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Directional spillovers from the U.S. and the Saudi market to equities in the Gulf Cooperation Council countries

Basel Awartani[a,*], Aktham I. Maghyereh[b], Mohammad Al Shiab[c]

[a] Plymouth Business School, Plymouth University, Drake Circus, Plymouth, United Kingdom
[b] Department of Economics and Finance, United Arab Emirates University, United Arab Emirates
[c] Business School, New York Institute of Technology, CERT Technology Park, Moroor Road, 5464 Abu Dhabi, United Arab Emirates

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ABSTRACT

The paper investigates returns and returns volatility spillovers from the U.S. and the Saudi market to equity markets in the Gulf Cooperation Council countries. A clear jump in net transmissions from both markets was spotted during the financial crisis in 2008. This new pattern of information transmission reflects an increase in association with the U.S. and the Saudi market. Therefore, we may conclude that the strong inter and intra diversification potential that once existed in the Gulf Cooperation Council Countries has been severely impaired in recent years.

1. Introduction

The cross market spillover of returns and volatilities is an important issue for many reasons. First, it reveals information regarding market efficiency. The finding of significant transmission in one direction indicates the existence of a trading opportunity that may be exploited to generate excess returns.

* Corresponding author. Tel.: +44 7776574627.
E-mail addresses: basel.awartani@plymouth.ac.uk, basela262@gmail.com (B. Awartani), a.almaghaireh@uaeu.ac.ae (A.I. Maghyereh), m.alshiab@nyit.edu (M.A. Shiab).

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Second, knowledge of directional spillovers may help in portfolio management; particularly in strategic asset allocation and market selection. Third, accounting for directional volatility may improve risk prediction, which is crucial for stock valuation models, option pricing models, value at risk and optimal hedging.

The objective of this paper is to measure net directional spillovers of returns and volatility from the U.S. and the Saudi equity market to the rest of stock exchanges in the Gulf Cooperation Council Countries (the GCC hereinafter) during the period that extends from 2004 to 2012.[1] In particular, our interest lies in investigating the transmission, and in detecting any changes in the nature of information spillovers of returns and volatility following the financial turmoil in 2008.

The GCC is a region with special characteristics. It includes countries that are mainly net exporters of oil and hence, financial markets in the area are exposed to shocks that hit the oil market. Moreover, the GCC block lies in a politically turbulent area and thus, the political sensitivity is another driving force behind these equity markets. The stock exchanges in these countries are new, segmented, less integrated with international markets, and therefore, these have high potential for regional and world portfolio diversification and hedging. Furthermore, the area has experienced tremendous growth in the last decade. The big rise in oil prices has created plenty of surpluses that attracted the interest in the area and its assets in terms of investment and diversification.

The transmission channels between the U.S., and the GCC block are numerous. First, there is substantial trade flows with the U.S. Most of the block's exports are directed toward the U.S., which consumes 25% of these countries' oil production.[2] Second, the GCC countries invest heavily in U.S. assets and companies, where Governments allocate high budgets for spending on U.S. weapons, military training, outsourcing and logistics. Due to these strong economic ties, most currencies in the block are pegged to the U.S. dollar. Therefore, we would expect signifcant spillovers from the U.S. financial market to the GCC stock exchanges.

Inside the block, the biggest market is the Saudi market. It is ranked among the top ten global emerging stock markets. It is also the leading market in terms of capitalization, as well as, in terms of other indicators such as the number of companies. In addition, the Saudi market is the oldest, the most liquid, and the market with the highest turnover ratio. Hence, it would be interesting as well to investigate the dynamics of transmissions from the Saudi market to other stock exchanges in terms of returns and volatility.

The return and volatility spillovers in the GCC have attracted little research. Throughout the last decade, we found eight studies that attempted to fill the gap on the issue of information transmission mechanisms related to GCC countries. Specifically, the flow of information from the Bahraini financial market to the Saudi stock exchange was investigated by Abraham and Seyyed (2006). The effect of deregulation and integration on information transmissions and long term correlations was the focus of Al-Khazali et al. (2006). The influence of increased market activity after 2002 on dynamic interrelationships was researched by Bley and Chen (2006). The comparison between own volatility spillovers and cross volatility transmissions with the U.S. was done by Yu and Hassan (2008). The information spills with the Euro Zone was the topic of the study of Olusi and Abdul-Majid (2008). The Intra and inter regional spillovers between the GCC and North Africa was tackled by Alkulaib et al. (2009). The influence of the U.S., UK and Japan was checked by Ajayi et al. (2010) and Neaime (2012). Finally, Maghyereh and Awartani (2012) have investigated spillovers between two regional markets located in the same country, namely, the Dubai Financial Market and the Abu Dhabi Stock Exchange.[3]

Our study extends beyond these empirical works in two directions: First we focus on the nature of transmission pre and post of the global financial meltdown in 2008. Second, we reveal dynamically the direction of spillovers of returns and volatilities between the U.S. and/or the Saudi market, and the

[1] The Gulf Cooperation Council countries consist of the following: Bahrain, Kuwait, Oman, Qatar, Saudi Arabia and the United Arab Emirates.

[2] These countries produce 20% of world oil output and control 47% of world oil reserves.

[3] Most of the recent literature on the GCC has focused on the information transmission between oil and stocks markets. For instance, see Hammoudeh and Aleisa (2004), Zarour (2006), Hammoudeh and Choi (2006, 2007), Malik and Hammoudeh (2007), Maghyereh and Al-Kandari (2007), Lescaroux and Mignon (2008), Arouri and Fouquaus (2009), Fayyad and Daly (2011), Mohanty et al. (2011), Arouri et al. (2011), and Awartani and Maghyereh (2013).

rest of stock exchanges in the GCC. This direction is now possible to generate given a set of spillover index measures that was recently proposed by Diebold and Yilmaz (2012). These measures can be computed across time using a rolling window and hence, the generated dynamics may also provide additional insights into the behavior of information transmission in a crisis and a non-crisis episode including trends, as well as bursts in spillovers, and this suits exactly the objective of the paper.[4]

Our empirical results indicate asymmetric transmissions. In particular, the return and volatility spillovers from the U.S. (and/or the Saudi market) to other exchanges are more pronounced and larger in magnitude, than transmissions in the opposite direction. Furthermore, our findings indicate that there exists a substantial change in the nature of transmission from the U.S. market to GCC equities during and following the financial crisis in 2008. Prior to the crisis, net transmissions from the U.S. to GCC equities were positive, albeit weak. However, during the year of the crisis, spillovers spiked, and stayed at a clearly higher level afterwards. A similar pattern regarding net transmission from the Saudi market was recorded. However, in the case of the Saudi market net transmissions were also strong before the crisis, albeit it became stronger afterwards. These results indicate that the diversification potential across U.S. and GCC equities that once existed has been severely impaired in recent years.

This study is related to the previous literature on information transmission in the GCC region. However, we follow a methodology that reveals the direction of spills, and we analyzed both crisis and non-crisis episodes. Our results are similar and different. For instance, we are similar to Yu and Hassan (2008), Olusi and Abdul-Majid (2008) and Ajayi et al. (2010) in that the transmission within the GCC is more important than the transmission from the U.S. or any other developed markets. However, our evidence suggests that this is only valid in a non-crisis situation, whereas in a crisis period net returns and volatility spillover from the U.S. plays a crucial role in the information transmission mechanism of the block. Moreover, within the block our results show that spillovers are asymmetric and hence, we are consistent with Abraham and Seyyed (2006) and Alkulaib et al. (2009). However, we are different in that the Saudi market is playing the dominant role and not the Bahraini market as in Abraham and Seyyed (2006), or the UAE financial markets as in Alkulaib et al. (2009). Finally we agree with all studies that has recorded an increase in integration and information transmission within the block during the last decade.

The rest of the paper is organized as follows: the next section contains a synopsis of the literature on return and volatility spillovers. Section 3, provides some information about GCC stock markets. In Section 4, we outline the methodology used to measure directional spills. Section 5 describes the data, and Section 6, reports the empirical results. The conclusion is included in Section 7.

