Global and Regional Volatility Spillovers to GCC Stock Markets

Alotaibi, Abdullah R and Mishra, Anil V

The Public Authority of Applied Education and Training, College of Business Studies, Kuwait, University of Western Sydney, School of Business, Australia

1 February 2015

Global and Regional Volatility Spillovers to GCC Stock Markets

Abdullah R. Alotaibi[a] and Anil V. Mishra[b]

[a]The Public Authority of Applied Education and Training, College of Business Studies, Kuwait

[b]University of Western Sydney, School of Business, Australia

Abstract

This paper examines the effects of return spillovers from regional (Saudi Arabia) and global (US) markets to GCC stock markets (Bahrain, Oman, Kuwait, Qatar, United Arab Emirates). The paper develops various bivariate GARCH models for regional and global returns: BEKK, constant correlation and dynamic correlation. The specification tests are used to choose between the models with and without asymmetric effects. The estimated innovations for the regional and global returns are then used as input for the univariate volatility spillover model which allows the unexpected returns of any particular GCC stock market be driven by three sources of shocks: local, regional from Saudi Arabia and global from US. We find significant return spillover effects from Saudi Arabia and US to GCC markets. Trade, turnover and institutional quality has significant impacts on regional volatility spillovers from Saudi Arabia to GCC markets. There are macroeconomic policy implications associated with the strengthening of intra-regional and cross-border trade in goods, services and assets and regulatory framework.

Keywords: Volatility spillovers; GCC stock markets; GARCH; BEKK; CCC; DCC

[a]Abdullah R. Alotaibi; The Public Authority of Applied Education and Training, Kuwait; College of Business Studies, Tel. No: +965 99558979; E-mail address: ar.alotaibi@paaet.edu.kw

[b]Corresponding author: Anil V. Mishra; University of Western Sydney, School of Business, Australia; Tel. No: +612 9685 9230; E-mail address: a.mishra@uws.edu.au

Global and Regional Volatility Spillovers to GCC Stock Markets

1. Introduction

During the past 20 years, GCC countries have gone through a period of important steps to improve economic and monetary integration towards establishing a single market, and forming monetary union at a certain stage. In addition, significant progress has been made in strengthening and deepening the various GCC financial markets[1]. As emerging markets mature and become increasingly integrated with global markets; their sensitivity to the volatility spillovers of stock markets increases, their portfolio diversification ability decreases and they become more vulnerable to external shocks. This study focuses on the impact of regional and global volatility spillovers to frontier GCC markets[2].

The study is primarily motivated by several reasons. First, GCC stock markets are classified as frontier markets[3] due to a number of market and institutional issues including liquidity, lack of effectiveness of their delivery versus payment settlement system, ownership limits on foreign investments, etc. GCC markets are frontier markets in which regional factors dominate global factors (Balcilar et al., 2013). Most previous studies on mean and volatility spillovers focus on how a single international market influences GCC stock markets but do not distinguish regional versus global market factors. This study distinguishes volatility spillovers from regional (Saudi Arabia) and global (US) market to GCC markets. There has not been any study that focuses on volatility spillovers from Saudi Arabia as a regional market and US as a

[1] GCC markets account for 40% and 23% of global proven oil and gas reserves respectively; sovereign wealths are estimated to be more than US$ 1 trillion in size and financial systems dominated by commercial banks (Espinoza et al., 2011).
[2] Marashdeh and Shrestha (2010) state that GCC markets are not fully integrated and these markets are not integrated with the developed markets as represented by the United States and European markets. The findings imply that there is a more profitable opportunity of portfolio diversification between the GCC and the developed countries than between the more integrated GCC markets.
[3] All GCC markets are frontier markets which aspire to be upgraded to the emerging market status as defined by the MSCI index provider.

global market on GCC stock markets. Second, understanding the sources of volatility is critical for providing important insight into the process of monetary and financial integration. In imperfectly integrated markets, regional factors are important in shaping their policy decisions and developing various regulatory requirements, like capital requirements or capital controls. Third, findings of this study can provide useful information for GCC central banks and policy makers regarding monitoring stock markets stability, development and coordination of the monetary policies in the on-going integration process. Fourth, fundamental contagion occurs as a result of greater economic and stock market integration and disseminate through trade and stock market integration (Neaime, 2012)[4]. We analyse the impact of trade and stock market integration variables (turnover, inflation, domestic credit, oil production, institutional quality) on volatility spillovers from Saudi Arabia to GCC markets.

Most of the studies on GCC stock markets have focused on the investigation of the first moment interaction among GCC countries, the integration with other developed markets such as US, the market efficiency and the impact of oil volatility on stock market returns. To our knowledge, no study has explored the impact of spillovers from global (US) and regional (Saudi) stock markets to GCC stock markets. The paper studies the effects of volatility spillovers from the US and Saudi stock market to GCC stock markets; Bahrain, Kuwait, Oman, Qatar, and the UAE. By considering innovations from the Saudi and US markets as regional and global shocks respectively, we analyze how much of the return volatility of any particular market in the GCC is driven by a global factor and how much is left to be explained by a regional one.

[4] Glick and Rose (1998) state that crisis tend to spread along the lines of trade linkages.

This study makes a methodological contribution. In order to investigate the volatility spillover effects from Saudi Arabia and the US to the GCC stock markets, we construct a bivariate GARCH(1,1) (constant correlation model, dynamic correlation model, BEKK model) for the Saudi Arabia and US returns. We then conduct specification tests to check whether the bivariate models are correctly specified and to compare their overall performances. The estimated innovations for the Saudi Arabia and US are then used as input in the univariate volatility spillover model for the GCC stock markets. Accordingly, we examine the magnitude and changing nature of spillovers from Saudi Arabia and US to five GCC markets.

The paper tries to answer the following questions: (i) What are the magnitude and changing nature of return spillovers from Saudi Arabia and US to GCC stock markets? (ii) What are the policy implications deriving from the findings regarding monitoring stock markets stability? (iii) What are the determinants of volatility spillovers from Saudi Arabia to GCC markets?

The paper is structured as follows: Section 2 provides the literature review. Section 3 describes the data on the six GCC stock markets, together with US, and offers some descriptive statistics. Section 4 discusses the econometric models of volatility spillovers and the specification tests, and section 5 reports the empirical results. Finally, section 6 concludes and provides policy implications.

2. Literature Review

The literature comprises of a number of alternative frameworks of ARCH and GARCH models (Engle (1982), Bollerslev (1986), Glosten et al (1993), Engle et al (1987), Bollerslev et al (1988), Bollerslev (1990), Engle and Kroner (1995) and Engle (2002)). GARCH models are now commonly used to model and analyze changes in the volatility of financial asset (Hamao et al (1990), Lin et al (1994), Susmel and Engle (1994), Choudhry (1996), Bekaert and Harvey (1997), Kanas (1998), Christofi and Pericli (1999), Ng (2000), Fratzscher (2002), Kim and In (2002), Baele (2005), Mukherjee and Mishra (2008), Beirne al et. (2010), Chiang et al. (2013), Zheng and Zuo (2013)).

We review studies on MENA and GCC region using GARCH type modeling. Abraham and Seyyed (2006) examine the flow of information among the Gulf stock markets of Saudi and Bahrain and find asymmetric volatility spillovers from the smaller but accessible Bahrain market to the larger but less accessible Saudi market. Hammoudeh and Choi (2007) use the univariate GARCH model with two volatility regimes of Markov switch to examine the volatility behaviour for the transitory and permanent components of each GCC stock markets. Malik and Hammoudeh (2007) examine the volatility and shock transmission mechanism among US equity, global crude oil market, and equity markets of Saudi Arabia, Kuwait, and Bahrain. In all cases, Gulf equity markets receive volatility from the oil market but only in the case of Saudi Arabia they find a significant volatility spillover from the Saudi market to the oil market. Hammoudeh and Li (2008) investigate sudden changes in volatility for five GCC stock markets using the iterated cumulative sums of squares algorithm, and analyze their effects on the estimated persistence of volatility. They find that GCC stock markets are more sensitive to major global factors than to local and regional factors. Yu and Hassan (2008) apply the EGARCH-M models with a generalized error distribution. They find large and predominantly positive volatility spillovers and volatility persistence in conditional volatility between MENA and world stock markets. They find volatility spillovers within the MENA region to be higher than cross-volatility spillovers for all the markets. Hammoudeh et al. (2009) use a multivariate VAR-GARCH to examine the dynamic volatility and volatility transmission for the service, financial and industrial sectors of Kuwait, Qatar, Saudi Arabia and the UAE. They suggest that past idiosyncratic volatilities matter more than past shocks and that there are moderate volatility spillovers between the sectors within the individual countries, with the exception of Qatar. They also find that the optimal portfolio weights favor the financial sector for Qatar, Saudi Arabia and the UAE, and the industrial sector for Kuwait. Arouri and Nguyen (2010) investigate the existence of short- and long-term relationships between oil prices and GCC stock markets. Concerning the short-term analysis, strong positive linkages between oil price changes and stock markets have been found in Qatar, Saudi Arabia and UAE. Their results indicate that when causality exists, it generally runs from oil prices to stock markets. The long-term analysis provides no evidence of long-term link between oil prices and stock markets in the GCC countries, except for Bahrain where the relationship between oil prices and stock market is positive and oil price fluctuations drive changes in the stock market. Balcilar et al. (2013) propose a dynamic herding approach which takes into account herding under different market regimes, with concentration on the Gulf Arab stock markets – Abu Dhabi, Dubai, Kuwait, Qatar and Saudi Arabia. Results support the presence of three market regimes (low, high and extreme or crash volatility) in those markets with the transition order "low, crash and high volatility', suggesting that these frontier markets have a different structure than developed markets. Results also yield evidence of herding behaviour under the crash regime for all of the markets except Qatar which herds under the high volatility regime. Balli et al (2013) examine spillover effects of local and global shocks on GCC-wide sector equity returns. They find GCC-wide sector returns have asynchronous responses to global and regional shocks. There is evidence that the GCC-wide sector equity markets are driven by their own volatilities. They indicate that the effect of global shocks on the volatility of GCC sector returns has been decreasing, whereas regional shocks have been affecting the sector indices with a positive and significant trend.

3. Data Description

The data employed are weekly[5] equity indices in terms of US dollars[6] provided by Morgan Stanley Capital International (MSCI)[7] over the period from June 2005 till May 2013. The stock market indices used are for the six members of GCC countries (Bahrain, Kuwait, Oman, Qatar, Saudi, and UAE), and one global market (USA).

We use Saudi Arabia as a regional market since it is the largest stock market in terms of market capitalization in the GCC. In terms of the size of the GCC markets, half of the volume is concentrated on Saudi stock market. Even more extremely, more than 80% of all share trading in terms of value takes place in Saudi Arabia (Kern, 2012)[8].

---

5 We use weekly returns to avoid the problems of non synchronous trading and the day of the week effects associated with daily data. Since the stock returns have more attractive statistical properties than prices, such as stationary and periodicity, we use continuously compounded weekly stock returns for all the stock market indices.

6 We use the US dollar denominated return to eliminate impact of exchange rates and to ease the comparison across countries.

7 The MSCI Emerging Markets Index is a free float-adjusted market capitalization index that is designed to measure equity market performance in the global emerging markets.

