Interdependence of oil prices and global factors affecting the stock market performance: A sectoral analysis of GCC countries

Bayan Albahooth

Bachelor Degree of Finance
Qassim University

Master Degree of Finance
Latrobe University

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College of Business,

Victoria University Melbourne Australia

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Abstract

Gulf Cooperation Council (GCC) countries are the major world suppliers of petroleum and petroleum products. Therefore, their stock markets are likely more vulnerable to changes in petroleum product prices. Moreover, the volatility of GCC stock markets is also influenced by other important global factors, such as the Morgan Stanley Capital International (MSCI) World index; as well as movements in international financial markets, particularly the United States (US) S&P 500 index. This thesis aims to investigate the independent relationship between oil prices and other global factors—including MSCI and US S&P 500 indices—among three major GCC stock market sectors (consumer discretionary, financial and real estate) in the period 2010–17 in which a major oil price decline directly affected the growth of GCC financial markets as GCC countries held 30% of the world's proven oil reserves. The objective of the research is to identify to what extent oil prices along with other global factors affect GCC stock market volatility at the sectoral level. Studying the volatility transmission behaviours of GCC stock markets at the sectoral level gives a better understating of the volatile behaviour of GCC equity markets. It also eliminates the masking of individual sector reactions that may result in the case of studying stock markets as a single block.

This research adopts various advanced econometrics quantitative methods to test hypotheses regarding the nature of volatility transmission behaviours involving GCC stock markets and a set of global factors, by using daily stock return of the selected variables under study. The methods applied include an exponential generalised autoregressive conditional heteroscedastic (EGARCH) model, vector autoregressive (VAR) model, Granger causality model, cross-correlation function (CCF) and multivariate GARCH-BEKK model. These models provide a comprehensive and in-depth view of how various selected sectors in GCC equity markets respond to volatility transmission with a set of the most influential global factors. The key research findings on volatility transmission effects between GCC stock markets and three global factors (West Texas Intermediate [WTI] oil price, MSCI and US S&P 500 index) suggest that the WTI oil price has a major influence on various selected sectors of GCC stock markets, while the MSCI and S&P 500 indices show less of an impact on the GCC sectors under study. The analysis findings are then used to obtain optimal weights and hedge ratios for building optimal, diversified portfolios that contain both oil and non-oil assets in the equity markets under study. Using

advanced analysis techniques, this research aims to derive practical, in-depth implications for both GCC stock market investors and government policy makers about volatility patterns for oil prices and global factors that affect GCC stock markets.

Declaration

I, Bayan Albahooth, declare that the PhD thesis entitled '**Interdependence of oil prices and global factors affecting the stock market performance: A sectoral analysis of GCC countries**' is no more than 100,000 words in length including quotes and exclusive of tables, figures, appendices, bibliography, references and footnotes. This thesis contains no material that has been submitted previously, in whole or in part, for the award of any other academic degree or diploma. Except where otherwise indicated, this thesis is my own work.

Signature: Date: 21/ 10/ 2020

List of Publications

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List of Abbreviations

ADF	Augmented Dickey–Fuller
ADX	Abu Dhabi Securities Exchange
AGCC	Arabian Gulf Cooperation Council
AIC	Akaike Information Criterion
ARCH	Autoregressive conditional heteroscedasticity
BSX	Bahrain Stock Exchange
CASE	Cairo and Alexandria Stock Exchange
CCF	Cross-correlation function
CVaR	Conditional VaR
DFM	Dubai Financial Market
EGARCH	Exponential GARCH
EMH	Efficient Market Hypothesis
GARCH	Generalised ARCH
GARCH-BEKK	Generalised ARCH- Baba, Engle, Kraft and Kroner
GCC	Gulf Cooperation Council
GARCH-M	GARCH-in-mean
GED	Generalised error distribution
GFC	Global financial crisis
HH	Hafner and Herwartz
IRF	Impulse response function
KSE	Kuwait Stock Exchange
MGARCH	Multivariate GARCH
MSCI	Morgan Stanley Capital International
MSM	Muscat Securities Market
MPT	Modern Portfolio Theory
OPEC	Organization of Petroleum Exporting Countries
OTC	Over-the-counter
P/E	Price-to-earnings ratio
PP	Phillips-Perron
QE	Qatar Exchange

SIC	Schwarz Information Criterion
S&P 500	Standard and Poor's 500
SR	Sharpe ratio
TASI	Tadawul All-Shares Index
TGARCH	Threshold GARCH
TR	Treynor ratio
UAE	United Arab Emirates
UK	United Kingdom
US	United States
VaR	Value at risk
VAR	Vector autoregressive
VD	Variance decomposition
VEC	Vector-error correction
WTI	West Texas Intermediate

Chapter 1 Introduction

The Gulf Cooperation Council (GCC) is a customs union of six countries: Saudi Arabia, United Arab Emirates (UAE), Kuwait, Bahrain, Qatar and Oman. Four of these are major oil-exporting countries regarded as influential decision makers in the Organization of Petroleum Exporting Countries (OPEC), having the largest worldwide oil reserves and undertaking 20% of oil production (Ghosh 2016). In GCC countries, oil exports largely determine government budget and expenditure. Since GCC economies are highly dependent on oil exports (e.g. during 2011–14, hydrocarbons accounted for around 70% of the total export earnings and around 80% of fiscal revenue), their national economic activities are greatly affected by price volatility in the global petroleum market.

Volatility in oil prices is driven by several local and global factors. Among the most important factors are the instability of oil supply and demand, the level of oil production in the United States (US) and the regional geopolitical environment. As previously mentioned, oil price volatility affects the level of capital and recurrent expenditure in the GCC economies. For instance, GCC countries' GDPs declined when the total GCC public revenue decreased by 35% when the oil price collapsed in 2014. Therefore, GCC economies' government expenditure will affect spending on infrastructure, defence, education and public sector wages.

Oil price volatility can impact oil revenues and, therefore, the profitability of firms trading in GCC stock markets. Further, oil prices directly correlate with government fiscal spending in the aforementioned economies. Therefore, volatility of oil prices has a remarkable influence on stock market performance across GCC countries. For example, the decline in oil price between 2014 and 2016—caused by several factors, including rapid efficiency in US shale oil production and the slowdown in China's economic rates—resulted in budget deficits and reduced government spending in oil-dependent nations (Wong & El Massah 2018). This, in turn, led to concerns about reduced corporate spending, which caused a decline in stock prices (Mimouni & Charfeddine 2016).

Because of the volatile nature of oil prices, GCC countries began to diversify their economies. However, the impact of oil price volatility differs among GCC countries, depending on their economic diversification and liberalisation efforts. For example, Bahrain (unlike Kuwait and Saudi Arabia) has a more diverse economy and is therefore less dependent on oil revenue (Arouri & Rault 2012). To achieve fiscal sustainability and build diverse economies, GCC governments have begun diversifying to non-oil revenue sources (i.e. real estate, industry and finance), thereby enhancing spending efficiency through expenditure rationalisation plans.

In addition, GCC stock market volatility is affected by several global factors, the most important being international financial markets—specifically the Morgan Stanley Capital International (MSCI) World and S&P 500 indices. GCC stock markets are also known to be strongly associated with the US economy via exchange rate links between GCC currencies and the US dollar. Further, GCC countries coordinate their monetary policies with those of the US and both have investment relationships and mutual foreign trade (Hammoudeh & Choi 2006). Therefore, GCC stock markets can be strongly affected by information from the US stock market.

Given the aforementioned critical issues related to GCC stock markets, this thesis contributes to the body of knowledge by applying various fundamental and advanced econometrics in an in-depth investigation of the nature of volatility transmission relationships between GCC stock markets at the sectoral level and the most influential worldwide global factors with regard to financial markets, including the West Texas Intermediate (WTI) oil price, the MSCI World index and the US S&P 500 index in the period 2010–17 with a particular focus on the periods before and after the oil price collapse in mid-2014. Volatility transmission between oil prices and GCC stock markets causes great concern among investors. Since GCC countries are oil dependent, investors need to understand the extent to which risk and portfolios values are influenced by oil price fluctuations (Arouri et al. 2011). Understanding the impact of oil prices on different GCC stock markets helps investors to build well-diversified portfolios of oil and non-oil stocks and enables them to manage the oil risk more effectively. Therefore, there is a need for a comprehensive and up-to-date study on the impact of oil prices and other related global factors on various GCC stock market sectors. This will enable GCC countries to not only reduce the negative impact of oil price fluctuations, but also to enhance their financial market stability.

1.1 Research Motivation

This thesis presents an empirical study of volatility transmission patterns and causality relationships between GCC stock markets at the sectoral level and a set of global factors: the WTI oil price, MSCI World index and S&P 500 index. Oil price is considered a critical factor in economic development throughout the world, particularly in countries considered major oil exporters, as is the case for GCC countries (Khalifa, Hammoudeh & Otranto 2014). The economies of GCC countries are heavily reliant on oil price and its volatility, since several domestic and international events influence oil prices (Wong & El Massah 2018). GCC stock markets that represent critical components of GCC economies are highly sensitive to oil price volatility along with other international markets that are linked directly or indirectly to GCC countries, as is the case for the MSCI World and S&P 500 indices.

Unlink most previous studies, this thesis focus on a sectoral analysis of GCC stock markets, not on overall indices. This can provide new and profound insights into the linkage between GCC stock markets at the sectoral level and the most influential global factors. This study relies on the fact that global factors affect GCC stock markets at the sectoral level differently, with heterogeneity in sector sensitivities to oil price being due to other global factors. This exploration of volatility transmission patterns at the sectoral level has important implications for policy makers, portfolio managers and investors, as the results will lead to optimal portfolio asset allocation and diversification.

For the empirical methodological framework, various fundamental and advanced econometric models are applied to investigate volatility transmission patterns and causality effects between GCC stock markets at the sectoral level and major global factors before and after the strong oil price collapse in mid-2014. These econometric models include an exponential generalised autoregressive conditional heteroscedastic (EGARCH) model, VAR model, Granger causality model, cross-correlation function (CCF) and multivariate GARCH-BEKK model, which are used to conduct a comprehensive and in-depth analysis of the periods before the sharp decline in oil price in mid-2014 ('pre-2014') and after it ('post-2014'). These advanced models allow examination of the behaviour of volatility transmission between GCC stock markets and global factors and the extent of variation in the level of influence on the GCC stock market sectors under consideration. Further, to manage risk, the findings are used to compute the optimal weight and hedge ratio for oil and non-oil stock portfolios. This research focuses on three GCC stock market sectors: the consumer discretionary, financial and real estate sectors (selected based on the Global Industry Classification Standard [GICS]) sector split.

1.2 Research Questions

This research addresses the following research questions:

1. Are there any similarities in the information asymmetry of selected GCC stock market sectors before and after the drop in oil price?
2. Does the volatility spillover between oil price and GCC stock markets at the sectoral level differ pre- and post-2014?
3. What are the impacts of global factors (MSCI World and S&P 500 indices) on volatility of the GCC stock market, at the sectoral level pre- and post-2014?
4. What is the optimal weight for oil and non-oil portfolio sector investment to minimise volatility transmission risk in GCC stock markets pre- and post-2014?

1.3 Contribution to Knowledge

This research investigates the correlation between the volatility of GCC stock markets and oil price, and other global factors (MSCI and S&P 500 indices). Going beyond a market level analysis, this research provides an in-depth analysis at the sectoral level for GCC stock markets. Studying the volatility of GCC stock markets at the sector level provides a better understating of volatile behaviour. It also eliminates the masking of individual sector reactions that may occur when studying stock markets as a single block.

Jouini and Harrathi (2014) examine volatility transmission between world oil price and GCC stock markets over weekly periods from 2005 to 2011. However, no study has been conducted at the sector level. Therefore, this study extends that of Jouini and Harrathi (2014) in several ways. First, studying volatility patterns at the sectoral level will provide an up-to-date and detailed explanation of volatility behaviours of GCC stock markets, which will lead to a better understanding of such behaviour. This study will also provide an up-to-date analysis, using daily data from the period 2010–17 for the GCC countries. This will lead to a better understanding of volatility patterns in GCC stock markets and oil price changes. Second, this study investigates and compares volatility transmission between oil price and GCC stock markets at the sectoral level before and after the mid-2014 oil price slump. This provides a unique contribution to the literature on volatility patterns at the sectoral level. Moreover, unlike previous studies, this research explores the volatility transmission patterns between various GCC stock sectors and oil price through three possible transmission mechanisms: interdependence, spillover and independence. In the interdependence mode, two variables affect each other; while in the spillover modem only one variable affects the other. Last, in the independence mode, there is no relationship between variables. This transmission classification provides an understanding of the natural volatility transmission in financial markets, a prediction of the volatility of link markets and selection of the 'dominant' sector whose behaviour is expected to drive change in other sectors. Finally, this study provides a more accurate interpretation of the scope of volatility effects.

1.4 Statement of Significance

This study provides new evidence on the volatility of GCC stock markets and the linkage between oil price and global factors at the sectoral level. The results will be helpful for investors and policy makers in decision making. Specifically, the study provides empirical evidence about volatility patterns and global factors that affect GCC stock market behaviours, which will be useful for GCC stock market investors and policy makers

The GCC economies are in a transition from dependence on oil revenues to economic diversification. Therefore, it is important to undertake a detailed investigation of the linkage between oil price and volatility of GCC stock markets at the sectoral level in recent years. This will highlight the dependency relationship between oil price and stock market returns at the sectoral level (consumer discretionary, financial and real estate), which will help investors understand the diversification of the GCC stock market.

The study also provides empirical evidence that investors should consider risks and returns when managing their portfolios in the stock markets, by measuring the optimal weight and hedge ratio. This will help investors to build efficient diversified portfolios with oil and non-oil assets to reduce the risk, while preserving the expected return.

1.5 Thesis organisation

The remaining chapters in this thesis are organised as follows:

- **Chapter 2** presents an overview of the GGC economics and their stock markets Moreover, it discusses the related studies in the literature about the interdependence relationship between GCC stock market and oil prices and other global factors, including S&P 500 stock market index and MSCI World index. We then outline the Efficient Market Hypothesis (EMH) and modern portfolio theory. Finally, we investigate the related determination of an optimal weight and hedge ratio strategy for portfolio diversification, which is an important objective for market decision makers and participants.

- **Chapter 3** presents primary descriptive statistics and evaluates GCC markets performance at the sectoral level. The market performance evaluation is conducted via several risk-adjusted performance measurements, including the Sharpe ratio (SR), Treynor ratio (TR), VaR and conditional value at risk (CVaR). The augmented Dickey–Fuller (ADF) and Phillips–Perron test are applied to check the stationarity of the data. We focus on two main sample periods before and after the slump drop in oil price in mid-2014, and compares the results of the analysis pre- (2010 – mid-2014) and post-2014 (mid-2014 - 2017) for selected GCC stock market sectors, including consumer discretionary, financial and real estate. A set of GARCH family models is applied; including the EGARCH, Glosten–Jagannathan–Runkle GARCH (GJR-GARCH) and GARCH-in-mean (GARCH-M) are applied to capture the asymmetry effect which can help to identify the effects of good and bad news on stock markets.

- **Chapter 4** describes an empirical study of volatility spillover between the selected set of GCC stock market sectors and some of the most influential global factors in financial markets, including the WTI oil price, MSCI World index and S&P 500 index, using two econometric models: the VAR and CCF models. The VAR is an advanced univariate autoregressive (AR) model due to its ability to capture linear interdependencies of multiple time series variables and analyse the dynamic impacts of random disturbances (fluctuations) between them. CCF is a two-stage model introduced by Cheung and Ng (1996). We apply the CCF model based on the Hafner and Herwartz (HH) (2006) test to investigate the presence of causality in the variance between the selected global factors and GCC stock markets at sectoral level from 2010 to 2017. We study two periods before and after the slump in oil price in mid-2014 which allows us to conduct in-depth investigation about the interdependency patterns between the selected GCC stock market sectors, and WTI oil price and other global factors.

- **Chapter 5** presents a further investigation about the interdependency relationship between selected GCC stock markets sectors and a set of global factors, including WTI oil price, MSCI World index and S&P 500 index. We apply an advanced econometrics model to analyse volatility spillover effects called multivariate GARCH-BEKK model. The sampling period is divided into two periods before and after the slump in oil price to identify how GCC stock markets are depend on oil revenues at sectoral level, especially in the period after the slump in oil price. Furthermore, multivariate GARCH-BEKK model results are used to build a well-diversified portfolio to minimise risk for the same expected return.

- **Chapter 6** concludes the thesis with an overall summary and a discussion of the main contributions, key findings and policy implications. Furthermore, we identify the research limitations and recommendations for further research directions.

Chapter 2 Literature Review

In this chapter, we present an overview of the GGC countries and discuss studies related to the interdependence relationship between the stock market and oil prices and other global factors such as the S&P 500 stock market and MSCI World index. We then outline the Efficient Market Hypothesis (EMH) and modern portfolio theory. Finally, we discuss the determination of an optimal weight and hedge ratio strategy for portfolio diversification, which is an important objective for market decision makers and participants.

2.1 Overview of GCC Stock Markets

The GCC countries reserve 30% of the world's crude oil, which represents around 34% of world oil exports in 2017. GCC countries share similar economic and geopolitical challenges. However, Bahrain, for example, shows less reliant on oil revenues than do Kuwait and Saudi Arabia. Oil rents range from 2.5% of GDP for Bahrain to 44.5% for Kuwait. Figure 2.1 shows oil rents as a percentage of GDP for GCC countries from 2010 to 2017. This period includes the time when oil rents sharply declined in mid-2014, before oil prices recovered in later years. It is worth mentioning that the global financial crisis (GFC) in 2008, along with oil price decline in mid-2014, gave GCC countries greater exposure to international markets through global investment of their sovereign wealth funds and important economic reforms.

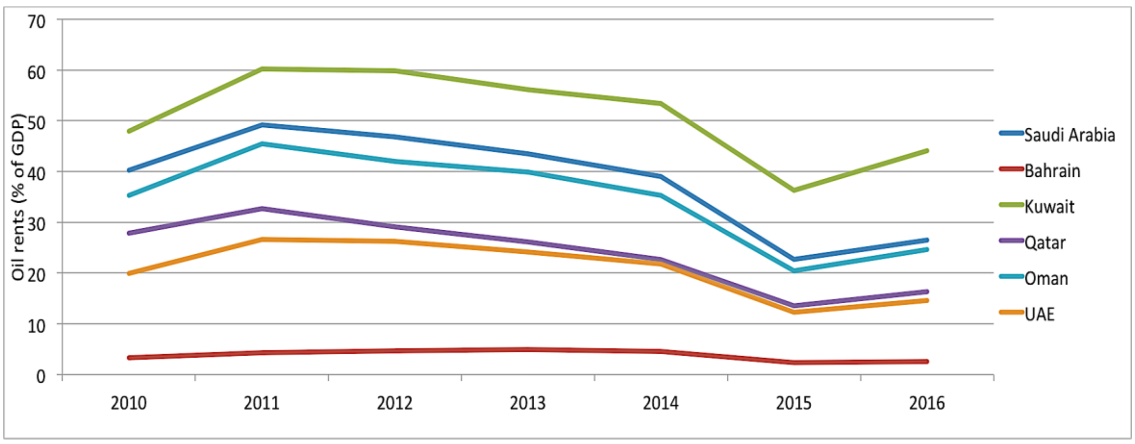

Figure 2.1: Oil rents (% of GDP) for GCC countries (source: World Development Indicators)

2.1.1 Saudi Arabian Stock Market

The stock market in Saudi Arabia is operated by the Saudi Stock Exchange, or Tadawul, and is supervised by the Saudi Capital Market Authority. Tadawul (2019) states that the market operates from Sunday to Thursday each week. The major stock market index in the Saudi stock market is the Tadawul All-Shares Index (TASI). The TASI has a base value of 1,000 as of 1985 and keeps track of how all companies listed in the Saudi Stock Exchange are performing (Tadawul 2019). The number of listed companies in Tadawul increased from 146 to 188 in the period 2010–18. Listed companies in the Tadawul include both domestic and foreign companies; those with different classes of shares are counted once to avoid duplication.

The market value of the stock market can be measured using the market capitalisation, which multiplies the share price by the number of all outstanding shares and considers all classes of shares. Unit trusts, investment funds and firms dealing solely with the business of holding shares of other listed companies are not included among the listed companies, irrespective of their legal status. Trading Economics (2018) indicates that in 2010, the market capitalisation for the Saudi stock market was US$375,000,000,000; this rose to US$451,378,840,000 in 2018, as shown in Figure 2.2. The highest market capitalisation between 2010 and 2018 was realised in 2015 and the lowest was in 2012 (Economics 2018).

Figure 2.2: Market capitalisation of listed companies (USD) in Saudi Arabia (source: Trading Economics)

The criterion for establishing whether the overall market is overvalued or undervalued is based on the ratio of the market capitalisation to the GDP of the country (World Bank 2018). In 2010, market capitalisation in Saudi Arabia accounted for 66.9% of the country's nominal GDP and fluctuated over the following years, reaching 65.6% in 2017. During this period, the highest market capitalisation was recorded in 2016 at 69.5% and the lowest was in 2011 at 50.5%.

Stock markets can also be valued using the price-to-earnings (P/E) ratio, which is the price that investors pay for each dollar of profit a company earns. Ceic Data (2018) indicates that the P/E ratio for Saudi Arabia's stock market was 18.5 in 2010, and declined to 16.1 in November 2018, as shown in Figure 2.3.

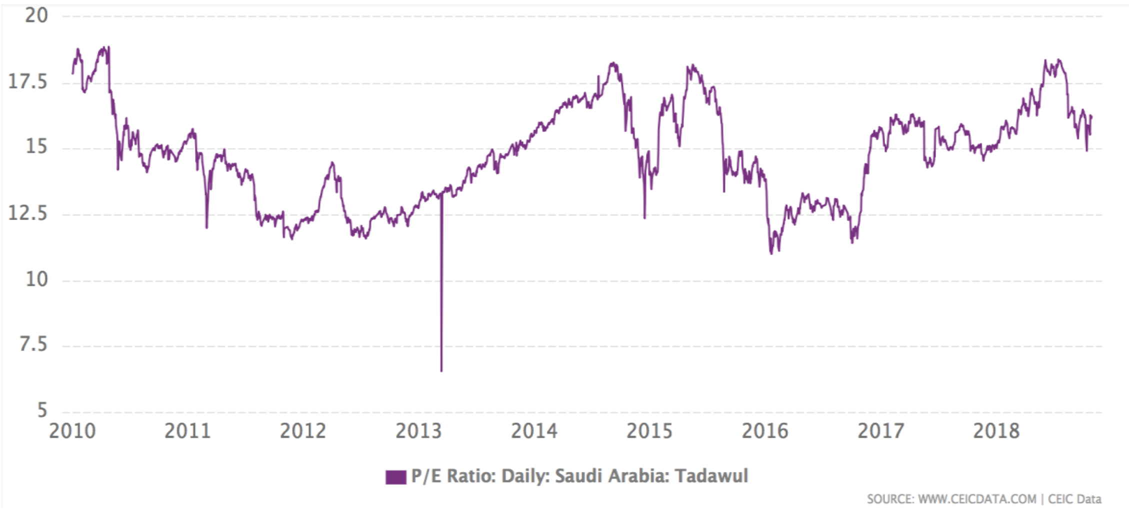

Figure 2.3: P/E ratio for Saudi Arabia 2010–18 (source: CEIC Data website)

Price fluctuations in the stock market are determined by market forces, which are the interactions of demand and supply forces. Factors affecting Saudi Arabia's stock market can be classified into various categories, such as firms' general and specific factors; micro and macroeconomic factors; and internal and external factors (In'airat 2018). Firm-specific factors consist of factors that are directly linked to how a firm is performing while a firm's general factors are those factors that arise from macroeconomic conditions.

Internal factors are microeconomic factors affecting the performance of a firm, such as dividend policy, profit after tax, return on equity, retention ratio and earning per share (Majanga 2015). In contrast, external factors affecting the stock market in Saudi Arabia are mainly related to macroeconomic conditions, such as the price of oil and inflation. The following paragraphs focus on explaining how the dividend policy and oil market price—which are classified as internal and external factors, respectively—affect stock market prices in Saudi Arabia.

The economy of Saudi Arabia is predominantly oil based, making the stock market vulnerable to oil price changes. In the short term, a drop in oil price in international markets creates panic among investors in stock markets. A mismatch between the demand and supply of stocks makes stock prices go down in the short term when international oil prices go down. If the price of oil remains low, the economy is affected because of a reduction in activities of the private sector and lower profitability of corporations. In mid-2014, the oil prices declined by approximately 50%. This steep decline saw the TASI experience a downward trend that could not be fully explained by market fundamentals, since a decline in the oil price does not have an immediate effect on economic growth. Sentiments held by investors made the stock market experience a sharp downward trend. As a result, a slump in the stock market was experienced in Saudi Arabia, as investors were afraid that the reduction in the oil price would trigger the government to reduce its expenditure, which would in turn reduce corporate profits. Figure 2.4 compares trends in the Saudi Arabia stock market (TASI) and other GCC countries as a result of the decline in the oil price in mid-2014.

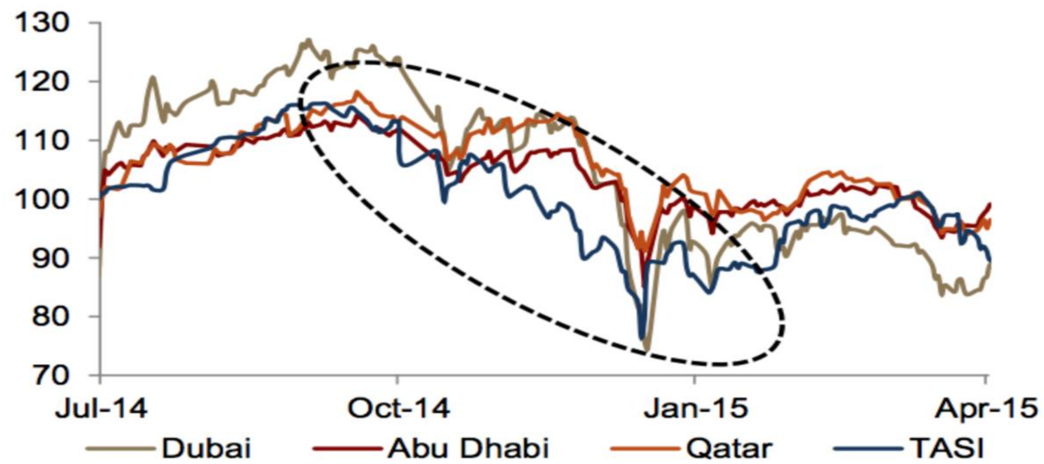

Figure 2.4: GCC stock market performance after a steep decline in the oil price in mid-2014

2.1.2 Abu Dhabi Emirates Stock Market

Abu Dhabi hosts most of the stock market activity within the UAE given the massive market capitalisation of the Abu Dhabi Securities Exchange (ADX). According to Ulussever and Demirer (2017), its volume stood at US$149 million by 2014 and it has since welcomed numerous other local and foreign investments. The ADX commenced its operations in 2000 by trading shares with some of the most prominent companies in the region (El Toukhy, Safar & Mahdi 2011). Many developments occurred in the Abu Dhabi stock market after 2010, largely as a result of numerous incentives regarding sharing of critical financial institutions, continued successes in the oil and gas industry, and the need to align with some of the leading global stock traders. Harrison and Moore (2012) note that Abu Dhabi also enjoyed major developments within the same period, gaining by 63% and joining the leading traders across the world. Its most significant trading statistics include the dramatic rise of its market capitalisation from Dh 123.26 billion to Dh 189.49 billion within a single year.

The Emirates Securities and Commodities Authority is one of the most conspicuous institutions at the heart of the recent developments in the stock markets within the UAE. This body provides essential oversight and legislation pertaining to relevant technicalities and information gaps. It has paved the way for a series of events and changes that occurred within the second decade into the 21st century. Louis and Balli (2014) consider that the most dominant players have emerged from some key industries relevant to the economic potential of the UAE. According to Onour (2017), this includes the banking, insurance, hospitality and service sectors. The inclination to reduce risks, coupled with the need for greater profits, have defined the historical identity of GCC stock markets within the last few years. The use within stock markets of essential tools such as the average directional index (ADX) has helped shape not only the positions of the numerous companies involved but also the mindsets of individual traders. Onour (2012) posits that the UAE hosts a mixed free market economy and explains the nature of participation in the stock market of locals as well as outsiders. While most players predominantly rely on oil and gas production, numerous other markets have been necessitated primarily by the greater integration of world cultures. People’s interests continue to change dramatically, with stock exchange platforms paving the way for better economic associations.

2.1.3 Dubai Emirates Stock Market

Most capitalisations occurred after 2010 as evidenced by an unprecedented increase in the volume of trade and an inclination towards a globalised approach. The year 2013 saw the greatest invest interest throughout the UAE. Dubai has been at the forefront of shaping the region's increased awareness of the numerous opportunities in the critical financial industry (Al-Malkawi & Pillai 2013). With the country hosting Expo 2020, it is likely that its stock market potential will continue growing in the long run. According to Sayegh (2014), 2013 also put Dubai on the global map, with its 107.6% gain, making its stock market the best global performer in US dollar terms. The most recent financial record establishes the Dubai Financial Market as surging to Dh95.70 billion, up from Dh47.35 billion within a single year (Sayegh 2014). Since 2010, citizens of Kuwait, Abu Dhabi and Dubai have shown a greater know-how of the operations of their stock markets. In this case, international players increasingly set the stage for greater competitiveness and avenues for more profits. According to Wang et al. (2013), communication companies, real estate companies and banks show some of the more significant trends, where foreign players may pose a certain degree of risk.

The value of market capitalisation for Dubai totalled US$104 billion by 2018 is shown in Figure 2.5. The implication of the oil price for the likes of Dubai is that it is increasingly difficult to remedy possible financial shortcomings at a greater scale (Al Mohana & Maatouq 2015). However, the overall expectation is that the international stock market will offer unlimited opportunities for growth of the financial sectors for Kuwait, Abu Dhabi and Dubai. This situation has resulted in an adverse effect on the stock exchange market for these three countries, largely because of the direct connection to the operations of numerous other sectors locally and beyond. According to Bley and Chen (2006), the inverse relationship races to the negative implications of oil price fluctuations, particularly on real output. In the same way, the stock market affects the oil industry, including the pricing of commodities, paving the way for an interconnection among diverse sectors (Al-Tamimi 2006). In 2014, there was an explicit scenario where the unprecedented drop in oil prices led to increased demand for the commodities, chiefly in emerging economies.

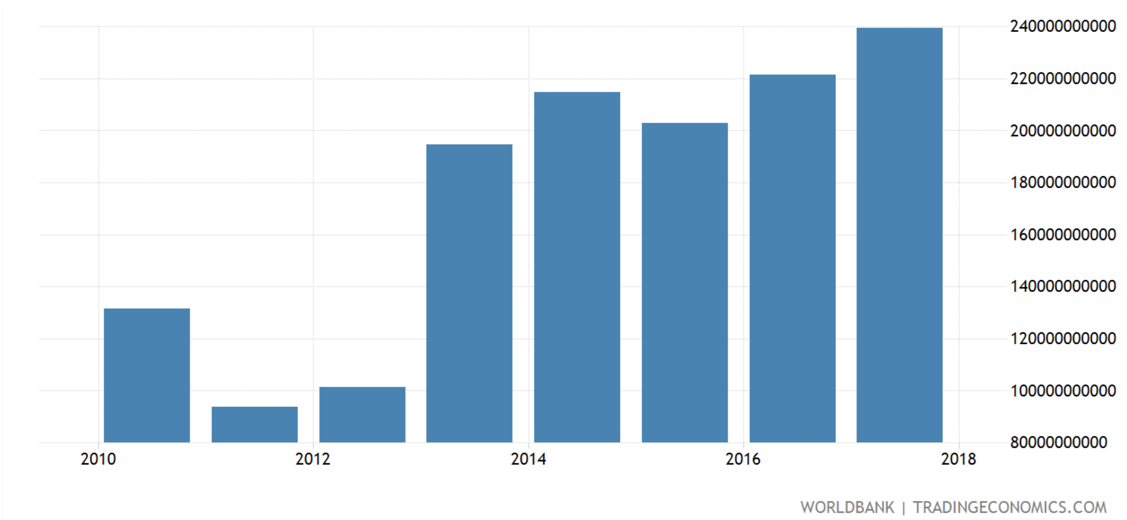

Figure 2.5: Market capitalisation of listed companies (USD) in Dubai (source: Trading Economics)

2.1.4 Kuwait Stock Market

Kuwait also experienced its highest All-Shares Index in 2013, standing at 8300.51. Despite fluctuations throughout the years, the situation of oil price slump cannot be compared with the compromising situations before 2010. Most developments in GCC stock markets are associated with a better approach to risk management, improved monitoring and supervision and essential stability owing to a globalised strategy. Examination of the history of the Kuwait Stock Exchange (KSE) reveals some of the primary contributors to its success and expansion. Two decades into the 21st century there is a greater inclination to involve foreign markets and take greater risks. The GCC region also manifests an underlying interest in diversifying its economic operations. While oil constitutes the largest source of economic trade in Kuwait, it does not fully define the operations of the stock market. Indeed, the fact that GCC regions have survived some substantial shortcomings suggests massive potential over coming years.

Market capitalisation for the top companies in Kuwait between 2010 to 2017 stood at US$16.9 billion for the National Bank of Kuwait, US$12.3 billion for Kuwait Finance House and US$6.8 billion for the Mobile Telecommunications Company. These companies are some of the biggest entities in the country. The total for the country stood at US$90 million, which is a significant increase from previous periods. Regarding the prices of oil and gas, GCC region’s reliance on the energy sector for most of its economic needs has major implications. Because the pricing takes its cues from an integrated body, WTI investors are wary of the economic identity of GCC region (Basher et al. 2014). Besides, the value of oil changes on a weekly basis, leading to greater scrutiny of the direct relationship between the stock markets of Kuwait, Abu Dhabi and Dubai. However, the underlying financial implication aligns with the fundamental aspects of their stock markets. An increase in oil prices principally causes an aggregate reduction in stock prices.

2.1.5 Oman Stock Market

The Muscat Securities Market (MSM) forms the stock market in Oman. In the period 2010–18, Oman's stock market displayed a fluctuating trend. The market was established in 1988 by a royal decree with the key purpose of regulating and controlling the securities market in the country (Almohamad, Mishra & Yu 2018). Also, the country needed securities firms to combine efforts with other firms to develop the Sultanate's financial sector infrastructure. In 2009, MSM exchange's standard share index recovered after a catastrophic economic period in 2008. After losing close to 50% of its value in 2008 following the GFC, the MSM rebounded in 2009 to register a 17% growth in its market capitalisation. This value was above the region's average, which was estimated at 12% (Almohamad, Mishra & Yu 2018).

The market had 116 companies and traded US$ 3,024.49 million securities in 2010. However, it reported that it was open to banks and firms in the insurance and service provision sector. In 2010, the index performance of the stock market was 6.1% but this declined to –15.7% in 2011. It displayed an improving trend to reach 18.6% in 2013 but declined again to –14.8% in 2015 (Jamaani & Roca 2015). Between 2015 and 2016, the market's index performance increased to 7% but dropped to –11.8% in 2017. Being a major oil producer, the Oman economy and its stock market have often been affected by trends in the oil market. Oil prices in 2014 experienced a global fall, which negatively impacted the stock market in the country. Other international stock markets have also influenced Oman's market, especially as a result of international trade. The strength of foreign currencies has shown a trend of affecting the country's stock market via an impact on its domestic economy. For instance, in mid-2009, MSM capitalisation was estimated at US$16.9 billion, which was below those of the Saudi, Kuwait and Qatar stock exchanges, at US$287.5 billion, US$122.3 billion and US$74.7 billion respectively (Asiri

& Abdalla 2015). In 2018, the market capitalisation was estimated at 18,327,494,322 OMR (Almohamad, Mishra & Yu 2018).

2.1.6 Qatar Stock Market

The Qatar Exchange (QE) market was established in 1995 as Doha's securities market. However, it only began operating in 1997. The exchange has since significantly expanded to become the leading stock market in the GCC (Joseph & Fernandez 2016). The key purpose of forming the QE market was to support the country's economy by offering a venue where capital could be raised for companies in Qatar to form part of their corporate strategy. The country also sought to provide a platform that could be used to trade diverse products both transparently and efficiently (Gharaibe 2016). The market currently lists 45 companies. Initially, the market accommodated only Qatari nationals but it now allows foreigners and GCC nationals to trade in securities.

In the period 2010–19, the QE Index in the market displayed a fluctuating trend. However, the QE Index was at its worst at the beginning of 2010 and at its best between late 2013 and mid-2014 (Joseph & Fernandez 2016). The poor performance in 2010 is alleged to have resulted from poor economic performance in 2009 following the GFC. Further, the low oil prices in late 2014 caused the trend to deteriorate until early 2016. and insurance data in the market reached its highest in 2014, estimated at 13,570,193.00 QAR (Joseph & Fernandez 2016). The market has also shown that it is affected by the world economy following poor performance in the years after the 2008 GFC.

2.1.7 Bahrain Stock Market

Although established in 1987, the Bahrain Stock Exchange (BSX) did not operate until 1989. It traded indexes and equities as well as derivative items on securities. In the present day, BSX market is referred to as a Bahrain Bourse, a shareholding company. As of 2017, BSX market had listed 42 companies, up from 29 in 1989 (Almohamad, Mishra & Yu 2018). In its history, BSX index reached its lowest of 1001.76 in 2003 and its highest of 2901.68 in 2008. The country is one of the smaller stock markets in the Middle East. The value of Bahrain market capitalisation from 2010 to 2017 is shown in Figure 2.6. Bahrain market capitalisation was estimated at US$17 billion in 2010, close to that of the MSM. Similar to Oman's stock market, that of Bahrain suffered a major obstacle in 2009 after the GFC in 2008 (Asiri & Abdalla 2015). It experienced an 18.5% decrease in market capitalisation in 2009. In 2010, BSX investor confidence index declined by 1.9 points, while that in UAE fell by 11.7 and that in Saudi Arabia, 8.6 points.

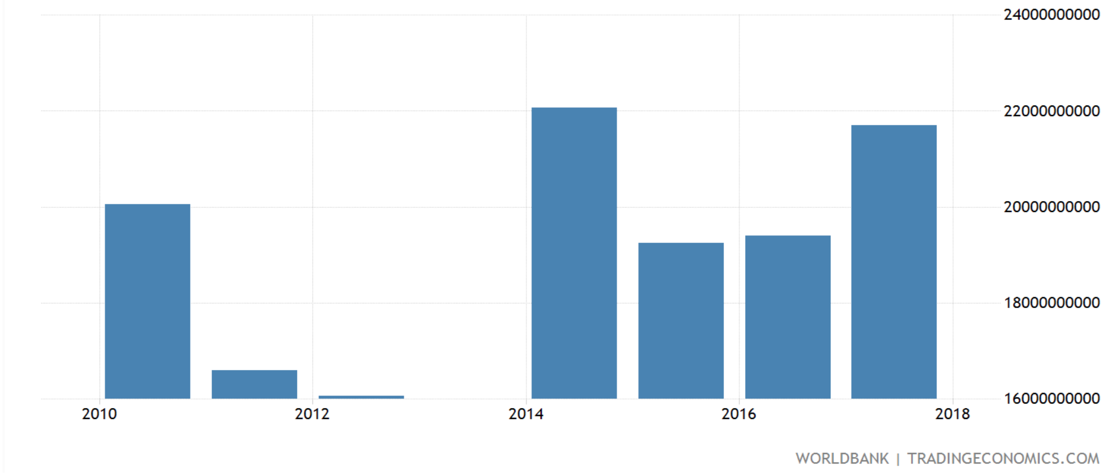

Figure 2.6: Market capitalisation of listed companies (USD) in Bahrain (source: Trading Economics)

BSX enhanced its system and transferred the records of listed companies to an electronic registry, which was considered a major success as it would enhance the protection of investors' data (Charfeddine & Khediri 2016). Bahrain all share index in the stock market in 2010 is 1418.10 compared with 2017's value of 1408.81 and the market capitalisation was estimated at 8,694,162,013 BD (Almohamad, Mishra & Yu 2018). Like Oman, the country has oil as one of its key trade products. As a result, changes in global oil prices indicate that the low prices in late 2014 had the effect of reducing the income from both trade and market capitalisation. Recovery of the market was witnessed in early 2014 after the GFC in 2008 and political unrest in the country in 2011 (Charfeddine & Khediri 2016). However, the second half of 2014 showed a major deterioration following the fall in oil prices. Also, the market is affected by global economic trends as it is a major oil exporter. In 2018, the All-Shares Index was recorded at 1351.81, a 16.9% increase on the 2017 value (Almohamad, Mishra & Yu 2018).

2.2 Stock Market Volatility

Stock market volatility is a remarkable phenomenon in the finance field. It is essential to provide accurate forecasting of volatility pricing to efficiently manage assets and to predict futures pricing and possible options for other derivatives. Derivative instruments pricing is an important procedure for hedging strategies. Understanding volatility patterns in stock market prices can enhance the accuracy of pricing options and derivatives.

Since the introduction of the Black and Scholes (1973) model for option pricing, it has been found that option pricing models allowing for changes in volatility can enhance option pricing (Merville & Pieptea 1989). Therefore, continuous improvements in option pricing models has led to rapid growth in the finance field. Rendleman and O’Brien (1990) reveal the importance of estimating volatility in insuring one’s assets via the purchase of put options. Rendleman and O’Brien (1990) emphasise how estimating volatility is important for insuring assets with more flexibility in purchase options. They highlight the need for pricing models that do not depend on constant variance.

Movements in stock markets are influenced by two main economic factors: capital investment and consumption (Schwert 1989). This indicates the importance for both economic policy decision makers and investors of understanding volatility. Moreover, volatility spillover is an extended and crucial factor in the interdependency of countries’ economics and capital flows. A large body of research has attempted to explain the stock price volatility phenomenon (e.g. Bulkley & Tonks 1992; French, Schwert & Stambaugh 1987; Grossman & Shiller 1980; LeRoy & Porter 1981; Poterba & Summers 1984; and many others). One research group focuses on the measurement of stock market volatility. Kenneth et al. (1987) studies the relationship between stock market volatility and stock return. The authors find a positive relationship between the expected market risk premium and stock return volatility. Moreover, they observe a negative relationship between an unpredicted change in the volatility of stock returns and unpredicted stock market returns, which provides evidence for an indirect positive relationship between unpredicted volatility and risk premiums.

Hamao et al. (1990) study the short-run interdependence of stock market returns and volatility across three major stock markets: New York, London and Tokyo. Daily opening and closing prices are used to analyse volatility spillovers, providing evidence of spillovers from New York to Tokyo and from London and New York to Tokyo. Kim and Rhee (1997) study the Tokyo Stock Exchange price limit system to test the hypotheses that price limits can reduce the volatility of stock prices and that trading activity is not affected by a price limit policy. Phylaktis et al. (1999) examine the impacts of price limits on stock instability in the Athens Stock Exchange. The outcomes are likewise strong to the recurrence of the estimation of the profits, and to the inflexibility of the limits. They propose, the data speculation, which infers that price limits simply decelerate the procedure of adjustment and have no impact on stock instability. An over-reaction theory is also proposed, in which it is accepted that investors will in general respond excessively to new data, such that price limits give them an opportunity to review data and reduce stock instability. Phylaktis et al (1999) obtain proof by carrying out tests on 10 stocks, which include both vigorously exchanged and less dynamic stocks, covering an assortment of enterprises on a market-wide price list.

Hee-Joon Ahn et al. (2001) explore a visibility-of-limit-orders approach in a pure order-driven market. They investigate the nature of the dynamic relation between order flow and transitory volatility and how the latter affects the variation between market orders and limit orders. They achieve predictable results: the presence of liquidity suppliers who enter the market and place limit orders on either the offer or ask side depends on which side will procure benefits from the liquidity arrangement. Their outcomes demonstrate that market profundity increases, resulting in an expansion in temporary instability, which reduces consequent to an increment in market profundity. Moreover, the informative intensity of idiosyncratic volatility is explored by Drew et al. (2005), who compare the activity of the customary Capital Asset Pricing Model with the multifactor model of Fama and French (1996) for stocks in the Shanghai Stock Exchange. They infer that multifactor model discoveries can be clarified by the turn of the year impact. They also reveal that Chinese investors consider little- and low-idiosyncratic-volatility firms as less safe than enormous- and high-idiosyncratic-volatility firms. The authors conclude that firm size, book-to-market value and idiosyncratic instability are risk factors, notwithstanding the hypothetically well-indicated market factor.

Frimpong and Oteng-Abayie (2006) demonstrate and estimate volatility (restrictive difference) on the Ghana Stock Exchange utilising random walk, GARCH (1, 1), EGARCH (1, 1) and threshold GARCH (TGARCH) (1, 1) models. The authors evaluate the competing volatility models and their detail and forecast production. They find that volatility bunching, leptokurtosis and asymmetry impacts are related to stock market returns on further developed stock markets. They utilise a one-of-a-kind, 3-days-a-week Databank Stock Index (DSI) to consider the elements of Ghana stock market volatility over a 10-year period. Similarly, data collected from the Taiwan over-the-counter (OTC) market is utilised by Tai et al. (2006) to explain whether trade size or number of exchanges is more useful for clarifying price volatility and market liquidity in the Taiwan OTC market. They separate firms into five size categories according to their market capitalisation. The analysis results demonstrate that the number of exchanges has a direct relationship with price volatility. Additionally, the authors examine how the global economic situation can influence the connection between data type and trading activities. This connection is also influenced by market patterns. The authors fill a gap in the literature by demonstrating that the economic situation affects the connection between data type and trader conduct. Minor firms on the Taiwan OTC market are traded according to firm-explicit data.