2. Literature review

There is extensive research on cross country return and volatility spillovers. However, the transmission from U.S. equities to the rest of equity markets has attracted the majority of this research.[5] The empirical findings on U.S. equity transmission were all similar and indicated pronounced returns and volatility spills from the U.S. financial market to the rest of equity markets across the globe. For instance, in terms of return propagation there are the studies of Janakiramanan and Lamba (1998) and Hsiao et al. (2003) who substantiated spillovers to the Pacific Basin and Asia Pacific regions. Same results on emerging markets were provided by Elyasiani et al. (1998); and on central Europe by Gilmore and McManus (2002); and on Latin America by Fernandez-Serrano and Sosvilla-Rivero (2003). Similarly, significant volatility interdependence with East Asian markets was recorded by Chuang et al. (2007), Gallo and Otranto (2007), Dao and Wolters (2008), Lee (2009), Yilmaz (2010), and Zhou et al. (2012); and with the Middle East and North African countries by Yu and Hassan (2008), Olusi and

[4] These measures are also computationally simple. Moreover, the multi-step forecasting and forecasting errors and their decompositions are straightforward to generate.

[5] For instance, see Elyasiani et al. (1998), Janakiramanan and Lamba (1998), Gilmore and McManus (2002), Hsiao et al. (2003), Bessler and Yang (2003), Muherjee and Mishra (2005), Elyasiani and Zhao (2008), Sosvilla-Rivero and Rodríguez (2010), Hamao et al. (1990), Christofi and Pericli (1999), Hahm (2003), Kim et al. (2005), Wang et al. (2005), Baur and Jung (2006), Chuang et al. (2007), Chen et al. (2007), Morana and Beltratti (2008), and Yu and Hassan (2008) among many others.

Table 1
Macroeconomic and stock markets characteristics of the GCC in the year 2011.

	Bahrain	Kuwait	Oman	Qatar	Saudi Arabia	UAE – Dubai/ Abu Dhabi[a]
Stock markets indicators						
Start of trading	1987	1952	1989	1997	1935	1988
Start of electronic trading	1989	1995	1998	2002	1988	2000
Number of listed companies	44	206	136	42	150	104
Market capitalization (US$ bn)	17.1	100.9	19.7	128.4	338.8	49.54/64.4
Market capitalization/total GCC market capitalization	2.4	14	3	18	47	16
Market cap./GDP	82.2	87.6	36.9	89.4	81.3	35.2
Turnover ratio	1.5	19.4	12.9	15.5	84.6	15.9
P/E ratio	11.7	20.0	12.8	NA	15.7	11.6/9.9
Macroeconomic indicators						
GDP (US$ bn)	20.8	115.2	53.4	143.6	416.8	321.0
Oil and gas revenue/GDP	33.9	54.8	47.2	61.1	54.0	34.4
FDI, net inflows (US$bn)	0.155	0.880	2.332	5.534	21.560	3.984
Net foreighn asset/GDP	1.3	2.4	0.4	1.4	1.5	4.5

Sources: Data were obtained from multiple sources including the Arab Monetary Fund, World Bank and the International Finance corporation.

[a] The UAE has two stock markets: Dubai Financial Market (DFM) and Abu Dhabi Stock Exchange (ADSE).

Abdul-Majid (2008), Ajayi et al. (2010), Neaime (2012), and Korkmaz et al. (2012); and with Europe by Kanas (1998), Eger and Kočenda (2007), and Morana and Beltratti (2008).[6]

Though there are a vast number of studies that examined the issue of information transmission mechanisms across markets, only a few of them focused on GCC equities. Among others, Abraham and Seyyed (2006) examined the flow of information among GCC exchanges, and found asymmetric spillovers of volatility from the smaller, but accessible Bahraini market, to the larger but less accessible Saudi market. Also, Al-Khazali et al. (2006) analyzed the effect of deregulation and integration efforts on information transmissions, and found that measures taken to liberalize capital markets in the GCC contributed significantly to the recent increase in linkages between these markets. Similar results on the effect of deregulation on stock market interdependence in the GCC have been recorded by Bley and Chen (2006). The return and volatility transmission between the GCC and North African countries was studied by Alkulaib et al. (2009). Their results indicated a regional inconsistency in the information transmission among stock markets, and that the UAE's stock market led all markets in the region. Finally, Maghyereh and Awartani (2012) investigated return and volatility spillovers between Dubai financial market and Abu Dhabi stock exchange, and found asymmetry in the information transmission mechanism, in which, the Dubai financial market played the dominant role.

Our paper is directly related to this strand of the literature, and we aim to provide additional knowledge into the issue of directional transmissions in GCC financial markets. We turn now to discuss the characteristics of GCC equity markets.

3. The GCC stock markets

In Table 1, we show some indicators on stock markets operating in the GCC.[7] The table also includes some macroeconomic data about composing countries. As can be seen in the table, the contribution

[6] Another strand of the literature had focused on interdependence during market events. For instance, the effect of deregulation on information transmission in East and South East Asia was done by Click and Plummer (2005). The effect of the introduction of the Euro was documented by Melle (2002) and Savva et al. (2009). The Russian crisis spillover effects were recorded by Lucey and Voronkova (2008). Finally, Studies like Bracker et al. (1999), Pretorius (2002), Johnson and Soenen (2003) and Nam et al. (2008) tackled the factors that are likely to cause pronounced spillovers.

[7] The GCC was established in 1981. In this block of countries seven stock markets are operating in parallel and each contains different listed stocks. The only country with two markets is the UAE: the Dubai Financial Market and the Abu Dhabi Stock Exchange. Regional markets in the U.S. sense are nonexistent.

of oil and gas revenues to GDP is substantial. It is 34% in Bahrain, but it may go up to 61% as in Qatar. This reflects the high sensitivity of GCC economies and stock markets to global cycles, and oil price fluctuation. In the table, the number of companies listed in the GCC stock markets ranges from as low as 43 companies in Qatar to as high as 135 in Saudi Arabia. The Saudi market is considered as the leading market in the block. It is also ranked among the top ten global emerging stock markets. Moreover, it is the most liquid, the oldest, and the one with the highest turnover ratio. Therefore, we expect an information transmission mechanism in which Saudi equities play the dominant role. The rest of markets are relatively liquid, the most liquid of them are the Kuwaiti Financial Market and the Dubai Financial Market. The smallest and the least liquid among the six countries' exchanges is the Bahraini Stock Market. Finally, the Qatari and the Omani Stock Markets suffer from low liquidity as well.

In terms of capital, the table indicates that the largest capital market is the Saudi market. It accounts for 47% of the total capitalization traded in the block. Following in terms of capitalization is the United Arab Emirates and then the Kuwaiti stock markets; both account together for another 40% of traded capital. The Qatari stock exchange offers another 12% of capital to trade. The smallest markets are the Bahraini and the Omani market, and both trade only 2.4%, and 3%, of total floated shares respectively.

The GCC economies experienced a strong economic growth that was fueled by a rise in oil prices in the last decade. As a result, the stock market capitalization in these countries has grown exponentially. The market cap has increased from $117 billion in 2003 to $1.1 trillion in 2005. As a share of GDP, it has jumped six folds, and from 27% to 177%. However, it dropped sharply to 73% ($650 billion) after the global financial turmoil in 2008, and the collapse in stock prices. The ensued Dubai credit crunch has induced further drops in 2009. The fears of a long global recession and falling oil prices were heightened.

The GCC stock markets are segmented with significant restrictions on capital mobility and foreign ownership compared to other stock markets in developed and emerging economies. Disclosure of companies also suffers occasionally from lack of common accounting standards, transparency and reliability in terms of market information. This is in addition to the general atmosphere of regional economic and political instability. There are inherent structural weaknesses in these markets that include among other things, the small number of firms, the large institutional holdings, the low diversification potential across sectors, the deficient corporate governance and disclosure standards, and the continuing weaknesses in banks' supervision and regulations. A broad range of legal, regulatory and supervisory reforms have been made recently to open up markets, and to increase their transparency. However, the access to international investors still remains low; and the effect of these adjustments is yet to be seen.

