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Time-varying characteristics of cross-market linkages with empirical application to Gulf stock markets

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Abstract

Purpose – The purpose of this paper is to propose an empirical procedure for examining the time-varying features of cross-market correlations in selected Gulf stock markets.

Design/methodology/approach – The paper directly infers the cross-market linkages from the stock data using a multivariate dynamic conditional correlation GARCH model (DCC-GARCH). The paper attempts to date the structural breaks in the time-paths of the conditional correlation indices to investigate whether the cross-market comovement encompasses significant changes in nature or not.

Findings – Conditional cross-market correlations between studied markets are shown to be time-varying, past-dependent and subject to structural breaks. However, the comovements are still small within the Gulf region and insignificant between the Gulf stock markets and the world market.

Research limitations/implications – Even though the paper attempted to relate the observed changes in market linkages to major economic and political events that the Gulf region experienced during the sample period, a more careful, in-depth analysis is needed since the primary objectives of this paper consist only of measuring stock market comovements and detecting their possible structure changes.

Practical implications – For global investors, there is still room for international and regional diversification in Gulf markets, given the low degree of comovements documented in the study.

Originality/value – The application of the DCC-GARCH model and structural change test in a linear framework appears to be suitable for studying the time-varying properties of cross-market linkages between markets in the Gulf region. It also provides information about the degree of financial integration of the studied markets with the world stock market through an analysis of the conditional correlation coefficients.

Keywords Capital markets, Stock markets, Persian Gulf States

Paper type Research paper

1. Introduction

Capital market integration and comovements are among the important issues in international finance that interest both policymakers and global investors. Indeed, knowing the level of market comovements allows the investors to improve their portfolio performance by investing in less correlated assets, and helps the policymakers to plan adequate policies for internal capital markets in the event of higher interdependence with global economic and financial conditions.

In recent years, financial researchers have largely devoted their attention to the cross-market linkages in developed markets and also in major Asian and Latin American emerging markets such as China, Argentina, and Mexico. Some evidence of significant volatility spillovers, interdependence, and contagion among these markets has been provided (Richards, 1995; Harvey, 1995; Forbes and Rigobon, 2002; Johnson

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and Soenen, 2003; Hsin, 2004; Bekaert *et al.*, 2005; Syriopoulos, 2007; Gilmore *et al.*, 2008). However, less attention has been given to the smaller emerging markets, especially to those in the Gulf region where share dealing is a relatively recent phenomenon.

The Gulf stock markets have several features in common: market capitalization relative to the size of the economy is small, listed companies are few, trading volume is low, and access to these markets for direct investment in equities was permitted for foreign investors only recently, with the exception of some limited access to investors by the Gulf Cooperation Council states[1]. However, recently imposed capital requirements to fund budget deficits and boost economic activity have driven the Gulf country governments to embark on capital market liberalization, privatization, and broad-ranging structural reforms, allowing foreign investors greater access to their stock markets. These singularities of Gulf markets in terms of organization, trading mechanisms, international openness, and liquidity may imply different linkages and transmission patterns than those in the developed and major emerging stock markets. We can take as examples the cases of South Korea and Taiwan, which ranked among the most liquid markets of the world in 2003 with turnover ratios (trading value as a share of market capitalization) of 23.68 and 18.52, respectively. Moreover, these markets have been open to foreign capital flows and trading activities since the late 1980s[2].

This paper departs from previous studies by focusing on the time-varying characteristics of cross-market linkages within the Gulf stock markets and their common linkage with the world market. Three main issues are pursued in this paper. First, instead of modeling the comovement by vector autoregressive (VAR) and realized correlations as in past studies, which captured the causal linkages but did not allow quantification of the comovement, this paper directly infers the cross-market linkages from the stock data using a multivariate dynamic conditional correlation GARCH model (DCC-GARCH). Second, we are interested in dating the structural breaks in the time-paths of the conditional correlation indices, to highlight whether the cross-market comovement encompasses significant changes in nature or not. Finally, we try to correlate changes in market linkages with the major economic events that have occurred in the Gulf region over the whole sample period.

The empirical investigation, based on daily natural log returns, was conducted on a sample of five individual stock markets in the Gulf region and the world stock market index over the period from June 2, 2005 to April 2, 2008. We obtained significant market interactions within the Gulf region which might reflect the fact that all the individual markets were engaging in an ongoing process of regional financial integration. Further, the level of conditional market linkages still remains relatively low and varies considerably over time. More importantly, the comovement was found to strengthen particularly at the time of major oil shocks and regional political tensions. With regard to the bilateral interdependences between Gulf and world stock markets, we provide evidence against the hypothesis of global market integration because the DCC are very low and insignificant in all cases. Taken together, these results point to a potential for international portfolio diversification benefits from investing in the Gulf stock markets, but investors must bear in mind the high degree of financial interdependence during periods of economic downturn and political conflicts. Finally, the strong evidence of structural changes in the time-paths of estimated comovement indices would have an important effect on the forecasting of expected returns and volatility dynamics in the markets studied.

The remainder of the article is organized as follows. Section 2 describes the empirical methodology, including our modeling strategy for conditional mean, variance, and correlation dynamics, as well as our framework for testing the presence of structural changes in linear regression models. Section 3 presents the data used in the paper and discusses the empirical results. We provide some concluding remarks in section 4.

2. Empirical methodology

As stated in the introduction, this paper investigates the dynamic linkages across the stock markets of the Gulf region and the world stock market. Econometrically speaking, we first measure the time-varying amount of comovements across the markets under consideration and then examine whether any existing breakpoints in the estimated comovement time-series are associated with major economic events during the study period.