Katsikas (2007) demonstrates a negative connection between volatility and autocorrelation in significant European stock list prospect markets. The author proposes that prospect costs are non-linearly predictable so that short-term trading might deliver unusual returns. Moreover, the volatility itself is an asymmetric capacity of past mistakes as negative blunders have a much greater effect on volatility than positive ones. In particular, autocorrelation is low during volatile periods and high in normal periods. Kim (2007) inspects changes in everyday return volatility related to open market share repurchases and concludes that it is the consequent real buyback trading action, not the declaration, that is altogether adversely connected with changes in everyday return volatility. He discovers proof that an open market share repurchase firm, by effectively repurchasing its offers when the offer value falls, reduces daily return volatility. The author utilises univariate methods to control the examination, as well as numerous relapse investigations to investigate relationships between the volatility of daily returns and various factors.

Rao (2008) applies the multivariate GARCH (MGARCH) and VAR approach to examine co-mix and volatility spillover increases in Arabian Gulf Cooperation Council (AGCC) markets and advanced markets. His study demonstrates that AGCC markets show critical own and cross overflow of developments, volatility spillover and determination. The author examines the co-combination and volatility perseverance of six Middle East rising AGCC value markets with advance markets. The work of O’Shea et al. (2008) highlights the conjecture around small and mid-cap companies operating in industries that are speculative by nature and the fact that they use disclosure to increase price volatility and market interest on a repeated basis. When this type of disclosure is too frequent, selfpromotion or limited expertise in disclosure practices is evident, which can mislead investors.

Mollah and Mobarek (2009) examine the time-varying risk return relationship and the persistence of shocks with regard to volatility, finding that long-term persistence shock exists in emerging markets, in contrast to developed markets. It should be noted that the dataset used is not consistent in its time period, and the authors examine ways to study global diversification in the future. They consider that volatility measurement is essential when trying to establish the cost of capital for investment and portfolio management and option pricing, as well as market regulations. They find that certain unique characteristics such as dataset size can help more accurately portray the nature of the world economy, while additional empirical findings regarding volatility testing reveal risk return properties of developed, as well as emerging, markets.

Girard and Omran (2009) examine the impact of the speed of dissemination of order flow data on stock return volatility, using a dataset of 79 traded companies at the Cairo and Alexandria Stock Exchange (CASE). The relationship between volatility and volume is examined, showing that information size and direction do not have a noticeable impact on conditional volatility, meaning that there might instead be noise trading and speculative bubbles in place. In addition, ongoing volatility is not alleviated when lagged or contemporaneous trading volume is used with the GARCH model. The results show that when volume is categorised into its predicted and unpredicted components, volatility is less apparent. Kumar (2010) examines the statistical characteristics of a volatility index in the Indian context and its connection to the Indian stock market, alongside its ability to accurately predict upcoming variance. The author examines the volatility transmission of India in relation to developed markets, using the quantile regression method to research the empirical relationships of a volatility index. Volatility spillovers across emerging and developed markets are examined via volatility indices that are ex ante. In the time frame examined in this study, the average Ivix level is 35.89%. Volatility forecasts obtained from Ivix provide valuable data regarding previous market volatility, meaning that Ivix is a reliable estimator of future realised volatility.

Liu and Hung (2010) use alternative GARCH-type models with daily volatility forecasting and value at risk (VaR) for the Taiwanese stock index futures markets, which was affected significantly by the worldwide financial crisis of 2008. They undertake a forecast evaluation using different proxy tools for symmetric and asymmetric loss functions, in addition to back-testing and two utility-based loss functions to examine risk management practice in greater depth. Their results show that the EGARCH model offers daily volatility forecasts with the greatest reliability, and that the standard GARCH model, as well at those with highly persistent and long-memory properties, deliver sub-standard performance.

Volatility transmissions across portfolios in cross-listed equities and with exchange rate differences, along with volatility persistence in home and foreign equities are the main focuses in the study of Koulakiotis et al. (2010), alongside exchange rate disparities across the United Kingdom (UK) and German markets. In their study, volatility persistence is examined as the priority in foreign equities in the UK and German markets. The next focus is the respective home portfolios of cross-listed equities, and the third is exchange rate disparities. It is shown that volatility persistence is more evident than error persistence from cross-listed equities—foreign or home—as well as with exchange rate differences. The study of Shamiri and Isa (2010) focuses on the sharing of global data regarding return and volatility spillovers from US and Japan markets to Asia–Pacific markets. This is achieved by examining daily stock market return data for a specific time frame. The study attempts to determine if more economic, monetary and financial integration has a substantial impact on the source and level of volatility spillovers to individual markets. The findings include that the US market requires more attention if international investors are to profit from Asia–Pacific securities. However, using global hedging strategies in Asia–Pacific markets requires data relating to Japanese volatility, for the best results.

Joon Byun, Woo Rhee and Kim (2011) examine whether the greater value attached to implied volatility from a stochastic volatility model is superior to the implied volatility of forecasting performance. Causality tests across implied and realised volatility are used to estimate forecasting performance. It is suggested that a trading strategy related to the forecasting power of an implied volatility delivers positive results, especially in a highly volatile market or a low-return market. It is also shown that during a growth period in a volatile market, it is increasingly valuable to appraise forecasting performances of intraday future volatility, both theoretically and practically. Implied volatilities are suggested as more important for future realised volatility. In research conducted by Hussainey et al. (2011), the link across dividend policy and share price changes in the

UK stock market is examined. Multiple regression analyses are employed to ascertain the relationship of share price changes and both the dividend yield and dividend payout ratio, showing that there is a positive correlation between dividend yield and stock price changes. Conversely, a negative correlation exists between dividend payout ratio and stock price movements. It is shown that dividend policy is important when trying to establish share price changes for companies listed on the London Stock Exchange.

Ishida et al. (2011) suggest an innovative approach to calculate continuous-time stochastic volatility models for use in the S&P 500 stock index, which employs intraday high-frequency observations of the S&P 500 index as well as the Chicago Board Options Exchange implied volatility index. In their model, a framework is used to employ intraday high-frequency data of index estimates, which is especially useful when it comes to increasing the reliability of the leverage aspect that facilitates the diffusive elements of the price process and its spot variance process. In their work, the value of suitable changes to moment conditions is underlined, particularly when realised measures are estimated with data stemming from non-contiguous non-full-day trading sessions.

2.3 Technical Analysis Theories

The growing linkages between Global business markets in various factors, including currency, commodity and stocks, lead to raise several changes in the process of stock prices estimations (Zhang, Xu, & Xue, 2017). One of the main fundamental aspect of the stock market is for the investors to estimate the behavior of which stocks are valuable, which ones are overpriced, and hence, the decision to buy or sell (Shah, Isah & Zulkernine, 2019). In this regard, several theories have been postulated that explains the behavior of the stock markets, and how investors respond the excepted stock market behavior. Among such theories, we focus on theories that are related to the research technical analysis, include Efficient Market Hypothesis (EMH), and Modern Portfolio Theory (MPT) and capital asset pricing; which are discussed on the section below.

2.3.1 Efficient Market Hypothesis

The efficient market hypothesis (EMH) is a complete contrast of the above-mentioned theories, which are based on a technical and fundamental estimation of the firm's value. The proposition of the efficient market hypothesis is that there can never be an accurate and consistent estimation of beta values that represents a firm's value (Rossi & Gunardi, 2018). Instead, the EMH proposes that all the relevant information regarding a firm's share, including insider information, are necessary for estimating the value of a stock. The EHM theory, therefore, proposes that it is almost impossible to outperform the market by either determining or estimating undervalued stock or stocks with inflated prices. A major assumption of the theory is that the stock values are always a fair representation of the fair value of exchanges (Gabriela ğiĠan, 2015). As a result, the proponents of the EMH proposes that it is safer to invest in the low-cost and passive stock portfolio than in riskier and active ones.

The first comprehensive study about market efficiency theory was introduced by Fama (1970). EMH theory is an investment theory that implies that current share prices fully reflect all trading information. This theory explains that it is technically impossible to outperform the stock market consistently via a technical analysis, as stock prices are supposed to react only to new information. EMH theory has three types of tests that rely on the available relevant information. First, we have the weak-form test, which depends on past stock prices' history (Alexander, 1964, Fama, 1995, Fama, 1965). Secondly, are the semi-strong tests, which depend on all available public information and the past history of stock prices (Fama et al., 1969, Wand, 1980). Finally are the strong-form tests based on both public and private information (Jensen, 1968).

A study by Leković (2018) explored the validity of the efficient market hypothesis. The study used a systematic review approach in which studies from the period 1995 – 2016 were review. A total of 40 studies were explored. The results found that there is neither presence nor absence of validity of the theory. However, with regards to the validity of the concept in financial markets, Leković (2018) found that there are significant validity and consistency regarding the same. Born et al. (2017) tested the validity of the efficient market hypothesis by examining the stock trade patterns following president Trump's tweets between the time of election to the inauguration. The study found that the variation in stock trading in response to specific tweets targeting ten companies were not significant and only lasted a short period. The study, therefore, confirmed the assumption of the efficient market hypothesis that the stock values are dependent on all the possible information. Kumar and Jawa (2017) also admit that the efficient market hypothesis is valid, considering the fact that it is the cornerstone of modern financial markets. However, the study indicated that the EMH is vulnerable to certain non-informational futilities, especially in the emerging market economies. For instance, the study reported a similar trend of stock market trading in India in correspondence to specific calendar events.

Campanella, Mustilli, and D'Angelo (2016) confirmed the reliability of the efficient market hypothesis in predicting the stock market prices as compared to the technical and fundamental analysis. However, similar to the study by Born et al. (2017), the study also confirmed that market anomalies could sometimes challenge the validity of the EMH. Charfeddine and Khediri (2016) found that the GCC stock markets have varying degree of time-varying efficiency. In other words, the efficiency of the stock market varies with specific time periods. An evidence of the same was reported during the Arab Spring revolution. Meero (2018) found that the stock markets of the GCC are not efficient at the weak form of efficiency. In other words, contrary to the proposition that all current information is important in determining stock values, Meero (2018) reports that historical information, trend and data can be used by investors to make profits in the GCC stock markets. Elango and Hussein (2010) found also confirm that the GCC stock market are not efficient at the weak form of efficiency, and hence call for the use of integrated GCC stock market for better performance prediction.

Several studies were conducted to examine EMH theories in the GCC region. Most of them examined the presence of the weak form of the EMH. For instance, Gandhi et al. (1980) investigated EMH theory on the Kuwait Stock Exchange (KSE) during the period from 1975 to 1978. The authors found KSE was an inefficient market and had high serial correlation and volatility. Butler and Malaikah (1992) examined Saudi Arabia and Kuwait stock markets for the period from 1985 to 1989. They found high serial correlation linkages in both stock markets, which implied that market's inefficiency. Furthermore, Elango and Hussein (2008) investigated EMH theory of six GCC stock markets during the period from 2001 to 2006, and concluded that all GCC markets reject the weak form efficiency. Moreover, Jamaani and Roca (2015) showed no evidence of the weak-form efficiency of GCC stock markets. However, some studies found an indication of weak form efficiency in some GCC stock markets as in the study of Oman Dahel and Labbas where they found a weak form efficiency, Saudi Arabia, Kuwait, Bahrain, and Oman. In this research, we aim to study the linkage between oil price volatility and the stock markets of GCC countries based on the EMH through evaluate the existence of the weak form of EMH in GCC stock markets.

2.3.4 Modern Portfolio Theory

The model of Modern Portfolio Theory (MPT) is introduced by Markowitz (1952) to illustrate how to expand portfolio returns of firms by taking into the account the level of predefined portfolio risk. MPT is considered as an instrumental in safeguarding the investments of investors from loss of value. The theory closes in on the fact and directs investors towards appreciating that risk is inevitable when it comes to chart an upward trajectory (Roncalli 2014). The risk of the portfolio is a function of each asset's variance. It also forms a swift correlation between the need that each asset portrays. Calculating the risks that come with each level of portfolio asset makes an individual accept that there is a combination of many different assets (Marston 2011). Any combination of assets, for instance, the MSCI index and S&P500 index can be demonstrated graphically, with the risk of the portfolio on the X-axis and the investor's expected returns on the Y-axis. This way, it is possible to empirically determine efficient portfolios and ones that are not.

MPT asserts that the risks and returns of a given investment should not be considered or examined independently. Instead, they should be explored as part of a large portfolio (Rani, 2012). With regard to the same, a fundamental assumption of MPT is that the investor is risk-averse. Aversion, in this regard, implies that the investor has the capacity to invest in multiple low-risk assets. Within the asset portfolio, therefore, MPT asserts that the investor can create a portfolio that offers him or her maximum return within a determined risk level. Alternatively, the investor can construct a portfolio that minimizes risks within a given level of expected returns (Rani, 2012). Using statistical elements such as variance and correlation, MPT assumes that the value of an individual asset is less important considering its overall effect on the portfolio.

Beyhaghi and Hawley (2012) confirm the validity of modern portfolio theory. The authors argue that the widespread adoption and use of the theory are based on the long-standing validity that has persisted over time. Lee, Cheng, and Chong (2015) compared the validity of both CAPM and the MPT in estimating the stock values in Malaysia. The study used ordinary least square estimator – regression analysis. The study found that CAPM is efficient in predicting the moving averages of the stock prices. However, such predictions are vulnerable to unsystematic risks. The study found that the MPT is a better predictor, especially with respect to the elimination of both systematic and unsystematic financial risks. Omisore, Yusuf, Christopher (2012) also confirmed the validity of the MPT over the CAPM, which is commonly used together. The study reported that MPT is effective in reducing the associated risks of the portfolio. The study, however, reported that the CAPM model is commonly used to estimate the perceived risks or expected return associated with a specific portfolio. Bendob, Chikhi, and Bennaceur (2017) found that the modern portfolio theory was more reliable and profitable in investing in the GCC stock market compared to the traditional Capital Asset Pricing Model (CAPM). It can, therefore, argue that MPT is a reliable estimator of stock prices; however, it is dependent on technical and fundamental analysis, unlike the EMH, which only depends on all the information relevant regarding the particular asset. Investors are then able to construct portfolios that can optimize or multiple expected returns respect to the market risk levels. Investors with stocks at the GCC stock market find MPT very useful since it can construct efficient frontiers to their stocks so that they are manipulated to give the highest return possible concerning provided risks in the market. Investments are not supposed to be perceived independently but should be evaluated based on how investment affects general returns and risks. MPT enables an investor to construct multiple assets at the same time.

It informs an acceptance and careful analysis of risks whilst factoring in the desired level of expected returns whilst decreasing the intensity of risk. The statistical measures associated with the stock of GCC, such as a strong correlation between oil prices and the value of stocks reveal a consistent pattern in the wake of how a person/entity conduct themselves with their entire portfolio (Kakushadze & Serur 2018). Further related studies focusing on GCC stock markets are discussed in Section 2.6. In this research, we apply MPT to effectively identify portfolios optimal weights and hedge ratios for investors in GCC stock markets and assess the level of oil price impact on building well-diversified portfolios including oil and non-oil stocks and enable investors to manage the oil risk more effectively.

2.3.2 Capital Asset Pricing Model

The Capital Asset Pricing Model (CAPM) is used to establish the relationship between expected return and systematic risk of specific assets, often the stocks. The model is used to determine the prices of risky securities and to develop expected returns of given assets when the cost of capital is known (Elbannan, 2015). The CAPM is based on the assumption that when investors decide to buy a specific asset, they expect to be paid in terms of the risk they took, and the time value of the money. As such, CAPM has two major components, the expected return and time value of money (Elbannan, 2015).

2.4 Stock Markets and the Oil Price

Numerous studies have investigated the relationship between oil prices and stock values in international markets and find strong evidence for interdependency, where the volatility of oil price can be transmitted across stock markets (Baele 2005; Beirne et al. 2010; Worthington & Higgs 2004). El-Sharif et al. (2005) study the association between oil price movement and UK stock returns in the oil and gas sectors in a multifactor model, using daily data for 1989–2001. They find a positive, often significant, relationship, which indicates the impact of crude oil price volatility on stock values within these sectors. Further, Malik and Ewing (2009) use the GARCH-BEKK model to examine volatility transmission between oil price and indices for five US sectors (financial, industrial, consumer services, health care and technology) through the observation of weekly data from 1992 to 2008. The results confirm significant shock and volatility transmission between oil prices and the various stock market sectors. Filis, Degiannakis and Floros (2011) conclude time-varying interdependency between oil price and stock markets in both the oil-exporting and oil-importing countries they examine. Guesmi and Fattoum (2014) investigate the interdependency between oil price and the stock markets of five oil-importing (US, Italy, Germany, Netherland and France) and four oil-exporting countries (Saudi Arabia, Kuwait, UAE and Venezuela). They find a positive relationship with oil pricing volatility in oil-exporting countries.

In the GGC economies, several studies have been conducted to explore volatility transmission between stock market and oil prices. There is clear evidence that changes in oil markets have a major influence on stock market activities in these countries (Arouri et al. 2011; Jouini & Harrathi 2014; Khalifa, Hammoudeh & Otranto 2014). The GCC economies are expected to be vulnerable to changes in oil prices because they are major suppliers of oil (Ghosh 2016; Ravichandran & Alkhathlan 2010). To investigate the relationship between oil price and the stock market in five GCC countries, Hammoudeh and Choi (2006) apply a vector-error correction (VEC), using weekly data from 1994 to 2004. They find interdependence between the oil price and GCC markets and conclude that the oil price is one of the most important factors affecting stock markets. Moreover, Malik and Hammoudeh (2007) study volatility transmission among US equity markets, the global oil market and equity markets of three GCC countries. The authors apply the Box–Jenkins technique to sample daily data from 1994 to 2001. They find volatility transmission from the global oil market to all GCC stock markets. Specifically, it is observed that only Saudi Arabia experiences significant volatility transmission—from the Saudi equity market to the global oil market. Arouri and Fouquau (2009) use ordinary least squares (OLS) regression to study the short-run relationship between oil prices and GCC stock markets, using weekly data from 2005 to 2008. They find some evidence for slight non-linearity in Qatar, Oman and UAE and conclude that the relationship between oil price changes and GCC stock markets is asymmetric and regime switching.

Arouri et al. (2011) investigate links between the oil price and GCC stock markets in terms of returns and volatility in a VAR-GARCH model, using daily data from 2005 to 2010. Results show significant shock and volatility spillover between the oil price and stock markets. Naifar and Al Dohaiman (2013) use a Markov regime-switching model to study the impact of oil price volatility on GCC stock markets under crisis and non-crisis regime shifts using daily data from 2004 to 2011. They find evidence of volatility transmission between OPEC oil price and GCC stock markets that are regime dependent, with the exception of the Omani market, which is found to have low volatility transmission. Awartani and Maghyereh (2013) study volatility spillover between GCC countries and oil price for the period 2004–12. A bidirectional interdependency is found between oil price and GCC stock markets during the period under consideration.

The aforementioned studies focus on the relationship between oil price and the GCC stock market by analysing daily and weekly market data. Unlike previous studies, the current study undertakes an in-depth analysis of volatility transmission between oil price and various GCC stock sectors. Focusing on the sector level of stock markets provides a better and more detailed understanding about volatility transmission between GCC stock markets and oil price changes.

2.5 Sensitivity of Stock Markets to Global Factors

The stock markets associated with GCC are largely influenced by several international factors. These include global oil prices, the stock prices of major stocks, the value of a foreign currency against local ones, and others. These factors are responsible for determining production costs and the cost of products (prevailing market prices) (Khalfaoui, Boutahar & Boubaker 2015). Consequently, they dictate the level and frequency of foreign direct investment inflows, aside from there are various studies that have highlighted the impact of global tenets in multiple markets. Classens (2014) documented the impact of changes in global oil prices relative to the performance of stocks in their respective markets. The study by Krishnamurthy and Khalid (2010) investigated the impact of international oil prices on the stock markets owned by the Gulf Cooperation Council (GCC). They were interested in the investigation because the member states of GCC are major oil suppliers. Therefore, GCC stock markets are relatively volatile; thus, vulnerable to be affected by small changes in oil price (Arouri, Jouini & Mguyen 2013). Jouini et al. (2013) adds by stating that the expected findings include a significant influence in slight price changes on returns from GCC's stock markets. The effect was likely to be felt in the long-term, and it was defined as the period required for the price change effect to be experienced as working its way upwards because of macroeconomic indicators.

The six-member states of GCC share several socio-economic and political similarities. Their stock market also tends to display a consistent pattern across all the states (Thewissen, Arslan-Ayaydin & Dorsman 2020). Emirates stands out as a lucrative and emerging market, whereas al the rest, excluding Bahrain, are not known by foreign investors. The stock markets of GCC countries are relatively unique since they respond to minor events in the political and economic spheres of these states and surrounding regions. For instance, there is a consistent link between stock prices and oil prices in these GCC states. Arouri (2013) identified that negative changes in the prices of oil triggered larger changes when it comes to returns from the stock market compared to positive changes in the prices of oil. Additionally, these findings suggest that when there is an empirical relationship, it stretches from stock markets to oil prices in most scenarios.

In this research, we focus on how GCC stock markets are influenced by global factors, including US and world financial markets (Alotaibi & Mishra 2015; Assaf 2003). GCC economies are mostly oil dependent and their oil prices take their signal from the future prices of US crude oil (WTI). The US stock market index (S&P500) also affects GCC stock markets. US and GCC economies are highly interrelated as a result of coordination between their monetary policies. Consequently, information from the US stock market can influence GCC stock markets. Several studies examine global factor effects in multiple markets, such as the equity markets of Canada, Japan, UK and US. Jones and Kaul (1996) focus on the importance of global oil changes to explain fluctuations in stock markets and find the impact is significant only in Canadian and US markets. Huang et al. (1996) use an unrestricted VAR model to examine the links between daily returns of oil futures and US stock returns. They find that oil future returns influence some individual oil company stock returns, but have a negligible impact on broad-based market indices, including the S&P 500. Moreover, Sadorsky (1999) study the relationship between fuel oil prices and stock prices in an unrestricted VAR model using US monthly data from

January 1947 to April 1996. The study focuses on the importance of using oil price in the interpretation of other variables' movements; that is, interest rate and industrial production.

Few studies, however, examine the influence of global factors in GCC economies. Hammoudeh and Li (2008) use the iterated cumulative sums of squares (ICSS) algorithm and weekly data to investigate the effect of volatility patterns on five GCC stock markets. They find evidence of regional and global factor effects on GCC stock markets. Hammoudeh and Alesia (2004) study GCC stock market sensitivity to WTI oil future returns in a VEC model for the period 1994–2001. They find the Saudi stock market to have the highest sensitivity to changes in oil prices compared with other GCC stock markets. Further, Hammoudeh and Aleisa (2004) investigate volatility transmission between US equity, oil price and GCC stock markets in a GARCH model using daily data from 1994 to 2001. They identify evidence for significant volatility transmission from the Saudi stock market to oil price. Zarour (2006) investigate the impact of oil price increases on five GCC stock markets in a VAR model using daily data. They find that the market response to oil prices is higher and faster following an increase in oil price. Jouini and Harrathi (2014) examine the volatility interaction between world oil price and GCC stock markets over weekly periods from 2005 to 2011. They use the GARCH-BEKK process to investigate the asymmetric response of conditional volatility to negative shocks. They find, similar to previous studies, associations between shock, volatility and GCC stock markets and world oil prices.

Further investigation of GCC stock market sensitivity at the sectoral level to global factors (e.g. the MSCI World index and S&P 500 index) is very important for several reasons. First, the six GCC countries are among the major oil producers in the world; hence, their stock price indices may be influenced by oil price fluctuations and other factors. Second, this knowledge will allow investors to make important investment decisions in local and world markets and assist policy makers responsible for stock market regulation. Finally, GCC monetary policies follow those of the US, because their exchange rates are tied to the US dollar. This study addresses the relationship between stock market sectors and global factors, allowing for the identification of specific sectors that provide a channel for international diversification over high-fluctuation periods.

This study addresses the volatile nature that makes it respond to slight changes. The relationship between stock and oil markets is a matter that has undergone extensive investigation, more so because of volatility transmission (Reinganum & Becker 2018). The phenomenon is common across all financial markets, but more intense in GCC member states. Optimal weight and hedge ratios are particularly influential for investors who are interested in making stock predictions with regards to future performances. Over the years, multiple methods have been used to conduct the same task, only that they do not provide consistent results (Kahn 2018). The phenomenon of volatility transmission is measured using hedge ratios and features as a matter of urgent concern for investors and companies. It is a matter of critical concern amongst GCC countries because they strongly rely on oil and their stock markets are determined (directly or indirectly) by the price of this special commodity.

2.6 Modern Portfolio, Optimal Weight and Hedge Ratios

There is a consistent relationship between GCC stock performance and the performance of other stocks, such as the MSCI index and S&P500 index. As noted earlier, the stock market of GCC countries is largely affected by minor changes in international patterns and events. These states are major producers of oil and gas; commodities that are used widely in industries, transportation, and other purposes. No country in the world does not consume oil on a minute-by-minute basis. Consequently, since oil is a major determining product, it tends to reflect a positive relationship with the upward or downward trend of international stocks. Changes in the prices of these stocks tend to have a positive effect on the GCC stock markets since investors use the surplus returns to finance international ambitions (Baker & Ricciardi 2014). Oil is an important commodity that determines the performance of many stocks in foreign markets, such as the New York Exchange. Companies in America require oil to drive manufacturing and transportation processes. When prices of oil shoot up, these firms will encounter additional operating expenses; thus cut on their production capacities or lay-off workers (Butler, Philbrick & Gordillo 2016). All two scenarios represent the decreased productivity of these organizations. The stock prices of their stocks will subjectively decrease in value to reflect what is happening at the respective firms.

There tend to be spillover effects between the market indexes and hedge funds for GCC states. Modern Portfolio Theory (MPT) has been widely used to estimate the optimal weight and hedge ratios of GCC stocks. Special attention is given to these market regions because of its high volatile nature that makes it respond to slight changes. The relationship between stock and oil markets is a matter that has undergone extensive investigation, more so because of volatility transmission (Reinganum & Becker 2018). The phenomenon is common across all financial markets, but more intense in GCC member states. Optimal weight and hedge ratios are particularly influential for investors who are interested in making stock predictions with regards to future performances. Over the years, multiple methods have been used to conduct the same task, only that they do not provide consistent results (Kahn 2018). The phenomenon of volatility transmission is measured using hedge ratios and features as a matter of urgent concern for investors and companies. It is a matter of critical concern amongst GCC countries because they strongly rely on oil and their stock markets are determined (directly or indirectly) by the price of this special commodity.

In GCC region, volatility transmission between oil price and GCC stock markets is a cause of great concern for investors. Since these countries are oil dependent, investors have a need to understand the extent to which risk and portfolio values are influenced by oil price volatility (Arouri et al. 2011). In this research, we aim to study to what extend oil price can affect the performance of GCC stock markets at the sectoral level which can help investors to build well-diversified portfolios including oil and non-oil stocks and enable them to manage the oil risk more effectively.

Numerous previous studies have investigated the effectiveness of optimal weight and hedge ratio strategies by examining the impact of oil price changes on the stock market. Arouri et al. (2011) study volatility transmission, portfolio design and hedging effectiveness in Europe, the US oil and sector stock returns using a VAR-GARCH model and weekly data from 1998 to 2009. They find a unidirectional spillover from oil to stock markets in Europe, and bidirectional spillover in the US. They also suggest that the optimal portfolios in both markets should have outweighed stocks in oil assets. Moreover, Kang and Yoon (2013) study volatility transmission between oil futures prices and 10 Asian emerging country indices via a VAR-bivariate GARCH model using weekly data from 1999 to 2012. Moreover, they analyse the optimal weighted and hedge ratios for optimising a portfolio to minimise exposure to risk. The results provide evidence for volatility transmission from the future oil market to some of the emerging Asian stock markets. The examination of optimal weight suggests that adding oil assets to a well-diversified portfolio improves overall risk-adjusted return performance and a hedge ratio could be accomplished by taking a short position in the Asian stock market. Hamma, Jarboui and Ghorbel (2014) and Kang and Yoon (2013) examine volatility transmission between oil price and the Tunisian stock index at the sectoral level and determine the best strategy for oil index portfolio hedging. They use conditional correlations estimated from a GARCH-BEKK model for weekly data from 2006 to 2012. They find most relationships to be unidirectional—from the oil market to the Tunisian stock market—and show that hedging strategies that have oil and stock assets reduce portfolio risk considerably.

Kang and Yoon (2014) use a bivariate GARCH model to investigate volatility transmission between world oil prices and five industrial sector indices for the Korea stock market. They use weekly closing market data from 2000 to 2009 and analyse the optimal weight and hedge ratio to build an optimal portfolio. They find significant sensitivity to the world oil price and suggest adding oil assets into a well-diversified portfolio to improve the overall risk-adjusted return performance and effectively hedge the oil price risk. Little attention has been given to the impact of oil prices on stocks by sector, especially in GCC countries. The current study examines the linkage between oil prices and three sector stock indices in GCC countries. Further, the findings are used to compute the optimal weight of an oil stock portfolio, as well as optimal hedge ratios for analysing hedging effectiveness.

Chapter 3 Data and Impact Analysis of GCC Stock Market Sector Returns Using GARCH Models Pre- and Post-2014

3.4 Introduction

This chapter presents primary descriptive statistics and evaluates the market performance of GCC stock markets at the sectoral level. The market performance evaluation is conducted via several risk-adjusted performance measurements, including the Sharpe ratio (SR), Treynor ratio (TR), VaR and conditional value at risk (CVaR). The augmented Dickey–Fuller (ADF) and Phillips–Perron test are applied to check the stationarity of the data. The research focuses on two main sample periods before and after the drop in oil price in mid-2014, and compares the results of the analysis pre- and post-2014. Further, a set of GARCH family models is applied; including the EGARCH, Glosten–Jagannathan–Runkle GARCH (GJR-GARCH) and GARCH-in-mean (GARCH-M) are applied to capture the asymmetry effect. GARCH family models help to determine the effects of good and bad news on stock markets. This study focuses on three major non-oil GCC stock market sectors (consumer discretionary, financial and real estate) from 2010 to 2017.

3.5 Conceptual Framework for Data Description and Market Performance

This section outlines the conceptual framework as shown in Figure 3.1. First, the primary descriptive statistics analysis is performed for the sample data from 2010 to 2017, which includes two main periods before and after oil shock (pre- and post-2014). Following this, the efficiency of the selected sectors of the GCC stock market is examined through evaluation of the weak form of EMH. Further, GCC stock market performance is evaluated via four risk-adjusted performance measurements (SR, TR, VaR and CVaR) to identify potential losses in the selected GCC stock market sector returns over the total sample period, as well as pre-2014 and post-2014. Then, a set of unit root tests, including the ADF and PP (Karam), are applied to identify whether the time series have a unit root (non-stationary) and then ensure they are stationary for further data analysis. Finally, various GARCH family models, including EGARCH, GJR-GARCH and GARCH-M, are employed to capture the asymmetry effect of selected GCC stock market sectors to help determine the effects of good and bad news on GCC stock markets. This improves insights into the effects of information asymmetry on GCC stock markets at the sectoral level in the periods before and after the sharp drop in oil price.

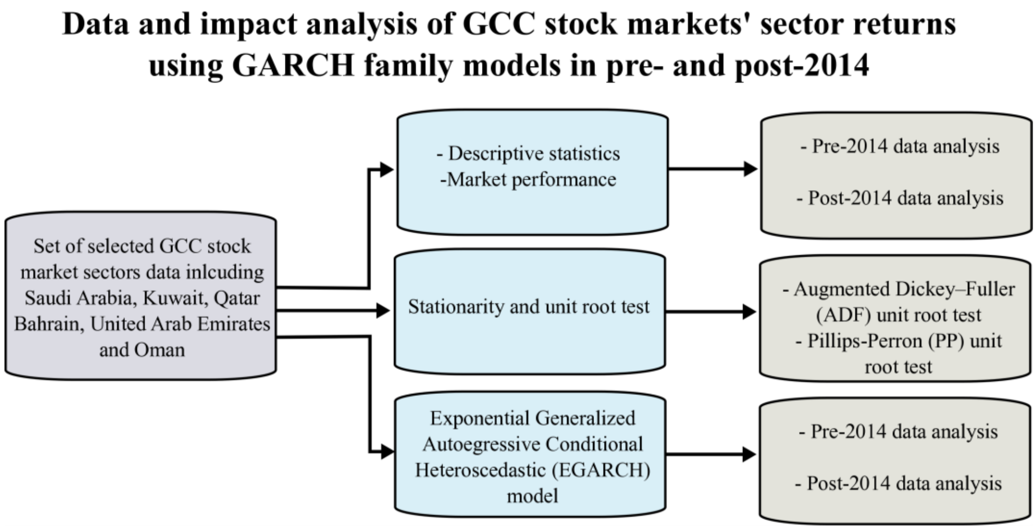

Figure 3.1: Conceptual framework with fundamental and in-depth analysis approaches

3.6 Data Description

This section presents the dataset collected for the selected GCC stock market sectors. The daily data employed in this study are obtained from the Gulf Base website for seven major GCC stock markets, along with the WTI oil price and the MSCI World and US S&P 500 indices.

Stock market data for all six GCC members are used in this thesis, with different sample periods because of data availability limitations. The obtained dataset consists of the daily-adjusted price from 2010 to 2017, except the Kuwait data ranges from 2012 to 2017. The study focuses on three sectors for each stock market, which also vary based on data availability for each stock market, as shown in Table 3.1. For each series, the daily return, R_t, of the stock market is calculated according to the following equation:

$$R_t = \frac{I_t - I_{t-1}}{I_{t-1}} \tag{3.1}$$

where I_t is the stock index-adjusted price on day t, and I_{t-1} is the stock index-adjusted price on the previous day.

Table 3.1: GCC stock markets with selected sectors 2010–17

Country and stock exchange	Index used	Sectors covered	Time period
Saudi Arabia	Tadawul All-Shares Index (TASI)	Banks Real estate Retail	2010–17 daily data
United Arab Emirates	Abu Dhabi Securities Exchange (ADX) Dubai Financial Market (DFM)	Banks Real estate Services	2010–17 daily data
Qatar	Qatar Exchange (QE)	Banks Real estate Services	2010–17 daily data
Bahrain	Bahrain Stock Exchange (BSX)	Banks Services Industrial	2010–17 daily data
Oman	Muscat Securities Market (MSM)	Banks Services Industrial	2010–17 daily data
Kuwait	Kuwait Stock Exchange (KSE)	Banks Services Industrial	2010–17 daily data
WTI	West Texas Intermediate (WTI) oil market		2010–17 daily data

3.7 Descriptive Statistics

3.7.1 Full Sample Period Analysis

The descriptive statistics for the returns for each sector of the GCC countries and other international stock index returns (WTI, MSCI and S&P 500) are presented in Table 3.2. The descriptive statistics include the mean, standard deviation, maximum and minimum values, skewness and kurtosis.

Table 3.2: Descriptive statistics for GCC stock markets at sectoral level with WTI 2010–17

Country	Sector	Mean%	Std. dev%	Skewness	Kurtosis	Min	Max	JB
Saudi Arabia	Banks	0.007	1.169	0.0636	10.605	-0.0640	0.0884	4156.6**
	Real Estate	0.570	1.526	-0.3595	9.6939	-0.0950	0.0987	3255.9**
	Retailing	0.057	1.247	-0.6414	10.713	-0.0827	0.0695	4391.7**
Abu Dhabi	Banks	0.045	1.146	0.5534	11.965	-0.0775	0.0887	5963.6**
	Real Estate	0.526	2.380	4.0691	1708.5	-0.0983	0.9709	2.E+08**
	Services	0.018	1.459	0.1901	6.2733	-0.0713	0.0730	793.66**
Dubai	Banks	0.057	1.304	0.5459	11.914	-0.0718	0.1156	5894.9**
	Real Estate	0.057	2.093	0.1113	7.0334	-0.0910	0.1495	1192.6**
	Services	-0.020	2.758	0.9406	9.4605	-0.1000	0.1499	3309.4**
Qatar	Banks	0.059	1.014	-0.0016	15.738	-0.0996	0.0857	11818 **
	Real Estate	0.046	1.598	1.2903	25.553	-0.1017	0.2043	37533 **
	Services	0.080	1.037	0.0769	18.032	-0.0889	0.0988	16460 **
Bahrain	Banks	0.027	0.876	-0.4041	10.854	-0.0563	0.0525	4478.1**
	Services	-0.010	0.659	-0.1606	11.562	-0.0454	0.0405	5273.4**
	Industrial	-0.050	1.431	-0.2103	18.537	-0.0972	0.0968	17353 **
Oman	Banks	-0.010	0.927	-0.5000	14.324	-0.0780	0.0702	9300.4**
	Services	0.007	0.562	-0.4836	10.464	-0.0424	0.0401	4076.6**
	Industrial	0.001	0.647	-0.7369	14.040	-0.0496	0.0442	8927.5**
Kuwait	Banks	-0.010	0.588	-0.7706	8.2545	-0.0334	0.0325	2157.7**
	Services	-0.010	0.706	-0.0264	3.6712	-0.0233	0.0322	21.628**
	Industrial	0.028	0.673	1.2360	24.556	-0.0280	0.0832	22460 **
WTI		0.0008	2.175	0.3274	6.7959	-0.1073	0.1272	1097.9**

Note: ** significant at 5% level, std. dev = standard deviation, JB = Jarque–Bera normality test, WTI = West Texas Intermediate oil index.

3.7.1.1 *Return And Risk Analysis*

The highest daily average stock returns for the total sample period are recorded by real estate sectors in the Saudi Arabia (0.58%) and Abu Dhabi (0.53%) stock exchanges. This shows that investment in the real estate sector gives a higher return in the Saudi Arabia and Abu Dhabi stock markets. The real estate sector in Saudi Arabia has an average return of 0.58% per day. Complementing high return always followed with higher volatility (Adam, Marcet & Nicolini 2016), the real estate sector in the Abu Dhabi stock exchange records a standard deviation of 2.00%, which implies the highest volatility among daily returns; other sectors, such as real estate in Saudi Arabia and Qatar show similar stock fluctuations, at around 1.15%. The Dubai services sector presents high volatility (~2.70%) with a low expected returned, which is not a preferred position for an investor. These findings are mostly consistent with those Trabelsi (2017) and Mensi (2017). In terms of the relationship between risk and return, the results for the real estate sector support the fundamental principle of high risk equalling high return. Further, investors prefer to invest in stock that has high volatility to obtain high returns. WTI records a negligible average daily return with a standard deviation of 2.17%. WTI represents high volatility in terms of its minimum and maximum values as a natural result of oil price movements.

Figure 3.2 illustrates how the daily mean return and standard deviation of the daily return are distributed in the selected sectors of the GCC market in the study sample. Daily stock market sector return averages range from –0.02% in the Dubai services sector to 0.80% in the Qatar services sector. The highest level of risk observed is in the Abu Dhabi real estate sector, with a standard deviation of 2.38%; the lowest level of risk is observed in the Muscat services sector, with a standard deviation of 0.562%. The oil market is highly volatile and risky over the sample period, as indicated by the standard deviation of 2.17%. This high volatility in the oil market is unsurprising, given that the price of oil over the sample period ranges from US$30 to US$113.

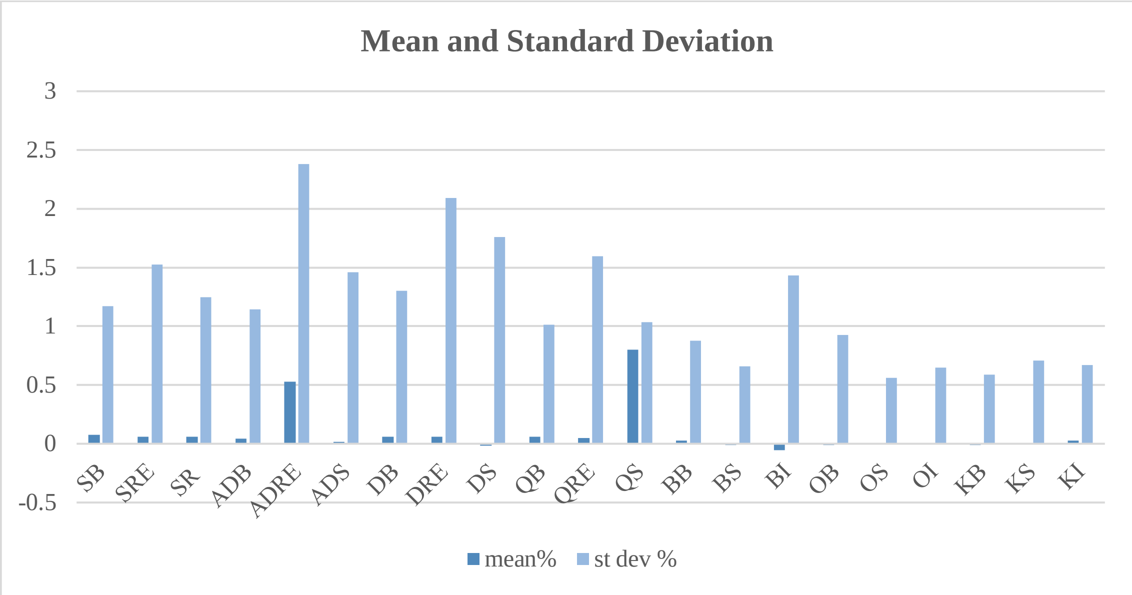

Figure 3.2: Mean and standard deviation for selected sectors of GCC stock markets (note: SB, SRE, SR, ADB, ADRE, ADS, DB, DRE, DS, QB, QRE, QS, BB, BS, BI, OB, OS, OI, KB, KS and KI are abbreviations for GCC stock market sectors)

3.7.1.2 GCC Stock Market Distribution Analysis

The distributions of the GCC stock market sector returns are positively skewed for the bank sector in Saudi Arabia; industrial sector in Kuwait; and all sectors in Abu Dhabi, Dubai and Qatar. This indicates they have a distribution with an asymmetric tail extending towards more positive values. However, negatively skewed distributions indicate an asymmetric tail extending towards more negative values for the real estate and retail sectors in Saudi Arabia; banks in Qatar; and all sectors in Bahrain, Oman and Kuwait. Kurtosis measures the degree to which a distribution has a higher or lower peak than a normal distribution. The results indicate that kurtosis is positive and greater than 3 in all sectors.

The above results imply that returns in all three sectors in all seven markets have peaked distributions and are not normally distributed. For example, returns in the real estate sector of the Abu Dhabi market are highly peaked, with an asymmetric tail extending towards more positive values (positive skewness). The estimated Jarque–Bera statistics recorded in column 9 of Table 3.2 confirm that the daily returns for all sectors do not follow a normal distribution. Therefore, the null hypothesis of a normal distribution is rejected. This might be because GCC stock markets differ from the rest of the world's markets as they trade from Sunday to Thursday over the sample period.

3.7.1.3 *Volatility Clustering Analysis*

The movement exhibited by the daily market returns during the full sample period in different GCC stock market sectors are shown in Figures 3.3 and 3.4. It is inferred that a period of low volatility tends to be followed by a prolonged period of low volatility and a period of high volatility is followed by a prolonged period of high volatility, which means that volatility clusters and there is an ARCH effect, as presented in the following section. These figures reveal that most index returns are close to level from the beginning of 2013, and some, such as the banks sectors in Saudi Arabia and Qatar, show a high level of volatility related to the high price of oil in the same period. Abu Dhabi and Dubai bank sectors show a similar level of low volatility in the early period and the volatility increases. However, in mid-2014, there is a slight increase in returns and a high-volatility period is indicated. The service sectors in Abu Dhabi and Dubai and the bank sector in Bahrain display a similar level of volatility over the period.