The last decade witnessed a global financial turmoil and turbulent markets. An interesting issue that arises from these circumstances is the nature and dynamics of transmission of price and volatility in the GCC stock exchanges, and this is the objective of the paper. We turn next to discuss Diebold and Yilmaz (2012) directional measures.

4. Methodology

We model stock market returns (or volatilities) as N market vector auto regression.[8] Let market returns (or volatilities), x_i to be modeled as a vector autoregressive process, $VAP(p)$ that can be written as $x_i = \sum_{i=1}^{p} \Phi x_{t-i} + \varepsilon_t$, where $x_t = (x_{1,t}, x_{2,t}, \ldots, x_{N,t})$, and Φ is an $N \times N$ matrix of parameters to be estimated. Also assume that the vector of error terms ε is independently and identically distributed with zero mean, and Σ covariance matrix. If the VAR system above is covariance stationary, then there exists a moving average representation that is given by $x_t = \sum_{i=0}^{\infty} A\varepsilon_{t-i}$, where the $N \times N$ coefficient matrices A_i obey a recursion of the form $A_i = \Phi_1 A_{i-1} + \Phi_2 A_{i-2} + \cdots + \Phi_p A_{i-p}$ with A_0 is the $N \times N$ identity matrix and $A_i = 0$ for $i > 0$.

A transformation of coefficients in the moving average representation above can be used to identify variance decompositions (or impulse responses). The aggregation of these decompositions will be used

[8] The discussion and notation contained in this section followed Diebold and Yilmaz (2009, 2012).

subsequently to compute the gross spills from a particular market to other stock markets, and also in the opposite direction. However, for the measure to be stable, decompositions should be independent of the ordering of markets. Cholesky decomposition is not suitable as it is sensitive to ordering.

A framework that produces invariant decompositions is the generalized VAR that has been first proposed by Koop et al. (1996), and Pesaran and Shin (1998) (the KPPS hereafter). The KPPS, forecast error variance decomposition (H step ahead) is computed as

$$\theta_{ij}^{g}(H) = \frac{\sigma_{jj}^{-1}\sum_{h=0}^{H-1}(e_i' h_h \Sigma e_j)^2}{\sum_{h=0}^{H-1}(e_i' h_h \Sigma e_j)}$$

where Σ is the variance matrix of the vector of errors ε, and σ_{jj} is the standard deviation of the error term of the jth market. Finally, e_i is a selection vector with one on the ith element, and zero otherwise. In order to get a unit sum of each row of the variance decomposition, we normalize each entry of the matrix by the row sum as[9]

$$\widetilde{\theta}_{ij}^{g}(H) = \frac{\theta_{ij}^{g}(H)}{\sum_{j=1}^{N}\theta_{ij}^{g}(H)}$$

In the equation above, note that the decomposition including own shocks in each market sums to one, i.e. $\sum_{j=1}^{N}\theta_{ij}^{g}(H) = 1$, and that the total decomposition over all markets sums to N, i.e. $\sum_{j=1}^{N}\widetilde{\theta}_{ij}^{g}(H) = N$.

The factorization above is used in this paper to compute the total spillover index as

$$S^{g}(H) = \frac{\sum_{i,j=1}^{N}\widetilde{\theta}_{ij}^{g}(H)}{\sum_{i,j-1}^{N}\widetilde{\theta}_{ij}^{g}(H)}\Big|_{i\neq j} \times 100 = \frac{\sum_{i,j=1}^{N}\widetilde{\theta}_{ij}^{g}(H)}{N}\Big|_{i\neq j} \times 100 \tag{1}$$

The index in (1) measures the total information flow among GCC stock markets including the U.S. (and/or the Saudi market). It is an off-diagonal addition of the proportion of the forecast error variance of all x_i's due to shocks to x_j, for all $i \neq j$.

The net volatility spillovers from the U.S. (and/or the Saudi market) to other stock exchanges are computed as

$$S_{i}^{g}(H) = S_{i\circ}^{g}(H) - S_{\circ i}^{g}(H) \tag{2}$$

where $S_{i\circ}^{g}(H)$ represents the spillover transmitted from the U.S. (and/or the Saudi market) to other GCC stock exchanges and it is calculated as

$$S_{i\circ}^{g}(H) = \frac{\sum_{j=1}^{N}\widetilde{\theta}_{ij}^{g}(H)}{\sum_{j=1}^{N}\widetilde{\theta}_{ij}^{g}(H)}\Big|_{i\neq j} \times 100 \tag{3}$$

Similarly, $S_{\circ i}^{g}(H)$ is the directional spillovers received by the U.S. (and/or the Saudi market) from all other markets which is computed as

$$S_{i\circ}^{g}(H) = \frac{\sum_{j=1}^{N}\widetilde{\theta}_{ij}^{g}(H)}{\sum_{j=1}^{N}\widetilde{\theta}_{ij}^{g}(H)}\Big|_{i\neq j} \times 100 \tag{4}$$

[9] Though the KPPS is robust to ordering, its decompositions do not sum up to one as in Cholesky factorization. Thus, the normalization of the sum will enable an intuitive computation of the contribution of a particular market, and an intuitive sum of contributions across markets.

The net spillover measure in (2) indicates whether the U.S. (and/or the Saudi market) is a net giver or a net receiver in a system of transmission that includes the GCC stock exchanges and the U.S. (and/or the Saudi market). We now turn to discuss the data set and the empirical results.

5. Data set description

The empirical analysis uses dataset that covers the period extends from the 2nd of January 2004 to the 30th of March 2012, and includes market indices in local currencies. The data were retrieved from Thomson Reuters Datastream. The stock market indices are capital weighted, and they include all companies traded in the GCC. The U.S. market was represented by the S&P 500 index.[10] From the indices, we measure weekly continuously compounded returns as the change in log price indices, Friday to Friday and over the whole sample. This has resulted in 430 weekly return observations.

The data set shows that all stock markets in the GCC were growing exponentially untill November 2005. This strong growth was supported by rising oil prices, corporate profits, and structural reforms. The mood however, began to drop by the end of 2005, and sharp declines swept stock markets in early 2006. These were partially reversed by the end of 2007, and until the outbreak of the financial turmoil in 2008; where markets have tumbled by more than 40%. Afterwards, it recovered marginally; however, at a slower pace. The recent or even previous losses were never recouped.[11] The advent of the Arab Spring and political revolutions in the Middle East, the uncertainties facing the global economy, and the continuing fallout of the financial crisis may have contributed to a weak stock market performance after 2008; where upward trends were short lived.

Table 2, Panel A, reports a summary statistics of the return series over the full sample. The table reports the mean, standard error, skewness and excess kurtosis coefficients and the Jarque–Bera statistics to test the null hypothesis that returns are normally distributed. The returns to all indices are negatively skewed and leptokurtic, and the Jarque–Bera statistics rejects the null hypothesis of normality very strongly. The table also reports the Ljung–Box portmanteau statistics for the last two and half months (previous 10 weeks). For all indices, returns are serially correlated. To measure the latent volatility we used a simple range based estimator that was first proposed by Garman and Klass (1980). Specifically, we used weekly high, low, opening and closing prices from Monday open to Friday close. For any market *i*, the volatility in week t is computed as

$$\sigma_{i.t}^2 = 0.511(H_{i,t} - L_t)^2 - 0.019[(C_{i,t} - o_{i,t})(H_{i,t} + L_{i,t} - 20_{i,t}) - 2(H_{i,t} - O_{i,t})(L_{i,t} - O_{i,t})] - 0.383(C_{i,t} - O_{i,t})^2 \quad (5)$$

where *H*, *L*, *O* and *C* are the Monday to Friday open, high, low, the Monday open and the Friday close respectively. A variety of summary statistics of the natural logarithm of volatilities is included in Table 2, Panel B. The table indicates that the least volatile market was the Bahraini stock exchange, while the most volatile one was the Dubai financial market. Finally, all markets exhibited spikes in volatility during the recent global financial crises. Also, in all markets, volatility persists and clusters as indicated by the data set.[12]

6. Empirical findings

6.1. Simple correlation analysis

We first estimate simple correlation coefficients. Table 3, Panels A and B, contains simple return and volatility correlations between the Saudi market and equities in the rest of markets respectively.