It is now common for financial researchers and practitioners to choose a GARCH specification for modeling the dynamics of the second moment of stock return distributions over time. The main advantage of this specification is its ability to capture persistence (or long memory) in the volatility and leptokurtic distribution of stock return series. In particular, previous studies, including for example Bekaert and Harvey (2000), and Kim and Singal (2000), suggest that GARCH-class models appear to successfully describe the stochastic properties of emerging markets returns.

However, insofar as the analysis is concerned with the joint behavior of multiple return series, a multivariate GARCH model is needed to gauge the time-series patterns of conditional return volatility, covariances, and correlations. For this purpose, many studies have extended the univariate GARCH model of Bollerslev (1986) to multivariate cases such as VEC, BEKK, and constant conditional correlation models (see Bauwens *et al.*, 2006 for a detailed survey). Of these models, we intentionally rely on the multivariate DCC-GARCH model of Engle (2002) to measure the comovements of sample markets, for several reasons. First, use of the DCC-GARCH model is entirely justified by the presence of the conditional heteroscedasticity in our return data, as we will show in the following section. Second, it provides a very useful way to describe the dynamic evolution of a large correlation matrix over time. Third, the model overcomes the computational constraints of the multivariate models when the number of markets in the system is particularly large. This is handled by adopting a two-step estimation procedure: in the first stage a set of univariate GARCH models is estimated for each stock market, and in the second stage a simple specification is used to model the conditional correlations based on the standardized residuals we obtain from the first stage. Using this approach we can employ the simple interpretation of univariate GARCH specification in capturing directly the presence of heteroscedasticity effect on return volatility while providing consistent estimates of the conditional correlation matrix (Kearney and Poti, 2006). Moreover, as noted by Chiang *et al.* (2007), the model allows us to account for the impact of common factors by adding additional explanatory variables in the mean equation. Finally, the DCC-GARCH enables the quantification of the comovement amounts between markets, which is not possible when using the VAR model.

More concretely, we assume that the return on each individual market depends on four components: a common factor (δ_0), a country factor (δ_1), a global market factor (δ_2), and a country-specific disturbance (ε). Further, the return on the world market index is assumed to follow a first-order autoregressive process. Accordingly, if these k return series are normally distributed with a zero mean and a conditional variance-covariance matrix H_t, a multivariate DCC-GARCH model can be written as

$$\begin{cases} r_t = \mu_t + \varepsilon_t, \;\; \varepsilon_t | I_{t-1} \rightarrow N(0, H_t) \\ H_t \equiv D_t R_t D_t \end{cases} \tag{1}$$

where r_t refers to the $(k \times 1)$ vector of the returns on stock market indices; ε_t is a $(k \times 1)$ vector of return innovations conditional on the information set at time $(t - 1)$; $\mu_{it} = \delta_{0i} + \delta_{1i} r_{it-1} + \delta_{2i} r_{wt-1}$ for individual market i; $\mu_{wt} = \delta_{0w} + \delta_{0w} r_{wt-1}$ for the world market with r_w denoting its return; D_t refers to a $(k \times k)$ diagonal matrix, the elements on its main diagonal being the time-varying standard deviations of the returns on each stock market in the sample and $D_t = \text{diag}(h_{1t}^{1/2} \ldots h_{kt}^{1/2})$ where h_{it} follows a standard univariate GARCH(1,1) process; R_t is the $(k \times k)$ conditional correlation matrix and is defined as follows:

$$R_t = (\text{diag}(Q_t))^{-1/2} Q_t (\text{diag}(Q_t))^{-1/2}. \tag{2}$$

In equation 2, $Q_t = (1 - \alpha - \beta)\bar{Q} + \alpha u_{t-1} u'_{t-1} + \beta Q_{t-1}$ refers to a $(k \times k)$ symmetric positive definite variance-covariance matrix where u_t is the standardized error terms and defined as $u_t = \varepsilon_{it} / \sqrt{h_{it}}$, $\bar{Q}$ is the $(k \times k)$ unconditional variance matrix of u_t, and α and β are non-negative scalar parameters satisfying $\alpha + \beta \prec 1$[3].

The conditional correlation coefficient ρ_{ijt} between two markets i and j at time t is then expressed by the following equation:

$$\rho_{ijt} = \frac{(1 - \alpha - \beta)\bar{q}_{ij} + \alpha u_{i,t-1} u_{j,t-1} + \beta q_{ij,t-1}}{\left((1 - \alpha - \beta)\bar{q}_{ii} + \alpha u_{i,t-1}^2 + \beta q_{ii,t-1}\right)^{1/2} \left((1 - \alpha - \beta)\bar{q}_{jj} + \alpha u_{j,t-1}^2 + \beta q_{jj,t-1}\right)^{1/2}} \tag{3}$$

where q_{ij} refers to the element located in the ith row and jth column of the matrix Q_t.

The DCC-GARCH model as described above is estimated using a two-stage procedure. In the first stage, a univariate GARCH(1,1) model is estimated for each return series included in the multivariate system. During the second stage, the transformed residuals from the first stage (i.e. the estimated residuals standardized by their conditional standard deviations) are used to infer the conditional correlation estimators. The log-likelihood of the observations on ε_t is given by

$$L = -\frac{1}{2} \sum_{t=1}^{T} \left(n \log(2\pi) + \log|D_t R_t D_t| + \varepsilon'_t D_t^{-1} R_t^{-1} D_t^{-1} \varepsilon_t \right).$$

We employ the procedure of Bai and Perron (2003) to investigate whether structural breaks exist in the time-varying cross-market comovements. The key idea is to determine the number and location of breaks in a linear regression model.