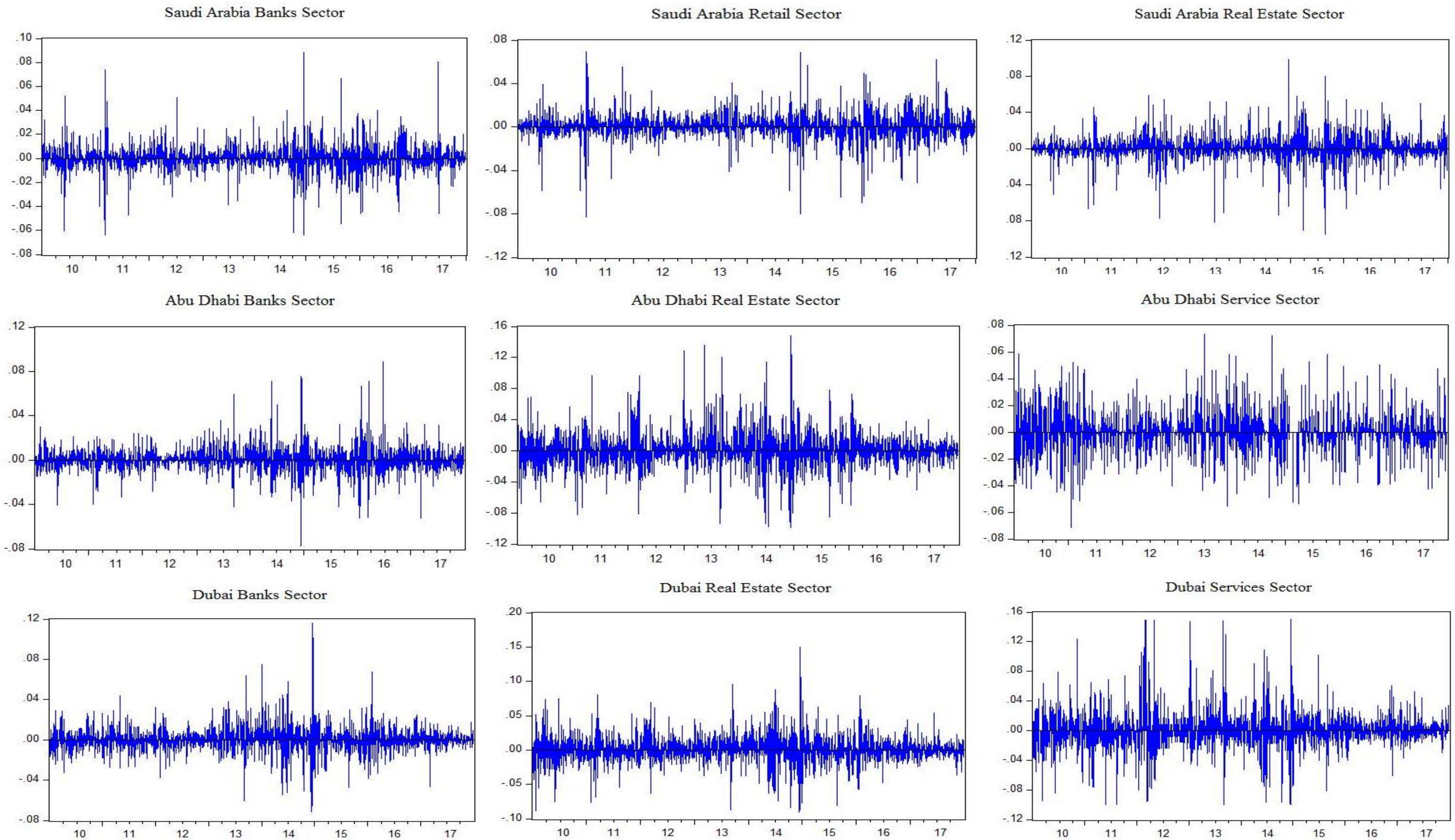

Figure 3.3: Recorded daily returns for market sectors in Saudi Arabia, Abu Dhabi and Dubai, 2010–17

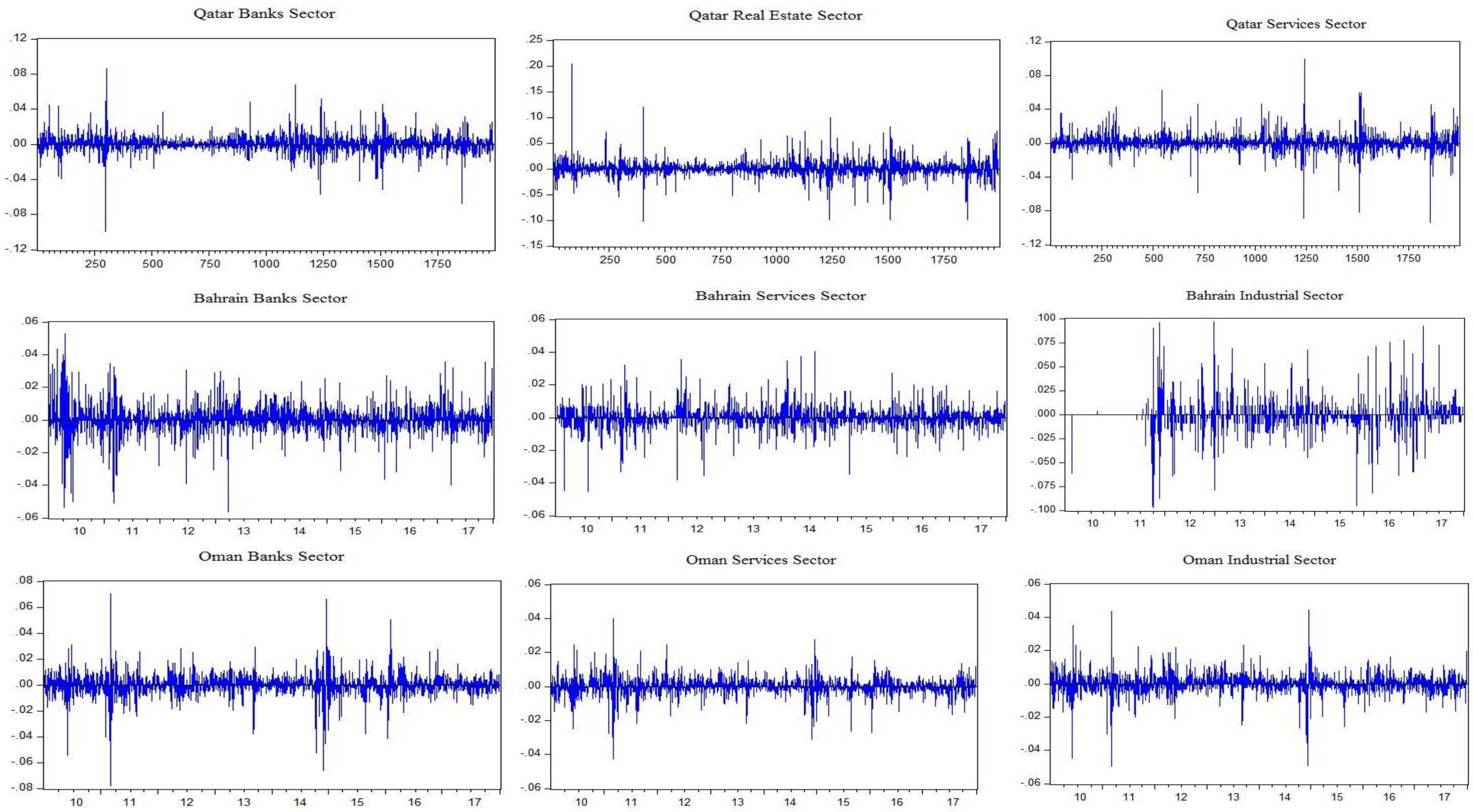

Figure 3.4 Recorded daily returns for market sectors in Qatar, Bahrain and Oman, 2010–17Sub-sample Period Analysis (Pre-and Post-Mid-2014)

The full sample period is divided into two periods for analysis: before (January 2010–August 2014) and after the oil price drop (September 2014–December 2017). Thus, the empirical analysis might easily consider the possible effect of the oil price drop, as presented in Table 3.3. Among Saudi Arabia's sectors, the real estate sector experiences less of an effect from the drop in oil price, as the return post-2014 is 0.02%. However, the returns for the bank and services sectors become negative after the drop in oil price, and the standard deviation is higher post-2014 for all Saudi Arabia sectors. In addition, the distributions of Saudi sector returns are positively skewed for banks, which indicates an asymmetric tail extending towards more positive values—or negative, for real estate and retail. However, post-2014 the skewed values reduce, which implies the tail becomes shorter for all but the real estate sector; all sectors have positive kurtosis greater than 3 for both periods. The returns for all sectors in the Abu Dhabi stock market are affected by the drop in oil price, as shown by the means in the post-2014 period (–0.037% for banks, –0.044% for real estate and –0.022% for services). In addition, all sectors present high risk post-2014, with the highest value being for the real estate sector, at 2.39%. The distributions of Abu Dhabi sector returns are positively skewed for all sectors in both periods and become higher post-2014 (with the exception of the real estate sector); they have positive kurtosis greater than 3 for both periods. All but the services sector in the Dubai stock market are affected by the drop in oil price. The Dubai services sector shows a negative return pre-2014, which becomes positive (0.09%) post-2014; however, the standard deviation is higher post-2014 for all Dubai sectors. The distributions of Dubai sector returns are positively skewed for the bank and service sectors and negative for real estate pre-2014; however, post-2014 all sectors have a positive skew and positive kurtosis, with a value greater than 3 for both periods. Moreover, the Qatar sectors show a negative mean and high risk post-2014. The bank sector is less affected by the drop in oil price than are other Qatar sectors. The distributions of Qatar sector returns are positively skewed for all sectors pre-2014; however, post-2014 all sectors have a negative skew and a positive kurtosis with a value greater than 3 for both periods.

Bahrain sectors show a negative mean both pre- and post-2014, except for the bank sector in the pre-2014 period. However, the standard deviations become lower post-2014 for all Bahrain sectors. The distributions of Bahrain sector returns are negatively skewed for all sectors and show positive kurtosis with a value greater than 3 for both periods. The Oman bank sector shows the worst mean returns pre- and post-2014, compared with other Oman sectors, with high risk post-2014. The services and industrial sectors show a negative mean after the drop in oil price, with the same level of risk. The Oman sector returns distributions are negative skewed for all sectors with positive kurtosis greater than 3 for both periods. The returns for the Kuwait bank and services sectors are affected (–0.05% and –0.04%, respectively) by the drop in oil price. However, the industrial sector shows the same level of returns pre- and post-2014. The distributions of Kuwait sector returns are positively skewed for the bank sector and negatively skewed for the services and industrial sectors, pre-2014; however, post-2014 bank and services sector return distributions have a negative skew and the industrial sector has a positive skew. All sectors have positive kurtosis values greater than 3 for both periods.

Table 3.3: Descriptive statistics for sub-periods of GGC stock markets at the sectoral level for pre-2014 (2010–mid-2014) and post-2014 (mid-2014–17)

Country	Sector	Pre- 2014					Post-2014				
		Mean %	Std. dev%	Skewness	Kurtosis	JB	Mean %	Std. dev %	Skewness	Kurtosis	JB
Saudi	Banks	0.0426	0.9647	0.1305	14.055	5849**	-0.062	1.4944	0.1027	7.0390	391.8**
Arabia	Real Estate	0.0779	1.2554	-0.4983	10.207	2532**	0.017	1.9596	-0.2110	7.2712	441.3**
	Retail	0.0126	1.0074	-0.3056	14.406	6241**	-0.081	1.6151	-0.5805	6.8411	385.7**
Abu Dhabi	Banks	0.0849	0.9444	0.5002	9.1089	1869**	-0.037	1.4676	0.6261	10.375	1357**
	Real Estate	0.0419	2.3633	0.4986	6.7314	727.8**	-0.044	2.3913	0.1990	8.5390	746.5**
	Services	0.0386	1.3842	0.1707	5.7733	380.9**	-0.022	1.4944	0.2236	7.5229	500.9**
Dubai	Banks	0.0990	1.1936	0.3697	7.3988	969.9**	-0.031	1.4959	0.7759	14.781	3430**
	Real Estate	0.1238	2.0227	-0.0108	5.7262	362.3**	-0.077	2.2247	0.3299	8.8099	830.5**
	Services	-0.0307	3.0222	1.0367	8.4869	1677**	0.009	2.1339	0.2318	11.045	1577**
Qatar	Banks	0.0096	0.9391	0.1905	24.092	2163**	-0.018	1.1455	-0.1479	7.1346	415.2**
	Real Estate	0.0832	1.4594	2.7301	43.089	7959**	-0.026	1.8473	-0.1433	9.1981	930.4**
	Services	0.1348	0.8756	0.5589	10.790	3011**	-0.032	1.2971	-0.0860	17.599	5151**
Bahrain	Banks	0.0527	0.9604	-0.4780	10.401	2678**	-0.025	0.6732	-0.1266	7.4387	468.6**
	Services	-0.0031	0.6991	-0.1595	11.779	3710**	-0.026	0.5707	-0.1934	8.6334	755.9**
	Industrial	-0.0451	1.4126	-0.3600	20.668	1503**	-0.066	1.4683	0.0654	14.778	3289**
Oman	Banks	-0.0031	0.8356	-0.6872	16.775	9206**	-0.060	0.907	-0.2917	10.988	1531**
	Services	0.0288	0.5690	-0.4298	10.616	2822**	-0.035	0.5479	-0.6270	10.145	1256**
	Industrial	0.0273	0.6325	-0.4536	12.326	4218**	-0.053	0.6740	-1.1862	16.498	4484**
Kuwait	Banks	0.0222	0.6228	0.1460	3.3702	5.246**	-0.046	0.7589	-0.3765	10.559	1389**
	Services	0.0301	0.7285	-0.0284	3.8339	16.47**	-0.038	0.7339	-0.0431	3.4319	4.672*
	Industrial	0.0297	0.6065	-0.3534	5.8482	203.1**	0.027	0.6337	2.0899	31.877	2050**

Note: ** and * significant at 5% and 10% level, std. dev = standard deviation and JB = Jarque-Bera normality test.

The summary statistics for the daily return series follow the oil price drop. In contrast, the means become negative post-2014 and the standard deviations for all sectors are high in the period after the oil price drop, as a result of high volatility in oil prices. The volatility of all variables increases after the oil price drop, which suggests that the drop in oil price affects market volatility and increases market uncertainty. As a result, the Dubai services sector shows a positive mean return after the oil price drop and a low level of volatility compared with the period before mid-2014. Moreover, the Bahrain sectors show a low level of volatility after the oil price drop. This implies that the Dubai services sector and all Bahrain sectors are less affected by the volatility of oil because of early diversification of their economies. All return series show non-zero skewness with more negative values post-2014; and excess kurtosis in both periods.

3.7.2 Market Efficiency of GCC Stock Markets (Autocorrelation)

This section examines the market efficiency of selected GCC stock market sectors. The concept of EMH is introduced to assess the efficiency of the stock markets (Malkiel & Fama 1970). EMH is an investment theory that implies that current share prices fully reflect all trading information. This implies that it is technically impossible to outperform the stock market consistently via a technical analysis, as stock prices are supposed to react only to new information. The weak form of EMH is used in this research to evaluate the efficiency of GCC stock markets. The EMH weak form assumes that past information is reflected in current share prices (Sewell 2011). If a stock market holds to the weak form of EMH then analysis tools cannot be used to outperform the stock market through superior returns. The Ljung–Box Q test is here used to evaluate the weak form of EMH for the selected GCC stock market sectors. The hypotheses explored by the Ljung–Box Q test are: H_0: the selected GCC sectors follow a random walk;H_1: the selected GCC sectors are autocorrelated. The test statistic is:

$$\mathrm{LB} = n(n+2)\sum_{k=1}^{m}\left(\frac{p^2k}{n-k}\right)\sim x^2m \quad (3.2)$$

Table 3.4 reports the results of the first six sample autocorrelation coefficients for each time series for GCC stock market sectors. The results provide strong evidence for positive first-order correlation, except for the services and industrial sectors in Bahrain and the bank sector in Kuwait. The null hypothesis of a random walk is rejected and the alternative hypothesis of autocorrelation is accepted. Moreover, there is no evidence for negative correlation and it seems that all series have the same correlation sign. It is known that a positive autocorrelation generally means that returns can be predictable in the short term. Overall, most of the GCC stock markets are not efficient, as indicated by the Ljung–Box Q test results.

Table 3.4: Autocorrelation coefficients for selected sectors of GCC stock markets 2010–17

Country	Sector	L (1)	L (2)	L (3)	L (4)	L (5)	L (6)	Decision
Saudi Arabia	Banks	22.280 (0.000)	22.453 (0.000)	22.946 (0.000)	25.893 (0.000)	27.461 (0.000)	29.050 (0.000)	Reject H_0 not weak form
	Real Estate	17.045 (0.000)	17.493 (0.000)	17.891 (0.000)	17.891 (0.001)	18.426 (0.002)	20.985 (0.001)	Reject H_0 not weak form
	Retail	36.433 (0.000)	36.435 (0.000)	44.013 (0.000)	44.077 (0.000)	49.023 (0.000)	49.195 (0.000)	Reject H_0 not weak form
Abu Dhabi	Banks	2.0429 (0.0529)	2.7203 (0.0566)	3.2685 (0.0352)	4.2467 (0.0736)	4.2614 (0.0124)	6.779 (0.0418)	Reject H_0 not weak form
	Real Estate	6.681 (0.009)	8.6403 (0.0133)	8.7179 (0.0332)	10.05 (0.0396)	10.091 (0.0426)	20.071 (0.0026)	Reject H_0 not weak form
	Services	8.3216 (0.0039)	12.32 (0.0021)	15.295 (0.0015)	15.572 (0.0036)	20.49 (0.0010)	20.838 (0.0019)	Reject H_0 not weak form
Dubai	Banks	19.324 (0.000)	22.491 (0.000)	22.618 (0.000)	22.618 (0.000)	24.032 (0.000)	27.193 (0.000)	Reject H_0 not weak form
	Real Estate	4.7979 (0.0284)	5.1402 (0.0765)	5.4843 (0.1396)	6.8763 (0.1426)	8.9695 (0.1103)	13.942 (0.0302)	Reject H_0 not weak form
	Services	8.3216 (0.0039)	12.32 (0.0021)	15.295 (0.0015)	15.572 (0.0036)	20.49 (0.0010)	20.838 (0.0019)	Reject H_0 not weak form
Qatar	Banks	15.62 (0.000)	15.636 (0.000)	21.275 (0.000)	26.943 (0.000)	37.128 (0.000)	41.063 (0.000)	Reject H_0 not weak form
	Real Estate	8.931 (0.0028)	9.8069 (0.0074)	26.761 (0.000)	27.154 (0.000)	27.304 (0.000)	29.823 (0.000)	Reject H_0 not weak form
	Services	14.873 (0.000)	19.912 (0.000)	27.869 (0.000)	29.739 (0.000)	29.86 (0.000)	29.89 (0.000)	Reject H_0 not weak form
Bahrain	Banks	4.976 (0.0256)	7.7071 (0.0212)	7.9447 (0.0471)	7.9637 (0.0929)	8.0147 (0.1554)	10.142 (0.1188)	Reject H_0 not weak form
	Services	0.0548 (0.8148)	0.5834 (0.7470)	0.93741 (0.8164)	0.943 (0.9183)	4.0813 (0.5378)	6.0927 (0.4129)	Weak form
	Industrial	0.52353 (0.4693)	7.7584 (0.0206)	17.135 (0.000)	28.48 (0.000)	30.775 (0.000)	31.848 (0.000)	Reject H_0 not weak form
Oman	Banks	86.144 (0.000)	95.773 (0.000)	96.785 (0.000)	96.785 (0.000)	101.44 (0.000)	101.76 (0.000)	Reject H_0 not weak form
	Services	89.748 (0.000)	112.67 (0.000)	121.99 (0.000)	122.03 (0.000)	125.23 (0.000)	127.66 (0.000)	Reject H_0 not weak form
	Industrial	132.33 (0.000)	171.66 (0.000)	186.23 (0.000)	189.79 (0.000)	194.4 (0.000)	194.47 (0.000)	Reject H_0 not weak form
Kuwait	Banks	0.03326 (0.8553)	0.3029 (0.8595)	3.1789 (0.3649)	14.757 (0.005)	14.771 (0.0113)	15.67 (0.0156)	Weak form
	Services	0.71382 (0.0982)	14.477 (0.000)	14.925 (0.001)	15.55 (0.003)	18.338 (0.002)	18.822 (0.004)	Reject H_0 not weak form
	Industrial	13.051 (0.000)	18.117 (0.000)	25.958 (0.000)	29.678 (0.000)	30.049 (0.000)	31.124 (0.000)	Reject H_0 not weak form

3.7.3 Correlations Between GCC Stock Market Sectors and Global Factors

This section examines the correlations between the GCC stock market sectors and global factors, including WTI, MSCI and S&P 500, as presented in Table 3.5. The results indicate a weak relationship between the WTI and GCC sectors. The Abu Dhabi, Dubai, Qatar and Bahrain sectors are negatively correlated with WTI, which implies that an increase in the WTI oil price leads to decreases in these sectors. In addition, there is a strong correlation between the MSCI and S&P 500 and the GCC stock market sectors. The Saudi real estate and retail sectors are highly correlated with MSCI world index and S&P 500 index, which indicates that investors can achieve high returns when diversifying their portfolios and investing more in these stocks. Moreover, Abu Dhabi, Dubai, Qatar and Bahrain sector returns have a strong positive correlation with MSCI and S&P 500. To obtain further information about the links between WTI oil price, MSCI world index and S&P 500index and the GCC stock market sectors, we estimate models as discussed in following chapters.

Table 3.5: Estimated correlation coefficients between selected sectors of GCC stock market and WTI, MSCI and S&P 500

Saudi Arabia	WTI	MSCI	S&P 500	SB	SRE	SR
WTI	1.000					
MSCI	-0.4474	1.000				
S&P 500	-0.5392	0.9542	1.000			
SB	0.2105	0.4264	0.3105	1.000		
SRE	0.4923	0.9037	0.9190	0.5685	1.000	
SR	0.2188	0.8686	0.8299	0.7211	0.9122	1.000
Abu Dhabi	**WTI**	**MSCI**	**S&P 500**	**ADB**	**ADRE**	**ADS**
ADB	-0.3032	0.9321	0.8915	1.000		
ADRE	-0.1723	0.6313	0.5772	0.7571	1.000	
ADS	-0.1793	0.7874	0.7359	0.8592	07410	1.000
Dubai	**WTI**	**MSCI**	**S&P 500**	**DB**	**DRE**	**DS**
DB	-0.4830	0.9377	0.9149	1.000		
DRE	-0.2103	0.8509	0.8030	0.9349	1.000	
DS	0.2562	-0.0801	-0.1474	-0.0287	0.1314	1.000
Qatar	**WTI**	**MSCI**	**S&P 500**	**QB**	**QRE**	**QS**
QB	-0.3846	0.9369	0.9328	1.000		
QRE	-0.4713	0.8881	0.8793	0.9255	1.000	
QS	-0.3149	0.9107	0.9223	0.9617	0.8497	1.000
Bahrain	**WTI**	**MSCI**	**S&P 500**	**BB**	**BS**	**BI**
BB	-0.2357	0.8580	0.7903	1.000		
BS	-0.1262	0.6615	-0.1912	0.3291	1.000	
BI	0.4219	-0.6809	-0.7926	-0.4105	0.3558	1.000
Oman	**WTI**	**MSCI**	**S&P 500**	**OB**	**OS**	**OI**
OB	0.0890	0.038493	-0.0329	1.000		
OS	-0.0769	0.837493	0.7941	0.3038	1.000	
OI	0.2893	0.513754	0.4324	0.5482	0.8567	1.000
Kuwait	**WTI**	**MSCI**	**S&P 500**	**KB**	**KS**	**KI**
KB	0.8540	-0.1699	-0.4093	1.000		
KS	0.5845	0.2762	0.0735	0.7755	1.000	
KI	0.1155	0.5158	0.4876	0.3261	0.6107	1.000

3.8 Market Performance Measures

This section discusses the performance of the selected GCC stock market sectors over the total sample period, with further investigation of these stock markets' performance before and after the drop in oil price. The risk-adjusted return is measured using SR, TR, VaR and CVaR.

3.8.1 Sharpe Ratio

The SR is used in this study to measure the relative performances of the selected GCC stock market sectors pre- and post-2014. SR is a common risk-adjusted performance method that measures the amount of excess return per unit of the total risk of an index over the risk-free rate in a given period. A higher SR indicates that the index has better performance, and vice versa. SR is estimated as follows:

$$SR_{sec} = \frac{AR_{sec} - RFR}{\sigma_{sec}} \tag{3.3}$$

where AR_{sec} is the average return of a selected GCC stock market index, RFR is the risk-free rate in a given period and σ_{sec} is the standard deviation of the index return. This study uses the average risk-free rate over the study period 2010–17 for each GCC country to estimate the AR; the annual average risk-free rate of return is divided by 365 (number of days per year). Table 3.6 presents the SR estimates for the GCC stock market sectors for the full period, pre-2014 and post-2014. It shows that the Saudi retail sector outperforms the other Saudi sectors during the full and pre-2014 periods but not post-2014. All Saudi sectors underperform post-2014 compared with pre-2014, except that the real estate sector has a higher SR post-2014 than other sectors as a result of the drop in oil price. The Abu Dhabi and Dubai bank sectors have high SR in the full and pre-2014 periods, compared with post-2014, when all sectors underperform. Moreover, the Qatar service sector has the highest SR in the full and pre-2014 periods among all Qatar stock markets but the lowest, post-2014. The Oman and Kuwait sectors underperform post-2014, although the Kuwait industrial sector overperforms. Overall, several GCC stock market sectors display outperformance in the full and pre-2014 periods, including the Saudi retail and Qatar service sectors. However, most GCC stock market sectors underperform post-2014. The Saudi real estate and Kuwait industrial sectors are exceptions, potentially because of the drop in oil price during the period after mid-2014.

Table 3.6: Results of risk-adjusted performance measurement based on SR for the full period (2010–17) and pre- and post-2014

SR	Sector	Full period	Pre-2014	Post-2014
Saudi Arabia	SB	0.0014	0.0341	-0.0420
	SRE	0.0340	0.0540	0.0083
	SR	0.0409	0.1188	-0.0550
Abu Dhabi	ADB	0.0341	0.0848	-0.0277
	ADRE	0.0031	0.0146	-0.0214
	ADS	0.0085	0.0173	-0.0122
Dubai	DB	0.0388	0.0781	-0.0251
	DRE	0.0247	0.0581	-0.0380
	DS	-0.0087	0.0015	-0.0121
Qatar	QB	0.0523	0.0990	-0.0261
	QRE	0.0256	0.0537	-0.0196
	QS	0.0709	0.1481	-0.0321
Bahrain	BB	0.0241	0.0484	-0.0469
	BS	0.0249	-0.0140	-0.0533
	BI	-0.0403	-0.0342	-0.0526
Oman	OB	-0.0159	-0.0173	-0.0137
	OS	0.0030	0.0337	-0.0657
	OI	-0.0082	0.0245	-0.0750
Kuwait	KB	-0.0268	0.0279	-0.0727
	KS	-0.0149	0.0410	-0.0757
	KI	0.0333	0.0443	0.0244

3.8.2 Treynor Ratio

The second risk-adjusted performance measure used in this thesis is TR, which estimates the excess return risk. TR differs from SR through its use of systematic risk (β) rather than standard deviation as a measure of market risk. A higher TR shows that the index has superior performance, and vice versa. TR is computed as:

$$TR_{sec} = \frac{AR_{sec} - RFR}{\beta_{sec}} \tag{3.4}$$

where AR_{sec} is the average return of a selected GCC stock market index, RFR is the risk-free rate in a given period and β_{sec} measures the response of sector volatility to change in the overall stock market index. Table 3.7 presents the TR results for the GCC stock market sectors for the full period, pre-2014 and post-2014. The results are similar to those for SR in the post-2014 period, except for the Saudi bank and real estate and Kuwait service sectors. These sectors have positive values, indicating that investors could achieve a better return during this period. The risk represented by β coefficients indicates that some sectors, such as those of Saudi Arabia, Qatar and Kuwait, are less volatile ($\beta < 1$) than the overall market. For some sectors, such as the Abu Dhabi, Dubai, Bahrain and Oman banks, $\beta > 1$,which indicates these sectors are more volatile than their overall markets. Investors in these sectors experience high risk with expected high returns. In the post-2014 period, β coefficients become higher than in the pre-2014 period because of high risk due to the drop in oil price.

Table 3.7: Results of risk-adjusted performance measurement based on TR for the full period (2010–17) and pre- and post-2014

TR	Sector	Full period	Pre-2014	Post-2014	β	
					Pre-2014	Post-2014
Saudi Arabia	SB	0.0001	0.0006	0.0545	0.8765	0.9158
	SRE	0.0003	0.0010	0.1367	0.8911	-0.0894
	SR	0.0002	0.0008	-0.0266	0.7494	0.8337
Abu Dhabi	ADB	0.0026	0.0029	-0.0052	0.2744	0.4701
	ADRE	0.0010	0.0023	-0.0006	1.1647	1.4976
	ADS	0.0255	0.0471	-0.0236	0.0431	0.0633
Dubai	DB	0.0003	0.0009	-0.0006	0.6837	0.7719
	DRE	0.0005	0.0013	-0.0008	1.3742	1.2515
	DS	0.0011	0.0033	-0.0011	1.2073	0.8737
Qatar	QB	0.0002	0.0008	-0.0005	0.4504	0.8516
	QRE	0.0005	0.0019	-0.0009	0.9896	1.2960
	QS	0.0004	0.0015	-0.0007	0.4504	0.7798
Bahrain	BB	-0.0002	0.0003	-0.0006	1.5526	1.1890
	BS	-0.0004	0.0005	-0.0015	0.4595	0.6551
	BI	-0.0008	0.0001	-0.0029	0.9229	1.2236
Oman	OB	-0.0009	0.0002	-0.0018	1.3174	1.5333
	OS	-0.0006	0.0001	-0.0009	0.6830	0.8700
	OI	-0.0007	0.0001	-0.0012	0.5763	0.6476
Kuwait	KB	0.0083	0.0009	-0.0435	0.0243	0.1146
	KS	0.0083	-0.0002	0.0643	-0.0194	0.0457
	KI	-0.0030	0.0007	-0.0116	0.0097	0.0509

3.8.3 Value at Risk and Conditional Value at Risk

This section presents the results for VaR and CVaR. VaR is a risk-adjusted performance measure used in this study to identify potential losses in selected GCC stock market sector returns over the full study period, pre-2014 and post-2014, for a given confidence level. VaR can be used by any entity, such as a stock index or portfolio, to measure its risk exposure to capture the potential loss in value of the entity from adverse market movements over a specified period. For example, if the VaR on a selected sector return is r_i in period t_i with a 95% confidence level, then there is a 5% chance that the sector return will decrease by around r_i during that period, t_i. VaR can be expressed as follows:

$$VaR_{\alpha}^{\%} = \mathcal{Z}_{\alpha}\sigma \tag{3.5}$$

where $\mathcal{Z}_{\alpha}$ is a given confidence interval and σ is the standard deviation for a selected GCC stock market return. $VaR_{\alpha}^{\%}$ indicates the expected worst loss for a selected GCC stock market sector in a given period.

CVaR is a risk-adjusted performance measure that takes a weighted average over a specified time period. While VaR computes the maximum potential loss that could occur over a time period with a given confidence level, CVaR measures the average loss over a certain given period with a specific confidence level when the loss exceeds the VaR value.

Table 3.8 presents both VaR and CVaR results for the GCC stock market sectors pre-2014 and post-2014 with 95% confidence. The overall results of VaR present high-risk coefficients for most GGC stock market sectors in the post-2014 period compared with pre-2014, which indicates the effect of links between GCC stock market sectors and oil price. Specifically, the Saudi Arabia and Qatar sectors show a higher loss exposure post-2014 compared with pre-2014; the highest risk coefficient is reported for the Saudi and Qatar real estate sectors. These sectors have post-2014 volatility coefficients of 1.95% and 1.84% respectively, at a 95% confidence level, which implies that the worst loss did not exceed –0.0306 and –0.0285 for Saudi and Qatar real estate, respectively. The Abu Dhabi and Dubai sectors show a strong effect of loss post-2014, except their services sectors have lower risk coefficients post-2014. This might be a result of the earlier diversification plans of the UAE economy compared the other GCC countries. Bahrain sectors other than the industries sector show lower coefficients of maximum loss post-2014, which might be a result of less dependence on oil revenues and a diversified economy. Oman sectors have higher coefficients of loss for all sectors post-2014 than for pre-2014. The selected Kuwait sectors, with the exception of services, show a high risk coefficient post-2014; services has a slightly lower coefficient post-2014 compared with pre-2014.

The CVaR analysis results reveal the average loss in GCC stock market sectors. Most GCC sectors show higher average risk coefficients post-2014 than pre-2014. The Abu Dhabi and Dubai sectors have the highest average risk exposure post-2014, particularly in the real estate sector, with values of 0.0558 and 0.0525, respectively. Bahrain sectors have lower coefficients of average loss post-2014 than pre-2014, which may result from the country's early diversification as mentioned earlier. In summary, the link between the oil price and GCC stock market sector returns indicates a higher average VaR and CVaR post-2014 compared with pre-2014.

Table 3.8: Results of risk-adjusted performance measurement based on VaR and CVaR for pre- and post-2014

Country	Sector	VaR			CVaR	
		Full period	Pre-2014	Post-2014	Pre-2014	Post-2014
Saudi Arabia	SB	0.0167	0.0116	0.0247	0.0228	0.0341
	SRE	0.0223	0.0158	0.0306	0.0317	0.0466
	SR	0.0181	0.0114	0.0272	0.0228	0.0416
Abu Dhabi	ADB	0.0156	0.0128	0.0220	0.0200	0.0338
	ADRE	0.0354	0.0342	0.0375	0.0506	0.0558
	ADS	0.0253	0.0253	0.0247	0.0346	0.0349
Dubai	DB	0.0186	0.0173	0.0227	0.0250	0.0360
	DRE	0.0325	0.0296	0.0363	0.0462	0.0525
	DS	0.0391	0.0409	0.0299	0.0642	0.0517
Qatar	QB	0.0147	0.0110	0.0167	0.0198	0.0281
	QRE	0.0208	0.0167	0.0285	0.0289	0.0457
	QS	0.0126	0.0105	0.0182	0.0172	0.0324
Bahrain	BB	0.0115	0.0121	0.0107	0.0235	0.0159
	BS	0.0099	0.0105	0.0089	0.0374	0.0394
	BI	0.0184	0.0182	0.0198	0.0174	0.0144
Oman	OB	0.0128	0.0123	0.0139	0.0197	0.0288
	OS	0.0083	0.0083	0.0084	0.0148	0.0191
	OI	0.0091	0.0090	0.0096	0.0139	0.0154
Kuwait	KB	0.0105	0.0098	0.0112	0.0125	0.0182
	KS	0.0121	0.0125	0.0118	0.0140	0.0162
	KI	0.0103	0.0094	0.0111	0.0157	0.0153

3.9 Stationarity and Unit Root Test

This section presents unit root tests used to determine whether a time series has a unit root. Refining data is a key concept in submitting financial time series to stock analysis. Before examining linkage and volatility effects between GCC stock markets, the oil price and other global factors, we conduct a stationarity test to identify time series properties, as this can strongly influence time series behaviour and its properties, such as spurious regressions. The main conditions of stationary data imply that mean, variance and covariance remain constant over time. If data are non-stationary, this can lead to misleading conclusions about the variables under study. Therefore, non-stationary data must The ADF test (Dickey & Fuller 1979), PP test (Phillips & Perron 1988) and Kwiatkowski–Phillips–Schmidt–Shin test (Kwiatkowski et al. 1992) are the most well-known and popular strategies for testing the stationary properties of a time series (Asteriou and Hall 2011) (Taheri 2014). Applying these two test can ensure the robustness and the correctness of further data analysis procedures. A non-stationary time series—also known as a time series with unit roots—can be identified using unit root tests. The number of unit roots contained in a series is equal to the number of time series to become stationary. There are several tests for unit root/stationarity of observed time series.

3.9.1 Augmented Dickey–Fuller Test

The ADF test (Dickey & Fuller 1979) is employed as a prerequisite analysis step for the presence or absence of a unit root in a time series. ADF is based on the regression of the observed time series on a period of lagged value. The regression can include an intercept and time trend. The basic objective of the ADF test is to examine the existence of the unit root in the time series, where the null hypothesis represents the existence of a unit root (non-stationary); the alternative hypothesis states that the time series is stationary. Thus, the hypothesis of H_0 (time series has a unit root [non-stationary]) versus H_1 (time series is stationary) is represented by the following regression equation:

$$\Delta Y_t = \gamma + \alpha Y_{t-1} + \beta_1 \Delta Y_{t-1} + \beta_2 \Delta Y_{t-2} + \dots \dots + \beta_p \Delta Y_{t-p} + \epsilon_t \qquad (3.6)$$

where Y_t represents a time series of selected GCC stock market sectors, ΔY_t is the difference of a time series where $\Delta Y_t = Y_t - Y_{t-1}$, and ε_t is an error term.

The ADF test is applied to the selected GCC stock market sectors to ensure the data are stationary; the optimal lag length is 1, selected based on the Schwarz Information Criterion (SIC). Testing for the presence of stationary is a very important pre-analysis step because the entire analysis might derive misleading statistical interpretation.

3.9.2 Phillips–Perron (Karam) Test

The PP test is a nonparametric statistical method that enhances the ADF test by introducing a nonparametric correction factor to overcome the problem of serial correlation in the error term in the DF test. The ADF test is based on the assumption that the error terms are independent and have constant variance, whereas the PP test has fewer assumptions concerning the distribution of errors. The PP test can be expressed in the following manner as shown in Phillips and Perron (1988):

$$\Delta Y_t = \alpha + \rho Y_t + \varepsilon_t \tag{3.7}$$

where Y_t represents a time series of selected GCC stock market sectors and ΔY_t is the difference of a time series, $\Delta Y_t = Y_t - Y_{t-1}$. The term ε_t is a white noise error term and ρ is a nonparametric correction coefficient that is included in the PP test to account for any serial correlation and heteroscedasticity in the error term, ε_t.

Table 3.9 presents the results of the ADF and PP tests to check for time series stationarity. On the basis of the results, the null hypothesis is rejected and the alternative hypothesis is accepted, which means that all series are stationary. All time series are stationary at the 5% significance level.

Table 3.9: ADF and PP test results for the period 2010–17

Country	Sector	ADF		PP		Order of integration
		Constant	Constant & trend	Constant	Constant & trend	
Saudi Arabia	Bank	-16.40***	-16.41***	-36.86***	-36.48**	I(0)
	Real Estate	-37.54***	-37.64***	-37.68**	-37.67**	I(0)
	Retail	-8.241***	-15.55***	-35.08**	-35.07**	I(0)
Abu Dhabi	Bank	-41.75**	-41.74**	-41.75**	-41.74**	I(0)
	Real Estate	-39.90**	-39.92**	-39.90**	-39.91**	I(0)
	Services	-45.09**	-45.08**	-45.99**	-45.98**	I(0)
Dubai	Bank	-37.08**	-37.07**	-36.89**	-36.88**	I(0)
	Real Estate	-40.25**	-40.24**	-40.32**	-40.31**	I(0)
	Services	-39.70**	-39.80**	-39.82**	-39.89**	I(0)
Qatar	Bank	-38.39**	-38.40**	-38.38**	-38.39**	I(0)
	Real Estate	-21.86**	-21.86**	-38.27**	-38.27**	I(0)
	Services	-37.04**	-37.09**	-37.18**	-37.23**	I(0)
Bahrain	Bank	-43.60**	-43.59**	-43.72**	-43.72**	I(0)
	Services	-41.79**	-41.79**	-41.84**	-41.84**	I(0)
	Industrial	-16.24**	-16.24**	-42.83**	-42.81**	I(0)
Oman	Bank	-33.29**	-33.30**	-33.39**	-33.40**	I(0)
	Services	-32.24**	-32.24**	-32.80**	-32.79**	I(0)
	Industrial	-22.63**	-22.63**	-31.59**	-31.59**	I(0)
Kuwait	Bank	-34.23**	-34.25**	-34.32**	-34.34**	I(0)
	Services	-21.05**	-21.07**	-33.25**	-33.24**	I(0)
	Industrial	-30.20**	-30.21**	-30.74**	-30.74**	I(0)

Note: ** and * significant at 5% and 10% level; ADF and PP are the statistics tests for the unit root.

3.10 Information Asymmetry

This section presents the GARCH family models used to capture information asymmetry in the GCC stock market returns. To apply GARCH models, the time series must be stationary and exhibit the ARCH effect. The previous section presented volatility clustering and the results of the unit root test; the time series for all GCC stock market sectors were shown to be stationary. Moreover, the data analysis indicates that the volatility of selected GCC stock market sectors is not constant, which in turn implies the existence of heteroscedasticity effects. Before determining the best-fit GARCH models, including EGARCH, GJR-GARCH and GARCH-M, the ARCH test is performed to ascertain the existence of ARCH effects. The following hypotheses are tested:

H_0: There is no significant sign of the ARCH effect in the GCC stock markets at the sectoral level.

H_1: There is significant sign of the ARCH effect in the GCC stock markets at the sectoral level.

The ARCH effect is demonstrated by the LM test results, which show a significant sign for all GCC stock market sectors. This significant sign indicates that the null hypothesis is rejected and he alternative hypothesis that there is an ARCH effect, is accepted.

3.10.1 Methodology

3.10.1.1 EGARCH Model

The EGARCH model captures asymmetric effects between positive and negative stock market returns. Data are analysed here using the EGARCH model, which is a predictive model for the volatility of a stock return. EGARCH is one of the most well-known ARCH models, all of which use past data to estimate the volatility of current data in situations where volatility clustering occurs (Box et al. 2015). The EGARCH model in particular uses the natural logarithm of the conditional variance to test whether there is a varying return variance affected by positive and negative excess returns, and examine the hypothesis of a negative relationship between excess returns and market variance. The EGARCH (1,1) model can be written as:

$$r_t = \mu + \phi\, r_{t-1} + \epsilon_{t-1} \tag{3.8}$$

$$\ln(h_t^2) = \omega + \alpha \left|\frac{\epsilon_{t-1}}{h_{t-1}}\right| + \gamma \left(\frac{\epsilon_{t-1}}{h_{t-1}}\right) + \beta \ln h_{t-1}^2 \tag{3.9}$$

where $\ln(h_t^2)$ is a logarithmic conditional variance, ω is a constant of the regression, ϵ_{t-1} is a squared prediction error of the return and β is an estimate from past data. The coefficient γ represents the asymmetric effect as $\gamma \neq 0$ and $\gamma < 0$ when there is leverage effect (i.e. when bad news has a stronger effect than good news). The particular advantage of the EGARCH approach is that it captures the conditional effect, thereby ensuring that the conditional variance is always positive (Bruce & Thilakaratne 2015). The $\alpha + \gamma$ term is believed to capture the effect of bad news according to the literature, as bad news is associated with sharp volatility of returns, while β captures the effect of good news.

3.10.1.2 GJR-GARCH Model

The GJR-GARCH model is one of the ARCH family models (Glosten, Jagannathan & Runkle 1993) introduced to avoid the symmetric positive and negative shocks hypothesis of the EGARCH model. GJR-GARCH is an extension of EGARCH used to capture volatility leverage effects while taking into account the possibility of asymmetries. The specifications of the GJR-GARCH conditional variance equation are as follows:

$$r_t = \mu + \phi\, r_{t-1} + \epsilon_{t-1} \tag{3.10}$$

$$\sigma_t^2 = c + \alpha\, \epsilon_{t-1}^2 + \gamma d_{t-1}\epsilon_{t-1}^2 + \beta\, \sigma_{t-1}^2 \tag{3.11}$$

where the variable $d_{t-1} = 1$, if $\epsilon_{t-1} < 0$ and $d_{t-1} = 0$ if $\epsilon_{t-1} \geq 0$. The variable ε_{t-1} represents good news if $\epsilon_{t-1} \geq 0$ and bad news if $\epsilon_{t-1} < 0$. The coefficient γ is the asymmetry or leverage parameter. Good news has an impact on α and bad news impacts $\alpha + \gamma$. If γ is significant and positive, negative shocks have a larger effect than positive shocks.

3.10.1.3 GARCH-in-Mean (GARCH-M) Model

The GARCH-M model is used to model the correlation between expected return and market risk by allowing the conditional mean to directly rely on conditional variance as a measure of expected risk. The GARCH-M model consists of two main equations, as follows:

Mean equations $$\mathrm{r}_t = \mu + \gamma\, \sigma_t + u_t \tag{3.12}$$

Variance equations $$\sigma_t^2 = c + \alpha u_{t-1}^2 + \beta\, \sigma_{t-1}^2 \tag{3.13}$$

where the coefficient γ represents the risk parameter in the conditional mean equation. If γ is significant and positive, the return is positively related to its past volatility. This implies that the increase in the excepted return is caused by the increase in the expected risk.

3.10.2 Empirical Results

The results of applying the EGARCH, GJR-GARCH and GARCH-M models are shown in Tables 3.10, 3.11 and 3.12. The results of the ARCH, EGARCH and Mann–Whitney U tests for all selected sectors before and after the oil price drop in mid-2014 are presented in Table 3.10. All sectors show a statistically significant ARCH effect, with a *p*-value of less than 5% in the ARCH test results for all sectors. Thus, the null hypothesis is rejected and the alternative hypothesis (i.e. an ARCH effect is present) is accepted. Therefore, the EGARCH test is applied to capture the effects of bad and good news on the stock market indices (Bruce & Thilakaratne 2015).

In addition, we estimate the effect of oil price volatility on GCC stock market sectors before and after the drop in oil price. The results of the EGARCH test show that all selected GCC stock market sectors have a significant effect in the pre-2014 and post-2014 periods, with the exception of the Abu Dhabi real estate and Dubai and Qatar services sectors, which have a significant effect after the drop in oil price ($p < 0.05$). Therefore, the null hypothesis is rejected and the alternative hypothesis (i.e. there is a leverage effect in the GCC stock market sectors) is accepted. The results indicate that volatility in the oil price has a significant effect on the GCC stock market sectors. In contrast, some sectors show an insignificant effect after the drop in oil prices, including the Abu Dhabi and Kuwait services sectors and all Bahrain sectors. These contrasting results indicate that some GCC countries might withstand the effect of oil price volatility through diversifying their economies earlier than other countries.

The presence of an asymmetry effect indicates that good news has less effect on conditional variance than does bad news. Further, the selected GCC stock market sectors show varying coefficients for the asymmetry effect. The results also indicate that the effect of volatility of stock sector returns post-2014 is higher than that pre-2014. For example, the banking sectors in all GCC countries return a slightly higher coefficient than other sectors. The variations and fluctuations in volatility indicate some periods with high and low volatility. A high-volatility period gives a signal of bad news and a low-volatility period gives a signal of good news. The results show that the high volatility of the oil price affects most sectors in the GCC stock markets pre- and post-2014.

Moreover, we conduct an analysis to determine whether the information asymmetry effects are uniform between pre- and post-2014. The Mann–Whitney test is employed to determine whether the asymmetry effect is uniform in both study periods, and to test the following hypotheses:

H_0: The effect of information asymmetry on GCC stock market sectors is the same pre- and post-2014.

H_1: The effect of information asymmetry on GCC stock market sectors is not the same pre- and post-2014.

The results of the Mann–Whitney test indicate that the effect of information asymmetry for most sectors is not the same pre- and post-2014. The effect of information asymmetry before the drop in oil price is greater than that after the price drop. However, the result for some sectors, such as the Saudi bank sector, is not statistically significant, indicating the same effect of information asymmetry pre-2014 and post-2014 periods. As a result, some countries show a high correlation between information asymmetry and volatility in the oil price; for example, this is true for Saudi Arabia, one of the major oil supply countries.

Table 3.11 displays the results of the GJR-GARCH tests for all selected sectors before and after the oil price drop in mid-2014. All selected GCC stock market sectors show a statistically significant ARCH effect; thus, the null hypothesis is rejected and the alternative hypothesis (i.e. an ARCH effect is present) is accepted. Therefore, the GJR-GARCH test is applied to capture the effect of information asymmetry. The results of the GJR-GARCH tests show that all selected GCC stock market sectors have a significant effect of the coefficient γ in the pre-2014 and post-2014 periods, with the exception of the Abu Dhabi real estate, Dubai services, Qatar real estate and services and Bahrain services and industrial sectors, which have a significant effect after the drop in oil price ($p < 0.05$). Therefore, the null hypothesis is rejected and the alternative hypothesis (i.e. there is a leverage effect in GCC stock market sectors) is accepted. The results indicate that the volatility in oil price has a significant effect on GCC stock market sectors. Further, the coefficient $\alpha + \gamma$ measures the continues impact of shocks on these sectors. The results show that most sectors have a higher coefficient post-2014 than pre-2014. For example, Saudi real estate has a value of 0.3796 pre-2014 and 0.4546 post-2014, which indicates a stronger effect of shocks post-2014 than pre-2014.

