Volatility Transmission Across GCC Stock Markets

Ibrahim Onour

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Ibrahim A.Onour*

Abstract

The study of volatility transmission across markets commonly termed “volatility spillover” provides useful insights into how information disseminates across markets. Research results in this area have useful implications for issues such as international or regional diversification and market efficiency. In this paper, multivariate GARCH model was employed to investigate volatility and information transmission across the Gulf Cooperation Council (GCC) markets. The model separates direct volatility transmission from indirect transmission, which is mainly due to cross-regional diversification and hedging strategies undertaken by portfolio managers. Findings of the study show that effects of indirect volatility transmission are more prominent than direct transmission effects across the GCC markets.

إنتقال تذبذب أسعار الأسهم بين أسواق الأسهم لدول مجلس التعاون الخليجي

ابراهيم أونور

ملخص

تهتم الورقة بقياس انتقال تذبذب (volatility) أسعار الأسهم بين أسواق الأسهم لدول مجلس التعاون الخليجي باستخدام النماذج العامة للتباين المتغير المشروط ذات الارتباط الذاتي المتسلسل (GARCH). توضح نتائج الدراسة بأن تأثير تذبذب الاسعار الغير مباشر الناتج من وجود تكامل مشترك (Co integration) بين أسعار بورصات دول مجلس التعاون لدول الخليج الأكثر تأثيراً على تباين أسعار الأسهم مقارنة بالتباين الناتج من عمليات البيع والشراء المباشر في الأسواق ذاتها، الأمر الذي يؤكد أهمية تأثير المستجدات الإقليمية في دول المجلس على أداء البورصات المحلية. كما توضح الدراسة أيضاً أن السوق الكويتي هو من أكثر الأسواق تأثراً بالهزات التي تحدث في أسواق دول مجلس التعاون، حيث يتأثر السوق الكويتي بالذبذبات التي تحدث في كل من سوق دبي المالي والسوق السعودي دون أن يؤثر فيهما بصورة مباشرة.

* Associate Professor of International Finance, Arab Planning Institute, P.O. Box 5834, Safat, Kuwait. Email: onour@api.org.kw

Introduction

After the crash of October 1987, the issue of volatility inter-dependence among capital markets gained momentum and became the subject matter of much research in financial economic literature. King and Wadhwani (1990) investigated a number of US markets after the crash and showed that markets overreact to the events of other markets, irrespective of the economic value of information transmitted. Eun and Shim (1989) identified that about 26% of international stock markets variability may be explained by variability in return in other stock markets. Cheung and Ng (1996) showed that variability of stock returns of Asian-Pacific markets is closely associated with the variability of stock returns in major US stock markets.

The primary objective of this paper is to investigate volatility inter-dependence among six of Gulf Cooperation Council (GCC) stock markets, namely Abu-Dhabi, Bahrain, Dubai, Kuwait, Muscat, and Saudi stock markets.(1) These markets exhibit some common characteristics that identify them as a unique group. GCC countries have close and common economic, institutional, and cultural ties. Consequently, these markets share a number of common features beside dual stock listings among them.

In recent years, these markets have adopted structural reforms aimed at trading systems sophistication and transparency improvement by adopting new regulatory framework, trading rules, reporting, surveillance, settlements and clearance systems. All these efforts came in conjunction with the newly adopted agreement requiring GCC member states equal treatment of all GCC nationals in all investment activities, including stock ownership and establishment of new business and allowing free mobility of capital and labor of GCC nationals in member countries. The new agreement also calls for harmonization of all investment-related laws and regulations among GCC countries.

This paper is motivated by the growing literature on the conditional variance analysis. In the literature, different methods are adopted for measuring volatility spillover. Some of the methods include the cross-market correlation approach (Cheung and Ng, 1996). Others adopt GARCH modeling approach (Bollerslev, 1990, and Hamao et al., 1990). In this paper, the latter approach is followed.