Suppose there are m multiple structural breaks $(n_1, \ldots, n_m)$ in the time-path of the dependant variable. The problem of dating structural breaks consists of finding the breakpoints $(\tilde{n}_1, \ldots, \tilde{n}_m)$ that minimize the objective function $(\tilde{n}_1, \ldots, \tilde{n}_m) = \arg\min_{(n_1, \ldots, n_m)} RSS_n(n_1, \ldots, n_m)$ where RSS_n is the resulting residual sum of squares based on the m linear regressions of the following form:

$$y_t = \beta x_t^{\mathrm{T}} + \varepsilon_t \quad (t = 1, \ldots, n) \tag{4}$$

where y_t is the estimated conditional correlation series at the time t, $x_t = (1, y_{t-1})^{\mathrm{T}}$ is the (2×1) vector of observations of the independent variables with the first component equal to unity, β is the (2×1) vector of regression coefficients, and ε_t is assumed to be $iid(0, \sigma^2)$.

Based on the above framework, we test the null hypothesis of "no structural break" against the alternative of an unknown number of breaks given some specific upper bound M $(1 \leq m \leq M)$ where M is set equal to 5. Whenever m exceeds this upper bound, a higher value is thus set. As noted by Bai and Perron (2003), the common way to estimate the optimal number of breaks is to consider an information criterion. Three methods are then suggested: (a) the sequential procedure proposed by Bai and Perron (1998) which consists of testing the null hypothesis of m breaks vs the alternative of $(m + 1)$ breaks; (b) the Bayesian Information Criterion (BIC) as used by Yao (1988); and (c) the modified Schwarz criterion (Liu *et al.*, 1997). Given the purpose of our test, we decided to rely solely on the BIC to select the optimal number of breaks since the modified Schwarz criterion tends to underestimate the number of breaks when some are actually present in the dataset (Bai and Perron, 2003). Accordingly, the final number of breaks corresponds to the one with the lowest BIC score.

3. Data and results

3.1 Data and preliminary analysis

To conduct the study, we used daily total US dollar natural log returns computed from Morgan Stanley Capital International (MSCI) indices. In addition to the world market index, the sample markets include Kuwait, Oman, Qatar, the United Arab Emirates (UAE), and Saudi Arabia ($k = 6$). Data were gathered from Datastream International for the period from June 2, 2005 to April 2, 2008, and were date-matched across the six markets. The equity markets are generally closed on Thursdays and Fridays in the Gulf region, while the developed markets close for trading on Saturdays and Sundays. Therefore, matching of price-data from these markets results in a loss of some data points. Relevant descriptive statistics and stochastic properties of daily returns are presented in Table I.

Panel A reveals a number of intriguing features that are typical of emerging and frontier emerging markets. If we refer to the mean and standard deviations of the daily return series as measures of average market return and risk, respectively, we observe that the Gulf stock markets have higher volatilities, but not necessarily higher returns, compared to the world market over the study period. This implies that investing in these markets is not always profitable in terms of risk-adjusted performance. Among the Gulf stock markets, Kuwait and Oman provide the highest daily returns and the lowest risk.

The Engle (1982) test for conditional heteroscedasticity rejects the null hypothesis of no ARCH effects for all the markets we studied. In addition, skewness, which measures the distributional asymmetry, is negative for all the six markets and excess kurtosis is positive. The Jarque-Bera (JB) test statistic strongly rejects the hypothesis of normality. These observations show that the quasi-maximum likelihood (QML) approach proposed by Bollerslev and Wooldridge (1992) is essential to the estimation of our empirical model in the sense that it allows us to draw statistical inferences for unknown parameters under potential misspecifications of the empirical model (i.e. conditional mean and variance equations). In this paper, we are primarily concerned with the presence of non-normal error terms as indicated by the JB test[4].

	Kuwait	Oman	Qatar	UAE	S. Arabia	World
Panel A: summary statistics						
Mean (%)	0.093	0.051	0.022	−0.013	−0.023	0.043
Std-deviation (%)	1.187	1.104	1.643	2.001	2.464	0.748
Skewness	−0.288***	−0.406***	−0.267***	−0.678***	−0.424***	−0.319***
Excess Kurtosis	10.578***	10.968***	4.737***	6.0140***	14.419***	2.002***
JB	3,465.008***	3,734.878***	701.849***	1,173.485***	6,441.860***	136.352***
Q(12)	6.819	13.063	11.187	32.743***	13.978	27.274***
ARCH(12)	120.776***	21.929***	86.208***	134.887***	111.812***	91.104***
No. of observations	741	741	741	741	741	741
Panel B: autocorrelations						
Lag						
1	0.038	0.078	−0.014	0.023	0.017	0.136
2	−0.005	−0.013	0.028	−0.013	−0.003	0.018
3	0.040	−0.014	0.004	0.102	0.063	−0.026
4	0.025	−0.060	0.069	0.016	0.091	−0.012
5	−0.001	0.051	0.0495	0.152	−0.063	−0.025
6	−0.026	0.055	−0.042	−0.029	0.006	−0.068
Panel C: unconditional correlations of r_{it} *(in percentage)*						
Kuwait	100	12.868	13.996	26.866	22.175	0.025
Oman		100	28.315	26.317	15.353	5.354
Qatar			100	32.246	19.227	2.976
UAE				100	31.159	1.078
S. Arabia					100	−0.251
World						100