Table 3.10: GCC stock market sector results from the EGARCH tests for pre- and post-2014

Country	Sector	Pre-2014				Post-2014				Mann–Whitney test	ARCH
		α	β	γ	$\alpha+\gamma$	α	β	γ	$\alpha+\gamma$		
Saudi Arabia	Bank	0.2738	0.9026	-0.119***	0.1548	0.2657	0.9334	-0.104***	0.1617	-1.574	151.2***
	Real Estate	0.3781	0.8277	-0.077***	0.3011	0.3922	0.8475	-0.115***	0.2772	-0.747	144.8***
	Retailing	0.2069	0.9328	-0.079***	0.1279	0.3235	0.9043	-0.084***	0.2395	-2.529	96.79***
Abu Dhabi	Bank	0.3475	0.9081	-0.054***	0.2935	0.1719	0.9612	-0.156***	0.0159	-2.728**	170.6***
	Real Estate	0.2787	0.9135	-0.01648	0.2622	0.1674	0.9598	-0.165***	0.0024	-0.117	78.25***
	Services	0.0613	0.9853	-0.0626***	-0.0013	0.2165	0.5997	-0.0185	0.1980	-1.333	9.421***
Dubai	Bank	0.1884	0.9741	-0.0524***	0.1360	0.2749	0.9549	-0.101***	0.1739	-1.766*	222.5***
	Real Estate	0.1928	0.9488	-0.0303**	0.1625	0.2387	0.9506	-0.120***	0.1187	-1.973**	105.8***
	Services	0.3817	0.8678	-0.0184	0.3633	0.2517	0.9449	-0.132***	0.1197	-1.892**	270.7***
Qatar	Bank	0.2332	0.9802	-0.060***	0.1732	0.2895	0.9156	-0.134***	0.1555	-1.77*	41.20***
	Real Estate	0.6099	0.7215	-0.1368***	0.4731	0.3464	0.8550	-0.151***	0.1954	-1.219	17.43***
	Services	0.3838	0.8553	-0.0213	0.3625	0.3080	0.9268	-0.132***	0.1760	-2.874***	85.11***
Bahrain	Bank	0.1348	0.9786	-0.0122	0.1226	0.3864	0.8053	-0.0447	0.3417	-2.622***	165.7***
	Services	0.3316	0.8797	-0.0270**	0.3046	0.3850	0.3640	-0.0531	0.3319	-1.558	11.20***
	Industrial	0.4905	0.8799	-0.0974***	0.3931	0.3127	0.6702	-0.0270	0.2857	-1.517	292.0***
Oman	Bank	0.3526	0.9135	-0.102***	0.2506	0.5722	0.8974	-0.15***	0.4222	-0.772	285.1***
	Services	0.4305	0.8998	-0.048***	0.3825	0.3918	0.9155	-0.07***	0.3218	-2.937***	363.3***
	Industrial	0.5216	0.8343	-0.050***	0.4716	0.3705	0.9249	-0.15***	0.2205	-2.778***	304.4***
Kuwait	Bank	0.1591	0.9202	-0.0654*	0.0937	0.2628	0.9285	-0.11***	0.1528	-1.606*	108.8***
	Services	0.0119	0.8153	-0.01002	0.0018	0.1432	0.9162	-0.0071	0.1361	-1.743*	53.72***
	Industrial	0.2339	0.9258	-0.051***	0.1829	0.0780	0.9009	-0.11***	-0.0320	-0.075	20.05***

Note: ***, ** and * = significance at 1%, 5% and 10% level.

Table 3.11: GCC stock market sector results from GJR-GARCH tests for pre- and post-2014

Sector	Pre-2014					Post-2014					ARCH
	ω	α	β	γ	$\alpha+\gamma$	ω	α	β	γ	$\alpha+\gamma$	
SB	9.52e-06	0.0374***	0.7654***	0.1928***	0.2302	9.99E-06	0.0499**	0.8349***	0.1523***	0.2022	89.372***
SRE	3.03E-05	0.1972***	0.5667***	0.1824***	0.3796	9.08E-05	0.0954**	0.4761***	0.3610***	0.4564	18.142***
SR	7.63E-06	0.0462***	0.8241***	0.1049***	0.1511	1.05E-05	0.0347	0.8565***	0.1370***	0.1717	4.5458**
ADB	1.28E-05	0.1611***	0.6284***	0.1724***	0.3335	1.07E-05	0.0079	0.8392***	0.2179***	0.2258	54.77***
ADRE	3.22E-05	0.1305***	0.8210***	-0.0042	0.1263	2.19E-05	0.0139	0.8260***	0.2335***	0.2474	19.50***
ADS	1.98E-06	0.0586***	0.9589***	0.0558***	0.0028	1.08e-05	-0.0295***	0.9200***	0.1184***	0.0889	9.176***
DB	2.75E-06	0.1272***	0.8911***	0.0716***	0.0556	1.03E-05	0.1234***	0.7565***	0.1465***	0.2699	47.77***
DRE	2.55E-05	0.0647***	0.8384***	0.0627***	0.1274	2.99E-05	0.0555**	0.7798***	0.1971***	0.2526	28.00***
DS	8.27E-05	0.2159***	0.6955***	0.0086	0.2245	3.57E-05	0.0795**	0.7299***	0.2153***	0.2948	203.1***
QB	1.86E-06	0.0883***	0.8490***	0.1276***	0.2159	8.72E-06	0.0497*	0.7804***	0.2019***	0.2516	16.26***
QRE	5.49E-05	1.3462***	0.2341***	-0.7228	0.6234	5.33E-05	0.0867***	0.6001***	0.3282***	0.4149	5.984**
QS	1.02E-05	0.2373***	0.6685***	0.0109	0.2482	1.17E-05	0.0812**	0.6736***	0.3028***	0.3840	32.71***
BB	1.77E-06	0.0734***	0.9212***	-0.0340***	0.0394	8.48E-06	0.1694***	0.6277***	0.0668**	0.2362	113.7***
BS	6.34E-06	0.1885***	0.7171***	-0.0033	0.1852	1.54E-05	0.0165	0.4047***	0.1988***	0.2153	4.730**
BI	3.21E-06	0.2361***	0.8247***	-0.0146	0.2215	8.70E-05	0.1973***	0.4547***	-0.1074**	0.0899	320.2***
OB	4.52E-06	0.1144***	0.7284***	0.1959***	0.3103	7.36e-06	0.2057***	0.6195***	0.3249***	0.5306	311.3***
OS	2.22E-06	0.1918***	0.7036***	0.1000***	0.2918	1.66e-06	0.1709***	0.7084***	0.1562***	0.3271	318.1***
OI	4.86E-06	0.2460***	0.5947***	0.1274***	0.3734	2.08e-06	0.1056***	0.6904***	0.3331***	0.4387	197.5***
KB	2.92E-06	0.0306	0.8461***	0.0991*	0.1297	3.50e-06	0.0468**	0.7958***	0.1736***	0.2204	1.0964*
KS	7.96E-07	0.0254*	0.9611***	-0.0039	0.0215	2.89e-06	0.0539**	0.8917***	-0.0134	0.0405	0.0590*
KI	2.54E-06	0.0837***	0.8171***	0.0576**	0.1413	4.32e-07	-0.0169***	1.0031***	0.0143***	-0.0026	15.17***

Note: ***, ** and * = significance at 1%, 5% and 10% level.

Table 3.12 displays the results of GARCH-M tests for all selected sectors before and after the oil price drop in mid-2014. The results show that the coefficients α and β are positive and significant for all sectors in both periods. The coefficient β has a high value between 65% and 95%, which implies the presence of volatility clustering. The significant sign of α and β for all sectors in both periods shows that past volatility from news has impacts on current volatility. Also, the values of $\alpha + \beta$ are around 0.80 but less than 1, which means that the GARCH process is mean reverting. Further, the coefficient σ is positive for all sectors in both periods but is not significant for all sectors. The pre-2014 Saudi bank and real estate, Dubai bank, Qatar bank and services and Bahrain industrial sectors have significant signs (0.287, 0.2642, 0.2520, 0.2157, 0.3121, 0.2826, respectively), which means high risk produces high returns. These significant signs at a confidence level of 5% indicate that when volatility increases by 1%, expected returns increase by, in the case of the Saudi bank sector, 0.2871. However, other sectors do not have a significant sign, which indicates that increased risk does not necessarily lead to increases in expected returns. However, the post-2014 Saudi real estate, Abu Dhabi real estate, Dubai bank and real estate and Oman services sectors have values that are significant at the 5% confidence level (0.3204, 0.2894, 0.2608, 0.3019, 0.2182, respectively). These significant signs indicate that these sectors can expect higher returns when volatility is high.

Some studies have demonstrated a significant relationship between information asymmetry and volatility (Hahn, Ligon & Rhodes 2013). This supports other studies that show a positive relationship between stock return and oil prices (Hammoudeh & Alesia 2004). Malik and Hammoudeh (2007) find that there is volatility transmission from the global oil market to GCC stock markets. Further, a study on public opinion in the UK using time series data finds that investors react more strongly to bad news than good news, which creates an entirely different sort of asymmetry with regard to information (Soroka 2006). The volatility rate, as well as the leverage effect measured, clearly indicates a positive relationship between asymmetry and volatility, and that the effect of bad news is greater than that of good news.

Table 3.12: GCC stock market sector results from GARCH-M tests for pre- and post-2014

GARCH-M	Pre-2014					Post-2014					ARCH
	ω	α	β	$\alpha+\beta$	σ	ω	α	β	$\alpha+\beta$	σ	
SB	8.87E-06	0.1277***	0.7125***	0.8402	0.2871 (0.0513)	1.18E-05	0.1775***	0.7691***	0.9466	0.2397 (0.1156)	65.78***
SRE	1.47E-05	0.1840***	0.6723***	0.8563	0.2642 (0.0228)	4.44E-05	0.2370***	0.6238***	0.8608	0.3204 (0.0524)	65.67***
SR	5.24E-06	0.0995***	0.8181***	0.9176	0.1853 (0.1714)	1.19E-05	0.1600***	0.7845***	0.9445	0.1172 (0.4200)	75.84***
ADB	9.26E-06	0.2255***	0.6582***	0.8837	0.1124 (0.3297)	9.39E-06	0.1259***	0.8094***	0.9353	0.2122 (0.1765)	62.05***
ADRE	1.96E-05	0.1127***	0.8463***	0.9590	0.1007 (0.3914)	2.26e-05	0.1441***	0.8052***	0.9493	0.2894 (0.0463)	64.51***
ADS	1.25E-06	0.0374***	0.9501***	0.9875	0.0315 (0.7801)	5.63e-05	0.1017***	0.4644***	0.5661	0.0617 (0.8659)	0.4349
DB	3.50E-06	0.0949***	0.8727***	0.9676	0.2520 (0.0241)	1.11E-05	0.2343***	0.7026***	0.9369	0.2608 (0.0344)	48.44***
DRE	1.93E-05	0.1059***	0.8375***	0.9434	0.1595 (0.1962)	2.95E-05	0.1732***	0.7574***	0.9306	0.3019 (0.0406)	30.46***
DS	4.57E-05	0.1865***	0.7374***	0.9239	0.0222 (0.8193)	2.76E-05	0.2001***	0.7062***	0.9063	0.0367 (0.7802)	155.5***
QB	1.35E-06	0.1085***	0.8652***	0.9737	0.2157 (0.0289)	7.42E-06	0.0672*	0.7759***	0.8431	0.2322 (0.1037)	23.26***
QRE	8.24E-06	0.1009***	0.8153***	0.9162	0.0160 (0.8958)	3.21E-05	0.0792**	0.6695***	0.7487	0.0706 (0.6472)	7.455***
QS	8.74E-06	0.2243***	0.6177***	0.842	0.3121 (0.0119)	8.45E-06	0.0850**	0.6963***	0.7813	0.1174 (0.3575)	34.29***
BB	1.45E-06	0.0722***	0.9115***	0.9837	0.1517 (0.1768)	7.53E-06	0.1591***	0.6130***	0.7721	0.0818 (0.7050)	99.55***
BS	3.55E-06	0.1183***	0.7307***	0.849	0.0926 (0.4695)	1.02E-05	0.OO86	0.4704***	0.4790	0.4095 (0.2916)	4.649**
BI	2.60E-05	0.3023***	0.6075***	0.9098	0.2826 (0.0420)	7.34E-05	0.0496**	0.5728***	0.6224	0.0246 (0.9671)	325.9***
OB	3.56E-06	0.0811***	0.7678***	0.8489	0.0107 (0.9225)	5.54e-06	0.1726***	0.6478***	0.8204	0.1928 (0.1102)	327.5***
OS	1.60E-06	0.1261***	0.7478***	0.8739	0.0097 (0.9207)	9.82e-07	0.1491**	0.7532***	0.9023	0.2182 (0.0695)	345.9***
OI	3.97E-06	0.2017***	0.6335***	0.8352	0.1825 (0.1024)	1.58e-06	0.0544	0.7586***	0.8130	0.01619 (0.9092S)	202.2***
KB	2.91E-06	0.0311	0.8476***	0.8787	0.1395 (0.6316)	2.92e-06	0.0521	0.8040***	0.8561	0.0700 (0.6606)	0.8788
KS	9.15E-07	0.0248**	0.9564***	0.9812	0.6054 (0.1509)	3.08e-06	0.0579*	0.8803***	0.9382	0.3716 (0.2822)	0.0368
KI	2.54E-06	0.0784**	0.8174***	0.8958	0.0711 (0.7333)	3.45e-05	0.1500***	0.6704***	0.8204	0.7945 (0.2571)	16.84***

Note: ***, ** and * = significance at 1%, 5% and 10% level.

3.10.3 Performance Comparison

To identify which GARCH model best presents volatility among GARCH family models, Table 3.13 shows the results of Akaike Information Criterion (AIC) and Schwarz Criterion (SC) tests; the best GARCH model has the lowest AIC and SC coefficients. The results show that the EGARCH model has the lowest coefficients for AIC and SC for the largest number of GCC stock market sectors, followed by the GARCH-M model and then the TGARCH model. Therefore, the EGARCH model is the optimal model to present the volatility of GCC stock market sectors based on the AIC and SC test results. This is consistent with the findings of several studies, including Ghufran et al. (2016) Mohammed, Bakar and Ariff (2018) and Emenike (2010), all of which conclude that the EGARCH model is the best fit for stock market volatility.

Table 3.13: AIC and SC tests for GARCH models

Sector	EGARCH		GJR-GARCH		GARCH-M	
	AIC	SC	AIC	SC	AIC	SC
SB	-6.8515	-6.8207	-6.6718	-6.6498	-5.7573	-5.7195
SRE	-6.2666	-6.2358	-6.0677	-6.0458	-5.2730	-5.2352
SR	-6.7211	-6.6903	-6.5612	-6.5392	-5.6203	-5.5825
ADB	-6.7503	-6.7200	-6.6671	-6.6454	-5.8607	-5.8461
ADRE	-4.8418	-4.8158	-4.7557	-4.7340	-5.0167	-4.9792
ADS	-5.7710	-5.7450	-5.6757	-5.6540	-5.7545	-5.7170
DB	-6.2694	-6.2477	-6.2033	-6.1816	-6.0048	-5.9674
DRE	-5.1658	-5.1441	-5.1102	-5.0886	-5.0796	-5.0421
DS	-4.5785	-4.5525	-4.4592	-4.4375	-5.1794	-5.1419
QB	-6.9916	-6.9699	-6.8613	-6.8396	-6.3468	-6.3092
QRE	-6.1337	-6.1077	-5.7988	-5.7772	-5.4069	-5.3694
QS	-6.9470	-6.9210	-6.7470	-6.7253	-6.4739	-6.4363
BB	-6.8467	-6.8204	-6.7073	-6.6854	-7.2478	-7.2097
BS	-7.4449	-7.4186	-7.1764	-7.1545	-7.5449	-7.5068
BI	-10.324	-10.298	-6.4901	-6.4682	-5.6875	-5.6494
OB	-7.1868	-7.1606	-7.0601	-7.0382	-6.7173	-6.6794
OS	-7.9619	-7.9356	-7.8243	-7.8024	-8.0318	-7.9939
OI	-7.6877	-7.6614	-7.5599	-7.5380	-7.8397	-7.8017
KB	-7.3452	-7.2991	-7.3468	-7.3085	-7.2570	-7.2194
KS	-7.0216	-6.9756	-7.0054	-6.9671	-7.1470	-7.1094
KI	-7.5155	-7.4794	-7.4831	-7.4447	-7.0574	-7.0197

3.11 Summary

This chapter has presented primary descriptive statistics and examined the market performance of selected GCC stock market sectors pre-and post-2014. The descriptive statistics show that both the return and risk increased after the drop in oil price for most GCC stock market sectors. Moreover, the weak form of the EMH was tested to check the market efficiency of the selected GCC stock market sectors. The results show that most GCC stock market sectors are not efficient. Further, we used a set of risk-adjusted performance measures, including SR, TR, VaR and CVaR, to evaluate market performance before and after the drop in oil price in mid-2014. The overall performance evaluation showed a significant effect in the period after the drop in oil price; most selected GCC stocks had higher risk ratios than in the period before the drop in oil price.

We applied a set of GARCH models, including EGARCH, GJR-GARCH and GARCH-M, to capture asymmetry effects, which helped determine the effects of good and bad news on GCC stock markets. EGARCH analysis results show that all selected GCC stock market sectors experienced a significant effect in the pre-2014 and post-2014 periods, with the exception of the Abu Dhabi real estate and Dubai and Qatar services sectors, which showed a significant effect after the drop in oil price. This implies that the volatility in oil price had a significant effect on most GCC stock market sectors. Moreover, it shows that all selected GCC stock market sectors experienced an asymmetry effect, which implies that good news has less effect on conditional variance than does bad news. The analysis results indicate that the effect of information asymmetry differed before and after the drop in oil price for most selected GCC stock market sectors. These outcomes suggest the presence of a link between volatility in the oil price and GCC stock markets. Similarly, a GJR-GARCH was applied and showed that all selected GCC stock market sectors had a significant effect in both the pre-2014 and post-2014 periods, with the exception of the Abu Dhabi real estate, Dubai services, Qatar real estate and services and Bahrain services and industrial sectors, which showed a significant effect after the drop in oil price. Last, the GARCH-M test results indicate significant positive effects for all sectors in both periods. This implies that past volatility from news impacts current volatility. Specifically, in the pre-2014 period, Saudi bank and real estate, Dubai bank, Qatar bank and services and Bahrain industrial sectors had a significant sign that indicates high risk and high return. Other sectors did not have a significant sign, which indicates that increased risk does not necessarily lead to increased expected returns. However, post-2014 period, the Saudi real estate, Abu Dhabi real estate, Dubai bank and real estate and Oman services sectors were significant.

Chapter 4 Testing Volatility Spillover Using the Causal Relationship Between GCC Stock Markets and Global Factors

4.4 Introduction

This chapter describes an empirical study of volatility spillover between a set of selected GCC stock market sectors and some of the most influential global factors in financial markets, including the WTI oil price, MSCI World index and S&P 500 US index, using two econometric models: the VAR and CCF models. The VAR is an advanced univariate autoregressive (AR) model due to its ability to capture linear interdependencies of multiple time series variables and analyse the dynamic impacts of random disturbances (fluctuations) between them. CCF is a two-stage model introduced by Cheung and Ng (1996). This chapter applies the CCF model based on the Hafner and Herwartz (HH) (2006) test to investigate the presence of causality in the variance between oil prices and global factors (MSCI and S&P 500) and three major GCC stock market sectors (consumer discretionary, financial and real estate) from 2010 to 2017. The study period is divided into two sub-periods—before and after the drop in oil price in mid-2014—to allow investigation of the dependency relationships between the selected GCC stock market sectors, and the oil price and other global factors.

4.5 Conceptual Framework

In this chapter, the nature of interrelated and causality relationships between GCC stock markets and global factors is examined by applying two models: VAR and CCF models. The variables included in this study are three major GCC stock market sectors, namely consumer discretionary, financial and real estate, as well as oil prices and global factors (MSCI and S&P 500) from 2010 to 2017. The CCF model deploys the HH test to examine the existence of causal relationships during the two main study periods (before and after the drop in oil price in mid-2014) and investigate dependency relationships between selected GCC stock market sectors, oil price and other global factors during these periods. Figure 4.1 illustrates the theoretical framework for Chapter 4.

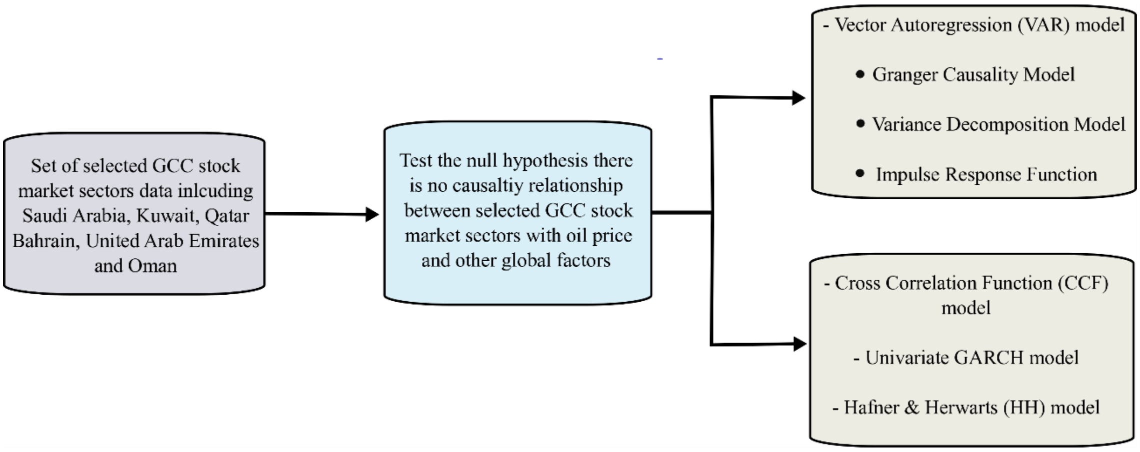

Figure 4.1: Conceptual framework of applied models used to investigate the nature of the causal relationship between global factors and sectoral GCC equity indices

4.6 Methodology

4.6.1 Vector Autoregressive Model

VAR models have been widely used to examine the possibility of linear interdependencies among selected GCC stock market sectors and global factors, including the WTI oil price and the MSCI and S&P 500 indices. The basic p-lag VAR model is written as:

$$R_t = c + \phi_1 R_{t-1} + \ldots + \phi_p R_{t-p} + \varepsilon_t \quad (4.1)$$

where R_t is a four-stationary-variable vector of returns (selected GCC stock market sectors, WTI oil price, MSCI and S&P 500) at time *t*; *p* is the lag length; *C* is an intercept; $\phi_1 - \phi_p$ are parameter matrices; and ε_t is a vector of error terms. To determine the appropriate lag length for the VAR model, the AIC and SC are employed. The hypotheses to be tested for the VAR model are:

H_0: there is no causal effect between GCC stock market sectors and global factors.

H_1: there is a causal effect between GCC stock market sectors and global factors.

4.6.2 Granger Causality Model

Following estimation of the VAR model, the next step is to investigate the nature of the relationships between global factors (WTI oil price, MSCI and S&P 500) and GCC stock market sectors. A Granger causality test is used to capture the dynamic relationship over the two sub-periods, pre- and post-2014. It is one of most well-known methods to examine causality relationships, as proposed by Granger (1969). The null hypothesis H_0: $x_{t-1} = x_{t-2} = 0$ is tested against the alternative hypothesis, which states that the joint shocks of one variable affect another. Granger causality tests are performed by fitting a VAR model as follows:

$$y_t = \alpha + \sum_{t=1}^{p} \beta y_{t-1} + \sum_{t=1}^{p} \mu_t x_{t-1} + \varepsilon_t \tag{4.2}$$

The test determines whether the group of μ coefficients are jointly significant with p time lags. This study aims to examine the existence of a Granger causality relationship between GCC stock market sectors and global factors. The hypotheses to be tested are as follows:

H_0: WTI and MSCI jointly do not Granger-cause selected GCC stock market sectors.

H_1: WTI and MSCI jointly Granger-cause selected GCC stock market sectors.

H_0: WTI and S&P 500 jointly do not Granger-cause selected GCC stock market sectors.

H_1: WTI and S&P 500 jointly Granger-cause selected GCC stock market sectors.

A block exogeneity F-test is used to identify the direction of causality in the relationship by checking whether or not the group of coefficients are jointly significant.

4.6.3 Variance Decomposition Model and Impulse Response Function

Granger causality tests are used to interpret and make inferences about the nature of causal relationships within a sample period. A variance decomposition (VD) test can be used to further study causal relationships beyond the sample period as it shows the amount of forecast error variance for a variable that contributes to innovations (or shocks) in other variables. An impulse response function (IRF) test is applied to examine the effect of any innovations (shocks) over time on various variables under study. Specifically, we study the response of a set of selected GCC stock market sector variables to the shock of a set of global factors: WTI oil price and MSCI and S&P 500 index variables.

4.6.4 Cross-Correlation Function Model

The CCF model is applied to examine the causality in variance between oil prices and global factors using sectoral GCC equity indices. The CCF model involves a two-stage procedure. In the first stage, a univariate GARCH model is applied to account for responses to the shocks, while in the second stage, standardised residuals and standardised squared residuals series from each univariate model are generated and used to calculate the CCF. The causality in variance test is defined according to Cheung and Ng's (1996) equation as follows:

$$h_t^2 = \varphi_0 + \varphi_1 h_{t-1}^2 + \varphi_2 u_{t-1}^2 \qquad (4.3)$$

Equation 4.2 represents the conditional variance of the sector index, where φ_0 is a constant, φ_1 is a coefficient of AR component, h_{t-1}^2 is an AR component for h_t^2, φ_2 is a coefficient of error term and u_{t-1}^2 is the square of past shocks in the return. The hypotheses to be tested are:

H_0: there is no causal effect between GCC stock market sectors and global factors.

H_1: there is a causal effect between GCC stock market sectors and global factors.

4.7 Empirical Results

4.7.1 Vector Autoregressive Model Estimation Results

VAR estimation is applied to examine how changes in global factors, including WTI, MSCI and S&P 500, affect GCC stock markets at the sectoral level and the dynamic interrelationships between them. VAR models are used to test the null hypothesis H_0: of no causal effect versus the alternative H_1: there is a causal effect. The results indicate that all variables in the GCC stock market sectors, as well as WTI, MSCI and S&P 500 respond to their own lag.

Overall, there is a substantial influence of global factors on GCC stock markets both pre- and post-2014. Appendix 1 presents the estimation results from the VAR estimation for the Saudi stock market sectors and selected global factors. In the full sample period result, Saudi bank, real estate and retail sectors show a significant causal effect of change in oil price and MSCI has a causal significant effect on Saudi bank and retail sectors. Moreover, in the pre-2014 period, selected Saudi stock market sectors are affected by WTI oil price and S&P 500, whereas they have no significant relationship with MSCI. In the post-2014 period the results of VAR estimation show that there is a significant causal effect of WTI oil price and S&P 500 on Saudi bank and real estate sectors, and MSCI has a significant effect on Saudi bank and retail sectors.

Appendices 2–3 shos the results for VAR estimation involving Abu Dhabi and Dubai stock market sectors and the selected global factors, pre-and post-2014. The full sample period results include a significant causal effect resulting from changes in the WTI oil price and S&P 500 on the Abu Dhabi bank sector; whereas pre-2014, there is no significant link between the selected global factors and Abu Dhabi sectors, except that MSCI has a significant link with the Abu Dhabi services sector. Further, in the post-2014 period, S&P 500 has a significant effect on the Abu Dhabi bank and services sectors, whereas the WTI oil price and MSCI index do not show any sign of effects. The full sample period analysis results for the Dubai sectors indicate a significant causal effect of the WTI oil price and S&P 500 on Dubai bank and real estate sectors. Moreover, in the pre-2014 period, there is no obvious link between global factors and Dubai sectors, except for the relationship between the WTI oil price and he Dubai real estate sector. In the post-2014 period, there is a significant effect only of the S&P 500 index on the Dubai bank and real estate sectors.

The results for the selected Qatar and Bahrain sectors in relation to the global factors are presented in Appendices 4–5. The Qatar VAR estimation results indicate that there is no significant relationship between WTI oil price and Qatar sectors in the full sample period. However, there are significant causal effects of MSCI on the Qatar bank sector and of S&P 500 on the Qatar bank and real estate sectors. In pre-2014 period, Qatar bank and real estate sectors are exposed to a significant causal effect from WTI oil price and S&P 500 index; while in post-2014 period, there is no sign of a significant causal effect between Qatar sectors, WTI oil price and S&P 500 index, although there is a significant causal effect of MSCI on the Qatar services sector. The VAR estimation results for the Bahrain sectors in relation to the WTI oil price, MSCI world index and S&P 500 index show the absence of any significant causal effect of the WTI oil price and MSCI on

Bahrain sectors, but there is a significant causal effect of S&P 500 index on the Bahrain industrial sector in the full sample period. The estimation results for the pre-2014 period show a significant causal effect of the WTI oil price on the Bahrain bank and services sectors but not of the MSCI and S&P 500 indices. In post-2014 period, WTI oil price and S&P 500 index have a significant causal effect on the Bahrain services sector, and MSCI has a significant causal effect on the Bahrain services sector.

Finally, Appendices 6–7 present the VAR estimation results for the Oman and Kuwait sectors in relation to the selected global factors. In the full sample period for the Oman sectors, the estimation results reveal a significant link of the WTI oil price and MSCI, with the services and industrial sectors, and Oman industrial sector, respectively. Moreover, a significant relationship is found between the S&P 500 index and the Oman services sector. In the pre-2014 period, there is a significant effect of oil price on Oman's industrial sector. Further, there is a significant effect of MSCI and S&P 500 indices on all Oman sectors. Post-2014, the WTI oil price has a significant effect on the Oman bank and services sectors but there is no significant effect of MSCI and S&P 500 indices. In the full sample period for the Kuwait sectors, a significant link is found between the WTI oil price and he Kuwait bank and services sectors. Further, there is a significant effect of MSCI on the Kuwait bank sector. In the pre-2014 period, there is a significant effect of the oil price on the Kuwait services sector and post-2014, the WTI oil price has a significant effect on the Kuwait bank and services sectors. There is also a significant effect of MSCI on the Kuwait bank sector.

In general, VAR estimation results for the selected GCC sectors are mostly consistent with those of Arouri et al. (2010) and Jouini (2013). The results indicate that there is a significant impact of the most influential selected global factors on the selected GCC sectors. This can be explained by considering the dependency between GCC stock markets as major oil exporters, and the oil price (Fayyad & Daly 2011). Moreover, there is a strong relationship between the global financial market MSCI and most GCC stock markets; this can be explained by the close financial links among GCC stock markets as major oil exporters, which makes GCC countries highly influential in global financial markets. Further, most GCC stock markets have tight links with the major US stock market S&P 500 index, which may be driven by the pegging of the Saudi currency to the US currency (Hammoudeh & Al-Gudhea 2006).

4.7.2 Granger Causality Estimation (Block Test) Results

This section tests Granger causality among the GCC stock markets and the selected global factors. The hypotheses tested are as presented in Section 4.3.2. Table 4.1 presents the results of Granger causality tests for all GCC stock markets. There is an observed causal relationship between the oil price and the Saudi bank sector in both the full and pre-2014 periods, but there is no sign of a causal effect for other Saudi sectors. Further, there is a significant causal effect of MSCI on the Saudi bank and real estate sectors in the full period, and for all sectors in the post-2014 period. S&P 500 shows a causal relationship with the Saudi bank and real estate sectors pre-2014, but no significant causal effect in the full period or post-2014.

In the Abu Dhabi stock market, a causal relationship is seen between the oil price and the bank sector in the pre-2014 period, while there is no significant causal relationship between oil and other sectors. Moreover, MSCI shows a causal relationship with the services sector pre-2014 and with real estate post-2014. Last, a causality relationship is seen between S&P 500 and the Abu Dhabi bank sector in the pre-2014 period. In the Dubai stock market, there is a significant causal relationship between the oil price and the bank and real estate sectors in both the full and pre-2014 periods, but no significant causality in the post-2014 period. There is a causal relationship of MSCI with Dubai bank and real estate sectors in the pre-2014 period.

Qatar stock market results show the existence of a causal relationship between the oil price and the bank and real estate sectors in the pre-2014 period. Moreover, there is a causal relationship between all Qatar sectors and MSCI in the pre-2014 period. S&P 500 also shows a causal with the Qatar real estate sector in the full period and pre-2014. The Bahrain stock market results indicate a causal effect of the oil price on the bank sector in both the full and post-2014 periods; and on the services sector pre-2014. However, there is no significant causal relationship between the MSCI and Bahrain sectors. The S&P 500 index presents a causal relationship with the Bahrain services and industrial sectors in the full period; the Bahrain industrial sector pre-2014; and the Bahrain services sector post-2014. The oil price has a causal relationship with the Oman bank and services sectors in the full period and the services sector pre-2014. In addition, S&P 500 presents a causal relationship with all Oman sectors in the full period and with the services and industrial sectors pre-2014. However, there is no causal relationship between Oman sectors and the

MSCI index. The Kuwait bank and services sectors present a causal relationship with oil in the full period and post-2014, and the services sector pre-2014. Further, there is a causal relationship between MSCI and the Kuwait bank sector in the full period and pre-2014, but no such relationship for the S&P 500 index.

Table 4.2 presents the results of causality test estimation of the joint shocks of WTI oil price and MSCI, and WTI oil price and S&P 500 index, with regard to the GCC stock market sectors. The results indicate that the joint shock of WTI oil price and MSCI does not have a significant causal effect on Saudi sectors for any sample period, while the joint shock of WTI oil price and S&P 500 index has a significant causal effect on the Saudi bank and real estate sectors in the pre-2014 period. Further, the Abu Dhabi real estate sector experiences a significant causal effect of the joint shock of WTI oil price and S&P 500 index in all sample periods. The Dubai real estate and services sectors show a significant causal effect of the joint shock of WTI oil price and MSCI in both the full sample and pre-2014 periods. In addition, the joint shock of WTI oil price and S&P 500 index has a significant causal effect on all Dubai sectors for all sample periods. Oman sectors show a significant causal effect of the joint shock of WTI oil price and S&P 500 index for the full sample and pre-2014 periods. However, Qatar, Bahrain and Kuwait do not show any sign of a significant causal effect for the joint shock of WTI oil price and MSCI, or the joint shock of WTI oil price and S&P 500 index. Overall, the most significant causal effect is presented between GCC stock market sectors and the joint shock of WTI oil price and S&P 500 index because of a high correlation between the WTI oil price and S&P 500 index.

In summary, most of the selected sectors in GCC stock markets show a causal effect from WTI oil price and S&P 500 index in the pre-2014 period but not the post-2014 period. However, bank sectors in some GCC stock markets show a causal effect from WTI oil price in the post-2014 period, as seen clearly for the Saudi, Bahrain and Kuwait bank sectors. Further, MSCI has a significant causal effect in some GCC stock market sectors in the post-2014 period but not the pre-2014 period. The joint shock of WTI oil price and S&P 500 index has a more significant causal effect on some GCC stock market sectors in the pre-2014 period than post-2014.

Table 4.1: Granger causality/block exogeneity Wald test of GCC stock market sectors, WTI, MSCI and S&P 500, 2010–17

Sector		Full period			Pre-2014			Post-2014	
Saudi Arabia	Bank	Real Estate	Retail	Bank	Real Estate	Retail	Bank	Real Estate	Retail
WTI	0.5054**	0.0945	0.6820	0.0937**	1.4338	0.1553	1.0278*	0.1606	0.2552
MSCI	0.9528*	0.4191**	1.8211	0.9991	1.0155	0.0011	0.8322*	0.8819**	0.7793*
S&P 500	0.5527	0.1889	0.2399	0.9552*	0.6487**	0.3415	0.7471	0.1007	0.9650
Abu Dhabi	Bank	Real Estate	Services	Bank	Real Estate	Services	Bank	Real Estate	Services
WTI	0.1362	0.1127	0.0656	7.8693***	0.0037	0.0100	0.0090	0.1110	0.1853
MSCI	0.0061	0.0327	0.4341	0.3567	1.5162	0.6462**	0.2950	0.2671*	0.6478
S&P 500	1.2946	0.0849	0.9256	0.4484*	0.5662	1.4884	0.0498	0.4770	0.1952
Dubai	Bank	Real Estate	Services	Bank	Real Estate	Services	Bank	Real Estate	Services
WTI	1.5291**	0.0029*	0.2255	1.0658**	0.0160*	0.2336	0.4375	0.0076	0.0353
MSCI	1.3096	0.1372	1.6544	0.2952**	0.7303***	0.5334	0.8299	1.8754	0.3025
S&P 500	0.2779	0.0349	1.6781	0.8420	0.0768	0.6774	0.1658	0.0204	1.1351
Qatar	Bank	Real Estate	Services	Bank	Real Estate	Services	Bank	Real Estate	Services
WTI	1.3614	0.1778	0.8348	0.9444**	0.2192**	0.3934	0.4835	0.0377	0.7657
MSCI	0.8961	1.809	0.2358	0.035**	0.1597**	0.9877*	1.9782	1.2462	0.1923
S&P 500	0.0805	0.2441**	0.2412	0.7391	0.9425**	0.5277	0.3864	0.4820	0.6953
Bahrain	Bank	Services	Industrial	Bank	Services	Industrial	Bank	Services	Industrial
WTI	0.003***	0.8542	0.5812	0.3756	0.177*	0.0259	6.8771***	0.2444	0.6446
MSCI	0.0806	0.3192	1.3379	0.9507	0.9251	1.0805	0.5890	1.2419	0.3572
S&P 500	1.1147	0.9762*	0.1443***	0.2384	0.5485	0.7256***	0.2407	0.9754**	0.9948
Oman	Bank	Services	Industrial	Bank	Services	Industrial	Bank	Services	Industrial
WTI	0.2676*	0.7677**	1.8089	0.6258	0.9676**	0.2938	0.0722	1.5982	1.2113
MSCI	0.7889	0.5402	0.1356	1.6706	0.4818	0.837	1.0817	0.8027	0.1755
S&P 500	0.1395*	0.0225**	0.9444**	0.6637	0.0961**	1.712**	0.2073	0.0059	0.0011
Kuwait	Bank	Services	Industrial	Bank	Services	Industrial	Bank	Services	Industrial
WTI	0.0004*	0.1796**	0.8044	0.1219	0.0184*	1.4911	0.0648*	0.6159*	0.1026
MSCI	0.5453*	0.7556	0.0038	0.2394**	0.0461	0.4533	0.1409	0.8568	0.1450
S&P 500	0.5477	0.6922	0.1222	0.6631	0.5947	0.1926	0.0327	0.1531	0.4991

Note: ***, **, * indicate statistical significance at the 1%, 5% and 10% levels, respectively in F-statistics tests for causality.

Table 4.2: Granger causality/block exogeneity Wald test of GCC stock market sectors with joint shocks of WTI & MSCI and WTI & S&P 500, 2010–17

Sector	Full period			Pre-2014			Post-2014		
Saudi Arabia	Bank	Real Estate	Retail	Bank	Real Estate	Retail	Bank	Real Estate	Retail
WTI&MSCI	0.2875	0.7035	1.5154	2.0135	1.6921	1.6982	0.7069	1.3237	0.8774
WTI&S&P 500	0.2576	0.3714	0.7768	2.5684**	2.4584**	1.8162	1.1195	1.5280	1.0578
Abu Dhabi	Bank	Real Estate	Services	Bank	Real Estate	Services	Bank	Real Estate	Services
WTI&MSCI	0.4876	0.9913	0.6971	1.7625	2.1854	0.3117	0.7950	0.3468	1.3481
WTI&S&P 500	1.6994	0.7354*	0.0853	1.4635	0.2478***	0.5503	1.7322	2.6970**	0.7868
Dubai	Bank	Real Estate	Services	Bank	Real Estate	Services	Bank	Real Estate	Services
WTI&MSCI	1.8635	2.5625**	2.5513**	1.2746	3.0198**	3.5126***	1.3940	1.4850	0.4608
WTI&S&P 500	2.7085**	3.8271***	2.8035**	3.0186**	3.9444**	3.3282**	2.9458**	3.2021**	1.2120
Qatar	Bank	Real Estate	Services	Bank	Real Estate	Services	Bank	Real Estate	Services
WTI&MSCI	1.0602	0.8889	0.6491	0.6357	0.9499	1.4229	0.6461	0.4923	0.2615
WTI&S&P 500	0.9562	0.0884	0.5432	0.4659	0.3577	1.1766	0.6857	0.2861	0.4674
Bahrain	Bank	Services	Industrial	Bank	Services	Industrial	Bank	Services	Industrial
WTI&MSCI	0.9924	1.7324	1.0317	1.0701	1.3313	0.7391	0.3946	1.2693	1.1411
WTI&S&P 500	0.3698	0.7062	1.4454	0.0919	0.8189	0.9298	2.0980	0.2152	2.3188
Oman	Bank	Services	Industrial	Bank	Services	Industrial	Bank	Services	Industrial
WTI&MSCI	1.6622	2.5569	2.0389	2.2815	2.8616	2.5257	0.6748	0.5884	0.6569
WTI&S&P 500	2.0786*	4.1013***	2.3316*	3.1921**	5.2109***	3.3721***	0.7221	1.3708	0.8551
Kuwait	Bank	Services	Industrial	Bank	Services	Industrial	Bank	Services	Industrial
WTI&MSCI	0.9024	0.6982	0.4837	1.0164	0.4978	1.2617	1.0047	0.8566	1.0293
WTI&S&P 500	0.6946	0.1176	0.4895	1.0632	0.5462	1.0166	0.3347	0.1391	1.3936

Note: ***, **, * indicate statistical significance at the 1%, 5% and 10% levels, respectively, in F-statistics tests for causality.

Table 4.3: Summary results of Granger causality (block tests)

Causality test	Full period			Pre-2014			Post-2014			Comments
Saudi Arabia	SB	SRE	SR	SB	SRE	SR	SB	SRE	SR	
WTI →	✔			✔			✔			Shocks from the WTI oil price have a causal effect on the Saudi bank sector in all periods. This may be a direct effect of the variation in oil-related lending and business activities. Moreover, the joint shock of WTI oil price and S&P 500 has a causal effect on the Saudi bank and real estate sectors. This is expected as Saudi sectors are likely sensitive to oil prices because oil income affects fiscal spending and oil receipts form the largest part of external and government income. Moreover, US and Saudi economies have a tight relationship and can thus have both direct and indirect impacts on each other. The main implication of this is that the global factors have diverse shock transmission effects on the selected Saudi stock market sectors, which is an important indicator to be taken into consideration by investors and policy makers.
MSCI →	✔	✔					✔	✔	✔	
S&P 500 →				✔	✔					
WTI & MSCI →										
WTI & S&P 500 →				✔	✔					
Abu Dhabi	ADB	ADRE	ADS	ADB	ADRE	ADS	ADB	ADRE	ADS	
WTI →				✔						The joint shock from the WTI oil price and S&P 500 index has a significant causal effect on Abu Dhabi real estate in all periods. Abu Dhabi is one of the largest exporters of crude oil in the Gulf area and its real estate sector depends mainly on government fiscal spending from oil income. It is clear that various sectors, including real estate, are highly exposed to shocks from oil price volatility. The analysis results demonstrate the leading role of oil prices and the domination of the S&P 500 market over the Abu Dhabi equity market as part of the GCC.
MSCI →						✔		✔		
S&P 500 →				✔						
WTI & MSCI →										
WTI & S&P 500 →		✔			✔			✔		
Dubai	DB	DRE	DS	DB	DRE	DS	DB	DRE	DS	
WTI →	✔	✔		✔	✔					The joint shock from the WTI oil price and S&P 500 has a causal effect on Dubai sectors for all sample periods. Similar to the Abu Dhabi stock market, the Dubai stock market relies partially on oil revenues and its economic relationship with the US S&P 500 market because they share their monetary policy
MSCI →				✔	✔					
S&P 500 →										
WTI & MSCI →		✔	✔		✔	✔				
WTI & S&P 500 →	✔	✔	✔	✔	✔	✔	✔	✔		

Causality test	Full period			Pre-2014			Post-2014			Comments
Saudi Arabia	SB	SRE	SR	SB	SRE	SR	SB	SRE	SR	
										with the US and for other economic diversification reasons that mean the Dubai stock market is exposed to shock transmission from international financial markets.
Qatar	QB	QRE	QS	QB	QRE	QS	QB	QRE	QS	
WTI →				✔	✔					Qatar sectors show a weak effect of WTI oil price pre-2014, which is expected because of Qatar’s dependency on gas revenues as a major supplier of gas rather than oil supplies for government fiscal spending. There is a causal effect of MSCI on Qatar sectors, which is expected because of high leverage on the international financial market through heavy dependency on investing its sovereign wealth fund in global financial stock markets; and because of the link between MSCI and Qatar stock market, which is included in the MSCI emerging markets index.
MSCI →				✔	✔	✔				
S&P 500 →		✔			✔					
WTI & MSCI →										
WTI & S&P 500 →										
Bahrain	BB	BS	BI	BB	BS	BI	BB	BS	BI	
WTI →	✔				✔		✔			Bahrain sectors exhibit a significant causal effect from S&P 500 for the full and post-2014 periods. Moreover, shock transmission from S&P 500 strongly affects Bahrain sectors. This may be due to early economy diversification that led Bahrain to invest its sovereign wealth fund in global financial stock markets, giving it higher exposure to S&P 500 as the dominant international market among global financial markets. Moreover, Bahrain as a part of the GCC is strongly linked to the US economy and its monetary policies, which is a strong indicator of high exposure to diverse shock transmission to Bahrain sectors from S&P 500.
MSCI →										
S&P 500 →		✔	✔			✔		✔		
WTI & MSCI →										
WTI & S&P 500 →										
Oman	OB	OS	OI	OB	OS	OI	OB	OS	OI	
WTI →	✔	✔			✔					Oman sectors are exposed to causal effects from the joint shock of WTI oil price and S&P 500 in both the full sample and pre-2014 periods. Similar to other GCC countries, Oman is highly sensitive to both oil prices and US market through sharing of monetary policies, which provides a strong indicator of high exposure to diverse shock transmission of Oman sectors from both WTI oil price and S&P 500.
MSCI →										
S&P 500 →	✔	✔	✔		✔	✔				
WTI & MSCI →										
WTI & S&P 500 →	✔	✔	✔	✔	✔	✔				

Causality test	Full period			Pre-2014			Post-2014			Comments
Saudi Arabia	SB	SRE	SR	SB	SRE	SR	SB	SRE	SR	
Kuwait	KB	KS	KI	KB	KS	KI	KB	KS	KI	
WTI →	✓	✓			✓		✓	✓		The Kuwait bank sector shows a significant causal effect from WTI oil price for all sample periods. This may be explained by the fact that the Kuwait economy is highly dependent on oil revenues (as one of the world's top-10 oil exporters), which are the backbone of government spending given that oil receipts form the largest part of government income. This implies that government fiscal spending drives the growth of various sectors in Kuwait, especially banking.
MSCI →	✓			✓						
S&P 500 →										
WTI & MSCI →										
WTI & S&P 500 →										

4.7.3 Variance Decomposition Estimation Results

The VD analysis determines how much of the forecast error variance for GCC stock market sectors can be explained by shocks to the oil price, MSCI and S&P 500. It indicates the relative effect that a selected market has on another market within the VAR model. Table 4.4 reports the VD results for the Saudi sectors and factors including WTI, MSCI and S&P 500 for the 1-, 5-, 10- and 15-day periods. Saudi sectors demonstrate a high contribution from their own shocks and shocks to other sectors in terms of fluctuations in all Saudi sectors. For example, shocks to Saudi banking are expected to cause 42.69% and 46.38% of the fluctuations in the Saudi real estate and retail sectors respectively, which may be a result of the dependency of both sectors on the bank sector to inject continuous liquidity. For example, the housing ministry of Saudi Arabia began to increase home ownership by relying on its banking sector to support citizens with loans as part of its 2030 reform plan (Vision 2030).

