ESSAYS ON MODELLING THE VOLATILITY DYNAMICS AND LINKAGES OF EMERGING AND FRONTIER STOCK MARKETS

A thesis submitted for the degree of Doctor of Philosophy

By

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ABSTRACT

This thesis consists of three essays and empirically studies the behaviour of emerging and frontier stock markets against instability in the commodity and international financial markets. The first essay considers symmetric and asymmetric dynamic conditional correlation multivariate GARCH models to examine the correlations between the Gulf Cooperation Council (GCC) stock markets and the Brent and OPEC crude oil price indices and to gauge the oil shocks effect on the dynamics of the GCC stock markets. The analysis uses weekly data covering the period December 31st, 2003 to December 27th, 2012. The results show that: (i) two of the GCC stock markets are asymmetrically correlated with both the Brent and OPEC crude oil price indices and only two are symmetrically correlated with Brent oil; (ii) all the GCC stock markets exhibit positive and symmetric conditional correlations overtime and these correlations are more pronounced during periods of high oil price fluctuations.

The second essay investigates the contagion effect and volatility spillovers from the U.S. financial, the Dubai and the European debt crises to the GCC stock markets, with particular focus on financial and non-financial sectors. It uses weekly data for the period December 31st, 2003 to January 28th, 2015 and applies GARCH models and indicators of crisis. The empirical results show that: i) contagion effects are present on some of the GCC stock markets and are more pronounced during the U.S. financial and Dubai debt crises, with a larger impact on financial sectors; ii) there is significant evidence of volatility spillovers from the financial sectors of the U.S., European and Dubai stock markets to some of the GCC sectors considered, even though spillovers are rather weak in magnitude.

The last essay investigates the extent to which the GCC stock markets are correlated and integrated with those of the Asian countries. The analysis is carried out using the Johansen cointegration approach, the dynamic conditional correlation (DCC) GARCH model, and a standard correlation analysis based on a rolling window estimation scheme. The sample period of the analysis spans from December 31st, 2003 to September 30th, 2015. The empirical analysis offers three main results. First, there is a relatively moderate evidence of cointegration among some of the GCC and Asian stock markets particularly with of those of strong economic linkages among them. Second, evidence of time-varying correlation is found in some cases, while not large in magnitude, and shocks to volatility are highly persistence. Third, stock returns show a common trend exists, only during the global financial crisis.

Dedicated to My Family

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CONFERENCES

I have presented material from **Chapter 2** titled ‘‘Domestic and global oil shock effects on the GCC stock markets: DCC-GARCH approach’’ at the young Finance Scholars' Conference and Quantitative Finance Workshop, 8^{th}-9^{th} September 2014, University of Sussex, and at the Graduate School Poster Conference, 11^{th}-12^{th} March 2014, Brunel University, UK.

I have presented **Chapter 3** titled “Contagion effect and volatility spillovers to the frontier stock markets: Evidence from recent financial and debt crises” and **Chapter 4** titled “The GCC and Asian stock market linkages: Evidence from cointegration and correlation measures” at the annual Doctoral Symposium, Department of Economics and Finance, Brunel University, UK.

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CHAPTER ONE

1.1. INTRODUCTION

Volatility and movements of financial assets, especially during distressed market periods, are of great interest for market participants and academics. They are key inputs for investors in many financial activities, such as portfolio selection, asset pricing, hedging strategies and risk management. For instance, investors can determine market risk of a portfolio of assets by measuring the volatility and correlations among the returns of the assets to optimize their portfolio holdings. Policymakers can also use these estimates as part of inputs to formulate regulatory policies aimed at market stability.

Following the crash of major international stock markets around the world in 1987, serious questions were raised concerning the joint collapse of different types of financial markets and how this crash was rapidly reflected in the dramatic movements of these markets. Since then, the world has undergone other crises, with the one in 2007–2008 regarded as the most severe. As a result, a key concern regarding the contagion effect and volatility transmission across diverse stock markets arose among academics and market participants (Kyle and Xiong, 2001; Kaminsky et al., 2003; Chiang and Li, 2007 and Kenourgios et al., 2011, among others), and the role that economic linkages may have played for the continuously high comovements among stock markets was regarded as crucial in some studies (Forbes and Rigobon, 2001; Chambet and Gibson, 2008; Lahrech and Sylwester, 2011).

Generally, foreign investors have been willing to expand their investment opportunities to improve the risk-return trade off and optimize the diversification benefits of their portfolio by considering the emerging markets of developing countries. Emerging financial markets are characterized by low levels of linkages with developed markets, high volatility and higher sample mean returns (Bekaert and Harvey, 1997; Aggarwal et al., 1999). However, in recent years, due to the economic globalization and the rapid development of emerging financial markets, benefits of portfolio diversification have reduced substantially. As a consequence, investors have shown an increasing interest in a group of markets established in less developed countries than the emerging economies, the so-called frontier markets (see Goetzmann et al., 2005; Speidell and Krohne, 2007; Berger et al., 2011; De Groot et al., 2012).[1]

The empirical literature regarding volatility dynamics and cross-markets movements has primarily focused on emerging and developed financial equity markets, and has provided mixed results. Less attention has been paid to frontier markets, such as those of the Gulf Cooperation Council (GCC), despite their increasing importance in the international economic context. The seven stock markets in the six GCC countries namely, Bahrain, Kuwait, Oman, Qatar, Saudi Arabia and the United Arab Emirates (UAE), have become more attractive to foreign investors, given the tax haven opportunities (little tax charged on capital gains), low interest rates, diversification benefits and return potentials and the low level of restrictions on capital flow. Furthermore, the economy of these countries has gained benefit from the increase on oil prices, given their high dependence on oil revenues which it also has offered further investment opportunities to foreign investors.

Frontier financial markets, and in particular the GCC stock markets, are not isolated from the internal, regional and global risk events. Stock markets in the GCC region are subject to high volatility because of their link with the oil markets, and are also connected with global markets, such as those of the U.S., Eurozone and Asian regions, through trade and investments agreements. All these aspects have stimulated a growing number of studies on GCC stock markets, in recent years. Some of this literature has focused on the relationship between GCC stock markets and oil prices (see Hammoudeh, and Aleisa, 2004; Bashar, 2006; Al Janabi et al., 2010; Arouri and Rault, 2012), while other literature has looked at the impact of domestic, regional and global risk factors on the GCC stock markets (see Bley and Chen 2006; Hammoudeh and Choi, 2006; Hammoudeh and Li, 2008). Despite this literature, empirical results are rather inconclusive, and several key questions remain, in particular those related to the effect of several types of shocks on volatility and stock markets movements within the GCC region.

Is the high volatility of emerging and frontier stock markets associated with regional or global events? Are oil prices and these stock markets strongly correlated over time? Why do emerging and frontier stock markets crash jointly during crisis

[1] Frontier markets have different financial features than those of emerging and developed markets. They are known for their lesser integration with developed and emerging equity markets and are smaller and less liquid.

periods? Do global and regional crises have a contagious effect on these stock markets, given their different structures and sizes? Can economic integration and trade between the countries be a source of long-term linkages or interdependence across the emerging and frontier markets? Can financial and economic relationship be a source of volatility for these stock markets?

This thesis aims to answer those questions. It consists of three empirical essays. The first essay focuses on changes in oil prices and their impact on the returns, volatility and correlation dynamics of the stock markets of OPEC and non-OPEC members in the GCC countries. The second essay investigates the effects of contagion and volatility spillovers from the global financial, the Dubai and European debt crises to the GCC stock markets looking at financial and non-financial sectors. The third essay studies the link among the stock markets of both the GCC and Asia regions using cointegration and conditional correlations measures.

Chapter 2 explores the way in which the stock markets of the GCC region are correlated over time with crude oil prices and how cross-market dependence between the seven GCC equity markets changes with fluctuating oil prices. Given the instability in crude oil prices, predicting the behaviour of stock prices is always challenging, as the mixed empirical evidence shows (for survey, see Filis et al., 2011). In order to estimate the dynamic correlations between crude oil return indices and GCC stock market returns and to infer whether the conditional correlations among the asset returns in the GCC markets may change over time, this chapter employs two types of multivariate GARCH models: the dynamic conditional correlation (DCC) model proposed by Engle (2002) and the asymmetric DCC model developed by Cappiello et al. (2006).

Correlation measures are, among other several empirical methods, largely used in the empirical literature to study the connection between financial markets, as they may offer relevant information on designing hedging strategies and portfolio management. The empirical literature has shown that correlation among financial asset returns tends to increase more after a negative shock than after a positive shock of the same magnitude (see, for example, Longin and Solnik, 2001; Ang and Chen, 2002; Taamouti and Tsafack, 2009), the so-called asymmetric correlation effect. This effect, mostly observed during extreme market downturns, is very important for foreign investors, as it implies less portfolio diversification benefit (see Campbell et al., 2008).

Chapter 2 makes the following contributions to the existing literature. Firstly, while previous studies have mostly focused on the symmetric correlation among oil prices and stock markets, with a very few exceptions (see, for instance, Apergis and Miller, 2009; Arouri et al., 2011a; Broadstock and Filis, 2014), this chapter uses the asymmetric DCC model developed by Cappiello et al. (2006) to analyse the impact of changes in oil prices on the frontier stock markets of the GCC countries. Given the fact that these countries differ in terms of the levels of crude oil exports and production, economic diversification, and markets size and structure, the analysis based on asymmetric correlation can offer important information on the different dynamics of these frontier stock markets. Secondly, this study considers both the external (Brent) and domestic (OPEC) oil market indices and all the GCC aggregate stock markets (OPEC and non-OPEC members). Thirdly, GCC cross-market dynamics are further analysed by considering the most recent oil shock, which occurred as a result of the global financial crisis, so to examine whether the correlation of these markets may have changed accordingly.

The empirical results of chapter 2 reveal that: (i) two GCC stock markets, namely Oman and Qatar, are asymmetrically correlated with Brent oil and OPEC oil market indices, while Abu Dhabi and Saudi Arabia are symmetrically correlated with the Brent oil price index; (ii) all the GCC stock markets exhibit positive and symmetric conditional correlations overtime, and these correlations are more pronounced during periods of high oil price fluctuations; and (iii) those GCC stock markets that are OPEC members show, on average, low to moderate correlations, and shocks to their current volatility are highly persistence.

Chapter 3 investigates the contagion effect and volatility spillovers from the U.S. financial crisis and the Dubai and European debt crises to the financial and non-financial sectors of the emerging and frontier stock markets in the GCC region.

The recent 2008 U.S. financial crisis, triggered by the subprime turmoil, spread around the world and resulted in a sharp decline in international financial markets. Emerging and frontier stock markets in the GCC region were not immune to this global financial shock: share prices plunged, losing about 50 percent to 75 percent of their values in 2008. The two subsequent European and Dubai debt crises also hit the GCC stock markets. A reduction in oil prices, high stock market volatility and tightened liquidity conditions were observed, with a negative impact on investor confidence.

According to an IMF report in 2009, the most volatile sector during these periods was the financial sector; especially for those stock markets of Kuwait and the UAE (these GCC countries have a closer linkage to the international equity and credit markets). Similarly, the profitability of the non-financial sector dropped in most of the GCC countries. Overall, the global financial crisis and the subsequent debt crises in Dubai and Europe have put the share prices of the GCC stock markets at lower levels compared to pre crises periods. All these facts pose some relevant questions. Can the contagion effect explain this drop in prices? If this is the case, how large was the contagion effect, and were the dominant sectors of the GCC stock markets more affected by the crises? Also, was there any indication of volatility transmission across the frontier markets, and, if yes, what was the magnitude? This chapter aims to answer these questions.

In the empirical analysis, the recently developed approach by Grammatikos and Vermeulen (2012), who combine GARCH models with indicators of crisis, is employed to test for the contagion effect. Further, a VAR(1)-GARCH(1,1) model (see Ling and McAleer, 2003) is used to investigate volatility transmission effect. The use of this model is suggested, as it is simple to implement and is able to capture interactions of cross-market volatility (e.g., Chan et al., 2005; Arouri et al., 2011a; Syriopoulos et al., 2015). In order to analyse the effects of both contagion and volatility spillover, the price indexes of the U.S., European and Dubai financial sectors are used. The analysis is carried out over four different periods, and considers both financial and non-financial sectors. The periods under investigation are: a tranquil period (December 2003–Tune 2008), the U.S. financial crisis (August 2008–November 2009), the Dubai debt crisis (November 2009–March 2010) and the European debt crisis (March 2010–January 2012).

The chapter contributes to the existing literature on contagion and volatility spillover in several respects. Firstly, it adds to the empirical literature by investigating the impact of the global financial crisis on the emerging and frontier stock markets of the GCC region looking at the contagion and volatility transmission. Secondly, it considers the European sovereign and Dubai debt crises when analysing the contagion and volatility transmission. Lastly, this chapter takes into consideration the financial and non-financial sectors of the GCC stock markets. The motivation is twofold. First, using aggregate data, once cannot investigate how shocks may impact on different sectors (see Hammoudeh et al., 2009; Arouri et al., 2011a; Balli et al., 2013, among others).

Second, the financial sectors are dominant in the GCC stock markets, and foreign participation and ownership are mostly concentrated in the financial sector.[2]

The empirical results show that: i) there is evidence of contagion effects for some of the GCC stock markets, and these effects are more pronounced during the U.S. financial and Dubai debt crises, with a larger impact on financial sectors; ii) there is significant evidence of volatility spillovers mostly from the financial sectors of the U.S., European and Dubai stock markets to both the financial and non-financial sectors of the GGC markets, even though the magnitude of spillovers is rather weak.

Chapter 4 empirically studies the extent to which stock market returns cointegrate and correlate over time, with a special focus on the stock markets of the fast developing economies of the GCC and Asian countries. Over the last decade, Asian economies have become the most important trade partners for the GCC countries, both in terms of hydrocarbon and manufactured goods and food exports. Nowadays, this trade link accounts for approximately 60 percent of total GCC foreign trade, and migrant workers from Asia (who account for more the half of the GCC labour force) seem to have significantly contributed to the GCC's economic prosperity and growth.

Correlations are important measures to understand portfolio decisions, as low values of correlation among portfolio of assets may increase investor diversification benefits. In addition, strategies of portfolio management that rely on financial assets that are cointegrated seem to be more effective in the long-run.

The study attempts to explore whether international financial market liberalization and economic relationship among GCC and Asian countries may have contributed to the increasing correlation and integration across the two regional stock markets of these countries. Further, using cointegration, one is able to establish the potential benefits of portfolio diversification decisions. The analysis is conducted using weekly data over the period 2003–2015, and employs the Johansen multivariate cointegration approach, the Engle's (2002) DCC-GARCH model, and unconditional correlations estimated using a rolling window of four calendar years.

Chapter 4 contributes to the literature in several respects. Firstly, it studies the extent to which economic integration and bilateral trade affect cross-country

[2] Although the access by foreigners to GCC markets has ranged from less restricted (Bahrain 100% and Oman 70%) to more restricted (Saudi Arabia), in 2015, the authorities of the Saudi Arabian stock market (Tadawul) finally liberalized their market by allowing foreign ownership and 100% access.

comovements in the stock prices of the GCC and Asian countries. Secondly, it analyses the extent to which the bivariate correlations between GCC and Asian stock returns have changed from 2004 to 2015. Third, using a rolling window scheme to estimate standard unconditional correlation over time in order to capture whether a common trend exists among these markets in the long-run, this study is able to ascertain the degree of integration (see Billio et al., 2015).

The empirical findings of chapter 4 provide evidence of cointegration relationship among quite some GCC stock markets and emerging Asian stock markets, with the exception of the stock market in Japan and China, which show no cointegration with all GCC countries. These findings may be due to the relevant role played by economic linkages. The empirical results also show that the time-varying conditional correlations of the Asian stock markets are low with Bahrain and Oman and reasonable with Qatar, Saudi Arabia and UAE. This result suggests that taking advantage of diversification opportunities when investing in these markets can lead to potential portfolio benefits. Further, correlations are more pronounced among the GCC stock markets and the most developed Asian markets (e.g., Japan) than for the emerging and frontier markets. Lastly, the financial integration pattern generated by the standard unconditional correlation measure indicates that comovements among the two regional stock markets tend to be more pronounced in the years 2004–2008, while they reduce afterwards.

Chapter 5 summarises the main results of the thesis and draws some policy implications.

CHAPTER TWO

DOMESTIC AND GLOBAL OIL SHOCK EFFECTS ON THE GCC STOCK MARKETS: ASYMMETRIC DCC-GARCH APPROACH

2.1. INTRODUCTION

Oil-price shocks are regarded as one of the principal exogenous determinants of macroeconomic fluctuations across the globe (see e.g. Hamilton, 1983; Kilian, 2008; Hamilton, 2011a; Engemann et al., 2011), and they may have great impact on the performance of stock markets (see Huang et al., 1996; Filis et al., 2011; Lee and Chiou, 2011; Ciner et al., 2012; Ciner, 2012, among others). The dynamics of these fluctuations may differ among oil-exporting and oil-importing countries (see Fillis et al., 2011). Empirical studies have focused on developed economies and used Brent or WTI (West Texas Intermediate) crude oil indices to investigate the correlations between stock markets and these indices. To the best of the author's knowledge, there are no studies that investigate the role of asymmetry in the correlation dynamics considering both the Brent and OPEC oil indices and all the Gulf Cooperation Council (GCC) stock markets. This chapter attempts to fill this gap.

Asymmetric correlations in stock market returns are observed during market stress. When a negative shock hits the stock markets, returns show a tendency to be particularly correlated. Instead, if the markets are hit by a positive shock of the same magnitude, returns display a lower correlation than in the former case.

The GCC countries are among the largest exporter of crude oil which dominates more than 75% of their total export earnings, and those belonging to the OPEC (Saudi Arabia, Qatar, Kuwait and the United Arab Emirates) contribute to the total OPEC oil reserves and the total OPEC crude oil output for about 52% and 49%, respectively. Although the six GCC countries almost share similar economic and political characteristics, they vary in their dependence on oil revenues with Saudi Arabia is the largest producer of crude oil and Bahrain is the least.

Over the last four decades, the GCC countries have been subjected to several oil shocks. The two most significant shocks were in 1981-1986 ("The great price collapse") and in 2007-2008 ("Growing demand and stagnant supply") (see Hamilton, 2011b, for a survey). The first shock led to a decline in oil prices of up to $12 per barrel in 1986, and since then the GCC countries have pegged their local currencies to the U.S. Dollar so to avoid any possible future risk to their economies. More specifically, the crude oil exports are priced in the U.S. Dollar which is the world's dominant reserve currency. Therefore, the GCC currencies' peg to the U.S. Dollar enables those countries to stabilize their domestic currency against any fluctuations and avoid uncertainties in global transactions and trade.

The second shock increased prices dramatically up to $145 per barrel in 2008, with a significant positive impact on the GCC economies. Given the fact that the GCC's economic activities are highly sensitive to changes in oil prices, it is uncertain as to what extent international and domestic shocks caused by fluctuations in Brent or OPEC oil prices may induce instability in the stock markets of these economies. This seems to suggest that oil and stock markets have moved together over the last years. Therefore, it is worthwhile to investigate whether and to what extent shocks from oil markets may have affected the dynamics among the GCC's asset returns.

The first goal of this chapter is to study the relationship between Brent and OPEC crude oil indices and the GCC stock markets. Secondly, to investigate the dynamic linkages across the GCC stock markets, this chapter focuses on the impact of some extreme events that caused high fluctuations in oil prices, since these fluctuations are suggested to be the major source of volatility in most of these stock markets. This part of the investigation is motivated by the fact that, when financial markets are hit by negative news, volatility increases and conditional correlations tend to increase significantly among equity series in the region. Given that the correlation coefficients are essentially conditional on market volatility, ignoring the impact of the negative news when estimating the cross-market correlations could result in biased estimates which may impact on portfolio decisions (see Cappiello et al., 2006).

The first contribution of this chapter is to extend the literature on the relationship between oil prices and stock markets by using the Asymmetric Dynamic Conditional Correlation (ADCC) multivariate GARCH model (see Cappiello et al., 2006). This model has the advantage to capture the asymmetric (leverage) effect between asset returns' correlations during markets turmoil. So far, the ADCC model has been used so examine the asymmetric correlations between worldwide stocks and bonds indices (Cappiello et al., 2006), the diversification benefits and changes on asset returns' correlations in

Australian markets (Gupta and Donleavy, 2009) and the asymmetric correlation dynamics between treasury and swap yields in the US (Toyoshima et al., 2012). A second contribution of this chapter is to consider both external (Brent) and domestic (OPEC) oil market indices and all the GCC stock markets (OPEC and non-OPEC member) to better understand the impact of different sources of oil shocks on the markets' performance. Lastly, when studying the dynamics among the GGC stock markets, the analysis takes into account the most recent oil shock following the 2008-2009 global financial crisis, when oil prices dropped sharply from $145 to about $35 per barrel. This is because these stock markets are found to be less sensitive to domestic and regional factors than to extreme global events (see Hammoudeh and Li, 2008). Indeed, the higher volatility during the extreme global events hit the markets severely, while local events, which were characterized by a lower volatility, affected the markets only marginally.

Within this framework, several questions can be addressed. Is the time varying conditional correlations between Brent and OPEC oil markets and the GCC stock markets asymmetric? Would the time-varying correlation of oil-stock returns increase or decrease in the GCC countries? If increasing assets' correlation exists, then what are the consequences on international and domestic portfolio diversification? [3] Are the GCC stock markets of OPEC and non-OPEC member countries strongly correlated overtime? Yet, how has the recent 2008-2009 oil shock affected the dynamic of correlations between the GCC stock markets? The aim of this chapter is to attempt to answer these questions.

The results of this chapter suggest that the GCC stock markets exhibit different correlation dynamics with oil markets. The markets of Qatar and Oman are asymmetrically correlated with oil markets of Brent and OPEC, while the stock markets of Abu Dhabi and Saudi Arabia show symmetric correlation with the Brent oil market only. Further, GCC stock market correlations tend to show an increasing upward trend during periods of high oil price fluctuations, which are associated with periods of regional and global market stress.

[3] Over the last years, the GCC countries have drawn attention from international investors, given the political instability of the neighbouring countries (see for example Egypt, Syria and Iran). As a result, more investments have been headed to the GCC markets. Investors have also taken advantages from the fiscal taxation system, as national capital gains are not taxed, whereas those for international investors are only marginally taxed.

The rest of this chapter is organised as follows. Section 2.2 offers a brief overview of previous studies in the related literature. Section 2.3 presents the empirical methodology. The data is described in Section 2.4. Section 2.5 presents and discusses the empirical results. Section 2.6 offers a summary and conclusion.

2.2. A BRIEF OVERVIEW OF THE PREVIOUS LITERATURE

A growing body of literature has considered time varying relationships between the oil and stock market (see Cifarelli and Paladino, 2010; Chang et al., 2010; Choi and Hammoudeh 2010; Filis et al., 2011; Ciner et al., 2012, among others).

As for the GCC stock markets, the empirical literature has mainly focused on three aspects. First, recent studies have investigated changes in volatility and volatility spillovers between oil and stock markets in the GCC region. In this context, Malik and Hammoudeh (2007) investigated shock and volatility transmission between the West Texas Intermediate (WTI) oil market and three GCC stock markets, namely Saudi Arabia, Kuwait, and Bahrain. The study employed a multivariate GARCH approach with Baba, Engle, Kroner and Kraft (BEKK) parameterization using daily data over the period 1994 to 2001. Their empirical results showed that for all the three GCC stock markets volatility from the WTI crude oil market exert a relevant impact. Furthermore, their results indicated that there is volatility transmission from the Saudi stock market to the WTI oil market. Hammoudeh and Li (2008) focused on five GCC stock markets (Bahrain, Kuwait, Oman, Saudi Arabia and the UAE) and analysed changes in their volatility. The authors applied the Iterated Cumulative Sums of Squares (ICSS) algorithm for weekly data covering the period from 1994 to 2001. Their findings indicated that the GCC stock markets experienced are large shifts in their volatility likely due to their link with the oil markets. Unlike previous studies, Arouri et al. (2011b) used more recent daily data over the period 2005 to 2010 for the six member countries of the GCC region to explore the volatility spillovers between these stock markets and the Brent spot prices. In their empirical analysis, they used a Vector Autoregressive Moving Average–Generalized Autoregressive Conditional Heteroskedasticity (VAR–GARCH) model. Their empirical results revealed that: (i) there is evidence of volatility spillovers between oil market and the GCC equity markets and mostly pronounced during the crisis period; (ii) increasing oil market volatility, as a result of the (supply and demand) oil shocks, raised the GCC stock markets volatility.

Second, other studies have focused on the changes in oil prices and their impact and relationship with stock markets in the GCC region. Balcilar and Genc (2010) applied the Markov-Switching Vector Autoregressive (MS-VAR) approach to study the linkage between oil prices and six GCC stock market returns over the period 1994-2010. The study concluded that there is no lag and lead correlation between both oil and stock market, and this result contrasts with those in Mohanty et al. (2011). More specifically, Mohanty et al. (2011) assessed the relationship among the crude oil prices (the WTI) and equity returns in four GCC countries (Bahrain, Kuwait, Oman, and Qatar) using stock returns at country and industry levels. The empirical analyses were based on weekly data for the period 2005-2009 and used the Seemingly Unrelated Regression (SUR) approach. The findings strongly suggested the existence of positive relationship between the WTI crude oil prices and the GCC stock markets at the country level, with the exception of Kuwait, while at the industry level, only 12 out of 20 industries listed in these markets are positively linked with oil prices.

Third, other empirical works have studied the long-run linkages between GCC equity markets and oil prices. Hammoudeh and Aleisa (2004) explored whether the GCC equity markets of Bahrain, Kuwait, Oman, Saudi Arabia and the UAE are linked with the WTI spots and future prices. For this study, the Johansen cointegration technique was used for the daily data spanning from 1994 to 2001. The authors concluded that Saudi market has, by far, the strongest linkages with the oil market. Based on weekly data over the period 1994 to 2004, Hammoudeh and Choi (2006) employed cointegration tests and Vector Error Correction (VEC) models to analyse the relationship among five GCC stock markets and the WTI spot prices. The authors showed that these markets do not have statistically significant link with the WTI spot prices, despite the presence of a long-run equilibrium relationship among them. However, Maghyereh and Al-Kandari (2007) claimed that the previous work on relationship between oil prices and the GCC stock markets failed to identify any linkages, since the presence of potential nonlinear relationship. Therefore, the authors applied nonlinear cointegration approach developed by Breitung and Gourieroux (1997) and Breitung (2001). The authors used daily data covering the period 1996-2003. The empirical results suggested the existence of non-linear linkages between the Bahrain, Kuwait, Oman, and Saudi Arabia equity markets and the WTI price index. More recently, Arouri and Rault (2012) attempted to explore the long-run linkages between four GCC equity markets, namely Bahrain, Kuwait, Oman, and Saudi Arabia, and OPEC spot prices. The study used recently developed bootstrap panel cointegration methods and the Seemingly Unrelated Regression (SUR) techniques for monthly data ranging from 1997 to 2007. The empirical results showed evidence of long-run dependencies across the GCC and oil markets. Furthermore, the SUR results showed that higher prices of oil have a positive impact on the GCC markets, with the exception of the Saudi market. Focusing on linkage between all the six GCC stock markets and OPEC oil returns in the short-term and long term, Akoum et al. (2012) used the wavelet coherency methodology for weekly data over the period 2002 through 2011. The authors showed that GCC stock returns and OPEC basket oil returns move together in the long term, but they are not dependent on each other in the short-run period.

2.3. EMPIRICAL METHODOLOGY

This section presents the dynamic correlations models used in the empirical analysis: the DCC model proposed by Engle (2002) and the ADCC model developed by Cappiello et al. (2006). The DCC and ADCC models are used to investigate whether the dynamic correlations between crude oil return indices and GCC stock market returns can be asymmetric. These models are then applied to check whether the conditional correlations between asset returns in GCC markets change over time and whether they may increase during periods of higher volatility caused by oil shocks.

Engle (2002) developed the dynamic conditional correlations model (DCC) which nests the constant conditional correlation (CCC) model of Bollerslev (1990) and assumes that conditional correlations are time-dependent. A feature of this model is that it can be estimated even for high-dimensional data set using a two-step procedure. In the first step, the conditional variances are obtained by estimating a series of univariate GARCH models. In the second step, the intercept coefficients of conditional correlations are estimated.

Let the $n \times 1$ vector $\{y_t\}$ be a multivariate stochastic process and y_t the log-returns of stock indices and the log-returns of the oil price index.

The conditional mean innovation process $\varepsilon_t \equiv y_t - \mu_t$ has a $n \times n$ conditional covariance matrix, H_t:

$$y_t = \mu_t + \varepsilon_t$$

$$\varepsilon_t = H_t^{1/2} z_t$$

$$z_t \sim f(z_t, O, I, v) \tag{2.1}$$

$$H_t = \sigma(H_{t-1}, H_{t-2}, \dots, \varepsilon_{t-1}, \varepsilon_{t-2}, \dots),$$

where $E_{t-1}(y_t) \equiv \mu_t$ denotes the mean of y_t conditional on the available information at time $t-1$, I_{t-1}. z_t is an $n \times 1$ vector process such that $E(\mathrm{z}_t) = 0$ and $E(z_t z_t') = I$. $f(z_t; 0, \mathrm{I}, v)$ denotes the multivariate student-t density function:

$$f(z_t; 0, I, v) = \frac{\Gamma(\frac{v+n}{2})}{\Gamma\left(\frac{v}{2}\right)(\pi(v-2))^{n/2}} \left(1 + \frac{z_t' z_t}{v-2}\right)^{-\frac{v+n}{2}}, \tag{2.2}$$

where $\Gamma(.)$ is the gamma function and v is the degree of freedoms, for v>2. The student-t distribution is used as it allows modelling the thickness of the tails.