8 Hammoueh and Aleisa (2004) use linear VEC models for daily period February 25, 1994 to December 25, 2001 and find that Saudi Arabia plays the leading role in moving over GCC markets, without being responsive to their shocks. Assaf (2003) states that Saudi Arabia is more segmented and closed market lagging in receiving shocks from other markets. Saudi Arabia has been one of the best performing G-20 economies in recent years. Real GDP growth averaged 6 ¼ percent per annum during 2008-12, with the non-oil sector growing at average rate of 7 ¾ percent. Saudi Arabia is the largest crude oil exporter and the only producer with significant spare capacity. In 2011, Saudi Arabia formally committed through the G-20 to use its systemic position in the oil market to promote global stability. Saudi Arabia has committed financial support to a number of countries in transition (Egypt, Jordan, Yemen, and Morocco) and to other GCC countries (Bahrain, Oman) (IMF Country Report 13/229). Over the period 1985-2009, Saudi Arabia's outward gross FDI to Arab countries amounted to about $20 billion. In many cases, Saudi Arabia's FDI has represented over 40 percent of Arab countries' total FDI receipts from other Arab countries. Saudi Arabia's International Investment Position indicates that foreign assets amounted to 157 percent of GDP in 2010 while external liabilities amounted to 47 percent of GDP (IMF Country Report 12/272).

[INSERT TABLE 1]

Table 1 presents summary statistics on the weekly returns of the five GCC markets (Bahrain, Kuwait, Oman, Qatar, UAE), regional market (Saudi Arabia) and global market (US). The mean returns for all stock markets are negative except Oman and US. Volatility for the GCC markets ranges from 2.33% (Bahrain) to 5.27% (UAE) as shown by the standard deviation. To check the overall degree of the residual autocorrelations, the Ljung–Box statistics indicate the persistence of linear dependency of market returns in Bahrain, Kuwait, and Oman. For the squared returns, the Ljung–Box statistics show strong evidence of non-linear dependency in returns of all markets. This implies correlation in the variance process, and it is an indication that the returns is a candidate for conditional heteroskedasticity modeling. The residual of return series usually have ARCH effect, namely, the large changes tend to be followed by large changes, of either sign, and small changes tend to be followed by small changes. The Engle (1982) ARCH test of order five rejects the null hypothesis of no ARCH effects for all the markets. The ARCH test reveals that all returns exhibit conditional hetroscedasticity.

We assess the shape and overall patterns of the distribution of returns by looking at the measures of skewness and kurtosis. Skewness measures the degree of symmetry and kurtosis measures the degree of peakedness. All of the stock markets are negatively skewed with values ranging from -0.89 to -1.78 implying that the return series have a distribution skewed to the left. High positive Kurtosis value is reported for all stock market returns which imply that there is a high peak at the centre of the returns and the distribution of returns has fatter tails than a normal distribution.

Ideally, for the distribution to be symmetrical or normal, skewness should be very close to zero and kurtosis equal to 3.

4. The Model

In this paper, we aim to analyze how much of the return volatility of any particular market in the GCC is driven by global factor (US) and how much is left to be explained by regional factor (Saudi Arabia). Bekaert and Harvey (1997) develop a model which allows the impact of world and local factors on volatility to be time varying. Ng (2000) employs the same approach but extends into a two factor model in which unexpected returns on any particular market are influenced not only by news impact effect from home but also by two foreign shocks; a regional shock and a global shock. In this section, we allow three sources of unexpected returns to affect GCC stock markets: a domestic shock, a regional shock from Saudi Arabia, and a global shock from the US. In this section, we construct bivariate GARCH(1,1) models for the Saudi Arabia and US returns. We also present univariate volatility spillover models for five GCC stock markets. Further, we discuss the estimation procedure and the specification tests.

4.1 Bivariate model for the Saudi Arabia and US

The joint process for Saudi Arabia and US returns in bivariate GARCH(1,1) model is:

$$\begin{bmatrix} R_{sa,t} \\ R_{us,t} \end{bmatrix} = \begin{bmatrix} \alpha_{sa,0} \\ \alpha_{us,0} \end{bmatrix} + \begin{bmatrix} \alpha_{sa,1} \alpha_{sa,2} \\ \alpha_{us,1} \alpha_{us,2} \end{bmatrix} \begin{bmatrix} R_{sa,t-1} \\ R_{us,t-1} \end{bmatrix} + \begin{bmatrix} \varepsilon_{sa,t} \\ \varepsilon_{us,t} \end{bmatrix} \qquad (1)$$

$$\varepsilon_t \mid \mathrm{I}_{t-1} \sim N(0, H_t)$$

where $(R_{sa,t}, R_{us,t})$ represents the return of respectively the aggregate Saudi Arabia and US market, $[\alpha_{sa,1}, \alpha_{sa,2}; \alpha_{us,1}, \alpha_{us,2}]$ is a matrix of parameters linking lagged returns in the Saudi and US to expected returns, and $(\varepsilon_{sa,t}, \varepsilon_{us,t})$ is their vector of innovations. H_t is the conditional variance-covariance matrix.

Standard GARCH models assume that positive and negative error terms have a symmetric effect on the volatility. In other words, good and bad news have the same effect on the volatility. This assumption which is known as leverage effect (Black, 1976) is frequently violated, in that the volatility increases more after bad news than after good news, i.e., volatility is higher after negative shocks than after positive shocks of same magnitude. To allow for leverage effect on volatility in the conditional variance H_t, GJR-GARCH model which is proposed by Glosten et al. (1993) is used to extend symmetric models to allow for asymmetry. We examine three different bivariate specifications for the conditional variance-covariance matrix H_t with and without asymmetric effects: (1) a constant correlation model, (2) a dynamic correlation model, and (3) a BEKK model.

4.1.1 Bivariate Constant Correlation Model (CCC):

The constant correlation model is derived by Bollerslev (1990) in which the conditional correlations are constant and thus the conditional covariances are proportional to the product of the corresponding conditional standard deviations. The conditional variance-covariance matrix is given by:

$$H_t = D_t^{1/2} R D_t^{1/2} \tag{2}$$

where R is a symmetric positive definite matrix of time-invariant unconditional correlations of the standardized residuals,

$$R = \begin{bmatrix} 1 & \rho_{12} \\ \rho_{12} & 1 \end{bmatrix} \quad (3)$$

ρ_{12} represents the correlation coefficient and D_t is a diagonal matrix of conditional variances,

$$D_t = \begin{bmatrix} \sigma_{1,t}^2 & 0 \\ 0 & \sigma_{2,t}^2 \end{bmatrix} \quad (4)$$

Thus, the bivariate conditional variance-covariance matrix H_t is:

$$\begin{bmatrix} \sigma_{11,t} & \sigma_{12,t} \\ \sigma_{12,t} & \sigma_{22,t} \end{bmatrix} = \begin{bmatrix} \sqrt{\sigma_{11,t}} & 0 \\ 0 & \sqrt{\sigma_{22,t}} \end{bmatrix} \begin{bmatrix} 1 & \rho_{12} \\ \rho_{12} & 1 \end{bmatrix} \begin{bmatrix} \sqrt{\sigma_{11,t}} & 0 \\ 0 & \sqrt{\sigma_{22,t}} \end{bmatrix} \quad (5)$$

in which each $\sigma_{i,t}^2$ is a univariate symmetry GARCH model:

$$\sigma_{i,t}^2 = \alpha_{i,0} + \sum_{i=1}^{q} \alpha_i \varepsilon_{i,t-1}^2 + \sum_{i=1}^{p} \beta_i \sigma_{i,t-1}^2 \quad (6)$$

Following Glosten et al. (1993) to allow for asymmetric effects, the univariate GARCH model is:

$$\sigma_{i,t}^2 = c_{i,0} + \sum_{i=1}^{q} \alpha_i \varepsilon_{i,t-1}^2 + \sum_{i=1}^{p} \beta_i \sigma_{i,t-1}^2 + \gamma \varepsilon_{i,t-1}^2 d_{t-1} \quad (7)$$

where α_i are ARCH parameters, β_i are GARCH parameters, $d_t = 1$ if $\varepsilon_t < 0$ and $d_t = 0$ otherwise. The effect of the shock ε_{t-1}^2 on the conditional variance $\sigma_{i,t}^2$ is different according to the sign of ε_t. This means good news ($\varepsilon_t > 0$) has an impact of α, while bad news ($\varepsilon_t < 0$) has an impact of $\alpha + \gamma$, i.e., volatility increases more in response to a negative ε_t than to a positive ε_t.

4.1.2 Bivariate Dynamic Correlation Model (DCC):

Engle (2002) proposes a generalization of the CCC model by making the conditional correlation matrix time-dependent. The model is then called a dynamic conditional correlation (DCC) model. The model assumes that each conditional variance follows a univariate GARCH process and the conditional correlation matrix is (essentially) allowed to follow a univariate GARCH equation. The conditional variance-covariance matrix H_t is written as:

$$H_t = D_t^{1/2} R_t D_t^{1/2} \tag{8}$$

where R_t is a time-dependent matrix of conditional correlations $\rho_{ij,t}$:

$$R_t = \begin{bmatrix} 1 & \rho_{12,t} \\ \rho_{12,t} & 1 \end{bmatrix} \tag{9}$$

D_t is a diagonal matrix of conditional variances:

$$D_t = \begin{bmatrix} \sigma_{11,t}^2 & 0 \\ 0 & \sigma_{22,t}^2 \end{bmatrix} \tag{10}$$

Thus, the bivariate conditional variance-covariance matrix H_t is:

$$\begin{bmatrix} \sigma_{11,t} \, \sigma_{12,t} \\ \sigma_{12,t} \, \sigma_{22,t} \end{bmatrix} = \begin{bmatrix} \sqrt{\sigma_{11,t}} & 0 \\ 0 & \sqrt{\sigma_{22,t}} \end{bmatrix} \begin{bmatrix} 1 & \rho_{12,t} \\ \rho_{12,t} & 1 \end{bmatrix} \begin{bmatrix} \sqrt{\sigma_{11,t}} & 0 \\ 0 & \sqrt{\sigma_{22,t}} \end{bmatrix} \tag{11}$$

where $\sigma_{i,t}^2$ is a univariate GARCH model.

The conditional correlation matrix R_t is allowed to change like in a univariate GARCH model, but with a transformation that guarantees that it is actually a valid correlation matrix. To estimate the dynamic correlations, the DCC model first specifies the dynamic process on the variance-covariance matrix of $\tilde{\varepsilon}_t$, Q_t:

$$Q_t = (1 - \lambda_1 - \lambda_2)\overline{Q} + \lambda_1 \tilde{\varepsilon}_{t-1} \tilde{\varepsilon}_{t-1}^{'} + \lambda_2 Q_{t-1} \tag{12}$$

$$\begin{bmatrix} q_{11,t} & q_{12,t} \\ q_{12,t} & q_{22,t} \end{bmatrix} = (1-\lambda_1-\lambda_2)\begin{bmatrix} 1 & \bar{q}_{12} \\ \bar{q}_{12} & 1 \end{bmatrix} + \lambda_1 \begin{bmatrix} \tilde{\varepsilon}_{1,t-1} \\ \tilde{\varepsilon}_{2,t-1} \end{bmatrix} \begin{bmatrix} \tilde{\varepsilon}_{1,t-1} \\ \tilde{\varepsilon}_{2,t-1} \end{bmatrix}' + \lambda_2 \begin{bmatrix} q_{11,t-1} & q_{12,t-1} \\ q_{12,t-1} & q_{22,t-1} \end{bmatrix} \quad (13)$$

where $\tilde{\varepsilon}_{i,t} = \varepsilon_{i,t} / \sqrt{\sigma_{ii,t}}$ is the vector of standardized residuals and $\overline{Q}$ is the unconditional correlation matrix of $\tilde{\varepsilon}_t$. λ_1 and λ_2 are parameters that govern the dynamics of conditional correlations. λ_1 and λ_2 are nonnegative and satisfy $0 \le \lambda_1 + \lambda_2 < 1$.