Market Growth

Policy makers in GCC countries have realized that in order to have diversified economies and be less dependent on oil resources, restrictions on equity investments should be removed so that foreign investments can be channeled towards development needs. Since efficient and well-regulated capital markets are crucial for achieving such a goal, all GCC countries during the past five years, embarked on new regulatory reforms aimed at deepening their stock markets. In this context, laws have been enacted to improve prudential regulations of commercial banks. Anti-money laundering policies have been adopted to safeguard against unwanted inflow of money to the region. Restrictions have also been eased for capital mobility between GCC countries.

Following these policy reforms, there has been a substantial surge in the liquidity of GCC stock markets as indicated by the significant rise in turn-over ratios and the expanding market capitalization during the past three years. Table 1 indicates the size of GCC stock markets gaining average annual growth of 139%, and turn-over ratio increase of 155 % annually. Despite sluggish progress of privatization in GCC countries in general, the number of listed companies increased from 330 to 602 companies.(2)

Table 1. Growth Indicators

	Market Capitalization (million US$)		Turn-over ratio* (%)		No. of Listed Companies	
	2007	2002	2007	2002	2007	2002
Bahrain	6765	27016	0.9	4.0	41	51
Kuwait	26926	135362	12.1	100.1	90	196
Muscat	3559	23086	2.3	22.6	95	125
Saudi	76364	518984	8.8	131.4	76	111
Abu Dhabi	6224	121128	0.4	39.4	16	64
Dubai	8456	138179	1.3	74.8	12	55

*Defined as the ratio of traded shares to the total outstanding shares.
Source: Arab Capital Markets Statistics/Arab Monetary Fund.

Data Analysis

Data employed in this study are daily closing price indices for GCC stock markets, and Brent crude oil price as reported in the Wall Street Journal and recorded as daily series in the data base of the Center for Energy Studies of Louisiana State University .The sample period covers data from May 2004 to Sept, 2006, including 363 observations.(3) Summary statistics for stock returns are presented in Table 2.

Table 2. Summary Statistics

	Bahrain	Kuwait	Muscat	Saudi	Abu Dhabi	Dubai
Mean	0.028	0.23	0.15	0.37	0.41	0.65
St.deviation:	3.5	2.8	2.3	5.5	7.8	12.1
Skewness:	-2.3	0.26	1.6	2.1	7.7	10.3
Kurtosis:	93	62.6	65.5	58.7	134	166.4
JB test (p-value)	769 (0.00)	571 (0.00)	628 (0.00)	505 (0.00)	727 (0.00)	724 (0.00)
Q(5) (p-value)	22.6 (0.00)	47.7 (0.00)	44.3 (0.00)	45.6 (0.00)	2.26 (0.81)	15.4 (0.00)
$Q^2(5)$ (p-value)	3.7 (0.58)	87.5 (0.00)	79.9 (0.00)	82.1 (0.00)	0.03 (0.98)	243 (0.00)
LM ARCH(1) (p-value)	1.6 (0.84)	86.4 (0.00)	79.0 (0.00)	81.1 (0.00)	0.01 (0.98)	180 (0.00)
LM ARCH(5) (p-value)	3.7 (0.47)	142.1 (0.00)	119.1 (0.00)	124 (0.00)	0.03 (0.98)	213 (0.00)

While the six markets exhibit positive mean returns, Table 2 shows varying unconditional volatility. The skewness and high values of kurtosis coefficients indicate the distributions of returns characterized by positive skewness and peakness relative to a normal distribution.(4) The positive skewness results imply a higher probability for stock prices increase. The Jarque-Bera (JB) test statistic provides evidence to reject the null hypothesis of normality for the unconditional distribution of the daily price changes. The sample autocorrelation statistic indicated by the Ljung-Box, Q statistic, rejects the null hypothesis of uncorrelated price changes up to five lags for five markets in the group, but only the Abu Dhabi market shows evidence of uncorrelated price changes.

Investigation of ARCH (Autoregressive Conditional Hetroskedasticity) behavior of stock returns, conducted by $Q^2(5)$ and LM (Lagrange Multiplier) test statistics show evidence of stock returns persistence (ARCH effect) for all markets, except for the Abu Dhabi and Bahrain stock markets. Since the standard LM and Ljung-Box statistics cannot detect nonlinear dependence in time series, the persistence in stock returns of these two markets, could be more complex than can be captured by the LM and Q statistics.