[10] The S&P 500 is a market value weighted index that includes the 500 largest companies in the U.S. This index is one of the most commonly used benchmarks for overall performance evaluation of U.S. stock market. It covers approximately 75% of U.S. equities.

[11] Note that oil prices and stock markets in the U.S. also tumbled following the crisis. However, these markets were able to recover afterwards at a high pace. On the contrary, the GCC stock exchanges stayed hovering around the same level.

[12] The figures of price indices, returns and returns volatilities were omitted to economize on space.

Table 2
Descriptive statistics, market returns and volatilities.

	U.S.	Saudi Arabia	Bahrain	Kuwait	Oman	Qatar	Abu Dhabi	Dubai
Panel A: Summary statistics of return series[a]								
Mean	0.000095	0.00006	0.00004	0.00007	0.000156	0.00027	0.00016	0.00023
Median	0.000281	0.00060	0.00006	0.00028	0.00016	0.00026	0.00022	0.00012
Maximum	0.01939	0.01363	0.00608	0.00848	0.01190	0.01409	0.01796	0.01393
Minimum	−0.023476	−0.02285	−0.00831	−0.00902	−0.01563	−0.02197	−0.01586	−0.03155
Std.Dev.	0.003706	0.00427	0.00182	0.00212	0.00277	0.00435	0.00383	0.00521
Skewness	−0.425458	−1.5148***	−0.34643***	−0.4505***	−0.9109***	−0.5568***	−0.19835*	−0.7044***
	(0.000332)	(0.00000)	(0.00347)	(0.00014)	(0.00000)	(0.00000)	(0.09426)	(0.00000)
Kurtosis	7.15730***	5.08099***	2.76345***	2.54467***	7.53796***	4.10413***	3.86392***	3.8706***
	(0.00000)	(0.00000)	(0.00000)	(0.00000)	(0.00000)	(0.00000)	(0.00000)	(0.00000)
Jarque–Bera	930.789***	627.0126***	145.4293***	130.5643***	1077.510***	324.006***	270.313***	303.994***
	(0.00000)	(0.00000)	(0.00000)	(0.00000)	(0.00000)	(0.00000)	(0.00000)	(0.00000)
Q(10)	23.295***	24.967***	48.573***	25.753***	45.349***	11.969	36.388***	120.643***
	(0.009709)	(0.00540)	(0.00000)	(0.00409)	(0.00000)	(0.28716)	(0.00007)	(0.00000)
Panel B: Summary statistics of return volatilities[b]								
Mean	−9.508073	−9.02817	−10.96137	−10.4003	−10.56003	−9.23063	−9.63811	−8.73243
Median	−9.569264	−9.02075	−10.83697	−10.3529	−10.57080	−9.25738	−9.55767	−8.63177
Maximum	−4.993003	−4.38769	−6.58075	−6.50998	−4.91514	−4.85527	−2.50186	−4.610799
Minimum	−13.337202	−14.1955	−19.94811	−17.6983	−18.20532	−15.9415	−16.0563	−16.103675
Std.Dev.	1.337015	1.63173	1.63782	1.59840	1.90384	1.74564	1.77147	1.49720
Skewness	0.204007	0.00624	−0.71897*	−0.52277*	−0.2182***	−0.2769**	−0.24983*	−0.42387*
	(0.085247)	(0.95826)	(0.00000)	(0.00011)	(0.06691)	(0.01960)	(0.00000)	(0.00039)
Kurtosis	0.168347	−0.15610	2.36015***	1.51676***	1.32381***	0.26788	0.76237***	1.17224***
	(0.479697)	(0.51522)	(0.00000)	(0.00000)	(0.00000)	(0.26128)	(0.00138)	(0.00000)
Jarque–Bera	3.490467	0.43327	136.8479***	60.23899***	34.48742***	6.76822**	14.85190***	37.19886***
	(0.174604)	(0.80522)	(0.00000)	(0.00000)	(0.00000)	(0.03390)	(0.00059)	(0.00000)
Q(10)	723.037***	579.765***	79.753***	87.632***	372.843***	411.967***	370.880***	399.164***
	(0.00000)	(0.00000)	(0.00000)	(0.00000)	(0.00000)	(0.00000)	(0.00000)	(0.00000)

Notes: *Q*(10) is the Ljung–Box statistics for serial correlation. The values in parenthesis are the actual probability values.

[a] Returns are measured weekly from Friday-to-Friday returns. The sample size is 430. See text for details.

[b] Volatilities are measured weekly as range based for Monday-to-Friday returns and in logs. The sample size is 430. See text for details.

* Indicate the rejection of the null hypothesis of associated statistical tests at the 10% level.

** Indicate the rejection of the null hypothesis of associated statistical tests at the 5% level.

*** Indicate the rejection of the null hypothesis of associated statistical tests at the 1% level.

Table 3
Correlation analysis.

	Bahrain	Kuwait	Oman	Qatar	Abu Dhabi	Dubai
Panel A: simple correlation between Saudi Arabia returns and GCC returns						
Entire sample	0.22	0.31	0.33	0.40	0.40	0.46
1/2004 to 6/2008	0.15	0.31	0.09	0.17	0.32	0.34
6/2008 to 3/2012	0.28	0.28	0.54	0.66	0.51	0.60
Bias adjusted	0.21	0.21	0.42	0.54	0.40	0.48
Panel B: Simple Correlation between Saudi Arabia Volatility and GCC Volatilities						
Entire sample	0.20	0.16	0.22	0.30	0.13	0.36
1/2004 to 6/2008	0.06	0.09	0.19	0.20	0.47	0.32
6/2008 to 3/2012	0.52	0.29	0.41	0.47	0.19	0.47
Bias adjusted	0.42	0.23	0.32	0.30	0.15	0.38

	Saudi Arabia	Bahrain	Kuwait	Oman	Qatar	Abu Dhabi	Dubai
Panel C: simple correlation between U.S. returns and GCC returns							
Entire sample	0.36	0.14	0.14	0.31	0.32	0.16	0.25
1/2004 to 6/2008	0.05	0.007	−0.003	0.032	−0.01	−0.04	0.03
6/2008 to 3/2012	0.61	0.22	0.24	0.40	0.49	0.32	0.38
Bias adjusted	0.40	0.13	0.14	0.24	0.31	0.19	0.23
Panel D: simple correlation between U.S. volatility and GCC volatilities							
Entire sample	0.21	0.18	0.13	0.44	0.34	0.02	0.24
1/2004 to 6/2008	−0.001	−0.04	−0.06	0.18	0.03	0.04	0.06
6/2008 to 3/2012	0.45	0.31	0.28	0.42	0.40	0.01	0.32
Bias adjusted	0.18	0.11	0.10	0.16	0.15	0.003	0.12

Similarly Panels C and D describe the simple retrun and volatility correlation with the U.S. market. We compute over two samples. The first extends from January 2004 and untill June 2008, or shortly before the financial crisis; while the second covers the crisis period and beyond from June 2008 to March 2012. Therefore, these samples may be considered as pre and post crisis samples respectively.

The simple correlation analysis indicates a clear secular change in correlations between the Saudi market and other GCC stock markets. Panels A and B show that pre crisis correlation among countries is positive and moderate. However, in the post crisis period, these correlations doubled due to erratic markets following 2008.[13] Panels C and D show that all countries have no association in terms of returns and volatility with the U.S. market in the pre-crisis period. On the contrary, some correlations are even negative, and most of them are tiny and negligible. However, once we move into a crisis state, correlations jumped for all countries. In fact the correlation with the U.S. equity has spiked from almost none pre-crisis to more than 30% in the period following the financial turmoil in 2008.[14]

The simple correlation analysis also shows that association within the block is moderate, and it strengthens in a crisis situation.[15] This indicates a medium diversification potential within the block that becomes low during modes of stress. On the contrary, the association with the U.S. during normal times is weak, and hence, a great diversification may be realized by combining U.S. and GCC equities. However, these diversification benefits disappear once we kick off into a crisis mode as returns and volatility correlations jump to high levels.