Then, the dynamic process on the variance-covariance matrix Q_t is used to get the dynamic correlation matrix R_t :

$$R_t = diag(Q_t)^{-1/2} Q_t diag(Q_t)^{-1/2} \quad (14)$$

The dynamic correlation estimator for bivariate DCC model is:

$$\begin{bmatrix} 1 & \rho_{12,t} \\ \rho_{12,t} & 1 \end{bmatrix} = \begin{bmatrix} 1 & q_{12,t} \big/ \sqrt{q_{11,t} q_{22,t}} \\ q_{12,t} \big/ \sqrt{q_{11,t} q_{22,t}} & 1 \end{bmatrix} \quad (15)$$

4.1.3 Bivariate BEKK Model:

To ensure positive definiteness, a new parameterization of the conditional variance matrix H_t, Baba et al. (1989), Engle and Kroner (1995), and Kroner and Ng (1998) propose the BEKK model:

$$H_t = C'C + A'\varepsilon_{t-1}\varepsilon'_{t-1}A + B'H_{t-1}B \quad (16)$$

where C, A and B are $n \times n$ matrices of parameters, and C is a upper triangular matrix. BEKK are expressed in quadratic forms to ensure that the H_t matrix is positive definite. The purpose of decomposing the constant term into a product of two triangular matrices is also to guarantee the positivity of H_t; $C'C > 0$ is symmetric and positive definite. The bivariate BEKK model is:

$$\begin{bmatrix} \sigma_{11,t}\,\sigma_{12,t} \\ \sigma_{12,t}\,\sigma_{22,t} \end{bmatrix} = \begin{bmatrix} c_{11,t}\,c_{12,t} \\ c_{12,t}\,c_{22,t} \end{bmatrix} + \begin{bmatrix} a_{11,t}\,a_{12,t} \\ a_{12,t}\,a_{22,t} \end{bmatrix}' \begin{bmatrix} \varepsilon^2{}_{1,t-1} & \varepsilon_{1,t-1}\varepsilon_{2,t-1} \\ \varepsilon_{1,t-1}\varepsilon_{2,t-1} & \varepsilon^2{}_{2,t-1} \end{bmatrix} \begin{bmatrix} a_{11,t}\,a_{12,t} \\ a_{12,t}\,a_{22,t} \end{bmatrix} + \begin{bmatrix} b_{11,t}\,b_{12,t} \\ b_{12,t}\,b_{22,t} \end{bmatrix}' \begin{bmatrix} \sigma_{11,t-1}\,\sigma_{12,t-1} \\ \sigma_{12,t-1}\,\sigma_{22,t-1} \end{bmatrix} \begin{bmatrix} b_{11,t}\,b_{12,t} \\ b_{12,t}\,b_{22,t} \end{bmatrix} \quad (17)$$

To allow for asymmetric effects following Glosten et al.(1993), we extend the conditional variance matrix H_t in the symmetric version of the BEKK by adding $G'\lambda_{t-1}\lambda'_{t-1}G$ term to (16).

$$H_t = C'C + A'\varepsilon_{t-1}\varepsilon'_{t-1}A + B'H_{t-1}B + G'\lambda_{t-1}\lambda'_{t-1} \quad (18)$$

4.2 Univariate volatility spillover model

Following Bekaert and Harvey (1997), we allow innovations in Saudi Arabia and the US to effect the stock return of a GCC market through the error term. We use asymmetric volatility spillover model which allow the return of each GCC market be driven by a local shock, a regional shock, and a global shock. To capture the leverage effect found in the returns of many stock indices, and to avoid imposing non-negativity restrictions on the values of the GARCH parameters to be estimated, we employ the exponential GARCH (EGARCH) representation developed by Nelson (1991) where conditional variance depends on both the sign and the size of lagged residuals. The model explicitly is capable of capturing any asymmetric impact of shocks on volatility. In addition, this model allows volatility to be affected differently by good and bad news.

The univariate volatility spillover model for each GCC market i is specified to allow for the past Saudi and US returns in the mean equation of market i and for the current return shocks of Saudi and the US in the unexpected return:

$$R_{i,t} = \alpha_{i,0} + \beta_i R_{i,t-1} + \gamma_i R_{saudi,t-1} + \delta_i R_{us,t-1} + \varepsilon_{i,t} \quad (19)$$

$$\varepsilon_{i,t} = e_{i,t} + \phi_{i,t} e_{saudi,t} + \psi_i e_{us,t}$$

$$e_{i,t} \mid I_{t-1} \sim N(0, \sigma_{i,t}^2)$$

$e_{i,t}$ is a purely idiosyncratic shock which is assumed to follow a conditional normal distribution with mean zero and variance $\sigma_{i,t}^2$ and is assumed to be uncorrelated with Saudi return shock $e_{saudi,t}$ and US return shock $e_{us,t}$.

The conditional variance $\sigma_{i,t}^2$ equation follows an asymmetric GARCH(1,1):

$$\log(\sigma_{i,t}^2) = a_{i,0} + \theta z_{t-1} + a_{i,1}(|z_{i,t-1}| - E(|z_{i,t-1}|)) + b_{i,1}\log(\sigma_{i,t-1}^2) \tag{20}$$

The variance is conditional on its own past values as well as on past values of the standardized innovations $z_{i,t} = \varepsilon_t \sigma_t^{-1}$. The parameter θ measures the asymmetric effect of shocks on volatility. A negative and statistically significant θ indicates that a leverage effect exists. The second term $a_{i,1}(|z_{i,t-1}| - E(|z_{i,t-1}|))$ represents the magnitude effect.

We differentiate between the relative influence of the US and Saudi Arabia on the GCC markets because there exists a possibility of common news driving both the Saudi Arabia and US markets. We orthogonalize the innovations from the aggregate Saudi Arabia market and the US using their standardized residuals from the bivariate model estimation in the first step. The innovations from Saudi Arabia and the US are orthogonalized by assuming that the Saudi Arabia return shock is driven by a purely idiosyncratic shock and by the US return shock. The orthogonalized Saudi Arabia and US innovations, $e_{saudi,t}$ and $e_{us,t}$ respectively are given by:

$$\begin{bmatrix} e_{saudi,t} \\ e_{us,t} \end{bmatrix} = \begin{bmatrix} 1 & -\dfrac{\mathrm{cov}_{t-1}(\varepsilon_{saudi,t}, \varepsilon_{us,t})}{\mathrm{var}_{t-1}(\varepsilon_{us,t})} \\ 0 & 1 \end{bmatrix} \begin{bmatrix} \hat{\varepsilon}_{saudi,t} \\ \hat{\varepsilon}_{us,t} \end{bmatrix} \tag{21}$$

Under this orthogonalization procedure, the regional shock (Saudi) is unrelated to the global shock (US).

4.3 Estimation and Specification Tests

4.3.1 Estimation

We examine the magnitude and changing nature of return spillovers from Saudi and the US to five members of GCC stock markets. First, we estimate the three bivariate models outlined in section 4.1 for the US and Saudi returns. We estimate both the symmetric and asymmetric case for each different bivariate model. In the second step, conditional on the estimates for Saudi and the US and assuming that the purely idiosyncratic shocks are normally distributed with mean zero and a time-varying variance, we estimate the univariate EGARCH model outlined in section 4.2 for each GCC stock market by maximizing the loglikelihood function.

Given T observations of the return vector, the parameters of the different bivariate GARCH models are estimated by maximizing the conditional loglikelihood function:

$$L_T(\theta_f) = \sum_{t=1}^{T} l_t(\theta_f) = \sum_{t=1}^{T} \left(-\log(2\pi) - \frac{1}{2}\log|H_t| - \frac{1}{2}\varepsilon_t' H_t^{-1} \varepsilon_t \right) \tag{22}$$

where θ_f denotes the vector of all the parameters to be estimated. Non-linear optimization techniques are used to calculate the maximum likelihood estimates based on the Broyden, Fletcher, Goldfarb, and Shanno (BFGS) algorithm[9].

4.3.2 Specification Tests

In order to check whether the bivariate models are correctly specified and to compare their overall performances, we follow Richardson and Smith (1993) approach to test for orthogonality conditions implied by a bivariate normal

[9] See Press et al. (1988).

distribution. To conduct the specification tests, we use generalized method of moments (GMM) to estimate standardized residuals, $\hat{z}_t = C_t'^{-1}\hat{\varepsilon}_t$ where C_t is obtained through the Cholesky decomposition of H_t. Under the null hypothesis that the model is correctly specified, the following conditions on $\hat{z}_t$ should hold:

$$E[\hat{z}_{i,t}\hat{z}_{i,t-j}] = 0 \qquad \text{for } i = Saudi, US \qquad (23)$$

$$E[(\hat{z}_{i,t}^2 - 1)(\hat{z}_{i,t-j}^2 - 1)] = 0 \qquad \text{for } i = Saudi, US \qquad (24)$$

$$E[(\hat{z}_{saudi,t}^2 \hat{z}_{us,t}^2)(\hat{z}_{saudi,t-j}^2 \hat{z}_{us,t-j}^2)] = 0 \qquad (25)$$

for $j = 1, \ldots\ldots, \tau$. The above conditions are tested, respectively, for serial correlation in $\{\hat{z}_{i,t}\}$, $\{\hat{z}_{i,t}^2 - 1\}$, and $\{\hat{z}_{saudi,t}^2 \hat{z}_{us,t}^2\}$. With $\tau = 4$, the test statistics for no serial correlation are asymptotically distributed as $\chi^2(4)$. We also test the null hypothesis that $\hat{z}_t$ follows a bivariate standard normal distribution by examining the following conditions on the third and fourth moments:

$$E[\hat{z}_{i,t}^3] = 0 \qquad \text{for } i = Saudi, US \qquad (26)$$

$$E[(\hat{z}_{saudi,t}^2 \hat{z}_{us,t})] = 0 \qquad (27)$$

$$E[(\hat{z}_{saudi,t} \hat{z}_{us,t}^2)] = 0 \qquad (28)$$

$$E[\hat{z}_{i,t}^4 - 3] = 0 \qquad \text{for } i = Saudi, US \qquad (29)$$

$$E[(\hat{z}_{saudi,t}^2 \hat{z}_{us,t}^2 - 1)] = 0 \qquad (30)$$

where equations (26) and (29) test for skewness and excess kurtosis, respectively. Equations (27) and (28) test for cross-skewness and equation (30) tests for cross-kurtosis. All tests are $\chi^2(1)$ distributed with 1 degree of freedom.