Notes: Data are daily total US dollar natural log returns computed from MSCI indices. The test for kurtosis coefficient has been normalized to zero. JB is the Jarque-Bera test for normality based on excess skewness and kurtosis. Q(12) is the Ljung-Box test for autocorrelation of order 12. ARCH(12) is the Engle (1982) test for conditional heteroscedasticity for 12 lags. Although we performed the Ljung-Box and Engle (1982) tests for lower lag lengths (1, 3, 6, and 9), we choose to report only the results for the 12th lag in order to show the long memory property in stock market returns and volatility. *, **, and ***indicate significance of coefficients at the 10, 5, and 1 percent levels, respectively

Table I.
Descriptive statistics and stochastic properties of the data

We also examined the presence of autocorrelation patterns in stock market returns from the countries studied, using the Ljung-Box test. The results obtained reject the null hypothesis of no autocorrelation of order 12 for the UAE and the world markets. The first autocorrelations, reported in Panel B, are generally low except for Oman and the world markets, which suggests that we need to include an autoregressive correction in the mean equations.

Panel C reports the unconditional correlations among sample markets. As we can see, cross-market correlations in the Gulf region are not high and range from 12.868 percent (between Kuwait and Oman) to 32.246 percent (between Qatar and UAE). It is interesting to note that there is a very low correlation between Gulf and world stock markets, which never exceeds 6 percent. A negative correlation is observed between Saudi Arabia and world markets. This is indicative of the fact that the Gulf markets in our study are generally disconnected from the world market trends, and thus global investors can still benefit from adding financial assets from the Gulf region to their diversified portfolios.

Table II presents some key financial indicators for the selected Gulf markets in 2007. We see that Saudi Arabia leads the region in terms of market capitalization ($522.7 billion) and turnover ratio (120.1 percent) as measured by the ratio of value traded to market capitalization. It is also important to note that the ratio of stock market capitalization to GDP is high and ranges from 40 percent in Oman to 222 percent in Qatar. These figures testify to the importance of equity markets in understanding the rapid development and high economic growth rates of their respective countries during the recent period. Finally, the Gulf stock markets are characterized by high degree of market concentration due to the small number of listed companies in the exchange, which ranges from only 32 in Qatar to 156 in Kuwait.

In addition, to the extent that return properties depend upon the qualitative characteristics of the stock markets, one should note that the Gulf stock markets are limited by several structural and regulatory weaknesses such as large institutional holdings, low sectoral diversification, a high degree of economic vulnerability, and strong dependence on the oil and petrochemical sectors. For most of the countries in the Gulf region, oil revenues represent from 32 percent (UAE) to 44 percent (Saudi Arabia) of GDP according to the statistics of the Arab Monetary Fund. Recently, a broad range of legal, regulatory, and supervisory changes have led to increasing transparency, liquidity, and efficiency in the banking and financial sectors. For example, in March 2006 the Saudi authorities lifted the restriction that limited foreign residents to dealing only in mutual investment funds, and the other markets have progressively followed suit.

3.2 Estimation results of the DCC-GARCH model

Table III contains parameter estimates and a number of diagnostic tests for the DCC-GARCH model. The coefficients relating the return series to their lagged values are significant for Oman and world markets (panel A). Thus, these stock markets display some predictability using previous returns. Significant sensitivities to previous world market changes are observed for Oman, Qatar, and the UAE. The ARCH and GARCH coefficients reported in panel B are significant for all countries. Accordingly, our results appear to be consistent with previous results in the literature. The small size of the ARCH coefficients, which measure the impact of past shocks on conditional variance, indicates in particular that Gulf market volatility does not change very rapidly. However, the GARCH coefficients, which measure the repercussions of lagged volatility on current volatility, are large, indicating gradual fluctuations of the volatility over time. Moreover, we note that the estimated coefficients α and β satisfy the stationary conditions for all the variance and covariance processes.

Market	Number of companies[a]	Market capitalization ($ billion)	Market capitalization (% GDP)[a]	Value traded ($ billion)	Turnover ratio (%)
Kuwait	156	193.5	190	120.6	62.3
Oman	125	22.7	40	4.7	20.7
Qatar	32	95.5	222	24.7	25.9
UAE	89	240.8	177	122.1	64.8
S. Arabia	77	522.7	202	628.1	120.1

Note: [a]Numbers in 2005
Source: Arab Monetary Fund and Emerging Markets Database