The DCC-GARCH proposed by Engle (2002) can be successively estimated for large time-dependent covariance matrices. The covariance matrix in the DCC-GARCH model can be decomposed such as:

$$H_t = \Sigma_t^{1/2} C_t \, \Sigma_t^{1/2}, \tag{2.3}$$

where $\Sigma_t^{1/2}$ is the diagonal matrix and along the diagonal are the conditional standard deviations, i.e.:

$$\Sigma_t^{1/2} = diag\left(\sigma_{1,t}, \sigma_{2,t}, \dots, \sigma_{n,t}\right), \tag{2.4}$$

and C_t is the conditional correlations matrix. The estimation procedure consists of two steps. In the first step, the conditional variances, $\sigma_{i,t}$ for the i=*1,...,n* assets are estimated using the univariate GARCH(1,1) model proposed by Bollerslev (1986):

$$\sigma_{i,t}^2 = \omega_i + a_i \varepsilon_{i,t-1}^2 + b_i \sigma_{i,t-1}^2, \tag{2.5}$$

where ω_i, a_i, and b_i are parameters to be estimated.

In the second step, using the standardized residuals obtained from the first step, the conditional correlations are then estimated. More specifically, the matrix of the time-varying correlation has the form:

$$C_t = Q_t^{*-1/2} Q_t Q_t^{*-1/2}, \tag{2.6}$$

and the correlation matrix, $Q_t = \left(q_{ij,t}\right)$, is computed as

$$Q_t = (1-\alpha-\beta)\bar{Q} + \alpha(z_{t-1}z'_{t-1}) + \beta Q_{t-1}, \tag{2.7}$$

where z_t are the standardized residuals by their conditional standard deviation, i.e. $z_t = (z_{1,t}, z_{2,t}, \dots, z_{n,t})' = (\varepsilon_{1,t}\sigma_{1,t}^{-1}, \varepsilon_{2,t}\sigma_{2,t}^{-1}, \dots, \varepsilon_{n,t}\sigma_{n,t}^{-1})'$, $\bar{Q}$ is the standardized residuals of the unconditional covariance, and $Q_t^{*-1/2}$ is a diagonal matrix composed of the square roots of the inverse of the diagonal elements of Q_t, i.e. $Q_t^{*-1/2} = diag\ (q_{1,1,t}^{-1/2}, q_{2,2,t}^{-1/2}, \dots, q_{n,n,t}^{-1/2})$. So the correlation coefficients, $\rho_{ij,t}$, is presented as follows:

$$\rho_{ij,t} = \frac{q_{ij,t}}{\sqrt{q_{ij,t}q_{jj,t}}} \quad ,i,j\ =\ 1,2,\dots,n\ and\ i\ \neq\ j. \tag{2.8}$$

Since equations (2.6) and (2.7) do not allow for asymmetries, Cappiello et al. (2006) extend the DCC model to allow for the leverage effect to have an impact on the conditional correlations of assets' returns and asset specific news impact curve. The Asymmetric Generalized DCC (AG-DCC) model is expressed as:

$$Q_t = (\bar{Q} - A'\bar{Q}A - B'\bar{Q}B - G'\bar{N}G) + A'z_{t-1}z'_{t-1} + G'n_{t-1}n'_{t-1} + B'Q_{t-1}B, \tag{2.9}$$

where the $n \times 1$ indicator function $n_t = I[z_t < 0] \circ z_t(I[\cdot])$ takes a value of *1* if the argument is true and *0* otherwise, "∘" denotes the Hadamard product, $\bar{\mathrm{Q}}$ and $\bar{\mathrm{N}}$ indicate the unconditional correlations matrices of z_t and $\mathrm{n_{t}}$. For $\bar{N} = [n_t n'_t]$, Q_t becomes positive definite with probability 1 if $(\bar{Q} - A'\bar{Q}A - B'\bar{Q}B - G'\bar{N}G)$ is positive definite. If the matrices *A, B* and *G* are replaced by scalars, α, β and γ, the A-DCC(1,1) becomes distinct from the model AG-DCC(1,1). This study focuses only on the asymmetric effect and does not consider the asset-specific news impact.

2.4. DATA DESCRIPTION

The data used in the empirical analysis consists of seven stock market indices for the six GCC countries and is taken from DataStream. The GCC stock market indices are Abu Dhabi Securities Exchange (ADX), Dubai Financial Market (DFM), Qatar Exchange (QE), Muscat Securities Market (MSM), Saudi Stock Exchange (Tadawul), Kuwait Stock Exchange (KSE) and Bahrain Stock Exchange (BSE). As for the oil prices, this study uses Brent and OPEC crude oil price indices. Data for these indices is taken from Bloomberg. Brent crude oil index is regarded as the world common crude oil index representative (Maghyereh, 2004; Filis et al., 2011), whereas the OPEC index is the domestic one for those GCC countries which are OPEC members.

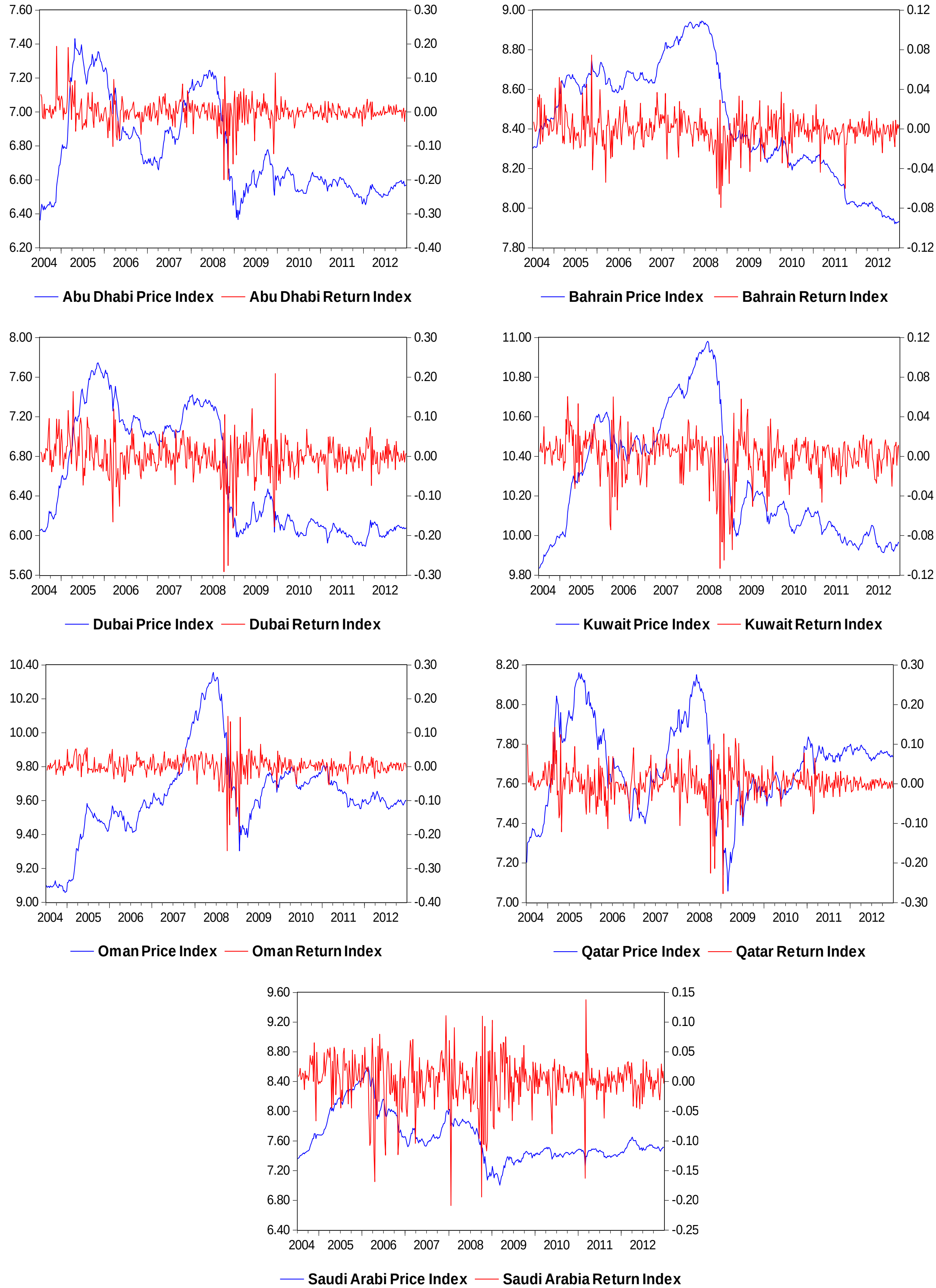
The data for the GCC stock markets covers the period from 31/12/2003 to 27/12/2012.[4] Following Ang and Chen (2002) and Cappiello et al. (2006), the present study uses returns at a weekly frequency alleviating asynchronous trading days. In particular, Wednesday to Wednesday closing prices are applied to avoid the 'weekend' effect given that the end of the week days varies across the GCC countries. All returns are continuously compounded and the asset prices are denominated in US dollar.

In Figure 2.1, the dynamics of the GCC stock markets (Panel A), Brent oil index and OPEC oil index (Panel B) are illustrated. Similar patterns are shown. In particular, movements are mostly observed during the gradual rise of oil prices until the end of 2005, the decrease in oil prices in 2006, the sharp increase of oil prices in 2007-2008, the dramatic decline in oil price during the financial turmoil in mid of 2008 and the beginning of 2009.

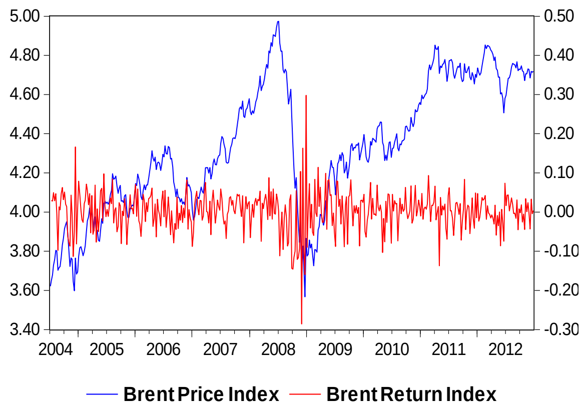
[4] The current analysis is restricted to this period given the availability of the data.

Figure 2.1: GCC stock market indices (Panel A) and crude oil price indices (Panel B) from 2004-2012

Panel A: GCC stock market indices



Panel B: Crude oil price indices



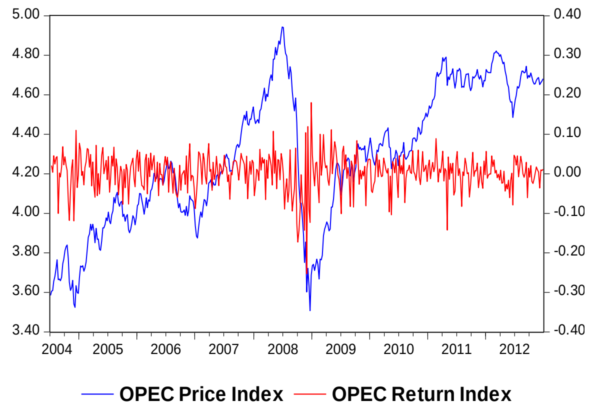


Table 2.1 reports the descriptive statistics for the seven GCC stock and oil returns. The figures show that these indices exhibit the standard financial features of the returns. All the stock markets returns have a positive average (except that of Bahrain), with the highest value for Qatar (this country has observed a sharp increase in gas export which has been reflected in strong performance of its stock).

Table 2.1: Descriptive statistics of the GCC stock returns and oil returns

	Mean	Standard deviation	Skewness	Kurtosis	Jarque-Bera	ARCH(5)
GCC stock markets						
Abu Dhabi	0.043	0.260	-1.039	10.682	1166.344***	6.702***
Bahrain	-0.042	0.118	-0.395	6.849	284.417***	8.398***
Dubai	0.004	0.340	-1.006	10.297	1055.395***	13.445***
Kuwait	0.015	0.159	-1.396	7.738	557.017***	31.676***
Oman	0.060	0.225	-1.815	19.966	5543.895***	25.953***
Qatar	0.065	0.303	-1.188	11.269	1363.441***	9.150***
Saudi Arabia	0.042	0.293	-1.489	7.244	165.689***	11.562***
Oil markets						
Brent	0.138	0.363	-0.295	7.970	461.211***	35.567***
OPEC	0.137	0.329	-0.822	6.160	234.224***	20.313***

Notes: Skewness, Kurtosis and Jarque-Bera test results are reported for weekly returns. *** denotes significance at the 1% level.

For volatility, the largest value for the standard deviation is observed for the stock returns for Dubai. This result may be due to the fact that stock market in Dubai has experienced financial and debt crisis. Brent crude oil index has slightly high average returns and is more volatile than OPEC oil index. These differences in Brent and OPEC return statistics are important for analysing the GCC markets behaviour against the instabilities of these markets.

When looking at the figures for the skewness and kurtosis, clear-cut evidence of asymmetry is found and returns exhibit fat tails. The hypothesis of normality is also rejected (see the Jarque-Bera results). We also run the LM test to check for ARCH errors. The results show ARCH effects are statistically significant. Overall, the GCC stock and oil returns exhibit asymmetry and heavy tails, confirming the standard properties of financial returns.

In Table 2.2, the unconditional correlations for the stock returns are reported. The GCC stock markets show an average unconditional correlation of about 0.47. The highest correlation is observed for the UAE stock markets, and the average constant correlation between the GCC and crude oil markets is low. The OPEC oil market shows relatively higher correlation coefficients with the GCC stock markets than with Brent oil market.

Table 2.2: Unconditional correlation among the GCC returns and oil returns

	GCC stock markets							Oil markets	
	Abu Dhabi	Bahrain	Dubai	Kuwait	Oman	Qatar	Saudi Arabia	Brent	OPEC
Abu Dhabi	1.000	0.391	0.799	0.465	0.553	0.439	0.460	0.093	0.144
Bahrain		1.000	0.430	0.491	0.450	0.331	0.294	-0.036	0.019
Dubai			1.000	0.495	0.567	0.433	0.486	0.163	0.193
Kuwait				1.000	0.475	0.366	0.386	0.082	0.140
Oman					1.000	0.488	0.426	0.116	0.217
Qatar						1.000	0.365	0.112	0.164
Saudi Arabia							1.000	0.006	0.078
Brent								1.000	0.908
OPEC									1.000

In order to further investigate the presence of asymmetry in the second moment, a nonparametric test by Cappiello et al. (2006) for the presence of asymmetry in the conditional variances of stock returns is run for all the seven markets. More specifically, it is investigated whether negative shocks can affect the variances of the stock returns more than positive ones of the same magnitude. The negative lagged returns are calculated as follows: $E\lfloor y_{it}^2 | y_{it-1} < 0 \rfloor$. Then, the squared returns of the stocks are regressed on a constant and a negative lagged returns' indicator function. After that, the outcome is tested using the null hypothesis: $E\lfloor y_{it}^2 | y_{it-1} < 0 \rfloor = E\lfloor y_{it}^2 | y_{it-1} > 0 \rfloor$. The findings are reported in Table 2.3. The coefficients of the asymmetric term are statistically significant at 1% and 10% for six return series, with the exception of Bahrain, indicating strong evidence of asymmetry.[5]

Table 2.3: Nonparametric asymmetry test results in the conditional variances of the GCC stock returns

Stock market	Asymmetric term coefficient
Abu Dhabi	-1.448*
	(0.760)
Bahrain	-0.152
	(0.287)
Dubai	-3.979***
	(0.999)
Kuwait	-2.045***
	(0.360)
Oman	-7.358***
	(0.828)
Qatar	-3.131***
	(0.918)
Saudi Arabia	-4.569***
	(0.765)

Notes: *, **, *** denotes significance level at 10%, 5%, 1%, respectively. Standard errors are in parenthesis.

2.5. EMPIRICAL RESULTS

This section presents and discusses the empirical results. The DCC and ADCC multivariate GARCH models are first estimated to analyse the asymmetry in the conditional correlation dynamics between the GCC stock markets and Brent and OPEC oil indices. Then, the time-varying conditional correlations among the GCC stock markets are computed using those models.

[5]The result for the Bahrain's stock market may be due to the fact that this market is the less volatile (see also Awartani et al., 2013).

2.5.1 Time-varying correlation between the GCC stock, Brent and OPEC oil returns

As a preliminary step, a sequence of univariate GARCH models is estimated for each of the seven GCC return series. The specification of models is chosen on the basis of Bayesian Information Criteria (BIC)[6]. The results are reported in Table 2.4. In the second step, the conditional correlations among each pair assets' returns are estimated using the standardized residuals obtained from step one after fitting GARCH(1,1).

Table 2.4: Estimation results of univariate GARCH (1,1) for the GCC and oil returns

	ω_i	a_i	b_i	*Q*(5)	ARCH(5)	BIC
GCC stock markets						
Abu Dhabi	0.036***	0.062	0.936***	0.777 [0.854]	0.148 [0.980]	-4.049
	(0.062)	(0.040)	(0.036)			
Bahrain	0.000	0.104**	0.818***	3.847 [0.278]	0.747 [0.588]	-5.434
	(0.001)	(0.044)	(0.070)			
Dubai	0.000	0.262***	0.706***	6.307 [0.097]	1.137 [0.339]	-3.548
	(0.002)	(0.085)	(0.073)			
Kuwait	0.004***	0.291***	0.650***	0.577 [0.901]	0.110 [0.990]	-5.150
	(0.001)	(0.108)	(0.111)			
Oman	0.002**	0.240***	0.718***	1.306 [0.727]	0.262 [0.933]	-4.762
	(0.001)	(0.093)	(0.117)			
Qatar	0.001	0.178**	0.857***	4.940 [0.176]	0.953 [0.446]	-4.042
	(0.001)	(0.088)	(0.064)			
Saudi Arabia	0.003*	0.397***	0.591***	2.048 [0.562]	0.411[0.840]	--3.835
	(0.001)	(0.117)	(0.075)			
Crude oil markets						
Brent	0.005***	0.077***	0.880***	4.065 [0.254]	0.769 [0.572]	-3.306
	(0.002)	(0.024)	(0.035)			
OPEC	0.005***	0.080***	0.884***	2.256 [0.520]	0.432 [0.825]	-3.470
	(0.002)	(0.024)	(0.032)			

Notes: Equation (2.5) is estimated for all markets. Q(5) is the Ljung–Box statistic for serial correlation in the residuals. ARCH is the Engle (1982) test for conditional heteroscedasticity of order 5. *p*-values of Q-statistics and ARCH test are in brackets. *, **, *** denote statistical significance at 10%, 5% and 1%, respectively. Standard errors are in parenthesis.

[6] Bayesian information criterion (BIC) or sometimes called Schwarz (SIC) of Schwarz (1978) is among the most common information criterion besides (AIC) of Akaike (1974) and (HIC) of Hannan-Quinn that are used basically for estimating and selecting different order of models of the same data. The BIC is mostly used in selecting GARCH family models and is expressed as, $BIC = \ln \hat{\sigma}^2 + {}^{k}/_{T} \ln T$, where is the $\hat{\sigma}^2$ residual variance, k denotes the number of parameters to be estimated and T is the sample size. The AIC is presented as $= \ln \hat{\sigma}^2 + {}^{2k}/_{T}$. The BIC is distinguished from other information criterions like AIC is in its stiffer penalty terms. In practice, when choosing the model or lag length order, the lowest BIC or AIC information criterion should be selected (See Brooks, 2002, for more explanation).

In table 2.4, the parameters of the ARCH (a_i) and GARCH (b_i) effects, respectively, are reported. They are statistically significant for all the stock and oil market returns under investigation. The conditional volatility reaction to the past shocks, a_i, is the highest in Saudi (0.397) and Kuwaiti (0.291) stock markets, respectively. The highest volatility persistence, measured by b_i, is observed for Abu Dhabi (0.936), while the lowest is registered for Saudi Arabia (0.591). In the context of oil markets, the OPEC market shows relatively higher response to the previous shocks and persistence in volatility, with values of a_i and b_i equal to 0.080 and 0.884 respectively, than in the Brent market (a_i=0.070; b_i=0.880).

Table 2.5 and Table 2.6 present the estimated results for the DCC and ADCC models between the GCC stock returns and oil returns of Brent and OPEC, respectively. In both tables, the GCC countries are split in two groups: OPEC and non-OPEC members. This is done to check whether their stock markets react differently to the instabilities from the two considered oil indexes, given that only the countries that are OPEC members have control over fluctuations of oil prices. More specifically, in Table 2.5, the estimates of α and β of the DCC models are significant only in the case of Abu Dhabi and Saudi Arabia stock markets while they are insignificant for the other markets. For those markets which display symmetric correlations (see for example Saudi Arabia), one can argue that this result can be mainly due to the large spare capacity of crude oil of those countries to control over oil price fluctuations. As for the estimates of the parameters of the ADCC model, we observe that significance is found for Oman and Qatar. In particular, it should be noticed that the asymmetric parameters, γ, show negative values, which imply that these stock markets and Brent oil index tend to be more correlated when negative news hit the market. This result is also shown in Figure 2.2, which illustrates the time-varying conditional correlations for the four markets. As one can see, the correlations among these markets and the Brent are more pronounced during the global financial crisis and the Arab Spring period. As such, portfolio diversification may be not workable within those stock markets when it is most desirable.

However, it appears from Table 2.6 that only two stock markets, namely Qatar and Oman, show highly significant asymmetric correlation with OPEC oil index. In particular, the results concerning the asymmetric correlations suggest that these stock markets and OPEC oil index tend to be more correlated during market crashes. This confirms previous findings with Brent oil index. In addition, the persistence of shocks to correlations with the OPEC oil index in case of Qatar stock market is higher than that with Brent oil index. Therefore, it can be highly risky to invest in these markets, which are particularly sensitive to external and internal fluctuations of oil prices. All the other markets display no significant correlation with OPEC oil index for both models. Furthermore, the presence of herding behaviour can be also another explanation for the shock and volatility transmission during market stress periods in these markets (Balcilar et al., 2013). Since the GCC stock markets are characterized by a significant presence of investors with short-investment horizon, the pricing of stocks mostly depends on the behaviour of those investors' that sell and buy assets swiftly so to yield high returns.

Table 2.5: DCC and ADCC estimates. GCC stock and Brent oil returns

		DCC model				ADCC model				
		α	β	*H*(5)	BIC	α	β	γ	*H*(5)	BIC
OPEC members	Abu Dhabi	0.025*	0.949***	44.695	-7.430	0.018	0.953	-0.010	31.480	-7.307
		(0.015)	(0.016)	[0.211]		(0.015)	(0.040)	(0.016)	[0.025]	
	Dubai	0.237	0.823***	30.048	-6.822	0.020**	0.000	-0.060***	23.443	-6.785
		(050)	(0.000)	[0.037]		(0.013)	(1.613)	(0.013)	[0.174]	
	Kuwait	0.024	0.251	17.073	-8.328	0.122***	0.000	0.059***	17.079	-8.280
		(0.042)	(0.448)	[0.518]		(0.041)	(0.458)	(0.024)	[0.517]	
	Qatar	0.033	0.801***	24.431	-7.190	0.092***	0.662***	-0.117***	19.298	-7.284
		(0.039)	(0.101)	[0.141]		(0.027)	(0.148)	(0.028)	[0.373]	
	Saudi Arabia	0.048*	0.867***	20.145	-7.25	0.047	0.305	-0.072*	35.818	-7.110
		(0.027)	(0.068)	[0.324]		(0.053)	(0.191)	(0.043)	[0.007]	
Non-OPEC members	Oman	0.000	0.726	22.175	-8.084	0.028***	0.518***	-0.059***	21.514	-8.021
		(0.000)	(1.270)	[0.224]		(0.010)	(0.210)	(0.008)	[0.254]	
	Bahrain	0.000***	0.861	43.059	-8.811	0.000	0.983***	-0.004	43.775	-8.799
		(0.000)	(1.571)	[0.001]		(0.004)	(0.011)	(0.006)	[0.000]	

Notes: Equations (2.7) and (2.9) of the DCC and ADCC models are estimated between the GCC stock market and Brent oil market return indices. *, **, *** denote significance at 10%, 5%, 1% level, respectively. *H*(5) is the multivariate Portmanteau test of Hosking (1980) for serial correlation. p-values for H(5) are in brackets. Standard errors are in parenthesis.

Figure 2.2: Time-varying conditional correlations of the four GCC stock markets with Brent oil market

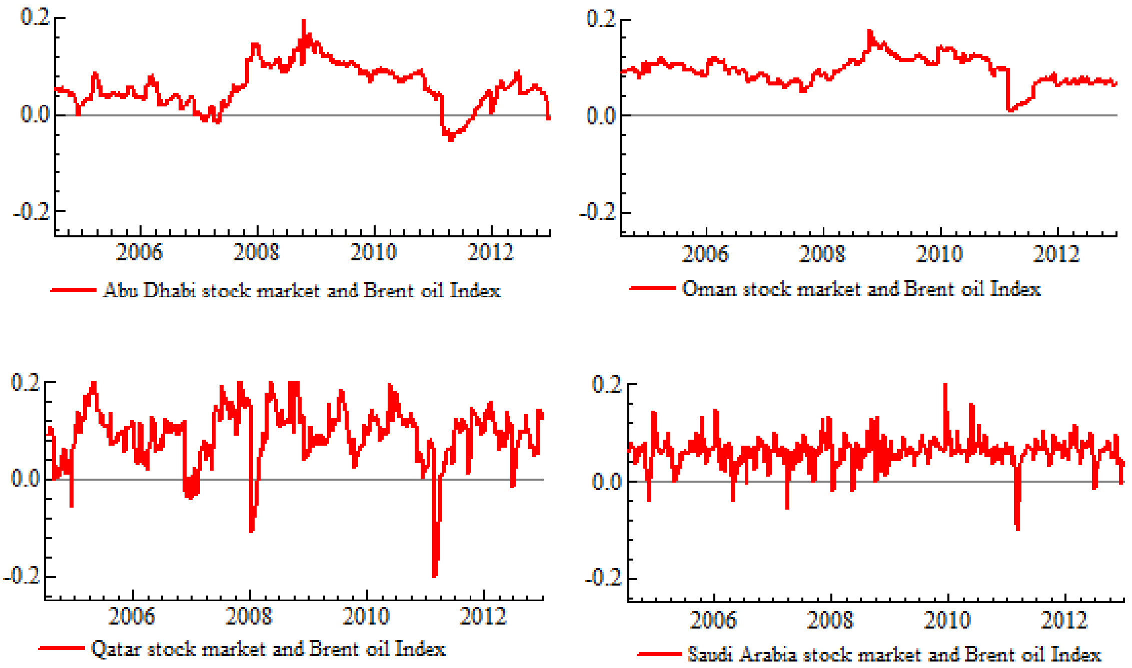


Table 2.6: DCC and ADCC estimates. GCC stock and OPEC oil returns

		DCC model				ADCC model				
		α	β	$H(5)$	BIC	α	β	γ	$H(5)$	BIC
OPEC members	Abu Dhabi	0.009	0.960***	33.716	-7.668	0.017	0.962***	-0.009	33.365	-7.473
		(0.019)	(0.028)	[0.014]		(0.011)	(0.014)	(0.013)	[0.015]	
	Dubai	0.000	0.833	21.792	-6.996	0.034	0.000	-0.060	20.481	-7.053
		(0.000)	(0.912)	[0.241]		(0.049)	(0.779)	(0.050)	[0.306]	
	Kuwait	0.049	0.673***	13.604	-8.612	0.109	0.696**	-0.120	11.780	-8.609
		(0.037)	(0.129)	[0.754]		(0.082)	(0.326)	(0.095)	[0.858]	
	Qatar	0.043	0.774***	19.926	-7.483	0.069**	0.800***	-0.076**	46.160	-7.363
		(0.041)	(0.093)	[0.337]		(0.028)	(0.085)	(0.036)	[0.170]	
	Saudi Arabia	0.014	0.862***	19.913	-7.272	0.000	0.989***	0.008	20.773	-7.260
		(0.026)	(0.278)	[0.338]		(0.006)	(0.013)	(0.010)	[0.291]	
Non-OPEC members	Oman	0.010	0.964***	24.629	-8.138	0.055*	0.485***	-0.082***	20.564	-8.202
		(0.011)	(0.018)	[0.135]		(0.031)	(0.195)	(0.029)	[0.301]	
	Bahrain	0.024	0.885***	25.756	-8.862	0.028	0.914***	-0.014	25.818	-8.849
		(0.021)	(0.072)	[0.105]		(0.023)	(0.193)	(0.753)	[0.104]	

Notes: Equations (2.7) and (2.9) of the DCC and ADCC models are estimated between the GCC stock market and OPEC oil market return indices. . *H*(5) is the multivariate Portmanteau test of Hosking (1980) for serial correlation. p-values for H(5) are in brackets. *, **, *** denote significance at 10%, 5%, 1% level, respectively. Standard errors are in parenthesis.