To circumvent the low power of the LM test in detecting conditional hetroskedasticity of price returns, the Kocenda and Briatka (2005) test - known as K2K - is employed to account for hidden nonlinear dependence in stock returns by testing for strict white noise process that reflect sequence of independent and identically distributed (iid) random variable.(5)

Results in Table 3 confirm evidence of nonlinear dependence and reject the null hypothesis of iid stock returns for the six markets.

Table 3. Nonlinear Dependence Test (K2K)*

Dimension	Bahrain	Kuwait	Muscat	Saudi	Abu Dhabi	Dubai
2	0.098	0.527	0.587	0.48	0.38	0.425
3	0.146	0.744	0.840	0.64	0.55	0.592
4	0.186	0.918	1.07	0.78	0.69	0.727
5	0.227	1.06	1.29	0.90	0.81	0.845
6	0.268	1.20	1.48	1.03	0.93	0.95
7	0.31	1.33	1.64	1.15	1.04	1.04
8	0.35	1.45	1.80	1.26	1.16	1.13
9	0.39	1.55	1.96	1.34	1.25	1.22
10	0.44	1.64	2.09	1.43	1.34	1.28

*Values in entries are K2K statistics. All values of K2K reject the null hypothesis of iid at the 1% significance level - critical values included in Kocenda and Briatka (2005).

Volatility Transmission

To identify conditional volatility of stock returns, common factors such as oil price changes that simultaneously influence GCC markets, need to be controlled. Thus, in the following stock returns stated as a function of oil price change, ΔE_t , and own lagged values beside conditional standard deviation of returns, as a measure of risk factor(6).

One important motive for taking the conditional standard deviation as explanatory variable is to ensure consistency property of a quasi-maximum likelihood estimator.[(7)] As a result, conditional volatility of stock returns, R_t, is determined as:

$$R_t = a_0 + \sum_{i=1}^{k_1} a_i R_{t-i} + \sum_{j=0}^{k_2} \delta_j \Delta E_{t-j} + \lambda \sqrt{h_t} + e_t \quad (1)$$

$$\text{where} \quad e_{t/t-1} \sim N(0, h_t)$$

$$h_t = \beta_0 + \sum_{i=1}^{q} \beta_i e^2{}_{t-i} + \sum_{i=1}^{p} \alpha_i h_{t-i} \quad (2)$$

The significance and sign of the coefficient λ, reflect risk attitude of investors. A significant and negative sign of the coefficient, λ, indicates risk aversion behavior, and insignificance implies risk neutral behavior. Conditional volatility of stock returns is depicted in Equation 2 as GARCH (Generalized Autoregressive Conditional Hetroskedasticity) process, where h_t stand for conditional variance; p, and q are lag parameters for AR(p) and MA(q) components.

Multivariate GARCH model that accommodates volatility spillover among stock markets, as well as volatility persistence within each market, is the VECH model which was introduced by Bollerslev, Engle, and Wooldridge (1988), stated as:

$$Vech(H_t) = B_0 + \sum_{i=1}^{p} B_i vech(H_{t-i}) + \sum_{i=0}^{q} A_i vech(e_{t-i} e'_{t-i}) \quad (3)$$

The notation vech(.) is the vector half operator which transforms asymmetric (dxd) matrix into a vector of length d=(d+1)d/2 by stacking the elements of the upper triangular half of the matrix. Ht denotes the conditional variance matrix. One major problem related to vech specification of multivariate GARCH models is the large number of parameters included in the estimation process.

An alternative approach developed by Engle and Kroner (1995) - and they termed the Baba, Engle, Kraft and Kroner or BEKK representation - specifies the conditional variance in GARCH (1,1) as:

$$H_t = \alpha'\alpha + \beta' H_{t-1} \beta + A' e_{t-1} e'_{t-1} A \quad (4)$$

where α in this case is a (6x6) lower triangular matrix and β is a (6x6) square matrix of parameters. The matrix β reflects the extent to which current levels of conditional variances are related to past conditional variances. Parameters in matrix A estimates the extent to which conditional variances are linked with past squared errors. The elements in A captures the impact of news on conditional volatility.