Table II. Equity markets in selected Gulf countries in 2007

Table III.
Estimation results

	Kuwait	Oman	Qatar	UAE	S. Arabia	World
Panel A – parameter estimates-mean equations						
δ_0	0.001*	0.000	0.000	0.000	−0.001**	0.000
	(0.000)	(0.000)	(0.001)	(0.000)	(0.000)	(0.000)
δ_1	0.044	0.160**	0.001	0.041	−0.030	0.135**
	(0.044)	(0.040)	(0.037)	(0.041)	(0.038)	(0.041)
δ_2	0.052	0.112*	0.213**	0.302**	0.060	–
	(0.055)	(0.047)	(0.076)	(0.081)	(0.086)	
Panel B – parameter estimates-GARCH process						
ϖ_0 ($\times 10^4$)	0.069	0.065	0.144	0.085	0.128	0.0103
	(1.557×10^{-6})	(1.612×10^{-6})	(3.281×10^{-6})	(2.008×10^{-6})	(1.999×10^{-6})	(0.417×10^{-6})
ϖ_1	0.045**	0.084**	0.070**	0.096**	0.066**	0.087**
	(0.006)	(0.013)	(0.014)	(0.014)	(0.009)	(0.018)
ϖ_2	0.900**	0.867**	0.876**	0.885**	0.910**	0.896**
	(0.016)	(0.021)	(0.022)	(0.012)	(0.011)	(0.022)
α	0.002					
	(0.003)					
β	0.945**					
	(0.091)					
Panel C – robust tests for model standardized residuals						
Skewness	0.053	−0.638**	−0.377**	−0.857**	−0.843**	−0.397**
Kurtosis	7.615**	8.388**	5.928**	5.231**	7.712**	1.317**
JB	1,788.392**	2,220.208**	1,101.312**	934.666**	1,921.716**	73.015**
$Q(12)$	6.288	6.118	17.041	26.89**	10.046	7.808
ARCH(12)	112.020**	6.851	48.135**	23.758*	62.253**	11.622

Notes: The Bollerslev and Wooldridge (1992) robust standard errors are given in parentheses. ϖ_0, ϖ_1, and ϖ_2 refer to the parameters of a GARCH(1,1) process. The test for kurtosis coefficient has been normalized to zero. JB is the Jarque-Bera test for normality based on excess skewness and kurtosis. Q(12) is the Ljung-Box test for autocorrelation of order 12. ARCH is the Engle (1982) test for conditional heteroscedasticity. * and **indicate significance of coefficients at the 5 and 1 percent levels, respectively

The diagnostics of standardized residuals are provided in panel C. One can recognize that the indices of kurtosis are in general lower than those for the returns, or equivalently from the statistical point of view, the unconditional distribution of return innovations becomes less leptokurtic. However, the JB test statistics for normality still indicate that the conditionally normal GARCH process is not sufficiently fat-tailed to accommodate the excess kurtosis present in the raw data. This result justifies our decision to use the QML procedures in estimating our models. We also compute the Lung-Box statistic to test the null hypothesis of absence of autocorrelation, and the Engle (1982) test of absence of ARCH effects in the return innovation series. Overall, the results lead us to conclude that the DCC-GARCH specification we employ reduces the values of the statistics of these tests.

3.3 Conditional volatilities and time-varying patterns of comovements

The daily volatility of selected countries and the world stock market index, as measured by the conditional variance, is depicted in Figure 1. As expected, the markets we studied are significantly more volatile than the world market. The Saudi stock

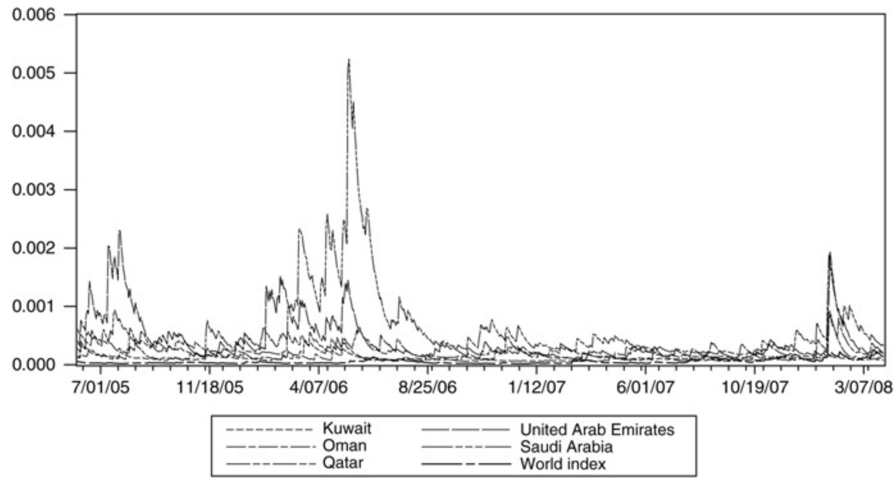

Figure 1.
Time-varying conditional variance of selected countries

market displays the highest level of conditional volatility compared with other markets. Its daily volatility peak is seen on May 17, 2006 with 0.52 percent, or an annualized variance of 188.59 percent, reflecting the crisis of 2006. This figure also shows that the Gulf stock markets have reacted to the subprime crisis and to the main local and regional events. Indeed, the recent increases in stock price volatility appear to be strongly associated with sharp upward movements in oil prices and regional inflation.

DCC within some Gulf markets and with the world market, as well as their 95-percent confidence intervals, are plotted together in Figure 2. The correlations between the Gulf markets are relatively low, 22.86 percent on average. The average time-varying correlations are quite similar to the unconditional correlations reported in Table I. All else being equal, this would suggest substantial opportunities for risk diversification within the Gulf stock markets because they generally do not co-move. However, the conditional correlations vary considerably over time and from a couple of countries to another, ranging from 12.9 percent between Kuwait and Oman and 13.75 percent between Kuwait and Qatar to 31.10 percent between the UAE and Saudi Arabia and 32.10 percent between Qatar and the UAE. In addition, a close examination of the behavior of the DCC indicates a potential for sudden changes in their time-paths, which of course needs to be analyzed carefully.

The extent of the conditional relationship with the world market is another interesting characteristic of the Gulf stock market returns: their daily correlations are particularly low and average about 1.52 percent. It is also observed that the evolution of these correlations includes some periods of negative values. For global portfolios, an appropriate asset allocation in the Gulf stock markets then leads to achieving superior risk-adjusted performance.