Table 2.7 reports the average correlation coefficients between stock returns and Brent and OPEC oil indices for OPEC and non-OPEC GCC countries. Despite the fact that OPEC and Brent oil indices move closely, the average correlations in Table 2.7 display some differences in magnitude and in some cases are also insignificant. For those coefficients which are significant, the stock markets' correlations are higher mostly in case of the Brent index than those with OPEC index.

Table 2.7: Average dynamic conditional correlation coefficients. GCC stock markets and Brent and OPEC oil markets

	Stock market	Correlation Coefficients	
		Brent	OPEC
OPEC members	Abu Dhabi	0.122*	0.075
		(0.072)	(0.086)
	Dubai	0.152***	0.134***
		(0.050)	(0.047)
	Kuwait	0.081	0.102
		(0.053)	(0.064)
	Qatar	0.213***	0.216**
		(0.053)	(0.085)
	Saudi Arabia	0.235***	0.117**
		(0.077)	(0.052)
Non-OPEC members	Oman	0.133***	0.182**
		(0.510)	(0.054)
	Bahrain	-0.026	-0.006
		(0.052)	(0.048)

Notes: *, **, *** denote significance at 10%, 5%, 1% level, respectively. Standard errors are in parenthesis.

2.5.2 Dynamic conditional correlations across the GCC stock markets

In this section, the time-varying conditional correlations among the GCC stock markets are first investigated, and then the correlation dynamics across those markets of the GGC countries which are OPEC members are studied. It is worthwhile determining whether the correlations among these stock markets increase or decrease over time in reaction (if any) to extreme events or shocks. The analysis has an important implication in managing risk and portfolio diversification in those markets. The DCC model is used to this end.[7] The results are presented in Table 2.8. Panel A shows the estimated coefficients of the DCC model when the oil shock is not taken into account (no dummy in the model), and the GCC stock market returns exhibit approximately low to medium positive average correlations, ranging from 0.231 to

[7] The ADCC model is also used. However the results are insignificant for all stock markets. Thus, no asymmetric effect is captured among the correlations of the GCC stock market returns.

0.462, with the exception of Abu Dhabi and Dubai markets, which display the highest conditional correlation of 0.752. In addition, the GCC stock markets' correlations with the Dubai stock market are positively higher in magnitude than that in any other market of the region. All these results could be of some interests for investors who intend to diversify their portfolio of assets relatively to these markets which display low correlation.

In order to take into account the impact of the oil shock that resulted in the aftermath of the financial crisis on the stock returns' correlation dynamics, the DCC model is re-estimated with dummy representing this event. The results are reported in Table 2.8, Panel B. It emerges that, when controlling for this extreme event, the correlations are now lower than in the previous case, and this implies that the gains from a diversification portfolio decision can increase. In addition, the persistence of shocks to correlations ($\alpha + \beta$) are relatively moderate, 0.845, and it is slightly lower than the previous case when the dummy is not included in the DCC estimated equation. These results are in line with those in Cappiello et al. (2006), where the persistence of shocks tends to reduce, when considering the impact of negative news in the specification of the model.

Further to the above mentioned market event, the present study also shed light on the major events in the oil price indices which affect the correlation dynamics between the GCC stock markets. In Figure 2.3, the plots of the correlations for some countries' stock markets are illustrated.[8] It emerges that correlations increase more during periods of high oil price fluctuations (the gradual rise of oil prices until the end of 2005, the decrease in oil prices in 2006, the sharp increase of oil prices in 2007-2008, the jump of the Brent crude in 2011, and the fall of oil prices during mid of 2012) and during the financial crisis in mid of 2008 and the beginning of 2009. These results seem to be consistent with those of other studies (see Longin and Solnik, 2001; Ang and Chen, 2002; Cappiello et al., 2006, among others).

The current study also examines the variations in the correlation dynamics among those GCC/OPEC stock markets. It is interesting to see how these markets react to news that arises from the fluctuations of domestic OPEC oil index. Therefore, the DCC model is re-estimated for those markets only. The results are reported in Table 2.8 (see Panel C). It emerges that the correlation coefficients are positive, symmetric

[8] This study presents those correlations that are more positively pronounced.

and statistically significant at 1%. Furthermore, the correlation coefficients are in some cases lower than those for all the stock markets (see Panel A). Moreover, the persistence of shocks to correlations is slightly higher for the GCC/OPEC markets (0.982) than that for all the GCC stock markets (0.937). This indicates that shocks to their correlation dynamics take even longer time to decay.

Table 2.8: Estimation results of DCC model among the GCC stock markets

Panel A: DCC model without dummy. All GCC stock markets							
	Abu Dhabi	Bahrain	Dubai	Kuwait	Oman	Qatar	Saudi Arabia
Abu Dhabi	1.000	0.279***	0.752***	0.336***	0.419***	0.432***	0.362***
		(0.070)	(0.031)	(0.063)	(0.081)	(0.065)	(0.047)
Bahrain		1.000	0.325***	0.400***	0.339***	0.278***	0.231***
			(0.062)	(0.055)	(0.053)	(0.071)	(0.062)
Dubai			1.000	0.361***	0.462***	0.433***	0.402***
				(0.059)	(0.060)	(0.058)	(0.045)
Kuwait				1.000	0.287***	0.285***	0.275***
					(0.066)	(0.069)	(0.063)
Oman					1.000	0.383***	0.334***
						(0.060)	(0.057)
Qatar						1.000	0.350***
							(0.065)
Saudi Arabia							1.000
α	0.018						
	(0.018)						
β	0.919***						
	(0.153)						
$(\alpha+\beta)$	0.937						
$H(5)$	223.054	[0.816]					
BIC	-32.664						

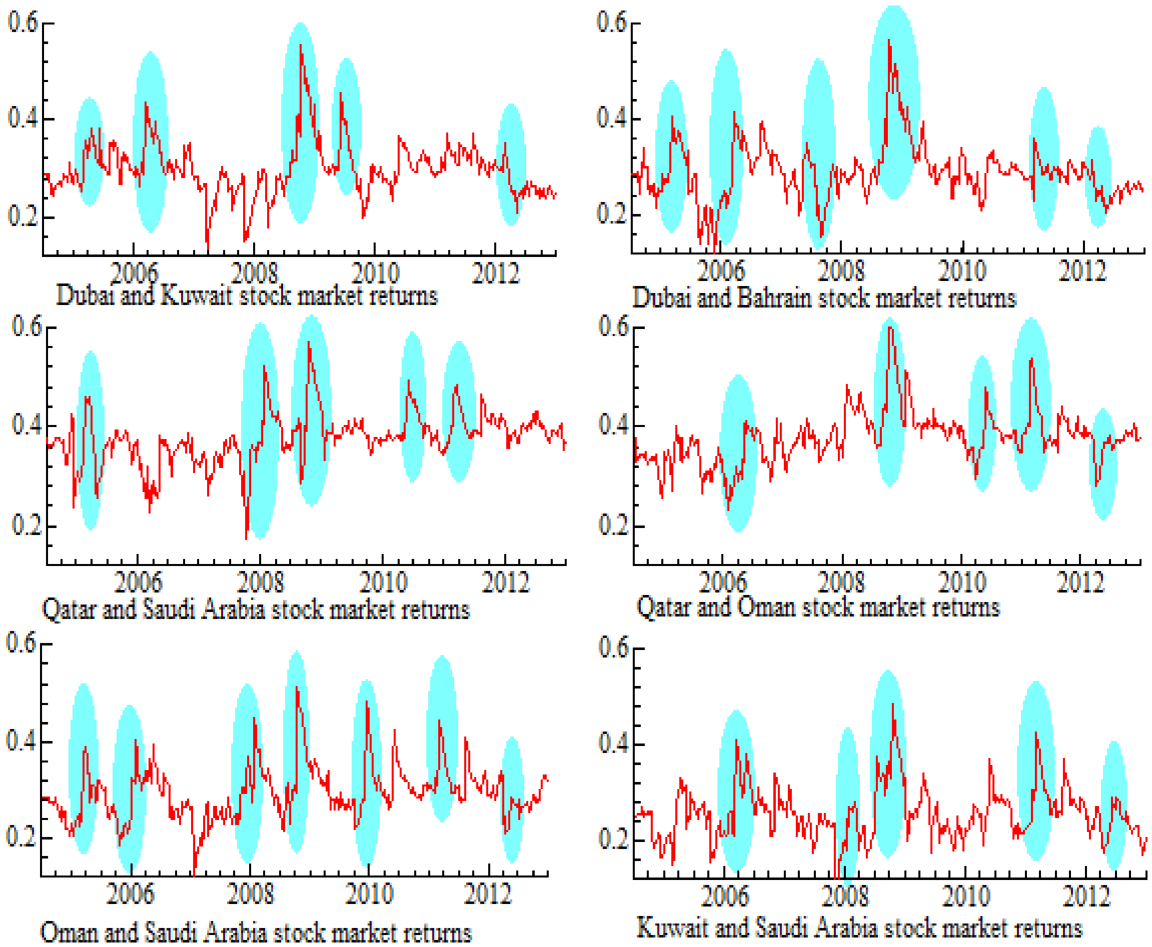
Panel B: DCC model with oil shock dummy. All GCC stock markets							
	Abu Dhabi	Bahrain	Dubai	Kuwait	Oman	Qatar	Saudi Arabia
Abu Dhabi	1.000	0.259***	0.745***	0.289***	0.404***	0.468***	0.368***
		(0.070)	(0.031)	(0.063)	(0.081)	(0.065)	(0.047)
Bahrain		1.000	0.280***	0.370***	0.281***	0.279***	0.163***
			(0.053)	(0.045)	(0.048)	(0.052)	(0.050)
Dubai			1.000	0.295***	0.406***	0.455***	0.386***
				(0.048)	(0.045)	(0.044)	(0.044)
Kuwait				1.000	0.227***	0.286***	0.251***
					(0.053)	(0.051)	(0.053)
Oman					1.000	0.378***	0.266***
						(0.047)	(0.051)
Qatar						1.000	0.374***
							(0.054)
Saudi Arabia							1.000
α	0.021***						
	(0.008)						
β	0.824***						
	(0.100)						
$(\alpha+\beta)$	0.845						
$H(5)$	270.386	[0.109]					
BIC	-33.072						

Table 2.8- Continued from the previous page

Panel C: DCC model. GCC/OPEC stock markets					
	Abu Dhabi	Dubai	Kuwait	Qatar	Saudi Arabia
Abu Dhabi	1.000	0.744*** (0.035)	0.266*** (0.069)	0.443*** (0.064)	0.329*** (0.064)
Dubai		1.000	0.249*** (0.074)	0.434*** (0.064)	0.331*** (0.067)
Kuwait			1.000	0.247*** (0.073)	0.208*** (0.077)
Qatar				1.000	0.380*** (0.070)
Saudi Arabia					1.000
α	0.012** (0.005)				
β	0.970*** (0.013)				
$(\alpha+\beta)$	0.982				
$H(5)$	106.230	[0.859]			
BIC	-22.530				

Notes: Equations (2.7) and (2.8) of the DCC model are estimated between the GCC stock market return indices. *H*(5) is the multivariate Portmanteau test of Hosking (1980) for serial correlation. p-values for *H*(5) are in brackets. *, **, and *** indicate statistical significance at the 10%, 5% and 1% level. Standard errors are in parentheses.

Figure 2.3: Dynamic correlations among selected GCC stock markets



2.6. CONCLUSION

This chapter investigates the relationship of the Brent and OPEC crude oil markets with each of the stock markets' returns in the GCC region by focusing more on the asymmetric effect in the conditional volatility and conditional correlations. The analysis consists of two steps. First, the symmetric and asymmetric DCC model are used to detect whether GCC stock markets are symmetrically or asymmetrically correlated with both the external (Brent) and domestic (OPEC) crude oil indices. Second, the DCC model is applied to examine whether the GCC stock markets are correlated overtime, especially during periods of high volatility of oil prices. The findings indicate that only four GCC equity stock markets, namely Abu Dhabi, Oman, Qatar, and Saudi Arabia, display time varying correlations with oil markets. More specifically, Abu Dhabi and Saudi Arabia exhibit symmetric correlations with the external (Brent) oil market, while Qatar and Oman exhibit asymmetric correlations with the external (Brent) and internal (OPEC) oil markets, with downward correlations being more frequent than upward correlations during market crashes. The results also show that all the stock markets considered are positively correlated and exhibit time-dependent correlations that tend to increase more during high price fluctuations of oil and during the global financial crisis period. Thus, the oil prices can be considered as a risk factor for some of the GCC stock markets.

All in all, our results have important economic and financial implications: the symmetric and asymmetric correlations between Brent oil return index and the stock returns of Abu Dhabi, Saudi Arabia, Oman and Qatar markets suggest that risk managers should be fully aware of the fact that these markets are not safe from external oil shocks; the low correlations among some of the GCC stock market returns may be an important signal for those investors who want to maximize their profit, and an appropriate portfolio strategy should be delivered; the GCC countries may move away from crude oil dependence so to reduce any potential risk due to oil shocks; policy makers may take action by setting more regulations so to reduce instability in the markets.

CHAPTER THREE

CONTAGION EFFECT AND VOLATILITY SPILLOVERS TO THE FRONTIER STOCK MARKETS: EVIDENCE FROM FINANCIAL AND DEBT CRISES

3.1. INTRODUCTION

Financial and debt crises tend to be repeated phenomena and their impact is not only restricted to the economies and financial markets where they originated, but spreads widely through various channels to other economies. The recent 2008 global financial crisis, triggered by U.S. subprime turmoil, is considered the worst and most severe the world has experienced since the Great Depression in the 1930s. It has led some advanced economies into an unpredicted recession and the international stock markets have observed a large fall. The frontier stock markets were not exempt from this crisis, since share prices dropped dramatically, particularly in September 2008 when the Lehman Brothers collapsed, and two subsequent debt crises in Dubai and Europe accelerated the fall in share price.

Can the contagion effect explain this drop in prices? If this is the case, how large was the contagion effect? And were the dominant financial sectors in the GCC stock markets more affected by the crises? Was there any indication of volatility transmission across the frontier markets due to the crises? And, if yes, what was the magnitude?

In order to answer these questions, this work uses the definition of contagion proposed by Pericoli and Sbracia (2003, p.575), that "(Shift-) contagion occurs when the transmission channel intensifies or, more generally, changes after a shock in one market", and refers to Kaminsky et al. (2002) for the volatility spillovers.

This chapter follows the approach by Grammatikos and Vermeulen (2012), who combine GARCH models with indicators of crisis to test for contagion effect, and apply a VAR(1)-GARCH(1,1) model (see Ling and McAleer, 2003) to investigate volatility transmission effects. In order to capture interactions of cross-market volatility, models such as BEKK models can be also used (e.g., Arouri et al, 2011a; Syriopoulos et al., 2015). However, the VAR(1)-GARCH(1,1) is here applied as it requires an estimation of a smaller number of parameters than the BEKK model does. In order to investigate the contagion and volatility transmission effects, this study uses the price indexes of the U.S., European and Dubai financial sectors.

The empirical analysis is carried out over four different periods and considers both the financial and non-financial sectors. The periods under investigation are: i) tranquil (pre-crisis), December 2003–June 2008; ii) the U.S. financial crisis, August 2008– November 2009; iii) the Dubai Debt crisis, November 2009–March 2010; and iv) the European debt crisis, March 2010–January 2012.

This study makes a number of contributions. Firstly, it adds to the empirical literature on financial crisis, contagion effects and volatility transmission by looking at the most important frontier markets located in the GCC region, namely Bahrain, Kuwait, Oman, Qatar, Saudi Arabia and the United Arab Emirates (UAE). Secondly, this study also offers empirical evidence on the degree of contagion effect and volatility spillovers during the European debt crisis. Thirdly, to the best of our knowledge, this is the first work to consider the Dubai debt crisis when studying the contagion effect and volatility transmission on the GCC frontier markets. This is done because Dubai not only exists within the GCC region, but it also shares similar economic, political and geographical characteristics with the other GCC countries, and this suggests potential spillover effects across these countries. Finally, this study considers financial and non-financial sectors of the GCC stock markets. The motivation is threefold. First, aggregate data do not allow the degree to which the impact of shocks may vary across sectors to be highlighted (see Hammoudeh et al., 2009; Arouri et al., 2011b; Balli et al., 2013, among others). Second, the financial sectors are dominant in the GCC stock markets and the foreign participation and ownership is mostly concentrated in these sectors.[9] Third, given the financial nature of the crises in question, it is expected that the financial sectors would be more affected.

The empirical analysis delivers two main results. First, it points to evidence of the contagion effects among the GCC stock markets during the U.S. and Dubai debt crises, with a larger impact on financial sectors. In particular, the U.S. financial crisis affects the stock market of Saudi Arabia (both financial and non-financial sectors), Bahrain and Qatar (financial sectors), and Oman and Kuwait (non-financial sectors), while the Dubai debt crisis impacts on the stock markets of Oman and UAE (both financial and non-

[9] Although the access to the GCC markets by those foreigners ranges from less restricted markets (Bahrain 100% and Oman 70%) to more restricted (Saudi Arabia). However, in 2015, the authorities of the Saudi Arabia stock market (Tadawul) finally liberalized their market by allowing foreign ownership to have 100% access to its market.

financial sectors) and Qatar and Saudi Arabia (financial sectors); the contagion effect from the European sovereign debt crisis is significant only for the non-financial sectors of UAE, Kuwait and Saudi Arabia. Second, evidence of volatility spillovers is found from the stock markets of the U.S., Dubai and Europe to both the financial and non-financial sector of the GCC markets, even though spillovers are rather weak in magnitude.

The remainder of this study is organized as follows. Section 3.2 reviews the related literature. In Section 3.3, the data are described, while Section 3.4 is devoted to a description of the empirical methodology. Section 3.5 presents and discusses the empirical findings. Section 3.6 offers a summary and conclusion.

3.2. LITERATURE REVIEW

The empirical literature on volatility spillover effect is huge. In this section, we briefly review a few comparative studies on the methodologies for spillover detection. Hamao et al. (1990) were the first to apply GARCH (1,1) model to study the volatility spillovers between major financial markets. Since then, different univariate and multivariate GARCH family models have become the most commonly techniques used in the literature to detect the transmission of volatility across financial markets due to their ability in capturing the several stylized facts of financial assets (e.g., time varying volatility, heavy tailed distributions, access kurtosis, non-linearity), (see Soriano and Climent, 2005, for a survey of these models). Furthermore, several other approaches have been developed that involve a combination of GARCH family specifications with other techniques when detecting volatility spillovers across different financial markets. For instance, Bekaert and Harvey (1997) proposed a cross-sectional approach that allows the global and domestic Information to have an effect on the conditional variances of emerging markets. Aggrawal et al. (1999) merged GARCH (1,1) model with Iterated Cumulative Sum of Squares (ICSS) by Inclan and Tiao (1994) so to detect the global and local factors behind the sudden changes in volatility across emerging stock markets. Sola et al. (2002) developed a technique to detect volatility spillovers among financial markets based on a bivariate Markov-Switching approach. Their approach differs from the multivariate GARCH models as it considers the transmission of crisis as sporadic event rather than structural. Furthermore, it also accounts for the duration and the timing of volatility spillovers mechanism from one financial market to another. More recently, Chiang and Wang (2011) developed a range-based volatility measure instead of a return-based one to detect the volatility transmission between financial markets due to the former ability to capture the volatility extreme behaviour. Kohonen (2013) applied a structural model where the volatility spillovers are detected through standard likelihood ratio test using an external source of information based on the Google search engine data.

This section is devoted to a brief discussion about some comparative studies on previous studies that focus on shock transmission and volatility spillovers in the GCC stock markets. This literature can be divided into two main strands.[10] The first one investigates the volatility of oil prices and its spillover effects. In this context, Malik and Hammoudeh (2007) used the BEKK-GARCH technique to study the volatility transmission from world oil prices to three stock markets in the GCC region (Bahrain, Kuwait and Saudi Arabia). The study suggested the presence of a volatility transmission effect between the GCC stock markets and oil prices. Al Janabi et al. (2010) applied a bootstrap simulation in their study, and concluded that the movements of GCC markets are not affected by the changes in oil prices. Mohanty et al. (2011) employed the seemingly unrelated regression (SUR) technique to study the linkage between oil price changes and GCC stock markets from 2005 to 2009. Their results showed that oil prices are positively linked with all GCC stock returns except for Kuwait. Arouri et al. (2011b) considered the return and volatility transmission from the world oil prices to the six GCC stock markets based on the VAR-GARCH model. The findings pointed to the presence of return and volatility spillovers from the prices of oil to the GCC stock markets. Within the same framework, Awartani and Maghyereh (2013) analysed the volatility transmissions between oil returns and stock market returns in the GCC region. They concluded that there are significant returns and volatility spillovers from oil markets to GCC stock markets. Lately, Jouini and Harrathi (2014) employed the asymmetric BEKK-GARCH model to assess the volatility spillovers among GCC and oil markets. The empirical results provided evidence of volatility spillovers between GCC stock markets and oil prices. Khalifa et al. (2014) used the Multi-Chain Markov Switching (MCMS) method to investigate the volatility transmission of the six GCC stock markets with three different international markets (Oil-WTI prices, S&P 500 index and MSCI-world). Their findings indicated strong interdependence across the markets and the existence of spillover effects among these markets.

[10] For a comprehensive survey on the contagion effect during the global financial crisis, see Dimitriou et al. (2013).

The second strand focuses on volatility transmission from global and regional shocks to the stock markets of GCC countries. For instance, Abraham and Seyyed (2006) investigated the volatility spillovers across two stock markets in the GCC region namely Bahrain and Saudi Arabia using daily data from 1998 to 2003 and a bivariate EGARCH model. They found the volatility spillover is asymmetric from the more liberalized Bahraini market to the more capitalized Saudi market. Hammoudeh and Li (2008) studied the influence of sudden shifts on the volatility of five GCC stock market indices by employing the iterated cumulative sums of squares (ICSS) algorithm. The authors suggested that global major events have more impact on the GCC stock markets than to regional or local ones. Sedik and Williams (2011) applied the Trivariate GARCH(1,1) technique to examine the global and regional spillovers and their impact on the GCC equity markets. They showed that the GCC stock markets are not immune from global and regional financial shocks. With reference to the impact of the U.S. financial crisis, they found episodes of contagion during this turmoil. Khalifa et al. (2014) investigated the volatility transmission between the six GCC stock markets and other international markets (Oil-WTI prices, S&P 500 index and MSCI-world) based on the Multi-Chain Markov Switching (MCMS) approach. Their findings revealed that: (i) strong interdependence of the S&P 500 index with the stock markets of Saudi Arabia and the UAE; (ii) volatility spillover from the S&P 500 index to Oman and Kuwait; and (iii) volatility transmission from Qatar to the S&P 500 index. Using several multivariate GARCH models, Alotaibi and Mishra (2015) tested the volatility spillovers to the GCC markets from the U.S. and Saudi Arabia markets. They highlighted significant spillovers of returns from the stock markets in Saudi Arabia and the U.S. markets to the GCC region's markets.

Some studies of this literature have also paid attention to sector-wise indices rather than aggregate stock equities in the GCC region when studying volatility spillovers. For instance, Hammoudeh et al. (2009) applied the multivariate VAR(1)-GARCH(1,1) approach to investigate shock and volatility transmission among the banking, service, industrial and insurance sectors of four GCC stock markets, namely the UAE, Qatar, Saudi Arabia and Kuwait. Their study was conducted prior to the U.S. financial crisis, and their results illustrated moderate volatility transmission across sectors at the country level, except for Qatar. Similarly, Balli et al. (2013) explored the effects of spillovers of domestic and global (U.S.) shocks on the wide-sector returns of the GCC equity markets. The authors observed that the wide sectors are driven by their own volatilities, while the impact of the shocks from the U.S. markets on these domestic GCC sectors' volatility has a downward sloping trend.

All in all, previous studies offer a large amount of evidence on shock transmission and volatility spillovers, while little is said about contagion effect. This study, while providing further evidence on shock transmission and volatility, aims to fill this gap.

3.3. DATA DESCRIPTION

This study uses price indices of financial and non-financial sectors for six GCC countries, namely Bahrain, Kuwait, Oman, Qatar, Saudi Arabia and the United Arab Emirates (UAE). Data are at daily frequency and span from December 30th, 2003 to May 20th, 2015. In order to study the contagion effects and volatility spillovers from the U.S. financial, Dubai debt and European sovereign debt crises to the GCC stock markets, this work uses the U.S., European and Dubai financial price indexes. All the indexes are extracted from DataStream.

Daily data for the sectors are turned into weekly frequency so as to avoid any possible biases when using data at daily frequency (for instance, the bid-ask bounce and non-synchronous trading times).[11] We compute weekly returns by taking the log difference of prices for all equity indices.

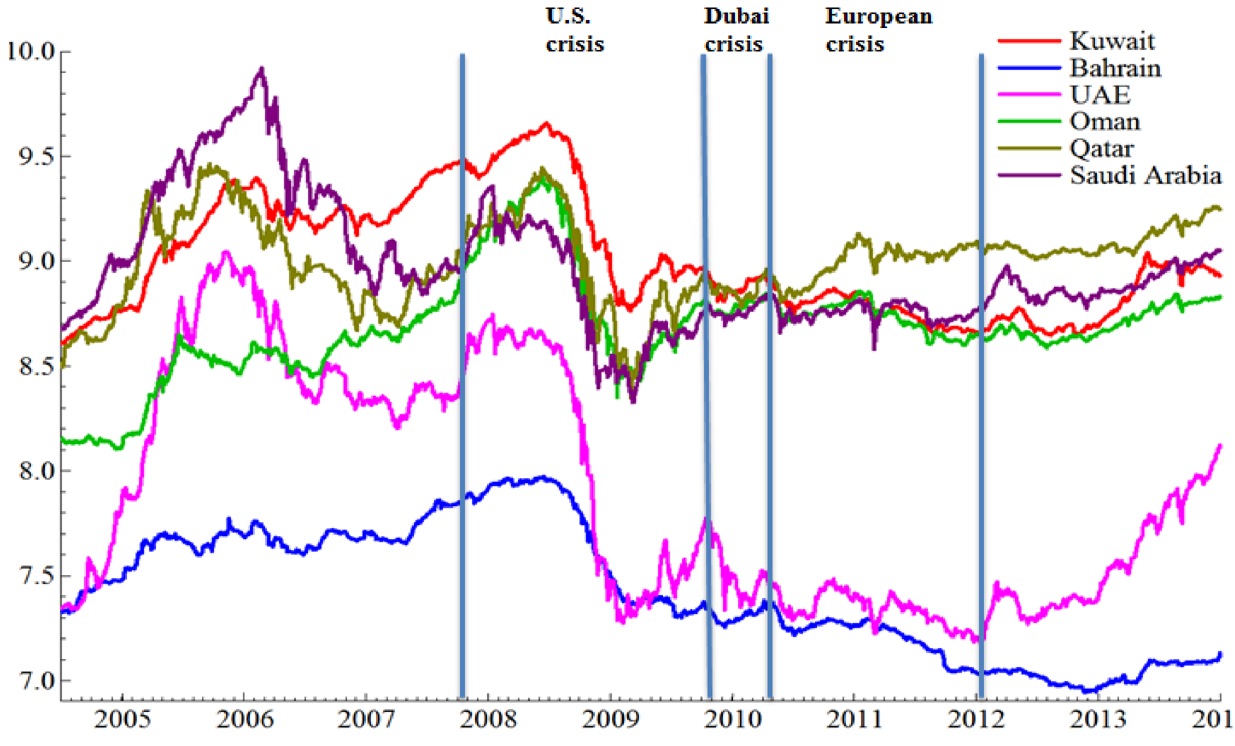
Since the aim of the chapter is to investigate the transmission of shocks from the U.S. financial crisis, the European sovereign debt crisis and the Dubai debt crisis to the GCC financial and non-financial sectors, we consider four different periods: tranquil (December 2003–June 2008), the U.S. financial crisis (August 2008– November 2009), the Dubai Debt crisis (November 2009–March 2010) and the European debt crisis (March 2010–January 2012).