It is well known, that inference on cross stock market co-movement using correlation analysis is prone to bias and inaccuracy due to the dependence of the correlation measure on the state of volatility.[16] Specifically, during market stress, volatility is high and correlation estimates tend be

[13] The pre-crisis sample shows average correlations of 19.7% and 19% for returns and volatilities respectively. These have increased to 41% and 29% post crisis.

[14] We excluded the financial meltdown period (from June 2008 to November 2008) from the second sub sample, and found that correlations continue to be higher in the second subsample for both returns and volatilities and hence, figures are not reported.

[15] The two regional markets of the UAE, namely, the Dubai Financial Market and the Abu Dhabi Stock Exchange exhibited the highest correlation in returns and returns volatility. The correlation was roughly around 78%.

[16] An interesting discussion on this issue can be found in Forbes and Rigobon (2002).

upwardly biased. Therefore, if volatility is not accounted for, the rise in correlations may reflect only an increase in market volatility, and not higher interdependence.[17] Hence, for comparison based on correlations; the correlation measure should be corrected for varying volatility. By employing some restrictive assumptions, correlations may be corrected using the following formula[18]:

$$\rho_c^* = \frac{\hat{\rho}_c}{\sqrt{1 + ((\sigma_c^2 - \sigma_{nc}^2)/\sigma_{nc}^2)(1 - \hat{\rho}_c)^2}} \tag{6}$$

where ρ_c^*, is the corrected correlation in the crisis period, $\hat{\rho}_c$ is the uncorrected correlation coefficient, σ_c^2 and σ_{nc}^2 refer to the variance in high and in low volatility states respectively.[19]

Thus, we adjusted our correlation in the crisis period according to (6); and reported results in the fourth line of each panel in Table 3. As can be seen in all panels, correlations have been deflated to account for the increase in market stress. However, there still exists a clear jump in association compared to the pre-crisis period; and thus we may conclude safely that the rise in correlation after 2008 reflects a rise in co-movement in cross market returns and volatilities.[20]

6.2. Spillover index analysis

Table 4 reports the full sample spillover index matrix of returns and volatilities respectively. All results are based on vector autoregressions of order 2, and generalized variance decompositions of 10 week ahead forecast errors. The (i,j) entry in each panel is the estimated contribution to the forecast error variance of market i coming from innovations to market j. To All, is the directional spillovers from a market to all other markets. From All, is the directional spillovers from all markets to a particular market. The total spillover index as in (1) is reported in the lower right corner of each panel.

The directional spillovers from the U.S. market to stock indices is reported in the first column. The total contribution of the U.S. market across all stock markets as in (3) is reported just before the last row in the first column (parallel to item To All). Similarly, the directional spillovers from stock indices to the U.S. is reported in the first row. The total spills as in (4) is reported as the last observation in the first row of Panels A and B (down the item From All).

6.2.1. Net spillover from the Saudi market

Column 2 and Row 2 of Panel A in Table 4 reports returns bi-directional spills with the Saudi market. The panel shows,with the exception of the U.S., that transmissions from the Saudi market returns to all GCC stock markets' returns are larger than the transmission in the opposite direction. The gross directional return spills from the Saudi market to all stock exchanges in the GCC over the whole sample period are 51.4%, while the spills in the opposite direction are only 7.1%. This indicates that on the net, the Saudi market spills 44.3% to stock exchanges in the GCC countries.[21] The matrix also shows that in every pairwise comparison of directional spillovers with a particular GCC country, the Saudi market is a net giver. For instance, the transmission from the Saudi market to the Bahraini market is 5.5%; while it is less in the opposite direction (around 0.4%). This holds true with every country's stock market in the GCC. Note that these findings contradict Abraham and Seyyed (2006), who pointed out that the Bahraini market is more important than the Saudi market in the information transmission that includes both countries. It also stands at marked contrast to Alkulaib et al. (2009) who stressed the importance of the UAE markets in leading stock exchanges in the GCC.

Panel B of Table 4 contains the spillover matrix of volatility. The volatility spillovers are noticeably weaker than returns spillovers. One more time, if we exclude the U.S., and focus on the GCC, the gross directional volatility transmission is consistent with a system in which the Saudi Market is playing the

[17] This point has been raised thankfully to us by one of the referees.
[18] The adjustment in (6) was derived by Forbes and Rigobon (2002) based on a VAR (1) two-market model, and under the assumptions of no endogeneity or omitted variables problem between markets.
[19] We computed the sample standard deviations pre and post 2008 to represent the high and low volatility states respectively.
[20] Note that the Forbes Rigobon adjustment is very suitable here as we expect a unidirectional influence from the U.S. to the rest of markets in the GCC, and not the other way around. Therefore, we do not expect an endogeneity problem in our correction.
[21] These numbers are computed from (Panel A, Table 4) by excluding the interaction with the U.S.

Table 4
Return and volatility spillover matrices.

	U.S.	Saudi Arabia	Bahrain	Kuwait	Oman	Qatar	Abu Dhabi	Dubai	From All
Panel A: return spillovers									
U.S.	93.0	0.6	1.8	1.1	0.4	1.4	0.4	1.1	7
Saudi Arabia	13.9	78.7	0.4	2.0	2.6	1.4	0.3	0.8	21
Bahrain	2.8	5.5	86.1	2.2	0.7	0.2	2.7	0.2	14
Kuwait	3.1	6.7	5.9	79.7	1.6	0.3	2.1	0.6	20
Oman	9.4	5.8	8.8	2.7	71.3	0.2	1.4	0.4	29
Qatar	11.5	8.6	5.3	3.2	8.2	62.1	0.6	0.6	38
Abu Dhabi	2.5	11.7	2.5	5.7	6.0	4.4	65.6	1.5	34
Dubai	6.1	13.0	3.3	6.0	2.9	5.5	25.9	37.3	63
To All	49	52	28	23	22	13	33	5	226
All	142	131	114	103	94	76	99	42	
Total spillover index: 28.3%									
Panel B: Volatility Spillovers									
U.S.	95.2	0.0	1.8	0.3	2.1	0.2	0.1	0.3	5
Saudi Arabia	1.0	83.9	3.0	2.0	2.4	4.4	3.3	0.0	16
Bahrain	1.3	1.6	92.7	0.2	1.2	1.9	0.8	0.3	7
Kuwait	0.1	5.2	3.2	85.4	0.9	4.5	0.5	0.2	15
Oman	6.1	3.8	5.7	0.9	79.5	1.4	2.1	0.4	21
Qatar	2.3	4.1	3.3	6.8	5.5	77.2	0.4	0.4	23
Abu Dhabi	0.2	6.6	4.5	5.0	4.7	9.1	69.8	0.2	30
Dubai	0.2	4.7	5.5	2.9	5.0	7.1	14.3	60.2	40
To All	11	26	27	18	22	29	22	2	156
All	106	110	120	103	101	106	91	62	
Total spillover index: 19.5%									

Note: The underlying variance decomposition is based on a weekly VAR system with two lags. The (i,j) value is the estimated contribution to the variance of the 10 step ahead stock return (volatility) forecast error of country i coming from innovations to stock returns volatility of country j. The decomposition is generalized, and thus it is robust to the ordering shown in the column heading.

dominant role. The volatility transmission from the Saudi market to the rest of all GCC stock markets is 26%; while spillovers in the opposite direction is 15%. Hence, the Saudi market is a net giver of volatility to other GCC stock exchanges. It is however, worth to note that the nature of volatility transmissions differ from return transmissions in that the paiwise volatility spillover results are not universal in favor of a dominant Saudi market. For instance, the Bahraini market and the Kuwaiti stocks gives and receives approximately the same to the Saudi market, and the direction of net spills is almost neutral. A similar conclusion on flow of information from the Bahraini market to the Saudi market was arrived at by Abraham and Seyyed (2006), who found that there are significant volatility transmissions from the smaller but accessible Bahraini market to the larger but more restricted Saudi market.[22]

To obtain the dynamics of transmission in both returns and volatility, we now estimate the vector autoregression using 100 week rolling window, and we assess the extent and nature of spillover variation over time using the corresponding time series of the spillover index. We graph the time series plot of the total spillover index of volatility in Fig. 1. The figure shows an increase in spillovers until the financial turmoil in 2008. This reflects a gentle increase in linkages and integration between GCC stock markets in the run up to the financial crisis.[23] Note also that spillovers burst to a new higher level in the year of the crisis. Afterwards, the new level of higher interdependece has been maintained. We repeated the exercise using a two week forecast horizon, and results were not any

[22] Note also that transmissions in the whole system is less, and that the flow of volatility from the rest of GCC stock exchanges to the Saudi market is relatively bigger than in the case of return spillovers.

