1,t}^2 & \sigma_{12,t} \\ \sigma_{12,t} & \sigma_{2,t}^2 \end{pmatrix}$.

Engle and Kroner (1995) and Kroner and Ng (1998) state that the DVEC systems can be estimated using full information maximum-likelihood method. The log-likelihood function of the joint distribution is the sum of all the log-likelihood functions of the conditional distribution, i.e. the sum of the logs of the multivariate-normal distribution.

Letting L_t be the log-likelihood of observation t, n be the number of stock exchange and L be the joint log likelihood gives. $L = \sum_{t=1}^{T} L_t$

$$L_t = \frac{n}{2}\ln(2\pi) - \frac{1}{2}\ln\left|\sum_t\right| - \frac{1}{2}\varepsilon'_t \sum_t^{-1} \varepsilon_t \quad (4)$$

A numerical procedure, e.g. BHHH algorithm, is often used to maximize the log-likelihood function. The maximum-likelihood estimate is then applied to obtain the estimate of unknown parameters. In this study, I choose the first derivative method of Marquardt as the optimization algorithm.

The Marquardt algorithm is the modification of BHHH. The starting values of the parameters in the mean equations and constants in the conditional varience-covarience equations are obtained from their corresponding univariate GARCH models by a two step estimation approach.

Results

We observed that the daily market returns (Figure 2) gives an indication of volatility clustering and Leverage effects. Volatility clustering is a common appearance in financial markets. Large return (± sign) are expected to follow large returns, and small returns (± sign) to follow small returns. While leverage effects are the case in which asset returns are often observed to be negatively correlated with changes in volatility, Khedhiri & Muhammad (2008). Since bad news has a degree of expectations about future volatility that is not replicated for good news counterparts effect which was obvious on the return at the regional markets during the financial crises in the USA markets. We can identify volatility clustering around late 2008 which identifies the beginning of the Global Financial Crises (GFC).

In Table 3 it is found that the correlation coefficients between the selected GCC countries and developed markets are relatively high for instance the highest correlation between the market returns of USA and GCC markets is (0.2602) with QATAR. The lowest correlation was between the USA and BAHRAIN (0.0883), this would imply a closer relationship between these markets and the developed markets are not significant compared to the relationship between developed markets of the US and UK (0.3392). Also it is highly noticeable that the developed markets of UK and USA have higher correlation with Oil of (0.4190) and (0.2146) respectively while the highest correlation between the GCC and Oil found with OMAN (0.1444), this mean that the developed markets of USA and UK are more correlated with Oil because the advanced countries are highly dependent on oil as an input for their industrial manufacturing sectors while the GCC countries are not an industrial countries; also the price of oil in the oil producing countries is very low and relatively constant comparable with industrial countries, *then we may conclude that the GCC markets receive portion of it's volatility from oil markets through a third party here will be the advanced markets reaction to oil prices volatility.*

Overall there appears to be a stronger relationship between USA and QATAR (0.2602) compared to UK and QATAR (0.1379). It is noticeable that the correlation between UAE and QATAR with the advanced countries are the highest among the GCC countries which could be explained that the stock market of UAE and QATAR are relatively more liberalized than other GCC stock markets.

It is appeared from the results that there is a strong and close relationship between the GCC markets; for instance Kuwait market is more correlated with the Bahrain market (0.4150) than any of the developed and GCC markets while Oman is highly correlated with Qatar (0.4952) and UAE with Oman (0.4630).

In addition Figure 3 shows the conditional correlations, where it is observed a bidirectional relation of increase in the conditional correlations between regional markets of GCC countries, the Global markets of (USA & UK) and oil prices during the GFC. It is clear from the results that the conditional correlations between UK from the developed market and Qatar and Oman from the GCC markets are very low that diverges to zero which indicates the least relation among the GCC countries with the developed markets.

The DVEC model provides us with results of the variance and covariance relationships between the countries under our study Table A.2 in the Appendix. Equations (4A.1) to (4A.8) represent the variance of the markets while the equations (4A.9) to (4A.36) represent the co-variance relation between different markets. The results from those equations are presented in Figure 4.