Figure 3.1 reveals turbulent periods affecting the GCC stock markets performance over the period 2003–2015. During the tranquil period, 2003–2007, the performance of the GCC stock markets was particularly positive, due to a rise in oil prices, which reached a peak in August 2008. In the subsequent period, characterized

[11] More specifically, we make further adjustment of data for the GCC sectors in order to match them accurately with the trading days of the U.S., Europe and Dubai. When analysing the contagion effect during the U.S. financial crisis, the GCC daily data are converted into weekly data from Tuesday to Tuesday trading days and hence the sample period runs from December 30, 2003 to May 19, 2015.However, when analysing the contagion effect during the European and Dubai financial debt crises, we convert the GCC daily data into Wednesday to Wednesday weekly data and the study period runs from December 31, 2003 to May 20, 2015.

by the U.S. financial crisis, the stock markets in the GCC region were not immune from the collapse of the international markets, and the share prices dropped sharply, with the largest fall registered for the stock markets of the UAE, 65%, followed by the Saudi Arabia and Kuwait markets, with dips of 61% and 50%, respectively. In addition, during the collapse of Lehman Brothers, the stock market capitalization of the GCC region declined dramatically by 41% ($400 billion), resulting in high volatility across these markets. While some of the GCC stock markets might have recovered, given the period of high oil prices, the debt crisis that occurred in Dubai in 2009 hampered any potential economic recovery and triggered a gradual decline in the share prices in some of the GCC markets, such as the UAE, Oman and Kuwait (see Figure 3.1). This decline was then reinforced by the impact that the European debt sovereign crisis, which took place in 2010, had on the GCC stock markets. Given the exposure of these stock markets to the European economies through the demand for oil, the Kuwaiti Banks Index registered the biggest losses on the Kuwait Stock Exchange on 19th May 2010, and a few days later the indexes of the Dubai and Qatar markets declined by 6%.

Figure 3.1: The GCC stock market indices during the periods of the U.S. financial crisis, Dubai debt crisis and the European debt crisis



Notes: The periods under investigation are: i) tranquil (pre-crisis), December 2003–June 2008; ii) the U.S. financial crisis, August 2008– November 2009; iii) Dubai debt crisis, November 2009-–March 2010; and iv) the European debt crisis, March 2010–January 2012.

In Table 3.1, the descriptive statistics for the returns of the GCC financial and non-financial sectors for the four sub periods are reported: the tranquil period (December 2003–June 2008), the U.S. financial crisis (August 2008– November 2009), the Dubai debt crisis (November 2009–March 2010) and the European debt crisis (March 2010–January 2012).

During the tranquil period, the average weekly mean returns are positive for all the GCC financial and non-financial sectors. This period features an increase in oil prices. However, the mean returns are negative in all the cases during the global financial crisis, which severely affected most financial markets around the world as well as the GCC stock markets. This might indicate a contagion effect. The financial and non-financial sectors of the GCC stock markets reveal different reactions to the developing debt crisis in Dubai and Europe. Looking at both the financial and non-financial sectors in Table 3.1, the average weekly mean return of the UAE and Saudi is negative during the Dubai debt problem, while this mean return is negative only for Bahrain and Oman during the European debt crisis.

Table 3.1: Descriptive statistics for the returns of the financial and non-financial sectors of the GCC countries over the four subsample periods

Descriptive stat.	Mean				Standard deviation			
Sample sub periods	Tranquil period	U.S. financial crisis	Dubai debt crisis	European debt crisis	Tranquil period	U.S. financial crisis	Dubai debt crisis	European debt crisis
GCC financial sectors								
Bahrain	0.003	-0.007	0.003	-0.002	0.015	0.022	0.012	0.013
Kuwait	0.004	-0.006	0.014	0.002	0.023	0.044	0.027	0.020
Oman	0.005	-0.006	-0.001	0.000	0.022	0.048	0.053	0.022
Qatar	0.005	-0.005	0.004	0.002	0.042	0.058	0.032	0.028
Saudi Arabia	0.001	-0.008	-0.025	0.000	0.050	0.053	0.091	0.030
UAE	0.008	-0.002	-0.011	0.001	0.041	0.065	0.045	0.030
GCC	0.006	-0.007	-0.005	0.001	0.026	0.056	0.045	0.018
GCC non-financial sectors								
Bahrain	0.002	-0.001	0.002	-0.001	0.012	0.012	0.010	0.011
Kuwait	0.005	-0.007	-0.001	-0.002	0.032	0.069	0.032	0.036
Oman	0.006	0.000	-0.009	-0.001	0.030	0.067	0.020	0.022
Qatar	0.003	-0.002	0.000	0.005	0.041	0.048	0.032	0.021
Saudi Arabia	0.003	-0.002	-0.024	0.001	0.038	0.046	0.056	0.018
UAE	0.002	-0.004	-0.003	0.002	0.038	0.054	0.021	0.026
GCC	0.003	-0.002	0.002	0.002	0.026	0.044	0.033	0.016

Notes: The four subsample periods are: pre-crisis period (December 2003-June 2008), U.S. financial crisis (August 2008- November 2009), Dubai debt crisis (November 2009-March 2010) and European debt crisis (March 2010-January 2012).

The standard deviation of the GCC financial and non-financial sectors returns varies before and during the three crisis sub periods. The sectors are less volatile before the crisis, and then the volatility increases during the U.S. financial crisis, particularly among the non-financial sectors. However, financial sectors are more volatile than non-financial sectors during both debt crises, in particular for those sectors in Bahrain and Qatar.

3.4. EMPIRICAL METHODOLOGY

This section describes the methodology used in the empirical analysis. As for the study of the contagion effect, we use the approach of Grammatikos and Vermeulen (2012), which combine GARCH models and indicators of crisis. This approach is particularly suitable for examining the behaviour of stock markets during phases of crisis, because of the GARCH's ability to capture volatility changes over different periods. Furthermore, the inclusion of indicator variables in the model allows the coefficients to differ before and during the crisis periods. Thus, whenever the coefficient of the indicator variable is significant, it indicates the transmission of the crisis. To analyse volatility spillover effects, we apply a VAR(1)-GARCH(1,1) model as proposed by Ling and McAleer (2003).

3.4.1 The contagion (shock transmission) model

According to Grammatikos and Vermeulen (2012), the model for the pre-crisis period is specified as follows:[12]

$$r_{i,j,t} = \alpha_{i,j} + \lambda_{i,j} r_{i,j,t-1} + \beta_{i,j} r_{us,t} + \gamma_{i,j} r_{us,t-1} + \varepsilon_{i,j,t} \quad (3.1a)$$

where $r_{i,j,t}$ denotes the stock market return index of country i (Bahrain, Kuwait, Oman, Qatar, the UAE and Saudi Arabia), j denotes the financial or non-financial sector, t indicates the time period, $r_{i,j,t-1}$ is the one day lagged return, $r_{us,t}$ is the U.S. financial sector's return and $r_{us,t-1}$ is the U.S. financial sector's return lagged by one period. In equation (3.1a), all the factors are assumed to be observed and exogenous for all the GCC financial and non-financial sectors. The lagged effect of returns in equation (3.1a) is used to capture the persistence in the stock markets. The lagged effect of the U.S.

[12] In our analysis, unlike Grammatikos and Vermeulen (2012), we do not use the exchange rate in equations (3.1a)–(3.4), because the GCC countries pegged their currencies against the U.S. Dollars in the 1980s. Instead, we use oil price changes as a control variable, since the GCC countries are the main oil exporters. However, the results are not reported here as they are qualitatively similar to those without oil price changes.

sector's return is added to the equation so as to account for the non-synchronous trading days. We use the residuals from the estimated GARCH(1,1) type to capture the specific news relevant for each of the GCC countries.

The GARCH(1,1) model is specified as follows:

$$\sigma_{i,j,t}^2 = \omega_{i,j} + a_{i,j}\varepsilon_{i,j,t-1}^2 + b_{i,j}\sigma_{i,j,t-1}^2, \tag{3.1b}$$

where $a_{i,j}$ and $b_{i,j}$ represent the volatility dynamic coefficients.

In order to capture the movements of the GCC stock market sectors during the crisis period, equation (3.1a) is extended by adding an indicator variable, so that it equals one during the crisis period $I(crisis = 1)$ and zero during the tranquil time $I(crisis = 0)$. Equation (3.1a) can then be rewritten as:

$$r_{i,j,t} = \alpha_{i,j} + \lambda_{i,j}r_{i,j,t-1} + \gamma_{i,j}r_{us,t-1} + \gamma_{i,j}^{crisis}I(crisis = 1)r_{us,t-1} + \varepsilon_{i,j,t}, \tag{3.2}$$

$$\begin{aligned} r_{i,j,t} = \alpha_{i,j} + \lambda_{i,j}r_{i,j,t-1} + \beta_{i,j}r_{Dubai,t} + \beta_{i,j}^{crisis}I(crisis = 1)r_{Dubai,t} + \gamma_{i,j}r_{Dubai,t-1} \\ + \gamma_{i,j}^{crisis}I(crisis = 1)r_{Dubai,t-1} + \varepsilon_{i,j,t}, \end{aligned} \tag{3.3}$$

$$\begin{aligned} r_{i,j,t} = \alpha_{i,j} + \lambda_{i,j}r_{i,j,t-1} + \beta_{i,j}r_{Europe,t} + \beta_{i,j}^{crisis}I(crisis = 1)r_{Europe,t} \\ + \gamma_{i,j}r_{Europe,t-1} + \gamma_{i,j}^{crisis}I(crisis = 1)r_{Europe,t-1} + \varepsilon_{i,j,t}, \end{aligned} \tag{3.4}$$

where $\beta_{i,j}^{crisis}$ and $\gamma_{i,j}^{crisis}$ are the coefficients of the crisis transmission added to equation (3.1a) to capture the full crisis effect and $I(crisis = 1)$ is the indicator. If $\beta_{i,j}^{crisis}$ and $\gamma_{i,j}^{crisis}$ are significant and different from zero, then the presence of crisis transmission is detected.[13]

[13]Notice that we do not include the contemporaneous U.S. returns, $r_{us,t}$, in equation (3.2), because of the different opening and closing times among the GCC and the U.S. stock markets. However, we include this variable only in the case of Dubai (equation 3.3) and Europe (equation 3.4).

3.4.2 Volatility spillover model

In order to estimate the volatility spillover, a VAR(1)-GARCH(1,1) model is applied. The conditional mean equation of the VAR(1)-GARCH(1,1) model for each pair of sector returns is specified as follows:

$$R_t = \mu + \emptyset R_{t-i} + \varepsilon_t, \qquad \varepsilon_t = H_t^{1/2}\eta_t \tag{3.5}$$

where $R_t = \left(r_t^{S(GCC)}, r_t^{S(US)}\right)^T$ is a vector of stock returns, $r_t^{S(GCC)}$ are the returns of the GCC of the financial and non-financial sector indices, $r_t^{S(US)}$ are the returns of the U.S. financial sector index, ∅ denotes a *2 x 2* matrix of coefficients with ∅=$\begin{pmatrix} \emptyset_{11} & \emptyset_{12} \\ \emptyset_{21} & \emptyset_{22} \end{pmatrix}$, ε_t=$\left(\varepsilon_t^{S(GCC)}, \varepsilon_t^{S(US)}\right)^T$ the conditional mean equation's vector of the error terms of the sector returns, $\eta_t = \left(\eta_t^{S(GCC)}, \eta_t^{S(US)}\right)^T$ is a sequence of random errors that are independent and identically distributed *($i.i.d$)*, and H_t is the conditional variances matrix of the sector returns ($S(GCC)$ and $S(US)$), where

$$h_t^{S(GCC)} = C_{S(GCC)}^2 + \beta_{S(GCC)}^2 h_{t-1}^{S(GCC)} + \alpha_{S(GCC)}^2 \left(\varepsilon_{t-1}^{S(GCC)}\right)^2 + \beta_{S(US)}^2 h_{t-1}^{S(US)} + \alpha_{S(US)}^2 \left(\varepsilon_{t-1}^{S(US)}\right)^2 \tag{3.6}$$

$$h_t^{S(US)} = C_{S(US)}^2 + \beta_{S(US)}^2 h_{t-1}^{S(US)} + \alpha_{S(US)}^2 \times \left(\varepsilon_{t-1}^{S(US)}\right)^2 + \beta_{S(GCC)}^2 \times h_{t-1}^{S(GCC)} + \alpha_{S(GCC)}^2 \times \left(\varepsilon_{t-1}^{S(GCC)}\right)^2. \tag{3.7}$$

Both equations (3.6) and (3.7) assume that, when positive shocks and negative shocks of the same magnitude hit the markets, the same impact on conditional variances is observed. The time-varying volatility transmission through stock return series is ruled by cross values of error terms, $\left(\varepsilon_{t-1}^{S(GCC)}\right)^2$ and $\left(\varepsilon_{t-1}^{S(US)}\right)^2$. They capture the impact of direct effects of shock transmission. $h_{t-1}^{S(GCC)}$ and $h_{t-1}^{S(US)}$ are lagged conditional variances, which directly account for the transfer of risk across sectors. Stationarity is ensured by setting the roots of the equation $|I_2 - AL - BL| = 0$ outside the unit circle, where I_2 is a 2 x 2 identity matrix and *L* is a lag polynomial.

Equations (3.5), (3.6) and (3.7) are repeated to estimate the volatility transmission from Dubai and Europe financial sectors to the GCC financial and non-financial sectors. The models are estimated using quasi-maximum likelihood (QML) to obtain the parameters of the bivariate model that are more robust to any departure from the normality condition (Ling and McAleer, 2003).

3.5. EMPIRICAL RESULTS

In Section 3.5.1, we present and discuss the results from estimating equations (3.2), (3.3) and (3.4). Section 3.5.2 shows the estimation results for equations (3.5), (3.6) and (3.7) using the VAR(1)-GARCH(1,1) model.

3.5.1 Estimation results of the contagion effect during the U.S., Dubai and European crises

Table 3.2 presents the empirical findings of equation (3.2) for the returns of the financial (Panel A) and non-financial (Panel B) sectors of the GCC stock markets using the U.S. returns. As for the financial sectors (Panel A), the coefficient of the lagged dependent variable is positive and significant for most of the countries but not Kuwait and Saudi Arabia. The highest value is observed for the UAE (0.163). As far as the coefficient of the one period lagged return for the U.S. is concerned, we observe that all the estimated returns are insignificant, except those for the UAE. As for the U.S. crisis period, the dependence parameter shows different results in the case of the GCC financial sectors. We find that the lagged return coefficients are significant for Bahrain and Saudi Arabia at the 1% level, and for Qatar at the 10% level. This indicates the presence of contagion effect from the U.S. financial crisis to the financial sectors of those countries.

As for the non-financial sectors (Panel B), the estimation results present quite a similar picture to that for the financial sectors (Panel A). The coefficients of the lagged dependent variable are all positive and significant (at different significance levels), except for the non-financial sector of Saudi Arabia. We also notice that the significant coefficients are lower in magnitude than those in case of financial sectors.

The GCC non-financial sector returns' dependence on the one period lagged U.S. returns presents similar results to those for the financial sectors in Panel A. Dependence is positive and significant for the UAE non-financial sector, but rather smaller in magnitude (0.105). However, during the U.S. crisis, the dependence on the U.S. lagged returns becomes significant for the non-financial sectors of Oman, Kuwait and Saudi Arabia, with estimated coefficients equal to -0.295, -0.202 and -0.179, respectively. Thus, strong evidence of crisis transmission from the U.S. is found only for the Saudi financial and non-financial sectors, with a larger impact on the financial sector.

Overall, the empirical results show that only some of the GCC financial and non-financial sector returns are affected by the U.S. financial crisis triggered by the subprime crisis. In particular, the Saudi stock market seems to be the most affected by the U.S. crisis, a result in line with that in Khalifa et al. (2014), who point to strong interdependence between the Saudi and U.S. stock markets. One potential explanation for the low degree of comovement among other GCC's sectors and the U.S. financial sector relies on the illiquidity that affects these frontier markets (see also Didier et al., 2012). Moreover, as pointed out by Grammatikos and Vermeulen (2012), countries with small capitalization tend to be more isolated from extreme events in the U.S., and the GCC markets are small in capitalization ($650 billion in mid-2009).

Table 3.2: Estimation results of equation (3.2) for the GCC financial and non-financial sectors before and during the U.S. financial crisis

	Panel A: Financial sectors				Panel B: Non-Financial sectors			
	Lagged index return	Lagged U.S. return	Lagged U.S. return* crisis dummy (a)	Contagion based on (a)	Lagged index return	Lagged U.S. return	Lagged U.S. return* crisis dummy (a)	Contagion based on (a)
Bahrain	0.113**	-0.010	0.134***	Yes	-	-	-	
	(0.053)	(0.018)	(0.031)		-	-	-	
Kuwait	0.066	0.021	0.011	No	0.081**	0.028	-0.202*	Yes
	(0.048)	(0.029)	(0.085)		(0.041)	(0.042)	(0.123)	
Oman	0.129***	0.013	-0.169	No	0.117***	0.037	-0.295**	Yes
	(0.043)	(0.030)	(0.101)		(0.038)	(0.027)	(0.145)	
Qatar	0.109***	0.012	0.175*	Yes	0.022**	0.042	0.054	No
	(0.042)	(0.043)	(0.093)		(0.047)	(0.048)	(0.095)	
Saudi Arabia	-0.021	-0.027	0.234***	Yes	-0.075	0.017	-0.179**	Yes
	(0.054)	(0.038)	(0.079)		(0.065)	(0.042)	(0.071)	
UAE	0.163***	0.163***	-0.128	No	0.101**	0.105**	-0.131	No
	(0.049)	(0.030)	(0.090)		(0.041)	(0.044)	(0.096)	
GCC	0.131***	0.085***	-0.072	No	0.121**	0.045	0.034	No
	(0.047)	(0.023)	(0.063)		(0.048)	(0.029)	(0.071)	

Notes: Equation (3.2) is estimated using a GARCH(1,1) for the pre-crisis and U.S. crisis periods (December 2003-November 2009). *, **, *** denote significance at the 10%, 5% and 1% level, respectively. The independent variables include the lagged return of the respective GCC's financial index (Panel A) and non-financial index (Panel B), and the lagged value of the U.S. financial index return. Note that Bahrain's non-financial sector ARCH effect is insignificant and hence any GARCH model is not applicable in this case. Standard errors are given in parentheses.

Table 3.3 shows the estimation results of equation (3.3). The results for the financial sectors are presented in Panel A, while those for the non-financial sectors are in Panel B. As for the financial sectors, the coefficient of the dependent lagged return variable is positive and significant for Oman and Qatar, while it is negative and highly significant for the UAE. This implies that some of the GCC's financial sectors do not perform well before the Dubai debt crisis. This may be due the fact some of these markets still not recovered from the severe impact of the U.S. financial crisis.

Moving to the contemporaneous effect of the Dubai financial sector on the GCC financial sectors, it emerges that the coefficients are positive and highly statistically significant, but rather small in magnitude. Perhaps, not surprisingly, the highest impact of this debt crisis on the financial sectors is observed for the UAE financial sectors (see Panel A), and this may be due to the fact that the Dubai financial sector belongs to the UAE. During the crisis, we observe that the linkage of the GCC financial sectors with the Dubai financial sector becomes stronger, particularly for Oman (-0.346), Qatar (-0.097) and Saudi (0.259). We also find that the Kuwait and Bahrain financial sectors show no response to such a crisis. Looking at the lagged dependence on the Dubai financial sector, positive and statistically significant values are found for the financial returns of Bahrain and Oman at the 1% significant level, and for the UAE at the 5% significant level, while those for Kuwait, Qatar and Saudi Arabia are insignificant. However, these changes during the Dubai debt crisis, as the coefficients for the sector returns of Oman (0.369) and Qatar (0.570) become significant. It should be noted that the Oman and Qatar financial sectors are experiencing intensified shock transmission from the U.S. and Dubai crises after a relatively long period of time. In addition, we observe that the financial crisis transmission from Dubai to the Qatar financial sector is the strongest. Overall, the returns of GCC financial sectors significantly depend on the Dubai financial returns, and this effect is more pronounced during the debt crisis, particularly in case of Oman and Qatar.

Panel B in Table 3.3 displays the estimation results of equation (3.3) for the GCC non-financial sectors. The results show that the response of the returns of the GCC sectors to the Dubai crisis before and during the crisis is slightly different compared to the returns of the GCC financial sector in Panel A. More specifically, the lagged dependent return coefficients before the crisis are positive and statistically significant for the non-financial sectors of Oman and the UAE. The impact of Dubai's contemporaneous returns on the GCC sectors is highly significant for all the countries, and the magnitude ranges from 0.024 for Oman to 0.489 for the UAE. In addition, both sectors of Saudi Arabia exhibit a similar response to Dubai's current financial returns. When looking at the non-financial sectors, no significant link is observed between these sectors and the lagged financial returns of Dubai, except for Oman (0.107) and Kuwait (0.043). During the debt crisis, the only contagious impact is found in the case of the UAE (0.186) and it takes some time to hit the Oman non-financial sector (0.216) (see the coefficient of the lagged Dubai returns during the crisis).

Table 3.3: Estimation results of equation (3.3) for the GCC financial and non-financial sectors before and during the Dubai debt crisis

Panel A: Financial sectors						
	Lagged index return	Dubai return	Dubai*crisis dummy (a)	Lagged Dubai return	Lagged Dubai return*crisis dummy (b)	Contagion based on (a) and (b)
Bahrain	0.087	0.083***	-0.055	0.035***	-0.080	No
	(0.061)	(0.004)	(0.048)	(0.013)	(0.088)	
Kuwait	0.038	0.077***	0.059	0.005	-0.036	No
	(0.046)	(0.006)	(0.184)	(0.017)	(0.182)	
Oman	0.108***	0.035***	-0.346***	0.133***	0.369**	Yes
	(0.039)	(0.012)	(0.121)	(0.011)	(0.144)	
Qatar	0.103**	0.098***	-0.097**	-0.003	0.570***	Yes
	(0.042)	(0.008)	(0.043)	(0.028)	(0.062)	
Saudi Arabia	0.057	0.076***	0.259**	0.014	0.066	Yes
	(0.058)	(0.015)	(0.114)	(0.042)	(0.161)	
UAE	-0.212***	0.615***	0.613***	0.113**	0.094	Yes
	(0.065)	(0.017)	(0.091)	(0.048)	(0.138)	
GCC	0.157***	0.185***	0.257***	-0.028	0.039	Yes
	(0.058)	(0.009)	(0.096)	(0.032)	(0.079)	
Panel B: Non-financial sectors						
	Lagged index return	Dubai return	Dubai*crisis dummy (a)	Lagged Dubai return	Lagged Dubai return*dummy crisis (b)	Contagion based on (a) and (b)
Kuwait	0.023	0.161***	0.053	0.043*	-0.345	No
	(0.040)	(0.019)	(0.291)	(0.022)	(0.272)	
Oman	0.237***	0.024***	-0.170	0.107***	0.216*	Yes
	(0.043)	(0.008)	(0.143)	(0.011)	(0.115)	
Qatar	0.007	0.139***	0.013	0.010	-0.044	No
	(0.047)	(0.009)	(0.155)	(0.026)	(0.169)	
Saudi Arabia	-0.028	0.071***	0.098	0.027	0.080	No
	(0.060)	(0.009)	(0.167)	(0.039)	(0.154)	
UAE	0.140***	0.489***	0.186***	-0.023	-0.074	Yes
	(0.043)	(0.010)	(0.063)	(0.024)	(0.143)	
GCC	0.078	0.164***	0.049	0.046**	-0.088	No
	(0.055)	(0.006)	(0.136)	(0.023)	(0.095)	

Notes: Equation (3.3) is estimated using a GARCH(1,1) model for the pre-crisis and Dubai crisis periods (December 2003–March 2010). *, **, *** denote significance at the 10%, 5% and 1% level, respectively. The independent variables include the lagged return of the respective GCC's financial sectors (Panel A) and non-financial sectors (Panel B), and the Dubai financial sector return and its lagged value. The standard errors are given in parentheses.

The estimation results of equation (3.4) for the GCC financial and non-financial sector returns before and during the European sovereign debt crisis are reported in Table 3.4. Panel A shows that all the coefficients of the lagged dependent returns are positive and statistically significant at different significant levels, except those for Kuwait and Saudi. Surprisingly, these results are similar to those reported in Panel A of Table 3.3 and Table 3.4. It indicates that the current return values of the financial sector in Kuwait and Saudi Arabia are not affected by their own shocks at time $t-1$. The contemporaneous dependence of the GCC financial sectors on the European financial returns is also highly significant for all the countries except Oman, with the highest values found for the UAE and Saudi financial sectors: 0.312 and 0.248, respectively. None of the GCC financial sectors show any significant tie with the European contemporaneous returns during the crisis period, except that of the UAE. In general, most of the GCC financial sectors show no significant link with the lagged European financial returns during the European debt crisis, with the exception of the sectors of Oman and Bahrain, with the former being more strongly linked (see Panel A).

Moving to the GCC non-financial sectors (see Panel B of Table 3.4), the results show that the coefficient of the dependent lag return is insignificant for Kuwait, Qatar and Saudi Arabia, while it is positive for the rest of the GCC non-financial sectors, with an average performance of 16%. The contemporaneous dependence of the GCC non-financial sectors on the European financial returns is positive and highly significant, and it is also higher in magnitude in most cases. During the crisis, however, this dependence intensifies for the UAE and Saudi Arabia, while the rest of the GCC non-financial sectors do not experience similar phenomena. Further, this dependence on the European returns takes longer to become significant across all the sectors (see the coefficient of the lagged European returns). Overall, we observe that the non-financial sectors of UAE, Saudi Arabia and Kuwait are affected the European crisis while no response is observed from the financial sectors of the GCC markets.

Table 3.4: Estimation results of equation (3.4) for the GCC financial and non-financial sectors before and during the European debt crisis

Panel A: Financial sectors						
	Lagged index return	European return	Europe*crisis dummy (a)	Lagged European return	Lagged European return*dummy crisis (b)	Contagion based on (a) and (b)
Bahrain	0.134***	0.056***	-0.038	0.043**	0.007	No
	(0.052)	(0.018)	(0.039)	(0.017)	(0.032)	
Kuwait	0.038	0.085***	-0.016	0.021	0.063	No
	(0.045)	(0.023)	(0.045)	(0.027)	(0.049)	
Oman	0.127***	-0.021	-0.023	0.144***	0.031	No
	(0.043)	(0.034)	(0.049)	(0.035)	(0.053)	
Qatar	0.090**	0.179***	-0.064	0.061	-0.046	No
	(0.039)	(0.028)	(0.063)	(0.041)	(0.065)	
Saudi Arabia	0.061	0.248***	-0.027	0.008	0.095	No
	(0.061)	(0.034)	(0.058)	(0.038)	(0.060)	
UAE	0.207***	0.312***	-0.140*	0.054	0.012	Yes
	(0.043)	(0.034)	(0.081)	(0.039)	(0.057)	
GCC	0.179***	0.179***	-0.045	0.035	0.014	No
	(0.042)	(0.021)	(0.043)	(0.023)	(0.035)	
Panel B: Non-financial sectors						
Kuwait	0.027	0.188***	-0.088	0.149***	-0.143***	Yes
	(0.045)	(0.028)	(0.069)	(0.037)	(0.051)	
Oman	0.173***	0.037	-0.054	0.105***	0.037	No
	(0.046)	(0.036)	(0.044)	(0.031)	(0.044)	
Qatar	0.023	0.184***	-0.084	0.048	-0.026	No
	(0.046)	(0.030)	(0.056)	(0.039)	(0.062)	
Saudi Arabia	-0.021	0.268***	-0.092**	0.129***	-0.066	Yes
	(0.061)	(0.033)	(0.045)	(0.035)	(0.053)	
UAE	0.096**	0.207***	-0.152***	0.061*	-0.012	Yes
	(0.041)	(0.031)	(0.055)	(0.032)	(0.049)	
GCC	0.158***	0.191***	-0.069	0.035	0.006	No
	(0.047)	(0.025)	(0.045)	(0.025)	(0.043)	

Notes: Equation (3.4) is estimated using a GARCH(1,1) model before the crisis and during the European crisis periods (December 2003–January 2012). *, **, *** denote significance at the 10%, 5% and 1% level, respectively. The independent variables include the lagged return of the respective GCC's financial sectors (Panel A) and non-financial sectors (Panel B), and the European financial sector return and its lagged value. The standard errors are given in parentheses.

3.5.2 Estimation results of volatility transmission from the U.S., Dubai and Europe financial sectors

This section presents the empirical results of the estimated bivariate VAR(1)-GARCH(1,1) model for all pairs of the U.S., Dubai and European financial sectors with each of the GCC stock markets. The analysis considers each of the GCC financial and non-financial sectors.

3.5.2.1 Volatility spillovers from the U.S. financial sector to the GCC financial and non-financial sectors

Table 3.5 reports the results of the estimated bivariate VAR(1)-GARCH(1,1) between the return index of the U.S. financial sector and the return indices of the financial (Panel A) and non-financial sectors (Panel B), respectively, of Bahrain, Kuwait, Oman, Qatar, Saudi Arabia and the UAE. As one can see from Panel A, none of the GCC financial sector indices' one period lagged return values are significant in the mean equation. This result indicates that they cannot be used to forecast their own future returns. In contrast, past return values have an effect on the current own return values for the U.S. Interestingly, the impact of each of the GCC financial sectors' past values on the U.S. current values is significant in all cases except Kuwait. The highest positive impact of these GCC financial lagged returns on the U.S. returns is observed for the UAE financial sector (0.176), while the highest negative coefficient is found for the Saudi financial sector (-0.159). Overall, the results show that there is transmission of information from the GCC financial sectors to the U.S. financial sector, but not the reverse.