Despite the BEKK model including smaller number of parameters (N(5N+1)/2) compared to the number of parameters in vech model ((N(N+1)(N(N+1)+1)/2), the number of parameters in the case of six markets still seems large (93 parameters). Another problem related with the general specification of BEKK model in Equation 4, as noted by Bauwens (2005), is that interpretation of the basic parameters is not obvious since Equation 4 has nonlinear parameters.

To resolve the over-parameterization problem, Bollerslev (1990) proposed constant conditional correlations among the elements of covariances in quation 4 so that $h_{ij(t-1)} = \rho_{ij}\sqrt{h_{ii(t-1)}h_{jj(t-1)}}$ and restrict the elements of matrices A and B to only diagonal terms. However, since the off-diagonal terms of matrix B represent indirect volatility transmission across markets in this paper, all elements of matrix B are maintained and only the diagonal terms of matrix A are reserved. The cross product terms of residuals (the off-diagonal terms of matrix A) does not have meaningful interpretation of volatility transmission effects. When including these changes, the set of Equation 4 may be stated as:

$$h_{jj,t} = c_i + \sum_{i=1}^{6}\beta_{1i}h_{1i(t-1)} + \sum_{i=2}^{6}\beta_{2i}h_{2i(t-1)} + \sum_{i=3}^{6}\beta_{3i}h_{3i(t-1)} + \sum_{i=4}^{6}\beta_{4i}h_{4i(t-1)} + \sum_{i=5}^{6}\beta_{5i}h_{5i(t-1)} + \sum_{i=1}^{6}a_{ii}\, e^2_{ii(t-1)} + \varepsilon_j \qquad (5)$$

$$\text{for} \quad j = 1,2\ldots\ldots 6$$

Where c_i are constants, β_{ki} (i = 1,...6) are conditional variance-covariance parameters, and ε are residuals terms.

The coefficients in the variance terms in Equation 5 reflect direct volatility transmission, and the coefficients of covariance terms represent indirect volatility transmission, whereas coefficients of squared residuals reflect transmission of news across stock markets.

Estimation of parameters in Equation 5 is performed maximizing the log-likelihood function:

$$L(\Omega) = -N\ln(2\pi) - (1/2)\sum_{t=1}^{N}(\ln|H_t| + e_t' H_t^{-1} e_t) \qquad (6)$$

where N is the number of observations and Ω , represents the parameter vector to be estimated.[8]

Estimation

Estimation results of Equation 1, reveal significant short-term effect of oil price change on stock returns of the Muscat and Bahrain markets, albeit they are smaller in terms of market capitalization (Table A1, Appendix), and relatively less oil-dependent economies among GCC countries.[9] Significant and negative coefficient values of (λ), show risk aversion attitude characterizing the Saudi, Kuwait, and Bahrain stock markets.[10] However, insignificant (λ) coefficients for the Abu-Dhabi and Dubai markets, reflect risk neutral behavior of investors. Table A2, Appendix, signify stationarity conditions stipulated by GARCH-type volatility of Equation 2.

Estimation of Equation 5 presented in Table 4 indicates there is direct volatility transmission from the Saudi and Dubai markets to the Kuwait stock market, and from the Muscat to the Abu Dhabi market. Estimation results show that the effects of indirect volatility transmission are more prominent than the direct volatility shocks. This is revealed by significant indirect volatility transmission across all GCC markets, which is indicated by significant covariance coefficients (β_{ij} i≠j) for the six GCC markets. Significant indirect volatility transmission across GCC markets is probably due to cross-regional portfolio management and hedging strategies undertaken primarily by investment funds managers.

News transmission effect indicates that the Kuwait and Bahrain markets are the only GCC markets that respond significantly to outside news. Volatility in the Kuwait stock market reacts to its internal news, and to news originating from the Saudi and Dubai stock markets.