The behaviour of conditional covariance's (Figure 4) indicates that the correlations between the log returns of the GCC and USA, the GCC and the UK and the GCC and Oil are not constant over the study period particularly the noticeable spike recorded in the previous Figures coincides with the beginning of the GFC late 2008. The contagious effects of the GFC which began in the USA/UK appears to have been transmitted to the GCC countries simultaneously as indicated by the covariance relationships between the US/UK, Oil and the GCC markets as indicated in the above covariance relationships. The leverage effect is clearly operating here as shown by the increase in the conditional variance across all both GCC countries, oil international market and the developed markets of the USA and UK. It is also evident from an examination of Figure 5 that the volatility observed in the multivariate DVEC model estimation for the eight markets is changing over time. It is noticeable that the volatility for the Oil international market return and emerging markets of GCC countries are more volatile than the advanced markets of USA and UK over the study period. This coincides with previous research findings, Bekaert and Harvey (1997), Rao, (2008) and recently with Fayyad and Daly, (2010).

Summary and Conclusions

Volatility plays an essential role in controlling and forecasting risks in various financial operations. In our study, volatility is mainly represented in terms of conditional variances or conditional standard deviations. Here we estimate conditional correlation/covariance and volatility by applying DVEC and providing summary statistics and conditional variance covariance relationships between developed markets and emerging markets of selected GCC countries.

Overall, the results indicate that the model perform well statistically. An important finding from the study is that conditional co-variances show significant changes over time for all markets. This is an important finding as the DVEC model is designed to overcome the problems associated with time invariant correlation coefficient estimates. It is also noticeable that the volatility for the emerging markets of the GCC countries except Kuwait and Qatar are more volatile than the advanced markets of USA and UK over the study period. In addition we find that the daily market returns indicate volatility clustering and leverage effects since the correlations between the regional markets of (Kuwait, Qatar, Bahrain, Oman and UAE), Oil and the Global markets of (USA & UK) increased significantly during the financial crises. It is noticeable that QATAR, UAE and OMAN markets are relatively more correlated than its neighbouring countries with the advanced markets of the UK and USA. We also observe that the GCC Countries have higher correlation across the region than globally. Here we can conclude that as non of the GCC markets have high correlation with Oil while the advanced market of USA and UK does with oil, then we can conclude that the GCC markets receive the volatility of Oil markets through a third party here will be the advanced markets reaction to oil prices volatility.

Finally, it is noticeable that the emerging markets of the GCC countries are subject to conditions within the Arabian Gulf region, which increases their potential benefits for international diversification.

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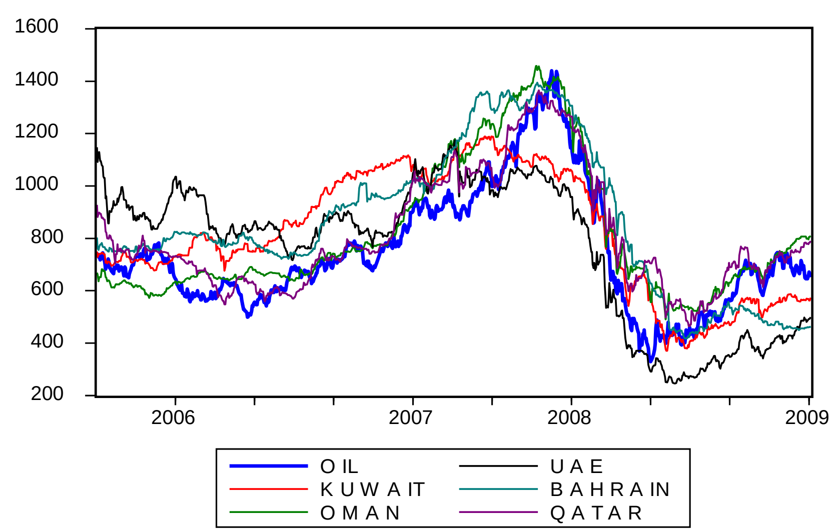
Figure 1: Five GCC stock Markets & Brent oil prices for the period between 21/04/2006 to 5/10/2009.



Note: Oil prices have been rescaled to be comparable with the average of the GCC stock market indices

Figure 2: Markets daily returns, for the period between 21/09/2005 -12/02/2010.