[23] The evidence on increased linkages among the block is consistent with Bley and Chen (2006) and Al-Khazali et al. (2006) who both recorded increased integration among the group of GCC countries during the same period.

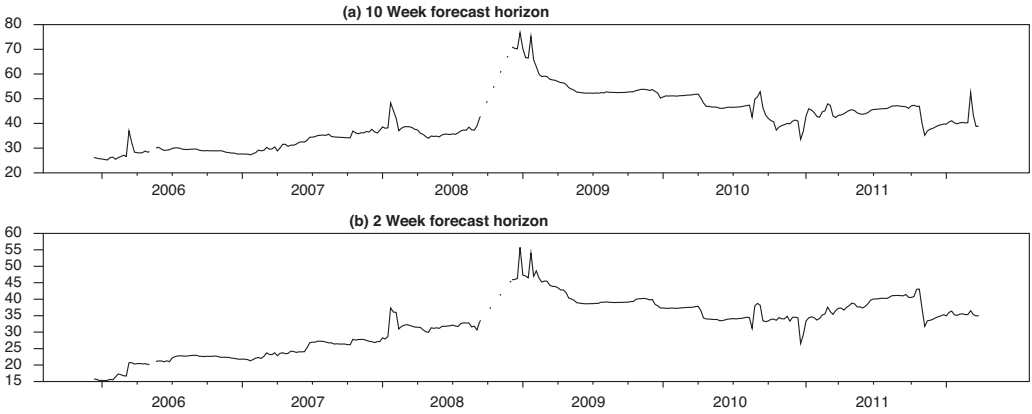

Fig. 1. GCC volatility spillover index.

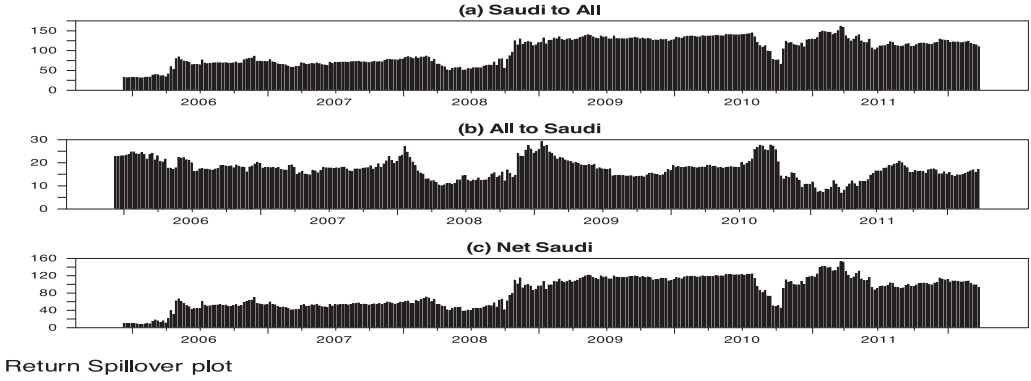

Fig. 2. Net returns spillover from the Saudi market to the GCC block.

different.[24] The dynamic behavior of total return spillover index looks very similar and hence, its figure was not displayed in the paper.

To investigate the dynamic directional spills between the Saudi market and the GCC stock markets, we computed the corresponding time series of gross spillovers as in (2)–(4). The bar charts of these measures are presented in Figs. 2 and 3. The return spills from the Saudi market to all stock exchanges as in (3) are plotted in Panel A of Fig. 2. The opposite spills in returns as in (4) in Panel B. And finally, the net spills as in (2) are plotted in Panel C. The panels in the figure reveal bi-directional spillovers between the GCC stock markets and the Saudi market. However, the transmission from the Saudi market to the stock exchanges in the GCC is multifolds higher.

The bar graph in Fig. 2 shows that in the year of the financial crisis, return spills bursts in both directions. However, the net spill from the Saudi market to GCC stock exchanges has jumped by more. This burst in return transmission has continued following the 2008 crisis. This crisis has resulted in a higher level of net directional spills of returns from the Saudi stock market to the rest of equities in the GCC.[25]

Similarly, for directional volatility spills, we find that they are also bidirectional, though asymmetric (see Panels A–C in Fig. 3). In particular, there is significant transmission of volatility from the Saudi

[24] These findings are robust to lag selection as various lags in the VAR model show similar results.

[25] Note that occasionally the net spill is in the opposite direction as well. For instance, during the crisis year, there is some weak evidence that other GCC equities were a net giver to the Saudi market.

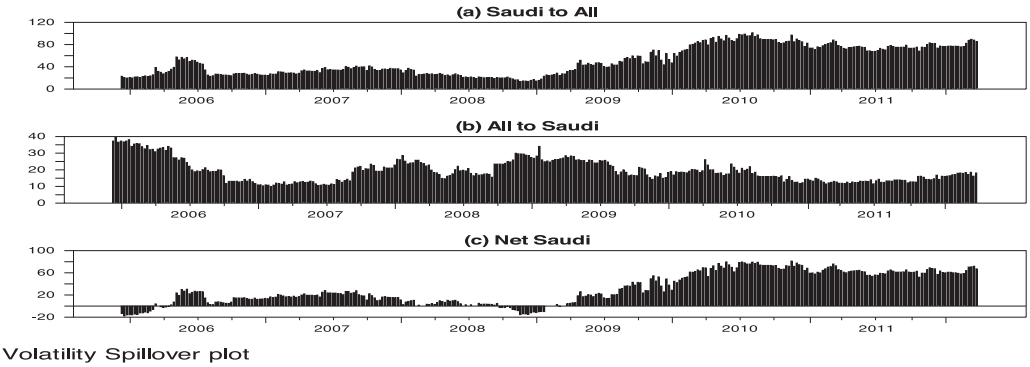

Fig. 3. Net volatility spillover from the Saudi market to the GCC block.

market to the rest of the GCC equity markets, while the feedback effect is weak. Therefore, we may conclude that there are asymmetric return and volatility spillover effects from the Saudi market to the stock markets in the GCC countries. These asymmetries have intensified following the global financial turmoil in 2008.

Findings of previous studies related to the GCC have indicated pronounced transmissions from the smaller and accessible markets, such as the Bahraini and Emirati stock markets, to the larger but unaccessible Saudi market.[26] Our empirical results are genuinly different, and they show that the Saudi stock market is central in the information transmission mechanism that governs stock markets in the GCC. The Saudi market simply plays the dominant role.

6.2.2. Net spillover from the U.S. market

The panels in Table 4 also illustrate return and volatility spillovers between the GCC and the U.S. market. As mentioned previously, Panel A presents the return spillover matrix. The data in the panel are consistent with previous literature that stressed the unidirectional transmission from U.S. stock markets to the rest of stock markets around the globe.[27] The transmission mechanism of return spillovers presented in Table 4 indicates that the U.S. market gives more than it receives. Panel B presents the volatility spilover matrix and it shows similar pattern. It should be noted here that compared to the Saudi Market, the U.S. association with GCC equities is substantially less in terms of returns and volatility transmissions. The net transmission of returns and volatility from the U.S. are 42% and 6% respectively compared to 67% and 12% of net spills from the Saudi market. However, when the directional measure is computed dynamically over rolling windows (see down), net spills of volatility from the U.S. to other GCC stock markets appear to be clearer. Yet, it is still only pronounced in the period following the global financial crisis in 2008.

Fig. 4 describes the dynamics of directional return spillovers from the U.S. stock market to the GCC markets. As can be seen in the figure, while return transmission from the U.S. to GCC equities is low in the pre-crisis period, net transmission noticeably jumped to a higher level following the global financial crisis in 2008. Fig. 5 shows the dynamics of directional volatility transmissions from the U.S. to the GCC. It indicates that the U.S.'s net volatility spills on GCC equities has been low, but it has jumped to a high level post 2008. Compared to Saudi market transmissions across the GCC, the U.S. transmissions are less pronounced and negligible in normal conditions. However, in stress, the U.S. market's role becomes more important and comparable in the information transmission mechanism of the GCC countries.