Moving to the estimated conditional variance equation of the VAR(1)-GARCH(1,1) model, the coefficients of the ARCH and GARCH effects turn out to be significant at different levels. The GCC financial sectors are sensitive to their past conditional volatility with the exception of that of Bahrain. The volatility coefficients are significant at 1%, and the most volatile financial sectors are those of Qatar (0.963) and Kuwait (0.930). A similar result for Kuwait is also found by Hammoudeh et al. (2009). The average GCC financial sector is also highly significant with volatility persistence of 0.925. This indicates that the past conditional volatility of the average GCC financial index can be used to predict most of the GCC financial sectors' current volatility.

Furthermore, all the GCC financial sectors depend on their own past shocks, as $(\varepsilon_{t-1}^{S(GCC)})^2$ coefficients are significant at 1%.

With respect to the volatility spillover effect between the U.S. financial and the GCC financial sectors, the results show that lagged U.S. financial shocks, $(\varepsilon_{t-1}^{S(US)})^2$, significantly determine the current volatility of the GCC financial sectors of Bahrain (0.139), Saudi (-0.384) and the UAE (-0.179). Thus, the unexpected changes in the U.S. financial sector imply higher volatility in the financial sectors of Bahrain, Saudi Arabia and the UAE. However, only the current volatility of the financial sectors of Kuwait (-0.016), Saudi (0.153) and the UAE (0.070) are sensitive to the U.S. financial sector's past volatility, $(h_{t-1}^{S(US)})^2$, which indicates evidence of volatility spillover from the U.S. to these three financial sectors. Overall, the results show that the conditional volatility of the financial sectors in the Saudi Arabia and UAE stock markets is mostly affected by the changes in the shocks $(\varepsilon_{t-1}^{S(US)})^2$ and volatility $(h_{t-1}^{S(US)})^2$ in the U.S. financial sector.

The results for the GCC non-financial sectors show a similar picture to some extent (see Panel B in Table 3.5). When considering the one period lagged values of returns of the GCC non-financial sectors, it emerges that the corresponding coefficients are significant for Oman, Saudi and the UAE, and can be employed to forecast the current returns of these sectors. In contrast to Saudi's sensitivity to its past own returns, the highest response to changes in the U.S. financial prices is observed in Saudi returns with an estimated significant (1%) coefficient of 0.329. This result shows that the flow of information is relatively moderate from the U.S. financial sector to the Saudi non-financial sector and the U.S. financial sector is much more important in predicting future returns of the Saudi non-financial sector than its own past returns. A similar result is found in Khalifa et al. (2014).

As for the estimates of the conditional variance equation, the coefficients are highly significant in most of the cases. The sensitivity of GCC non-financial sectors to their past volatility is significant at 1%. Moreover, the coefficients of the ARCH term of the GCC non-financial sectors suggest that their current volatility is also affected by their own past shocks. For the volatility spillover, the current volatility of the non-financial sectors of Kuwait and Saudi Arabia is highly determined by U.S. previous shocks $(\varepsilon_{t-1}^{S(US)})^2$ and past volatility $(h_{t-1}^{S(US)})^2$. However, the impact of U.S. past shocks is more pronounced in these two countries' non-financial sectors than the past volatility.

Oman's non-financial volatility is also affected by the past volatility of the U.S., even if the spillover effect is marginal (-0.048). For a clearer picture in regards to the volatility spillovers from the U.S. to GCC financial and non-financial sectors, the results are depicted in Figure 3.2. The left hand side of this figure reports the financial sectors of the GCC countries while the right hand side shows the non-financial sectors of these markets. The arrows indicate the direction of the volatility spillovers from the U.S. financial sector (placed in the middle of Figure 3.2) to both sides. When comparing the results in Panel A and Panel B, in Table 3.5, we notice that there is clear evidence that the conditional volatility of both the financial and non-financial sectors of the Saudi Arabia and Kuwait stock markets are mostly influenced by volatility spills from the U.S. financial sector (see the directions of the arrows in the figure to both sides). Furthermore, the same impact is also observed in only the UAE financial sector and the non-financial sectors of Oman.

Figure 3.2: Volatility spillovers between the U.S. financial sector and the GCC financial and non-financial sectors

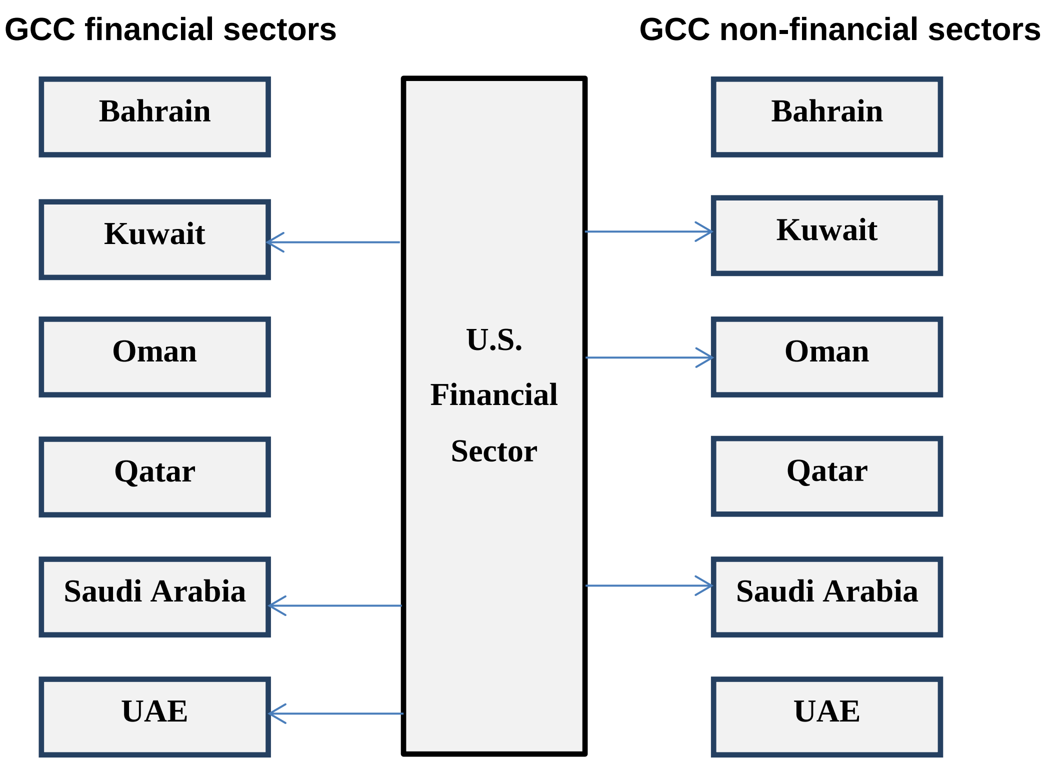


Table 3.5: Estimation results of VAR(1)-GARCH(1,1) model between the U.S. financial sector and the GCC financial (Panel A) and non-financial (Panel B) sectors

Panel A	U.S.	Bahrain	U.S.	Kuwait	U.S.	Oman	U.S.	Qatar	U.S.	Saudi	U.S.	UAE	U.S.	GCC
Conditional mean equation														
S(US)	-0.147***	0.031	-0.096***	0.030	-0.111***	-0.006	-0.100**	-0.028	-0.132***	-0.0002	-0.103**	0.003	-0.086*	-0.005
	(0.038)	(0.046)	(0.038)	(0.042)	(0.036)	(0.031)	(0.041)	(0.024)	(0.047)	(0.019)	(0.043)	(0.022)	(0.448)	(0.033)
S(GCC)	0.035**	0.139***	0.018	0.039	0.038	0.117***	0.043	0.108**	0.116***	-0.159***	0.060	0.176***	0.062**	0.109***
	(0.018)	(0.051)	(0.029)	(0.043)	(0.028)	(0.044)	(0.037)	(0.047)	(0.038)	(0.021)	(0.043)	(0.045)	(0.029)	(0.040)
Conditional variance equation														
Constant	0.001	0.000	0.004***	0.002	0.002	0.011***	-0.004***	0.001	0.002**	0.000	0.003***	0.010***	0.004***	0.002**
	(0.001)	(0.093)	(0.001)	(0.001)	(0.002)	(0.002)	(0.001)	(0.001)	(0.000)	(0.001)	(0.001)	(0.002)	(0.001)	(0.001)
$(\varepsilon_{t-1}^{S(US)})^2$	0.381***	0.139***	0.324***	0.012	0.285***	-0.037	0.333***	0.005	0.234***	-0.384***	0.295***	-0.179***	0.319***	-0.074
	(0.036)	(0.049)	(0.042)	(0.035)	(0.029)	(0.033)	(0.035)	(0.034)	(0.033)	(0.056)	(0.036)	(0.058)	(0.038)	(0.033)
$(\varepsilon_{t-1}^{S(GCC)})^2$	0.092*	0.794***	0.038	0.359***	0.131***	0.584***	0.040*	0.281***	0.062***	0.695***	0.045**	0.518***	0.073***	0.404***
	(0.052)	(0.066)	(0.043)	(0.066)	(0.039)	(0.063)	(0.022)	(0.039)	(0.023)	(0.056)	(0.021)	(0.051)	(0.027)	(0.050)
$(h_{t-1}^{S(US)})^2$	0.932***	0.009	0.937***	-0.016***	0.953***	0.021	0.935	-0.007	0.975***	0.153***	0.954***	0.070***	0.941***	0.003
	(0.012)	(0.025)	(0.015)	(0.013)	(0.012)	(0.022)	(0.014)	(0.012)	(0.009)	(0.023)	(0.012)	(0.024)	(0.014)	(0.012)
$(h_{t-1}^{S(GCC)})^2$	-0.170*	-0.006	-0.017	0.930***	-0.065***	0.751***	-0.008	0.963***	-0.035***	0.742***	-0.032***	0.813***	-0.025***	0.925***
	(0.089)	(0.135)	(0.015)	(0.024)	(0.025	(0.055)	(0.005)	(0.009)	(0.009)	(0.035)	(0.012)	(0.036)	(0.010)	(0.019)
$H(10)$	46.910		33.124		46.063		47.082		26.324		23.577		34.452	
	[0.152]		[0.694]		[0.173]		[0.148]		[0.924]		[0.990]		[0.634]	
BIC	-9.784		-9.410		-9.011		-8.540		-8.191		-8.515		-9.199	

Table 3.5- Continued from the previous page

Panel B	U.S.	Kuwait	U.S.	Oman	U.S.	Qatar	U.S.	Saudi	U.S.	UAE	U.S.	GCC
Conditional mean equation												
S(US)	-0.137***	0.042*	-0.123***	0.040	-0.101***	-0.054**	-0.140***	0.329***	-0.094**	-0.025	-0.099***	-0.074**
	(0.036)	(0.022)	(0.042)	(0.032)	(0.037)	(0.023)	(0.048)	(0.045)	(0.041)	(0.025)	(0.035)	(0.031)
S(GCC)	0.054	0.066	0.062**	0.151***	0.041	0.027	-0.011	-0.148***	0.075**	0.095**	0.042**	0.117***
	(0.048)	(0.043)	(0.032)	(0.041)	(0.034)	(0.046)	(0.040)	(0.053)	(0.036)	(0.043)	(0.020)	(0.043)
Conditional variance equation												
Constant	0.000	0.000	0.005***	0.003**	0.003***	0.007***	0.001	0.000	0.004***	0.003***	0.004***	0.002**
	(0.001)	(0.050)	(0.001)	(0.002)	(0.001)	(0.001)	(0.001)	(0.030)	(0.001)	(0.001)	(0.001)	(0.001)
$(\varepsilon_{t-1}^{S(US)})^2$	0.192***	-0.412***	0.385***	0.069	0.307***	-0.044	0.160***	-0.337***	0.378***	0.016	0.322***	0.004
	(0.033)	(0.050)	(0.058)	(0.047)	(0.034)	(0.039)	(0.044)	(0.062)	(0.036)	(0.027)	(0.034)	(0.028)
$(\varepsilon_{t-1}^{S(GCC)})^2$	0.090***	0.431***	0.106***	0.435***	0.044**	0.441***	0.087**	0.572***	0.002	0.274***	0.065**	0.410***
	(0.021)	(0.041)	(0.029)	(0.035)	(0.022)	(0.052)	(0.037)	(0.054)	(0.023)	(0.032)	(0.031)	(0.040)
$(h_{t-1}^{S(US)})^2$	0.978***	0.164***	0.906***	-0.048*	0.946***	0.015	0.982***	0.074***	0.920***	-0.011	0.942***	-0.007
	(0.008)	(0.021)	(0.029)	(0.029)	(0.012)	(0.015)	(0.008)	(0.018)	(0.014)	(0.009)	(0.012)	(0.010)
$(h_{t-1}^{S(GCC)})^2$	-0.078***	0.854***	-0.023**	0.911***	-0.021**	0.880***	-0.080***	0.747***	0.000	0.960***	-0.026***	0.916***
	(0.012)	(0.018)	(0.011)	(0.014)	(0.010)	(0.026)	(0.020)	(0.036)	(0.007)	(0.009)	(0.010)	(0.017)
$H(10)$	41.144		42.119		40.453		42.619		30.377		33.620	
	[0.334]		[0.297]		[0.363]		[0.279]		[0.806]		[0.672]	
BIC	-8.264		-8.843		-8.622		-8.226		-8.650		-9.385	

Notes: Equations (3.5), (3.6) and (3.7) of the bivariate VAR(1)-GARCH(1,1) model are estimated between U.S. financial (U.S.) return index and each of the GCC financial (Panel A) and non-financial (Panel B) return indices (GCC). The optimal lag order for the VAR model is selected using the AIC information criteria. *, **, *** denote significance levels at the 10%, 5% and 1%, respectively. . *H*(10) is the multivariate Portmanteau test of Hosking (1980) for serial correlation of order (10). p-values for *H*(10) are in brackets. The standard errors are given in parentheses.

3.5.2.2 Volatility spillovers from the Dubai financial sector to the GCC financial and non-financial sectors

Table 3.6 provides the estimation results of the bivariate VAR(1)-GARCH(1,1) model between the Dubai financial index and the GCC financial (Panel A) and non-financial sectors (Panel B).

By looking at Panel A, one can see that one period lagged returns of the GCC financial sectors for Bahrain, Oman, Saudi and the UAE are all significant, while one period lagged returns for the Dubai financial sector are significant at the 10% level and positive for the UAE financial sector. In addition, the one period lagged returns of the Oman and Qatar financial sectors are significant for the Dubai financial returns with a positive estimated coefficient of 0.235 and a negative one of -0.043, respectively.

When considering the results of the conditional variance equation, we observe that the estimated coefficients of past news or shocks from the Dubai financial sector to all the GCC financial sectors are statistically significant at different levels. This result seems to suggest that past shocks from the Dubai financial sector can be used to forecast the current volatility of all the financial sectors of the GCC market. Further, the own shocks of the Dubai and GCC financial sectors can predict their current volatility, since the coefficients are highly significant at 1%. However, for the financial sector of Dubai, only the GCC past shocks ($(\varepsilon_{t-1}^{S(GCC)})^2$) of Bahrain, Oman and the UAE are significant.

The estimated coefficients of past own volatility of both the Dubai financial index $(h_{t-1}^{S(Dubai)})^2$ and all the GCC financial sectors $(h_{t-1}^{S(GCC)})^2$ are statistically significant at 1% level. This indicates that their past own volatility is important in forecasting the future conditional volatility of these sectors. Looking at the volatility spillover effect between the Dubai financial sector and the GCC financial indexes, past volatility for Dubai is significant and affects all GCC financial sectors' volatilities, with the exception of the Saudi financial sector. Similarly, the past volatility of the GCC financial sectors also affects Dubai's financial current volatility but not Qatar.

In Panel B of Table 3.6, the estimation results of the VAR(1)-GARCH(1,1) model for both the Dubai financial and non-financial sectors of the GCC stock markets are reported. Looking at the one period lagged values of returns for the Dubai financial sector in the mean equation, we notice that only those coefficients for the non-financial sectors of Kuwait (10%), Oman (1%) and the UAE (1%) are significant. This indicates that the Dubai financial returns can only predict the future returns of these sectors. On the other hand, the non-financial sectors of Oman, Qatar and UAE one period lagged return values significantly affect the Dubai financial sector, though the coefficients are small in magnitude and negative in the case of Oman and UAE.

When looking at the estimated variance equation in Panel B of Table 3.6, we find similar results to those in Panel A for the GCC financial sectors. It should be noted that past shocks (see the term $(\varepsilon_{t-1}^{S(Dubai)})^2$) have an effect on all the GCC non-financial sectors, except those of Oman and the UAE, but the estimated coefficients are small in magnitude. As for the volatility spillovers from Dubai's past volatility $(h_{t-1}^{S(Dubai)})^2$ to the GCC non-financial sectors, the results show that the estimated coefficients are only significant for Qatar and the UAE, though they are small in size. To provide a clear picture of the volatility spillovers across the GCC (financial and non-financial markets) and Dubai markets, the results are also illustrated in Figure 3.3. When looking at Figure 3.3, it emerges that the volatility transmission from Dubai financial index is more pronounced in the financial sectors of the GCC stock markets, except Saudi Arabia (see the direction of the arrows from Dubai financial sector to the left hand side in this figure). However, only the non-sector of Qatar and the UAE stock markets (in the right hand side of the figure) seem to be affected by the volatility from the Dubai index.

Table 3.6: Estimation results of VAR(1)-GARCH(1,1) model between the Dubai financial sector and the GCC financial (Panel A) and non-financial (Panel B) sectors

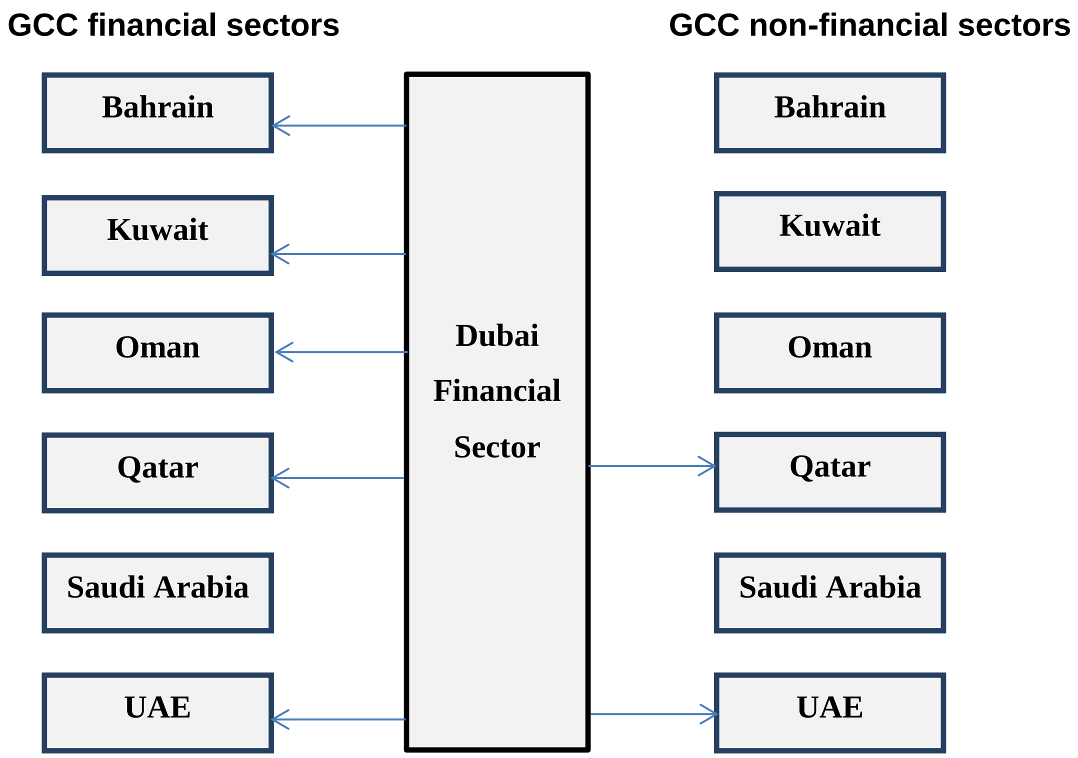
Panel A	Dubai	Bahrain	Dubai	Kuwait	Dubai	Oman	Dubai	Qatar	Dubai	Saudi	Dubai	UAE	Dubai	GCC
Conditional mean equation														
S(Dubai)	-0.243***	0.080	-0.166***	0.031	-0.015	-0.081	-0.277***	0.007	0.167**	-0.031	-0.007	0.247***	-0.169***	0.259***
	(0.048)	(0.087)	(0.057)	(0.060)	(0.072)	(0.075)	(0.072)	(0.041)	(0.073)	(0.026)	(0.048)	(0.056)	(0.051)	(0.071)
S(GCC)	-0.001	0.079*	0.002	-0.045	0.235***	0.066*	-0.043**	-0.017	0.042	-0.116***	-0.007	0.173***	-0.025	0.083
	(0.007)	(0.045)	(0.012)	(0.040)	(0.046)	(0.036)	(0.021)	(0.046)	(0.031)	(0.034)	(0.018)	(0.040)	(0.018)	(0.051)
Conditional variance equation														
Constant	0.019***	0.005***	0.018***	0.003***	0.033***	0.000	0.024***	0.000	0.028***	0.014***	0.014***	0.006***	0.017***	0.000
	(0.002)	(0.001)	(0.002)	(0.001)	(0.003)	(0.004)	(0.002)	(0.004)	(0.003)	(0.003)	(0.002)	(0.001)	(0.002)	(0.003)
$(\varepsilon_{t-1}^{S(Dubai)})^2$	0.990***	0.047***	0.916***	0.040**	0.668***	0.118***	1.006***	0.114***	1.291***	0.113*	1.128***	0.124***	1.077***	0.224***
	(0.054)	(0.013)	(0.055)	(0.016)	(0.111)	(0.027)	(0.079)	(0.038)	(0.128)	(0.066)	(0.077)	(0.034)	(0.059)	(0.034)
$(\varepsilon_{t-1}^{S(GCC)})^2$	0.531***	0.506***	0.074	0.399***	1.085***	0.226***	0.115	0.497***	0.062	0.821***	0.555***	0.466***	0.329***	0.550***
	(0.181)	(0.053)	(0.126)	(0.048)	(0.092)	(0.054)	(0.081)	(0.075)	(0.090)	(0.079)	(0.088)	(0.055)	(0.108)	(0.077)
$(h_{t-1}^{S(Dubai)})^2$	0.594***	0.035***	0.658***	0.019**	0.297***	0.100**	0.525***	0.127***	0.201***	0.066	0.637***	0.061***	0.454***	0.213***
	(0.033)	(0.006)	(0.039)	(0.007)	(0.066)	(0.049)	(0.057)	(0.026)	(0.070)	(0.048)	(0.029)	(0.017)	(0.036)	(0.025)
$(h_{t-1}^{S(GCC)})^2$	0.396***	0.843***	0.133**	0.923***	0.398***	0.934***	0.053	0.923***	0.220***	0.666***	0.178***	0.881***	0.597***	0.624***
	(0.111)	(0.034)	(0.061)	(0.020)	(0.095)	(0.014)	(0.034)	(0.026)	(0.083)	(0.064)	(0.048)	(0.033)	(0.101)	(0.051)
$H(10)$	36.512		18.641		21.297		83.229		41.921		18.901		73.095	
	[0.524]		[0.996]		[0.987]		[0.322]		[0.305]		[0.995]		[0.636]	
BIC	-8.981		-8.426		-8.250		-7.406		-7.274		-8.718		-9.105	

Table 3.6- Continued from the previous page

Panel B	Dubai	Kuwait	Dubai	Oman	Dubai	Qatar	Dubai	Saudi	Dubai	UAE	Dubai	GCC
Conditional mean equation												
S(Dubai)	-0.030	-0.070*	-0.172***	0.214***	-0.126**	0.001	0.238***	-0.048	-0.167***	0.344***	-0.172***	0.181**
	(0.080)	(0.040)	(0.051)	(0.047)	(0.064)	(0.057)	(0.081)	(0.064)	(0.042)	(0.072)	(0.058)	(0.084)
S(GCC)	-0.001	-0.066	0.044***	0.115***	-0.030*	-0.042	0.022	0.022	-0.027*	0.108***	-0.005	-0.010
	(0.016)	(0.052)	(0.014)	(0.038	(0.017)	(0.042)	(0.021)	(0.056)	(0.015)	(0.036)	(0.012)	(0.042)
Conditional variance equation												
Constant	0.015***	0.007***	0.020***	0.006***	0.018***	0.004***	0.027***	-0.007*	0.023***	0.000	0.015***	0.004***
	(0.002)	(0.001)	(0.003)	(0.001)	(0.002)	(0.001)	(0.003)	(0.004)	(0.002)	(0.010)	(0.002)	(0.001)
$(\varepsilon_{t-1}^{S(Dubai)})^2$	0.803***	0.066**	0.897***	0.025	0.874***	0.104***	1.271***	0.120*	1.232***	-0.037	0.919***	0.043*
	(0.078)	(0.029)	(0.053)	(0.023)	(0.054)	(0.025)	(0.128)	(0.068)	(0.073)	(0.029)	(0.062)	(0.022)
$(\varepsilon_{t-1}^{S(GCC)})^2$	0.111**	0.503***	-0.302***	0.512***	0.101	0.330***	-0.285***	0.451***	-1.741***	0.426***	-0.244**	0.403***
	(0.056)	(0.059)	(0.069)	(0.042)	(0.079)	(0.035)	(0.112)	(0.061)	(0.138)	(0.071)	(0.124)	(0.057)
$(h_{t-1}^{S(Dubai)})^2$	0.755***	-0.012	0.644***	-0.017	0.692***	-0.047***	0.140*	-0.082	0.264***	0.040**	0.713***	-0.018*
	(0.049)	(0.011)	(0.043)	(0.012)	(0.032)	(0.011)	(0.076)	(0.053)	(0.053)	(0.019)	(0.033)	(0.009)
$(h_{t-1}^{S(GCC)})^2$	-0.041	0.879***	0.168***	0.871***	-0.015	0.943***	0.338***	0.876***	0.782***	0.898***	0.089	0.916***
	(0.039)	(0.024)	(0.040)	(0.017)	(0.034)	(0.012)	(0.096)	(0.039)	(0.066)	(0.029)	(0.056)	(0.024)
$H(10)$	75.730		27.635		31.167		22.496		22.978		20.393	
	[0.552]		[0.893]		[0.523]		[0.978]		[0.978]		[0.991]	
BIC	-7.809		-7.950		-7.747		-7.889		-8.142		-8.495	

Notes: Equations (3.5), (3.6) and (3.7) of the bivariate VAR(1)-GARCH(1,1) model are estimated between the Dubai financial return index (Dubai) and each of the GCC financial (Panel A) and non-financial (Panel B) return indices. For other details, please see notes in Table 3.5.

Figure 3.3: Volatility spillovers between the Dubai financial sector and the GCC financial and non-financial sectors



3.5.2.3 Volatility spillovers from the European financial sector to the financial and non-financial sectors of GCC countries

Table 3.7 reports the bivariate VAR(1)-GARCH(1,1) estimation results between the European financial sector and the GCC financial (Panel A) and non-financial (Panel B) sectors. As for the coefficients of the mean equation for both the European and GCC financial sectors, it emerges that Europe's one period lagged returns have a negative significant effect on the current returns only for the financial sectors of Oman, Saudi and the UAE at the 5% level (see Panel A). These results indicate that information flows from the European financial sector to the Oman, Saudi and UAE financial sectors, even though the impact is rather weak (the estimated coefficients are -0.078, -0.057 and -0.056, respectively). In contrast, the European financial sector's reaction to changes in GCC financial lagged returns is significant in most cases, and the estimated coefficients are positive except in the case of Saudi. The largest European response to price changes is observed for the Kuwaiti financial sector with an estimated coefficient of 0.188.

With respect to the variance equation, results show that past shocks from the European financial sector (see the ARCH term) only affect the current volatility of Bahraini and Qatari financial sectors, with significant estimated coefficients of 0.037 at the 10% level and 0.048 at the 5% level, respectively. Further, past own shocks of all the GCC financial sectors are significant. This indicates that all GCC financial sectors' own shocks can be used to predict their future volatility. None of the GCC financial sectors' past shocks affect the current volatility of the European financial sector, given that all the $(h_{t-1}^{S(Euro.)})^2$ coefficients are highly insignificant.

As for the volatility persistence term of both the European and GCC financial sectors, we observe that the current conditional volatility of all the GCC financial sectors is largely determined by their own past volatility rather than the European past volatility. The GCC financial past volatility is highly persistent for Qatar (0.969) and Kuwait (0.923), and less persistent for Bahrain (0.726). The volatility spillovers from European financial sector to Oman and Qatar are extremely weak (the estimated coefficients are 0.029 and 0.014, respectively) while they are slightly stronger for the Saudi financial index (0.383).

As for the results of the mean equation for the European financial sector and the GCC non-financial sectors, the one period lagged returns of the European financial sector significantly affect the return indices of non-financial sectors only in the case of Kuwait, at the 10% level, and the UAE, at the 1% level (see Panel B in Table 3.7), showing that the European financial sector provides short-term predictability for the Kuwait and UAE non-financial returns. On the other hand, lagged returns of the non-financial sectors for Kuwait, Oman, Saudi and the UAE significantly affect the current returns of the European financial sector (the estimated coefficients are 0.168, 0.069, 0.078 and 0.045, respectively). This implies that information flows from these GCC non-financial sectors of Kuwait, Oman, Saudi and the UAE to the European financial sector.