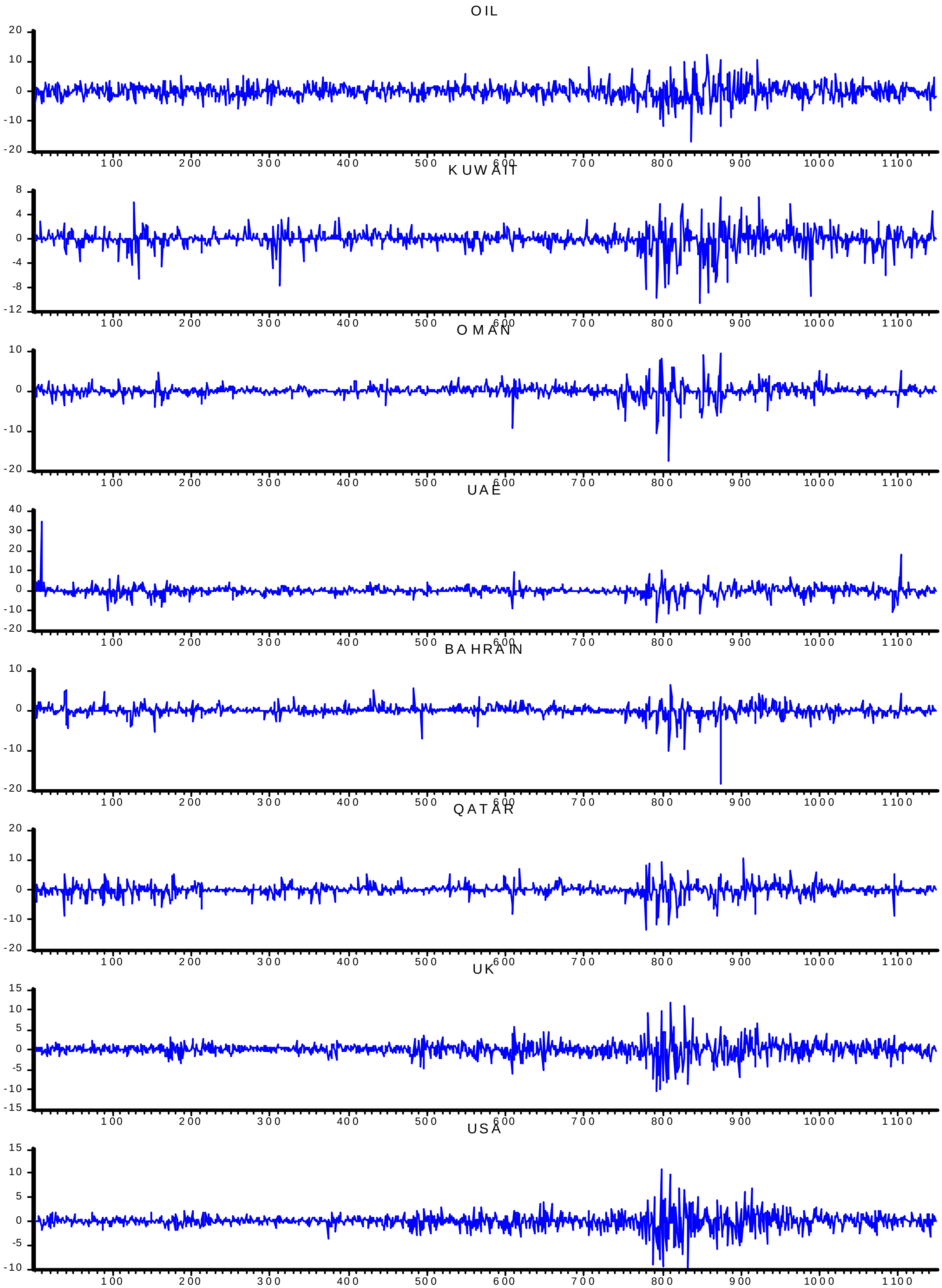


Figure 3: Estimated conditional corrolation for daily returns for oil and stock markets. Applying Multivariate GARCH-DVEC Model.