[26] See Abraham and Seyyed (2006) and Alkulaib et al. (2009) for more detailed results.

[27] From the recent literature, similar results can be found in Muherjee and Mishra (2005), Kim et al. (2005), Wang et al. (2005), Baur and Jung (2006), Chuang et al. (2007), Chen et al. (2007), Morana and Beltratti (2008), Yu and Hassan (2008), Elyasiani and Zhao (2008), and Sosvilla-Rivero and Rodríguez (2010).

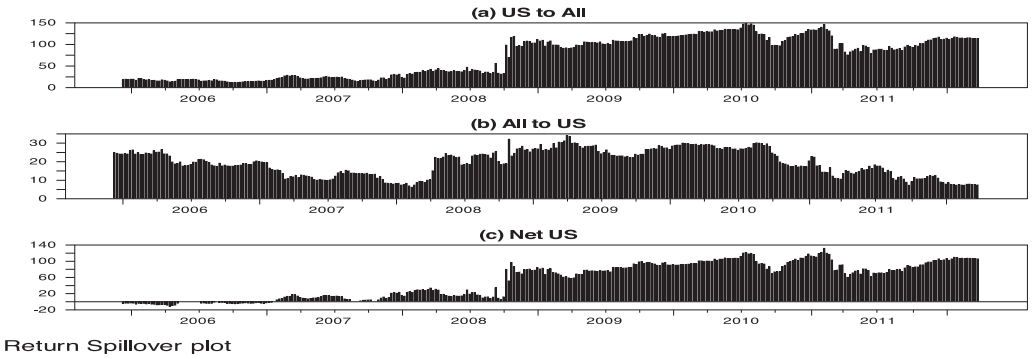

Fig. 4. Net returns spillover from the U.S. to the GCC block.

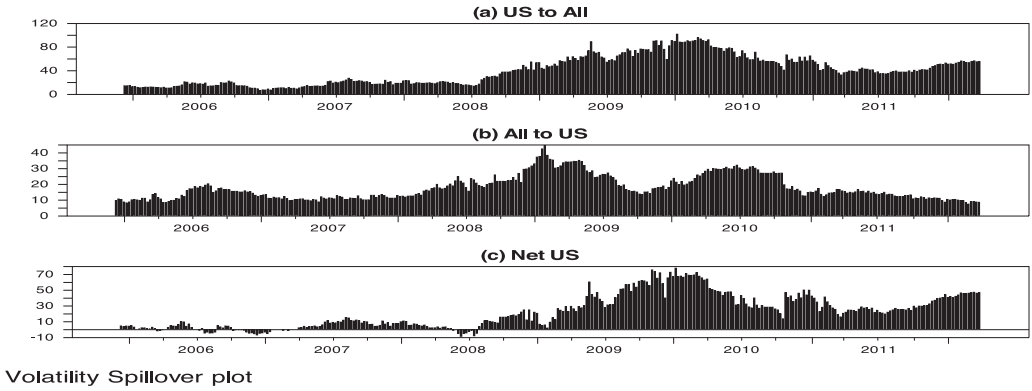

Fig. 5. Net volatility spillover from the U.S. to the GCC block.

Finally, the total spillover index as in (1) is reported at the right end corner of Panels A and B of Table 4. The total spillovers in the whole system composed of the GCC and the U.S. indicates that 28% of returns forecast error variance comes from return spillovers. Moreover, the total volatility spillover index measure indicates that on average, across our entire sample, 19.5% of volatility forecast error variance in all eight markets comes from transmissions.

6.3. *Dynamic conditional correlation analysis*

To double check findings under another data generating process, we estimated a traditional dynamic conditional correlation model of multivariate generalized autoregressive conditional heteroskedasticity (the DCC hereinafter).[28] Panel A of Table 5 contains the estimation results of the dynamic conditional correlation model of the GCC without the U.S. Panel B presents estimates of the multi-variate GARCH when the U.S. is added to GCC equities.

Fig. 6 shows the dynamic conditional correlations between the Saudi market and each of the GCC equity markets. The plot of correlations of returns over the entire sample period shows that time varying correlations demonstarte some fluctuation, and that the pattern of the fluctuation is occasionally inconsistent for all combinations of Saudi equity and other GCC equity markets. It is also clear that all markets show a relatively moderate postive conditional correlations with the Saudi market ranging from 15% to around 60%. Note also the jump in pairwise conditional correlations in 2008 and the

[28] This model was first proposed by Engle (2002).

Table 5
Estimation results of the DCC model.

	Saudi Arabia	Bahrain	Kuwait	Oman	Qatar	Abu Dhabi	Dubai
Panel A: first-step, univariate GARCH estimates							
I. Returns equations							
Constant (μ)	3.97e4***	1.31e4	2.11e4**	2.55e4***	3.98e4**	1.302e4	2.679e4
II. Volatility equations							
Constant (c)	7.99e7***	6.22e7***	4.16e7***	2.80e7***	7.08e7***	7.14e7**	1.47e6***
	(0.0003)	(0.00018)	(0.0070)	(0.0013)	(0.0028)	(0.0296)	(0.034)
α	0.2957***	0.1878***	0.1766***	0.1462***	0.1867***	0.1348***	0.1161***
	(0.0000)	(0.0003)	(0.0001)	(0.0000)	(0.0000)	(0.00107)	(0.0000)
β	0.7031***	0.6417***	0.7460***	0.8211***	0.7878***	0.8204***	0.8231***
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
$Q(10)$	6.1679	2.4759	4.5128	10.2258	17.4073*	6.5215	14.8930
	[0.8010]	[0.9912]	[0.9213]	[0.4209]	[0.0658]	[0.7697]	[0.1360]
Panel B: second-step, correlation equation estimates							
θ_1	0.00816 (0.0002)***						
θ_2	0.97833(0.0000)***						
Log likelihood	13800.6274						
$Q(10)$	611.308 [0.0000]***						

	U.S.	Saudi Arabia	Bahrain	Kuwait	Oman	Qatar	Abu Dhabi	Dubai
Panel C: first-step, univariate GARCH estimates								
Constant (c)	4.55e7**	7.90e7***	6.15e7***	3.95e7**	2.78e7***	6.47e7***	6.55e7**	1.34e6*
	(0.01107)	(0.00161)	(0.00053)	(0.0159)	(0.0015)	(0.0060)	(0.0421)	(0.057)
α	0.1501***	0.2710	0.1914	0.1625	0.1496	0.1834	0.1304	0.1133
	(0.0000)	(0.0000)	(0.0006)	(0.0001)	(0.0000)	(0.0000)	(0.0007)	(0.0000)
β	0.8287***	0.7176***	0.6416***	0.7619***	0.8223***	0.7962***	0.8286***	0.8395***
	(0.0000)	(0.0000)	(0.0003)	(0.0002)	(0.0000)	(0.0000)	(0.0006)	(0.0002)
$Q(10)$	5.1628	7.6609	2.2354	5.8355	9.7453	18.3242**	6.5074	16.2288
	[0.8800]	[0.6619]	[0.9942]	[0.8289]	[0.4631]	[0.0497]	[0.7710]	[0.0933]
Panel D: second-step, correlation equation estimates								
θ_1	0.00801 (0.0000)***							
θ_2	0.9798(0.0000)***							
Log likelihood	15698.2239							
$Q(10)$	844.8930 [0.0000]***							

Notes: $Q(10)$ is the Ljung–Box statistics for serial correlation. The values in parenthesis are the actual probability values.
* Indicate the rejection of the null hypothesis of associated statistical tests at the 10% level.
** Indicate the rejection of the null hypothesis of associated statistical tests at the 5% level.
*** Indicate the rejection of the null hypothesis of associated statistical tests at the 1% level.

increased interconnectedness afterwards. The exception is the Kuwaiti market. In this market, the pre crisis correlations are higher than the post crisis ones; yet its paiwise correlation has jumped during the crisis. In fact, with the outbreak of the global financial crisis, correlations spiked and never reverted back to its initial levels thereafter. Thus, the DCC analysis yielded a good indication of a secular rise in transmissions and co-movement over the last few years in GCC equities.