4.4 Arellano-Bover/Blundell-Bond Estimation

We investigate impact of trade, turnover, GDP per capita, domestic credit, inflation and institutional quality variables (control of corruption and regulatory quality) on volatility spillovers from Saudi Arabia. To deal with basic problems of endogenity between variables the regression equation will be based on the Arellano-Bover/Blundell-Bond linear dynamic panel-data estimation. Building on the work of Arellano and Bover (1995), Blundell and Bond (1998) propose a system estimator that uses moment conditions in which lagged differences are used as instruments for the level equation in addition to the moment conditions of lagged levels as instruments for the differenced equation. This estimator is designed for datasets with many panels and few periods. The method assumes that there is no autocorrelation in the idiosyncratic errors and requires the initial condition that the panel-level effects be uncorrelated with the first difference of the first observation of the dependent variable. In these models, the unobserved panel level effects are correlated with the lagged dependent variables, making standard estimators inconsistent.

$$y_{it} = \delta y_{i,t-1} + x_{it}^{'}\beta + u_{it} \qquad i = 1,........,N \qquad t = 2,............T \tag{31}$$

where y_{it} is volatility spillover, δ is a scalar, $x_{it}^{'}$ is a $1 \times K$ vector of explanatory variables and β is a $K \times 1$ vector of parameters to be estimated. The error term u_{it} is composed of an unobserved effect and time-invariant effect μ_i and random disturbance term v_{it}.

5. Empirical Results

5.1 Specification tests of bivariate models

The main objective of this study is to investigate how shocks from Saudi and US market are transmitted to individual GCC stock markets. It is, therefore, important to correctly specify the bivariate model for the Saudi and US return series. Table 2 presents the results of the specification tests as outlined in section 4.3.2 for the three different bivariate models in symmetric and asymmetric cases. The univariate specification tests in Panel A show no evidence against the specifications for both the US and Saudi conditional mean and conditional variances in any of the three models. There is, however, evidence against zero serial correlations in $\{\hat{z}^2_{saudi,t}\hat{z}^2_{us,t}\}$ in both symmetric and asymmetric cases of BEKK and DCC models. The likelihood ratio strongly reject the null hypothesis of no asymmetry in the BEKK and CCC models, suggesting that there are significant asymmetric effects in the variance-covariance matrix. Finally, the likelihood ratio indicates that there is insufficient statistical evidence in support of the asymmetric DCC model.

[INSERT TABLE 2]

Panel B of Table 2 shows the results of the bivariate normality tests. The test statistics for zero skewness, excess kurtosis, cross skewness and cross kurtosis suggest that the estimated standardized residuals for Saudi and US both follow a univariate normal distribution. This indicates that the estimation results from all bivariate models are very similar. Since all models seem to give relatively similar results for the bivariate normality tests, we select asymmetric CCC model for the following reasons: first, the likelihood ratio test suggests that there are significant asymmetric effects in the variance-covariance matrix. Second, the specification tests for asymmetric CCC model show no evidence against zero serial correlations in all $\{\hat{z}_{i,t}\}$, $\{\hat{z}^2_{i,t}-1\}$, and $\{\hat{z}^2_{saudi,t}\hat{z}^2_{us,t}\}$. The CCC model with asymmetry is thus chosen as the correct specification for the bivariate model for Saudi and the US and the residuals obtained are used in the univariate volatility spillover models estimation for each individual GCC stock market.

5.2 Univariate volatility spillover model

5.2.1 Univariate EGARCH model

In this section, we report the empirical results for the univariate volatility spillover model. We first estimate a univariate EGARCH(1, 1) model for each individual GCC stock market index by restricting all coefficients measuring regional (Saudi) and global (US) volatility spillovers to the GCC region to be zero. The results are presented in Table 3. As shown in this table, the degree of volatility persistence (b_1) is very close to unity for all five GCC stock markets. Specifically, it is 0.929 for Bahrain, 0.986 for Kuwait, 0.974 for Oman, 0.919 for Qatar, and 0.953 for UAE, supporting the assumption of covariance stationarity of GARCH process and the volatility persistence for various finance time series. Persistence in variance refers to the property of momentum in conditional variance, i.e., past volatility explains current volatility. The leverage effect parameter (θ) is negative and statistically significant for all GCC stock market returns indicating that a leverage effect exists except in the case of Qatar. That means volatility is higher after negative shocks than after positive shocks of same magnitude, i.e., changes in stock prices tend to be negatively correlated with changes in volatility.

The Ljung-Box statistics for up to 5 lags, applied on standardized and squared standardized residuals show that the EGARCH model successfully accounts for all linear and nonlinear dependencies present in the return series. Finally, to assess the shape and overall patterns of the distribution of returns with respect to the normal distribution, the coefficients for skewness show that most GCC stock market returns are negative implying that the return series have a distribution skewed to the left. For kurtosis, the coefficients are positive and greater than 3 for all returns implying leptokurtic shape. In sum, the results indicate that univariate EGARCH model employed fits the data generally well.

[INSERT TABLE 3]

5.2.2 Univariate EGARCH and Volatility spillovers

We next estimate the univariate EGARCH(1,1) model as outlined in section 4.2, for each GCC market to test for volatility spillovers from the regional (Saudi) and global (US) markets. The results are reported in Table 4. The degree of volatility persistence in past volatility (b_1) is close to 1 for all five GCC stock markets implying that the movements of the conditional variance away from its long-run mean last a long time. These (b_1) values support the assumption of volatility persistence for various finance time series. The leverage effect parameter (θ), or asymmetric impact of past innovations on current volatility (ARCH effect), is negative and statistically significant for all GCC stock market returns indicating that a leverage effect exists, except in Oman, which is close to significant. This implies changes in stock prices tend to be negatively correlated with changes in volatility, i.e., volatility is higher after negative shocks than after positive shocks of same magnitude.

The skewness and kurtosis measures indicate that standardized residuals for all five GCC stock markets exhibit deviations from normality. Finally, all the estimated Ljung-Box statistics for the standardized and squared standardized residuals indicate that the univariate EGARCH models with spillover effect variables are correctly specified, including these variables in the EGARCH function produce a better specification.

[INSERT TABLE 4]

As shown in table 4, the local spillover effects of past own shocks for each GCC stock market are significant in Bahrain, Kuwait, Oman, Qatar and the UAE stock markets pointing to a strong ARCH effect. The highest size of the ARCH coefficient is 0.334 for Bahrain, and the smallest ARCH coefficient is 0.159 in Kuwait. The average size of the ARCH coefficient is 0.266. Result shows that the current conditional volatility of GCC stock markets depends on past shocks affecting return dynamics since ARCH coefficients are highly significant for all countries.

The GARCH estimated coefficients are all significant, suggesting persistence in volatility in all the five GCC stock markets. The degree of volatility persistence is quite close to 1 for each stock market implying that shocks to conditional variance take a long time to die out. Specifically, volatility persistence ranges from 0.929 in Bahrain to 0.984 in Kuwait. This finding suggests that past values of the conditional volatility in a particular GCC stock market can be employed to forecast future volatility.

[INSERT FIGURES 1.1 to 1.5]

The return spillover coefficients form the regional (Saudi) and global (US) markets are significant to each GCC stock markets. The magnitude of spillover coefficients from the regional (Saudi) market to each GCC market varies, with the coefficients of spillovers from global (US) being comparatively stable and in similar range, implying that investors are rewarded for bearing regional market risk more than bearing global market risk.

In terms of regional effects in the five GCC stock markets, the parameters of spillover effect from the regional market (Saudi) to each GCC market is significant and positive[10] almost in all cases except it is not significant in Kuwait and it is negative in Bahrain. The parameter magnitude of regional past shocks is on average 0.347, but shows considerable variation cross GCC stock markets; 0.045 for Kuwait and 1.826 for the UAE. This is in accordance with Neaime (2012) who finds that

[10] From a regional perspective, there are sizable positive spillover effects from non-oil activity in Saudi Arabia. Outward spillovers from Saudi Arabia are likely to be felt most strongly in its immediate neighbours (IMF Country Report 12/271). Cashin et al (2012) use a GVAR model and find that a one percent increase in Saudi non-oil GDP is estimated to increase GDP in GCC countries between 0.2 and 0.4 percent. Result from a GVAR model show that a positive shock to non-oil GDP in Saudi Arabia has a strong positive impact on the rest of the GCC.

Saudi Arabia has causal effects in both the mean and variance for UAE and Kuwait markets. The result suggests that effect of past shocks from regional market (Saudi) do have important return spillover effects in each of local GCC stock market. This finding emphasizes the need to strengthen cross border regulation framework to strengthen domestic assets stability. Furthermore, the persistence of volatilities from regional market (Saudi) is significant in all GCC stock markets except Kuwait. This result suggests that adverse events in Saudi economy has regional spillover effects in GCC markets.

Figures 1.1 to 1.5 illustrate volatility spillovers from Saudi Arabia to GCC markets. We find larger impact of volatility spillovers from Saudi Arabia to UAE and Qatar markets. Section 5.3 discusses the determinants of volatility spillovers of Saudi Arabia to GCC markets.

For the global spillover effects, the parameters of past shocks that originate from global market (US) are highly significant and positive for all five markets, implying that the conditional mean returns of all GCC stock markets are influenced by the US market. The average size of the parameters of global return spillover is 0.4. The parameter magnitude of global past shocks from the US market to Bahrain stock market is the smallest 0.233, while the parameter with the UAE is the largest 0.721. This may reflect the degree of foreign participation which is almost the highest in the UAE among all GCC markets (Sedik and Williams, 2011)[11].

[INSERT FIGURES 2.1 to 2.5]

[11] Foreign investment ceiling for listed stocks in GCC markets: Bahrain (49% in general; 10% for a single entity; some banks & insurance companies are 100% open to foreign ownership; 100% in general for GCC nationals), Kuwait (100% in general, 49% some banks), Oman (100% in general), Qatar (25% in general), UAE (49% in general, though different restrictions may apply to individual companies; 100% for GCC nationals with company's approval) (Standard & Poors, Global Stock Markets Factbook, 2012).

Figures 2.1 to 2.5 illustrates return spillovers from the global (US) market on five GCC markets: Bahrain, Kuwait, Oman, Qatar and UAE[12]. There is profound impact of volatility spillovers in 2008 and 2009. During this period, GCC stock indices fell (one-fifth in Oman, around one-third in Bahrain, Kuwait and UAE) compared to their levels at the beginning of 2007. Kuwait and UAE are the most affected by the recent financial crisis due to their strong links with global stock markets including US banks and equity markets. There has been a downturn in asset prices, higher cost of capital, a slowdown in capital inflows and a decrease in exports due to global financial crisis. Stock market capitalization has declined significantly between 2007 and 2009 as a result of crisis. In UAE, the stock market capitalization went down from $224.6 billion in 2007 to $109.6 billion in 2009, in Kuwait from $188 billion in 2007 to $95.9 billion in 2009.