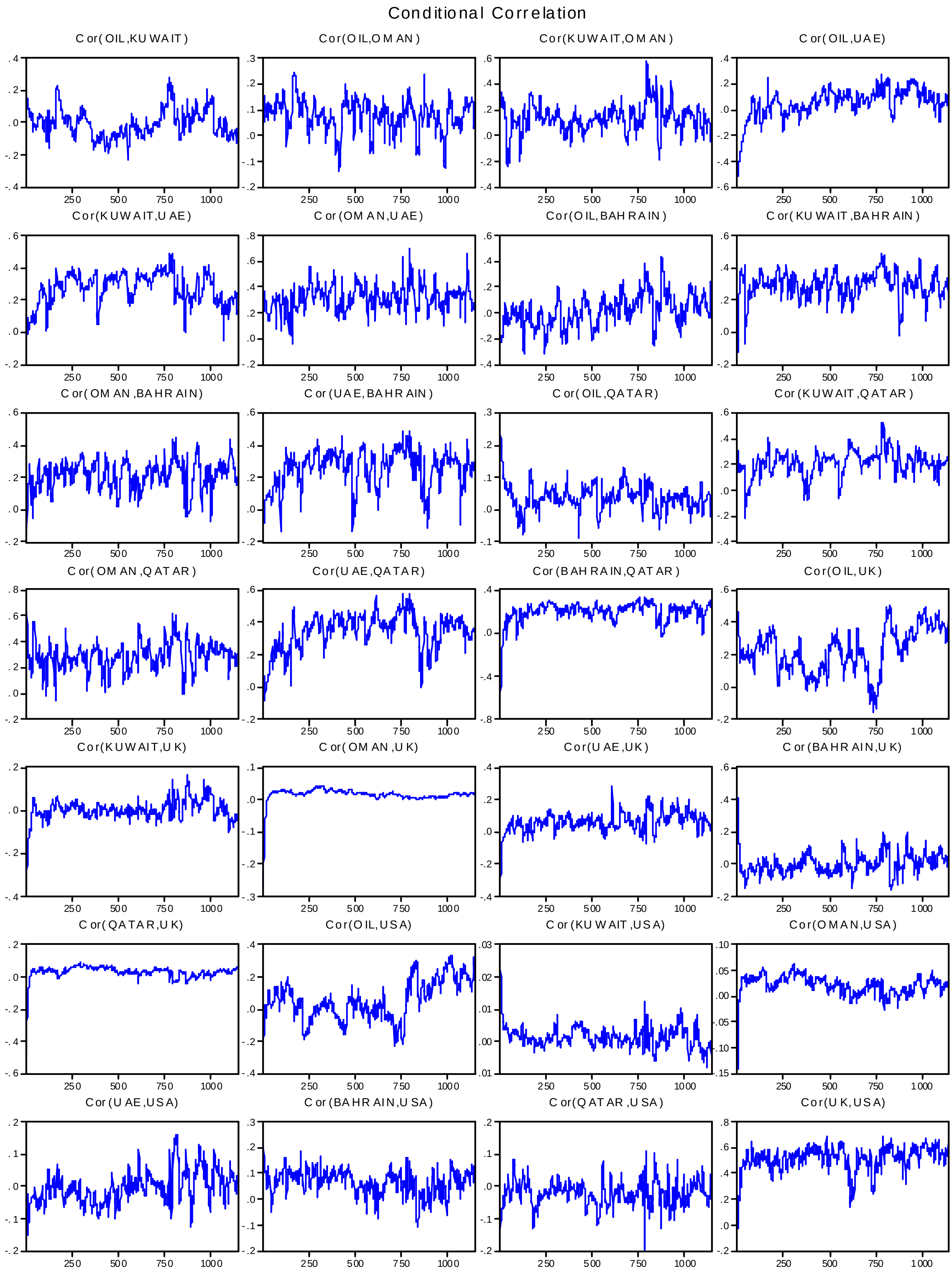


Figure 4: Estimated conditional covariance for daily returns for oil and stock markets. Applying Multivariate GARCH-DVEC Model.