The results related to the conditional variance equation show that past own shocks and past own volatilities are highly significant for all the sectors. In addition, past shocks from the European financial sector significantly affect the current volatility of the Kuwait (1%), Oman (1%), Saudi (1%) and UAE (5%) non-financial sectors. Similarly, the unexpected changes in the GCC non-financial sectors, $(\varepsilon_{t-1}^{S(GCC)})^2$, also have an impact on the European financial sector's current volatility. As for the European past volatility (see $(h_{t-1}^{S(Euro.)})^2$ in Panel B of Table 3.7), it has no significant effect on the GCC non-financial sectors, except for those of Oman, Saudi Arabia and the UAE, but rather very low in magnitude (-0.047, 0.039 and -0.013, respectively). On the other hand, most of the GCC past volatilities have no significant impact on the European financial sector, excluding Kuwait and Saudi Arabia, with magnitudes of 0.077 and -0.141, respectively. This shows rather weak cross effects of conditional volatility between the European financial index and GCC non-financial sector indices. However, the GCC non-financial sectors respond significantly to European past shocks rather than European past volatility. Figure 3.4 summarizes the results of the volatility transmission across the GCC (financial and non-financial sectors) and the European financial sector. Looking at this figure, we can see that both stock markets of Oman and Saudi Arabia are mostly receive volatility spills from the European financial index (the arrows from European financial index the point to both types of these countries' sectors). The other GCC stock markets receive volatility spills from the financial index of Europe (Qatar financial sector in left hand side of the figure and the UAE non-financial sector in the right hand side) while the rest are not affected.

To summarize the results, it emerges that: i) current returns of financial and non-financial sectors of each GCC market are good predictors of future returns of GCC individual markets (see also Khalifa et al., 2014; Jamaani and Roca, 2015); ii) all the GCC stock markets are generally driven by their own volatilities and their idiosyncratic shocks, regardless of the sectors considered (see also Hammoudeh et al., 2009; Balli et al., 2013); and iii) the stock markets of Oman and Saudi Arabia are more affected by external shocks, while the UAE and Qatar are more responsive to shocks that are developed within the GCC region.

Table 3.7: Estimation results of VAR(1)-GARCH(1,1) model between the European financial sector and the GCC financial (Panel A) and non-financial (Panel B) sectors

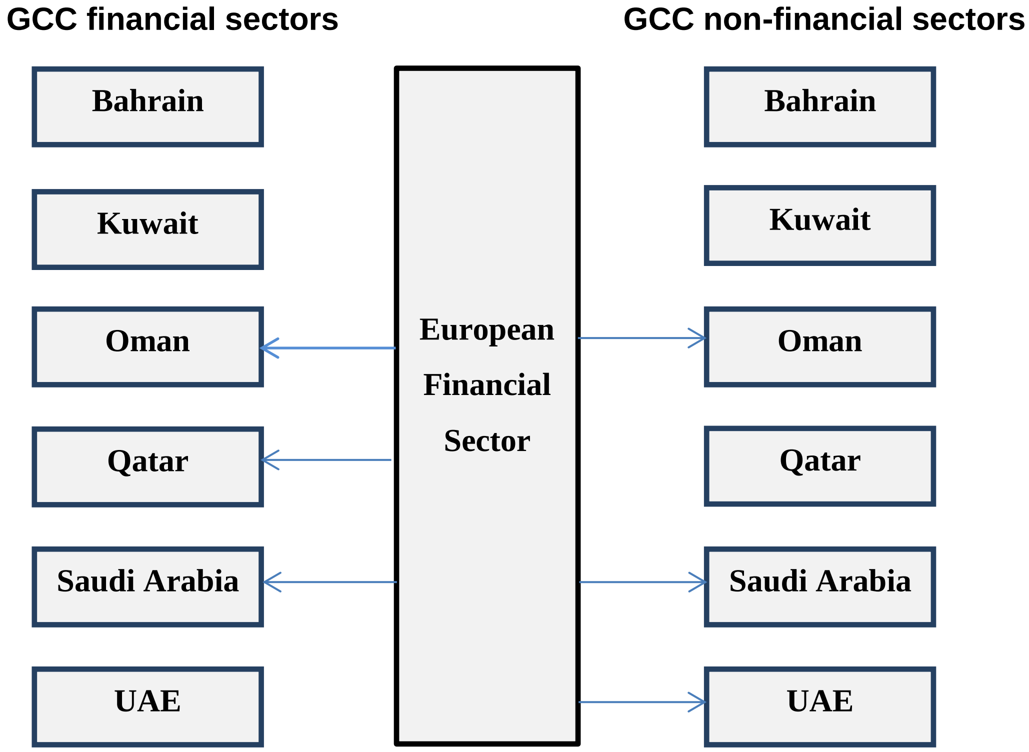
Panel A	Euro.	Bahrain	Euro.	Kuwait	Euro.	Oman	Euro.	Qatar	Euro.	Saudi	Euro.	UAE	Euro.	GCC
Conditional mean equation														
S(Euro.)	-0.044	0.045	-0.028	0.003	-0.055	-0.078**	-0.051	-0.021	-0.117**	-0.057**	-0.040	-0.056**	-0.023	-0.073*
	(0.039)	(0.061)	(0.039)	(0.051)	(0.043)	(0.035)	(0.038)	(0.023)	(0.051)	(0.026)	(0.039)	(0.025)	(0.039)	(0.041)
S(GCC)	0.051***	0.160***	0.042**	0.025	0.188***	0.105***	0.041	0.054	0.040	-0.115***	0.065**	0.156***	0.043**	0.125***
	(0.013)	(0.047)	(0.019)	(0.038)	(0.031)	(0.040)	(0.028)	(0.045)	(0.028)	(0.031)	(0.031)	(0.043)	(0.016)	(0.038)
Conditional variance equation														
Constant	0.004**	0.007***	0.004***	0.003***	0.003***	0.006***	0.004***	0.002***	0.006***	0.000	0.004***	0.007***	0.003***	0.002***
	(0.002)	(0.001)	(0.001)	(0.001)	(0.001)	(0.002)	(0.001)	(0.001)	(0.001)	(0.012)	(0.001)	(0.001)	(0.001)	(0.001)
$(\varepsilon_{t-1}^{S(Euro.)})^2$	0.341***	0.037*	0.324***	-0.016	0.357***	-0.083	0.371***	0.048**	0.365***	0.014	0.335***	-0.001	0.320***	-0.021
	(0.031)	(0.019)	(0.043)	(0.024)	(0.035)	(0.056)	(0.036)	(0.023)	(0.044)	(0.055)	(0.034)	(0.040)	(0.035)	(0.019)
$(\varepsilon_{t-1}^{S(GCC)})^2$	-0.124	0.541***	0.067	0.374***	-0.049	0.404***	-0.012	0.252***	-0.029	1.022***	-0.005	0.489***	0.030	0.447***
	(0.076)	(0.059)	(0.076)	(0.049)	(0.046)	(0.048)	(0.021)	(0.022)	(0.046)	(0.076)	(0.033)	(0.042)	(0.041)	(0.037)
$(h_{t-1}^{S(Euro.)})^2$	0.934***	-0.008	0.940***	0.003	0.932***	0.029*	0.925***	-0.014**	0.912***	0.383***	0.938***	0.010	0.945***	0.004
	(0.012)	(0.008)	(0.015)	(0.008)	(0.011)	(0.017)	(0.013)	(0.007)	(0.027)	(0.057)	(0.012)	(0.014)	(0.011)	(0.006)
$(h_{t-1}^{S(GCC)})^2$	0.073	0.726***	-0.029	0.923***	0.040	0.868***	0.001	0.968***	0.037	-0.314**	0.003	0.861***	-0.017	0.907***
	(0.058)	(0.042)	(0.032)	(0.019)	(0.024)	(0.029)	(0.005)	(0.004)	(0.066)	(0.151)	(0.017)	(0.022)	(0.016)	(0.013)
$H(10)$	47.342		44.233		35.459		42.205		38.084		47.143		39.286	
	[0.142]		[0.225]		[0.588]		[0.294]		[0.466]		[0.147]		[0.412]	
BIC	-9.527		-8.819		-8.574		-7.894		-7.653		-7.975		-8.916	

Table 3.7- Continued from the previous page

Panel B	Euro.	Kuwait	Euro.	Oman	Euro.	Qatar	Euro.	Saudi	Euro.	UAE	Euro.	GCC
Conditional mean equation												
S(Euro.)	-0.027	-0.053*	-0.044	0.022	-0.057	-0.026	-0.067	-0.002	-0.037	-0.078***	-0.042	-0.068*
	(0.036)	(0.032)	(0.040)	(0.038)	(0.035)	(0.026)	(0.043)	(0.060)	(0.039)	(0.030)	(0.035)	(0.038)
S(GCC)	0.168***	0.016	0.069**	0.199***	0.031	-0.002	0.078***	-0.019	0.045*	0.035	0.031	0.113***
	(0.034)	(0.045)	(0.027)	(0.047)	(0.029)	(0.045)	(0.027)	(0.056)	(0.026)	(0.038)	(0.019)	(0.039)
Conditional variance equation												
constant	0.003**	0.011***	0.005***	0.005***	0.004***	0.005***	0.002	0.000	0.004***	0.002***	0.003***	0.004***
	(0.001)	(0.002)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.009)	(0.001)	(0.001)	(0.001)	(0.001)
$(\varepsilon_{t-1}^{S(Euro.)})^2$	0.259***	0.223***	0.372***	0.12***	0.334***	0.017	0.075*	-0.209***	0.369***	0.041**	0.336***	0.010
	(0.033)	(0.046)	(0.031)	(0.036)	(0.036)	(0.031)	(0.044)	(0.040)	(0.034)	(0.019)	(0.038)	(0.023)
$(\varepsilon_{t-1}^{S(GCC)})^2$	-0.068	0.646***	-0.014	0.409***	0.017	0.366***	0.299***	0.634***	-0.045	0.244***	-0.002	0.398***
	(0.050)	(0.067)	(0.034)	(0.037)	(0.019)	(0.042)	(0.054)	(0.053)	(0.029)	(0.028)	(0.041)	(0.043)
$(h_{t-1}^{S(Euro.)})^2$	0.944***	-0.027	0.920***	-0.047***	0.939***	-0.004	0.998***	0.039***	0.927***	-0.013**	0.941***	-0.001
	(0.010)	(0.028)	(0.013)	(0.013)	(0.013)	(0.010)	(0.007)	(0.010)	(0.013)	(0.006)	(0.014)	(0.008)
$(h_{t-1}^{S(GCC)})^2$	0.077**	0.718***	0.012	0.893***	-0.011	0.917***	-0.141***	0.803***	0.008	0.969***	-0.012	0.901***
	(0.032)	(0.052)	(0.014)	(0.016)	(0.008)	(0.018)	(0.021	(0.024)	0.008	(0.006)	(0.018)	(0.021)
$H(10)$	40.759		35.298		38.168		26.476		47.167		47.703	
	[0.350]		[0.595]		[0.462]		[0.920]		[0.146]		[0.135]	
BIC	-7.874		-8.780		-7.894		-8.043		-8.333		-8.772	

Notes: Equations (3.5), (3.6) and (3.7) of the bivariate VAR(1)-GARCH(1,1) model are estimated between the European (Euro.) financial return index and each of the GCC financial (Panel A) and non-financial (Panel B) return indices. For other details, please see notes in Table 3.5.

Figure 3.4: Volatility spillovers between the European financial sector and the GCC financial and non-financial sectors



3.6 CONCLUSION

This chapter investigates the contagion effect and volatility spillovers from the U.S. financial, the Dubai debt and the European sovereign debt crises to the Gulf Cooperation Council stock markets, with a particular focus on financial and non-financial sectors. To test for contagion, this work uses a recently developed approach by Grammatikos and Vermeulen (2012), who combine GARCH models with indicators of crisis, and applies a VAR(1)-GARCH(1,1) model as proposed by Ling and McAleer (2003) to explore the volatility transmission effect between the markets under this study.

The empirical analysis is carried out over four different periods in order to examine the impact of the diverse crises on the financial and non-financial sectors in the GCC countries. The findings show strong evidence of a contagion effect from the U.S. crisis on the Saudi stock market (both financial and non-financial sectors), Bahrain financial sector and Oman non-financial sector. During the Dubai debt crisis the results show evidence of shocks transmission to the financial sectors of Oman, Qatar, Saudi Arabia and the UAE, and a contagious effect on the non-financial sectors of Oman and the UAE are observed. During the European sovereign debt crisis, evidence of contagion effect is found, and it is more pronounced in the non-financial sectors of the UAE, Kuwait and Saudi Arabia. Evidence of volatility spillovers from the U.S. financial sector to the financial sectors of Kuwait, Saudi Arabia and the UAE and to the non-financial sectors of Kuwait and Saudi Arabia is also found. This effect is even stronger in case of the Dubai financial sector, while the volatility transmission from the European financial sector is generally weaker. Overall, the results show that most of the GCC stock markets are mainly driven by their idiosyncratic shocks, with the exception of Saudi Arabia and Oman, which are mostly affected by external shock.

The central message from these findings is that frontier stock markets in the GCC region are relatively sensitive to crisis developed in the U.S., Europe and Dubai, in particular the financial sectors. As such, domestic and foreign investors should be cautious about simultaneously investing in some of the GCC stock markets either in financial or non-financial sectors, since some of these market sectors exhibit a contagion effect during crisis periods while others show only interdependence. Furthermore, policy makers in the GCC countries may undertake measures to protect GCC markets from possible contagion during a crisis, by injecting the markets with more money which may help frontier markets like the GCC to significantly restrict any potential contagion effect in the future. In fact, the injection of money may increase the financial market stability across the GCC stock markets.

CHAPTER FOUR

THE GCC AND ASIAN STOCK MARKET LINKAGES: EVIDENCE FROM COINTEGRATION AND CORRELATION ANALYSES

4.1. INTRODUCTION

Financial market integration is crucial for economic development across countries. Over the last years, an increasing financial integration among national stock markets has enabled international investors to explore new investment opportunities, so they can enhance the risk-adjusted returns for their assets portfolio. This fact has led researchers to investigate the linkages between stock markets more intensively. Some literature has concluded that large comovements across equity markets have reduced potential diversification benefits (Eun and Shim, 1989; Taylor and Tonks, 1989; Campbell and Hamao, 1992). However, some empirical evidence has shown that there is still a room for diversification gains when investing in emerging stock markets because of their low correlation with the stock markets in developed countries (Harvey, 1993; Bekaert and Harvey, 1995; Harvey, 1995; Korajczyk, 1996; De Roon et al., 2001; Li et al., 2003; D'Ecclesia and Costantini, 2006; Driessen, and Laeven, 2007), though benefits seem to have declined recently with an impact on portfolio decision-making. As a result, a new interest for the frontier markets has emerged due to their least integration with mature equities, with a perspective of return potential and diversification benefits (see e.g., Speidell and Krohne, 2007; Berger et al., 2011; Bley and Saad, 2012).

The empirical literature has also highlighted the important role played by trade openness, bilateral relations and strong economic linkages for the integration of financial markets (see e.g., Chen and Zhang, 1997; Pretorius, 2002; Forbes and Chinn, 2004; Chambet and Gibson, 2008; Lahrech and Sylwester, 2011). An important case is represented by the increasing linkage among the economies of the GCC countries and developing Asian regions. Nowadays, Asia region is the GCC's most dominant trade partner (60 percent of total GCC foreign trade), not only in terms of hydrocarbon exports, but also in terms of manufactured goods (including machinery) and food. Further, migrant workers from Asia count half of the GCC labour force (Körner and Masett, 2014).

Despite these intensified links in trade investment and labour force between Asian and GCC countries, there are no studies in the empirical literature that investigate the degree of integration and time-varying correlation among these stock markets. This work attempts to fill this gap.

This study contributes to the existing literature on international stock markets linkage in some respects. First, to the best of our knowledge, this is the first study to examine whether the stock markets in the GCC region are integrated with Asian stock markets by looking at the extent to which economic integration and bilateral trade may affect cross-country comovements in stock returns. The analysis is conducted over the period 2003-2015 using weekly data and a cointegration approach based on trace test by Johansen (1988) and Johansen and Juselius (1990). Second, it investigates the extent to which bivariate correlations between GCC and Asian stock returns may have changed from 2003 to 2015 using the multivariate DCC-GARCH model by Engle (2002). In this way, we are able to detect time varying correlations conditional on the volatility of stock returns, which give information to investors on the degree of riskiness of these stock markets and the level of their comovements over time. In fact, cross-market correlations are one of the most important indicators for investors seeking to reduce market risk and optimise their portfolio gains by diversifying across market. Therefore, the use of the DCC-GARCH model here is appropriate because it enables the cross market correlations to change over time by allowing periods of high volatility to have an effect, and these correlations are adjusted based on the receipt of new information (Engle, 2002). Third, this work uses standard unconditional correlation to capture comovements in stock returns over time among GCC and Asian stock equities using a 4-years rolling window estimation. Moreover, this method enables us to check whether common stock market integration trends may exists. The degree of comovement provides relevant information on potential gains from diversification portfolio decision.

The empirical analysis offers three main results. First, GCC stock markets, particularly those with tight financial linkages (Saudi Arabia and the UAE), exhibit moderate evidence of cointegration with most of Asian stock markets. Furthermore, the stock markets of Oman and Qatar are cointegrated with those of Indonesia, Malaysia, while there is no cointegration between all the GCC stock markets and those of Japan and China. This suggests a low degree of integration among these markets in the period of the analysis. Second, there is strong evidence of time-varying correlation across markets returns, although not large in magnitude, and shocks to volatility are highly persistence, with some degree of riskiness for portfolio investments in the short-run. Third, looking at the results from the rolling analysis, stock returns comovements among the two regions are more pronounced during the financial crisis while after the crisis, the comovements remain low. This result might indicate some independences between those countries market returns in the long-run.

The remainder of this chapter is structured as follows. Section 4.2 reviews the literature. Section 4.3 describes data and Section 4.4 presents the methodology. Section 4.5 discusses the empirical results. Section 4.6 concludes.

4.2. LITERATURE REVIEW

The literature of this chapter focuses on two different aspects: equity markets linkages in the regions of Asia, and stock markets integration in the GCC region.

A number of studies have investigated the degree of linkages between Asian stock markets and the other world markets, particularly the U.S. market. These studies differ in the extent to which Asian markets are linked with the global markets. The empirical results are mixed. Early examples of these studies conducted before 1997-1998 Asian financial crisis were those of Arshanapalli et al. (1995) and DeFusco et al. (1996). In particular, Arshanapalli et al. (1995) studied the comovements of a group of five Asian markets (Hong Kong, Malaysia, Philippines, Singapore and Thailand) with the U.S. and Japan over the period 1989 to 1992 using cointegration and error-correction methods (see Engle and Granger, 1987, and Johansen, 1988). Their empirical results indicated that these equity markets are more integrated with the U.S. than with Japan and innovations from the U.S. market have more impact on Asian markets after October 1987 crash. Based on similar framework, DeFusco et al. (1996) studied the linkages between the U.S. and 13 emerging markets including Korea, Philippines, Taiwan, Malaysia and Thailand from the Asian region. The sample size covers the period from 1989 to 1993. Their empirical findings pointed to the absence of long-run linkages across Asian markets at the regional level and with the U.S market. Moreover, the correlations between their stock returns were low and negative in some cases. They suggested that there were potential gains from diversification across these markets. In a related study conducted after the 1997-1998 Asian financial crisis, Ghosh et al. (1999) provided evidence of increasing linkage between some of the Asian emerging markets and the U.S. and the Japanese stock equities after the Asian financial crisis. Nine less developed Asian-Pacific stock markets are considered in the analysis (Hong Kong, India, Korea, Taiwan, Malaysia, Singapore, Thailand, Indonesia, and Philippines), and cointegration and error correction analysis were carried out. Similar results were found by Yang et al. (2003). More specifically, Yang et al. (2003) examined the short and long-run relationships of the same stock markets over the period 1995 to 2001 and divided the sample size into pre-crisis, transition period and post-crisis sub periods. To better understand the role of the U.S. stock markets and its impact of the Asian stock market linkages, Kim et al. (2008) used gravity models to study the global and the regional integration of the equity markets in East Asia namely Hong Kong, Indonesia, Japan, Korea, Malaysia, Philippines, Singapore and Thailand, from 1997 through 2004. The authors found that East Asian markets are less integrated in the regional level and more integrated globally.

Other recent empirical studies have reached opposite conclusions about the Asian market movements with the regional and international equity markets. For instance, Chi et al. (2006) applied the International Capital Asset Pricing Model to analyse the financial integration across 11 East Asian markets (China, Hong Kong, India, Indonesia, Japan, Malaysia, the Philippines, Singapore, South Korea, Taiwan and Thailand) and the U.S. market. Their analysis covers the period 1991 to 2005. Their empirical results showed that the degree of financial integration among Asian markets in the region and the leading Asian market (Japan) tend to be higher than that with the U.S. market. On the contrary, using quantity and price-based measures during the period 2001 and 2010, Park and Lee (2011) suggested that Asian stock markets have become more integrated with both the global and regional markets. This paper used a sample of 11 stock markets from emerging economies in Asia consisting of China, Hong Kong, India, Indonesia, Malaysia, the Philippines, South Korea, Singapore, Taipei; China, Thailand, and Viet Nam.

As regard the stock markets integration in the GCC countries, a number of studies have examined the relationship across regional GCC stock prices. For instance, Al-Khazali et al. (2006) investigated the level of regional integration across four stock markets in the GCC region including Bahrain, Kuwait, Oman and Saudi Arabia, using the Johansen-Juselius (1990) cointegration framework based on weekly data from 1994 to 2003. Their results suggested that there is a common stochastic trend that binds these four GCC stock markets together over the long term. More recently, Aloui and Hkiri (2014) studied the comovements among stock prices of the six GCC economies over the period 2005-2010 at daily frequency. They used the Wavelet technique claiming that this method allows them to assess the frequency components without losing the time information of the stock equity time series. Their results showed some changes in the comovement's patterns across these markets, with more being observed after 2007.

A few studies have attempted to explore linkages of the GCC stock markets with the global markets. Abraham et al. (2001) used monthly return data from 1993 to 1998 and applied the Markowitz (1959) mean-variance efficient asset allocation to examine correlation between the S&P500 stock index and three GCC stock markets namely Bahrain, Kuwait and Saudi Arabia. The authors found low correlation between the GCC and U.S. stock markets, and suggested that this result is highly important for effective diversification strategies. Using different data set and empirical methods, Bley and Chen (2006) studied the behaviour of six GCC stock markets in terms of the degree of comovement across markets returns and investigated the impact of the U.S. and the U.K. equity market on the GCC markets. The analysis was based on weekly data over the period 2000 to 2004 and the Johansen (1988) and Johansen and Juselius (1990) cointegration frameworks were used. Their results showed evidence of increasing integration between markets and their correlations with the U.S. and the U.K. remained stable and low. The authors pointed to a possibility of diversification benefits among the equity markets under study. Arouri and Nguyen (2010) analysed the stock market comovements within the GCC region and with the world stock market index. Authors applied the DCC-GARCH model over a short period of 2005-2008 and included all the six GCC stock markets except Bahrain. The empirical results suggested no comovement between GCC stock markets and the world stock markets index. Alkulaib et al. (2009) investigated the relationship across the stock markets in the Middle East and North Africa (MENA) including the six GCC stock markets. This study was based on daily data covers the period from 1999 to 2004 using state space procedure. Their results showed that the stock markets in the GCC region have significant linkage with the Levant and North Africa and the UAE financial market being the leading market in the region. In a recent study based on weekly data running from 2004 to 2011, Khalifa et al. (2014) employed the multi-chain Markov switching model to analyse the linkages across six stock markets in the GCC region and the global markets (S&P 500 and the MSCI-world). Their results indicated that there are some levels of interdependence between the GCC and the global stock markets, particularly Saudi Arabia, Abu Dhabi and Dubai.

Other studies have focused on the GCC stock markets' integration with oil prices. Maghyereh and Alkandari (2007) studied the linkages between oil prices and four stock markets in the GCC countries of Bahrain, Kuwait, Oman, and Saudi Arabia. The analysis is based on daily data spanning from 1996 to 2003. They employed Breitung's cointegration approach to detect nonlinearity in the cointegration and concluded that nonlinearity exists in the relationship between the markets in the GCC region and oil prices. Using monthly data from 1996 to 2007 for the same GCC stock markets in Maghyereh and Alkandari (2007), Arouri and Rault (2012) applied recent bootstrap panel cointegration methods and seemingly unrelated regression (SUR) techniques to analyse the long-run linkage among these stock markets and oil prices. Evidence of cointegration relationship across these markets is found. Similarly, Akoum et al. (2012) used the wavelet squared coherence approach to analyse the dependencies of GCC stock equities with OPEC oil prices in the short-term and long-term over the period 2002-2011. They suggested that dependencies among (GCC stock-oil) returns were stronger after 2007.

Overall, these studies highlight the need to further empirical research on the level of equity market linkages and the implications related to increased volatility and correlations across the GCC's stock markets and other international stock markets over critical period that witnessed the global financial crisis, European sovereign debt crisis and high fluctuations in oil prices and more political and economic uncertainty. This study aims to address these issues.

4.3. DATA DESCRIPTION

This study uses weekly data on stock price indexes taken from DataStream for 12 countries over the period 31/12/2003-19/07/2015. The countries comprises five GCC countries, namely Bahrain, Oman, Qatar, Saudi Arabia and the UAE (Dubai), and seven Asian countries, namely China, India, Indonesia, Japan, Korea, Malaysia and Singapore. The choice of these countries was mainly dictated by the availability of data and strong economic linkages among them.

Figure 4.1: Comovements between the GCC and Asian price indices

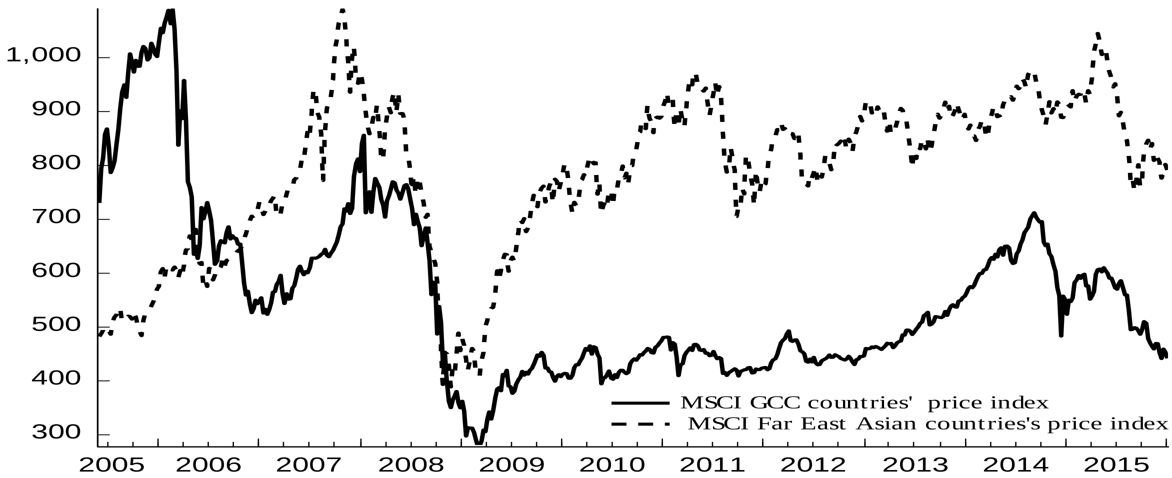


Figure 4.1 illustrates the price dynamics among the GCC stock markets (represented by the MSCI GCC countries price index) and all the Asian stock markets under study (represented by the MSCI Far East Asian countries price index)[14] over the period 2005 to 2015. As one can see, the two stock markets tend to move together, particularly after 2006 and onward. Furthermore, the impact of the 2008-2009 global financial crisis on the two regions is evident. In the aftermath of this turmoil, stock markets have started to recover and display relatively similar and stable movement.

Table 4.1: The GCC countries trade (exports and imports) with Asia region

	GCC exports to Asia			GCC imports from Asia		
	2004	2008	2014	2004	2008	2014
Bahrain	2.55	2.27	1.67	3.96	3.61	4.44
Oman	41.36	38.28	43.90	4.44	6.41	7.82
Qatar	5.60	4.66	12.59	2.88	4.01	4.41
Saudi Arabia	11.60	15.23	19.35	3.66	5.74	8.84
UAE	8.06	14.44	12.94	11.26	14.54	14.76

Notes: Values of exports and imports are calculated as % of each countries total exports and imports, respectively.
Source: DataStream

Table 4.1 reports both the total values of exports and imports of the GCC countries to and from Asian region in 2004, 2008 and 2014. The figures of exports and imports indicate substantial changes in trade between the two regions in recent years. When comparing the GCC trade patterns with Asian countries in 2004 and 2014, the values of exports and imports have increased, except Bahrain.[15] In the aftermath of the global financial crisis, when the world economy experienced a recession, the trade

[14] MSCI Far East Asian countries price index includes most of the Asian stock markets considered in this study. Therefore, it is expected these markets to exhibit similar patterns of movements.