Table 4. Estimates of Volatility Transmission

Parameters*	Bahrain (1)	Kuwait (2)	Muscat (3)	Saudi (4)	Abu Dhabi (5)	Dubai (6)
$\beta_{11(t-1)}$	-	-0.06(0.55)	0.02(0.74)	0.07(0.85)	0.30(0.36)	-0.78(0.40)
$\beta_{22(t-1)}$	15.1(0.10)	-	0.65(0.24)	2.1(0.46)	0.39(0.86)	4.25(0.51)
$\beta_{33(t-1)}$	7.1(0.48)	0.42(0.45)	-	-2.9(0.36)	5.4(0.03)	-1.13(0.87)
$\beta_{44(t-1)}$	-22.1(0.7)	6.9(0.05)	5.6(0.11)	-	-2.89(0.85)	28.5(0.53)
$\beta_{55(t-1)}$	0.99(0.26)	-0.03(0.63)	0.03(0.52)	-0.11(0.66)	-	0.69(0.25)
$\beta_{66(t-1)}$	-0.41(0.34)	0.05(0.05)	0.02(0.94)	0.04(0.77)	-0.05(0.60)	-
$\beta_{12(t-1)}$	3.9(0.01)	-0.01(0.85)	0.14(0.15)	0.39(0.39)	0.01(0.98)	2.1(0.04)
$\beta_{13(t-1)}$	0.06(0.96)	-0.11(0.10)	0.18(0.16)	0.18(0.64)	0.41(0.17)	1.11(0.20)
$\beta_{14(t-1)}$	-0.9(0.22)	0.04(0.27)	0.02(0.58)	-0.16(0.49)	-0.49(0.00)	-0.09(0.84)
$\beta_{15(t-1)}$	-0.36(0.50)	-0.05(0.10)	-0.02(0.55)	0.11(0.49)	0.31(0.01)	0.11(0.75)
$\beta_{16(t-1)}$	0.24(0.59)	0.01(0.54)	-0.01(0.52)	0.27(0.05)	-0.09(0.42)	-0.51(0.11)
$\beta_{23(t-1)}$	0.42(0.79)	0.11(0.20)	-0.06(0.52)	0.15(0.76)	-0.24(0.53)	1.18(0.29)
$\beta_{24(t-1)}$	0.68(0.37)	0.03(0.44)	0.02(0.66)	-0.53(0.02)	0.52(0.00)	0.09(0.85)
$\beta_{25(t-1)}$	-0.03(0.96)	-0.07(0.14)	-0.13(0.03)	-0.30(0.32)	0.61(0.01)	-0.75(0.27)
$\beta_{26(t-1)}$	0.83(0.12)	0.02(0.93)	0.02(0.47)	-0.36(0.03)	0.48(0.00)	-1.44(0.00)
$\beta_{34(t-1)}$	1.98(0.01)	-0.08(0.05)	0.01(0.70)	0.30(0.13)	-0.04(0.83)	-0.56(0.29)
$\beta_{35(t-1)}$	-0.98(0.20)	0.01(0.76)	0.06(0.14)	0.02(0.92)	0.01(0.92)	0.26(0.62)
$\beta_{36(t-1)}$	0.22(0.65)	-0.02(0.45)	-0.02(0.32)	-0.03(0.85)	0.08(0.49)	-0.68(0.03)
$\beta_{45(t-1)}$	-0.82(0.04)	0.03(0.14)	0.03(0.21)	0.10(0.40)	-0.11(0.22)	-0.17(0.53)
$\beta_{46(t-1)}$	-0.71(0.01)	-0.02(0.12)	-0.04(0.78)	-0.03(0.64)	0.02(0.68)	-0.25(0.17)
$\beta_{56(t-1)}$	0.34(0.09)	0.01(0.61)	0.01(0.21)	0.07(0.26)	-0.02(0.59)	0.45(0.00)
$\alpha_{11(t-1)}$	0.02(0.63)	0.06(0.38)	-0.02(0.77)	-0.02(0.95)	-0.27(0.39)	0.74(0.41)
$\alpha_{22(t-1)}$	-16.5(0.07)	0.10(0.05)	-0.65(0.24)	-1.8(0.53)	-0.70(0.75)	-4.2(0.50)
$\alpha_{33(t-1)}$	-7.1(0.48)	-0.42(0.45)	0.12(0.02)	2.95(0.36)	-5.4(0.03)	1.13(0.87)
$\alpha_{44(t-1)}$	22.3(0.73)	-6.9(0.05)	-5.6(0.11)	0.05(0.34)	2.9(0.85)	-28.6(0.52)
$\alpha_{55(t-1)}$	-0.83(0.34)	-0.02(0.73)	-0.02(0.59)	0.22(0.39)	-0.01(0.70)	-0.28(0.63)
$\alpha_{66(t-1)}$	0.44(0.30)	-0.04(0.04)	-0.01(0.79)	-0.08(0.50)	0.08(0.43)	0.07(0.14)