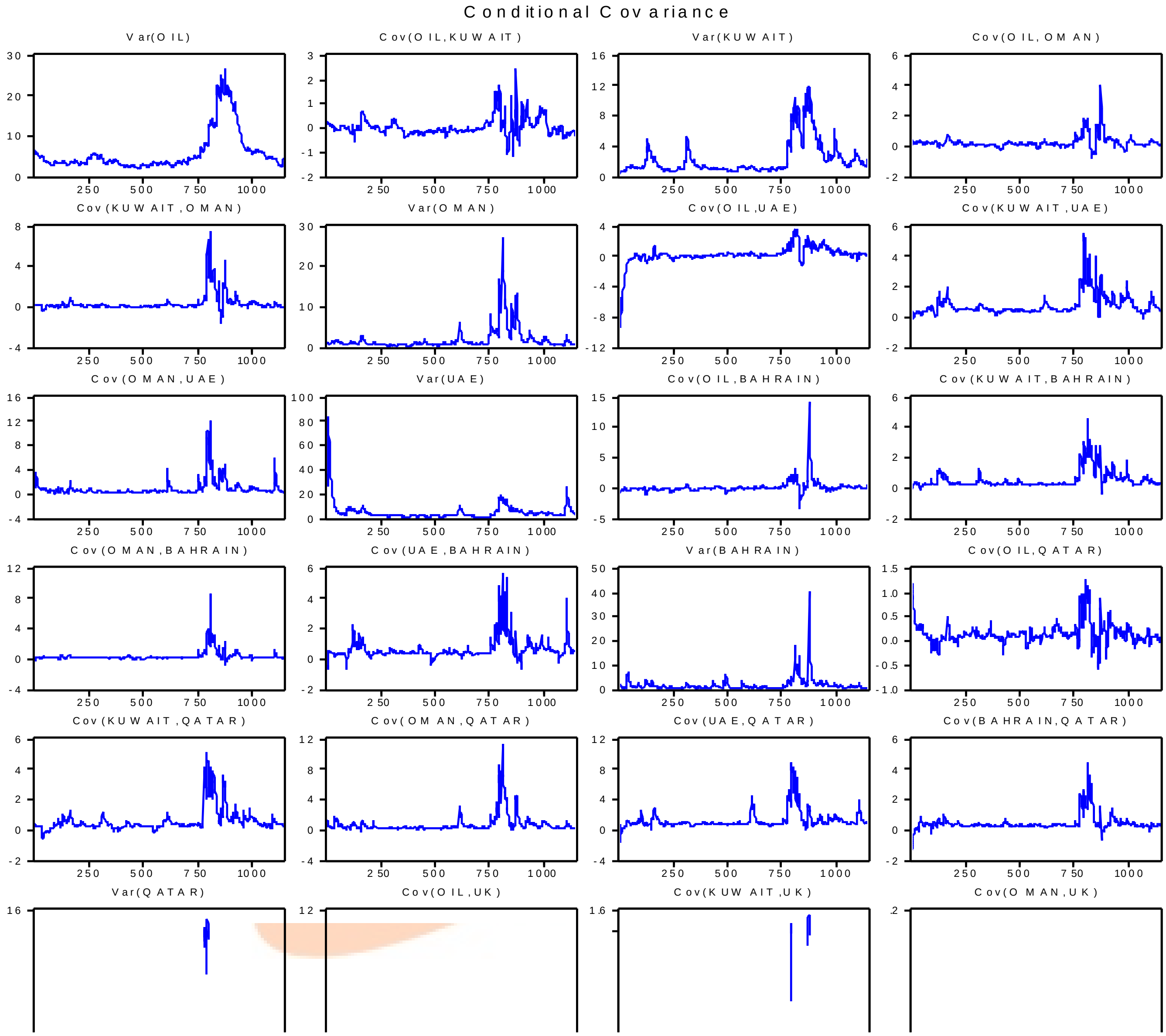


Figure 5: Estimated conditional variance for daily returns for GCC Countries, USA & UK. Applying Multivariate DVEC model