[15] In recent years, Bahrain has experienced political uncertainty which makes it less appealing business environment.

between the two regions was also affected, and reduced (see the values of exports and imports in 2008).

Table 4.2 reports figures for market capitalization as a percentage to GDP, volume and value of stock trading, and number of listed securities for each market of the GCC and Asian regions for the years 2004, 2008 and 2014. Between 2004 and 2008, market capitalization as a percentage to GDP of the stock markets in the two regions has dropped significantly. However, these figures have recovered after the crisis and started to increase (see market capitalization as a percentage to GDP in 2014). In the contrary, volume and value of stock trading have increased until 2008 but then, they have declined dramatically in 2014 for both regions with the exception of China which has experienced an increase in these figures[16]. For the number of listed securities, the stock markets in the GCC and Asia regions have experienced an increase in this number with the exception of Oman, UAE, and Malaysia which have experienced a reduction in the listed shares, particularly between 2008 and 2014.

Table 4.3 includes descriptive statistics for the stock returns. The returns are computed as continuously compounded returns using the log differences of price, $log\, p_t - log\, p_{t-1}$, where p_t is closing value of the index at day *t*. As can be seen from Table 4.3 (Panel A), Qatar and UAE have the highest mean and UAE is the most volatile, with the standard deviation of 0.320 while Bahrain stock market is the less riskier market. Looking at Panel B, the highest mean is observed for China and India, and stock returns for China are the most volatile, with standard deviation of 0.284. The negative skewness and excess kurtosis of all the market returns in both panels indicate non-normal distributions. The null hypothesis of normality is rejected at 1% level in all the cases as indicated by the Jarque-Bera normality test. Thus, the return characteristics of all stock markets of the GCC and Asian regions show that these markets can be suitably modelled by GARCH models.

[16] In 2014, China experienced reform policies, the economy is injected by $163 billion, cut interest rates for the first time since 2012, and for the first time, Hong Kong and China has become a trading partner in this year.

Table 4.2: Characteristics of sample stock markets in the GCC and Asia regions

	Market capitalization as % of GDP			Stocks traded, total value (% of GDP)			Turnover ratio of domestic shares (%)			Listed domestic companies, total		
	2004	2008	2014	2004	2008	2014	2004	2008	2014	2004	2008	2014
Panel A: GCC												
Bahrain	103.00	77.60	65.60	3.10	11.50	1.00	3.60	12.60	1.90	38	45	43
Oman	38.10	33.80	46.20	7.20	13.80	7.10	31.50	44.20	15.60	225	122	117
Qatar	113.50	66.50	88.50	1.30	41.80	26.00	4.50	38.10	32.30	36	43	43
Saudi Arabia	118.40	74.30	64.70	74.10	163.50	76.00	204.10	137.80	119.40	73	135	169
UAE	37.50	34.00	50.50	3.00	45.90	35.90	10.40	152.60	75.10	32	103	62
Panel B: Asia												
China	23.10	39.00	58.00	26.30	85.70	115.50	106.50	124.80	240.30	1373	1604	2613
India	53.70	52.90	76.10	54.40	75.60	35.70	117.80	75.00	54.20	4725	4921	5541
Indonesia	53.90	19.40	47.50	8.30	14.90	10.20	17.70	48.90	23.60	331	396	506
Japan	76.40	64.30	95.10	74.30	128.10	105.30	106.20	166.80	108.60	2276	2374	3458
Korea	52.10	47.00	86.00	68.70	118.50	91.80	150.90	149.10	105.80	683	1789	1849
Malaysia	145.60	82.00	135.80	44.30	36.10	42.40	32.30	32.40	29.90	955	972	895
Singapore	190.50	137.80	244.50	97.00	131.60	65.20	60.60	62.90	26.80	536	455	484

Notes: The GCC and Asia regions stock market information about domestic listed companies is given in terms of market capitalization (as % of GDP), total values of stock traded (as % of GDP) and turnover ratio of domestic shares (%). Turnover ratio is calculated by dividing the total value of domestic shares by the average market capitalization. Source: World Development Indicators.

Table 4.3: Descriptive statistics. GCC and Asian stock market returns, 2004-2015

Countries	Mean	Maximum	Minimum	Std. Dev.	Skewness	Kurtosis	Jarque-Bera
Panel A: GCC							
Bahrain	-0.006	0.074	-0.079	0.106	-0.426	7.361	505.048***
Oman	0.038	0.151	-0.248	0.193	-1.580	21.521	9031.423***
Qatar	0.071	0.143	-0.277	0.269	-1.150	11.962	2190.031***
Saudi Arabia	0.022	0.138	-0.259	0.271	-1.473	10.141	1526.663***
UAE	0.089	0.234	-0.291	0.320	-0.946	10.903	1689.270***
Panel B: Asian countries							
China	0.151	0.139	-0.259	0.284	-0.735	7.284	524.846***
India	0.133	0.177	-0.156	0.228	-0.523	6.323	310.439***
Indonesia	0.091	0.204	-0.233	0.240	-1.135	12.695	2536.423***
Japan	0.053	0.198	-0.211	0.214	-0.803	8.227	764.776***
Korea	0.056	0.148	-0.167	0.207	-0.354	9.333	1039.021***
Malaysia	0.061	0.098	-0.086	0.128	-0.375	6.496	326.973***
Singapore	0.022	0.164	-0.148	0.172	-0.247	9.744	1169.714***

Notes: The descriptive statistics are reported for the sample stock market return indices of the GCC counties (Panel A) and Asian countries (Panel B). Statistics include annualized mean, maximum, minimum, annualized standard deviation (std. Dev.), skewness, and Kurtosis and Jarque-Bera normality test. *** denotes significance at the 1% level.

Table 4.4 summarizes the unconditional correlations of the GCC and Asian stock returns. The unconditional correlation coefficients for the GCC-Asian stock market return indices indicate moderate pairwise correlations. On average, the highest values of the pairwise correlations are observed for Qatar and Asian markets, while Bahrain turns to be the least correlated with the Asian markets.

Table 4.4: Unconditional correlations of the GCC and Asian stock market returns, 2004-2015

	Bahrain	Oman	Qatar	Saudi Arabia	UAE
China	0.083	0.209	0.197	0.161	0.236
India	0.111	0.259	0.313	0.267	0.277
Indonesia	0.276	0.360	0.366	0.279	0.314
Japan	0.198	0.367	0.361	0.310	0.342
Korea	0.193	0.330	0.349	0.309	0.309
Malaysia	0.163	0.318	0.316	0.268	0.310
Singapore	0.183	0.372	0.344	0.327	0.352

4.4. EMPIRICAL METHODOLOGY

The first objective of this study is to empirically investigate the existence of a long-run relationship among the stock market indices of the GCC and Asian countries. To this end, the Johansen cointegration trace test (Johansen, 1988; and Johansen and Juselius, 1990) and the vector error correction model (VECM) are used. Second, the time-varying correlations among the GCC and Asian stock market returns are computed using DCC-GARCH model of Engle (2002) so to investigate whether stock returns' correlation coefficients vary over time. In order to test and capture the comovements of the stock markets considered from the two regions, in this chapter we consider both models (the Johansen cointegration test and the DCC-GARCH) based on bivariate analysis by using two series at a time (one series from the GCC stock markets and the other one from Asian markets).

Lastly, we estimate the unconditional correlation using a rolling window scheme to measure financial integration among those countries under investigation.

4.4.1 The Johansen cointegration trace test and VECM model

Let us consider an unrestricted vector autoregressive (VAR) with *p* lags, y_t with n-dimensional vector that are *I*(*1)* and assumed to be cointegrated:

$$y_t = \beta_1 y_{t-1} + \beta_2 y_{t-2} + \cdots + \beta_p y_{t-p} + u_t, \tag{4.1}$$

where y_t are the stock prices of the markets considered in this study. In order to apply the Johansen approach, (4.1) is modified into a vector error correction model (VECM):

$$\Delta y_t = \Pi y_{t-p} + \Gamma_1 \Delta y_{t-1} + \Gamma_2 \Delta y_{t-2} + \cdots + \Gamma_{p-1} \Delta y_{t-(p-1)} + u_t,$$

or

$$\Delta y_t = \Pi\, y_{t-p} + \sum_{i=1}^{p-1} \Gamma_i\, \Delta y_{t-i} + u_t, \tag{4.2}$$

where $\Pi = -(I_n - \sum_{i=1}^{\mathrm{p}} \beta_i)$ and $\Gamma_i = -(I_n - \sum_{j=1}^{i} \beta_{\mathrm{j}}),\ u_t \sim (0, \Sigma_u)$.

In (4.2), Γ is a coefficient matrix, $\Pi\, y_{t-p}$ denotes the long-run equilibrium relationships across the variables, and Δy_{t-i} are stationary variables. The lag length (p) is chosen using the Akaike (AIC) and Schwarz (SIC) information Criteria.

In order to test for the number of cointegrating vectors (the rank of Π), Johansen (1988) and Johansen and Juselius (1990) developed two test statistics: The trace and the maximum eigenvalue statistics. Given the robustness of the trace test statistic over the maximum eigenvalue test, we only consider the trace test statistic.

The trace statistics is defined in terms of the estimated value for the i^{th} ordered eigenvalue (λ_i) from Π the matrix and the number of observations (*T*), as follows:

$$\lambda_{trace}(r) = -T \sum_{i=r+1}^{n} In(1 - \lambda_i), \tag{4.3}$$

where r indicates the number of cointegrating vectors under null hypothesis. A significant cointegrated vector is indicated by a significant non-zero eigenvalue. As for the λ_{trace} test, the null hypothesis of a number of cointegrating vectors less than or equal to r is tested against its general alternative that there are more than n cointegrating vectors.

The trace tests' critical values are provided by Johansen (1988) and Johansen and Juselius (1990). However, in this chapter, the critical values of Johansen trace test are computed using Doornik (1998) relevant response surface, since the inclusion of 2008 financial crisis dummy variable in some cases. If the value of the test statistic of the coefficient is more than the critical value, the null hypothesis then, states that there r cointegrating vectors is rejected in favour for the general alternative that there are more than $r + 1$.[17]

4.4.2 Modelling dynamic conditional correlations: DCC-GARCH model

The DCC model is one of the various families of multivariate GARCH (MGARCH) models (for a survey of these models, see Bauwens et al., 2006; Silvennoinen and Terasvirta, 2009; Laurent et al., 2012). Several studies that employ the DCC model indicate that it is well suited to robustly capture the correlation dynamics across financial assets (Cho and Parhizgari, 2008; Yu et al., 2010; Filis et al., 2011; Laurent et al., 2012; Boudt et al., 2013; Jones and Olson, 2013).

The estimation of the DCC model requires two steps. In the first step, a univariate GARCH(1,1) model is estimated for each stock return index under investigation to obtain the standardized residuals for the second step:

$$\sigma_{i,t}^2 = \omega_i + a_i \varepsilon_{i,t-1}^2 + b_i \sigma_{i,t-1}^2, \tag{4.4}$$

[17] For more details on the trace test statistic, see Brooks (2014).

where ω_i, a_i and b_i are parameters to be estimated, and to ensure the positivity of $\sigma_{i,t}^2$, $\omega_i > 0$, $a_i \geq 0$, and $b_i \geq 0$. The condition $a_i + b_i < 1$ ensures the stationarity of the conditional variance.

The matrix of the multivariate conditional variance H_t is defined as:

$$H_t = D_t R_t D_t, \tag{4.5}$$

where D_t is an $n \times n$ diagonal matrix of time-varying standard deviations from GARCH (1,1) model with the conditional standard deviations $\sqrt{h_{it}}$ along the i^{th} diagonal, i=1, 2, …, n, and R_t is the $n \times n$ matrix of the time-varying conditional correlation.

Engle (2002) proposed the dynamic conditional correlations multivariate (DCC-GARCH) model. It requires the estimation of fewer parameters compared to other MGARCH models, for large dynamic covariance matrices. In the second step of the estimation procedure, the standardized residuals obtained from the first step,$u_{i,t} = \varepsilon_{i,t}/\sqrt{h_{it}}$, are used for estimating the conditional correlation parameters. The framework of the DCC model has the following structure:

$$R_t = Q_t^{*-1/2} Q_t Q_t^{*-1/2}\,. \tag{4.6}$$

The $n \times n$ time-varying covariance matrix of u_t, $Q_t = \left(q_{ij,t}\right)$ is given by:

$$Q_t = (1 - \alpha - \beta)\bar{Q} + \alpha(z_{t-1} z'_{t-1}) + \beta Q_{t-1}, \tag{4.7}$$

where α and β are nonnegative scalar parameters satisfying $\alpha + \beta < 1$, $\bar{Q}$ is the unconditional variance matrix of the standardized residuals of u_t, and $Q_t^{*-1/2} = diag\left(\frac{1}{\sqrt{q_{ii,t}}}, \dots, \frac{1}{\sqrt{q_{nn,1}}}\right)$ is the diagonal matrix consists of the square root of the inverse of the Q_t diagonal elements. In equation (4.5), as long as Q_t is positive definite, the correlation matrix R_t is found with ones on the diagonal and off-diagonal elements less one in absolute value.

4.4.3 A proxy for dynamic unconditional correlation

There is a selection of alternative proxies to measure financial integration across international markets. In this section we use the proxy of the unconditional correlation coefficient to find whether a common integration trend exists among the two regional stock markets. This proxy is the most commonly used in empirical analyses and is computed using rolling window scheme (see, for example, Kearney and Lucey, 2004), and Billio et al. (2015) show that it performs particularly well when compared to other integration measures. The unconditional correlation is computed as follows:

$$\bar{\rho} = \frac{2}{N(N-1)} \sum_{i=1}^{N} \sum_{j=i+1}^{N} \rho_{ij}, \tag{4.8}$$

where $\rho_{ij} = \frac{\sigma_{ij}}{\sigma_i \sigma_j}$, the returns covariance between assets i and j, σ_{ij} is the covariance, $i,\ j\ \in \{1, \dots, N\}$, and σ_i is the standard deviation. Prior to evaluating the comovements among a group stock market returns, it is essential to first examine the first and second moments and compute their bilateral correlations (see Billio et al., 2015). More specifically, increasing market integration of two groups of stock markets is indicated through an increase in the correlations mean (calculated over rolling windows), combined with a simultaneous decline in the correlations variance, as shown in the equation above.[18]

4.5. EMPIRICAL RESULTS

In the empirical analysis, we first present the results of the Vector Error Correction Model (VECM), and then we report the estimation results of the DCC-GARCH model. Lastly, we estimate the unconditional correlation among stock returns using a rolling window scheme.

4.5.1 Cointegration analysis and VECM model

As a preliminary step of the cointegration analysis, the unit root properties of all variables of GCC and Asian stock market indices are investigated using the Augmented Dickey-Fuller (ADF, hereafter) (Dickey and Fuller, 1979) and Phillips-Perron (PP, hereafter) (Phillips and Perron, 1988) unit root tests. The results are presented in Table 4.5. The null hypothesis of a unit root cannot be rejected for the levels of all stock markets. When looking at the first difference of the variables, the results show that null hypothesis of the unit root can be rejected at the 1% significant level in all cases. Since all variables are found to be *I*(1), hence it is legitimate to test for cointegration.

[18] While in the previous section, the DCC model has been used to capture the correlation which is conditional on the volatility, here the unconditional correlation is used to grasp the integration process.

The cointegration tests are based on the estimation of an unrestricted VAR model (Lütkepohl and Krätzig, 2004). We estimate bivariate VARs among the stock prices of GCC and Asian countries. We use the AIC and SIC criteria to select the lags of the VAR model, and opt for the more parsimonious model combining the two criteria. However, in some cases, residuals autocorrelation test results are also used in addition (for the number of lags, see Appendix, Table 1). When estimating the Johansen trace test statistic, a dummy variable is included in the regression to account for the U.S. financial crisis which takes the value of one for the period 06/08/2008 to 25/03/2009, and zero otherwise. In general, the contagious effect, caused by the financial crises, results in increasing dependencies in share prices across countries. Therefore, by excluding the impact of the crisis in our analysis, allows us to obtain unbiased results in finding linkages (see Edwards, 2000; Chen et al., 2002).

Table 4.5: ADF and PP unit root tests results

Panel A: GCC stock indices				
Test	ADF Test		PP Test	
Country	Level	1st Difference	Level	1 Difference
Bahrain	-0.709	-13.960	-0.940	-23.692
	(0.842)	(0.000)	(0.775)	(0.000)
Oman	-0.812	-12.153	0.754	-27.426
	(0.887)	(0.000)	(0.876)	(0.000)
Qatar	-2.271	-15.687	-2.409	-25.119
	(0.182)	(0.000)	(0.140)	(0.000)
Saudi Arabia	-2.112	-11.89	-2.266	-24.417
	(0.240)	(0.000)	(0.183)	(0.000)
UAE	-1.612	-15.115	-1.788	-24.099
	(0.476)	(0.000)	(0.386)	(0.000)
Panel B: Asian stock indices				
Test	ADF Test		PP Test	
Country	Level	1st Difference	Level	1st Difference
China	-0.839	-23.126	-1.107	-23.636
	(0.807)	(0.000)	(0.715)	(0.000)
India	-1.385	-12.019	-1.435	-24.277
	(0.591)	(0.000)	(0.566)	(0.000)
Indonesia	-1.650	-12.798	-1.752	-25.767
	(0.456)	(0.000)	(0.405)	(0.000)
Japan	-1.196	-25.82	-1.174	-25.806
	(0.678)	(0.000)	(0.687)	(0.000)
Korea	-2.188	-26.243	-2.168	-26.288
	(0.211)	(0.000)	(0.219)	(0.000)
Malaysia	-1.345	-23.25	-1.373	-23.293
	(0.610)	(0.000)	(0.597)	(0.000)
Singapore	-2.224	-24.536	-2.337	-24.791
	(0.198)	(0.000)	(0.161)	(0.000)

Notes: A model with constant is considered for all the stock indexes. The lag length for both unit root tests is selected using Schwarz information criterion. P-values are in parenthesis.

The Johansen trace test results between each pair of stock markets are reported in Table 4.6. The results are mixed. As for Saudi Arabia and UAE, there is strong evidence of cointegration between the stock price index of these countries and the stock price indexes of the Asian countries (only in two cases there is no cointegration). For the other GCC countries, the evidence is less pronounced. In particular, the stock index of Qatar is cointegrated with those of India, Malaysia, and Indonesia, while that of Oman is cointegrated with those indexes of Indonesia, Malaysia and Singapore, and that of Bahrain is cointegrated with those Indonesia and Singapore. In general, there is very little evidence of cointegration between the stock price index of China and those of GCC countries, and no cointegration between the stock price index of Japan and those of the GCC countries. These results are consistent with those in Fernández-Serrano and Sosvilla-Rivero (2001) and Gupta and Guidi (2012), when studying Japan's integration with emerging markets, and in Marashdeh and Shrestha (2012), who suggested that the GCC countries equity markets are not cointegrated with developed markets. The results for China and Japan suggest that investor may enjoy a potential benefit by including stocks of these markets in their portfolio so to improve the risk-adjusted returns.

Table 4.6: Bivariate Johansen cointegration test results

Country		Bahrain	Oman	Qatar	Saudi Arabia	UAE
		λ_{trace}	λ_{trace}	λ_{trace}	λ_{trace}	λ_{trace}
China	r=0	9.370	14.700	16.050	19.630*	14.340
	r≤1	0.870	0.980	1.740	1.480	0.170
India	r=0	9.020	15.870	18.600*	19.790*	21.550**
	r≤1	2.370	0.060	2.500	2.830	2.190
Indonesia	r=0	19.510*	20.410**	20.850**	29.750***	22.860**
	r≤1	0.660	0.030	1.940	2.880	0.410
Japan	r=0	13.520	16.000	9.380	17.810	15.110
	r≤1	4.640	3.040	1.330	6.110	5.920
Korea	r=0	15.620	16.050	11.790	23.930**	20.920**
	r≤1	0.230	0.490	2.540	2.840	1.000
Malaysia	r=0	19.610	19.080*	25.060***	29.160***	22.420**
	r≤1	0.720	0.080	2.290	0.930	0.370
Singapore	r=0	20.850**	29.330***	16.100	32.430***	26.920***
	r≤1	0.460	5.050	4.070	2.700	1.230

Note: r indicates the number of cointegrating vectors. The lag length is chosen using the AIC and SIC criterion along with the results of autocorrelation tests. The critical values of Johansen trace test are computed using the relevant response surface as in Doornik (1998), since the inclusion of 2008 financial crisis dummy variable. *, **, *** indicate significance at the 10%, 5%, and 1% levels, respectively.

After running the Johansen cointegration test, we estimate a bivariate VECM model based on the cointegration results. The results are presented in Table 4.7 for Bahrain, Table 4.8 for Oman, Table 4.9 for Qatar, Table 4.10 for Saudi Arabia and Table 4.11 for the UAE. Looking at the error correction term (ECT), the results are highly significant for some pairs of GCC-Asian stock markets, particularly in case of Indonesia, Malaysia and Singapore. The ECT implies that the short-run dynamics between some of GCC-Asian stock markets guarantee the reversion back to the common trend. The casual linkage among the GCC and Asian stock markets is guarantee by the significance of the lagged terms.

Table 4.7: VECM estimates and diagnostics for Bahrain

Short-run and long-run coefficient estimates					
Lag order (*p*)	1	2	3		ECT
Bahrain-Indonesia	-0.014	0.003	0.020		-0.002**
	(0.018)	(0.016)	(0.018)		(0.001)
Indonesia-Bahrain	-0.155*	-0.124	0.074		-0.010***
	(0.093)	(0.092)	(0.093)		(0.002)
Diagnostic tests	Q_{16}	FLM_h	LJB_K^L	$MARCH_{LM}$	
	58.778	12.109	1174.436	129.94	
	[0.184]	[0.437]	[0.000]	[0.000]	
Lag order (*p*)	1	2	3		ECT
Bahrain -Singapore	0.058**	-0.018	0.038		0.000
	(0.025)	(0.025)	(0.025)		(0.000)
Singapore-Bahrain	-0.173***	-0.133**	0.040		-0.002***
	(0.067)	(0.066)	(0.066)		(0.000)
Diagnostic tests	Q_{16}	FLM_h	LJB_K^L	$MARCH_{LM}$	
	46.575	4.564	616.62	132.8	
	[0.753]	[0.803]	[0.000]	[0.000]	

Notes: This table reports the estimates of the VEC model for Bahrain and Asian markets. ECT indicates the error correction term. FLM_h denotes Breusch-Godfrey LM test for autocorrelation up to order h. Q_h denotes the multivariate Ljiung-Box Portnebtau test. LJB_K^L is the multivariate Lomnichi-Jarque-Bera measure for non-normality. $MARCH_{LM}$ is the multivariate ARCH LM test. Numbers in brackets for diagnostic tests are p-values. *, **, *** indicate significance at the 10%, 5%, and 1% levels, respectively. Standard errors are in parenthesis.

Table 4.8: VECM estimates and diagnostics for Oman

Short-run and long-run coefficient estimates					
Lag order (*p*)	1	2	3	4	ECT
Oman-Indonesia	-0.051	-0.033	0.118***	0.026	-0.005***
	(0.037)	(0.037)	(0.037)	(0.037)	(0.002)
Indonesia-Oman	-0.048	-0.060	0.122***	-0.164***	-0.007***
	(0.049)	(0.049)	(0.049)	(0.049)	(0.002)
Diagnostic tests	Q_{16}	FLM_h	LJB_K^L	$MARCH_{LM}$	
	87.177	21.85	4785.285	290.06	
	[0.000]	[0.148]	[0.000]	[0.000]	
Lag order (*p*)	1	2	3		ECT
Oman-Malaysia	-0.020	0.021	0.103		-0.005***
	(0.066)	(0.065)	(0.065)		(0.001)
Malaysia-Oman	-0.068***	-0.059**	0.052*		-0.004***
	(0.027)	(0.028)	(0.027)		(0.001)
Diagnostic tests	Q_{16}	FLM_h	LJB_K^L	$MARCH_{LM}$	
	105.904	8.802	4364.696	328.019	
	[0.000]	[0.719]	[0.000]	[0.000]	
Lag order (*p*)	1	2			ECT
Oman -Singapore	0.117**	-0.114**			-0.027***
	(0.052)	(0.052)			(0.006)
Singapore-Oman	-0.097***	0.010			-0.013***
	(0.036)	(0.036)			(0.005)
Diagnostic tests	Q_{16}	FLM_h	LJB_K^L	$MARCH_{LM}$	
	100.138	15.692	4507.207	240.84	
	[0.000]	[0.205]	[0.000]	[0.000]	

Notes: This table reports the estimates of the VEC model for Oman and Asian stock markets. For other details, see notes in Table 4.7.

Table 4.9: VECM estimates and diagnostics for Qatar

Short-run and long-run coefficient estimates					
Lag order (*p*)	1	2	3		ECT
Qatar-Indonesia	0.007	-0.059	0.044		-0.020***
	(0.053)	(0.049)	(0.050)		(0.005)
Indonesia-Qatar	-0.028	0.012	0.105***		-0.024***
	(0.037)	(0.037)	(0.037)		(0.005)
Diagnostic tests	Q_{16}	FLM_h	LJB_K^L	$MARCH_{LM}$	
	71.007	13.194	1312.8	179.561	
	[0.027]	[0.355]	[0.000]	[0.000]	
Lag order (*p*)	1	2	3		ECT
Qatar-Malaysia	-0.038	-0.152*	0.113		-0.024***
	(0.089)	(0.088)	(0.088)		(0.006)
Malaysia-Qatar	-0.049**	0.003	0.038*		-0.015***
	(0.020)	(0.017)	(0.020)		(0.003)
Diagnostic tests	Q_{16}	FLM_h	LJB_K^L	$MARCH_{LM}$	
	27.428	13.011	1346.424	186.12	
	[0.195]	[0.368]	[0.000]	[0.000]	
Lag order (*p*)	1	2			ECT
Qatar -Singapore	0.179***	-0.097			-0.012***
	(0.067)	(0.067)			(0.004)
Singapore-Qatar	-0.078***	0.012			-0.013***
	(0.027)	(0.027)			(0.003)
Diagnostic tests	Q_{16}	FLM_h	LJB_K^L	$MARCH_{LM}$	
	78.613	13.218	1327.072	177.996	
	[0.006]	[0.105]	[0.000]	[0.000]	

Notes: This table reports the estimates of the VEC model for Qatar and Asian stock markets. For other details, see notes in Table 4.7.

Table 4.10: VECM estimates and diagnostics for Saudi Arabia

Short-run and long-run coefficient estimates								
Lag order (*p*)	1	2						ECT
Saudi- India	0.005	-0.031						-0.010***
	(0.046)	(0.046)						(0.003)
India-Saudi	0.006	-0.022						-0.004
	(0.038)	(0.038)						(0.003)
Diagnostic tests	Q_{16}	FLM_h	LJB_K^L	$MARCH_{LM}$				
	50.286	5.304	1244.803	63.318				
	[0.087]	[0.258]	[0.000]	[0.000]				
Lag order (*p*)	1	2	3	4	5	6	7	ECT
Saudi -Indonesia	0.023	-0.060	0.057	-0.015	0.056	0.084*	0.023	-0.007**
	(0.048)	(0.049)	(0.049)	(0.048)	(0.049)	(0.049)	(0.049)	(0.004)
Indonesia-Saudi	-0.019	-0.018	0.032	-0.046	0.102***	0.028	-0.007	-0.009***
	(0.036)	(0.036)	(0.037)	(0.036)	(0.036)	(0.037)	(0.036)	(0.003)
Diagnostic tests	Q_{16}	FLM_h	LJB_K^L	$MARCH_{LM}$				
	33.022	30.044	2273.881	369.42				
	[0.515]	[0.361]	[0.000]	[0.000]				
Lag order (*p*)	1	2	3	4	5	6	7	ECT
Saudi -Korea	0.056	-0.064	0.090*	0.057	0.067	0.089*	-0.097*	-0.015***
	(0.054)	(0.053)	(0.053)	(0.053)	(0.054)	(0.053)	(0.053)	(0.003)
Korea-Saudi	-0.043	-0.040	0.021	-0.055	0.076**	0.006	-0.018	-0.010***
	(0.034)	(0.033)	(0.034)	(0.034)	(0.034)	(0.034)	(0.033)	(0.003)
Diagnostic tests	Q_{16}	FLM_h	LJB_K^L	$MARCH_{LM}$				
	69.84	24.653	2539.404	393.25				
	[0.137]	[0.215]	[0.000]	[0.000]				
Lag order (*p*)	1							ECT
Saudi-Malaysia	-0.051							-0.009**
	(0.088)							(0.004)
Malaysia-Saudi	-0.017							-0.006***
	(0.021)							(0.002)
Diagnostic tests	Q_{16}	FLM_h	LJB_K^L	$MARCH_{LM}$				
	89.591	1.519	2242.179	66.477				
	[0.105]	[0.823]	[0.000]	[0.000]				
Lag order (*p*)	1	2	3	4				ECT
Saudi-Singapore	0.073	-0.080	-0.016	0.029				-0.010***
	(0.066)	(0.067)	(0.065)	(0.067)				(0.002)
Singapore-Saudi	-0.080***	-0.004	0.002	-0.012				-0.009***
	(0.027)	(0.031)	(0.024)	(0.027)				(0.001)
Diagnostic tests	Q_{16}	FLM_h	LJB_K^L	$MARCH_{LM}$				
	57.658	23.615	2829.354	217.63				
	[0.116]	[0.098]	[0.000]	[0.000]				

Notes: This table reports the estimates of the VEC model for Saudi Arabia and Asian stock markets. For other details, see notes in Table 4.7.