Fig. 7 shows the dynamic conditional correlations between the U.S. market and each of the GCC equity markets. As can be seen in the figure, in the pre-crisis period all markets show a relatively low postive conditional correlations with the U.S. market.[29] These correlations trended downward in the run up to the financial turmoil in 2008 reflecting a deterioration in the importance of the U.S. in the information transmission of returns. However, during the crisis year correlations jumped to a higher level and never reverted back to its initial levels thereafter. Thus, there is substantial evidence of a secular rise in transmissions and correlations with the U.S. over the last few years.

[29] The greatest correlation was with the Saudi market.

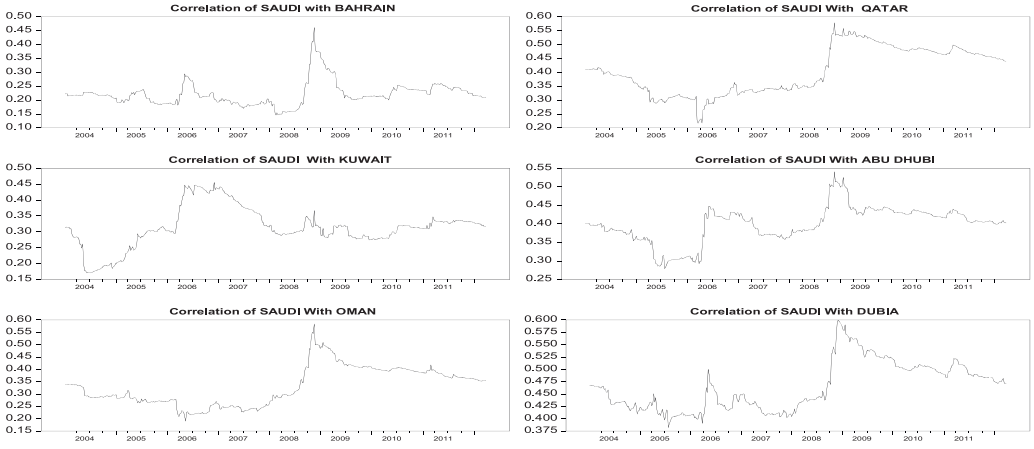

Fig. 6. Dynamic conditional correlations with Saudi Arabia.

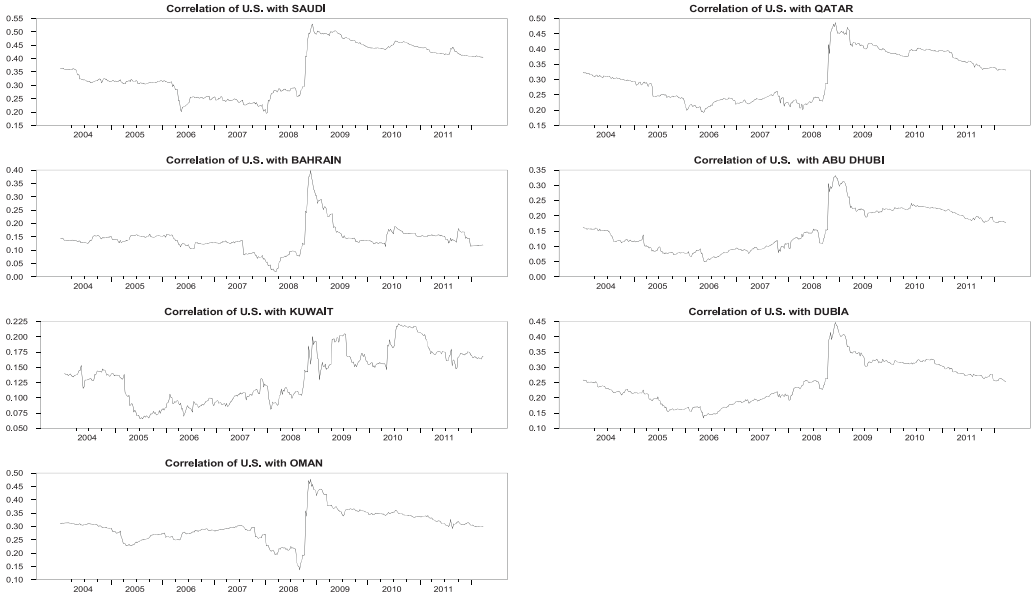

Fig. 7. Dynamic conditional correlations with the U.S.

It is worth to note that the downward trend in conditional correlations with the U.S. has reversed with the beginning of the credit crunch in 2006. A similar pattern can be detected in Fig. 6, where conditional association with the Saudi market has also increased following 2006. However, the evidence is not unanimous and in some countries the association has become even weaker.

7. Conclusions

In this paper, we investigate return and volatility spillover effects from the U.S. and the Saudi market to GCC equities using a new methodology that reveals additional information. Specifically, we study the dynamics of spillovers using indices that reveal transmission in both directions. Our focus was on the change in the nature of transmission following the Global financial meltdown in 2008. The

pre-crisis dynamics indicate that the information flow from Saudi returns and volatilities to the GCC stock exchanges is more important than the flow in the opposite direction.

These patterns contradict some of the previous findings on the information transmission mechanisms of the GCC. For instance, it contradicts Abraham and Seyyed (2006) who stressed the importance of the Bahraini market. Similarly, it is in contrast to Alkulaib et al. (2009) who indicated that the UAE exchanges are playing the leading role. In the period following the crisis, we recorded an even stronger role of the Saudi market. Its transmission to the rest of GCC equities has jumped to a higher level and stayed there.

Similar results were derived for the case of the U.S. stock exchange and the rest of GCC equities. The pre-crisis dynamics indicate a weak unidirectional information flow from U.S. returns and volatilities to the GCC block. Most of shocks in the block were own shocks and the influence of U.S. was weak. This result is in line with Yu and Hassan (2008) who indicated that own volatility spillovers are higher than cross volatility spillovers with countries from outside the block. However, these interrelationships have reversed following the crisis in 2008. The marginal role of the U.S. equities in the information flow has turned into a dominant role. In fact, the U.S. market has changed from a weak net spiller of returns and volatilities into an important player in the information transmission mechanism of the GCC. These results conform nicely with most of the literature that recorded significant information flows from the U.S. market to the rest of exchanges around the globe.[30]

We double checked the robustness of these findings to the data generating process by estimating a multi-variate GARCH (1,1) dynamic conditional correlation model as in Engle (2002). The same inference on association with either the U.S. or the Saudi market was drawn. There was a clear jump in the computed dynamic conditional correlations during 2008. The GCC equity association with either the U.S. or the Saudi market has jumped to a higher level. The high association has been maintained afterwards. Surprisingly, a simple correlation analysis could have also produced similar results.

These findings provide important and useful information for equity portfolio management and diversification. They indicate that the diversification potential between U.S. and GCC equities is high and that diversification among GCC equities is low. This result is only valid in a normal state. In crisis conditions, the diversification dispapears and the U.S. market becomes more associated with GCC equities. Therefore, equity investors in the U.S. may still achieve some diversification benefits by holding GCC equities within their portfolios, and the other way around. However, this advantage dispapears in crisis period given the jump in transmissions and correlations. In the case of a negative extreme market, diversification fails as evidenced during and after the market down turn in 2008.

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[30] The literature on the association of the U.S. market with other international equity markets is substantial. Among other works, see Hamao et al. (1990), Elyasiani et al. (1998), Janakiramanan and Lamba (1998), Christofi and Pericli (1999), Gilmore and McManus (2002), Hsiao et al. (2003), Bessler and Yang (2003), Hahm (2003), Kim et al. (2005), Wang et al. (2005), Muherjee and Mishra (2005), Baur and Jung (2006), Chuang et al. (2007), Chen et al. (2007), Morana and Beltratti (2008), Yu and Hassan (2008), Elyasiani and Zhao (2008), and Sosvilla-Rivero and Rodríguez (2010).

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