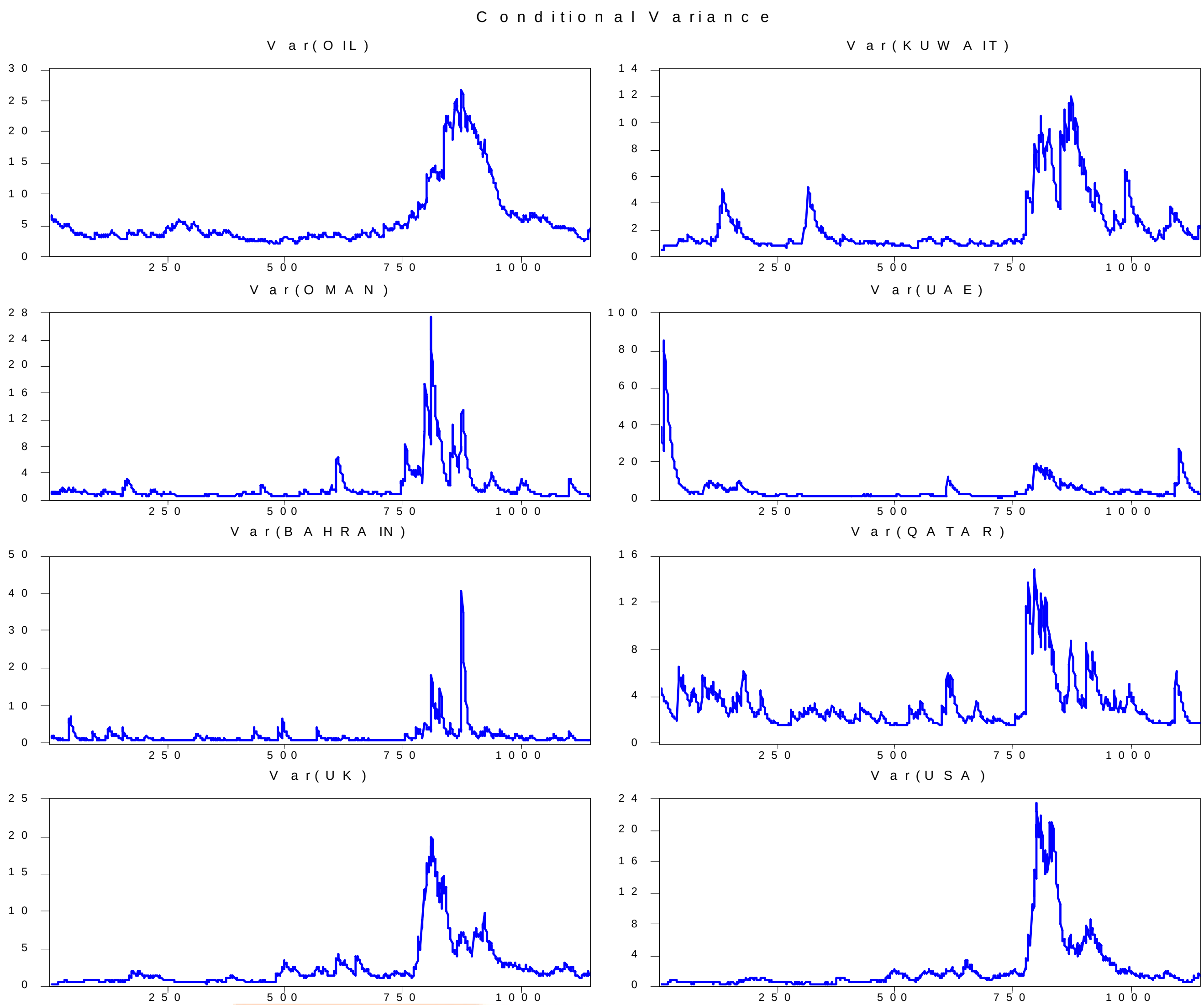


Table 1: GCC Economies, Stock markets and Oil in 2007

Market	Number of companies*	Market Capitalization ($ billion)	Market Capitalization (% GDP)*	Oil (%GDP)+
Bahrain	50	21.22	158	22
Kuwait	175	193.50	190	35
Oman	119	22.70	40	41
Qatar	40	95.50	222	42
UAE	99	240.80	177	32
S.Arabia	81	522.70	202	44

Source: Arab Monetary Fund and Emerging Markets Database.* Numbers in 2006

Table 2: Summary statistics of daily returns for eight markets, (21/09/2005—12/02/2010)

	OIL	KUWAIT	OMAN	UAE	BAHRAIN	QATAR	UK	USA
Mean	0.0082	-0.0374	0.0035	-0.0880	-0.0590	-0.0555	-0.0158	-0.0073
Median	0.0629	0.0000	0.0000	0.0000	0.0000	0.0000	0.0622	0.0590
Maximum	12.2218	7.1108	9.4448	34.6479	6.3089	10.5910	11.9123	10.7971
Minimum	-16.8320	-10.6353	-17.4857	-16.2348	-18.3787	-13.3108	-10.2992	-9.7023
Std. Dev.	2.4741	1.5897	1.5439	2.4823	1.3644	1.9633	1.7977	1.5969
Skewness	-0.1258	-1.3192	-1.6771	1.9609	-2.9829	-0.7443	-0.0876	-0.2927
Kurtosis	7.2229	12.0975	26.0093	42.1677	38.6187	10.6993	10.9545	11.6139
Jarque-Bera	855.3210	4288.225	25840.02	74052.81	62334.09	2938.981	3025.482	3562.532
Probability	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Sum	9.4744	-42.9038	4.0912	-100.9501	-67.7249	-63.6768	-18.1505	-8.4336
Sum Sq. Dev.	7015.303	2896.171	2731.835	7061.961	2133.625	4417.583	3703.824	2922.433
Observations	1147	1147	1147	1147	1147	1147	1147	1147

Table 3: Correlation between markets returns

	OIL	KUWAIT	OMAN	UAE	BAHRAIN	QATAR	UK	USA
OIL	1.0000	0.0568	0.1444	0.1063	0.1172	0.0835	0.4190	0.2146
KUWAIT	0.0568	1.0000	0.2974	0.3165	0.4150	0.3399	0.1033	0.1143
OMAN	0.1444	0.2974	1.0000	0.4630	0.3351	0.4952	0.1355	0.2469
UAE	0.1063	0.3165	0.4630	1.0000	0.2963	0.4323	0.1994	0.2339
BAHRAIN	0.1172	0.4150	0.3351	0.2963	1.0000	0.3201	0.0587	0.0883
QATAR	0.0835	0.3399	0.4952	0.4323	0.3201	1.0000	0.1379	0.2602
UK	0.4190	0.1033	0.1355	0.1994	0.0587	0.1379	1.0000	0.3392
USA	0.2146	0.1143	0.2469	0.2339	0.0883	0.2602	0.3392	1.0000