The results indicate fluctuations in the oil impact by their own shocks of around 96.48% in the short and long run. Further, shocks to other markets represent a range of impacts from 0.02% from real estate to 3.34% from S&P 500 that impact on the fluctuation of oil. The MSCI index presents 99% of own shocks that affect the fluctuation in MSCI in the long and short run. However, the shocks from other markets affect fluctuations in MSCI by 0.02% from oil to 0.54% from Saudi retail. In addition, the S&P 500 index fluctuation affects their own shocks by 99%. Also, shocks to oil will affect S&P 500 fluctuations by 0.98% and there is no contribution of shocks to other markets to the volatility of S&P 500.

Table 4.5 presents the results of the VD for Abu Dhabi sectors and global factors. The results indicate that the fluctuation of the oil price, MSCI and S&P 500 impact their own shocks by around 96.25%, 99.51% and 98.60%, respectively. In the short run the effect of shocks in the stock market is higher than in the long run. The fluctuations in the Abu Dhabi bank sector are affected by shocks to other markets, showing a range of 0.16% from oil to 22.58% from real estate. The shocks to real estate represent a high percentage of the cause in fluctuations in the bank sector, because of the relationship between these sectors. The MSCI index presents 99% of own shocks that affect the fluctuation of MSCI in the long and short run. However, the shocks from other markets affect the fluctuation of MSCI by 0.002% from banking to 0.217% from real estate. In addition, the S&P 500 index fluctuation affect by their own shocks by 99%. There is no contribution of shocks to other markets to the volatility in S&P 500. Abu Dhabi sector variance makes a high contribution to their own shocks, of around 98%.

The analysis results for the Dubai sectors and global factors are presented in Table 4.6. The Dubai bank sector variance makes a high contribution to its own shocks, of around 99%. Moreover, shocks to the bank sector represent a high percentage that affects the fluctuation in real estate and services, of around 44.32% and 17.55%, respectively. Further, the shocks to services, banking and real estate impact fluctuations in the services sector by 69.00%, 17.55% and 12.41%, respectively, in the short run. The outcomes indicate that fluctuations in the oil price, MSCI and S&P 500 are impacted by their own shocks. The fluctuations in the oil price are affected by 96% of the shocks come to oil and 3.22% of the shocks come to S&P 500. Shocks to the MSCI index cause 99% of variance in the MSCI in the long and short run. However, shocks from other markets affect the fluctuation in MSCI by 0.02% from S&P 500 to 0.13% from the Dubai services sector. In addition, S&P 500 index fluctuations affect their own shocks by 99%. There is no contribution of shocks to other markets to the volatility of S&P 500.

Table 4.7 presents the results for VD for the Qatar sectors, WTI, MSCI and S&P 500. The results show that the oil price, MSCI, S&P 500 and Qatar sector fluctuations are affected by their own shocks. The effect of shocks is stronger in lag 1 than in lag 15. Further, fluctuations in the Qatar real estate and services sectors are affected by shocks to the Qatar bank sector, by 29.65% and 26.39%, respectively. The VD analysis of Bahrain sectors and other factors is presented in Table 4.8. Fluctuations in Bahrain sectors are affected by their own shocks but there is no effect from shocks to other sectors. Further, shocks to the oil prices and S&P 500 affect fluctuations in oil price by 96.52% and 3.35%, respectively. In addition, fluctuations in MSCI and S&P 500 are impacted by their own shocks, by 99.97% and 99.23%.

Table 4.9 presents the VD analysis results for the Oman sectors. Shocks to Oman sectors from the WTI, MSCI and S&P 500 affect their fluctuation by 99.68%, 48.76% and 44.20%. However, shocks to the Oman bank sector affect fluctuations in the Oman services and industrial sectors, by 50.57% and 51.29%, respectively. In addition, the results indicate that the fluctuation in oil price, MSCI and S&P 500 affects their shocks by 96.50%, 99.77% and 99.93% respectively. The VD for the Kuwait sectors and other factors is presented in Table 4.10. As mentioned previously, the fluctuation of oil price, MSCI and S&P 500 is affected by own shocks. Moreover, Kuwait sector variances are affected by their own shocks, by 99.89%, 94.48% and 84.20%, respectively.

As a result, the WTI, MSCI and S&P 500 indices are affected by their own shocks. Further, GCC stock market sectors are affected by their own shocks as well as those from other sectors within the same country. The sector that most affects other sectors in the majority of GCC countries is the bank sector, which may be a result of the support it provides to other sectors.

Table 4.4: VD model estimation for Saudi sectors, WTI, MSCI and S&P 500, 2010–17

Period % / Saudi Arabia	Bank	WTI	MSCI	S&P 500	Real Estate	Retail
1	99.50	0.3326	0.1515	0.0191	0	0
5	98.56	0.3975	0.1839	0.0365	0.2834	0.5343
10	98.52	0.3997	0.1849	0.0363	0.2974	0.5518
15	98.52	0.3997	0.1875	0.0337	0.2978	0.5519
Real Estate	Real Estate	WTI	MSCI	S&P 500	Bank	Retail
1	57.03	0.0545	0.2612	0.0271	42.69	0
5	56.76	0.0709	0.2641	0.0113	42.79	0.0981
10	56.53	0.0715	0.3547	0.0244	42.57	0.4371
15	56.53	0.0716	0.3553	0.0246	42.57	0.4386
Retail	Retail	WTI	MSCI	S&P 500	Bank	Real Estate
1	49.82	0.0413	0.1063	0.0579	46.38	03.64
5	49.63	0.2469	0.2737	0.0974	46.02	03.81
10	49.62	0.2475	0.2901	0.0114	46.00	03.81
15	49.62	0.2475	0.2904	0.0114	46.00	03.81

Note: ***, **, * indicate statistical significance at the 1%, 5% and 10% levels, respectively.

Table 4.5: VD model estimation for Abu Dhabi sectors, WTI, MSCI and S&P 500, 2010–17

Period % / Abu Dhabi	Bank	WTI	MSCI	S&P 500	Real Estate	Services
1	99.85	0.1317	0.0009	0.0148	0	0
5	76.89	0.1096	0.0003	0.0116	22.14	0.0168
10	76.66	0.1625	0.0107	0.5881	22.55	0.0703
15	76.60	0.1646	0.0115	0.5911	22.58	0.0703
Real Estate	Real Estate	WTI	MSCI	S&P 500	Bank	Services
1	98.24	0.5109	0.0001	0.6103	1.744	0
5	98.08	0.0637	0.0558	0.0518	1.773	0.0121
10	96.16	0.0656	0.0735	1.2251	1.776	0.0431
15	96.81	0.0659	0.0751	1.2276	1.776	0.0432
Services	Services	WTI	MSCI	S&P 500	Bank	Real Estate
1	99.53	0.0121	0.1245	0.0413	0.2842	0.0009
5	99.08	0.0206	0.2648	0.0537	0.3561	0.0596
10	99.07	0.0221	0.2933	0.0539	0.4026	0.1565
15	99.06	0.0221	0.9245	0.0549	0.4027	0.1567

Note: ***, **, * indicate statistical significance at the 1%, 5% and 10% levels, respectively.

Table 4.6: VD model estimation for Dubai sectors, WTI, MSCI and S&P 500, 2010–17

Period % Dubai	Bank	WTI	MSCI	S&P 500	Real Estate	Services
1	99.81	0.1082	0.0669	0.0008	0	0
5	99.32	0.3410	0.1486	0.0288	0.1331	0.00819
10	98.81	0.3633	0.1533	0.3456	0.1661	0.0880
15	98.87	0.3639	0.1534	0.3461	0.1662	0.0907
Real Estate	Real Estate	WTI	MSCI	S&P 500	Bank	Services
1	55.54	0.0011	0.1245	0.0009	44.32	0
5	54.93	0.1875	0.3435	0.0316	44.53	0.1286
10	54.45	0.2046	0.3471	0.6374	44.19	0.1543
15	54.45	0.2066	0.3474	0.6385	44.19	0.1544
Services	Services	WTI	MSCI	S&P 500	Bank	Real Estate
1	69.82	0.0153	0.0939	0.1024	17.55	12.41
5	69.32	0.1623	0.4084	0.5420	17.96	12.28
10	68.91	0.1633	0.4166	0.5421	17.85	12.10
15	68.90	0.1635	0.4178	0.5484	17.85	12.10

Note: ***, **, * indicate statistical significance at the 1%, 5% and 10% levels, respectively.

Table 4.7: VD model estimation for Qatar sectors, WTI, MSCI and S&P 500, 2010–17

Period % Qatar	Bank	WTI	MSCI	S&P 500	Real Estate	Services
1	99.83	0.0890	0.0667	0.0131	0	0
5	99.04	0.2471	0.0783	0.0144	0.3569	0.2622
10	98.74	0.3067	0.1006	0.0178	0.5621	0.2768
15	98.72	0.3076	0.1007	0.0178	0.5608	0.2768
Real Estate	Real Estate	WTI	MSCI	S&P 500	Bank	Services
1	69.98	0.0138	0.1029	0.2481	29.65	0
5	69.49	0.0149	0.1298	0.2464	29.73	0.3723
10	69.36	0.0327	0.2681	0.2466	29.68	0.3889
15	69.36	0.0328	0.2732	0.2469	29.68	0.3896
Services	Services	WTI	MSCI	S&P 500	Bank	Real Estate
1	68.56	0.0002	0.1143	0.0113	26.39	4.916
5	67.88	0.0156	0.1368	0.0152	27.05	4.890
10	67.57	0.1290	0.1369	0.0205	27.17	4.965
15	67.57	0.1298	0.1369	0.0207	27.17	4.965

Note: ***, **, * indicate statistical significance at the 1%, 5% and 10% levels, respectively.

Table 4.8: VD model estimation for Bahrain sectors, WTI, MSCI and S&P 500, 2010–17

Period % Bahrain	Bank	WTI	MSCI	S&P 500	Services	Industrial
1	99.30	0.4915	0.1111	0.0940	0	0
5	99.17	0.4923	0.1589	0.1665	0.0113	0
10	98.80	0.4897	0.3409	0.1664	0.1713	0.0236
15	98.80	0.4899	0.3468	0.1664	0.1723	0.0238
Services	Services	WTI	MSCI	S&P 500	Bank	Industrial
1	98.25	0.0346	0.0153	0.1438	1.549	0
5	97.79	0.0633	0.2836	0.1933	1.593	0.0726
10	97.55	0.1068	0.3311	0.2452	1.592	0.1695
15	97.55	0.1068	0.3311	0.2461	1.592	0.1726
Industrial	Industrial	WTI	MSCI	S&P 500	Bank	Services
1	99.40	0.0167	0.0769	0.4042	0.0338	0.0641
5	98.68	0.2282	0.0775	0.5050	0.1495	0.0715
10	98.76	0.2587	0.0950	0.5043	0.1618	0.2210
15	98.75	0.2612	0.0951	0.5044	0.1619	0.2219

Note: ***, **, * indicate statistical significance at the 1%, 5% and 10% levels, respectively.

Table 4.9: VD model estimation for Oman sectors, WTI, MSCI and S&P 500, 2010–17

Period % Oman	Bank	WTI	MSCI	S&P 500	Services	Industrial
1	99.68	0.1417	0	0.1736	0	0
5	98.95	0.3862	0.3945	0.1698	0.0878	0
10	98.72	0.4860	0.4872	0.2078	0.0986	0
15	98.70	0.4870	0.4884	0.2098	0.1003	0.0007
Services	Services	WTI	MSCI	S&P 500	Bank	Industrial
1	48.76	0.2614	0	0.3974	50.57	0
5	47.92	0.8526	0.6813	0.2331	50.02	0
10	47.87	0.8426	0.7878	0.3445	50.08	0.0439
15	47.86	0.8433	0.8030	0.3441	50.08	0.0462
Industrial	Industrial	WTI	MSCI	S&P 500	Bank	Services
1	44.20	0.0861	0	0.3031	51.29	0.0407
5	42.96	0.5372	0.5540	0.1675	51.59	0.0421
10	42.55	0.5868	0.6043	0.1687	51.93	0.0423
15	42.44	0.5897	0.6081	0.1687	51.95	0.0423

Note: ***, **, * indicate statistical significance at the 1%, 5% and 10% levels, respectively.

Table 4.10: VD model estimation for Kuwait sectors, WTI, MSCI and S&P 500, 2010–17

Period % Kuwait	Bank	WTI	MSCI	S&P 500	Services	Industrial
1	99.89	0.0644	0.0390	0	0	0
5	99.03	0.0006	0.1632	0.1717	0.0727	0.6687
10	98.47	0.1343	0.1880	0.1737	0.0926	0.9316
15	98.47	0.1390	0.1881	0.1737	0.0929	0.9332
Services	Services	WTI	MSCI	S&P 500	Bank	Industrial
1	94.48	0.1869	0.0787	0.0648	4.834	0
0.05	94.47	0.1916	0.0819	0.0655	4.976	0.0237
10	94.35	0.1997	0.2551	0.0696	4.996	0.1299
15	94.33	0.2012	0.2644	0.0697	4.997	0.1324
Industrial	Industrial	WTI	MSCI	S&P 500	Bank	Services
1	84.20	0.0534	0	0	13.79	1.941
5	83.64	0.1042	0.0114	0.0693	14.16	2.006
10	82.77	0.1509	0.0384	0.0938	14.95	1.985
15	82.76	0.1529	0.0386	0.0947	14.96	1.985

Note: ***, **, * indicate statistical significance at the 1%, 5% and 10% levels, respectively.

4.7.4 Impulse Response Function (IRF) Analysis

To examine how the variables of interest respond to shocks to the WTI oil price, we apply estimates from the IRF. Figure 4.2 shows the IRF results, starting with the Saudi sectors; the results show that oil price shocks have a significant positive effect on the Saudi bank sector. The effects of the mid-2014 oil slump crisis are present for almost four periods and statistically significant for the first three periods. The same shocks to the oil crisis also draw a positive response from the Saudi real estate sector. The effects are present for almost three periods, before decreasing and losing their statistical significance, which also has a 49.23% correlation with the oil price. Lastly, shocks from the oil crisis also produce a significant positive response from the Saudi retail sector, which remains present for close to four periods. This indicates that the Saudi economy is highly dependent on oil revenue. An increase in oil prices generates a marked improvement in the Saudi economy.

The results of the IRF analysis for Abu Dhabi and Dubai show that of the Abu Dhabi sectors, the bank sector has a negative response for three periods. The real estate sector exhibits significant negative effects of shocks from the oil crisis that last over three periods. The services sector shows negative effects for two periods and then a positive effect for a small period following the oil crisis, but these effects rapidly became insignificant. As a result, the Abu Dhabi bank, real estate and services sectors show a negative correlation with oil: –30.32%, –17.23% and –17.93%, respectively. The Dubai sectors show similar responses; for the bank and real estate sectors, shocks from the oil price crisis led to a notably negative effect lasting three periods. Further, Dubai's services sector demonstrates a negative response to the oil price crisis for three periods. This result is consistent with the correlation between Abu Dhabi and Dubai and oil prices in Chapter 3; both countries have a negative correlation with oil prices.

The results of the IRF analysis for the Qatari bank sector indicate that oil price inflation has an insignificant effect initially but becomes significant later. The response of the real estate sector remains significant for more than two periods. The services sector also shows a positive and significant response to shocks from the oil crisis spanning two periods. However, these results reveal a lower level of significance than for the Saudi and Emirates sectors. The Qatari economy is not strongly correlated with oil prices as Qatar is a major supplier of gas.

For the Bahraini sectors, the IRF analysis indicates that shocks from the oil price crisis have a positive and significant effect on the bank sector over two periods. However, the services sector is not noticeably affected by oil price shocks. The industrial sector is barely affected by oil price rises for the initial period, but the effects become significant for the following two periods before becoming insignificant.

The results of the IRF analysis for the Omani and Kuwaiti sectors show that in Oman, oil price fluctuations have a negative effect for over two periods. However, the Kuwaiti sectors respond differently to the Omani sectors. The Kuwaiti bank sector exhibits very mild positive effects, which then become insignificant. The services sector shows significant positive effects following increased oil prices for three periods, after which these effects become insignificant. However, the industrial sector shows a negative effect from oil shocks for two periods.

In summary, Saudi, Bahrain and Kuwait sectors show a positive response to oil price, which supports the finding in Chapter 3 of a correlation between these sectors and oil prices. However, Abu Dhabi, Dubai, Qatar and Oman show a negative affect from shocks to oil, which is also consistent with the correlation between oil prices and GCC stock market sectors.

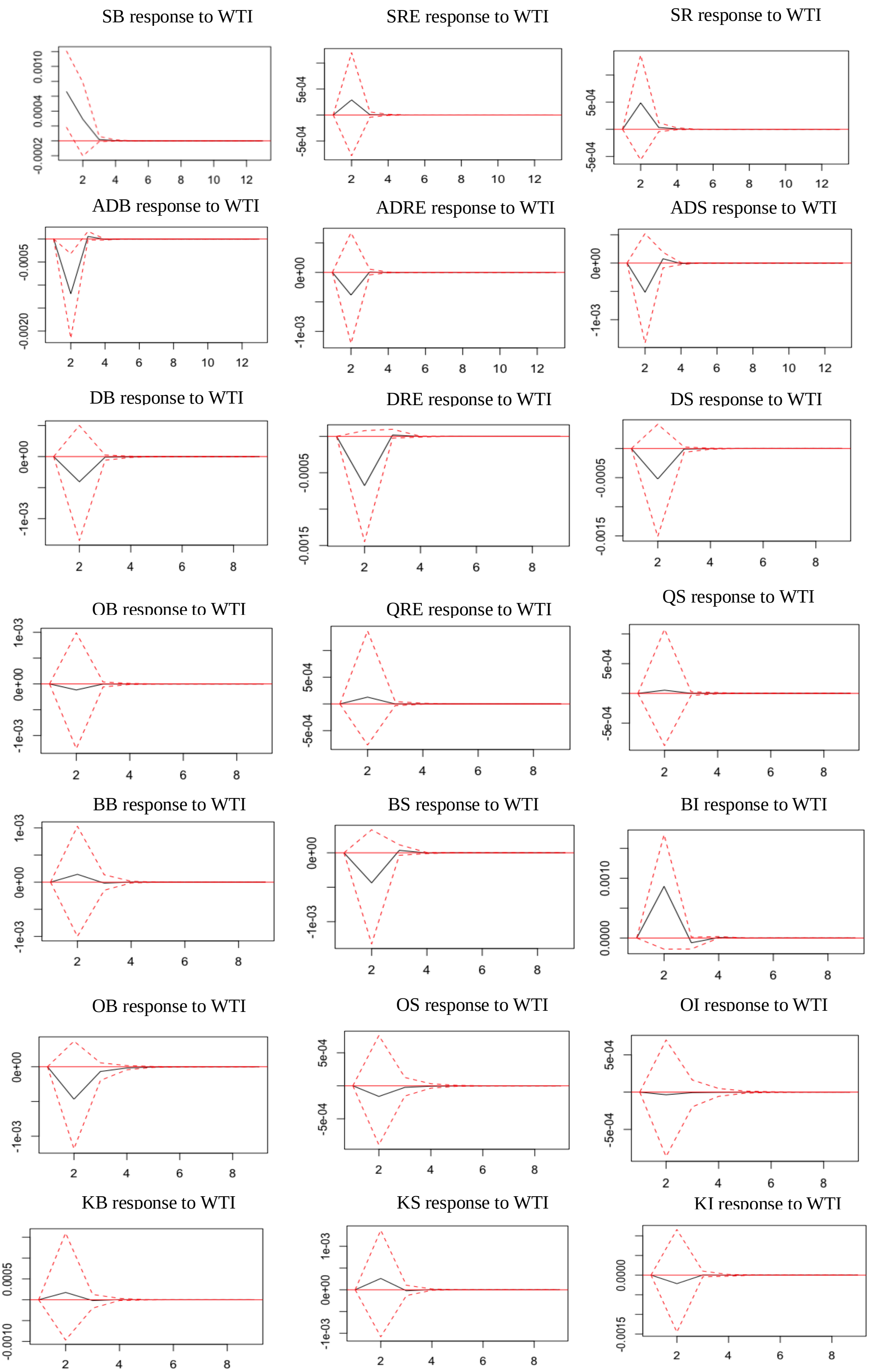

Figure 4.2: Impulse response functions

4.7.5 Causality in Variance—the HH Test

The significant effect on GCC stock market sectors of bad news and shocks in oil prices will affect stock market performance. To investigate whether there are volatility interactions between selected sectors of GCC stock markets and global factors, including crude oil (WTI), MSCI and S&P 500, we apply a causality in variance test called the HH test (Hafner & Herwartz 2006). The HH test examines the presence of causality in variance between two variables based on a Lagrange multiplier (Almohamad, Mishra & Yu) statistic, which tests the null hypothesis of H_0: there is no causality in the variance, against alternative hypothesis H_1: there is causality in the variance. This analysis involves two stages: the first stage requires estimating univariate GARCH models to ensure that the conditional variance processes fit the return series well. The second stage applies HH testing to examine the null hypothesis of no causality in variance.

4.7.5.1 First Stage—Univariate GARCH Model

The best univariate GARCH model specifications are chosen and reported in Table 4.11. All of the estimated GARCH model β parameters are statistically significant at the 1% level. Moreover, the coefficient of ARCH (α), a term that measures the effects of past shocks on current conditional volatility, ranges from 3.945 to 0.039, indicating that the conditional volatility has changed rapidly throughout the period of study. In contrast, the coefficient β of the GARCH term measuring the effects of past volatility on current conditional volatility ranges from 1.009 to 0.450, indicating the presence of high volatility. The Box–Pierce statistics for standardised residuals and squared standardised residuals show no autocorrelation in the time series.

Table 4.12 presents the results of the GARCH (1,1) model (variance equation) for the sub-periods for the GCC sectors and oil. Strong ARCH and GARCH effects are present in all of the time series, providing conditions of stability for the parameters $\omega > 0;\ \alpha \geq 0, \beta \geq 0$; it is surmised that these parameters remain below 1.0. For the selected sectors in Saudi Arabia, the results show stable conditions for the estimated GARCH model, except in the post-2014 retail sector. Moreover, the ARCH parameters of the selected sectors in Saudi Arabia exhibit a slight increase from pre- to post-2014, which may be related to the drop in oil price. Further, the UAE sectors, which include the Abu Dhabi and Dubai stock markets, support the stability conditions for the estimated GARCH model, and the ARCH parameters increase after the drop in oil price. The stock market sectors of Qatar, Oman and Kuwait show stable conditions for the GARCH model estimates; an increase in the ARCH parameter post-2014 is also noted. Conversely, the Bahrain sector shows unstable conditions after the drop in oil price and the ARCH parameters increase slightly post-2014, which may be a consequence of a significant dependence on oil revenue. Further, all selected stock market sectors show a positive coefficient in the variance equation, which is an important sign of conditional volatility. The volatility shocks on the return are proportionate to the extent of $\alpha + \beta$ in both periods. The estimated volatility results for the global factors (WTI, MSCI and S&P 500) differ according to stock market sector. For oil, the ARCH and GARCH effects are similar both pre- and post-2014. For the MSCI and S&P 500, the ARCH effects increase post-2014; in contrast, the GARCH effects decrease during this period.

Table 4.11: Univariate GARCH analysis results, 2010–17

Country	Sector	Variance equation					ARCH LM
		ω	α	β	$Q(12)$	$Q^2(12)$	
Saudi Arabia	SB	8.39E-05	0.1500***	0.7921***	14.78	6.828	0.1777
	SRE	1.76E-05	0.2533***	0.6934***	20.782	8.339	0.6669
	SR	5.31E-06	0.1401***	0.8284***	8.855	4.233	0.0398
Abu Dhabi	ADB	4.45E-06	0.1496***	0.8228***	24.114*	7.162	0.0436
	ADRE	2.46E-05	0.1395***	0.8210***	33.75**	20.07*	0.2397
	ADS	1.87E-06	3.9546*	1.0099***	27.19**	24.26**	0.2112
Dubai	DB	1.04E-05	0.2043***	0.7427***	21.501*	6.253	0.0037
	DRE	2.68E-05	0.1344***	0.8005***	29.52*	7.924	0.3532
	DS	4.22E-05	0.2362***	0.7268***	16.87	3.636	0.0392
Qatar	QB	3.44E-06	0.1659***	0.8082***	26.12**	8.303	1.5555
	QRE	1.53E-05	0.1546***	0.7844***	28.51*	0.992	0.0727
	QS	9.75E-06	0.2561***	0.6563***	38.86**	2.490	0.0131
Bahrain	BB	2.40E-05	0.2144***	0.4504***	18.02	5.22	0.2607
	BS	8.56E-06	1.2729***	1.0099***	29.89*	5.11	1.2653
	BI	2.42E-15	1.942***	0.8758***	0.0078	0.0071	0.0005
Oman	MB	5.03E-06	0.2511***	0.6928***	14.29	9.753	0.7340
	MS	1.45E-06	0.2219***	0.7403***	30.96**	8.848	0.0010
	MI	2.93E-06	0.2516***	0.6753***	26.65*	4.405	0.0371
Kuwait	KB	4.19E-06	0.1590***	0.7471***	21.18	2.55	0.3276
	KS	1.86E-06	0.0393**	0.9233***	21.43	10.83	0.3797
	KI	5.18e-06	0.0791***	0.7984***	14.57	0.375	0.0468
WTI		5.34E-06	0.0992***	0.8943***	4.99	5.37	0.4259
MSCI		2.12E-06	0.1111***	0.8621***	7.33	7.80	2.547

Note: ***, **, * indicate statistical significance at the 1%, 5% and 10% levels, respectively.

Table 4.12: Univariate GARCH analysis results for the sub-period pre- and post-2014

	Pre- 2014	Post-2014	Pre- 2014	Post-2014	Pre- 2014	Post-2014
Saudi Arabia	SB		SRE		SR	
Variance equation						
ω	8.75E-06	1.66E-05	3.16E-05	6.35E-05	6.07E-06	1.99E-05
α	0.1233***	0.1881	0.2835***	0.2628***	0.0956***	0.1792***
β	0.7766***	0.7457***	0.5541***	0.5670***	0.8425***	0.7542***
Abu Dhabi	ADB		ADRE		ADS	
Variance equation						
ω	1.30E-05	1.34E-05	3.13E-05	2.53E-05	1.96E-06	8.49E-05
α	0.2877***	0.1525***	0.1271***	0.1606***	0.0376***	0.2260***
β	0.5915***	0.7930***	0.8229***	0.7913***	0.6000***	0.6765***
Dubai	DB		DRE		DS	
Variance equation						
ω	2,60E-06	1.25E-05	2.39E-05	3.25E-05	0.00058	4.38E-05
α	0.0947***	0.2430***	0.1006***	0.1966***	0.1500**	0.2260***
β	0.8921***	0.7061***	0.8378***	0.7352***	0.6000***	0.6765***
Qatar	QB		QRE		QS	
Variance equation						
ω	1.67E-06	8.79E-06	5.57E-05	7.42E-07	1.03E-05	1.54E-06
α	0.1525***	0.2140***	0.1135***	0.3601***	0.2418***	0.2838***
β	0.8468***	0.7205***	0.2235***	0.4381***	0.6675***	0.7196***
Bahrain	BB		BS		BI	
Variance equation						
ω	1.80E-06	8.79E-06	6.38E-06	2.89E-05	3.20E-06	6.43E-05
α	0.0583***	0.2080***	0.1892***	0.1952***	0.2221***	0.1518***
β	0.9186***	0.6149***	0.7147***	0.1107***	0.8278***	0.5642***
Oman	MB	MS	MI			
Variance equation						
ω	3.89E-06	6.49E-06	1.46E-06	1.54E-06	4.35E-06	1.90E-06
α	0.2201***	0.3574***	0.1934***	0.2425***	0.3078***	0.2666***
β	0.7325***	0.6140***	0.7661***	0.7196***	0.5983***	0.6983***

Note: ***, **, * indicate statistical significance at the 1%, 5% and 10% levels, respectively.

4.7.5.2 Second Stage—Hafner and Herwartz (HH) Test

The existence of volatility in the time series prompted examination of the volatility spillover affecting the selected sectors of the GCC stock market and other global factors. We needed to identify which sectors of the GCC stock market would be affected by selected global factors such as oil prices, the MSCI World index and the US S&P 500, which are known to have important effects on the GCC stock market. To investigate these interactions, we use the HH test to examine the null hypothesis of no causality in variance. The results of tests for causality are reported in Table 4.13 for the full period 2010–17 and the sub-periods pre-2014 and post-2014. The results of the HH test indicate the ubiquitous presence of a causality affect between the selected GCC stock market sectors and oil price and other global factors throughout the full period of study. For example, there exists causality between the selected sectors of Saudi Arabia and Abu Dhabi and the oil price. In addition, some GCC stock markets, such as that of Qatar, do not exhibit significant signs of a causality effect, despite the influence of global factors over the full period. The Saudi stock market sectors demonstrate a significant causal effect with oil prices and S&P 500. However, there are no notable signs of a causal effect with the MSCI index for the duration of the full period.

For the pre-2014 period, the results show noticeable indications of causality between the three sectors of the Saudi stock market and oil prices; and between the Saudi retail sector and S&P 500. In the real estate sector, there is no evidence of causality with the MSCI and S&P 500 indices. However, the results differ in the post-2014 period, where there is no significant sign of a causal interaction between oil prices and the banking and real estate sectors, but there is an interaction between the Saudi sectors and MSCI and S&P 500.

In the pre- and post-2014 periods, the Abu Dhabi stock market sectors show significant signs of causality with oil prices. Further, the Abu Dhabi bank sector is not notably affected pre- or post-2014 by fluctuations in the MSCI; nor, post-2014, is the real estate sector. However, the services sector shows a significant sign of causality with the MSCI pre-and post-2014. There is no sign that the S&P 500 affects the Abu Dhabi sectors pre-2014, but effects become noticeable post-2014. All Dubai stock market sectors both pre- and post-2014 are appreciably affected by oil prices, with the exception of the post-2014 Dubai services sector. Although the pre-2014 Dubai banking sector is affected by the

MSCI, no interesting results are observed for pre-2014 Dubai sectors under the influence of S&P 500; however, such effects appear post-2014.

Qatar, Bahrain, Oman and Kuwait show significant signs of causality pre-2014 with oil prices, but there is no significant causal effect post-2014, except for in the Oman services sector. The pre-2014 MSCI index has significant causal effects on the Qatar services sector, the Bahrain bank and services sectors, the Oman services sector and the Kuwait bank and industrial sectors. The post-2014 period is significant for all sectors in Bahrain and Kuwait in terms of the MSCI index. Further, the results show that, pre-2014, the Qatar services sector, the Bahrain bank and services sectors, the Oman services and industrial sectors and the Kuwait bank and industrial sectors are all significantly affected by the S&P 500 index. Conversely, only the Bahrain sectors are affected post-2014. However, there is no evidence of causality between the GCC stock markets and other global factors in some of the predefined sub-periods pre- and post-2014. The results show a causal effect of oil prices, the MSCI and S&P 500 on the GCC stock market sectors, meaning the null hypothesis is rejected. However, in the pre-2014 and post-2014 periods, using oil prices as the performance markers of GCC stock market sectors is risky; however, there is no risk in using these sectors to signify global developments.

In general, the selected GCC stock market sectors have a causal effect from oil prices and other global factors at different intensities, pre-2014 and post-2014. This implies that the impact of oil price and other global factors on particular stock market sectors relies on the extent to which a sector is exposed to changes in these factors (Gogineni 2010). This varied exposure to oil price may be an opportunity for diversification among GCC stock markets to minimise risks through diversity in sectoral investing (Tiwari et al. 2018). In the pre-2014 period, all GCC stock market sectors have a causal effect from oil price. This finding is in consistent with those of Basher and Sadorsky (2006), Maghyereh and Al-Kandari (2007), Arouri and Rault (2010), Mohanty et al. (2011), Basher et al. (2012) and Bouri and Demirer (2016), all of which report a significant relationship between GCC stock market returns and oil price. Post-2014 some of the selected sectors in Saudi Arabia, Abu Dhabi, Dubai and Oman have a causal effect with oil price; this is not true for Qatar, Bahrain and Kuwait. The insignificant response in some countries may be due to their reliance on resources other than oil, as in the case of Qatar, which is a major natural gas exporter and is thus relatively immune to oil price effects (Bouri & Demirer 2016). Further, some countries began earlier to build a diversified economy and their non-oil sectors might not be highly dependent on oil prices, and thus they remained resilient after the drop in oil price. For example, Bahrain is a successful diversification story; its share of non-oil sectors reached around 80% of real GDP in 2016 (Nakibullah 2018).

With regard to the association between GCC stock markets and MSCI, the overall implications include the absence of a causal relationship between MSCI index and selected GCC sectors for the full study period, except for Oman and Kuwait. The estimated results are partially in line with those of Jouini (2013) and Khalifa, Hammoudeh and Otranto (2014) who report a similar link between the MSCI index and GCC stock markets, except for in Oman and Kuwait. This indicates a disconnected linkage among the selected sectors and the MSCI index, as a result of the fact that most GCC stock markets are isolated from international markets and foreign investors (Arouri et al. 2010). During the pre-2014 period, causal effects exists between most of the selected GCC stock markets and the MSCI index, except for Saudi Arabia. This result indicates GCC stock market sensitivity to world equity markets. Conversely, post-2014, Dubai, Qatar and Oman are immune to the causal link with the MSCI index. These findings are partially consistent with previous studies including those of Jouini (2013) and Khalifa, Hammoudeh and Otranto (2014), which report a link between several GCC stock markets and the MSCI World index, which is an indication of an increase in international investment in these GCC stock marketers (Khalifa, Hammoudeh & Otranto 2014). Finally, the estimated results for causal links between selected GCC stock market sectors and the S&P 500 index pre-2014 indicate an overall causal effect, except for the Dubai sectors. This implies a tied relationship between GCC stock markets and the US S&P 500 index. Moreover, most of the selected GCC sectors have a significant causal effect with the S&P 500 index in the post-2014 period. This indicates a strong tie between US and GCC countries' economies (Alotaibi & Mishra 2015). These findings are mostly consistent with those of Hammoudeh and Choi (2006) and partially with Khalifa, Hammoudeh and Otranto (2014), who refer to an existence of a mutual causal relationship with varying structures between most GCC stock markets and the major US stock market S&P 500.

Table 4.13: Test statistics for causality tests for the period 2010–17

Sector	HH test								
	WTI			MSCI			S&P 500		
	FULL	Pre- 2014	Post-2014	FULL	Pre- 2014	Post-2014	FULL	Pre- 2014	Post-2014
SB	2.9881***	0.1865***	2.2802***	5.0823	5.0540	2.2282***	8.6533*	7.2321	0.1991***
SRE	2.8103***	15.653***	1.0568*	2.8989	3.3373	20.7821***	6.7011	3.2393	18.97***
SR	3.7523***	17.169***	8.3221*	1.8245	6.5955	0.2501***	8.8056**	13.900***	19.31***
ADB	9.7287**	11.766**	8.0777*	1.9446	6.5093	0.2034	11.561**	4.8358	3.1603***
ADRE	9.1037**	12.850**	12.3405**	3.7293	9.1866*	7.2776	5.3948	4.2345	3.5093***
ADS	13.202***	19.208***	8.5014*	7.5982	12.630***	16.6478***	7.0089	8.0897*	0.2502***
DB	19.996***	13.570***	13.320***	6.1325	13.614***	4.2005	9.6671**	5.3108	2.9606***
DRE	7.8394**	12.216**	12.3738***	3.1681	7.6863	2.9331	11.309**	4.8360	3.459***
DS	5.1660	14.3005***	5.4144	2.1046	3.9338	0.9334	10.4682**	6.4839	0.3284***
QB	2.4000	12.135**	5.3670	4.1435	3.0700	7.6527	4.2134	3.1911	4.2122
QRE	6.1480	18.213***	1.8279	1.6201	1.7136	7.4832	3.111	2.9641	3.6669
QS	2.7620	15.434***	0.7149	2.9316	8.1848*	5.4389	3.6326	9.7596**	6.1709
BB	9.4941**	20.59***	2.4900	7.0167	7.9202*	30.91***	11.313**	10.101**	21.32***
BS	4.6961	16.91***	5.1714	5.6283	11.2060**	39.44***	9.7581**	8.9375*	22.94***
BI	3.7479	13.4695***	3.5971	0.9497	1.4603	23.18***	8.876*	2.2213	28.49***
OB	3.93467	17.90***	4.8655	6.1620	2.2928	4.1558	3.2542	3.5571	3.4219
OS	13.08***	57.68***	9.8170**	5.3084	34.96***	7.7739	7.0870	42.29***	8.7445*
OI	10.30**	15.39***	5.5397	11.29**	4.2929	3.5251	10.727**	10.234**	7.471
KB	32.31***	5.3511**	6.1355	40.61***	17.899***	20.79***	36.37***	8.7947*	4.5513
KS	8.1200*	2.6300**	6.0561	14.99***	6.3893	17.71***	15.99***	7.6157	3.3916
KI	0.4569	4.690**	4.9503	14.643***	27.26***	15.25***	7.5007	8.5851*	2.1835

Note: ***, **, * indicate statistical significance at the 1%, 5% and 10% levels, respectively.

4.8 Summary

This chapter has investigated interdependency relationships and causality effects between the selected GCC stock market sectors and a set of global factors: the WTI oil price, MSCI World index and S&P 500 index. A VAR model was deployed to capture linear interrelationships among the selected GCC stock markets and global factors. The results of the VAR estimation show that there was a significant impact of global factors including WTI, MSCI and S&P 500 on the selected sectors of GCC stock markets. Saudi sectors showed a significant causal effect resulting from changes in the WTI oil price for the periods pre-2014 and post-2014 that might be explained by the strong correlation between worldwide oil price changes and the economy of Saudi Arabia, a major oil exporter. The Abu Dhabi and Dubai bank sectors were affected by a significant causal relationship with S&P 500 in the post-2014 period. This is an indication of the importance of making plans for economic diversification at an early stage (Jawadi & Ftiti 2019). It is further noted that the WTI oil price had a significant causal effect on Bahrain, Oman and Kuwait sectors in the post-2014 period. Qatar sectors showed a significant causal effect from MSCI in the post-2014 period, while there was no significant effect from the WTI oil price. This may be explained by Qatar's major dependency on the gas supply as one of the largest gas exporters in the world (Alrub et al. 2018).

To better understand the impact of global factors on GCC stock markets, Granger causality and VD models were applied to identify the extent to which the selected global factors could affect the performance of GCC stock markets at the sectoral level. The overall results of the Granger causality tests indicate that most GCC sectors were affected by oil prices in both the full sample and pre-214 periods. The findings also show that MSCI world index and S&P 500 index had a wider impact on most GCC stock market sectors in the post-2014 period.

VD models measure the rate of forecast error for one market (in this case, the selected GCC stock market sectors) that is explained by another market (in this case, the selected global factors). The results of the VD analysis support the outcomes from the Granger causality tests. All variables under study, including the selected GCC sectors and global factors, showed a significant effect from their own shocks as well as shocks from other sectors within the same stock market. Notably, the bank sector is considered among the most dominant sectors in most GCC countries (Hammoudeh, Yuan & McAleer 2009).

Application of the IRF enabled examination of how GCC stock market sectors responded to innovations (shocks) in WTI oil prices. The estimated IRF indicates that the Saudi, Bahrain and Kuwait sectors showed a positive effect with oil prices, supporting the findings of Chapter 3. However, Abu Dhabi, Dubai, Qatar and Oman were negatively affected by shocks to oil, consistent with results showing a correlation between oil price and GCC stock market sectors performance.

Furthermore, CCF model was applied to estimate causal relationships among the selected variables in the study. The CCF analysis involved a two-stage procedure to detect causality in variances between the selected variables in two periods, pre-and post-2014, to determine if there is any difference in causality between these periods. The estimated results indicate causality between all selected sectors in the GCC stock market and the oil price pre-2014. However, post-2014 some GCC sectors did not have a causal effect with oil prices; in the case of the Qatar and Bahrain sectors this might be related to their early economic diversification plans and dependency on other sources of revenue rather than oil. Moreover, GCC stock market sectors appeared to show high sensitivity to the MSCI World equity index; most of the selected sectors had a causal relationship in both the pre- and post-2014 periods, while some sectors in Saudi Arabia, Dubai, Qatar and Oman were immune from such an effect. Regarding causality with the US S&P 500 index, the estimated results indicate a strong relationship between US and GCC countries' economies; an overall causal effect was revealed between GCC stock markets and the S&P 500 index.

Chapter 5 Volatility Transmission Multivariate GARCH-BEKK Model

5.4 Introduction

Recent changes in oil prices in the global economy have had major effects on world economies, especially those of GCC countries. As GCC countries' economies depend on oil revenues they will be affected by oil price volatility, as well as by other global factors such as the MSCI World and S&P 500 US indices. This chapter analyses volatility spillover between selected sectors in GCC stock markets and other factors (WTI oil price, MSCI World index and S&P 500 US index) using a multivariate GARCH-BEKK model. The sampling period is divided into two sub-periods—before and after a drop in oil price—to check if there is any change in the dependency on oil revenues. The results are then used to build a well-diversified portfolio to minimise risk for the same expected return.

5.5 Conceptual Framework

This chapter investigates volatility transmission and interdependency between oil prices and global factors (MSCI world index and S&P 500 index) for three major GCC stock market sectors (consumer discretionary, financial and real estate) from 2010 to 2017. We apply a multivariate GARCH-BEKK model to examine the existence and directionality of volatility transmission and interdependency during two main study periods—before and after the drop in oil price in mid-2014—and investigate the dependency relationships between the selected GCC stock market sectors and oil price, and other global factors in these periods. The results from the multivariate GARCH-BEKK model are used to construct a well-diversified portfolio that includes oil and non-oil stock to minimise the risk with the same expected return. Figure 5.1 presents the theoretical framework for this chapter.

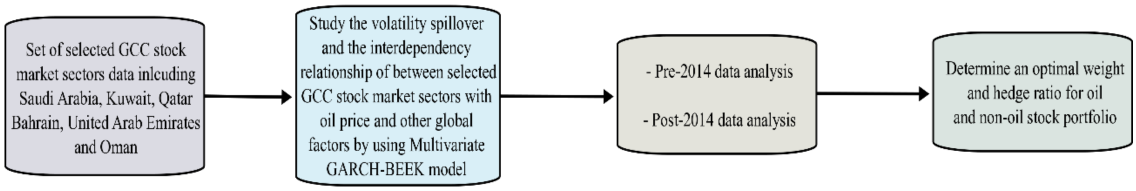

Figure 5.1: Theoretical framework for multivariate GARCH-BEKK models used to study volatility transmission and interdependency between oil price, global factors and sectoral GCC equity indices

5.6 Methodology

5.6.1 Multivariate GARCH-BEKK Model

We aim to use a multivariate GARCH model to conduct a further, in-depth analysis of volatility transmission between oil prices and GCC stock sectors. Unlike the CCF two-stage procedure method, a multivariate GARCH model provides estimates of coefficient sizes for volatility spillover and their weights can be used to calculate the optimal weight. Following Engle and Kroner (1995), We use a GARCH-BEKK model to investigate co-movement relationships between the oil price and global factors, and GCC stock markets at the sector level. The GARCH-BEKK model allows capturing of the volatility of the oil price and financial stock markets and ensures positivity of the conditional covariance matrix. We refer to the oil price, MSCI World index and S&P 500 index as (1) and the GCC stock sector return as (2). The conditional variance from the GARCH (1,1) model is written as:

$$x\_t = \gamma + \beta x_{t-1} + \varepsilon_t \qquad (5.15)$$

where x_t denotes the return on the sector index (*sec*) as well as the oil prices, MSCI World index and S&P 500 index (l). The residual vector $\varepsilon_t = (e_{1,t}, e_{2,t})$ is bivariate and normally distributed with its corresponding conditional variance–covariance matrix given by:

$$H_t = \begin{bmatrix} h_{11,t} & h_{12,t} \\ h_{21,t} & h_{22,t} \end{bmatrix} \qquad (5.16)$$

In a univariate GARCH (1,1) process, the conditional variance σ_t^2 is obtained from the variance equation 5.17. We adopt the BEKK representation, which is essentially a spectral decomposition of the conditional variance–covariance matrix. A multivariate GARCH (1,1) results from the operation:

$$\sigma_t^2 = \mu + \alpha_1 \varepsilon_{t-1} + \beta \sigma_{t-1}^2 \qquad (5.17)$$

$$H_t = C_0^{'} C_0 + A^{'} \varepsilon_{t-1}^{'} \varepsilon_{t-1} A + B^{'} H_{t-1} B \qquad (5.18)$$

where the elements for matrices *A* and *B* are given as:

$$A = \begin{bmatrix} a_{11} & a_{12} \\ a_{21} & a_{22} \end{bmatrix} \text{ and } B = \begin{bmatrix} b_{11} & b_{12} \\ b_{21} & b_{22} \end{bmatrix}$$

C_0 is a (2×2) lower triangular matrix of constants and decomposition of the constant term into a product of two triangular matrices aims to guarantee the positivity of H_t. *A* is a (2×2) matrix that presents the correlation of the conditional variances with past squared errors; its elements measure the effects of shocks on the conditional variances. *B* is a (2×2) matrix that shows the degree of volatility persistence in conditional volatility among the stock markets. H_t matrix elements rely on past values of themselves and past values of $\varepsilon_{t-1}' \, \varepsilon_{t-1}$. The BEKK parameterisation for the systematic GARCH is:

$$H_t = C_0^{`} C_0 + \begin{bmatrix} a_{11} & a_{12} \\ a_{21} & a_{22} \end{bmatrix}^{'} \begin{bmatrix} \varepsilon_{1,t-1}^2 & \varepsilon_{1,t-1}\varepsilon_{2,t-1}^{'} \\ \varepsilon_{2,t-1}\varepsilon_{1,t-1}^{'} & \varepsilon_{2,t-1}^2 \end{bmatrix} \begin{bmatrix} a_{11} & a_{12} \\ a_{21} & a_{22} \end{bmatrix} \qquad (5.19)$$

$$+ \begin{bmatrix} b_{11} & b_{12} \\ b_{21} & b_{22} \end{bmatrix}^{'} H_{t-1} \begin{bmatrix} b_{11} & b_{12} \\ b_{21} & b_{22} \end{bmatrix}$$

Matrix *A* captures the ARCH effects while matrix *B* shows the GARCH effects. The off-diagonal parameters (a_{12}, a_{21}, b_{12} and b_{21}) in both matrices show the cross-market effect of volatility shocks, in the case of (a_{12} and a_{21}), and volatility spillover, in the case of (b_{12} and b_{21}).