3.4 Perspective of structural changes

We now turn to investigate statistically whether any structural change occurred in conditional correlations between the Gulf and world stock markets over the sample period. To achieve this objective, the Bai and Perron (2003) testing procedure was applied to detect and date the possible structural breakpoints in our conditional correlation indices. In principle, a model's optimal number of breakpoints (*m*) is the one associated

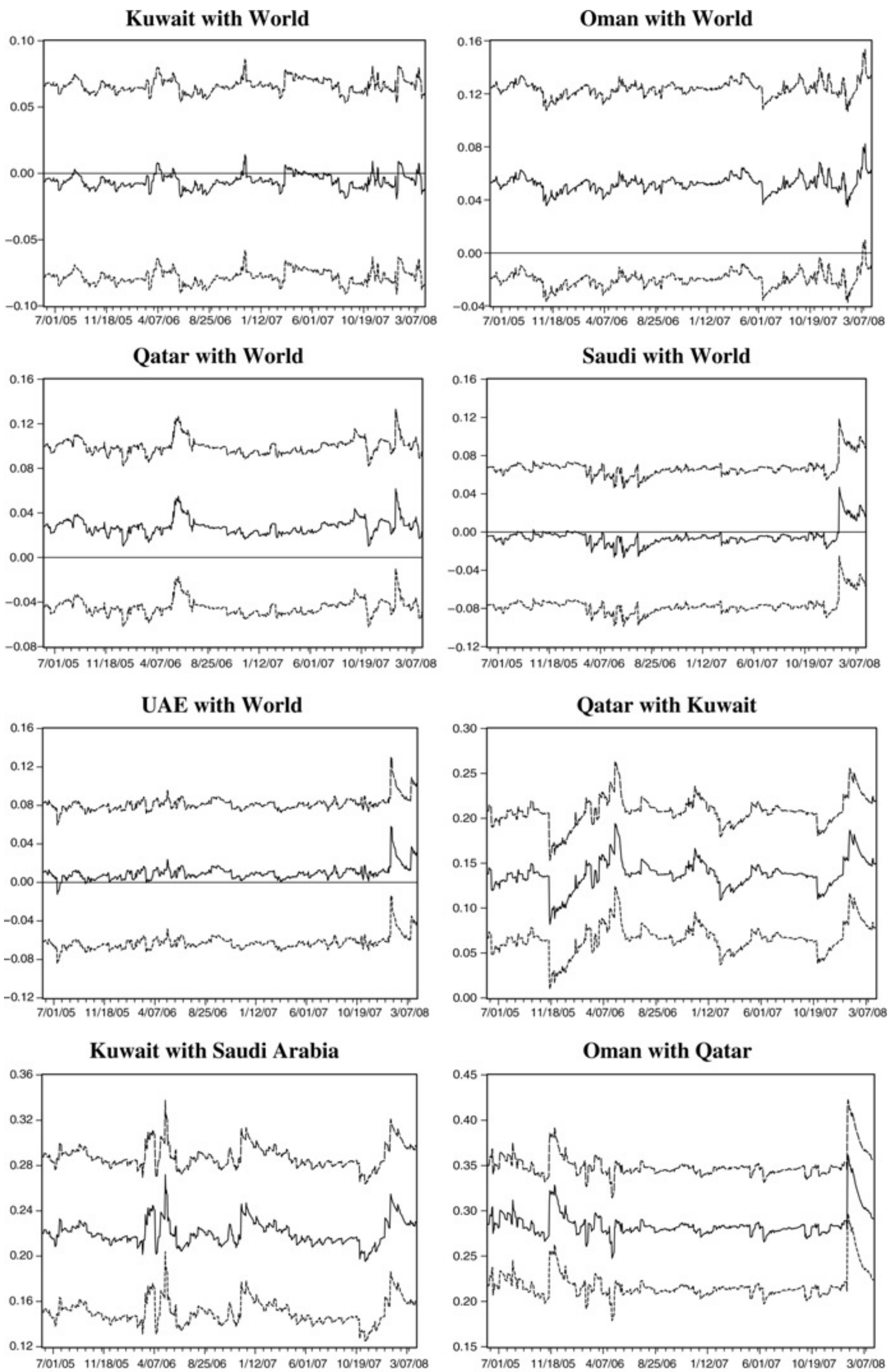

Figure 2.
Dynamic conditional correlations

(continued)

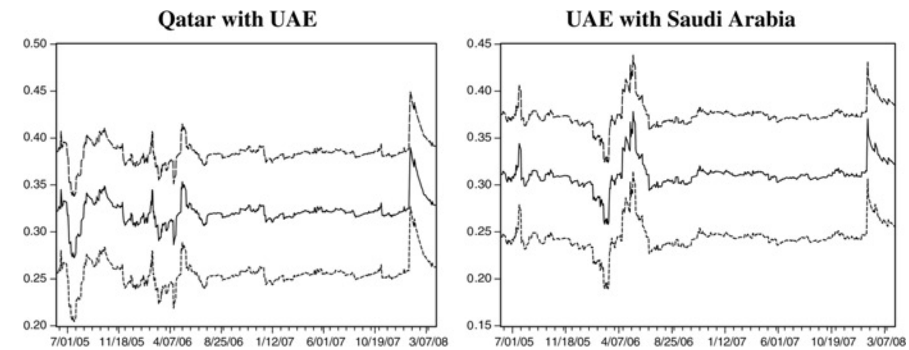

Figure 2.

with the minimum BIC, as discussed in section 2. The optimal breakpoints obtained for each market and their 95 percent confidence intervals are reported in Table IV.