Appendices

Table A.1 Unit root test

Null Hypothesis: Unit root (individual unit root process)
Date: 04/03/10 Time: 18:22
Sample: 1 1148
Series: OIL, KUWAIT, OMAN, UAE, BAHRAIN, QATAR, UK, USA
Exogenous variables: Individual effects
Automatic selection of maximum lags
Automatic selection of lags based on SIC: 0 to 1
Total number of observations: 9167
Cross-sections included: 8

Method	Statistic	Prob.**
ADF - Fisher Chi-square	1174.56	0.0000
ADF - Choi Z-stat	-33.3273	0.0000

** Probabilities for Fisher tests are computed using an asympotic Chi -square distribution. All other tests assume asymptotic normality.

Intermediate ADF test results D(UNTITLED)

Series	Prob.	Lag	Max Lag	Obs
D(OIL)	0.0000	0	22	1146
D(KUWAIT)	0.0000	0	22	1146
D(OMAN)	0.0000	0	22	1146
D(UAE)	0.0000	0	22	1146
D(BAHRAIN)	0.0000	0	22	1146
D(QATAR)	0.0000	0	22	1146
D(UK)	0.0000	0	22	1146
D(USA)	0.0000	1	22	1145

Table A.2 The estimated DVEC model for the variance and covariance equations has the form:

GARCH1 = M(1,1) + A1(1,1)*RESID1(-1)^2 + B1(1,1)*GARCH1(-1) (4A.1)
GARCH2 = M(2,2) + A1(2,2)*RESID2(-1)^2 + B1(2,2)*GARCH2(-1) (4A.2)
GARCH3 = M(3,3) + A1(3,3)*RESID3(-1)^2 + B1(3,3)*GARCH3(-1) (4A.3)
GARCH4 = M(4,4) + A1(4,4)*RESID4(-1)^2 + B1(4,4)*GARCH4(-1) (4A.4)
GARCH5 = M(5,5) + A1(5,5)*RESID5(-1)^2 + B1(5,5)*GARCH5(-1) (4A.5)
GARCH6 = M(6,6) + A1(6,6)*RESID6(-1)^2 + B1(6,6)*GARCH6(-1) (4A.6)
GARCH7 = M(7,7) + A1(7,7)*RESID7(-1)^2 + B1(7,7)*GARCH7(-1) (4A.7)
GARCH8 = M(8,8) + A1(8,8)*RESID8(-1)^2 + B1(8,8)*GARCH8(-1) (4A.8)
COV1_2 = M(1,2) + A1(1,2)*RESID1(-1)*RESID2(-1) + B1(1,2)*COV1_2(-1) (4A.9)
COV1_3 = M(1,3) + A1(1,3)*RESID1(-1)*RESID3(-1) + B1(1,3)*COV1_3(-1) (4A.10)
.
.
.
COV5_8 = M(5,8) + A1(5,8)*RESID5(-1)*RESID8(-1) + B1(5,8)*COV5_8(-1) (4A.33)
COV6_7 = M(6,7) + A1(6,7)*RESID6(-1)*RESID7(-1) + B1(6,7)*COV6_7(-1) (4A.34)
COV6_8 = M(6,8) + A1(6,8)*RESID6(-1)*RESID8(-1) + B1(6,8)*COV6_8(-1) (4A.35)
COV7_8 = M(7,8) + A1(7,8)*RESID7(-1)*RESID8(-1) + B1(7,8)*COV7_8(-1) (4A.36)

** Here Ai and Bi are (n,n) symmetric matrix each element of the covariance matrix only depends on the corresponding past elements and .The value for A & B matrices are available below in Table A.3 in the appendix while (Figure 4) in the results simulates the previous equations (5A.1-36) as variance and covariance for the eight markets