5.3 Determinants of Volatility Spillovers from Saudi Arabia to GCC economies

[INSERT TABLE 5]

Table 5 illustrates the impact of trade, turnover, GDP per capita, domestic credit, inflation and institutional quality variables (control of corruption and regulatory quality) on volatility spillovers from Saudi Arabia to GCC economies, by employing various versions of equation (31). Appendix Table A.1 illustrates data sources of variables. Trade is sum of exports and imports as percent of GDP from World Bank's World Development Indicators. Trade variable is positive and significant implying that Trade enhances information sharing between stock

[12] There are trade links between US and GCC markets. For instance, in 2012, US export in $ million is highest in UAE (22570) followed by Qatar (3577), Kuwait (2682.8), Oman (1746.9) and Bahrain (1209.2). In terms of US imports in million $, the highest import is from Kuwait (13346.1) followed by UAE (2313.7), Oman (1422), Qatar (1055.8) and Bahrain (733.3).

markets[13]. Investors may be inclined to hold securities of close trading partners for various reasons including hedging, familiarity with host country's products or spillovers of information. Investors are better able to attain accounting and regulatory information on foreign markets through trade in goods. Mishra (2007) and Lane and Milesi Feretti (2008) state that bilateral equity investment is strongly correlated with the underlying patterns of trade in goods and services.

Turnover is total value of shares traded during the period divided by the average market capitalization during the period. Turnover is from Standard & Poors Global Stock Market's Factbook. Turnover variable appears to be positive and significant implying that GCC markets share more information as value of share trading relative to stock market capitalization increases. GDP per capita is gross product divided by mid- year population. GDP per capita is from World Bank's World Development Indicators. GDP per capita is positive and significant implying tendency of GCC countries to engage in international asset trade, leading to information sharing among markets. Higher GDP per capita is associated with lower risk aversion and the international asset trade is perceived as riskier than domestic trade; this may also raise international asset trade. Inflation appears to be negative and significant indicating that GCC stock markets share more information in low-inflation environment. Control of corruption index focuses on the measure of corruption within the political system, the rate of severity of corruption within the state, the intrusiveness of the country's bureaucracy, corruption among public officials etc. Regulatory Quality consists of indicators related to the regulations of exports,

[13] The linkages between GCC and Saudi Arabia's economy are via trade and financial markets (IMF Country Report 12/271). In 2012, Saudi Arabia's export in US$ million was highest in Bahrain (5294.87) followed by UAE (4260.17), Qatar (2171.25), Kuwait (1954.49) and Oman (1027.45). In terms of Saudi Arabia's imports in US$ million, the highest import was from UAE (3531.2), followed by Bahrain (1292.9), Oman (657.99), Kuwait (504.17) and Qatar (129.16).

imports, business ownerships, equities ownerships, banking, foreign investment, price controls, tariffs, unfair competitive practices etc. Control of corruption and regulatory quality are governance variables from World Bank's Worldwide Governance Indicators (www.govindicators.org). Control of corruption and regulatory quality variables are positive and significant implying more information sharing among GCC stock markets in good regulatory environment.

6. Conclusions

This paper examines the spillover effects from (global) US and the regional (Saudi) to the five GCC stock markets; namely Bahrain, Kuwait, Qatar, Oman and UAE. We use MSCI weekly stock market indices data from June 2005 to May 2013. We employ the EGARCH model to account for asymmetries in the spillover volatility transmission mechanism. The leverage effect parameter, or asymmetric impact of past innovations on current volatility, is negative and statistically significant for all GCC stock market returns indicating that a leverage effect exists. We find local spillover effects to be statistically significant in all five stock markets pointing to a strong ARCH effect. The regional spillover effects from Saudi Arabia to each GCC market are found to be positive and significant in four GCC markets (Kuwait Oman, Qatar, UAE); and negative and significant in Bahrain. The global spillover effects from global market (US) is highly significant and positive for all five GCC markets. The regional spillover effects in Qatar and UAE are greater in magnitude as compared to global spillover effects in these markets.

We also investigate the determinants of volatility spillovers from Saudi Arabia to GCC markets. We find that trade, GDP per capita, institutional quality variables (control of corruption and regulatory quality) have positive and significant impact;

and inflation is found to have a negative and significant impact on volatility spillovers from Saudi Arabia. Our research findings have macroeconomic policy implications.

First, we recommend that GCC markets should increase intra-regional and cross border trade by providing monetary and fiscal incentives to trading partners and devising policies aimed at lifting trade and capital flow barriers. This would increase financial development and spur growth. Second, GCC economies should aim at development of their financial sectors. A well established GCC regional financial stock and bond market would reduce huge costs associated with servicing the accumulated public debt, lower the cost of raising capital, allow companies to increasingly rely on local markets rather than the world market. Third, we recommend that investors may focus on volatility trading and construct their portfolios using hedge ratios to minimize risk. This will enable investors to trade depending on market movement of underlying equities. Fourth, we also recommend that regulatory policies in markets should focus on cross border coordination and supervision among GCC countries to minimize adverse spillover effects. Although a few GCC countries already enforce best international practices on the regulation and supervision of capital markets, others are in the process of strengthening their frameworks. Fifth, GCC stock markets should position themselves globally through strategic partnerships and mergers, foreign institutional investments, cross listing of firms, corporatisation of exchanges and introduction of private ownership. This will enable adoption of higher governance standards by exchanges and send positive signal to listed companies. For instance, Saudi Arabia should improve and liberalize its current account, and promote greater integration with the world financial markets. Saudi Arabia's stock market lacks transparency and there is huge government ownership in listed companies (Neaime, 2012). Sixth, GCC economies are dependent mainly on oil resources. We recommend that GCC economies should continue their diversification efforts towards services and industrial sectors. This will reduce their vulnerability to external shocks due to oil and oil related products.

Policy makers need to take into account for the transmission channels through which global shocks impact the local economy. The size and impact of future external shocks and their persistence in GCC stock markets will depend on the future policies and to prevent transmission of shocks in domestic economies. This may require financial market, monetary and fiscal reforms.

7. References

Abraham, A., Seyyed, F., 2006. Information transmission between the Gulf Equity markets of Saudi Arabia and Bahrain. Res. Int. Bus. Finance 20(3), 276–285.

Arellano, M., Bover, O., 1995. Another look at the instrumental variable estimation of error-components models. J. Econ. 68, 29–51.

Arouri, M., Nguyen, D., 2010. Stock returns and oil price fluctuations: short and long-run analysis in the GCC context. Int. J. Glob. Energy Issues 33(3/4), 121–138.

Assaf, A., 2003. Transmission of stock price movements: the case of GCC stock markets. Rev. Middle East Econ. Finance 1(2), 73–92.

Baba, Y., Robert, E., Kraft, D., Kroner, K., 1989. Multivariate Simultaneous Generalized ARCH. Discussion paper 89–57. University of California, San Diego.

Baele, L., 2005. Volatility spillover effects in European equity markets. J. Financial Quant. Anal. 40, 373–401.

Balcilar, M., Demirer, R., Hammoudeh, S., 2013. Investor herds and regime switching: evidence from Gulf Arab stock markets. J. Int. Financial Mark. Instit. Money 23, 295–321.

Balli, F., Basher, S.A., Louis R.J., 2013. Sectoral equity returns and portfolio diversification opportunities across the GCC region. J. Int. Financial Mark. Inst. Money. 25, 33–48.

Beirne, J., Caporale, G., Schulze-Ghattas, M., Spagnolo, N., 2010. Global and regional spillovers in emerging stock markets: a multivariate GARCH-in-mean analysis. Emerg. Mark. Rev. 11(3), 250–260.

Bekaert, G., Harvey, C., 1997. Emerging equity market volatility. J. Financial Econ. 43, 29–77.

Black, F., 1976. Studies of Stock Price Volatility Changes. Proceedings of the Business and Economics Section of the American Statistical Association, 177–181.

Blundell, R., Bond, S., 1998. Initial conditions and moment restrictions in dynamic panel-data models. J. Econ. 87, 115–143.

Bollerslev, T., 1986. Generalized autoregressive conditional heteroskedasticity. J. Econ. 72, 307–327.

Bollerslev, T., 1990. Modeling the coherence in short-run nominal exchange rates: a multivariate generalized ARCH model. Rev. Econ. Stat. 72, 498–505.

Bollerslev, T., Engle, R., Wooldridge, J., 1988. A capital asset pricing model with time varying covariances. J. Political Economy 96, 116–131.

Cashin, P., Mohaddes, K., Raissi, M., 2012. The global impact of systemic economies and MENA business cycles. IMF, WP/12/255.

Chiang, S., Chen, H., Lin, C., 2013. The spillover effects of the sub-prime mortgage crisis and optimum asset allocation in the BRICV stock markets. Glob. Finance J. 24, 30–43.

Choudhry, T., 1996. Stock market volatility and the crash of 1987: evidence from six emerging markets. J. Int. Money Finance 15(6), 996–981.

Christofi, A., Pericli, A., 1999. Correlation in price changes and volatility of major Latin American stock markets. J. Multinati. Financial Manag. 9(1), 79–93.

Engle, R., 1982. Autoregressive conditional heteroskedasticity with estimates of UK inflation. Econometrica. 50, 987–1008.

Engle, R., 2002. Dynamic conditional correlation: a simple class of multivariate generalized autoregressive conditional heteroskedasticity models. J. Bus. Econ. Stat. 20(3), 339–350.

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

Engle, R., Lilien, D., Robbins, R., 1987. Estimating time varying risk premia in the term structure: The ARCH-M Model. Econometrica 55, 391–407.

Espinoza, R., Prasad, A., Williams, O., 2011. Regional financial integration in the GCC. Emerg. Mark. Rev. 12, 354–370.

Fratzscher, M., 2002. Financial market integration in Europe: on the effects of the EMU on stock markets. Int. J. Finance Econ. 7, 165–193.

Glick, R., Rose, A.K., 1998. Contagion and Trade: Why are Currency Crises Regional? Federal Reserve Bank of San Francisco Working paper, 98–103.

Glosten, L., Jagannathan, R., Runkle, D., 1993. On the relation between the expected value and the volatility of the nominal excess return on stocks. J. Finance 48, 1779–1802.

Hamao, Y., Masulis, R., Ng, V., 1990. Correlations in price changes and volatility across international stock markets. Rev. Financial Stud. 3, 281–307.

Hammoudeh, S., Aleisa, E., 2004. Dynamic relationships among GCC stock markets and NYMEX oil futures. Contemp. Econ. Policy 22, 250–269.

Hammoudeh, S., Choi, K., 2007. Characteristics of permanent and transitory returns in oil-sensitive emerging stock markets: the case of GCC countries. J. Int. Financial Mark. Instit. Money. 17(3), 231–245.

Hammoudeh, S., Li, H., 2008. Sudden changes in volatility in emerging markets: the case of Gulf Arab stock markets. Int. Rev. Financial Analys. 17(1), 47–63.

Hammoudeh, S., Yuan, Y., McAleer, M., 2009. Shock and volatility spillovers among equity sectors of the Gulf Arab stock markets. Q. Rev. Econ. Finance 49(3), 829–842.

IMF (2012). Country Report No. 12/271. 1–35.

IMF (2012). Country Report No. 12/272. 1–61.

IMF (2013). Country Report No. 13/229. 1–40.

Kanas, A., 1998. Volatility spillovers across equity markets: European evidence. Appl. Financial Econ. 8, 245–256.