The null hypothesis of stability is rejected for all the markets studied, since the Bai-Perron test detects breakpoints for the five markets. Five significant breakpoints were obtained for Oman, four for Qatar and the UAE, three for Kuwait, and two for Saudi Arabia. Similar results were obtained for the correlations within Gulf markets. Most of these breaks happened in 2006 as a reaction to financial liberalization and reforms occurring in the Gulf markets, and in 2007 as a result of the subprime crisis. However, it

Market	Optimal number of breakpoints	Estimated break dates	95% confidence intervals for break dates
Kuwait	3	June 2, 2006 November 6, 2006 July 24, 2007	May 24, 2006-June 20, 2006 October 30, 2006-November 9, 2006 June 20, 2007-August 9, 2007
Oman	5	November 3, 2005 April 26, 2006 December 14, 2006 May 18, 2007 October 22, 2007	October 26, 2005-November 16, 2005 April 19, 2006-May 10, 2006 November 24, 2006-December 27, 2006 April 30, 2007-May 25, 2007 August 17, 2007-November 9, 2007
Qatar	4	November 15, 2005 May 10, 2006 October 12, 2006 July 2, 2007	November 2, 2005-November 28, 2005 April 24, 2006-May 15, 2006 October 11, 2006-October 24, 2006 June 15, 2007-July 3, 2007
UAE	4	April 3, 2006 November 6, 2006 May 9, 2007 October 30, 2007	March 23, 2006-April 17, 2006 October 31, 2006-November 17, 2006 April 25, 2007-May 21, 2007 September 25, 2007-October 31, 2007
Saudi Arabia	2	February 28, 2006 September 4, 2006	February 21, 2006-February 29, 2006 September 3, 2006-September 15, 2006

Notes: The breakpoint selection procedure in the works of Bai and Perron (1998, 2003) is based on the Bayesian Information Criteria (BIC). First, we arbitrarily set the maximum number of breaks to 5. If the effective number of breaks is equal to 5, a higher number of breaks will be chosen so that the testing procedure captures all possible breakpoints. In principle, a model's optimal number of breakpoints is the one associated with the minimum BIC. For the countries considered in the present study, none of the volatility series has more than 5 breakpoints

Table IV. Results of the Bai-Perron test for multiple structural breakpoints in the conditional correlations with the world market is important to mention that the impact of these events on the conditional correlations is low in magnitude and that there is no clear upward trend in market comovements over the study period. Together these results suggest that recent market reforms and liberalization policies have not increased financial integration within the Gulf region or between the Gulf markets and the world market. Using different methodologies, other studies have reached the same conclusions (see for example, Darrat *et al.*, 2000; Abraham *et al.*, 2001; Achy, 2005; Simpson, 2008).

4. Conclusions

The aim of this article is to explore the time-varying characteristics of stock market linkages within the Gulf region and between the Gulf markets and the world market. The study has allowed us to provide answers to at least the following two important questions. First, are there still portfolio diversification opportunities in the Gulf region after the recent wave of economic reforms and liberalization operations? In this regard, earlier works have pointed out that diversification benefits would decrease with higher financial integration, which leads to a lower cost of capital and thus higher investment efficiency and economic growth (see for example Stulz, 1995, 1999, and references therein). Second, have the comovements in the Gulf stock markets encountered structural breaks under the impact of the lasting changes in the national and global economy?

At the empirical level, we have directly derived the cross-market linkages from the aggregate stock data using a multivariate DCC-GARCH model. A structural break test in the linear regression framework was then performed to date the structural breaks in the time-paths of the estimated market. Since comovement in international stock markets is a matter of great interest to both academics and practitioners, the results we obtained have important implications for the choice of asset allocation in internationally-oriented portfolio management as well as for economic policies in the Gulf region. Our main results can be summarized as follows.

First, we observe significant comovements among the Gulf markets, but these comovements are still small, indicating weak linkages between the stock markets of this region. Diversification within the Gulf region is nevertheless beneficial since market return behavior is, as indicated by our empirical results, far from homogeneous.

Second, the linkages between Arab markets and the world market are smaller and insignificant in all cases. There are then substantial opportunities for global investors to improve their portfolio risk-return performance. This may, however, change over time as financial markets embrace more foreign investments.

Finally, in order to improve their regional and international financial integration, the authorities in the Gulf region are encouraged to strengthen and expand their stock markets. In addition to market-opening efforts, significant improvements in market transparency, informational efficiency, trading mechanisms, and settlement procedures are particularly advised. In effect, our results point to weak regional and international financial relationships for the Gulf stock markets, while the Gulf economies have much in common including their growing levels of economic development and trade integration, as well as their increasing role in the world oil and financial markets.

Notes

1. The Gulf Cooperation Council was established in 1981 and includes six countries: Saudi Arabia, Kuwait, Oman, the United Arab Emirates, Qatar, and Bahrain.

2. For interested readers, further information and discussions concerning market characteristics and financial sector development in these countries can be found in Creane *et al.* (2004), Neaime (2005), and Naceur and Ghazouani (2007).
3. It should be noted that by imposing the restriction $\alpha + \beta \prec 1$ for the scalar parameters α and β, we obtain the mean-reverting DCC-GARCH model. If, on the other hand, $\alpha + \beta = 1$, we obtain the integrated DCC-GARCH.
4. The results of the maximum likelihood estimation (MLE) usually seen in statistic and econometric textbooks, and commonly used in empirical finance, are simply special cases of the QML method when the model is correctly specified.