5.6.2 Optimal Portfolio Weights and Hedge Ratios

Transmission of volatility between oil prices and GCC stock markets is considered an important element of an efficient diversified portfolio and of managing risk. In GCC stock markets, investors need to manage their portfolios to include assets from various sectors to minimise risk while maintaining the expected return. Portfolio managers are required to determine the optimal weights and hedge ratios to effectively hedge oil price change risk. Portfolio designs that demonstrate how oil price risk can be hedged effectively can be estimated based on the conditional variance and covariance of the GARCH-BEKK model. We refer to the oil price as *oil* and the GCC stock sector's return as *sec*. Following the research of Kroner and Ng (1998) and Kroner and Sultan (1993), the portfolio optimal weight of oil and sector stock assets can be expressed as:

$$w_{oil,sec} = \frac{h_{sec} - h_{oil,sec}}{h_{oil} + h_{sec} - 2h_{oil,sec}} \tag{5.20}$$

As the volatility of oil prices and stock market changes every moment, the optimal weight will be changing every moment; therefore we use the volatility float. This can be helpful to stock market investors because it provides insight into a stock's volatility under the condition that:

$$w_{oil,sec} = \begin{cases} 0, if\ w_{oil,sec} < 0 \\ w_{oil,sec}, if\ 0 \leq w_{oil,sec} \leq 1 \\ 1, if\ w_{oil,sec} > 1 \end{cases} \tag{5.21}$$

The conditional variances of the sector stock market and oil price are represented by h_{sec} and h_{oil} respectively, and $h_{oil,sec}$ is the conditional covariance between them. $w_{oil,sec}$ and (1 – $w_{oil,sec}$) are the weights of the oil and GCC stock prices in a portfolio of the two assets, respectively. Moreover, we measure the optimal portfolio hedge ratio based on the following equation, as suggested by Kroner and Sultan (1993):

$$w_{oil,sec} = \begin{cases} 0, if\ w_{oil,sec} < 0 \\ w_{oil,sec}, if\ 0 \leq w_{oil,sec} \leq 1 \\ 1, if\ w_{oil,sec} > 1 \end{cases} \tag{5.22}$$

The result for $\beta_{oil,sec}$ is an indicator of an oil/sector portfolio; a hedge ratio of $\beta_{oil,sec}$ suggests that one (buy) in oil asset should be (sell) by $\beta_{oil,sec}$ dollar of the stock market.

5.7 Empirical Results

5.7.1 Multivariate GARCH-BEKK Model

The conditional variance–covariance equation applied in this analysis successfully captures the volatility and cross-volatility spillover among variables. To measure the links between returns in GCC stock market sectors and the oil market, MSCI World index and S&P 500 index, the GARCH-BEKK model is used to estimate the results of time-varying variance–covariance. The GARCH-BEKK model is estimated with returns data from the GCC stock market and WTI oil prices, MSCI World index and the S&P 500 index. The results show the extent of volatility transmission between oil, the MSCI and the S&P 500 and stock markets in GCC countries, starting with Saudi sectors (bank, real estate and retailing) for the period 2010–16.

5.7.1.1 Saudi Stock Market

Beginning with the Saudi bank sector, Table 5.1 shows the analysis results for the three sectors in the Saudi stock market with the WTI, MSCI and S&P 500. A Box–Pierce serial correlation test is employed to ensure that the model is properly specified. A Q-statistic test for the standard residuals and square standard residuals is not significant, implying that the BEKK model is adequate. In the mean equation, r_{21} is not significant, which shows that the returns on the WTI oil price do not influence the returns on the Saudi sector stocks. However, MSCI and S&P 500 returns have a significant return spillover effect on the Saudi sectors. According to the estimation results of the variance equation, a_{11}, a_{22}, b_{11} and b_{22} are significant at the 1% level, which shows that volatility in the WTI oil price, MSCI, S&P 500 and Saudi sectors is subject to effects from their own past shocks and their own past volatility. The estimation results indicate a bidirectional effect between the Saudi bank sector and oil. Moreover, the Saudi bank sector is significantly related to shocks in both MSCI and S&P 500 indices. However, there is no statistically significant effect of volatility of the MSCI and S&P 500 on the average return of Saudi banks. The real estate sector has a bidirectional relationship with shocks and volatility in the oil price. Volatility in the MSCI has a significant spillover to the Saudi real estate sector, but this is not significant for the S&P 500. Moreover, the Saudi retail sector shows a unidirectional significant effect of shocks from oil, the MSCI and the S&P 500, and also a volatility spillover from the S&P 500.

The covariance matrix of the Saudi sector stocks with the WTI oil price, the MSCI and the S&P 500 is used to interpret the model parameter estimation. First, with regard to the effect of shocks in mean equations, the negative $a_{11}a_{12}$ of -0.0762 for Saudi retail with MSCI suggests a shock to MSCI returns has a negative effect on the next-day Saudi retail return covariance. Moreover, real estate and retail in Saudi Arabia have negative relationships with the S&P 500 (-0.0326 and -0.0301, respectively). Further, the coefficient $a_{21}a_{22}$ shows a negative relationship between Saudi bank and retail sectors and WTI, and real estate and retail and the S&P 500, implying that a shock to these sectors' index returns negatively affects the next day's two-asset return covariance. Conversely, joint shocks between WTI oil price and sector, represented by $a_{12}a_{21} + a_{11}a_{22}$, have a positive sign for most sectors in the Saudi market. For instance, the results show positive joint shock effects: the higher the joint shocks between WTI and Saudi banks, the higher the covariance between them by 0.1896.

Regarding the effects of variance and covariance, the negative sign of $b_{11}b_{12}$ for the Saudi bank sector with WTI implies that an increase in the WTI oil price index return variance has a negative effect on the next day's two-asset return covariance. Further, the negative $b_{21}b_{22}$ of -0.0855 for the Saudi real estate sector with the WTI oil price indicates an increase in the WTI return variance very weakly decreases the next day's two-asset return covariance. Moreover, the coefficient $b_{12}b_{21} + b_{11}b_{22}$ has a negative value for most sectors in the Saudi market, implying that the higher the past conditional covariance, the lower the conditional covariance in the future.

Table 5.1: Spillover effect between Saudi Arabia stock market sectors and WTI, MSCI and S&P 500 for the period 2010–17

TASI	SB & WTI	SRE&WTI	SR&WTI	SB&MSCI	SRE&MSCI	SR&MSCI	SB&S&P 500	SRE&S&P 500	SR&S&P 500
Conditional mean equation									
r_{11}	0.00016	0.0005*	0.0008***	0.0002	0.0004**	0.0009***	0.0002	0.0005*	0.0008***
r_{12}	0.0270***	0.0313***	0.0076	0.0182	-0.0029	0.0360	0.0239	0.0025	0.0432*
r_{21}	0.0002	0.0002	0.0000	0.0004***	0.0005***	0.0004***	0.0007***	0.0006***	0.0006***
r_{22}	-0.0593***	-0.0591***	-0.0405*	0.1139***	0.1013***	0.1119***	-0.0584**	-0.0659***	-0.0572**
Conditional variance equation									
c_{11}	-0.0182	-0.01837	-0.01950	0.003706	0.003138	-0.004765	0.0048098	-0.0043107	-0.0030370
c_{12}	0.0001	-0.00023	0.001215	-0.000116	-0.00074	-0.000942	0.001499	0.0024597	0.0030784
c_{22}	-0.0007	-0.00610	-0.00542	-0.005541	0.008894	0.0029297	-0.009750	-0.0075276	0.0039587
a_{11}	0.5101	-0.5212	0.4269	0.4789	-0.4031	0.4269	0.2485	0.5223	-0.4312
a_{21}	-0.2411***	0.1999***	-0.0497	0.0145	0.0157	-0.0497	0.0160	0.0011	-0.0186
a_{12}	0.0693***	-0.0449***	0.1181***	0.0685*	-0.0662	0.1181***	0.4374***	-0.0625	0.0699**
a_{22}	0.40461	0.5271	0.5099	0.4934	0.5966	0.5099	0.3743	-0.5904	0.5271
b_{11}	-0.14581	0.0528	0.0103	0.7795	-0.8445	0.0103	0.0929	-0.7451	-0.8502
b_{21}	-0.23248***	0.1183**	0.0847	0.0319	0.0035	0.0847	0.6859***	0.0113	0.0103
b_{12}	0.19870***	-0.1554***	0.0282	0.1042	-0.1456*	0.0282	-0.1642	-0.1714	-0.1298**
b_{22}	-0.8419	-0.7235	0.3589	-0.7246	0.5646	0.7115	-0.1235	0.6412	0.7598
$Q_1(12)$	17.91 (0.119)	3.511(0.991)	3.483(0.991)	18.688(0.960)	16.69(0.162)	15.643(0.208)	25.952(0.112)	26.079(0.101)	25.99(0.11)
Covariance matrix									
$a_{11}a_{12}$	0.03534	0.02340	0.05041	0.0328	0.02668	-0.0762	0.1086	-0.0326	-0.0301
$a_{21}a_{22}$	-0.09754	0.10536	-0.02534	0.00715	0.00936	0.04072	0.0059	-0.00064	-0.0098
$a_{12}a_{21} + a_{11}a_{22}$	0.18967	-0.2837	0.2118	0.2372	-0.2415	0.2284	0.10001	-0.3084	-0.2285
$b_{11}b_{12}$	-0.02897	-0.00821	0.00029	0.08122	0.1229	-0.1682	-0.01525	0.1277	0.1103
$b_{21}b_{22}$	0.1956	-0.0855	0.03039	-0.02311	0.0019	0.0701	-0.0847	0.0072	0.0078
$b_{12}b_{21} + b_{11}b_{22}$	0.07657	-0.05658	0.00608	-0.5615	-0.4773	-0.5475	-0.1241	-0.4796	-0.6473

Note: ***, **, * indicate statistical significance at the 1%, 5% and 10% levels, respectively.

The entire period is divided into two sub-periods to check the volatility spillover of oil price, MSCI and S&P 500 to Saudi sectors pre- and post-2014. Table 5.2 shows the results for Saudi sectors and the WTI oil price pre- and post-2014. As shown in the conditional variance equation, the current conditional volatility of the WTI and Saudi sectors is determined by their own past shocks (α_{11} and α_{22}) and conditional past volatility (b_{11} and b_{22}). Further, the Saudi bank sector is significantly affected by shocks to the WTI oil price pre-and post-2014, with a higher coefficient compared with post-2014. Further, there is a bidirectional effect of past volatility across Saudi bank sectors and oil pre-2014, but this is not significant post-2014. In the covariance matrix of Saudi banks and the WTI, the negative sign of $a_{11}a_{12}$ indicates that shocks to WTI returns have a negative effect on WTI and Saudi bank covariance in the next period; this is present in both periods but stronger post-2014. Shocks to Saudi banks have a positive effect in both periods, but the joint shocks become negative post-2014, which implies a lower covariance between them (by −0.2264).

Moreover, the positive sign of $b_{11}b_{12}$ indicates an increase in WTI variance has a positive effect on the Saudi bank and WTI covariance. The negative sign for $b_{21}b_{22}$ (−f di b) pre-2014 indicates that an increase in Saudi bank return variance very weakly decreases the next-day WTI and Saudi bank covariance; this becomes positive post-2014 but with a low coefficient. Thus, Saudi banks are affected more by oil price volatility and shocks pre-2014 than post-2014. Further, the Saudi real estate sector did not experience significant shock spillover pre-2014, but this becomes significant post-2014, from oil to the real estate sector. Also, there is a significant volatility spillover from oil to the Saudi real estate sector pre-2014, with the coefficient becoming lower post-2014. As shown in the covariance matrix, the negative sign of $a_{11}a_{12}$ pre-2014 becomes positive post-2014, which means shocks to the WTI have a positive effect on the WTI and the real estate sector in the next period. The sign of $a_{21}a_{22}$ is positive pre-2014, but becomes negative post-2014, suggesting that shocks to the real estate sector have a negative effect on the WTI and the real estate sector in the next period (−0.0349). Past variance of the WTI has a negative effect on the WTI and real estate covariance in both periods; this is also true for past variance of the real estate sector. The Saudi retail sector has a bidirectional shock spillover with the WTI pre-2014; this becomes unidirectional post-2014 (from the WTI to the real estate sector). There is a significant volatility spillover from the retail sector to oil pre-2014, which becomes weaker post-2014. In addition, there is a negative effect of shocks from oil to real estate, but this becomes positive post-2014. There is a negative sign of shock to retail, which means a negative effect on WTI and retail in the next period both pre- and post-2014, but the effect is less post-2014. Post-2014, the sign shows that an increase in WTI variance has a negative effect on the covariance between them. Also, $b_{21}b_{22}$ has a positive sign pre-2014 but a negative sign post-2014.

Table 5.3 shows the results for the Saudi sectors and the MSCI pre- and post-2014. The variance equation shows that the current conditional volatility of the MSCI and Saudi sectors is determined by their own past shocks (α_{11} and α_{22}) and the conditional past volatility (b_{11} and b_{22}). Regarding volatility spillover, Saudi banks experience significant negative shock spillover from the MSCI pre-2014, but this is not significant post-2014. Also, there is volatility spillover from the MSCI to the bank sector pre-2014. The Saudi real estate sector shows bidirectional volatility spillover with the MSCI pre-2014, which is not present post-2014. Also, there is a significant negative effect of shocks from real estate to the MSCI in both periods. The retail sector shows a bidirectional shock spillover pre-2014, but this is not significant post-2014. Moreover, there is also a bidirectional volatility spillover between retail and the MSCI in both periods, but the effect becomes greater post-2014. Thus, the Saudi sectors experience significant effects from volatility and shocks from the MSCI pre-2014, but this effect does not appear post-2014, except for in the retail sector.

Table 5.4 presents the results for the Saudi sectors and the S&500 pre- and post-2014. The results of the variance equation show that all sectors are affected by past own volatility and shocks. The Saudi bank sector has a significant effect of shocks from the S&P 500 pre-2014, but this effect disappears post-2014. Also, the bank sector shows a significant effect of volatility from the S&P 500 pre-2014. The Saudi real estate sector shows significant negative effects of shocks in the S&P 500 pre- and post-2014. However, there is no significant effect of the volatility spillover between Saudi retail and the S&P 500. As a result, the S&P 500 has a significant effect on the Saudi bank and real estate sectors in the period pre-2014.

Table 5.2: Spillover effect between Saudi Arabia stock market sectors with WTI oil price for the two sub-periods 2010–mid-2014 and mid-2014–2017

Saudi Arabia sector with WTI	Pre-2014			Post-2014		
	SB & WTI	SRE &WTI	SR &WTI	SB &WTI	SRE &WTI	SR &WTI
Conditional variance equation						
c_{11}	-0.00494	-0.0103	0.0003	-0.0253	-0.0259	-0.0268
c_{12}	0.00198	-0.00601	0.0005	-0.0006	0.0006	0.0003
c_{22}	-0.00734	0.0009	0.0095	-0.0127	-0.0125	-0.0122
a_{11}	0.5079	-0.4816	0.4529	0.4609	-0.4061	-0.3181
a_{21}	0.1773**	0.1189*	-0.2345***	-0.1087**	0.0537	0.0074
a_{12}	-0.01287	0.01673	-0.1336***	-0.0081	-0.1598***	-0.1283***
a_{22}	0.4064	0.5517	0.1827	-0.4931	-0.6499	-0.5781
b_{11}	-0.7566	-0.6400	-0.3153	0.0060	-0.0163	0.0491
b_{21}	0.7242***	-0.1718	1.4614***	-0.0065	0.1116	0.1169*
b_{12}	-0.1557***	0.2357***	-0.0258	0.0047	0.0451	-0.0579
b_{22}	-0.3086	0.6412	0.1071	-0.0055	-0.3789	-0.1865
Covariance matrix						
$a_{11}a_{12}$	-0.0065	-0.0081	-0.0605	-0.2272	0.2639	0.1839
$a_{21}a_{22}$	0.0721	0.0656	-0.0428	0.0536	-0.0349	-0.0043
$a_{12}a_{21} + a_{11}a_{22}$	0.2041	-0.2638	0.1141	-0.2264	0.2553	0.1829
$b_{11}b_{12}$	0.1178	-0.15088	0.0081	0.00002	-0.0007	-0.0028
$b_{21}b_{22}$	-0.2235	-0.1102	0.1566	0.00003	-0.0423	-0.0218
$b_{12}b_{21} + b_{11}b_{22}$	0.1208	-0.4509	-0.0715	-0.00006	0.0112	-0.0159

Note: ***, **, * indicate statistical significance at the 1%, 5% and 10% levels, respectively.

Table 5.3: Saudi Arabia stock market sectors with MSCI index for the two sub-periods 2010–mid-2014 and mid-2014–2017

Saudi Arabia sectors with MSCI index	Pre-2014			Post-2014		
	SB &MSCI	SRE &MSCI	SR &MSCI	SB &MSCI	SRE &MSCI	SR &MSCI
Conditional variance equation						
c_{11}	-0.0034	-0.0018	0.00006	-0.0066	-0.0072	-0.0062
c_{12}	0.0005	0.0105	0.0001	0.0001	-0.0012	0.0048
c_{22}	-0.0060	0.00009	0.0065	-0.0127	-0.0125	-0.0072
a_{11}	-0.4487	0.4317	-0.2560	0.4484	-0.3549	0.4581
a_{21}	-0.0538	-0.0494**	-0.1591***	0.0052	-0.0571**	0.0318
a_{12}	-0.1208*	0.0061	0.4411***	-0.1518	-0.1638	-0.0535
a_{22}	0.3967	-0.6138	-0.4534	0.4686	-0.6189	0.5667
b_{11}	-0.8107	-0.8714	0.8993	-0.1392	0.0483	0.3513
b_{21}	-0.1023	0.1315***	-0.2593***	0.1726	0.0681	-0.1165***
b_{12}	-0.1304*	-0.2436***	0.1990***	-0.1013	-0.2936	1.0522***
b_{22}	0.6344	0.0426	0.4905	0.1254	-0.4202	-0.3516
Covariance matrix						
$a_{11}a_{12}$	0.0542	0.0026	-0.1129	-0.0681	0.0581	-0.0245
$a_{21}a_{22}$	-0.0213	0.0303	0.0721	0.0024	0.0353	0.01803
$a_{12}a_{21} + a_{11}a_{22}$	-0.1715	-0.2653	0.0459	0.2093	0.2290	0.2579
$b_{11}b_{12}$	0.1057	0.2123	0.1790	0.0141	-0.0142	0.3967
$b_{21}b_{22}$	-0.0649	0.0056	-0.1272	0.0216	-0.0286	0.0409
$b_{12}b_{21} + b_{11}b_{22}$	-0.5010	-0.0692	0.3895	-0.0349	-0.0403	-0.2462

Note: ***, **, * indicate statistical significance at the 1%, 5% and 10% levels, respectively.

Table 5.4: Spillover effect between Saudi Arabia stock market sectors and S&P 500 index for the two sub-periods 2010–mid-2014 and mid-2014–2017

Saudi Arabia sectors with S&P 500 index	**Pre-2014**			**Post-2014**		
	SB &S&P 500	SRE &S&P 500	SR &S&P 500	SB &S&P 500	SRE &S&P 500	SR &S&P 500
Conditional variance equation						
c_{11}	-0.0035	-0.0033	-0.0029	-0.0075	0.0069	-0.0078
c_{12}	-0.0003	-0.0010	-0.0010	0.0001	0.00004	0.0003
c_{22}	-0.0056	0.0081	0.0071	-0.0126	-0.0156	-0.0131
a_{11}	0.4490	0.4265	0.4732	-0.5555	0.5375	-0.4771
a_{21}	-0.0045	0.0250	-0.1135	-0.0247	0.0155	-0.0102
a_{12}	-0.1215**	-0.1745***	0.0365	0.0874	-0.2378**	0.1146
a_{22}	-0.4610	0.6168	0.4859	0.5209	-0.6384	0.6182
b_{11}	-0.8226	-0.8328	0.8241	0.0004	-0.3661	0.00008
b_{21}	0.0082	0.0978***	0.0914	-0.0002	0.0289	0.00005
b_{12}	-0.1027*	0.0282	0.1109	-0.0006	0.0062	-0.0001
b_{22}	0.6430	0.5139	-0.5355	0.0045	0.0108	-0.0001
Covariance matrix						
$a_{11}a_{12}$	-0.0545	-0.0744	0.0172	-0.0485	-0.1278	-0.0547
$a_{21}a_{22}$	0.0020	0.0154	-0.0551	-0.0128	-0.0099	-0.0063
$a_{12}a_{21} + a_{11}a_{22}$	-0.2064	0.2587	0.2285	-0.2915	-0.3469	-0.2961
$b_{11}b_{12}$	0.0845	-0.0235	0.0914	-0.000002	-0.0022	-0.000009
$b_{21}b_{22}$	0.0053	0.0502	-0.0489	-0.000001	0.0003	-0.000008
$b_{12}b_{21} + b_{11}b_{22}$	-0.5298	-0.4252	-0.4311	0.000002	-0.0037	-0.0000001

Note: ***, **, * indicate statistical significance at the 1%, 5% and 10% levels, respectively.

5.7.1.2 Abu Dhabi Stock Market

Moving to volatility spillover relationship between Abu Dhabi stock market sectors and WTI oil price, MSCI World index and S&P 500. The conditional variance–covariance equation is applied to capture the volatility and cross-volatility spillover among them. Table 5.5 presents the result from the GARCH-BEKK model for the three sectors of the Abu Dhabi stock market: bank, real estate and services. To check the properties of the model, Q-statistic tests are used. The standard residuals and square standard residuals are not significant, implying that the BEKK model is adequate. According to the mean equation coefficients r_{21}there are no significant signs an effect of WTI oil price on Abu Dhabi stock market sectors, although there is a significant positive effect by one lag period of Abu Dhabi stock market sectors on MSCI and S&P 500 indices. According to the variance equation result, the coefficients of $a_{11}, a_{22}, b_{11} and\ b_{22}$ are significant at the 1% level, which indicates that the volatility of WTI, MSCI, S&P 500 and Abu Dhabi stock market sectors are affected by their own past shocks and their own past volatility. Moreover, the variance equation result shows a significant bidirectional relationship for WTI and Abu Dhabi sectors in shock spillover and a unidirectional volatility spillover from WTI to the bank sector. Further, there is a significant sign of shock and volatility spillover from the bank sector to the MSCI index. Also, the services sector shows a significant sign of shock transmission from MSCI and bidirectional volatility spillover.

The covariance matrix for the Abu Dhabi stock market sectors with the WTI, MSCI and S&P 500 is used to interpret the model parameter estimation. Regarding the effect of shocks in mean equations, the negative $a_{11}a_{12}$ for real estate with WTI shows that the shocks to the WTI has a negative effect on real estate and the WTI return covariance in the next period (–0.0043). Further, the bank sector has a negative effect with S&P 500 (–0.0685). Further, the negative sign of $a_{21}a_{22}$ indicates that shocks to the sector negatively affect the two variables' covariance in the next period, which is shown for the bank sector with WTI, MSCI and S&P 500 (–0.0713, –0.0296 and –0.0199, respectively), as well as real estate with MSCI and services with S&P 500 (–0.0030, –0.0024, respectively). Regarding the effects of variance–covariance, the negative sign of $b_{11}b_{12}$ shown for real estate with WTI, services with MSCI and banks and services with S&P 500 implies that an increase in WTI, MSCI and S&P 500 return variance has a negative effect on the next day's two-asset return covariance. Further, a negative sign for $b_{21}b_{22}$ as shown for real estate with WTI, banks with MSCI and real estate with S&P 500 indicates that an increase in the sector variance has a negative effect on the two-asset return covariance (–0.0091, –0.0931, –0.00002, respectively).

The period is divided into two sub-periods to check volatility spillover between WTI, MSCI and S&P 500 with Abu Dhabi stock market sectors. Table 5.6 shows results for the Abu Dhabi sectors and WTI oil price for the two periods. The variance equations show that current conditional volatility of the WTI and the Abu Dhabi sectors are determined by their own past shocks $a_{11}\, and\, a_{22}$ and their own past volatility $b_{11}\, and\, b_{22}$. Regarding volatility spillover, the bank sector has a significant effect of shocks and volatility spillover from WTI pre-2014, whereas this effect is not significant post-2014. The Abu Dhabi real estate sector shows a positive significant effect of volatility spillover post-2014. Further, the services sector does not show a significant result in either period with WTI oil price, which may related to diversification of this sector.

Table 5.7 presents the results for the Abu Dhabi sectors and MSCI World index for the pre-and post-2014 periods. As mentioned previously, the variance equations show that the current conditional volatility of the Abu Dhabi sectors and MSCI are determined by their own past shocks $a_{11}\, and\, a_{22}$ and their own past volatility $b_{11}\, and\, b_{22}$. Furthermore, the bank sector shows a bidirectional shocks effects and volatility spillover with MSCI pre-2014; this effect is insignificant post-2014. Also, the real estate sector shows a significant sign of volatility spillover to MSCI pre-2014 but post-2014 there is a shock spillover from the MSCI index by 0.3633. The services sector presents a high significant sign of volatility spillover from MSCI post-2014 (–1.6593). Table 5.8 shows the results for the Abu Dhabi sectors and S&P 500 US index. The current conditional volatility of the S&P 500 and Abu Dhabi sectors are determined by their own past shocks $a_{11}\, and\, a_{22}$ and their own past volatility $b_{11}\, and\, b_{22}$. The services sector shows a significant sign of shock spillover to S&P 500 pre-2014, while post-2014 there is a significant sign of shock spillover from the S&P 500. Also, there is bidirectional volatility spillover pre-2014; post-2014 this effect is from one direction. Real estate shows a bidirectional shock spillover and volatility spillover to S&P 500 pre-2014. Moreover, the services sector presents a significant sign of shock transmission from the S&P 500 index in both periods, but the effect is positive and weaker post-2104 (0.1981).

Table 5.5: Spillover effect between Abu Dhabi stock market sectors and WTI, MSCI and S&P 500 for the period 2010–17

ADX	ADB & WTI	ADRE & WTI	ADS & WTI	ADB & MSCI	ADRE & MSCI	ADS & MSCI	ADB & S&P 500	ADRE & S&P 500	ADS & S&P 500
Conditional mean equation									
r_{11}	0.0005***	0.0001	0.0001	0.0006***	0.00002	0.0001	0.0004**	0.00007	0.0001
r_{12}	0.0106	0.0433**	-0.0005	0.0286	0.0710	-0.0475	0.0056	-0.0299	-0.0028
r_{21}	0.0003	0.0001	0.0003	0.0047***	0.0004***	0.0004**	0.0004***	0.0007***	0.0007***
r_{22}	-0.0593***	-0.0502**	-0.0540**	0.1065***	0.1103***	0.1227***	-0.0615**	-0.0425*	-0.0484*
Conditional variance equation									
c_{11}	-0.01776	-0.0058	-0.0182	0.0028	0.0028	-0.0074	-0.0034	0.0029	0.0001
c_{12}	0.0033	-0.0004	0.0009	0.0052	-0.0009	0.0012	0.0005	-0.0043	-0.0001
c_{22}	-0.00035	-0.0089	-0.0120	0.0011	-0.0083	-0.0033	0.0047	0.0211	0.0141
a_{11}	0.5468	0.4621	0.5654	0.4281	0.4403	0.3198	-0.4323	-0.4675	-0.4713
a_{21}	-0.1561**	-0.0352**	-0.0333*	0.0556***	-0.0068	0.0249	-0.0354**	0.0130	-0.0127
a_{12}	0.02316**	-0.0094**	0.0425*	0.0330	0.0386	0.2978***	0.1585	-0.0618	-0.0659
a_{22}	0.4250	-0.4250	-0.2989	-0.5334	0.4439	0.3213	0.5639	0.4344	0.1916
b_{11}	0.0602	-0.8566	0.0036	-0.8295	-0.8482	-0.3388	0.83041	-0.8353	0.8301
b_{21}	-0.5527	0.0110	0.0653	-0.1290***	-0.0043	-0.1288***	0.1168	-0.0025	-0.1811***
b_{12}	0.1214***	0.0056	0.0007	-0.0139	-0.0144	0.6994***	0.1204	0.1245	0.0523
b_{22}	-0.8022***	-0.8242	0.4706	0.7210	-0.8307	-0.8151	0.0667	0.0080	-0.1463
$Q_1(12)$	12.82(0.112)	18.13(0.112)	18.29(0.107)	28.07(0.117)	18.10(0.113)	18.23(0.109)	28.53(0.521)	17.99(0.116)	18.33(0.106)
Covariance matrix									
$a_{11}a_{12}$	0.0126	-0.0043	0.0240	0.0141	0.0170	0.0952	-0.0685	0.0289	0.0310
$a_{21}a_{22}$	-0.0713	0.0149	0.0099	-0.0296	-0.0030	0.0080	-0.0199	0.0056	-0.00244
$a_{12}a_{21} + a_{11}a_{22}$	0.2463	-0.1961	-0.1704	-0.2265	0.1952	0.1101	-0.2493	-0.2039	-0.0895
$b_{11}b_{12}$	0.0073	-0.0048	0.0000	0.0115	0.0122	-0.2369	-0.0968	0.1043	-0.0436
$b_{21}b_{22}$	0.4434	-0.0091	0.0307	-0.0931	0.0035	0.1050	0.0779	-0.00002	0.0265
$b_{12}b_{21} + b_{11}b_{22}$	-0.1154	0.7061	0.0017	-0.5963	0.7047	0.1860	-0.5222	0.0064	0.1127

Note: ***, **, * indicate statistical significance at the 1%, 5% and 10% levels, respectively.

Table 5.6: Spillover effect between Abu Dhabi stock market sectors and WTI oil price for the two sub-periods 2010–mid-2014 and mid-2014–2017

Abu Dhabi sectors with WTI index	Pre-2014			Post-2014		
	ADB & WTI	ADRE & WTI	ADS & WTI	ADB & WTI	ADRE & WTI	ADS & WTI
Conditional variance equation						
c_{11}	0.0079	-0.0077	-0.0080	-0.0259	-0.0273	-0.0252
c_{12}	0.00001	0.0022	-0.0009	-0.0010	0.0007	0.0007
c_{22}	0.0065	0.0221	-0.0124	-0.0097	-0.0057	-0.0136
a_{11}	-0.4929	0.5783	-0.5435	0.4258	0.3001	-0.4827
a_{21}	-0.0472	-0.0129	-0.1281***	0.0727	-0.1371*	0.2529*
a_{12}	0.0413**	0.0122	-0.0588	0.0224	0.0266	-0.0450
a_{22}	0.6128	-0.3713	0.3006	0.5081	0.5109	0.1671
b_{11}	0.7524	0.7037	0.7074	0.0779	-0.0220	-0.00001
b_{21}	0.2597	0.1020	-0.0792	0.2672*	-0.1193	-0.00001
b_{12}	-0.0158**	0.0588	0.0026	-0.1293	0.2545**	0.000003
b_{22}	-0.4437	0.0149	0.4599	-0.4630	-0.7524	-0.0000005
Covariance matrix						
$a_{11}a_{12}$	-0.0203	0.0070	0.0319	0.2164	0.1533	-0.0806
$a_{21}a_{22}$	-0.0289	0.0048	-0.0385	0.0369	-0.0701	0.0422
$a_{12}a_{21} + a_{11}a_{22}$	-0.3040	-0.2149	-0.1558	0.2180	0.1497	-0.0921
$b_{11}b_{12}$	-0.0119	0.0414	0.0018	-0.0101	-0.0056	-0.0000
$b_{21}b_{22}$	-0.1152	0.0015	-0.0364	-0.1237	0.0898	0.0000
$b_{12}b_{21} + b_{11}b_{22}$	-0.3379	0.0165	0.3251	-0.0706	-0.0137	0.0000

Note: ***, **, * indicate statistical significance at the 1%, 5% and 10% levels, respectively.

Table 5.7: Spillover effect between Abu Dhabi stock market sectors and MSCI world index for the two sub-periods 2010–mid-2014 and mid-2014–2017

Abu Dhabi sectors with MSCI index	Pre-2014			Post-2014		
	ADB & MSCI	ADRE & MSCI	ADS & MSCI	ADB & MSCI	ADRE & MSCI	ADS & MSCI
Conditional variance equation						
c_{11}	0.0010	-0.0029	-0.0030	-0.0072	-0.0073	0.0071
c_{12}	-0.0065	-0.0114	-0.0011	0.0006	0.0002	-0.0015
c_{22}	0.0041	0.0037	-0.0143	-0.0109	0.0094	-0.0013
a_{11}	-0.3737	-0.4634	0.4899	-0.3610	0.3725	-0.3895
a_{21}	0.0931***	0.0115	0.0001	0.0422	-0.0273	-0.1901***
a_{12}	-0.2080***	-0.0436	0.1031	0.0991	0.3633***	-0.0855
a_{22}	-0.5462	-0.4933	0.2534	-0.4552	0.5544	-0.1260
b_{11}	0.7871	0.8082	0.8189	0.0483	-0.0001	0.0032
b_{21}	0.4109***	0.0755***	0.0214	-0.0751	-0.0161	-0.0000
b_{12}	0.1794***	0.1278	0.0348	0.2729	-0.0639	-1.6593***
b_{22}	-0.0446	-0.7240	-0.0165	-0.4367	0.7261	-0.0034
Covariance matrix						
$a_{11}a_{12}$	0.0777	0.0202	0.0505	-0.0358	0.1353	0.0333
$a_{21}a_{22}$	-0.0508	-0.0057	0.00003	-0.0192	-0.0151	0.0239
$a_{12}a_{21} + a_{11}a_{22}$	0.1847	0.2281	0.1241	0.1685	0.1965	0.0653
$b_{11}b_{12}$	0.1412	0.1033	0.0285	0.0132	0.00001	-0.0054
$b_{21}b_{22}$	-0.0183	-0.0546	-0.0003	0.0327	-0.0117	0.0000
$b_{12}b_{21} + b_{11}b_{22}$	0.0385	-0.5755	-0.0128	-0.0416	0.0008	0.0000

Note: ***, **, * indicate statistical significance at the 1%, 5% and 10% levels, respectively.

Table 5.8: Spillover effect between Abu Dhabi stock market sectors and S&P 500 index for the two sub-periods 2010–mid-2014 and mid-2014–2017

Abu Dhabi sectors with S&P 500 index	**Pre-2014**			**Post-2014**		
	ADB & S&P 500	ADRE & S&P 500	ADS & S&P 500	ADB & S&P 500	ADRE & S&P 500	ADS & S&P 500
Conditional variance equation						
c_{11}	0.0010	0.0004	0.0017	-0.0079	-0.0078	0.0074
c_{12}	0.0080	-0.0014	-0.0016	-0.0042	-0.0015	0.0008
c_{22}	0.0001	0.0218	0.0126	-0.0090	-0.0082	-0.0136
a_{11}	0.4472	-0.4613	-0.4556	-0.4469	-0.5102	-0.5802
a_{21}	-0.1127***	-0.0195*	-0.0301	-0.0379	-0.0295	0.0106
a_{12}	0.0742	0.2636**	-0.2095**	0.4783***	-0.1447	0.1981*
a_{22}	0.5596	-0.3916	0.2118	0.5538	-0.5314	0.1305
b_{11}	0.8481	-0.8430	0.8335	-0.0156	0.0150	0.0005
b_{21}	0.2909***	0.1273***	0.1334	0.1470***	0.0433	-0.0001
b_{12}	-0.0956**	-0.1197	-0.1296	0.0296	-0.2529	-0.0004
b_{22}	-0.0312	0.0155	0.4669	-0.4162	-0.7627	-0.0023
Covariance matrix						
$a_{11}a_{12}$	0.0332	-0.1216	0.0955	-0.2137	0.0738	-0.1149
$a_{21}a_{22}$	-0.0630	0.0076	-0.0063	-0.0210	0.0157	0.0013
$a_{12}a_{21} + a_{11}a_{22}$	0.2419	0.1755	-0.0902	-0.2657	0.2754	-0.0736
$b_{11}b_{12}$	-0.0811	0.1009	-0.1080	-0.0004	-0.0037	-0.0000
$b_{21}b_{22}$	-0.0090	0.0019	0.0623	-0.0612	-0.0331	0.0000
$b_{12}b_{21} + b_{11}b_{22}$	-0.0543	-0.0283	0.3719	0.0108	-0.0224	-0.0000

Note: ***, **, * indicate statistical significance at the 1%, 5% and 10% levels, respectively.

5.7.1.3 Dubai Stock Market

The relationships between Dubai stock market sectors and the WTI oil price, MSCI World index and S&P 500 US index are examined in this section. Table 5.9 presents the results from the GARCH-BEKK model for three sectors of the Dubai stock market—bank, real estate and services—with WTI, MSCI and S&P 500. First, we check the properties of the model using a Q-statistic test, which shows that the standard residuals and square standard residuals are not significant; hence the BEKK model is adequate to use. Considering the mean equation, there is no significant sign of the return of WTI on Dubai stock market sectors as shown by the coefficient r_{21}. Conversely, there is a significant positive effect by one lag period of the Dubai real estate sector from MSCI, and all three sectors from the S&P 500 index. According to the results from the variance equation, the coefficients a_{11}, a_{22}, b_{11} *and* b_{22} are significant at the 1% level, which indicates that the volatility of WTI, MSCI, S&P 500 and Dubai stock market sectors is affected by own past shocks and volatility. The results for volatility transmission show that the Dubai bank sector has a negative significant sign for shocks and volatility spillover from oil. Also, there are bidirectional shocks and volatility transmission from the MSCI index and the Dubai bank sector has unidirectional volatility spillover from the S&P 500 index. The Dubai real estate sector has a significant bidirectional effect of shocks with the oil and S&P 500 index, while there is a unidirectional significant effect of shocks and volatility from the MSCI index. The Dubai services sector has no significant signs with oil prices, whereas there is a significant bidirectional sign for volatility with MSCI and S&P 500 indices and unidirectional shocks from the S&P 500.

The covariance matrix for the Dubai stock market sectors with the WTI, MSCI and S&P 500 is applied to interpret the model parameter estimation. According to the shocks in the mean equation, the negative sign of the coefficient $a_{11}a_{12}$ *and* $a_{21}a_{22}$ for the Dubai bank sector and oil means that shocks to either have a negative effect on the next-day return covariance. Further, shocks to the Dubai bank sector have a negative effect on the next-day MSCI covariance (0.0159). In addition, the negative sign of the coefficient of $b_{11}b_{12}$ *and* $b_{21}b_{22}$ for the Dubai bank sector and oil indicates that an increase in the return variance has a negative impact on the next day’s two-asset return covariance.

Table 5.10 presents the results for the Dubai sectors and WTI oil price for the two periods, pre- and post-2014. As shown in the conditional variance equation, the current conditional volatility of the WTI and Dubai sectors is determined by their own past shocks (α_{11} and α_{22}) and the conditional past volatility (b_{11} and b_{22}). Further, the Dubai bank sector is significantly affected by shocks from the WTI oil price post-2014, with a higher coefficient compared with pre-2014. Further, there is a unidirectional effect of past volatility of Dubai bank sectors on oil pre-2014; the unidirectional effect of volatility spillover from oil becomes significant post-2014. In the covariance matrix for Dubai banks and the WTI, the positive sign of $a_{11}a_{12}$ indicates that shocks to WTI returns have a positive effect on WTI and Dubai bank covariance in the next period; this is present in both periods but stronger post-2014. Shocks to Dubai banks have a negative effect pre-2014 but positive post-2014; the joint shocks are negative pre-2014, which implies a lower covariance between them (−0.2982). However, the joint shocks become positive post-2014 (0.1513). Moreover, the positive sign of $b_{11}b_{12}$ indicates that an increase in WTI variance has a positive effect on Dubai bank and WTI covariance. The negative sign of $b_{21}b_{22}$ (−f incr) pre-2014 indicates that an increase in Dubai bank return variance very weakly decreases the next-day WTI and Dubai bank covariance; this becomes positive post-2014. Thus, Dubai banks are affected more by oil price volatility and shocks pre-2014 than post-2014.

The Dubai real estate sector shows a bidirectional shock spillover pre-2014 but does not experience this effect post-2014. Also, there is a significant volatility spillover from oil to the real estate sector pre-2014, which is not significant post-2014. As shown in the covariance matrix, there is a negative sign for $a_{11}a_{12}$ pre-2014 and post-2014, which means shocks to the WTI have a negative effect on the WTI and the real estate sector in the next period. The sign of $a_{21}a_{22}$ is positive pre-2014 and post-2014, suggesting that shocks to the real estate sector have a positive effect on the WTI and the real estate sector in the next period (0.0455). Past variance of the WTI has a negative effect on the WTI and real estate covariance pre-2014; this is also true for past variance of the real estate sector. The Dubai services sector has no significant sign with the WTI pre-2014; this relationship becomes unidirectional post-2014 (from the WTI to the services sector). Also, there is no significant volatility spillover from the services sector to oil for either period, but a positive effect of shocks from oil to services in both periods. There is a positive sign of shock spillover to services sector, which indicates a positive effect on

WTI oil price index and services sector in the next period pre-2014 period, but the effect becomes negative in post-2014 period. In post-2014, the sign shows that an increase in WTI oil price index variance has a positive effect on the covariance between them. Also, $b_{21}b_{22}$ has a negative sign pre-2014 but a positive sign post-2014 (0.5570).

The results for the Dubai sectors and the MSCI pre- and post-2014 are provided in Table 5.11. The variance equation shows that the current conditional volatility of the MSCI and Dubai sectors is determined by their own past shocks (α_{11} and α_{22}) and the conditional past volatility (b_{11} and b_{22}). Dubai banks experience significant negative shock spillover from the bank sector post-2014, but not pre-2014. Also, there is bidirectional volatility spillover pre-2014 that becomes insignificant post-2014. The Dubai real estate sector shows unidirectional shock spillover from real estate pre-2014, which becomes bidirectional post-2014. Also, there is unidirectional volatility spillover from MSCI pre-2014. The services sector shows bidirectional shock spillover pre-2014, but this is not significant post-2014. There is unidirectional volatility spillover from services pre-2014, but no significant sign of shock and volatility spillover post-2014. Thus, the Dubai sectors experience significant volatility and shock spillover from the MSCI pre-2014, but this effect does not appear post-2014, with the exception of shock spillovers for the bank and real estate sectors.

The results for volatility spillover between Dubai sectors and the S&500 pre- and post-2014 are shown in Table 5.12. The results for the variance equation show that all sectors are affected by past own shocks and volatility, as indicated by the significant sign of the coefficient (α_{11} and α_{22}) and (b_{11} and b_{22}). The Dubai bank sector has unidirectional shock spillover from the S&P 500 pre-2014, and from the bank sector post-2014. Also, the bank sector does not show a significant sign of volatility spillover pre-2014; a bidirectional volatility spillover appears post-2014. The Dubai real estate sector shows unidirectional shock spillover from S&P 500 pre-2014, but this spillover becomes insignificant post-2014. Further, there is unidirectional volatility spillover from S&P 500 in both periods. The results for the Dubai services sector show that there is a unidirectional shock spillover from services post-2014. Also, there is unidirectional volatility spillover from services pre-2014, which becomes bidirectional post-2014. As a result, the S&P 500 has a significant effect on most Dubai sectors in both periods.