Kern, S., 2012. GCC financial markets: long-term prospects for finance in the Gulf region. Deutsche Bank Res., Deutsche Bank AG, Germany, 1–42.

Kim, S., In, F., 2002. The Influence of foreign stock markets and macroeconomic news announcements on Australian financial markets. Pacific-Basin Finance J. 10, 571–582.

Kroner, K.F., Ng, V.K., 1998. Modelling asymmetric comovement of asset returns. Rev. Financial Stud. 11, 817–844.

Lane, P.R., Milesi-Ferretti, G.M., 2008. International investment patterns. Rev. Econ. Stat. 90(3), 538–549.

Lin, W., Engle, R., Ito, T., 1994. Do bulls and bears move across borders? International transmission of stock returns and volatility. Rev. Financial Stud. 7, 507–538.

Malik, F., Hammoudeh, S., 2007. Shock and volatility transmission in the oil, US and Gulf equity markets. Int. Rev. Econ. Finance 16(3), 357–368.

Marashdeh, H., Shrestha, M., 2010. Stock market integration in the GCC counties. Int. Res. J. Finance Econ. 37, 102–114.

Mishra, A.V., 2007. International investment patterns: evidence using a new dataset. Res. Int. Bus. Finance. 21(2), 342–360.

Mukherjee, K., Mishra, R., 2008. Stock Market Integration and Volatility Spillover: India and its Major Asian Counterparts. Munich Personal Re-Pec Archive, MPRA paper 12788, 1–32.

Neaime, S., 2012. The global financial crisis, financial linkages and correlations in returns and volatilities in emerging MENA stock markets. Emerg. Mark. Rev. 13, 268–282.

Nelson, D.B., 1991. Conditional heteroskedasticity in asset returns: a new approach. Econometrica 59, 347–370.

Ng, A., 2000. Volatility spillover effects from Japan and the US to the Pacific-Basin. J. Int. Money Finance 19(2), 207–233.

Press, W., Flannery, B., Tevkolsky, S., Vetterling, W., 1988. Numerical Recipes in C. Cambridge University Press, New York.

Richardson, M., Smith, T., 1993. A test for multivariate normality in stock returns. J. Bus. 66(2), 295–321.

Sedik, T.S., Williams, O.H., 2011. Global and regional spillovers to GCC equity markets. IMF Working paper, WP/11/138.

Standard and Poor 2012. Standard and Poor’s Global Stock Market Factbook. Dow Jones, New York.

Susmel, R., Engle, R., 1994. Hourly volatility spillovers between international equity markets. J. Int. Money Finance 13, 3–25.

Yu, J., Hassan, M., 2008. Global and regional integration of the Middle East and North African (MENA) stock markets. Quarterly Rev. Econ. Finance 48, 482–504.

Zheng, T., Zuo, H., 2013. Reexamining the time-varying volatility spillover effects: a Markov switching causality approach. N. Am. J. Econ. Finance. http://dx.doi.org/10.1016/j.najef.2013.05.001.

Appendix Table A.1: Data sources of variables

Variables	Description and data sources
Trade	Trade is sum of exports and imports of goods and services measured as a share of gross domestic product. Source: World Bank Development Indicators, Author's own calculations.
Turnover	Turnover ratio is total value of shares traded during the period divided by the average market capitalization during the period. Source: Standard & Poor's Global Stock Markets Factbook.
GDP per capita	GDP per capita is the ratio of gross domestic product to mid-year population. Source: World Bank Development Indicators, Author's own calculations.
Domestic credit	Domestic credit is domestic credit provided by banking sector as percent of GDP. Source: World Bank Development Indicators, Author's own calculations.
Inflation	Inflation is measured by the consumer price index and reflects the annual percentage change in the cost to the average consumer of acquiring a basket of goods and services that may be fixed or changed at specified intervals, such as yearly. Source: World Bank Development Indicators. Author's own calculations.
Oil production	Oil production is natural log value of world crude oil production by country in terms of 1000 barrels per day. Source: Organization of Petroleum Exporting Countries database.
Control of corruption	Control of corruption is control of corruption indicator. It captures perceptions of the extent to which public power is exercised for private gain, including corruption and private interests. Source: www.govindicators.org.
Regulatory quality	Regulatory quality is indicator of regulatory quality. It captures perceptions of the ability of government to formulate and implement sound policies and regulations that promote private sector development. Source: www.govindicators.org.

Table 1
Summary statistics for weekly equity market returns

	Bahrain	Kuwait	Oman	Qatar	Saudi	UAE	US
Mean	-0.129	-0.039	0.059	-0.006	-0.132	-0.205	0.081
Std. Dev.	2.333	3.206	2.873	4.090	4.251	5.276	2.560
Min	-15.719	-19.846	-20.297	-24.943	-27.308	-25.681	-16.748
Max	7.696	15.331	10.216	13.960	13.931	19.263	9.656
ρ	0.088	0.047	-0.021	-0.039	0.056	0.022	-0.049
ARCH(5)	24.604***	88.302***	52.693***	54.590***	40.714***	59.152***	39.373***
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
LB(5)	41.214***	17.416***	17.843***	8.913	4.328	4.501	5.179
	[0.000]	[0.004]	[0.003]	[0.112]	[0.503]	[0.479]	[0.394]
LB2(5)	28.723***	117.155***	82.133***	84.978***	60.056***	89.437***	57.128***
	[0.000]	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]
Skewness	-1.086	-1.168	-1.789	-1.044	-1.450	-0.897	-1.186
Kurtosis	9.388	11.402	13.942	10.088	9.945	6.661	9.712
Observations	415	415	415	415	415	415	415

Note: All weekly percentage returns are calculated in US dollars over the period June 2005 to May 2013. Mean is mean return. Std. Dev. is standard deviation of return. Min is minimum value of return. Max is maximum value of return. ρ is the first-order serial correlation of returns. ARCH(5) is a standard LM test for autoregressive conditional heteroskedasticity of order five . LB(5) is Ljung-Box statistics with five lags. LB2(5) is squared value of Ljung-Box statistics with five lags. p-values are given in brackets. *,**, *** denote significance at 1,5 and 10 percent level, respectively.

Table 2
Specification and normality tests for the Saudi Arabia and US returns

Panel A: Univariate specification tests

Model	Mean[a]		Variance[a]		Covariance[a]	LR Test for Asymmetry[a]
	Saudi	US	Saudi	US		
BEKK	1.471	2.542	2.873	5.357	16.86	
	(0.83)	(0.63)	(0.57)	(0.25)	(0.00)	
Asymmetric BEKK	2.602	4.712	0.837	0.754	12.06	80.286
	(0.62)	(0.31)	(0.93)	(0.94)	(0.01)	[0.000]
CCC	1.932	3.202	1.606	2.550	8.248	
	(0.74)	(0.52)	(0.80)	(0.63)	(0.08)	
Asymmetric CCC	2.692	4.123	1.730	1.314	7.333	31.677
	(0.61)	(0.38)	(0.78)	(0.85)	(0.12)	[0.000]
DCC	1.967	3.088	1.632	2.596	8.679	
	(0.74)	(0.54)	(0.86)	(0.66)	(0.08)	
Asymmetric DCC	1.947	3.072	1.611	2.564	8.652	-10.973
	(0.71)	(0.49)	(0.80)	(0.61)	(0.07)	[0.98]

Panel B: Bivariate normality tests

Model	Skewness[b]		Kurtosis[b]		Cross Skewness[b]		Cross Kurtosis[b]
	Saudi	US	Saudi	US	Saudi	US	
BEKK	0.221	1.649	4.683	7.282	0.213	5.965	2.375
	(0.99)	(0.79)	(0.32)	(0.12)	(0.99)	(0.20)	(0.66)
Asymmetric BEKK	0.172	0.383	2.621	2.296	0.426	5.496	1.988
	(0.99)	(0.98)	(0.62)	(0.68)	(0.98)	(0.24)	(0.73)
CCC	0.078	1.989	9.108	0.464	0.311	10.48	1.838
	(0.99)	(0.73)	(0.05)	(0.97)	(0.98)	(0.03)	(0.76)
Asymmetric CCC	0.135	0.958	3.632	8.682	0.671	7.873	0.549
	(0.99)	(0.91)	(0.45)	(0.07)	(0.95)	(0.09)	(0.96)
DCC	0.077	2.052	5.768	1.341	0.410	10.91	1.956
	(0.99)	(0.72)	(0.21)	(0.85)	(0.98)	(0.03)	(0.76)
Asymmetric DCC	0.074	2.047	0.410	4.464	0.394	10.75	1.942
	(0.96)	(0.70)	(0.98)	(0.34)	(0.93)	(0.02)	(0.71)

Note: Asymptotic p-values in brackets. [a] The test statistics is distributed as $\chi^2(4)$. [b] The test statistics is distributed as $\chi^2(1)$.

Table 3. Univariate EGARCH model estimation

Parameters	Bahrain	Kuwait	Oman	Qatar	UAE
α_1	-0.0418	-0.0302	0.1572	-0.0394	-0.0408
	(-0.420)	(-0.286)	(1.533)	(-0.353)	(-0.183)
α_2	0.1466**	0.0828	0.1211*	0.0679	0.0786
	(2.870)	(1.768)	(2.304)	(1.115)	(1.329)
a_0	0.1214**	0.0262**	0.0576***	0.2283***	0.1544***
	(3.091)	(2.564)	(3.667)	(7.034)	(3.704)
a_1	0.3222***	0.1499***	0.3143***	0.5419***	0.2375***
	(5.146)	(5.964)	(5.536)	(9.886)	(6.323)
b_1	0.9298***	0.9864***	0.9743***	0.9193***	0.9530***
	(39.913)	(221.24)	(129.14)	(77.881)	(72.493)
θ	-0.082*	-0.088***	-0.056**	0.0310	-0.074***
	(-2.526)	(-4.911)	(-2.635)	(1.007)	(-3.277)
Diagnostics on standardized and squared standardized residuals					
LB(5)	13.685	10.105	8.472	10.006	7.004
$LB^2(5)$	6.029	3.242	5.057	0.757	5.637
Skewness	0.0573	-0.551	-0.563	-0.284	-0.659
Kurtosis	4.345	4.075	5.861	6.409	5.433

Note: α_1 and α_2 are the coefficients of the constant and first order autoregressive process specified for the mean equations. a_1 is the measure of the autoregressive conditional heteroscedasticity (ARCH) effect. b_1 is the measure of volatility presistence. θ is the measure of the leverage effect. LB(5) and $LB^2(5)$ are the Ljung-Box statistics applied on the standardized and squared standardized residuals respectively. *t*-statistics in parentheses. *,**,*** indicate significance at 1,5 and 10 percent, respectively.