References

Abraham, A., Seyyed, F. and Al-Elg, A. (2001), "Analysis of diversification benefits of investing in the emerging Gulf equity markets", *Managerial Finance*, Vol. 27, pp. 47-57.

Achy, L. (2005), "Financial liberalization, savings, investment, and growth in MENA countries", *Research in Middle East Economics*, Vol. 6, pp. 67-94.

Bai, J. and Perron, P. (1998), "Estimating and testing linear models with multiple structural changes", *Econometrica*, Vol. 66, pp. 47-78.

Bai, J. and Perron, P. (2003), "Computation and analysis of multiple structural change models", *Journal of Applied Econometrics*, Vol. 18, pp. 1-22.

Bauwens, L., Laurent, S. and Rombouts, J.V.K. (2006), "Multivariate GARCH models: a survey", *Journal of Applied Econometrics*, Vol. 21, pp. 79-109.

Bekaert, G. and Harvey, C.R. (2000), "Foreign speculators and emerging equity markets", *Journal of Finance*, Vol. 55, pp. 565-613.

Bekaert, G., Hodrick, R.J. and Zhang, X. (2005), "International stock return comovements", working paper, Columbia University, New York, NY.

Bollerslev, T. (1986), "Generalized autoregressive conditional heteroscedasticity", *Journal of Econometrics*, Vol. 31, pp. 307-27.

Bollerslev, T. and Wooldridge, J.M. (1992), "Quasi maximum likelihood estimation and inference in dynamic models with time-varying covariances", *Econometric Review*, Vol. 11, pp. 143-72.

Chiang, T.C., Jeon, B.N. and Li, H. (2007), "Dynamic correlation analysis of financial contagion: evidence from Asian markets", *Journal of International Money and Finance*, Vol. 26, pp. 1206-28.

Creane, S., Goyal, R., Mobarak, A.M. and Sab, R. (2004), "Financial sector development in the Middle East and North Africa", working paper no. 04/102, IMF, Washington, DC.

Darrat, A., Elkhal, K. and Hakim, S. (2000), "On the integration of emerging stock markets in the Middle East", *Journal of Economic Development*, Vol. 25, pp. 61-78.

Engle, R.F. (1982), "Autoregressive conditional heteroscedasticity with estimates of the variance of UK inflation", *Econometrica*, Vol. 50, pp. 987-1008.

Engle, R.F. (2002), "Dynamic conditional correlation: a new simple class of multivariate GARCH models", *Journal of Business and Economic Statistics*, Vol. 20, pp. 339-50.

Forbes, K. and Rigobon, R. (2002), "No contagion, only interdependence: measuring stock market comovements", *Journal of Finance*, Vol. 57, pp. 2223-61.

Gilmore, C.G., Lucey, B.M. and McManus, G.M. (2008), "The dynamics of central European equity market comovements", *Quarterly Review of Economics and Finance*, Vol. 48, pp. 605-22.

Harvey, C.R. (1995), "Predictable risk and returns in emerging markets", *Review of Financial Studies*, Vol. 8, pp. 773-816.

Hsin, C.-W. (2004), "A multilateral approach to examining the comovements among major world equity markets", *International Review of Financial Analysis*, Vol. 13, pp. 433-62.

Johnson, R. and Soenen, L. (2003), "Economic integration and stock market comovement in the Americas", *Journal of Multinational Financial Management*, Vol. 13, pp. 85-100.

Kearney, C. and Poti, V. (2006), "Correlation dynamics in European equity markets", *Research in International Business and Finance*, Vol. 20, pp. 305-21.

Kim, E.H. and Singal, V. (2000), "Stock market openings: experience of emerging economies", *Journal of Business*, Vol. 73, pp. 25-66.

Liu, J., Wu, S. and Zidek, J.V. (1997), "On segmented multivariate regressions", *Statistica Sinica*, Vol. 7, pp. 497-525.

Naceur, S.B. and Ghazouani, S. (2007), "Stock markets, banks, and economic growth: empirical evidence from MENA region", *Research in International Business and Finance*, Vol. 21, pp. 297-315.

Neaime, S. (2005), "Financial market integration and macroeconomic volatility in the MENA region: an empirical investigation", *Review of Middle East Economics and Finance*, Vol. 3, pp. 231-53.

Richards, A.J. (1995), "Comovements in national stock market returns: evidence of predictability, but not cointegration", *Journal of Monetary Economics*, Vol. 36, pp. 631-54.

Simpson, J. (2008), "Financial integration in the GCC stock markets: evidence from the early 2000s development phase", *Journal of Economic Corporation*, Vol. 29, pp. 1-28.

Stulz, R. (1995), "The cost of capital in internationally integrated markets: the case of Nestlé", *European Financial Management*, Vol. 1, pp. 11-22.

Stulz, R. (1999), "International portfolio flows and security markets", in Feldstein, M. (Ed.), *International Capital Flows*, University of Chicago Press, Chicago, IL, pp. 257-93.

Syriopoulos, T. (2007), "Dynamic linkages between emerging European and developed stock markets: has the EMU any impact?", *International Review of Financial Analysis*, Vol. 16, pp. 41-60.

Yao, Y.C. (1988), "Estimating the number of change-points via Schwarz's criterion", *Statistics and Probability Letters*, Vol. 6, pp. 181-9.

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