Table 5.9: Spillover effect between Dubai stock market sectors and WTI, MSCI and S&P 500 for the period 2010–17

DFM	DB& WTI	DRE&WTI	DS&WTI	DB&MSCI	DRE&MSCI	DS&MSCI	DB&S&P 500	DRE&S&P 500	DS&S&P 500
Conditional mean equation									
r_{11}	-5.54E-07	0.0006	0.0001	6.84E-05	0.0007*	0.0002	4.07E-07	0.0007*	0.0001
r_{12}	0.0263**	0.0617***	0.0373	0.0326	-0.0212	-0.0400	0.0240	0.0485	-0.0225
r_{21}	0.0002	0.0003	0.0002	0.0004	0.0004**	0.0003	0.0007***	0.0007***	0.0006***
r_{22}	-0.0587**	-0.0506**	-0.0476*	0.1096***	0.1133***	0.1182***	-0.0460*	-0.0442*	-0.0279
Conditional variance equation									
c_{11}	-0.0197	-0.0188	0.0054	-0.0029	0.0034	-0.0011	0.0034	0.0004	-0.0036
c_{12}	-0.0011	0.0002	0.0002	0.0002	0.0009	0.0007	-0.0055	-0.0023	0.0028
c_{22}	-0.0003	-0.0066	-0.0096	-0.0067	-0.0081	0.0131	0.00007	-0.0182	0.0082
a_{11}	0.4098	-0.4999	0.4669	0.4178	-0.4237	0.3972	0.4304	-0.4026	0.4612
a_{21}	-0.0558	0.1152**	-0.0341**	0.0278*	0.0118	-0.0484***	-0.0401**	0.0397***	0.0036
a_{12}	-0.0549***	0.0659*	0.0154	0.1208***	-0.0891*	0.2006**	0.0494	-0.3140***	0.1972***
a_{22}	0.5735	0.4027	0.4992	-0.5739	-0.4263	0.5485	-0.5592	-0.4506	0.4914
b_{11}	0.0377	0.0067	0.8599	0.8436	0.8153	-0.8989	0.8301	0.8432	-0.8037
b_{21}	0.0116	-0.0009	0.0151	0.0601**	0.0208	-0.0487***	-0.0134	0.1474***	-0.0384**
b_{12}	-0.1874***	-0.1165	-0.0053	0.1572***	0.2763**	0.1875***	0.1853***	-0.1062	-0.3266**
b_{22}	-0.7696	-0.8451	0.7982	-0.6406	-0.8063	-0.6827	-0.7162	0.1417	0.1199
$Q_1(12)$	17.77(0.123)	26.76(0.118)	37.35(0.112)	17.71(0.125)	25.96(0.011)	36.53(0.106)	17.44(0.133)	26.59(0.109)	38.85(0.102)
Covariance matrix									
$a_{11}a_{12}$	-0.0224	-0.0329	0.0071	0.0504	0.0377	0.0796	0.0212	0.1264	0.0909
$a_{21}a_{22}$	-0.0320	0.0463	-0.0170	-0.0159	-0.00503	-0.0265	0.0224	-0.0178	0.0017
$a_{12}a_{21} + a_{11}a_{22}$	0.2380	-0.1937	0.2325	-0.2364	0.1795	0.2081	-0.2426	0.1689	0.2273
$b_{11}b_{12}$	-0.0071	-0.0007	-0.0045	0.1326	0.2252	-0.1685	0.1538	-0.0895	0.2624
$b_{21}b_{22}$	-0.0089	0.0007	0.0119	-0.0385	-0.0167	0.0332	0.0095	0.0208	-0.0046
$b_{12}b_{21} + b_{11}b_{22}$	-0.0311	-0.0055	0.6862	-0.5309	-0.6516	0.6045	-0.5970	0.1038	-0.0838

Note: ***, **, * indicate statistical significance at the 1%, 5% and 10% levels, respectively.

Table 5.10: Spillover effect between Dubai stock market sectors and WTI oil price for the two sub-periods 2010–mid-2014 and mid 2014–2017

Dubai sectors with WTI	Pre-2014			Post-2014		
	DB & WTI	DRE &WTI	DS &WTI	DB &WTI	DRE &WTI	DS &WTI
Conditional variance equation						
c_{11}	0.00924	0.0157	-0.0161	-0.0280	-0.0273	-0.0267
c_{12}	0.001507	0.0012	-0.0007	0.0001	0.0015	-0.0003
c_{22}	-0.008134	0.0004	0.01108	-0.0053	-0.0092	-0.0099
a_{11}	0.4597	-0.3515	-0.3213	0.2331	-0.3028	0.3722
a_{21}	0.0328	0.1198**	0.0052	0.1353	0.0802	-0.0914
a_{12}	0.0255	0.0832**	-0.0730	-0.0599**	0.0539	-0.0548*
a_{22}	-0.6504	0.3619	0.5358	0.6840	0.5671	0.6022
b_{11}	0.6970	-0.0332	0.0014	-0.0072	0.0004	-0.0015
b_{21}	0.2012**	-0.0554	0.0256	-0.0382	0.0748	0.0856
b_{12}	0.03323	0.4292***	0.0065	-0.1112*	0.0045	-0.0122
b_{22}	-0.4265	0.8419	-0.7692	-0.6073	0.7053	0.6511
Covariance matrix						
$a_{11}a_{12}$	0.0117	-0.0292	0.0234	0.1595	-0.1717	0.2241
$a_{21}a_{22}$	-0.0213	0.0433	0.0028	0.0925	0.0455	-0.0550
$a_{12}a_{21} + a_{11}a_{22}$	-0.2982	-0.1172	-0.1725	0.1513	-0.1674	0.2291
$b_{11}b_{12}$	0.0231	-0.0142	0.0000	0.0008	0.0000	0.0000
$b_{21}b_{22}$	-0.0858	-0.0466	-0.0197	0.0232	0.0527	0.0557
$b_{12}b_{21} + b_{11}b_{22}$	-0.2906	-0.0518	-0.0009	0.0086	0.0006	-0.0021

Note: ***, **, * indicate statistical significance at the 1%, 5% and 10% levels, respectively.

Table 5.11: Spillover effect between Dubai stock market sectors and MSCI World index for the two sub-periods 2010–mid-2014 and mid-2014–2017

Dubai sectors with MSCI	Pre-2014			Post-2014		
	DB & MSCI	DRE &MSCI	DS &MSCI	DB &MSCI	DRE &MSCI	DS &MSCI
Conditional variance equation						
c_{11}	0.0091	0.0090	-0.0007	-0.0075	0.0073	-0.0072
c_{12}	0.0008	0.0025	0.0006	-0.00008	-0.0002	-0.0006
c_{22}	-0.0080	-0.0013	0.0208	0.0059	-0.0094	0.0100
a_{11}	0.2677	-0.2907	0.4325	-0.3019	0.3683	-0.4219
a_{21}	-0.0001	0.0378*	-0.0481***	-0.0928***	-0.0588**	0.0217
a_{12}	0.0025	-0.0381	0.2505**	0.0675	0.2979**	-0.0618
a_{22}	0.6424	0.4004	0.6587	0.6396	0.5668	-0.6064
b_{11}	0.0310	-0.0715	-0.8642	0.0111	-0.0031	0.0013
b_{21}	-0.0083*	-0.0216	-0.0783***	-0.0295	0.0052	0.0113
b_{12}	-0.5709**	0.6619***	0.1128	0.2806	-0.1584	-0.0487
b_{22}	-0.0236	0.8208	-0.3545	-0.6450	0.6939	-0.6501
Covariance matrix						
$a_{11}a_{12}$	0.0006	0.01108	0.1083	-0.0204	0.1097	0.0261
$a_{21}a_{22}$	-0.00009	0.0151	-0.0317	-0.0594	-0.0333	-0.0131
$a_{12}a_{21} + a_{11}a_{22}$	0.1720	-0.1178	0.2728	-0.1993	0.1912	0.2545
$b_{11}b_{12}$	-0.0177	-0.0473	-0.0974	0.0031	0.0005	-0.00006
$b_{21}b_{22}$	0.0001	-0.0177	0.0277	0.0191	0.0036	-0.0073
$b_{12}b_{21} + b_{11}b_{22}$	0.0040	-0.073	0.2975	-0.0154	-0.0030	-0.0014

Note: ***, **, * indicate statistical significance at the 1%, 5% and 10% levels, respectively.

Table 5.12: Spillover effect between Dubai stock market sectors and S&P 500 for the two sub-periods (2010–mid-2014 and mid-2014–2017)

Dubai sectors with S&P 500	Pre-2014			Post-2014		
	DB &S&P 500	DRE &S&P 500	DS &S&P 500	DB &S&P 500	DRE &S&P 500	DS &S&P 500
Conditional variance equation						
c_{11}	0.0038	0.0034	-0.0031	0.0079	0.0074	-0.0077
c_{12}	0.0007	0.0007	-0.0102	0.0012	0.0042	-0.0009
c_{22}	-0.0083	-0.0080	-0.0056	-0.0001	-0.0082	-0.0073
a_{11}	0.4758	0.4508	-0.4430	-0.4550	-0.4802	-0.3788
a_{21}	-0.0319	-0.0149	0.0096	-0.1311***	0.0466	-0.1455***
a_{12}	0.1299**	0.1238*	-0.0834	0.0856	-0.1437	-0.0163
a_{22}	0.6355	0.4155	-0.5224	-0.5643	0.5721	-0.5675
b_{11}	0.7950	0.8187	-0.8337	0.0780	-0.0115	-0.1726
b_{21}	0.0337	0.0062	-0.0396**	0.0759**	-0.1177	-0.0515**
b_{12}	-0.0535	-0.0884**	0.0732	-0.6980***	0.0544***	1.4058***
b_{22}	0.4116	0.8157	0.7686	-0.6777	0.7162	0.4303
Covariance matrix						
$a_{11}a_{12}$	0.0618	0.0558	0.0369	-0.0389	0.0690	0.0061
$a_{21}a_{22}$	-0.0203	-0.0062	-0.0051	0.0740	0.0266	0.0826
$a_{12}a_{21} + a_{11}a_{22}$	0.2982	0.1855	0.2306	0.2455	-0.2814	0.2174
$b_{11}b_{12}$	-0.0425	-0.0724	-0.061	-0.0544	-0.0006	-0.2426
$b_{21}b_{22}$	0.0138	0.0051	-0.0304	-0.0515	-0.0843	-0.0221
$b_{12}b_{21} + b_{11}b_{22}$	0.3254	0.6673	-0.6437	-0.1059	-0.0146	-0.1467

Note: ***, **, * indicate statistical significance at the 1%, 5% and 10% levels, respectively.

5.7.1.4 Qatar Stock Market

The volatility transmission analysis for the Qatar stock market sectors and WTI oil price, MSCI World index and S&P 500 is presented in this section. The conditional variance–covariance equation is applied to capture the volatility and cross-volatility spillover among them. Table 5.13 presents the result from the GARCH-BEKK model for the three sectors of Qatar stock market: bank, real estate and services. To check the properties of the model, a Q-statistic test is used. The standard residuals is not significant, implying that the BEKK model is adequate. According to the mean equation coefficients r_{12}there is a significant sign for WTI return on Qatar bank sector return. Also, the coefficients r_{21} show that there is no significant sign on the return of Qatar stock market sectors on WTI. There is a significant positive bidirectional effect by one lag period of Qatar stock market sectors with MSCI and S&P 500 indices. According to the variance equation result, the coefficients of $a_{11}, a_{22}, b_{11} and\ b_{22}$ are significant at the 1% level, which indicates that the volatility of WTI, MSCI, S&P 500 and Qatar stock market sectors are affected by their own past shocks and their own past volatility. Moreover, the variance equation result indicates a significant unidirectional sign of shocks and volatility spillover from WTI to the Qatar real estate sector. The bank and services sectors do not show any significant sign with WTI. Further, there are no significant signs for shock and volatility spillover between Qatar sectors and the MSCI, except for shock spillover from the MSCI to the real estate sector. Moreover, the real estate sector shows evidence of bidirectional shocks and volatility spillover with the S&P 500 index and the bank sector hast a unidirectional volatility spillover from the S&P 500 index. However, the services sector does not show any interesting results of spillover with S&P 500 index.

The covariance matrix for the Qatar stock market sectors with the WTI, MSCI and S&P 500 is used to interpret the model parameter estimation. Regarding the effect of shocks in mean equations, the negative $a_{11}a_{12}$of the bank sector with WTI indicates that shocks to the WTI have a negative effect on the bank sector and WTI return covariance in the next period (–0.0037). Further, the bank sector has a negative effect with MSCI and S&P 500 (–0.0115 and –0.0006, respectively). The negative sign of $a_{21}a_{22}$ indicates shocks to the sector that negatively affect the two variables' covariance in the next period, which is shown for real estate services with WTI, and all Qatar sectors with MSCI. Qatar sectors have a positive effect with S&P 500 index (0.0291, 0.0206 and 0.0077 for bank, real estate and service, respectively). However, regarding the effects of variance–covariance, the negative sign of $b_{11}b_{12}$ for the bank sector with WTI, all Qatar sectors with MSCI and services with S&P 500 implies that an increase in WTI, MSCI and S&P 500 return variance has a negative effect on the next day's two-asset return covariance. Further, a negative sign of $b_{21}b_{22}$ as shown for banks and services with WTI, and real estate and services with S&P 500 indicates that an increase in the sector variance has a negative effect on the two-asset return covariance (–0.0240, –0.0107, –0.1103, –0.0281, respectively).

Table 5.14 shows the results of the Qatar sectors and WTI oil price for the two periods pre-and post-2014. The variance equations show that the current conditional volatility of the WTI and the Qatar sectors are determined by their own past shocks a_{11} and a_{22} and their own past volatility b_{11} and b_{22}. Regarding spillover, the Qatar bank sector shows a significant unidirectional effect of shock spillover from WTI pre-2014 but not post-2014. The Qatar real estate sector shows a bidirectional effect of shock spillover and a unidirectional effect of volatility spillover pre-2014; however there is no significant effect of shocks and volatility spillover post-2014. The Qatar services sector shows a unidirectional effect of shocks and volatility spillover from oil in both periods.

Table 5.15 presents the result for the Qatar sectors and MSCI World index for the pre- and post-2014 periods. As mentioned before, the variance equation shows that the current conditional volatility of the Qatar sectors and MSCI are determined by their own past shocks a_{11} and a_{22} and their own past volatility b_{11} and b_{22}. Further, the Qatar bank sector shows unidirectional shock spillover and bidirectional volatility spillover pre-2014, while this effect is insignificant post-2014. Also, the Qatar real estate sector shows a significant sign of shocks and volatility spillover with MSCI pre-2014; however, post-2014 there is unidirectional volatility spillover from the MSCI index (–0.3798). Conversely, the Qatar services sector shows a significant bidirectional effect of shocks and volatility spillover with MSCI post-2014; whereas pre-2014 there is unidirectional shock spillover from the Qatar services sector.

Table 5.16 provides the results for the Qatar sectors and S&P 500 US index. The current conditional volatilities of the S&P 500 and Qatar sectors are determined by their own past shocks a_{11} and a_{22} and their own past volatility b_{11} and b_{22}. The Qatar bank sector has a unidirectional effect of shock spillover from S&P 500 post-214 (–0.1129) but pre-2014 there is no significant sign of shocks and volatility spillover. The Qatar real estate sector shows unidirectional shock spillover from S&P 500 and bidirectional volatility spillover pre-2014; however post-2014 there is no significant sign. The Qatar services sector has unidirectional shock spillover from S&P 500 and bidirectional volatility spillover pre-2014, but the effect becomes unidirectional post-2104.

Overall, Qatar sectors show a weak effect of oil prices post-2014, with the exception of the services sector, which has a significant sign with oil. Also, there is a significant effect with the MSCI index pre-2014 although this effect becomes insignificant post-2014, except for the Qatar real estate and services sectors. The Qatar services sector has a significant effect of shocks and volatility spillover with the S&P 500 index in both periods.

Table 5.13: Spillover effect between Qatar stock market sectors and WTI, MSCI and S&P 500 for the period 2010–17

QE	QB & WTI	QRE & WTI	QS & WTI	QB & MSCI	QRE & MSCI	QS & MSCI	QB & S&P 500	QRE & S&P 500	QS & S&P 500
Conditional mean equation									
r_{11}	0.0005**	3.71E-05	0.0005**	0.0005**	-4.02E-08	0.0006**	0.0005***	-0.0001	0.0005***
r_{12}	0.0203**	0.0090	-0.0038	0.0100	-0.0666**	-0.0380**	0.0391**	0.0710***	-0.0057
r_{21}	0.0002	0.0002	0.0003	0.0004**	0.0004**	0.0004**	0.0007***	0.0006***	0.0007***
r_{22}	-0.0649	-0.0748***	-0.0672**	0.1211***	0.0946***	0.1054***	-0.0570**	-0.0934***	-0.0621**
Conditional variance equation									
c_{11}	0.0053	0.0201	0.0053	0.0076	0.0086	0.0032	0.0062	0.0017	0.0034
c_{12}	-0.0004	-0.0013	-0.0000	0.0004	0.0005	0.0003	-0.0010	0.0088	0.0007
c_{22}	0.0047	0.0062	0.0050	-0.0038	0.0085	-0.0051	-0.0040	0.0048	-0.0051
a_{11}	-0.4294	-0.364	-0.4169	-0.3729	-0.2739	0.4185	0.4711	-0.0815	-0.4572
a_{21}	0.0599	-0.0142	-0.0167	0.0244	-0.0357	-0.0009	-0.042	0.0603***	0.0133
a_{12}	0.0088	-0.1794***	0.0052	0.0309	-0.1362***	-0.0042	-0.0014	0.8992***	0.0048
a_{22}	0.592	0.6991	0.5986	-0.6136	0.7699	0.6084	-0.6943	0.3425	0.5816
b_{11}	-0.878	0.0092	0.8809	0.3892	-0.0285	-0.8351	-0.6153	0.8817	-0.8159
b_{21}	-0.0352	-0.0166	0.0163	-0.0169	-0.01344	0.0014	-0.0097	-0.2219***	0.0435
b_{12}	0.0052	0.2359***	0.0001	-0.0125	0.0142	0.00001	-0.0734***	0.1618**	0.0116
b_{22}	0.6825	-0.5682	-0.6614	-0.7303	-0.5437	-0.6458	-0.6911	0.4971	-0.6465
$Q_1(12)$	35.57	46.04	55.8	36.6	45.31	514.1	37.5	43.04	54.9
Covariance matrix									
$a_{11}a_{12}$	-0.0037	0.0653	-0.0021	-0.0115	0.0373	-0.0017	-0.0006	-0.0732	-0.0021
$a_{21}a_{22}$	0.0354	-0.0099	-0.0099	-0.0149	-0.0274	-0.0005	0.0291	0.0206	0.0077
$a_{12}a_{21} + a_{11}a_{22}$	-0.2536	-0.2519	-0.2496	0.2295	-0.2060	0.2546	-0.3270	0.0263	-0.2658
$b_{11}b_{12}$	-0.0045	0.0021	0.00008	-0.0048	-0.0004	-0.0008	0.0451	0.1426	-0.0094
$b_{21}b_{22}$	-0.0240	0.0094	-0.0107	0.0123	0.0073	0.00009	0.0067	-0.1103	-0.0281
$b_{12}b_{21} + b_{11}b_{22}$	-0.5994	-0.0091	-0.5826	-0.2840	0.0153	0.5393	0.4259	0.4023	0.5279

Note: ***, **, * indicate statistical significance at the 1%, 5% and 10% levels, respectively.

Table 5.14: Spillover effect between Qatar stock market sectors and WTI oil price for the two sub-periods 2010–mid-2014 and mid-2014–2017

Qatar sectors with WTI	Pre-2014			Post-2014		
	QB & WTI	QRE &WTI	QS &WTI	QB & WTI	QRE &WTI	QS &WTI
Conditional variance equation						
c_{11}	0.0163	-0.0169	0.0081	-0.0267	-0.0285	-0.0280
c_{12}	0.0002	-0.0012	0.0015	0.0002	-0.0002	0.0001
c_{22}	-0.0044	-0.0042	0.0078	-0.0066	-0.0069	0.0010
a_{11}	0.2579	0.0070	0.5583	-0.3553	0.0565	0.2038
a_{21}	-0.1428	0.1158***	-0.1328	0.1773	-0.1133	0.1407
a_{12}	0.0038*	0.5106***	0.0087**	0.0023	0.0832	0.0376*
a_{22}	0.6347	0.1450	0.4081	0.6393	0.7382	0.7497
b_{11}	-0.0004	-0.1103	0.7018	0.0141	-0.0203	-0.0007
b_{21}	0.0466	-0.0228	0.1155	0.1300	0.0301	0.0002
b_{12}	0.0118	0.6290***	-0.0759**	-0.0553	-0.2910	-0.1841***
b_{22}	-0.6460	0.0850	-0.0054	-0.54373	0.4421	-0.5309
Covariance matrix						
$a_{11}a_{12}$	0.0009	0.0036	0.0049	-0.2271	0.0417	0.1527
$a_{21}a_{22}$	-0.0906	0.0168	-0.0542	0.1133	-0.0837	0.1055
$a_{12}a_{21} + a_{11}a_{22}$	0.1632	0.0601	0.2267	-0.2267	0.0322	0.1580
$b_{11}b_{12}$	-0.00005	-0.0694	-0.0533	-0.0007	0.0059	0.0001
$b_{21}b_{22}$	-0.0301	-0.0019	-0.0006	-0.0707	0.0133	-0.0001
$b_{12}b_{21} + b_{11}b_{22}$	0.0008	-0.0237	-0.0126	-0.0148	-0.0177	0.0003

Note: ***, **, * indicate statistical significance at the 1%, 5% and 10% levels, respectively.

Table 5.15: Spillover effect between Qatar stock market sectors with MSCI world index for the two sub-periods 2010–mid-2014 and mid-2014–2017

Qatar sectors with MSCI	Pre-2014			Post-2014		
Conditional variance equation	QB &MSCI	QRE &MSCI	QS &MSCI	QB &MSCI	QRE &MSCI	QS &MSCI
c_{11}	0.0092	-0.0091	-0.0012	-0.0073	-0.0074	-0.0074
c_{12}	0.0000	-0.0009	0.0016	0.0005	0.0005	-0.0003
c_{22}	-0.0005	-0.0075	-0.0078	0.0062	-0.0108	0.0055
a_{11}	0.1900	0.2570	-0.4337	0.4190	-0.3675	0.3192
a_{21}	-0.0821*	-0.0104	-0.0832***	0.0264	-0.0239	-0.0781**
a_{12}	-0.0376	-0.2086***	0.1427***	0.0189	0.1057	0.0198
a_{22}	0.5967	0.9962	-0.4580	-0.6378	0.6843	0.7586
b_{11}	-0.0759	-0.0458	-0.8622	0.0047	-0.0190	-0.0066
b_{21}	0.1159*	0.0523*	0.2636***	0.0120	0.0224	0.0282
b_{12}	-0.3665***	0.1468	-0.0778***	0.2088	-0.3798***	-0.1341
b_{22}	0.7735	0.4402	0.0203	0.5799	0.4587	0.5287
Covariance matrix						
$a_{11}a_{12}$	-0.0071	-0.0536	-0.0616	0.0079	-0.0388	0.0063
$a_{21}a_{22}$	-0.0490	-0.0103	0.0381	-0.0168	-0.0164	-0.0592
$a_{12}a_{21} + a_{11}a_{22}$	0.1165	0.2582	0.1868	-0.2668	-0.2540	0.2406
$b_{11}b_{12}$	0.0278	-0.0067	0.0670	0.0009	0.0072	0.0008
$b_{21}b_{22}$	0.0896	0.0230	0.0053	0.0069	0.0102	0.0149
$b_{12}b_{21} + b_{11}b_{22}$	-0.1012	-0.0125	-0.0381	0.0052	-0.0172	-0.0073

Note: ***, **, * indicate statistical significance at the 1%, 5% and 10% levels, respectively.

Table 5.16: Spillover effect between Qatar stock market sectors with S&P 500 for the two sub-periods 2010–mid-2014 and mid-2014–2017

Qatar sectors with S&P 500	Pre-2014			Post-2014		
	QB & S&P 500	QRE & S&P 500	QS & S&P 500	QB & S&P 500	QRE & S&P 500	QS & S&P 500
Conditional variance equation						
c_{11}	-0.0036	-0.0022	-0.0023	-0.0079	-0.0076	-0.0078
c_{12}	-0.0001	-0.0094	0.0064	-0.0003	0.0004	0.0001
c_{22}	-0.0047	-0.0008	-0.0021	-0.0055	-0.0108	0.0056
a_{11}	0.4381	0.0250	0.5033	0.5007	-0.5546	-0.5309
a_{21}	0.0063	0.0171	-0.0122	0.0118	0.0149	0.0380
a_{12}	0.0292	0.8669***	0.1136***	-0.1129**	0.0661	0.1095*
a_{22}	0.6195	-0.1355	0.3212	0.6098	0.6326	0.6814
b_{11}	-0.8212	-0.5143	-0.3868	-0.0305	-0.0297	-0.0195
b_{21}	-0.0051	0.5530***	0.9215***	0.0569	0.0210	-0.0604*
b_{12}	0.0182	-0.4040***	-0.4606***	0.2288	-0.1207	0.1843
b_{22}	-0.6391	-0.3830	-0.0742	-0.6168	-0.5454	0.5705
Covariance matrix						
$a_{11}a_{12}$	0.0128	0.0217	0.0572	-0.0565	-0.0366	-0.0581
$a_{21}a_{22}$	0.0039	-0.0023	-0.0039	0.0072	0.0094	0.0259
$a_{12}a_{21} + a_{11}a_{22}$	0.2716	0.0114	0.1603	0.3040	-0.3499	-0.3576
$b_{11}b_{12}$	-0.0150	0.2078	0.1782	-0.0069	0.0035	-0.0035
$b_{21}b_{22}$	0.0032	-0.2118	-0.0684	-0.0351	-0.0114	-0.0344
$b_{12}b_{21} + b_{11}b_{22}$	0.5248	-0.0264	-0.3957	0.0318	0.0136	-0.0222

Note: ***, **, * indicate statistical significance at the 1%, 5% and 10% levels, respectively.

5.7.1.5 Bahrain Stock Market

The volatility spillover between the Bahrain stock market sectors and WTI oil price, MSCI World index and S&P 500 US index are examined in this section. Table 5.17 presents the result from the GARCH-BEKK model for three sectors of the Bahrain stock market (bank, services and industrial sectors) along with WTI oil price , MSCI world index and S&P 500 index. First, we check the properties of the model by applying a Q-statistic test, which shows the standard residuals are not significant and thus the BEKK model is adequate to use. The mean equation shows no significant sign of the return of WTI on Bahrain stock market sectors as coefficient r_{21} indicates. However, there is a significant positive effect by one lag period of the Bahrain services and industrial sectors with MSCI and all three sectors with the S&P 500 index. According to the results from the variance equation, the coefficients $a_{11}, a_{22}, b_{11}\ and\ b_{22}$ are significant at the 1% level, which indicates that volatility of WTI, MSCI, S&P 500 and the Bahrain stock market sectors is affected by own past shocks and volatility. The results for volatility transmission show that the Bahrain sectors have a significant sign for shock spillover from oil and volatility spillover from oil to the industrial sector. Also, there is a significant sign of shock spillover from the MSCI to the bank and services sectors. There is a bidirectional sign of volatility transmission between the bank sector and the MSCI index, and a unidirectional effect from the services sector on the MSCI index; the Bahrain industrial sector does not show any significant sign with the MSCI index. The Bahrain bank sector has bidirectional shock and volatility spillovers with the S&P 500 index. The services sector has a significant unidirectional effect of shocks and volatility from the S&P 500 index; the Bahrain industrial sector has a bidirectional effect of shock spillover with S&P 500, and unidirectional volatility spillover with the S&P 500 index.

The covariance matrix for the Bahrain stock market sectors with the WTI, MSCI and S&P 500 is examined to interpret the model parameter estimation. According to the shocks in the mean equation, the negative sign of the coefficient $a_{11}a_{12}$ for the Bahrain bank sector and oil means that shocks to either have a negative effect on the next-day return covariance. Further, shocks to the Bahrain services sector have a negative effect on the next-day MSCI covariance. The negative sign for the coefficient of $b_{11}b_{12}\ and\ b_{21}b_{22}$ for the Bahrain industrial sector and S&P 500 index indicates that an increase in the return variance has a negative impact on the next day’s two-asset return covariance.

Table 5.18 shows the results for the Bahrain sectors and WTI oil price for the two periods pre- and post-2014. As shown in the conditional variance equation, the current conditional volatility of the WTI and the Bahrain sectors is determined by their own past shocks (α_{11} and α_{22}) and the conditional past volatility (b_{11} and b_{22}). Further, the Bahrain bank sector is significantly affected by shocks from the WTI oil price post-2014, with a higher coefficient compared with pre-2014; whereas pre-2014 there is bidirectional spillover. Further, there is a unidirectional effect of past volatility of oil on the Bahrain bank sector pre-2014. The Bahrain services sector shows unidirectional shock spillover from the sector pre-2014 but does not experience this effect post-2014. Also, there is a significant volatility spillover from oil to the Bahrain services sector pre-2014 (–0.2640), which is not significant post-2014. The Bahrain industrial sector has unidirectional shock and volatility spillover from oil pre-2014 but not post-2014. Also, there is no significant volatility spillover from the Bahrain services sector to oil for both periods. The covariance matrix for Bahrain sectors and WTI oil price shows a negative sign post-2014, which means that all shocks and volatility have a negative effect.

The results for the Bahrain sectors and the MSCI pre- and post-2014 periods are presented in Table 5.19. The variance equation shows that the current conditional volatility of the MSCI and Bahrain sectors is determined by their own past shocks (α_{11} and α_{22}) and the conditional past volatility (b_{11} and b_{22}). The Bahrain bank sector experiences a positive significant effect of shock spillover from the MSCI pre-2014 (0.0923) and a negative effect post-2014 (–0.1926). Also, there is bidirectional volatility spillover post-2014, which is insignificant pre-2014. The Bahrain services sector shows unidirectional volatility spillover from the sector with MSCI pre-2014 (0.3027), but there is no significant sign post-2014 period. Moreover, the Bahrain industrial sector shows unidirectional volatility spillover from the sector pre-2014 (–0.0773), but no significant sign of volatility spillover post-2014.

The relationship between Bahrain sectors and S&P 500 is shown in Table 5.20. The results from the variance equation show that all sectors are affected by past own shocks and volatility through the significant sign of the coefficients (α_{11} and α_{22}) and (b_{11} and b_{22}). The Bahrain bank sector has unidirectional volatility spillover from the sector with S&P 500 in pre-2014 period, and this spillover becomes insignificant in post-2014 period. The Bahrain bank sector does not show a significant sign of shock spillover in both pre-and post-2014. The Bahrain services sector shows bidirectional shocks and volatility spillover pre-2014, but this spillover becomes unidirectional from S&P 500 in post-2014 period. The results for the Bahrain industrial sector indicate bidirectional shock spillover in pre-2014 period and unidirectional shock and volatility spillover from Bahrain services and S&P 500 in post-2014 period.

Bahrain sectors examined show a high, significant coefficient with WTI oil price in pre-2014 period. However, in the post-2014 period, there are no significant signs, except for the Bahrain bank sector. Further, Bahrain bank sector shows a relationship with the MSCI index both pre-and post-2014 periods, whereas the services and industrial sectors have a significant sign with MSCI only in pre-2014 period. S&P 500 has a significant effect on most Bahrain sectors in both periods.

Table 5.17: Spillover effect between Bahrain stock market sectors and WTI, MSCI and S&P 500 for the period 2010–17

BSX	BB & WTI	BS & WTI	BI & WTI	BB & MSCI	BS & MSCI	BI & MSCI	BB & S&P 500	BS & S&P 500	BI & S&P 500
Conditional mean equation									
r_{11}	0.0001	-0.0001	-5.46E-05	0.0001	-0.0001	-2.21E-05	0.0001	-0.0001	1.00E-05
r_{12}	-0.0100	-0.0045	0.0144*	-0.0091	0.0228	-0.0035	-0.0240	-0.0054	0.0011
r_{21}	0.0003	0.0002	0.0002	0.0004	0.0004**	0.0004***	0.0007***	0.0007***	0.0006***
r_{22}	-0.0559**	-0.0619**	-0.0490*	0.1267***	0.1251***	0.1172***	-0.0454*	-0.0609**	-0.0463*
Conditional variance equation									
c_{11}	-0.0050	-0.0052	-0.0049	-0.0011	-0.0067	0.0086	-0.0017	0.0090	0.0033
c_{12}	-0.0000	0.00018	-0.0001	0.0011	-0.0008	0.0002	-0.0013	0.0001	0.0001
c_{22}	0.0045	0.0062	-0.0056	0.0049	0.0058	-0.0069	0.0061	-0.0060	-0.0052
a_{11}	0.4419	0.5332	0.4805	0.1474	-0.4313	-0.2768	0.4303	-0.3913	0.4477
a_{21}	0.1565	-0.1777	-0.0472	-0.0323	-0.0391	0.0435	0.0936***	-0.0646	-0.0495***
a_{12}	-0.0075***	0.0109**	0.0396***	-0.3219***	0.0475**	0.0065	-0.1527***	0.0109*	-0.0511*
a_{22}	0.4511	0.3457	0.7084	-0.3174	0.4353	-0.6732	0.4391	0.3889	-0.643
b_{11}	-0.8716	-0.8291	-0.8596	-0.7351	-0.4237	0.0326	-0.8503	-0.1212	0.8194
b_{21}	0.1715	-0.0185	0.0777	0.7305***	0.3933***	-0.0351	0.2423***	-0.0674	-0.1044***
b_{12}	-0.0093	-0.0013	0.0617***	-0.5152***	0.0344	-0.0199	-0.0819***	0.1104**	-0.0611
b_{22}	0.7226	-0.0019	0.7177	-0.3377	-0.2086	-0.6357	-0.5047	0.1031	-0.7575
$Q_1(12)$	18.85	7.846	48.70	17.42	7.821	47.98	17.46	8.134	50.01
Covariance matrix									
$a_{11}a_{12}$	-0.0033	0.0058	0.0190	0.0474	0.0204	0.0017	-0.0657	-0.0156	-0.0228
$a_{21}a_{22}$	0.0705	-0.0614	-0.0334	0.0102	-0.0170	-0.0292	0.0410	-0.0251	0.0318
$a_{12}a_{21} + a_{11}a_{22}$	0.1981	0.1823	0.3385	-0.0363	-0.1896	0.1866	0.1746	-0.1547	-0.2853
$b_{11}b_{12}$	0.0081	0.0010	-0.0530	0.3787	-0.0145	-0.0006	0.0696	-0.0133	-0.0500
$b_{21}b_{22}$	0.1239	0.0000	0.0557	-0.2466	-0.0820	0.0223	-0.1222	-0.0069	0.0790
$b_{12}b_{21} + b_{11}b_{22}$	-0.6314	0.0015	-0.6121	-0.1281	0.1019	-0.0200	0.4093	-0.0199	-0.6143

Note: ***, **, * indicate statistical significance at the 1%, 5% and 10% levels, respectively.

Table 5.18: Spillover effect between Bahrain stock market sectors and WTI oil price for the two sub-periods 2010–mid-2014 and mid-2014–2017

Bahrain sectors with WTI	**Pre-2014**			**Post-2014**		
	BB & WTI	BS & WTI	BI & WTI	BB & WTI	BS & WTI	BI & WTI
Conditional variance equation						
c_{11}	0.0160	-0.0154	-0.0158	0.0262	0.0153	0.0252
c_{12}	0.0012	0.0006	0.0003	0.0005	0.0004	-0.0002
c_{22}	0.0000	-0.0045	0.0004	0.0061	0.0053	0.0136
a_{11}	0.28398	0.3875	0.3556	0.3631	0.4658	-0.4721
a_{21}	0.1922**	-0.5311***	-0.0161	-0.7047***	-0.2220	0.0667
a_{12}	-0.0356**	0.0123	-0.0346**	-0.0081	0.0284	0.0571
a_{22}	0.4145	0.3867	-0.7035	-0.4054	-0.3071	0.3712
b_{11}	0.0518	-0.1152	-0.0663	0.0230	0.1244	-0.0004
b_{21}	0.1554	0.0546	-0.0165	0.1303	3.4191	0.0004
b_{12}	-0.2274***	-0.2640***	-0.2325***	0.0004	-0.0035	0.0000
b_{22}	-0.7791	0.1284	-0.7682	-0.0030	-0.1227	-0.0001
Covariance matrix						
$a_{11}a_{12}$	-0.0101	0.0047	-0.0123	-0.1472	-0.1430	-0.1752
$a_{21}a_{22}$	0.0796	-0.2054	0.0113	0.2857	0.0681	0.0247
$a_{12}a_{21} + a_{11}a_{22}$	0.1108	0.1433	-0.2496	-0.1414	-0.1493	-0.1714
$b_{11}b_{12}$	-0.0117	0.0304	0.0154	0.00009	-0.0004	-0.00003
$b_{21}b_{22}$	-0.1211	0.0070	0.0126	-0.0004	-0.4196	-0.00006
$b_{12}b_{21} + b_{11}b_{22}$	-0.0757	-0.0292	0.0547	-0.00001	-0.0273	-0.00001

Note: ***, **, * indicate statistical significance at the 1%, 5% and 10% levels, respectively.

Table 5.19: Spillover effect between Bahrain stock market sectors and MSCI world index for the two sub-periods 2010–mid-2014 and mid-2014–2017

Bahrain sectors with MSCI	Pre-2014			Post-2014		
	BB & MSCI	BS & MSCI	BI & MSCI	BB & MSCI	BS & MSCI	BI & MSCI
Conditional variance equation						
c_{11}	0.0037	-0.0018	-0.0080	0.0039	0.0076	0.0072
c_{12}	0.0011	-0.0008	-0.0002	-0.0010	0.0001	0.0008
c_{22}	0.0066	-0.0064	-0.0040	0.0059	0.0054	0.0135
a_{11}	0.4782	-0.4621	-0.3426	0.4381	-0.2291	-0.4348
a_{21}	-0.0245	0.0587	-0.0039	-0.0708	-0.2501	0.0116
a_{12}	0.0923**	0.0482	0.0218	-0.1926***	-0.0254	0.1119
a_{22}	0.4627	0.3637	0.7482	-0.3446	0.3510	0.3392
b_{11}	-0.7919	-0.8373	0.3595	0.2296	-0.0001	-0.0017
b_{21}	-0.0624	0.3027***	-0.0773**	-0.8383**	-0.0032	0.0017
b_{12}	-0.0220	-0.0325	-0.0430	0.0624***	0.0002	0.0028
b_{22}	0.5260	-0.2020	-0.7531	-0.2278	0.0037	-0.0014
Covariance matrix						
$a_{11}a_{12}$	0.0441	-0.0223	-0.0074	-0.0844	0.0058	-0.0486
$a_{21}a_{22}$	-0.0113	0.0213	-0.0029	0.0244	-0.0878	0.0039
$a_{12}a_{21} + a_{11}a_{22}$	0.2190	-0.1652	-0.2564	-0.1373	-0.0740	-0.1462
$b_{11}b_{12}$	0.0174	0.02772	-0.0154	0.0143	-0.0003	-0.00005
$b_{21}b_{22}$	-0.0328	-0.0611	0.0582	0.1910	-0.00001	-0.00002
$b_{12}b_{21} + b_{11}b_{22}$	-0.4152	0.1593	-0.2674	-0.1046	-0.00001	-0.00007

Note: ***, **, * indicate statistical significance at the 1%, 5% and 10% levels, respectively.

Table 5.20: Spillover effect between Bahrain stock market sectors and ith MSCI world index for the two sub-periods 2010–mid-2014 and mid-2014–2017

Bahrain sectors with S&P 500	Pre-2014			Post-2014		
Conditional variance equation	BB & S&P 500	BS & S&P 500	BI & S&P 500	BB & S&P 500	BS & S&P 500	BI & S&P 500
c_{11}	0.0028	-0.0070	0.0036	0.0075	0.0074	0.0070
c_{12}	0.0001	0.0045	-0.0003	0.0001	0.0000	-0.0030
c_{22}	0.0082	0.0016	-0.0041	-0.0064	-0.0052	0.0098
a_{11}	0.4903	0.1626	0.4541	-0.5677	-0.5500	0.5826
a_{21}	0.0054	-0.6661***	0.0395*	-0.0990	-0.1154	-0.0977***
a_{12}	-0.0696	0.0802***	0.0453*	0.0685	0.0777**	0.1246
a_{22}	0.4573	0.2408	0.7403	0.3059	0.3887	0.3399
b_{11}	-0.8197	-0.1994	0.8125	0.0169	0.0804	-0.2500
b_{21}	-0.1709***	0.9709***	-0.0203	0.0118	0.1102	0.0731
b_{12}	-0.0499	-0.1931***	-0.0244	-0.0130	-0.0525**	-0.8655***
b_{22}	0.2124	0.5834	-0.7448	-0.0094	-0.0929	0.2571
Covariance matrix						
$a_{11}a_{12}$	-0.0341	0.0130	0.0205	-0.0389	-0.0427	0.0726
$a_{21}a_{22}$	0.0025	-0.1604	0.0293	-0.0303	-0.0448	-0.0332
$a_{12}a_{21} + a_{11}a_{22}$	0.2239	-0.0142	0.3379	-0.1805	-0.2227	0.1858
$b_{11}b_{12}$	0.0409	0.0385	-0.0198	-0.0002	-0.0042	0.2164
$b_{21}b_{22}$	-0.0363	0.5664	0.0151	-0.0001	-0.0102	0.0188
$b_{12}b_{21} + b_{11}b_{22}$	-0.1656	-0.3039	-0.6047	-0.0003	-0.0132	-0.1276

Note: ***, **, * indicate statistical significance at the 1%, 5% and 10% levels, respectively.

5.7.1.6 *Oman Stock Market*

The relationships between the Oman stock market sectors and WTI oil price, MSCI world index and S&P 500 are analysed here. The conditional variance–covariance equation is applied to capture the volatility and cross-volatility spillover among them. Table 5.21 presents the results from the GARCH-BEKK model for the three selected sectors of the Oman stock market: the bank, service and industrial sectors. To check the properties of the model, a Q-statistic test is used; the standard residuals and square standard residuals are not significant, implying that the BEKK model is adequate. According to the mean equation coefficients r_{21}there are no significant signs of the return of WTI on the Oman stock market sectors. However, there is a significant positive effect by one lag period of Oman stock market sectors from MSCI and S&P 500 indices. According to the variance equation result, the coefficients of $a_{11}, a_{22}, b_{11} and\ b_{22}$ are significant at the 1% level, which indicates that the volatility of WTI oil price, MSCI world index, S&P 500 index and the Oman stock market sectors are affected by their own past shocks and their own past volatility. Moreover, the variance equation results show a significant unidirectional shock spillover effect from the Oman bank sector to WTI. There is no significant sign of shock and volatility spillover from the bank sector to the MSCI index. However, the Oman bank sector shows unidirectional shocks and volatility spillover with S&P 500. The services sector shows a unidirectional significant sign of shock transmission with WTI and MSCI but there is no significant sign with the S&P 500 index. Oman's industrial sector shows a significant bidirectional sign of volatility transmission with WTI and a unidirectional sign with the MSCI index. There is no shock spillover effect between Oman industrial sector and S&P 500 index.

The covariance matrix for the Oman stock market sectors with the WTI, MSCI and S&P 500 is used to interpret the model parameter estimation. Regarding the effect of shocks in mean equations, the negative $a_{11}a_{12}$of the Oman industrial sector with WTI shows that shocks to the WTI have a negative effect on this sector and WTI return covariance in the next period (–0.0008). Further, a negative sign for $a_{21}a_{22}$ shows that shocks to the sector negatively affect the two variables' covariance in the next period, which is seen for the Oman bank, services and industrial sectors with WTI (–0.0852, –0.1244 and –0.0287, respectively); the services and industrial sectors with MSCI (–0.0130, –0.0300); and the bank and services sectors with S&P 500 (–0.0341 and –0.0350). With regard to the effects of variance–covariance, the negative signs of $b_{11}b_{12}$ for the Oman services sector with WTI, MSCI and S&P 500 and the Oman bank sector with S&P 500 implies that an increase in WTI, MSCI and S&P 500 return variance has a negative effect on the next day's two-asset return covariance. Further, the negative signs for $b_{21}b_{22}$ for the Oman bank and services sectors with WTI and the Oman industrial sector with S&P 500 indicate that an increase in sector variance has a negative effect on the two-asset return covariance (–0.0174, –0.0438, –0.0051, respectively).

Table 5.22 presents the analysis of the two sub-periods to investigate volatility spillover between the WTI and Oman stock market sectors. The variance equations show that the current conditional volatility of the WTI and the Oman sectors are determined by their own past shocks a_{11} and a_{22} and their own past volatility b_{11} and b_{22}. In regard to volatility spillover, the Oman bank sector has a significant unidirectional effect of shocks and a bidirectional volatility spillover from WTI pre-2014, but not post-2014. The Oman services sector shows a significant bidirectional effect of shocks and volatility spillover pre-2014. However, post-2014 the volatility spillover effect becomes unidirectional from the sector while the shock spillover remains a bidirectional effect. Further, the Oman industrial sector shows a significant unidirectional effect of shocks and volatility spillover from WTI pre-2014; this effect is present also post-2014 for shock spillover.

Table 5.23 presents the result for the Oman sectors and MSCI World index for the pre- and post-2014 periods. The variance equation shows that the current conditional volatilities of the Oman sectors and MSCI are determined by their own past shocks a_{11} and a_{22} and their own past volatility b_{11} and b_{22}. The Oman bank sector does not show any significant effect of shocks and volatility spillover with MSCI in either period. However, the services sector shows a significant unidirectional sign of volatility spillover from MSCI pre-2014 (0.1191) but not post-2014. The industrial sector has a strong bidirectional sign for shock and volatility spillover with MSCI pre-2014; while post-2014 there is no such effect. Table 5.24 shows the results for the Oman sectors and the S&P 500 US index. The current conditional volatilities of the S&P 500 and Oman sectors are determined by their own past shocks a_{11} and a_{22} and their own past volatility b_{11} and b_{22}. The Oman bank sector shows a significant sign of volatility spillover from S&P 500 pre-2014 (0.3361) but post-2014 there is such effect. The services sector has bidirectional shock and volatility spillover with S&P 500 pre-2014, but this effect becomes unidirectional from S&P 500 for shock spillover post-2014. The Oman industrial sector shows a unidirectional effect of shock and volatility spillover from S&P 500 pre-2014. Post-2014 the shock spillover from S&P 500 remains significant but is now negative (–0.0652).