Table 4. EGARCH models and volatility spillovers from Saudi and US markets

Parameters	Bahrain	Kuwait	Oman	Qatar	UAE
α_1	-0.0221	-0.0808	0.0704	-0.0498	-0.0905
	(-0.237)	(-0.765)	(0.751)	(-0.493)	(-0.491)
α_2	0.1571**	0.0766	0.1224**	0.0367	0.0248
	(3.168)	(1.640)	(2.500)	(0.732)	(0.499)
a_0	0.1203**	0.0321**	0.0438*	0.0533**	0.1241*
	(3.145)	(2.937)	(2.418)	(3.340)	(2.445)
a_1	0.3347***	0.1595***	0.3204***	0.2807***	0.2379***
	(5.497)	(5.875)	(5.990)	(7.444)	(4.547)
b_1	0.9290***	0.9845***	0.9796***	0.9838***	0.9566***
	(40.263)	(206.691)	(117.764)	(157.903)	(53.871)
θ	-0.072*	-0.089***	-0.044	-0.055**	-0.101**
	(-2.320)	(-4.764)	(-1.814)	(-2.744)	(-2.618)
Spillover from Saudi	-0.162*	0.045	0.222***	0.807***	1.826***
	(-1.989)	(0.368)	(3.728)	(7.883)	(13.541)
Spillover from US	0.233**	0.274**	0.555***	0.252**	0.721***
	(2.781)	(2.682)	(8.406)	(2.496)	(4.588)
Diagnostics on standardized and squared standardized residuals					
LB(5)	14.651	9.281	4.597	8.603	3.734
$LB^2(5)$	5.557	3.189	3.487	1.831	6.649
Skewness	0.063	-0.548	-0.343	-0.315	-0.525
Kurtosis	4.348	4.165	5.023	6.028	4.078

Note: α_1 and α_2 are the coefficients of the constant and first order autoregressive process specified for the mean equations. a_1 is themeasure of the autoregressive conditional heteroscedasticity (ARCH) effect. b_1 is the measure of volatility presistence. θ is the measure of the leverage effect. LB(5) and $LB^2(5)$ are the Ljung-Box statistics applied on the standardized and squared standardized residuals respectively. *t*-statistics in parentheses. *,**,*** indicate significance at 1, 5 and 10 percent, respectively.

Table 5: Determinants of Volatility Spillovers from Saudi Arabia to GCC stock markets

	(1)	(2)	(3)	(4)	(5)	(6)
Trade	0.012**	0.017**	0.015***	0.026***	0.013*	0.018*
	(0.048)	(0.014)	(0.002)	(0.009)	(0.053)	(0.098)
Turnover	0.012***		0.010***	0.012	0.009**	0.007*
	(0.001)		(0.000)	(0.183)	(0.042)	(0.077)
GDP per capita	0.000*	0.000***	0.000*	0.000**	0.000*	0.000***
	(0.055)	(0.008)	(0.098)	(0.025)	(0.053)	(0.000)
Domestic credit		0.012				
		(0.225)				
Oil production			0.335			
			(0.430)			
Inflation				-0.101**		
				(0.039)		
Control of corruption					0.814***	
					(0.000)	
Regulatory quality						1.537*
						(0.070)
Wald Chi^2	1537.44***	620.39***	4068.43***	118.36***	157.74***	213.37***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Arellano Bond Test m1	-1.568**	-1.833*	-1.644**	-1.325**	-1.521**	-1.535**
	(0.011)	(0.066)	(0.010)	(0.018)	(0.012)	(0.012)
Arellano Bond Test m2	0.100	-0.820	-0.034	-0.867	-0.224	-0.269
	(0.919)	(0.411)	(0.972)	(0.385)	(0.822)	(0.787)

Note: Volatility spillover from Saudi Arabia is dependent variable. Lag value of dependent variable is not reported. Constant not reported. Trade is sum of exports and imports as percent of GDP. Turnover is total value of shares traded during the period divided by the average market capitalization during the period. GDP per capita is gross product divided by mid- year population. Domestic credit is domestic credit provided by banking sector as percent of GDP. Oil production is natural log value of world crude oil production by country in terms of 1000 barrels per day. Inflation is measured by the consumer price index and reflects the annual percentage change in the cost to the average consumer of acquiring a basket of goods and services that may be fixed or changed at specified intervals, such as yearly. Control of corruption index focuses on the measure of corruption within the political system, the rate of severity of corruption within the state, the intrusiveness of the country's bureaucracy, corruption among public officials etc. Regulatory quality consists of indicators related to the regulations of exports, imports, business ownerships, equities ownerships, banking, foreign investment, price controls, tariffs, unfair competitive practices etc.