Table A.3 Transformed Variance/covariance Coefficients

Tranformed Variance Coefficients

	Coefficient	Std. Error	z-Statistic	Prob.
A1(1,1)	0.034330	0.008325	4.123848	0.0000
A1(1,2)	0.027467	0.016654	1.649241	0.0991
A1(1,3)	0.027443	0.019843	1.382990	0.1667
A1(1,4)	0.029614	0.014355	2.062931	0.0391
A1(1,5)	0.054567	0.023265	2.345486	0.0190
A1(1,6)	0.015493	0.017455	0.887609	0.3748
A1(1,7)	0.032281	0.009753	3.309832	0.0009
A1(1,8)	0.026490	0.013488	1.964016	0.0495
A1(2,2)	0.045625	0.005650	8.074525	0.0000
A1(2,3)	0.042366	0.012197	3.473443	0.0005
A1(2,4)	0.026796	0.010398	2.577137	0.0100
A1(2,5)	0.036982	0.015931	2.321363	0.0203
A1(2,6)	0.029726	0.008985	3.308372	0.0009
A1(2,7)	0.017923	0.019792	0.905543	0.3652
A1(2,8)	0.001351	0.017936	0.075327	0.9400
A1(3,3)	0.071874	0.010507	6.840709	0.0000
A1(3,4)	0.049484	0.009077	5.451768	0.0000
A1(3,5)	0.043832	0.019868	2.206161	0.0274
A1(3,6)	0.048273	0.012974	3.720724	0.0002
A1(3,7)	0.000950	0.013317	0.071351	0.9431
A1(3,8)	-0.005389	0.018411	-0.292724	0.7697
A1(4,4)	0.050052	0.005584	8.963526	0.0000
A1(4,5)	0.041571	0.017053	2.437779	0.0148
A1(4,6)	0.034137	0.011327	3.013766	0.0026
A1(4,7)	0.022738	0.016091	1.413086	0.1576
A1(4,8)	0.020770	0.018939	1.096723	0.2728
A1(5,5)	0.111934	0.016621	6.734393	0.0000
A1(5,6)	0.028209	0.017144	1.645412	0.0999
A1(5,7)	0.029810	0.022983	1.297063	0.1946
A1(5,8)	0.026147	0.029781	0.877971	0.3800
A1(6,6)	0.049866	0.008505	5.863039	0.0000
A1(6,7)	-0.006393	0.014065	-0.454560	0.6494
A1(6,8)	-0.020308	0.016070	-1.263756	0.2063
A1(7,7)	0.063105	0.009643	6.544410	0.0000
A1(7,8)	0.053601	0.010324	5.191782	0.0000
A1(8,8)	0.067612	0.011203	6.035243	0.0000
B1(1,1)	0.964635	0.008952	107.7551	0.0000
B1(1,2)	0.945771	0.043511	21.73632	0.0000
B1(1,3)	0.924854	0.064336	14.37527	0.0000
B1(1,4)	0.932322	0.035369	26.35977	0.0000
B1(1,5)	0.903565	0.040960	22.05979	0.0000
B1(1,6)	0.923924	0.099762	9.261327	0.0000
B1(1,7)	0.944080	0.016858	56.00223	0.0000
B1(1,8)	0.941773	0.028869	32.62209	0.0000
B1(2,2)	0.935122	0.007330	127.5770	0.0000
B1(2,3)	0.895748	0.037674	23.77649	0.0000
B1(2,4)	0.922609	0.031314	29.46351	0.0000

B1(2,5)	0.886745	0.046309	19.14829	0.0000
B1(2,6)	0.909782	0.029267	31.08549	0.0000
B1(2,7)	0.924901	0.095776	9.656902	0.0000
B1(2,8)	0.922618	1.349578	0.683635	0.4942
B1(3,3)	0.902271	0.013053	69.12229	0.0000
B1(3,4)	0.881033	0.029650	29.71452	0.0000
B1(3,5)	0.865485	0.051930	16.66650	0.0000
B1(3,6)	0.880697	0.035621	24.72377	0.0000
B1(3,7)	0.906196	0.254278	3.563806	0.0004
B1(3,8)	0.903929	0.317177	2.849919	0.0044
B1(4,4)	0.928403	0.005617	165.2907	0.0000
B1(4,5)	0.868389	0.051823	16.75666	0.0000
B1(4,6)	0.897535	0.035979	24.94589	0.0000
B1(4,7)	0.910641	0.064971	14.01609	0.0000
B1(4,8)	0.909345	0.105533	8.616693	0.0000
B1(5,5)	0.851539	0.016546	51.46490	0.0000
B1(5,6)	0.872060	0.071048	12.27423	0.0000
B1(5,7)	0.884236	0.098516	8.975561	0.0000
B1(5,8)	0.881468	0.168486	5.231705	0.0000
B1(6,6)	0.908543	0.013158	69.05113	0.0000
B1(6,7)	0.902696	0.146421	6.165072	0.0000
B1(6,8)	0.899612	0.132222	6.803808	0.0000
B1(7,7)	0.924176	0.010714	86.25917	0.0000
B1(7,8)	0.921901	0.014269	64.60910	0.0000
B1(8,8)	0.919742	0.012367	74.37235	0.0000