*Lagged coefficient subscripts refer to the stock markets: 1 = Bahrain; 2 = Kuwait; 3 = Muscat; 4 = Saudi; 5 = Abu Dhabi; 6 = Dubai. Values of constants are not reported in the table. Values in parenthesis are p-values. Bold numbers are significant up to 5% significant levels. All values are up to two decimal numbers.

Conclusion

This paper investigates volatility and information transmission across GCC stock markets, using multivariate GARCH specification of conditional volatility. The GARCH model employed in the paper separates the effect of direct volatility transmission from the indirect transmission effect. This latter type of volatility transmission is attributed to cross-regional portfolio diversification and hedging strategies undertaken mainly by managers of investment funds.(11)

The multivariate GARCH approach employed in this study also captures the effect of news and information transmission on volatility of stock markets. Results of the paper reveal that the Kuwait stock market is the most vulnerable to direct volatility shocks in GCC markets, as volatility shocks at Saudi and Dubai markets transmit to Kuwait stock market. The findings of the paper also reveal evidence of significant indirect volatility transmission across all GCC markets.

With regard to stock markets' reaction to news and information spillover, the Kuwait and Bahrain markets are the only GCC markets responding significantly to outside news and information. Volatility in the Kuwait stock market reacts to its own internal news, and to news originating from the Saudi and Dubai stock markets.

Evidences of indirect volatility transmission across all GCC markets enhance the currency unification policy planned for the year 2010. This is because as correlation of shocks becomes stronger among GCC capital markets, adjustment to such shocks becomes faster. This, in turn, reduces the cost of adjustment using monetary instruments.(12) More specifically, when the effect of an adverse temporary shock on a certain GCC market is transmitted to other GCC markets, its impact will be realized on varying degrees by other GCC markets.

As a result, the adverse effect of markets' downturn, such as capital transfer from one GCC market to another market in the region, becomes relatively smaller since the impact is no longer specific to a certain market in the region. On the other hand, when shocks are uncorrelated, the impact of any shock to any specific market will be limited to that market. Consequently, this may induce capital outflow from the affected market. This may require the use of monetary instruments to mitigate the impact of capital transfer in the affected country.

While volatility transmission provides some advantage in terms of gains in market efficiency, it also offers potential pitfalls. Greater spillover effects among GCC markets imply stronger co-movements between markets, therefore reducing the opportunities for regional diversification. Furthermore, market co-movements may also lead to market contagion as investors incorporate into their trading decisions information about price changes in other markets.

Footnotes

(1) Qatar stock market is not included in this research due to missing data during the sample period under investigation.

(2) The apparent increase in the number of listed companies in most GCC markets is mainly due to dual-listing of companies from other GCC markets, and change from private and family-owned, to public companies

(3) Due to differences in the weekend holidays among GCC stock markets viz a viz the Wall Street, harmonization of trading days has reduced the sample size to 363 observations.

(4) The skewness (sk) and excess kurtosis (k) statistics were calculated using the formulas:

$sk = \frac{m_3}{(m_2)^{3/2}}$, and $k = \frac{m_4}{(m_4)^2} - 3$, where m_j stands for the jth moment around the mean. Under the null hypothesis of normality, the two statistics are normally distributed with standard errors, $\sigma_{sk} = \frac{\sqrt{6}}{N}$, and $\sigma_k = \frac{\sqrt{24}}{N}$, where N is the sample size.