Figure 1.1 Return spillovers from Saudi Arabia to Bahrain

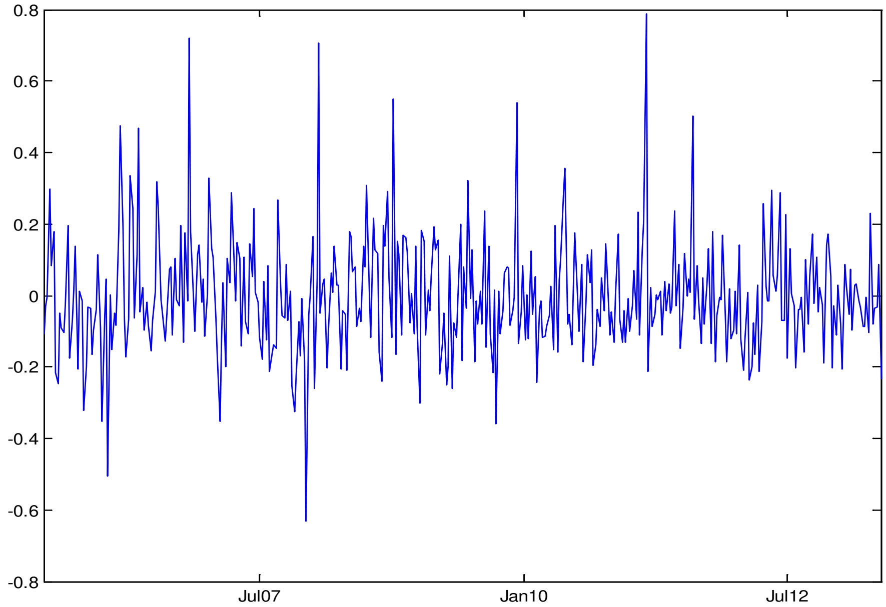

Figure 1.2 Return spillovers from Saudi Arabia to Kuwait

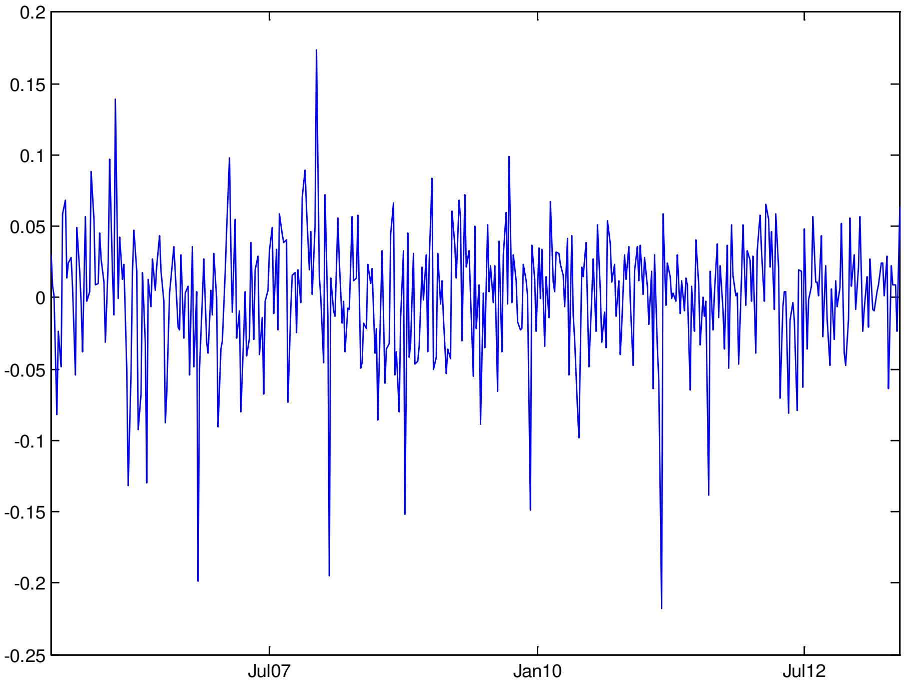

Figure 1.3 Return spillovers from Saudi Arabia to Oman

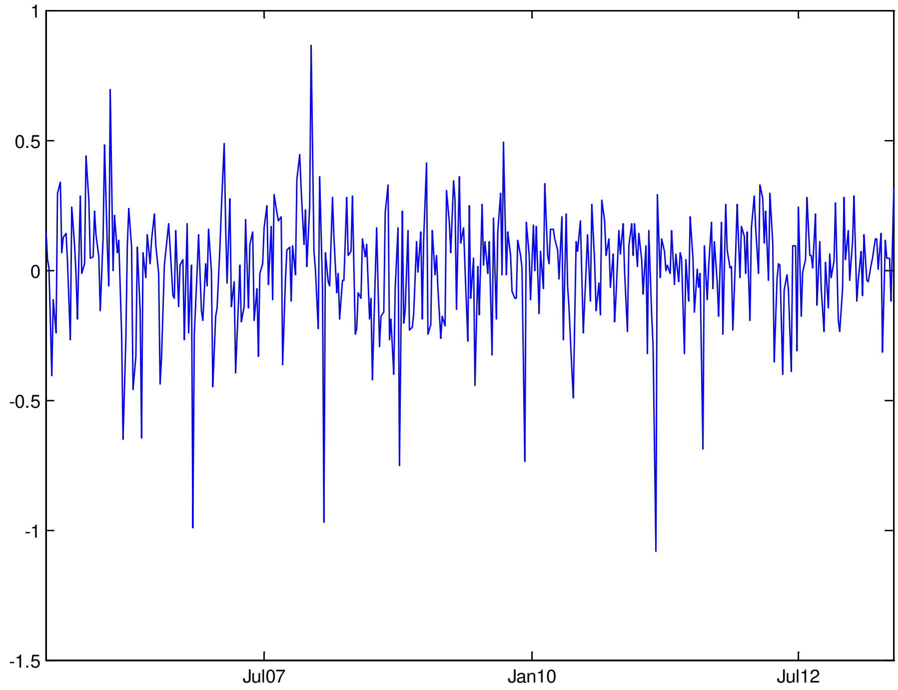

Figure 1.4 Return spillovers from Saudi Arabia to Qatar

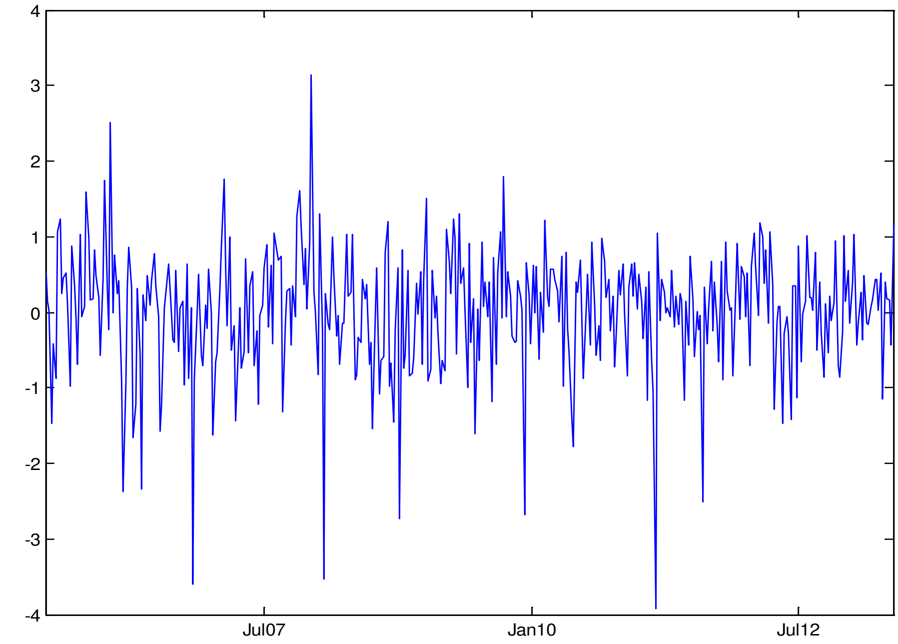

Figure 1.5 Return spillovers from Saudi Arabia to UAE

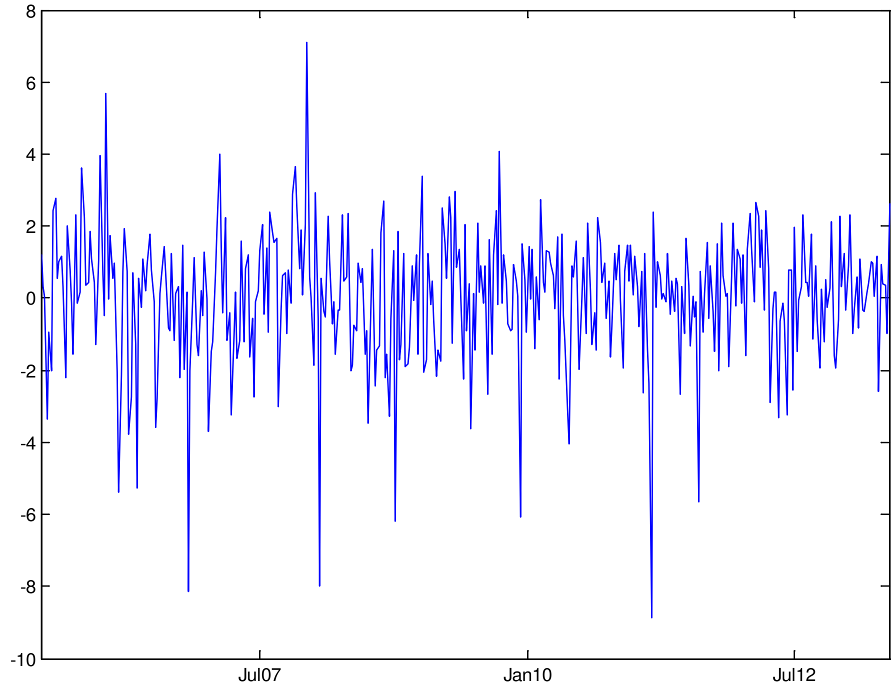

Figure 2.1 Return spillovers from the United States to Bahrain

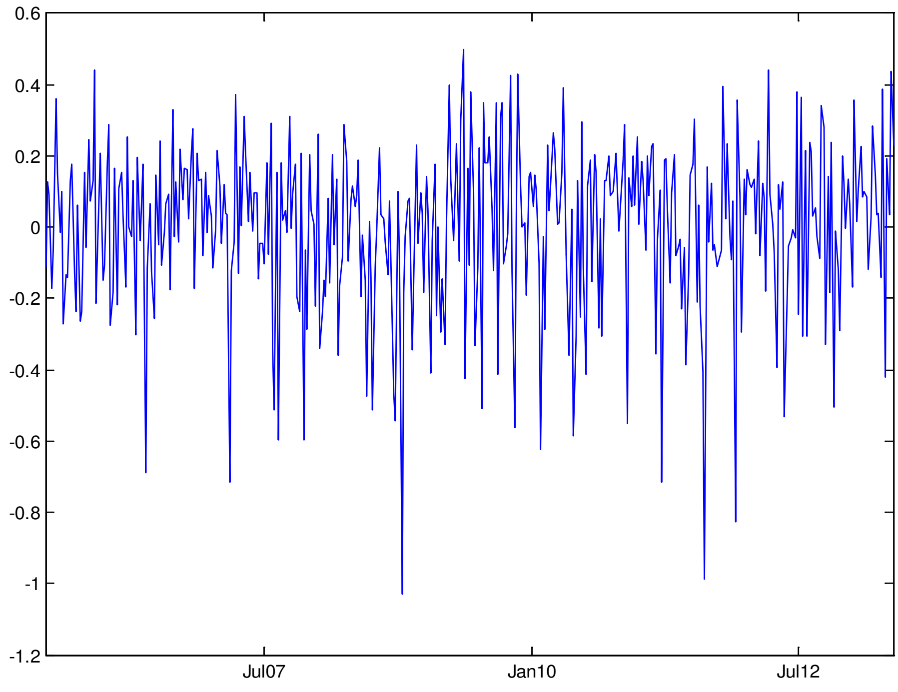

Figure 2.2 Return spillovers from the United States to Kuwait

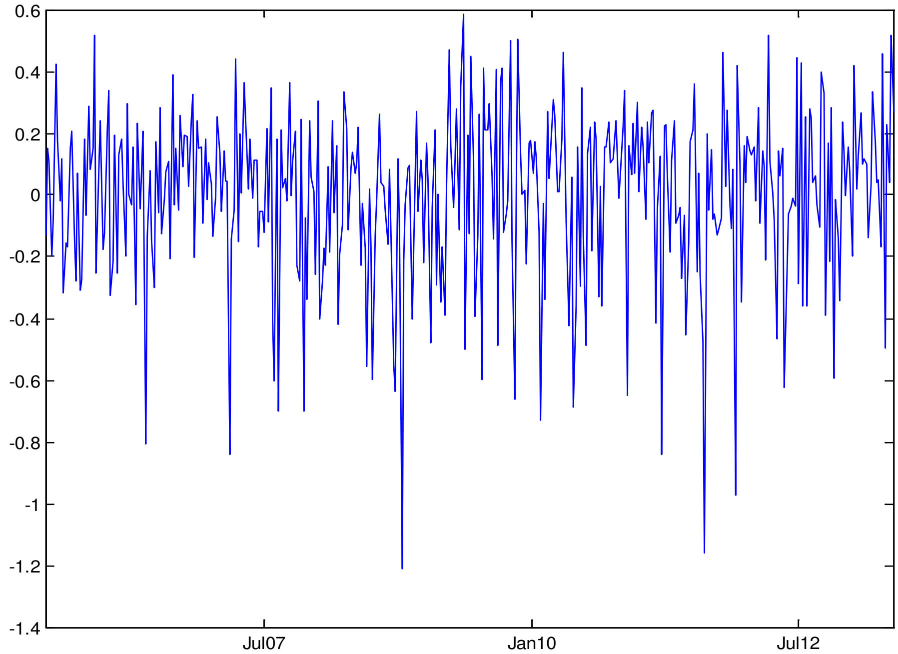

Figure 2.3 Return spillovers from the United States to Oman

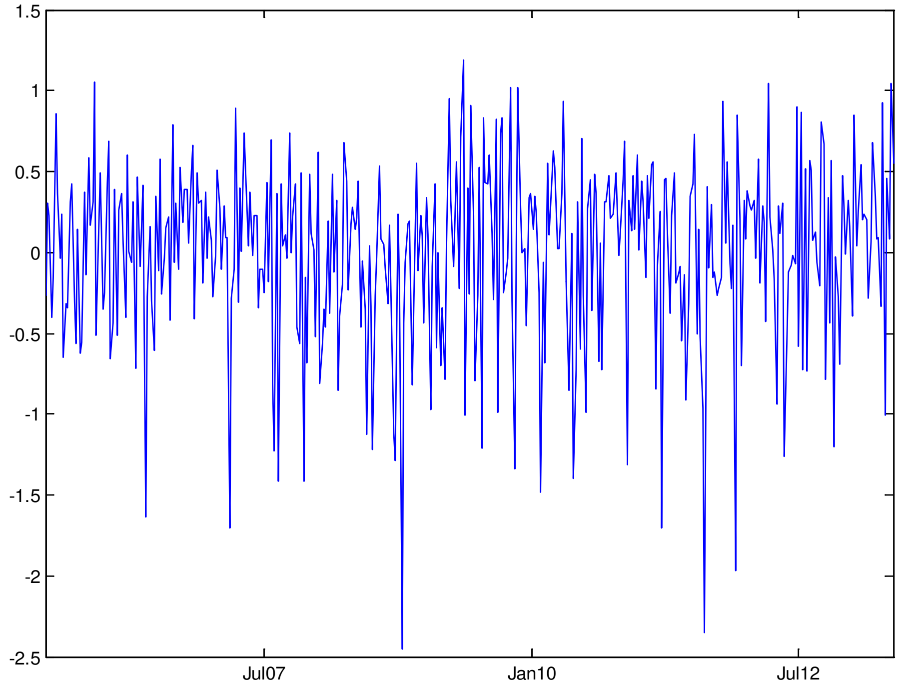

Figure 2.4 Return spillovers from the United States to Qatar

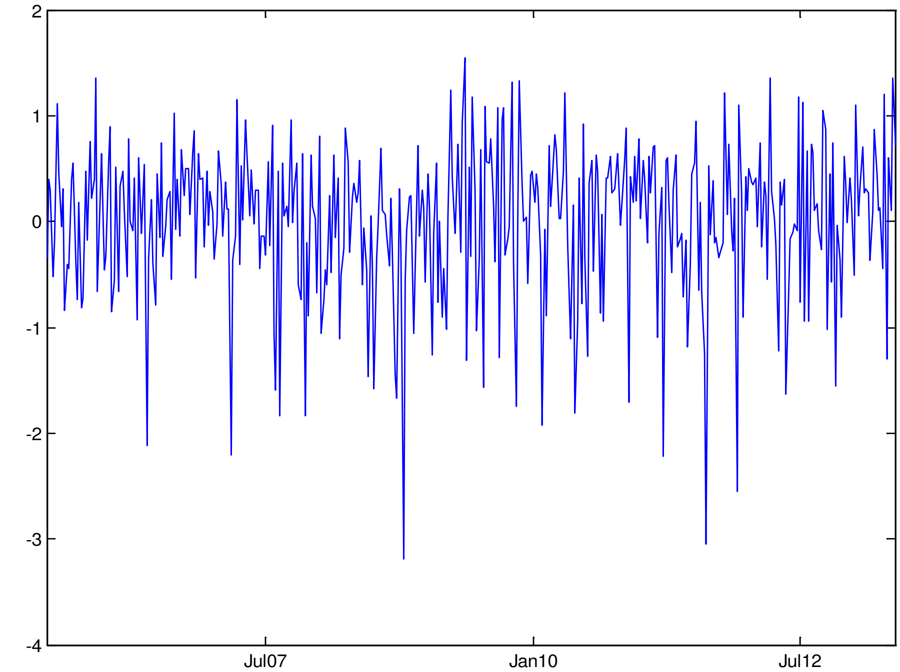

Figure 2.5 Return spillovers from the United States to UAE