Table 4.11: VECM estimates and diagnostics for UAE

Short-run and long-run coefficient estimates					
Lag order (*p*)	1	2	3	4	ECT
UAE-India	0.064	0.044	0.171***	0.059	-0.004
	(0.055)	(0.055)	(0.054)	(0.055)	(0.001)
India-UAE	-0.043	-0.011	0.029	-0.044	-0.003
	(0.031)	(0.031)	(0.031)	(0.031)	(0.001)
Diagnostic tests	Q_{16}	FLM_h	LJB_K^L	$MARCH_{LM}$	
	60.9	11.5	1480.87	209.7	
	[0.070]	[0.780]	[0.000]	[0.000]	
Lag order (*p*)	1	2	3		ECT
UAE-Indonesia	-0.007	-0.014	0.107*		-0.006***
	(0.061)	(0.057)	(0.059)		(0.002)
Indonesia-UAE	-0.063**	-0.015	0.040***		-0.006***
	(0.030)	(0.029)	(0.029)		(0.001)
Diagnostic tests	Q_{16}	FLM_h	LJB_K^L	$MARCH_{LM}$	
	48.48	15.29	1925	259.68	
	[0.530]	[0.500]	[0.000]	[0.000]	
Lag order (*p*)	1	2	3	4	ECT
UAE-Korea	0.033	-0.058	0.219***	0.064	-0.005***
	(0.064)	(0.065)	(0.064)	(0.064)	(0.001)
Korea -UAE	-0.073***	0.010	0.047*	-0.081***	-0.003***
	(0.028)	(0.026)	(0.027)	(0.027)	(0.001)
Diagnostic tests	Q_{16}	FLM_h	LJB_K^L	$MARCH_{LM}$	
	18.95	16.07	1760.66	397.09	
	[0.170]	[0.450]	[0.000]	[0.000]	
Lag order (*p*)	1	2			ECT
UAE-Malaysia	-0.078	0.155			-0.006
	(0.106)	(0.106)			(0.002)
Malaysia-UAE	-0.029*	-0.031*			-0.003
	(0.016)	(0.017)			(0.001)
Diagnostic tests	Q_{16}	FLM_h	LJB_K^L	$MARCH_{LM}$	
	72.74	7.66	1459.93	192.69	
	[0.050]	[0.470]	[0.000]	[0.000]	
Lag order (*p*)	1	2	3	4	ECT
UAE -Singapore	0.079	-0.062	0.262***	0.127	-0.003***
	(0.082)	(0.082)	(0.081)	(0.081)	(0.001)
Singapore-UAE	-0.080***	-0.002	0.006	-0.058***	-0.002***
	(0.022)	(0.022)	(0.021)	(0.022)	(0.000)
Diagnostic tests	Q_{16}	FLM_h	LJB_K^L	$MARCH_{LM}$	
	9.39	16.2	1803.97	214.98	
	[0.500]	[0.440]	[0.000]	[0.000]	

Notes: This table reports the estimates of the VEC model for the UAE and Asian stock markets. For other details, see notes in Table 4.7.

4.5.2 Dynamic conditional correlation

The multivariate DCC-GARCH model is estimated in order to examine the time-varying conditional correlations between each pair of GCC and Asian stock markets. As a first step, the standardized residuals of the univariate GARCH(1,1) specifications are obtained so to use those to estimate the conditional correlations of the DCC model.

Table 4.12: Univariate GARCH(1,1) estimation results

Stock markets							
Panel A: GCC	ω_i	a_i	b_i	$a_i + b_i$	Q(5)	ARCH(5)	BIC
Bahrain	0.000	0.138***	0.794***	0.932	4.447 [0.217]	0.096 [0.907]	-5.686
	(0.001)	(0.046)	(0.058)				
Oman	0.002***	0.261***	0.695***	0.956	0.904 [0.824]	0.182 [0.969]	-4.917
	(0.001)	(0.051)	(0.051)				
Qatar	0.002**	0.228***	0.749***	0.977	5.176 [0.159]	0.917 [0.468]	-4.097
	(0.001)	(0.080)	(0.079)				
Saudi Arabia	0.003***	0.421***	0.556***	0.977	2.014 [0.569]	0.398 [0.850]	-4.104
	(0.001)	(0.108)	(0.074)				
UAE	0.003*	0.313***	0.641***	0.954	5.426 [0.143]	0.996 [0.419]	-3.617
	(0.002)	(0.092)	(0.074)				
Panel B: Asia	ω_i	a_i	b_i	$a_i + b_i$	Q(5)	ARCH(5)	BIC
China	0.002	0.112*	0.864***	0.976	4.492 [0.212]	0.858 [0.508]	-3.693
	(0.002)	(0.059)	(0.069)				
India	0.003**	0.161**	0.796***	0.957	2.344 [0.503]	0.412 [0.840]	-4.079
	(0.001)	(0.068)	(0.082)				
Indonesia	0.003***	0.200***	0.784***	0.984	6.156 [0.104]	1.209 [0.303]	-4.281
	(0.001)	(0.058)	(0.053				
Japan	0.003**	0.102***	0.837***	0.939	0.916 [0.821]	0.174 [0.972]	-4.299
	(0.001)	(0.041)	(0.056)				
Korea	0.003***	0.292**	0.617***	0.909	1.438 [0.696]	0.277 [0.925]	-4.493
	(0.001)	(0.130)	(0.131)				
Malaysia	0.002***	0.139**	0.860***	0.999	3.332 [0.343]	0.625 [0.680]	-5.407
	(0.001)	(0.059)	(0.053)				
Singapore	0.002***	0.206**	0.764***	0.970	3.660 [0.300]	0.735 [0.597]	-4.973
	(0.001)	(0.096)	(0.105)				

Notes: Equation (4.4) of univariate GARCH(1,1) is estimated for all the GCC and Asian stock market returns. Q(5) is the Ljung–Box statistic for serial correlation in the residuals. ARCH is the Engle (1982) test for conditional heteroscedasticity of order 5. *p*-values of Q-statistics and ARCH test are in brackets. *, **, *** denote statistical significance at 10%, 5% and 1%, respectively. Standard errors are in parenthesis.

The results of univariate GARCH(1,1) model for each of the stock markets under investigation are reported in Table 4.12. The effects of the coefficients a_i (ARCH) and b_i (GARCH) are found to be statistically significant for all the stock markets. This result is in-line with the hypothesis of time varying volatility. Furthermore, the sum of the volatility dynamics ($a_i + b_i$) is close to unity, which shows that the stock returns' volatility is highly persistent and takes longer to return to its mean.

Once the GARCH(1,1) models are estimated, the standardized residuals from the conditional variance equations are obtained. In Table 4.13, the results for the DCC model are reported. As for the correlation coefficients ($\rho_{ij,t}$) of the DCC model, positive values, ranging from 0.028 (Bahrain-China) to 0.339 (Qatar-Singapore), are found. More specifically, Asian markets tend to be correlated with more developing GCC stock markets (Qatar and UAE), largest GCC stock markets for capitalization and Saudi Arabia (the biggest crude oil exporter). In addition, unlike the cointegration results in Table 4.6, China and Japan have quite moderate dynamic correlation with the GCC emerging markets (Qatar and UAE) and the GCC's largest stock market (Saudi Arabia). This result is consistent with the financial theory of the inverse relationship between cointegration and correlation measures (see Alexander, 2008, p.225). Overall, the results indicate absence of cointegration and correlations between some of the GCC and Asian stock markets. In addition, the sum of the volatility dynamics ($\alpha + \beta$) is close to unity, which indicates that the stock returns' behaviour for each pair-wise correlation is highly persistent and mean reverting.

This result implies that international diversification benefits exist whether investors intent to include some of these market assets in their portfolio. The results of the present study are in line with those in Bowman et al. (2010) and Gupta and Guidi (2012), who analyse the integration of Asian markets with other international capital markets.

Table 4.13: Bivariate DCC estimates among (GCC-Asian) stock market returns

GCC-Asian	α	β	$\alpha+\beta$	$\rho_{ij,t}$	*H*(5)	BIC
Bahrain-China	0.053	0.728***	0.781	0.028	11.707 [0.862]	-9.362
	(0.033)	(0.094)		(0.057)		
Bahrain-India	0.017	0.592**	0.609	0.058	12.831 [0.802]	-9.760
	(0.039)	(0.300)		(0.045)		
Bahrain-Indonesia	0.014	0.934***	0.948	0.200***	20.313 [0.316]	-9.958
	(0.012)	(0.035)		(0.050)		
Bahrain-Japan	0.023*	0.924***	0.947	0.105*	28.535 [0.054]	-9.917
	(0.012)	(0.034)		(0.058)		
Bahrain-Korea	0.067	0.030***	0.097	0.101*	16.868 [0.532]	-10.144
	(0.052)	(1.002)		(0.047)		
Bahrain-Malaysia	0.022	0.805***	0.827	0.090*	12.387 [0.827]	-10.986
	(0.025)	(0.178)		(0.050)		
Bahrain-Singapore	0.092	0.029***	0.121	0.075	12.044 [0.845]	-10.548
	(0.050)	(0.486)		(0.048)		
Oman-China	0.015	0.977***	0.992	0.152	19.797 [0.344]	-8.578
	(0.013)	(0.036)		(0.185)		
Oman-India	0.023	0.953***	0.976	0.153*	11.029 [0.893]	-8.983
	(0.018)	(0.045)		(0.079)		
Oman-Indonesia	0.060	0.828***	0.888	0.159***	25.068 [0.123]	-9.143
	(0.050)	(0.168)		(0.062)		
Oman-Japan	0.024	0.924***	0.948	0.250***	31.737 [0.024]	-9.161
	(0.017)	(0.071)		(0.067)		
Oman-Korea	0.028**	0.961***	0.989	0.127	36.122 [0.007]	-9.453
	(0.013)	(0.024)		(0.130)		
Oman-Malaysia	0.021	0.963***	0.984	0.245***	23.949 [0.157]	-10.234
	(0.051)	(0.132)		(0.091)		
Oman-Singapore	0.061***	0.858***	0.919	0.197***	19.768 [0.346]	-9.787
	(0.023)	(0.056)		(0.067)		
Qatar-China	0.049*	0.865***	0.914	0.200***	19.314 [0.373]	-7.815
	(0.026)	(0.083)		(0.055)		
Qatar-India	0.015*	0.968***	0.983	0.252***	20.604 [0.299]	0.101
	(0.009)	(0.023)		(0.092)		
Qatar-Indonesia	0.045*	0.934***	0.979	0.301***	15.681 [0.615]	-8.442
	(0.050)	(0.089)		(0.117)		
Qatar-Japan	0.044**	0.866***	0.910	0.321***	19.511 [0.361]	-8.422
	(0.018)	(0.036)		(0.060)		
Qatar-Korea	0.030*	0.963***	0.993	0.272	19.113 [0.384]	-8.634
	(0.016)	(0.037)		(0.350)		
Qatar-Malaysia	0.078*	0.695***	0.773	0.262***	23.271 [0.180]	-9.463
	(0.041)	(0.230)		(0.056)		
Qatar-Singapore	0.109***	0.848***	0.957	0.339***	15.586 [0.621]	-9.083
	(0.033)	(0.047)		(0.103)		

Table 4.13- Continued from the previous page

GCC-Asian	α	β	$\alpha+\beta$	$\rho_{ij,t}$	*H*(5)	BIC
Saudi-China	0.029***	0.942***	0.971	0.155**	9.286 [0.953]	-7.766
	(0.011)	(0.020)		(0.074)		
Saudi-India	0.025*	0.954***	0.979	0.225**	10.880 [0.899]	-8.199
	(0.014)	(0.037)		(0.096)		
Saudi-Indonesia	0.038**	0.945***	0.983	0.238*	24.482 [0.139]	-8.362
	(0.017)	(0.027)		(0.129)		
Saudi-Japan	0.052***	0.910***	0.962	0.231***	64.950 [0.000]	-8.548
	(0.015)	(0.025)		(0.082)		
Saudi-Korea	0.046**	0.933***	0.979	0.266**	18.387 [0.430]	-8.611
	(0.020)	(0.031)		(0.119)		
Saudi-Malaysia	0.040	0.942***	0.982	0.288***	18.844 [0.401]	-9.437
	(0.025)	(0.043)		(0.106)		
Saudi-Singapore	0.051***	0.922***	0.973	0.325***	21.646 [0.248]	-9.027
	(0.017)	(0.024)		(0.113)		
UAE-China	0.015*	0.970***	0.985	0.256***	15.628 [0.618]	-7.334
	(0.008)	(0.017)		(0.066)		
UAE-India	0.027**	0.948***	0.975	0.278***	14.468 [0.698]	-7.757
	(0.011)	(0.020)		(0.071)		
UAE-Indonesia	0.031*	0.947***	0.978	0.276***	13.776 [0.744]	-7.923
	(0.017)	(0.028)		(0.084)		
UAE-Japan	0.026	0.914***	0.940	0.285***	22.050 [0.229]	-7.900
	(0.017)	(0.050)		(0.053)		
UAE-Korea	0.016*	0.971***	0.987	0.265***	24.212 [0.148]	-8.162
	(0.010)	(0.017)		(0.088)		
UAE-Malaysia	0.024**	0.964***	0.988	0.263***	39.176 [0.416]	-8.985
	(0.010)	(0.020)		(0.101)		
UAE-Singapore	0.028**	0.955***	0.983	0.298***	22.848 [0.196]	-8.555
	(0.013)	(0.022)		(0.088)		

Notes: Equations (4.7) and (4.8) of the DCC model are estimated between the GCC and Asian stock markets returns. *H*(5) is the multivariate Portmanteau test of Hosking (1980) for serial correlation. p-values for diagnostic tests are in brackets. *, **, *** indicate significance at the 10%, 5%, and 1% levels, respectively. Standard errors are in parenthesis.

4.5.3 Unconditional correlations

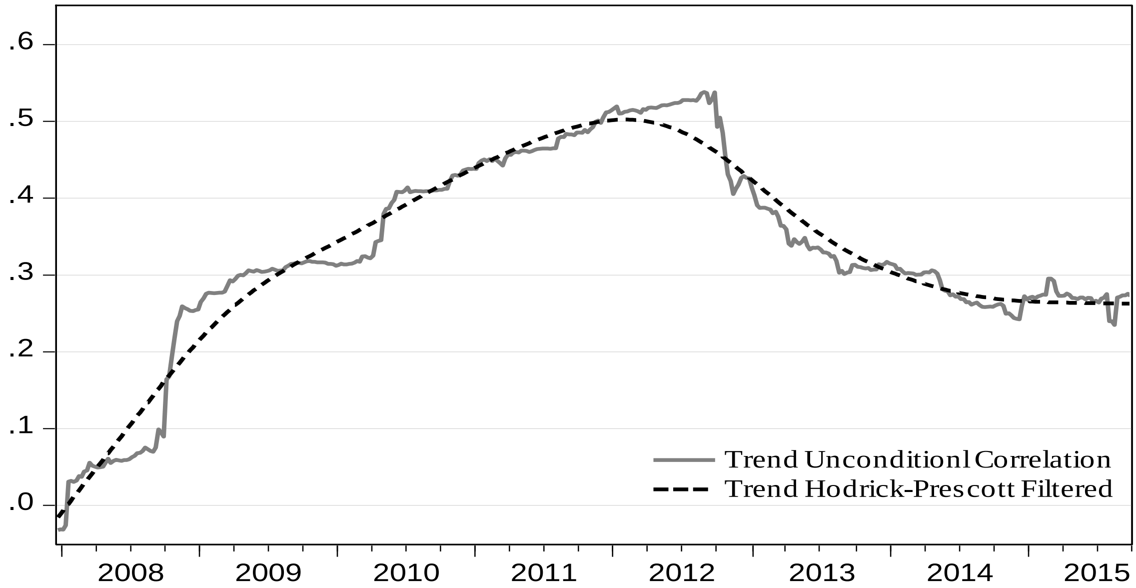
In this section, we present the unconditional correlations between Saudi Arabia stock returns and Asian stock market returns. A rolling window of four calendar years (208 weeks) is used to estimate the dynamic over time. The present study considers Saudi Arabia as the leading country for the GCC, with the highest market capitalization in the GCC region and the largest economic ties with Asia. For instance, during the period 2005-2012 Saudi Arabia accounted for more than 50% of Chinese investment in the GCC region, with 46% of all inward FDI. Furthermore, the GCC is biggest supplier of oil needs to Asian economies, and Saudi Arabia is the largest exporter (Körner and

Masetti, 2014). The integration trend is extracted via the unconditional correlation coefficient in order to capture the similarities between the comovements of the stock market returns of the two regions. From equation (4.8), the average correlations between the Saudi stock market returns (i) and the returns of every Asian stock market (j) considered in this study are computed over rolling windows, which is around four calendar years or 208 weekly observations at a time. The choice of the rolling window length is based on development in the trade and investment between the economies of the GCC and Asia regions. The estimated correlation coefficients of both assets ($i \text{ and } j$) denotes the end points of the windows (or the past window length).

In Figure 4.2, the dynamic of the unconditional correlation among Saudi Arabia stock market and all the Asian stock markets is illustrated. The integration trend is extracted via the unconditional correlation coefficient and then filtered by Hodrick-Prescott filter to obtain a smooth estimate of the long-term trend for the series. The correlation pattern shows an increasing integration from 2008 to 2012 across the markets under consideration. However, starting from 2013, these markets have become less integrated. When looking at the extracted trend, it emerges that the financial integration increase remarkably during the global crisis and reached a peak during 2011-2012, to decline afterwards and becomes stable at the beginning of 2014 and forward, particularly during the drop in the world trade and investments across countries after the US subprime crisis. The trend pattern reflects those market characteristics illustrated in Table 4.1. This study also uses Dubai financial market price index as a benchmark for the GCC stock markets, and a similar correlation coefficient is obtained.

Therefore, the integration patterns between the GCC and Asian stock markets captured by the proxy of unconditional correlations implies important indication for investors an policy makers about the degree of market integration across the stock markets of the two regions. The upward trend during the crisis period shows an increased integration while the flattened trend after the crisis indicates low integration between the stock markets in these two regions. Overall results suggest potential portfolio diversification benefits available in the recent years due to the decreased integration levels in the two regions. This result is also important for policy makers to ensure financial stability.

Figure 4.2: The GCC and Asian stock markets integration patterns



Notes: The figure illustrates the integration dynamics among the two regional GCC and Asian stock markets. The integration trend is extracted via the unconditional correlation coefficient and then filtered by Hodrick-Prescott filter to obtain a smooth estimate of the long-term trend for the series. A rolling window of 208 weeks is used to compute the coefficient of unconditional correlation.

4.6. CONCLUSION

This chapter explored the extent to which the GCC (Bahrain, Oman, Qatar, Saudi Arabia and the UAE) and Asian (China, India, Indonesia, Japan, Korea, Malaysia and Singapore) equity markets were cointegrated and moved together over the period December 31st, 2003 to September 30th, 2015.

This chapter uses three different methods to analyse the movement across the stock markets considered in the GCC and Asian regions. The first method is the Johansen trace statistics to test for cointegration. The second one is the DCC-GARCH model that is used to assess the time dependent conditional correlations. The third technique used in the analysis is the standard unconditional correlation which is computed using 4-years rolling window estimation. Using this measure we are able check for the existence of common trends across these markets.

The empirical results show evidence of cointegration between some of the stock price indices of the GCC countries and those of the emerging Asian countries. In particular, it emerges that the stock price index of Bahrain is the least cointegrated with those of the Asian markets, while that of Saudi Arabia and the UAE are the most cointegrated with the Asian stock indices. Furthermore, the results of the temporal casual dynamics tested through the VECM indicate the existence of short-term causality channels between GCC and Asian stock markets (see the significance of the lagged terms). For the error correction term (ECT), the results are highly significant for some pairs of GCC and Asian stock markets. This implies that the short-run dynamics among the stock markets considered guarantee the reversion back to the common trend.

The estimation results related to the DCC model offer relevant information on the time-varying correlations across the GCC and Asian stock markets. All the GCC stock markets exhibit no constant but increasing time-varying correlations with the Asian developed market (see, for example, Japan), while the lowest correlation with the emerging market of China is observed. Furthermore, findings indicate no constant correlations across the stock markets under investigation.

Overall, results of this study may be relevant for policy makers and investors. Policy makers should aim to find means to ensure financial stability, since a shock that hit one market can easily be transmitted to other markets in the two regions (see Yu et al., 2010). For investors, the results concerning cointegration and correlation imply that the international diversification benefits are limited for Saudi and the UAE countries and Indonesia, Malaysia, and Singapore, given the existence of a long-run relationship among stocks markets of these countries, the significant time-varying correlations and the high persistence of shocks to their volatility. However, evidence of independence between some of the GCC (Bahrain and Oman) markets and some of the Asian markets (China, India, Korea, and Japan) along with insignificant time-dependent correlations and no cointegration point to some diversification benefits across these markets. The results also imply that in the short run period there are some incentives for investors, despite a lack of arbitrage opportunities in some of the GCC and Asian stock markets in the long run period.

Appendix

Table 1:Diagnostic tests for VAR (*p*) specifications

Country	*p*	*Q*	*Q16*	p-value	LM test	p-value	Non-normality test	p-value	MARCH test	p-value
Panel A. Bahrain										
India	7	16	54.885	0.023	36.992	0.119	539.107	0.000	184.574	0.000
Malaysia	3	16	46.446	0.691	6.037	0.914	614.928	0.000	144.233	0.000
Indonesia	4	16	45.334	0.583	15.757	0.470	1270.336	0.000	223.312	0.000
Korea	3	16	72.918	0.029	13.302	0.348	1083.987	0.000	316.098	0.000
Singapore	4	16	58.790	0.137	21.401	0.164	1174.554	0.000	172.447	0.000
China	3	16	54.143	0.393	9.939	0.621	552.298	0.000	99.551	0.000
Japan	4	16	43.688	0.650	10.865	0.818	837.673	0.000	192.044	0.000
Panel B. Oman.										
India	4	6	10.665	0.221	17.564	0.350	4172.456	0.000	322.174	0.000
Malaysia	4	6	12.928	0.114	19.254	0.256	4362.966	0.000	384.753	0.000
Indonesia	5	7	10.587	0.226	21.111	0.391	3159.337	0.000	306.160	0.000
Korea	4	7	19.065	0.087	22.110	0.140	3821.544	0.000	458.248	0.000
Singapore	3	16	100.138	0.000	15.692	0.206	4507.207	0.000	240.841	0.000
China	2	16	129.554	0.000	12.310	0.138	4875.413	0.000	209.096	0.000
Japan	5	14	47.237	0.100	20.344	0.437	1969.367	0.000	351.180	0.000
Panel C. Qatar.										
India	6	16	74.786	0.000	30.161	0.180	1012.540	0.000	194.876	0.000
Malaysia	4	9	27.450	0.123	13.988	0.600	1338.197	0.000	205.816	0.000
Indonesia	4	9	24.243	0.232	17.618	0.347	1851.684	0.000	246.747	0.000
Korea	4	7	18.685	0.096	16.858	0.395	1831.257	0.000	424.191	0.000
Singapore	4	16	81.674	0.000	21.259	0.169	1462.414	0.000	236.948	0.000
China	3	16	86.235	0.000	16.041	0.189	1744.059	0.000	137.341	0.000
Japan	3	16	74.336	0.000	8.267	0.764	1216.991	0.000	155.393	0.000
Panel D. Saudi Arabia										
India	3	20	63.578	0.130	16.208	0.182	1627.178	0.000	187.474	0.000
Malaysia	2	21	91.996	0.102	9.186	0.327	2137.496	0.000	87.982	0.000
Indonesia	8	16	57.710	0.159	42.886	0.095	2615.935	0.000	371.081	0.000
Korea	8	19	49.815	0.136	40.362	0.147	2020.480	0.000	430.524	0.000
Singapore	5	21	78.701	0.102	25.405	0.186	2718.632	0.000	223.294	0.000
China	4	16	57.941	0.154	16.453	0.422	1828.409	0.000	187.750	0.000
Japan	4	16	47.751	0.483	11.107	0.803	1788.479	0.000	195.204	0.000
Panel E. UAE										
India	5	8	14.282	0.283	18.019	0.586	1475.164	0.000	244.933	0.000
Malaysia	3	10	34.424	0.187	9.990	0.617	1461.552	0.000	224.227	0.000
Indonesia	4	16	48.732	0.443	15.376	0.497	1924.751	0.000	383.892	0.000
Korea	5	7	11.280	0.186	17.992	0.588	1750.429	0.000	432.625	0.000
Singapore	5	7	9.380	0.311	17.475	0.622	1913.777	0.000	242.782	0.000
China	2	16	66.355	0.162	7.783	0.455	1707.883	0.000	140.898	0.000
Japan	3	16	55.554	0.342	14.133	0.292	1259.340	0.000	206.289	0.000

CHAPTER FIVE

CONCLUDING REMARKS

Volatility and movements are important components of market risk analysis and play a key role in many financial activities, such as portfolio risk management, pricing of assets, hedging and diversification strategies. Stock markets in developed and developing countries are exposed to different types of domestic, regional and external shocks.

This study considers frontier and recently upgraded emerging markets in the GCC region. Over the last years, these countries have seen a faster economic growth, and their markets have been able to attract international investors, even though the impact that a global negative shock has exerted on these countries, due to the fact that most of these countries are exporters of crude oil, and are engaged in international investment and trade agreements.

This study draws motivation from the inconclusive results on the empirical literature concerning the impact of local and international shocks on volatility of GCC stock markets (see, for instance, Bley and Chen, 2006; Hammoudeh and Choi, 2006; Hammoudeh and Li, 2008). It takes a deeper look at the sources of the increasing volatility and correlation dynamics across the GCC markets.

Chapter 2 contributes to the existing literature by examining the correlation dynamics between the oil markets and the seven GCC stock markets. This chapter considers the most recent fluctuations in crude oil prices and assesses their impact on shaping the volatility and correlation dynamics across the seven GCC markets. The empirical analysis employs data over the period 2003–2012, and uses both the asymmetric and symmetric dynamic conditional correlation multivariate GARCH models (see Engle, 2002, and Cappiello et al, 2006)

The results of this chapter suggest that the GCC stock markets exhibit different correlation dynamics with oil markets. The markets of Qatar and Oman are asymmetrically correlated with oil markets of Brent and OPEC, while the stock markets of Abu Dhabi and Saudi Arabia show symmetric correlation with the Brent oil market only. Further, GCC stock market correlations tend to show an increasing upward trend during periods of high oil price fluctuations, which are associated with periods of regional and global market stress.

Chapter 3 examines the contagion and volatility spillover effects from the global financial, the Dubai debt and the European sovereign debt crises on the financial and non-financial sectors of the GCC stock markets. This chapter adds to the literature by looking at the different crisis periods. Given the financial nature of these crises, it is assumed that the contagion and volatility spillover effects may have been different across the financial and non-financial sectors. To this end, a combination of GARCH and factor models by Grammatikas and Vermeulen (2012) are employed. For evaluating the volatility transmission effect, the VAR(1)-GARCH(1,1) approach of Ling and McAkeer (2003) is applied, and the estimations are carried out over four different periods between 2004 and 2015.

The two main results of chapter 3 are as follows. First, there were contagion effects from both the U.S. financial and Dubai debt crises, with significant higher impact on the GCC's financial sectors than the non-financial sectors. Second, evidence of volatility spillover from the U.S., Dubai and European financial sectors to the GCC markets is found both for the financial and non-financial sectors.

Chapter 4 contributes to the current literature on stock market comovements by considering the GCC and Asian countries, given that these two regions have significant economic linkages and bilateral trade. This chapter also investigates the extent to which the time-varying conditional correlations between the returns and volatilities of the GCC and Asian stock markets changed over the period 2003–2015. Further, standard unconditional correlations are also used to capture any common trend in the dynamics of stock returns over sample period.

In order to estimate the short-term and long-term linkages across the stock markets of the GCC and Asian countries, the Johansen's cointegration approach is applied. For the estimation of the dynamic conditional correlations between the GCC and Asian market returns and volatility, the DCC-GARCH model of Engle (2000) is applied. Moreover, to assess if a common integration trend exists across the two regional stock markets, a standard unconditional correlation with a 4-years rolling window estimation is used.

The empirical finding of chapter 4 point to a cointegration relationship among some of the GCC and Asian emerging stock markets, with the exception of China and Japan, whose stock markets are not cointegrated with the GGC ones. These results suggest that investors can diversify their portfolio of assets by buying stocks in these countries. The empirical results also indicate the existence of low to moderate cross-market correlations overtime with Asian stock markets, and correlations with shocks are highly persistent across the markets under study. Finally, findings concerning the rolling analysis suggest that the stock returns comovements among the two regions are higher during the financial crisis, while comovements remain low after the crisis.

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