(5) In fact, the K2K test is a more general form of BDS test introduced by Brock, Dechert, and Scheinkman (1987), which is used for testing the null hypothesis that the data are independently and identically distributed, against unspecified alternative. Kocenda and Briatka (2005) developed a computer program for calculating K2K statistics. K2K computer program is available at the website: http://home.cerge-ei.cz/kocenda/papers/k2k .

(6) Stock returns in international major markets also seem to be a relevant variable explaining changes in GCC stock markets, but according to recent research findings, e.g Shawkat and Choi (2006); and Abraham and Fazal (2006), GCC stock markets are not cointegrated with US equity markets.

(7) Newey and Douglas (2006) showed that when estimating the parameters in a time-varying conditional variance using a QMLE if the density from which the likelihood is constructed is non-Gaussian (or asymmetric) for a QMLE to be consistent, a conditional standard deviation needs to be included as an additional regressor.

(8) Maximization of the log likelihood in Equation 6, has QMLE features.

(9) Using ADF and PP unit root tests, it has been verified that stock returns for the six GCC markets are I(0).

[10] This could be due to speculative factors that characterize stock price changes in those markets.

[11] It should be noted that investment funds are the only equity investments accessible to foreigners in GCC countries over the sample period of this research.

[12] Bayoumi and Eichengreenn (1993) showed that while demand and supply shocks across US regions are higher than across European Union countries, the adjustment to shocks is faster in the US than in Europe.

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Appendices

Table A1. Stock Returns' Volatility

Parameters*	Bahrain	Kuwait	Muscat	Saudi	Abu Dhabi	Dubai
α_0 (p-value)	-8.4 (0.00)	-2.5 (0.95)	83.8 (0.01)	-25.2 (0.83)	135 (0.00)	8.1 (0.00)
α_1 (p-value)	-0.39 (0.00)	0.99 (0.00)	1.5 (0.00)	0.99 (0.00)	0.40 (0.88)	0.59 (0.00)
α_2 (p-value)	-0.01 (0.00)	-	-0.59 (0.00)	-	0.02 (0.00)	0.20 (0.07)
α_3 (p-value)	-0.04 (0.28)	-	-	-	0.06 (0.72)	0.17 (0.06)
δ_0 (p-value)	-7.3 (0.00)	1.6 (0.23)	-	2.4 (0.50)	0.40 (0.21)	0.15 (0.75)
δ_1 (p-value)	1.6 (0.03)	-	-6.2 (0.06)	-	5.8 (0.00)	0.65 (0.17)
δ_2 (p-value)	-2.5 (0.00)	-	12.4 (0.00)	-	-8.6 (0.00)	-0.80 (0.17)
δ_3 (p-value)	-0.83 (0.35)	-	-	-	-	-
δ_4 (p-value)	8.9 (0.00)	-	-	-	-	-
λ (p-value)	-0.78 (0.00)	-0.77 (0.01)	0.75 (0.00)	-5.9 (0.00)	0.11 (0.59)	-0.90 (0.33)

*Lags in Equation 1 have been determined by AIC criteria. Stationarity conditions of parameters of equation 2, impose the restriction that lagged variables corresponding to dashed «-» cells in the table be excluded.

Table A2. Parameter Estimates*

Parameters**	α_0	α_1	ϕ_0	ϕ_2
Bahrain GARCH(2,1)	703(0.00)	0.50(0.09)	0.20(0.07)	-
Kuwait GARCH(1,1)	229(0.00)	0.16(0.04)	0.01(0.35)	-
Muscat GARCH(2,1)	3306(0.00)	0.13(0.00)	0.002(0.87)	0.58(0.00)
Saudi GARCH(1,1)	4049(0.00)	0.25(0.00)	0.66(0.00)	-
Abu Dhabi GARCH(1,1)	375(0.00)	0.89(0.02)	0.01(0.50)	-
Dubai GARCH(1,1)	2.79(0.34)	0.61(0.00)	0.07(0.00)	-

** Values in paranthesis are p-values.
*Stationarity conditions of the equation
stipulate that:
be satisfied for all markets.