Overall, Oman sectors are strongly affected by oil prices pre-and post-2014, except that the bank sector does not show a significant sign with oil post-2014. However, the Oman sectors do not show any significant sign with the MSCI index other than that the industrial sector has a significant bidirectional result with MSIC pre-2014. The Oman sectors show a significant result with the S&P 500 index in both periods but this effect becomes insignificant for the bank sector post-2014.

Table 5.21: Spillover effect between Oman stock market sectors and WTI, MSCI and S&P 500 for the period 2010–17

MSM	OB & WTI	OS & WTI	OI & WTI	OB & MSCI	OS & MSCI	OI & MSCI	OB & S&P 500	OS & S&P 500	OI & S&P 500
Conditional mean equation									
r_{11}	0.0001	0.0001	3.20E-05	0.0001	5.66E-05	-2.54E-05	0.0001	0.0001	2.27E-05
r_{12}	0.0019	0.0090**	0.0073*	-0.0050	0.0090	0.0106	0.0185	0.0041	-0.0032
r_{21}	0.0003	0.0002	0.0003	0.0005***	0.0004**	0.0004***	0.0007***	0.0007***	0.0007***
r_{22}	-0.0619***	-0.0641**	-0.0687***	0.0924***	0.0964***	0.0920***	-0.0962***	-0.0780***	-0.0810***
Conditional variance equation									
c_{11}	-0.0053	-0.0047	-0.0029	0.0031	-0.0083	-0.0084	-0.0092	-0.0093	-0.0035
c_{12}	-0.0004	-0.0032	0.0045	0.0001	0.0000	0.0003	0.0004	-0.0000	0.0007
c_{22}	-0.0039	-0.00023	-0.0001	-0.0034	-0.0025	-0.0028	-0.0031	-0.0030	-0.0026
a_{11}	0.4394	0.4305	0.4367	0.3996	-0.3882	0.3196	0.2888	-0.3671	-0.4122
a_{21}	0.1350***	0.1983**	0.0433	0.0124	0.0212	-0.0441	-0.0541	-0.0499	0.0517
a_{12}	0.015	0.0042	-0.002	0.0188	-0.0316*	-0.0168	-0.0457*	-0.0023	-0.0081
a_{22}	-0.6312	-0.6278	-0.6638	0.6647	-0.6171	0.6818	0.6314	0.7034	0.6314
b_{11}	0.868	-0.8773	-0.8883	0.8426	0.0804	-0.0824	0.0743	0.1528	-0.8299
b_{21}	0.02635	-0.0778	0.5248***	-0.0232	-0.1112	0.1826***	-0.1410***	0.0747	0.0075
b_{12}	0.0300	0.0151	-0.0384***	0.0131	-0.0192	-0.0391	-0.0488	-0.0288	-0.0341
b_{22}	-0.6616	0.5631	0.2509	-0.7017	-0.6689	0.6213	-0.7177	0.5383	-0.6881
$Q_1(12)$	12.45	25.98	24.68	12.80	26.26	24.21	13.00	26.19	24.86
Covariance matrix									
$a_{11}a_{12}$	0.0065	0.0018	-0.0008	0.0075	0.0122	-0.0053	-0.0131	0.0008	0.0033
$a_{21}a_{22}$	-0.0852	-0.1244	-0.0287	0.0082	-0.0130	-0.0300	-0.0341	-0.0350	0.0326
$a_{12}a_{21} + a_{11}a_{22}$	-0.2753	-0.2694	-0.2899	0.2658	0.2388	0.2186	0.1848	-0.2581	-0.2606
$b_{11}b_{12}$	0.0260	-0.0132	0.0341	0.0110	-0.0015	0.0032	-0.0036	-0.0044	0.0282
$b_{21}b_{22}$	-0.0174	-0.0438	0.1316	0.0162	0.0734	0.1134	0.1011	0.0402	-0.0051
$b_{12}b_{21} + b_{11}b_{22}$	-0.5734	-0.4951	-0.2430	-0.5915	-0.0516	-0.0583	-0.0464	0.0801	0.5707

Note: ***, **, * indicate statistical significance at the 1%, 5% and 10% levels, respectively.

Table 5.22: Spillover effect between Oman stock market sectors and WTI oil price for the two sub-periods 2010–mid-2014 and mid-2014–2017

Oman sectors with WTI	**Pre-2014**			**Post-2014**		
Conditional variance equation	OB & WTI	OS & WTI	OI & WTI	OB & WTI	OS & WTI	OI & WTI
c_{11}	-0.0054	-0.0158	-0.0108	-0.0263	-0.0254	-0.0258
c_{12}	0.0061	0.0001	0.0033	-0.0003	0.0002	-0.0004
c_{22}	0.0000	0.0001	0.0000	0.0040	0.0026	0.0034
a_{11}	-0.4628	-0.2524	-0.4448	0.3813	0.3904	-0.4902
a_{21}	-0.3295***	-0.5938***	-0.4987	-0.0044	-0.5769*	0.1758
a_{12}	-0.0107	-0.0135*	0.0122***	0.0165	-0.0148*	0.0299**
a_{22}	0.5096	0.6450	0.4883	-0.7583	-0.7063	0.8397
b_{11}	-0.8078	0.1403	-0.6107	0.0106	0.2090	0.0111
b_{21}	0.3793***	-0.3459**	0.1041	-0.0907	-1.1002*	-0.0629
b_{12}	-0.1757***	0.2011***	-0.2401***	0.0266	-0.0189	0.0084
b_{22}	0.0824	-0.5220	0.0422	-0.6192	-0.5685	0.3101
Covariance matrix						
$a_{11}a_{12}$	0.0049	0.0034	-0.0054	-0.2891	-0.2758	-0.4117
$a_{21}a_{22}$	-0.1679	-0.3830	-0.2435	0.0033	0.4075	0.1476
$a_{12}a_{21} + a_{11}a_{22}$	-0.2323	-0.1547	-0.2233	-0.2892	-0.2672	-0.4064
$b_{11}b_{12}$	0.1419	0.0282	0.1466	0.0002	-0.0039	0.00009
$b_{21}b_{22}$	0.0312	0.1806	0.0043	0.0562	0.6254	-0.0195
$b_{12}b_{21} + b_{11}b_{22}$	-0.1333	-0.1428	-0.0508	-0.0090	-0.0979	0.0029

Note: ***, **, * indicate statistical significance at the 1%, 5% and 10% levels, respectively.

Table 5.23: Spillover effect between Oman stock market sectors and MSCI world index for the two sub-periods 2010–mid-2014 and mid-2014–2017

Oman sectors with MSCI	**Pre-2014**			**Post-2014**		
	OB & MSCI	OS & MSCI	OI & MSCI	OB & MSCI	OS & MSCI	OI & MSCI
Conditional variance equation						
c_{11}	-0.0034	-0.0086	-0.0001	-0.0071	-0.0072	-0.0073
c_{12}	0.0010	0.0002	0.0000	-0.0003	-0.0001	0.0000
c_{22}	0.0065	-0.0032	0.0038	0.0042	-0.0025	-0.0034
a_{11}	-0.4486	-0.2762	0.3070	0.4670	0.4056	0.4098
a_{21}	-0.0161	0.0018	-0.1925***	-0.0230	-0.0864	-0.0038
a_{12}	-0.0161	-0.0027	-0.1406***	-0.0130	0.0156	-0.0377
a_{22}	-0.5517	-0.7060	-0.4043	0.7611	0.7388	0.8061
b_{11}	-0.8142	0.2853	-0.8923	-0.0870	-0.1184	0.0146
b_{21}	-0.0368	-0.1711	0.4950***	0.0229	-0.0501	-0.0748
b_{12}	-0.0731	0.1191***	-0.1263***	-0.0100	0.0423	0.0685
b_{22}	-0.0032	-0.4354	-0.5677	0.5945	-0.5812	-0.3622
Covariance matrix						
$a_{11}a_{12}$	0.0072	0.0007	-0.0431	-0.0061	0.0063	-0.0154
$a_{21}a_{22}$	0.0089	-0.0012	0.0778	-0.0175	-0.0638	-0.0031
$a_{12}a_{21} + a_{11}a_{22}$	0.2477	0.1950	-0.0970	0.3557	0.2983	0.3305
$b_{11}b_{12}$	0.0595	0.0340	0.1127	0.0008	-0.0050	0.0010
$b_{21}b_{22}$	0.0001	0.0745	-0.2810	0.0136	0.0291	0.0271
$b_{12}b_{21} + b_{11}b_{22}$	0.0053	-0.1446	0.4440	-0.0520	0.0667	-0.0104

Note: ***, **, * indicate statistical significance at the 1%, 5% and 10% levels, respectively.

Table 5.24: Spillover effect between Oman stock market sectors and S&P 500 US index for the two sub-periods 2010–mid-2014 and mid-2014–2017

Oman sectors with S&P 500	Pre-2014			Post-2014		
	OB & S&P 500	OS & S&P 500	OI & S&P 500	OB & S&P 500	OS & S&P 500	OI & S&P 500
Conditional variance equation						
c_{11}	0.0075	0.0083	-0.0035	-0.0080	-0.0083	-0.0080
c_{12}	0.0026	-0.0013	-0.0009	0.0002	0.0009	-0.0002
c_{22}	-0.0034	-0.0022	0.0036	0.0041	-0.0014	-0.0035
a_{11}	-0.3610	0.2011	0.4346	0.4986	0.3324	0.5005
a_{21}	0.0412	-0.3306***	-0.2232	0.0043	0.0212	0.0396
a_{12}	0.0450	-0.0970***	0.0478***	-0.0617	-0.0430*	-0.0652***
a_{22}	0.5746	0.5989	-0.6450	0.7338	0.6458	0.7701
b_{11}	-0.5504	0.2468	-0.8224	0.0028	0.1140	-0.0026
b_{21}	0.1237	-0.8492***	0.0339	0.0341	-0.5762***	0.0157
b_{12}	0.3361***	0.2946***	0.0628***	0.0835	0.1135***	-0.0156
b_{22}	0.4254	-0.3052	0.5109	0.6271	-0.7007	0.3886
Covariance matrix						
$a_{11}a_{12}$	-0.0162	-0.0195	0.0207	-0.0307	-0.0143	-0.0326
$a_{21}a_{22}$	0.0237	-0.1980	0.1440	0.0031	0.0137	0.0305
$a_{12}a_{21} + a_{11}a_{22}$	-0.2056	0.1525	-0.2910	0.3656	0.2137	0.3829
$b_{11}b_{12}$	-0.1850	0.0727	-0.0516	0.0002	0.0129	0.00004
$b_{21}b_{22}$	0.0526	0.2592	0.0173	0.0214	0.4038	0.0061
$b_{12}b_{21} + b_{11}b_{22}$	-0.1926	-0.3255	-0.4181	0.0046	-0.1453	-0.0012

Note: ***, **, * indicate statistical significance at the 1%, 5% and 10% levels, respectively.

5.7.1.7 Kuwait Stock Market

Volatility transmission between the selected Kuwait stock market sectors and WTI oil price, MSCI World index and S&P 500 US index is examined in this section. Table 5.25 presents the result from the GARCH-BEKK model for the three sectors of the Kuwait stock market—bank, services and industrial sectors—with WTI, MSCI and S&P 500. First, to check the properties of the model the Q-statistic test is applied and the results show the standard residuals are not significant, which means that the BEKK model is adequate to use. Considering now the mean equation, there is no significant sign of the return of WTI on Kuwait stock market sectors as shown by the coefficient of r_{21}. However, there is significant positive effect by one lag period of the Kuwait services and industrial sectors from MSCI and S&P 500 index. According to the results for the variance equation, the coefficients a_{11}, a_{22}, b_{11} *and* b_{22} are significant at the 1% level, indicating that the volatility of WTI, MSCI, S&P 500 and Kuwait stock market sectors is affected by own past shocks and volatility. The results for volatility transmission show that the Kuwait bank sector has a positive significant sign of volatility spillover from two directions. Further, there is evidence for unidirectional shock transmission from the MSCI index while the Kuwait bank sector has unidirectional shock and volatility spillover from the S&P 500 index. The services sector has a significant unidirectional effect of shocks to oil from the sector (–0.2384) and there is a unidirectional significant effect of shock and volatility spillover to MSCI from the sector. However, there is no significant sign with the S&P 500 index. The Kuwait industrial sector experiences bidirectional shock spillover with WTI oil price (0.2705, 0.0431). There is a significant bidirectional sign of shock spillover with MSCI and unidirectional volatility spillover from the industrial sector, but no significant sign with the S&P 500 index.

The covariance matrix for the Kuwait stock market sectors with the WTI, MSCI and S&P 500 is examined to interpret the model parameter estimation. According to the shocks in the mean equation, the negative sign of the coefficients $a_{11}a_{12}$ *and* $a_{21}a_{22}$ for the Kuwait sectors and oil means that shocks to any of them have a negative effect on the next-day return covariance. For example, shocks to the Kuwait bank sector have a negative effect on the next-day MSCI covariance (–0.0227). In addition, the negative sign of the coefficient of $b_{11}b_{12}$ *and* $b_{21}b_{22}$ for the Kuwait bank sector and oil indicates that an increase in the return variance has a negative impact on the next day's two-asset return covariance.

Table 5.26 presents the results for analysis of the Kuwait sectors and WTI oil price for the two periods, pre-and post-2014. The variance equations show that the current conditional volatilities of the WTI and the Kuwait sectors are determined by their own past shocks a_{11} *and* a_{22} and their own past volatility b_{11} *and* b_{22}. In regard to volatility spillover, Kuwait bank sector has a significant unidirectional effect of volatility spillover from WTI in both periods, with a higher coefficient post-2014 period (0.1564). The services sector shows a unidirectional effect of shock spillover pre-2014 and a unidirectional effect of volatility spillover in post-2014 period. However, the industrial sector does not present a significant sign with WTI oil price in either period.

The results for the Kuwait sectors and MSCI World index pre-and post-2014 are presented in Table 5.27. As mentioned previously, the variance equations show that the current conditional volatility of the Kuwait sectors and MSCI are determined by their own past shocks a_{11} *and* a_{22} and their own past volatility b_{11} *and* b_{22}. Further, the Kuwait bank sector shows a unidirectional shock spillover in both periods with a higher coefficient in post-2014 (–0.0887) period. Also, there is bidirectional volatility spillover pre-2014 but this effect becomes insignificant post-2014. The Kuwait services sector does not present any significant sign of shock and volatility spillover with MSCI pre-2014 but post-2014 there is unidirectional shock spillover from the MSCI world index (–0.2185). The Kuwait industrial sector shows a significant unidirectional sign of shock spillover from the MSCI world index and a significant bidirectional effect of volatility spillover with the MSCI world index pre-2014 period; however, post-2014 period, there is no significant sign of shock or volatility spillover.

Table 5.28 presents the results for analysis of the Kuwait sectors and S&P 500 US index. The current conditional volatility of the S&P 500 and Kuwait sectors are determined by their own past shocks a_{11} *and* a_{22} and their own past volatility b_{11} *and* b_{22}. The Kuwait bank sector shows a unidirectional effect of shock and volatility spillover from the S&P 500 pre-214 (–0.2788, –0.0479, respectively). Post-2014, shock spillover is in the same direction of, but volatility spillover becomes bidirectional. The Kuwait services sector shows unidirectional shock spillover from the S&P 500 and bidirectional volatility spillover post-2014; however pre-2014 there is no significant sign. The industrial sector does not show any significant sign of shock and volatility spillover with the S&P 500 in either period.

To summarise, the Kuwait bank and services sectors experience a significant effect of shock and volatility spillover with WTI both pre-and post-2014. Also, the Kuwait sectors have many directional effects of shock and volatility with the MSCI index in both periods, except for the Kuwait services sector pre-2014, The bank and services sectors have significant transmission with S&P 500 in both periods (except for services pre-2014) with high coefficients post-2014. The industrial sector does not show any significant spillover effects with the WTI oil price and S&P 500 index but there is a significant sign of shock and volatility spillover with the MSCI index pre-2014.

Table 5.25: Spillover effect between Kuwait stock market sectors and WTI, MSCI and S&P 500 for the period 2010–17

KSE	KB & WTI	KS & WTI	KI & WTI	KB & MSCI	KS & MSCI	KI & MSCI	KB & S&P 500	KS & S&P 500	KI & S&P 500
Conditional mean equation									
r_{11}	1.84E-05	-5.34E-06	0.0003**	-5.64E-05	-4.83E-05	0.0003	-4.97E-05	-1.17E-05	0.0003
r_{12}	0.0014	0.0004	0.0054	0.0158	-0.0087	-0.0147	-0.0073	-0.0022	0.0157
r_{21}	0.0001	7.63E-05	-2.16E-05	0.0003*	0.0004**	0.0003*	0.0006***	0.0006***	0.0006***
r_{22}	-0.0695**	-0.0683**	-0.0740**	0.1319***	0.1265***	0.1187***	-0.0515*	-0.0587*	-0.0643**
Conditional variance equation									
c_{11}	-0.0051	-0.0041	-0.0046	0.0071	0.0061	-0.0058	0.0071	-0.0068	-0.0068
c_{12}	0.0052	0.0002	-0.0010	0.000	-0.0001	-0.0004	0.0017	-0.0001	0.0000
c_{22}	0.0004	-0.0070	0.0065	0.0024	-0.0069	-0.0063	0.0031	-0.0071	0.0066
a_{11}	0.4986	0.5766	-0.5578	0.2471	0.3796	-0.3276	0.4024	-0.5135	-0.5192
a_{21}	0.1284	-0.2384***	0.2705***	-0.0439	0.1268**	-0.1181*	0.1198	-0.0906	0.0745
a_{12}	-0.0083	-0.0001	0.0431**	-0.0368	-0.0671	0.2315***	-0.0419**	0.007	0.0266
a_{22}	-0.5423	0.0591	-0.1522	0.5174	0.0961	0.2312	0.4814	0.0778	-0.0878
b_{11}	-0.8523	-0.8192	-0.8281	0.1733	0.132	0.0965	-0.1711	-0.2454	0.154
b_{21}	-0.1987*	-0.205	0.0945	-0.0902	-0.3958***	-0.5414***	-0.2887	-0.0265	-0.2251
b_{12}	0.0136***	-0.0151	-0.02	0.6162***	0.0270	0.0104	0.3501***	-0.0656	0.0498
b_{22}	0.0433	-0.0178	0.0019	-0.3267	-0.1276	-0.0956	0.5321	0.004	-0.0718
$Q_1(12)$	26.97	24.01	18.91	27.21	24.18	19.13	26.55	24.20	18.96
Covariance matrix									
$a_{11}a_{12}$	-0.0041	-0.00005	-0.0240	-0.0090	-0.0254	-0.0758	-0.0168	-0.0035	-0.0138
$a_{21}a_{22}$	-0.0696	-0.0140	-0.0411	-0.0227	0.0121	-0.0273	0.0576	-0.0070	-0.0065
$a_{12}a_{21} + a_{11}a_{22}$	-0.2714	0.0341	0.0965	0.1294	0.0279	-0.1030	0.1886	-0.0405	0.0475
$b_{11}b_{12}$	-0.0115	0.0123	0.0165	0.1067	0.0035	0.0010	-0.0599	0.0160	0.0076
$b_{21}b_{22}$	-0.0086	0.0036	0.0001	0.0294	0.0505	0.0517	-0.1536	-0.0001	0.0161
$b_{12}b_{21} + b_{11}b_{22}$	-0.0396	0.0176	-0.0034	-0.1121	-0.0275	-0.0148	-0.1921	0.0007	-0.0222

Note: ***, **, * indicate statistical significance at the 1%, 5% and 10% levels, respectively.

Table 5.26: Spillover effect between Kuwait stock market sectors and WTI oil price for the two sub-periods 2010–mid-2014 and mid-2014–2017

Kuwait sectors with WTI	Pre-2014			Post-2014		
	KB & WTI	KS &WTI	KI &WTI	KB & WTI	KS &WTI	KI &WTI
Conditional variance equation						
c_{11}	0.0119	-0.0097	0.013	-0.0214	0.0078	-0.0227
c_{12}	0.0007	0.0000	0.0003	-0.0034	-0.0039	0.0003
c_{22}	-0.0060	0.0073	0.0057	0.0000	-0.0048	0.0069
a_{11}	0.5583	0.6180	0.4758	0.3369	-0.6158	-0.5421
a_{21}	-0.4840	-0.6312***	0.0409	0.0235	-0.0355	0.2538
a_{12}	-0.0267	0.0266	0.0175	0.0082	0.0245	0.0230
a_{22}	0.1145	-0.0055	-0.3361	0.6035	0.1228	-0.0126
b_{11}	0.1599	0.4013	-0.0033	-0.5223	-0.3406	-0.2133
b_{21}	-0.0958	0.1115	0.0066	-0.7670	3.1734***	0.6599
b_{12}	-0.0830***	-0.0347	-0.0022	0.1564***	-0.0378	-0.0635
b_{22}	0.0386	-0.0264	0.0009	0.2285	0.3624	0.2070
Covariance matrix						
$a_{11}a_{12}$	-0.0149	0.0164	0.0083	0.2033	-0.0756	0.0068
$a_{21}a_{22}$	-0.0554	0.0035	-0.0137	0.0142	-0.0043	-0.0032
$a_{12}a_{21} + a_{11}a_{22}$	0.0769	-0.0202	-0.1592	0.2035	-0.0765	0.0126
$b_{11}b_{12}$	-0.0132	-0.0139	0.0000	-0.0817	0.0128	0.0135
$b_{21}b_{22}$	-0.0037	-0.0029	0.0000	-0.1752	1.1501	0.1366
$b_{12}b_{21} + b_{11}b_{22}$	0.0141	-0.0145	0.0000	-0.2394	-0.2434	-0.0861

Note: ***, **, * indicate statistical significance at the 1%, 5% and 10% levels, respectively.

Table 5.27: Spillover effect between Kuwait stock market sectors with MSCI world index for the two sub-periods 2010–mid-2014 and mid-2014–2017

Kuwait sectors with MSCI	**Pre-2014**			**Post-2014**		
	KB & MSCI	KS & MSCI	KI & MSCI	KB & MSCI	KS & MSCI	KI & MSCI
Conditional variance equation						
c_{11}	0.0062	0.0069	0.0069	-0.0076	-0.0069	-0.0078
c_{12}	0.0025	0.0000	-0.0001	-0.0004	-0.0005	0.0000
c_{22}	0.0020	0.0071	0.0054	-0.0055	-0.0068	0.0071
a_{11}	-0.0325	0.0046	-0.0217	-0.2911	-0.4528	0.0882
a_{21}	-0.1782	0.1298	-0.0210	-0.0561	-0.2185***	-0.1558
a_{12}	0.1083**	-0.0140	0.1703***	-0.0887*	0.0097	0.0431
a_{22}	-0.2610	0.1249	0.3771	0.6068	0.1085	-0.3547
b_{11}	-0.3805	-0.0241	-0.0384	-0.0300	0.0004	-0.0174
b_{21}	-0.2409*	0.0023	-0.1060***	0.0021	0.0002	0.0024
b_{12}	0.5975***	-0.0750	-0.0271*	-0.1954	0.0002	0.0263
b_{22}	0.3801	0.0534	-0.0836	0.0328	0.0010	-0.0120
Covariance matrix						
$a_{11}a_{12}$	-0.0035	0.0000	-0.0036	0.0258	-0.0043	0.0038
$a_{21}a_{22}$	0.0465	0.0162	-0.0079	-0.0340	-0.0237	0.0552
$a_{12}a_{21} + a_{11}a_{22}$	-0.0108	-0.0012	-0.117	-0.1717	-0.0512	-0.0380
$b_{11}b_{12}$	-0.2273	0.0018	0.0010	0.0058	0.0000	-0.0004
$b_{21}b_{22}$	-0.0916	0.0001	0.0088	0.0000	0.0000	0.0000
$b_{12}b_{21} + b_{11}b_{22}$	-0.2886	-0.0014	0.0060	-0.0014	0.0000	0.0002

Note: ***, **, * indicate statistical significance at the 1%, 5% and 10% levels, respectively.

Table 5.28: Spillover effect between Kuwait stock market sectors and S&P 500 US index for the two sub-periods 2010–mid-2014 and mid-2014–2017

Kuwait sectors with S&P 500	Pre-2014			Post-2014		
	KB & S&P 500	KS & S&P 500	KI & S&P 500	KB & S&P 500	KS & S&P 500	KI & S&P 500
Conditional variance equation						
c_{11}	0.0069	0.0074	0.0073	-0.0065	-0.0061	-0.0074
c_{12}	0.0003	0.0001	0.0000	-0.0021	0.0014	-0.0001
c_{22}	0.0062	0.0071	0.0057	-0.0040	-0.0057	0.0074
a_{11}	0.3024	-0.0832	0.1852	-0.4803	-0.5508	0.5820
a_{21}	-0.2788**	0.0748	0.0329	-0.1711***	-0.2892***	-0.0652
a_{12}	0.0778	-0.1989	-0.0311	0.0316	0.0284	-0.0016
a_{22}	0.0041	-0.0127	0.3806	-0.5661	0.0653	0.0004
b_{11}	-0.0609	-0.0014	0.0000	0.3653	-0.1331	0.0000
b_{21}	-0.0479*	-0.0006	0.0000	0.4162***	0.4665**	0.0000
b_{12}	-0.0412	0.0106	0.0000	-0.3079***	-0.2112*	.00000
b_{22}	-0.0227	-0.0026	0.0000	-0.3590	0.4606	0.0000
Covariance matrix						
$a_{11}a_{12}$	0.0235	0.0165	-0.0057	-0.0151	-0.0156	-0.0009
$a_{21}a_{22}$	-0.0011	-0.0009	0.0125	0.0968	-0.0189	0.0000
$a_{12}a_{21} + a_{11}a_{22}$	-0.0204	-0.0138	0.0694	0.2665	-0.0442	0.00003
$b_{11}b_{12}$	0.0025	0.0000	0.0000	-0.1125	0.0281	0.0000
$b_{21}b_{22}$	0.0010	0.0000	0.0000	-0.1494	0.2149	0.0000
$b_{12}b_{21} + b_{11}b_{22}$	0.0033	0.0000	0.0000	-0.2593	-0.1599	0.0000

Note: ***, **, * indicate statistical significance at the 1%, 5% and 10% levels, respectively.

5.7.2 Optimal Portfolio Weights and Hedge Ratios

The empirical results presented above provide evidence for volatility transmission among the selected GCC stock market sectors and the oil market, which calls for an investigation of the implications of such results for portfolio design through the optimal weight and hedge ratios of oil and stock holdings. In this context, investors aim to minimise the risk of portfolios composed of oil and stock indices, without reducing the expected returns to hedge exposure to oil price movements.

The estimated results for the optimal weight and hedge ratio for each oil stock portfolio are shown in Table 5.29. For the Saudi sectors, the results indicate that the bank sector has the highest optimal weight pre-2014. However, the estimated optimal weight differs post-2014 for this sector. The optimal weight decreases for the bank sector post-2014 but increases for the real estate and retail sectors. For example, the optimal weight holding of oil in $1,000 of oil–bank sector portfolio is $906, compared with US$94 for the bank sector pre-2014; whereas post-2014 the optimal weight holding of oil decreases to $235, in $1,000 of oil–bank portfolio. The optimal weight holding of oil in $1,000 of oil–real estate and oil–retail portfolio is $222 and $101 respectively, compared with $778 and $899 for the real estate and retail sectors pre-2014. However, the optimal weight holding for oil post-2014 changes to $328 and $222 of oil–real estate and oil–retail portfolio. The bank sector has the highest ratio (95%) pre-2014, while real estate and retail have 56% and 80% respectively. However, post-2014 the highest hedge ratio is in the real estate sector (48%) and the lowest is in the bank sector (27%). The results show that $1,000 long in oil should be shortened by $950 of bank sector pre-2014; while post-2014, $1,000 long in oil should be shortened by $276 of the bank sector.

The results for Abu Dhabi sectors show that the optimal weight varies from 17% for the bank sector to 61% for the real estate sector, pre-2014. These outcomes suggest that the optimal holding of oil in $1,000 of oil–real estate sector portfolio is $612, compared with $388 for the real estate sector. Post-2014 the optimal holding for the real estate sector in $1,000 increases to $609, compared with $391 for oil stocks. The highest hedge ratio is in the real estate sector (100%) and the lowest in the bank sector (38%) pre-2014. Post-2014 real estate also presents the highest hedge ratio (39%) but this is less than pre-2014.

The optimal weight for Dubai sectors has a high value of 80% in the services sector and the lowest value of 6% in the real estate sector pre-2014. However, in post-2014 period, the estimate of the optimal weight changed to become for banks and services sectors while the real estate sectors become higher. For example, the optimal weight holding of oil in $1,000 of oil–bank sector portfolio is $319, compared with $681 for the bank sector pre-2014. Post-2014 the optimal weight holding of oil decreases to $252, in $1,000 of oil–bank portfolio. The bank sector has the highest ratio (63%) pre-2014, while the real estate and services sectors have the lowest (14% and 35%, respectively). However, post-2014 the highest hedge ratio is in the services sector (61%) and the lowest in banks (39%).

The results of Qatar sectors show that bank sector has a higher optimal weight (37%) pre-2014 period compared to in post-2014 period. However, the estimated results for optimal weights decrease in post-2014. The optimal weight holdings of oil in $1,000 of oil–bank, oil–real estate and oil–services sector portfolios are $371, $244 and $161 respectively, compared with $629 for bank, $756 for real estate and $839 for services sectors pre-2014. In post-2014, the optimal weight for investing in the sector stocks is higher. The bank sector has the highest ratio (54%) in pre-2014 period; the real estate and services sectors have 38% and 26%, respectively. However, in post-2014 period, the hedge ratio becomes lower for all Qatar sectors: bank (33%), real estate (28%) and services (21%).

The optimal weight for Bahrain sectors ranges from 55% for the bank sector to 31% for the industrial sector in pre-2014 period. However, in post-2014 period, the optimal weight decreases for all Bahrain sectors: for example, the optimal weight holding of oil in $1,000 of oil–bank sector portfolio is $469, compared with $531 for the bank sector pre-2014. However, post-2014 the optimal weight holding of oil in $1,000 of oil–bank sector portfolio decreases to $381. The highest hedge ratio is in the services sector (56%) and the lowest in the industrial sector (7%) pre-2014. However, post-2014 the bank has the highest hedge ratio (53%).

The optimal weights for the Oman sectors show that pre-2014 the optimal weight has a higher value than post-2014. For example, the optimal weight holdings of oil in $1,000 of oil–bank, oil–services and oil–industrial sector portfolios are $597, $643 and $252 respectively, compared with $403 for banks, $357 for services and $748 for industrial sectors pre-2014. Post-2014 the optimal weight holdings of oil decrease to $402, $591 and $194 respectively. Further, the highest hedge ratio is shown for the bank sector (78%)

pre-2014, while the services and industrial sectors have 16% and 37%, respectively. However, post-2014 the hedge ratio decreases for all Oman sectors: bank (65%), services (13%) and industrial (17%).

The Kuwait sector results show that the optimal weight ranges from 49% for the bank sector to 68% for the industrial sector pre-2014; these optimal weights decline post-2014. The results suggest that the optimal pre-2014holding of oil in $1,000 of oil–bank sector portfolio is $497. However, post-2014 the optimal holding of oil in $1,000 of oil–bank sector is $125, compared with $875 for the bank sector. The average values for hedge ratios suggest that the bank sector has the highest hedge ratio (85%) and the industrial sector has the lower hedge ratio (17%) pre-2014. Post-2014 all Kuwait sectors have a higher average hedge ratio than pre-2014. The results suggest that investors in GCC stock markets should own more oil stocks pre-2014; whereas post-2014 investors should invest more in sector stocks in the corresponding portfolio to minimise the risk without reducing the expected return.

Table 5.29: Optimal portfolio weight and hedge ratio for GCC stock market sector (2010–mid-2014 and mid-2014–2017)

Portfolio	Pre-2014		Post-2014	
	$w_{oil,sec}$	$\beta_{oil,sec}$	$w_{oil,sec}$	$\beta_{oil,sec}$
Saudi Arabia				
Oil/ Banks	0.9060	0.9500	0.2350	0.2762
Oil/ Real Estate	0.2221	0.5641	0.3280	0.4835
Oil/ Retail	0.1011	0.8011	0.2221	0.3158
Abu Dhabi				
Oil/ Banks	0.1741	0.3823	0.1491	0.3240
Oil/ Real Estate	0.6123	1.6001	0.3910	0.3906
Oil/ Services	0.3967	0.7091	0.3272	0.2864
Dubai				
Oil/ Banks	0.3191	0.6382	0.2523	0.3991
Oil/ Real Estate	0.0632	0.1456	0.4051	0.6027
Oil/ Services	0.8002	0.3501	0.4262	0.6146
Qatar				
Oil/ Banks	0.3711	0.5432	0.2831	0.3306
Oil/ Real Estate	0.2440	0.3825	0.2352	0.2835
Oil/ Services	0.1610	0.2623	0.1291	0.2185
Bahrain				
Oil/ Banks	0.4690	0.2341	0.3811	0.5327
Oil/ Services	0.5520	0.5690	0.4153	0.1282
Oil/ Industrial	0.3124	0.0783	0.2321	0.2642
Oman				
Oil/ Banks	0.5971	0.7811	0.4021	0.6575
Oil/ Services	0.6431	0.1610	0.5912	0.1385
Oil/ Industrial	0.2520	0.3741	0.1943	0.1796
Kuwait				
Oil/ Banks	0.4972	0.8511	0.1254	0.7471
Oil/ Services	0.6001	0.6671	0.1000	0.3075
Oil/ Industrial	0.6801	0.1702	0.5211	0.5102

5.8 Summary

This chapter has investigated volatility transmission between selected GCC stock market sectors and a set of global factors including the WTI oil price, MSCI World index and S&P 500 US index for the period 2010–17. The analysis focused on two main periods, pre-and post-2014, before and after a drop in oil price. A MGARCH-BEKK model was used to identify own and cross-spillovers of shocks and volatility.

Overall, the results of the MGARCH-BEKK estimation indicate a significant impact of global factors including WTI, MSCI and S&P 500 on the selected sectors of GCC stock markets. All Saudi sectors pre-2014 were affected by shocks and volatility from oil and MSCI, but only Saudi banks and real estate were affected by shocks and volatility from the S&P 500. Following the oil price drop, the Saudi bank and real estate sectors were affected by shocks from oil, MSCI and S&P 500. In Abu Dhabi only the bank sector was affected by shocks and volatility from oil, MSCI and S&P 500 pre-2014; post-2014 all Abu Dhabi sectors were affected by volatility in oil prices and the Abu Dhabi services sector was affected by shock and volatility from the MSCI. For Dubai pre-2014 period, banks and real estate sectors were affected by oil price volatility and most of Dubai sectors were affected by shocks and volatility from the MSCI. In post-2014 period, Dubai banks were affected by shocks and volatility from oil and most by shocks and volatility from S&P 500.

Qatar sectors were less affected by oil post-2014 although the services sector did show a significant effect. There was also a significant effect with the MSCI index pre-2014, which became insignificant post-2014 (except for real estate and services). The Qatar services sector experienced a significant effect of shock and volatility spillover with the S&P 500 index in both periods. Bahrain sectors showed a significant and high coefficient with WTI oil price in pre-2014 period. However, in post-2014 period, there was no significant sign except for the Bahrain bank sector, which exhibited a relationship with the MSCI index pre-and post-2014 periods; whereas service and industrial sectors had a significant relationship only with the MSCI world index in pre-2014 period. The S&P 500 had a significant effect on most Bahrain sectors in both periods.

With the exception of bank sector in post-2014 period, the Oman sectors experienced a strong effect of WTI oil price in both periods. However, the sectors generally showed no influence of the MSCI world index, with the exception of the industrial sector, which had a bidirectional relationship with the MSCI index in pre-2014 period. Oman sectors had a significant relationship with the S&P 500 index in both periods but this this was not significant for bank sector in post-2014 period. Kuwait bank and services sectors experienced a significant effect of shock and volatility spillover with both WTI oil price and S&P 500 in both periods. Also, Kuwait sectors have a significant volatility spillover effect of shock and volatility with MSCI index in both periods except Kuwait service sector pre-2014 period.

The overall results for interdependency between GCC stock markets sectors and global factors are consistent with those of Hammoudeh and Choi (2006) and Jouini (2013), who report evidence for a high-dependency relationship between the global factors examined here and most GCC stock markets.

Based on volatility transmission between oil and the GCC stock market sectors, the optimal weight and hedge ratio was examined. Most GCC stock markets experienced significant volatility transmission with WTI oil in pre-2014 period. This supports the results for optimal weights for GCC stock market sectors where most of GCC investors invest in oil stocks more than sectors stocks in pre-2014 period especially banks sectors. While in post-2014 period, most GCC stock market sectors reduce investing in oil stocks and increase investing in sector stocks. In overall, the results show that investors in GCC stock markets owned more oil stocks in pre-2014period; while in post-2014 period investors invested more in sector stocks in the corresponding portfolio to minimise risk without reducing the expected return. The overall results from the analysis of optimal weight and hedge ratio are partially consistent with those of Jouini and Harrathi (2014), who show that investors in GCC stock markets owned more oil stocks before the oil price drop than afterwards.

Chapter 6 Summary and Conclusions

This chapter provides an overall summary of the current study and its conclusions. The organisation of this chapter is as follows: Section 6.1 presents an overview of the overall study; Section 6.2 provides a summary of the analysis findings; Sections 6.3 and 6.4 explain the implications of the study and identify the study limitations; and some suggestions for further research directions are provided in Section 5.6.

6.1. Overview of the Research Study

The main objective of this study was to investigate links between oil prices and global factors such as the MSCI World and S&P 500 indices, and GCC stock market sectors at the sectoral level. Three major sectors were selected for this study: daily observations were collected for consumer discretionary, financial and real estate sectors in the period 2010–17 with an additional focus on two periods within the whole study period: before and after an oil price drop in mid-2014. The study examined volatility spillover effects between the above global factors and the GCC stock market sectors via an in-depth analysis using various financial analysis tools. GARCH family models, including EGARCH, TGARCH and GARCH-M, were applied to examine the volatility of GCC stock sector returns and identify asymmetric effects in the periods before and after the mid-2014 drop in oil price.

To understand the nature of relationship between the global factors and GCC stock markets, a CCF model was used to study causal relationships among the selected variables. Specifically, a two-stage procedure based on the HH test was applied to detect causality in variances. The HH test was used to examine the presence of causality between the global factors and selected GCC stock markets before and after the drop in oil price, and investigate whether causal effects differed between the two study sub-periods.

To conduct an in-depth analysis of volatility transmission between the global factors and selected GCC stock markets, an advanced multivariate GARCH-BEKK model was applied to capture not only directionality in volatility spillovers but also the precise weight for each volatility spillover direction. This information was then used to provide a clear and in-depth vision for investors and policy makers with regard to the effect of global factors on these sectors in GCC stock markets and which are the most and the least affected. Similar to aforementioned applied models, the GARCH-BEKK model captured volatility transmission with a focus on pre-2014 and post-2014 periods. The analysis results were then used to establish optimal weight and hedge ratios for an optimal portfolio of selected GCC stock market sectors. This will help investors in GCC stock markets to build optimal, diversified portfolios that contain both oil and non-oil assets.

6.2 Summary of Findings

This section provides a summary of the main analysis results presented in Chapters 3, 4 and 5. The findings from the statistical and information asymmetry analyses, the causal relationships between GCC stock market sectors and global factors, and the volatility transmission effects between global factors and GCC stock markets sectors are presented separately.

6.2.1 Statistical and Information Asymmetry Analysis

The findings from the information asymmetry analysis were:

- The selected GCC stock markets showed higher volatility of daily returns—as represented by standard deviations—in Saudi Arabia, Abu Dhabi, Dubai and Qatar than in Bahrain, Oman and Kuwait.
- Most GCC stock market sectors were found to be affected by the drop in oil price; mid-2014 they exhibited higher volatility of daily returns.
- The weak form of the EMH shows that the returns for most of the selected GCC stock markets were strongly correlated with their past returns.
- Risk-adjusted performance measurements, including SR and TR, show that most of the GCC stock market sectors underperformed post-2014 compared with pre-2014.
- The VaR and CVaR model results include higher risk coefficients for most GGC stock markets post-2014 than pre-2014, indicating links between the GCC stock market sectors and oil price. Specifically, the Saudi Arabia and Qatar sectors showed a higher loss exposure post-2014 than pre-2014; the highest risk coefficients were found for the Saudi and Qatar real estate sectors.

- A set of GARCH family models was applied to capture information asymmetry for the GCC stock market sectors in spillover volatility transmission. These models were EGARCH, TGARCH and GARCH-M. All selected GCC stock markets sectors showed a statistically significant ARCH effect at the 5% level.
- The EGARCH test was applied to capture the asymmetric impact of past innovations on current volatility, which was statistically significant for all GCC stock market returns in the pre-2014 and post-2014 periods. This indicates the existence of leverage effects, except for in the Abu Dhabi real estate and Dubai and Qatar services sectors, which showed a significant effect after the drop in oil price.
- TGARCH and GARCH-M models are also applied to capture asymmetric impacts on GCC stock market sectors. These models provided similar results to those of the EGARCH model by indicating that volatility in oil prices had a significant effect on the GCC stock market sectors. Most GCC sectors had a higher coefficient post-2014 period than pre-2014 period.

6.2.2 Testing Volatility Spillover Using the Causal Relationships between GCC Stock Markets and Global Factors

- The VAR model was applied to examine how changes in global factors including the WTI, MSCI and S&P 500 affected the GCC stock markets at the sectoral level in the pre-and post-2014 periods. The analysis results indicate that most sectors were more influenced by global factors pre-2014 than post-2014. This might be due to the dependency between GCC stock markets as major oil exporters and oil price (Fayyad & Daly 2011). Moreover, there is a strong relationship between the global financial market MSCI and most of the GCC stock markets. This may be explained by the close financial links among GCC stock markets as major oil exporters that make GCC countries highly influential in global financial markets. Further, most GCC stock markets have strong links with the major US stock market S&P 500 index, due to the pegging of the Saudi currency to the US currency (Hammoudeh & Al-Gudhea 2006).
- The Granger causality test was applied to test causality among GCC stock market sectors and the selected global factors. Most of the GCC sectors showed more causal effects from WTI oil price and S&P 500 before than after the oil price drop.

However, the bank sector in some GCC stock markets experienced a causal effect from WTI oil price in both periods. The MSCI had a significant causal effect in some GCC stock market sectors in the post-2014 period but not the pre-2014 period. These findings are partially consistent with those of previous studies including Jouini (2013) and Khalifa, Hammoudeh and Otranto (2014) in terms of links between several GCC stock markets and the MSCI World index. This is a reflection of the increased international investment in GCC stock market (Khalifa, Hammoudeh & Otranto 2014).

- The VD test was applied to further investigate causal relationships beyond the sample period, to reveal the amount of forecast error variance for variables that contribute to shocks to other variables. Moreover, the IRF test was applied to examine the effect of shocks over time on the various variables under study. The results of the VD test show that GCC stock market sectors were affected by their own shocks as well as those from other sectors within the same country. Notably, the sector that most affected other sectors in the majority of GCC countries was the bank sector, which may be a result of government support for banks in GCC countries (Hesse & Poghosyan 2016).
- The CCF model was applied to investigate the presence of causal relationships between the selected GCC stock market sectors and global factors including oil price, MSCI and S&P 500. The CCF model is applied in two main stages: the first stage involves estimating univariate GARCH models to ensure that the conditional variance processes fit the return series well. The second stage applies the HH test to examine the null hypothesis of no causality in variances. The HH test was applied here to examine the existence of causality in variances before and after the oil price drop in mid-2014. In the first stage, strong ARCH and GARCH effects were present in all selected GCC stock market sectors' time series, providing the conditions for stability for their parameters. In the second stage, the HH test showed that the selected GCC stock market sectors had a causal effect with oil price and other global factors at different intensities pre-2014 and post-2014 periods. This implies that the impact of oil price and other global factors on a particular stock market sector relied on the extent to which it was exposed to their changes (Gogineni 2010). This varied exposure to oil price may present an opportunity for diversification among GCC stock markets to minimise the risks through diversification in sectoral investing (Tiwari et al. 2018).

6.2.3 Volatility Transmission Multivariate GARCH-BEKK Model and Optimal Weight

- A MGARCH-BEKK model was applied to identify own and cross-shock and volatility spillover between oil prices changes, MSCI and S&P 500 with the selected sectors of GCC stock markets.
- There was a significant impact of global factors including WTI, MSCI and S&P 500 on the selected sectors of GCC stock markets. All Saudi sectors pre-2014 were affected by shocks and volatility in the WTI oil price and MSCI and post-2014 Saudi banks and real estate were affected by shocks from to the oil price, MSCI and S&P 500. These overall results are consistent with those of Hammoudeh & Choi (2006) and Jouini (2013), who report a strong dependency relationship between global factors and most GCC stock markets.
- Only the Abu Dhabi bank sector pre-2014 was affected by shocks and volatility in the oil price, MSCI and S&P 500. However, post-2014 all Abu Dhabi sectors were affected by oil price volatility and shocks and volatility from the MSCI.
- In pre-2014 period, Dubai bank and real estate were affected by oil volatility and most Dubai sectors were affected by shocks and volatility the from MSCI. Following the mid-2014 drop in oil price, Dubai banks were affected by shocks and volatility from oil and most sectors were affected by shocks and volatility from S&P 500.
- Qatar sectors were less affected by WTI oil price in post-2014 period, except services had a significant sign with WTI oil price. Also, there was a significant effect of the MSCI index pre-2014 but not after, except for the Qatar real estate and services sectors.
- Bahrain sectors had a significant and high coefficient with WTI oil price in pre-2014 period but this was true only for the Bahrain bank sector in post-2014 period. The Bahrain bank sector had a relationship with the MSCI index in both periods, whereas the services and industrial sectors only had a significant sign with MSCI world index in the pre-2014 period.
- Oman sectors were strongly affected by WTI oil price both pre- and post-2014, although the bank sector did not show a significant sign with WTI oil price in post-2014 period. However, Oman sectors had no significant signs with the MSCI

index, except that the industrial sector had a significant bidirectional relationship with the MSIC index in pre-2014 period.

- The Kuwait bank and services sectors demonstrated a significant effect of shock and volatility spillover with WTI oil price in both periods. They also had diverse directional effects of shock and volatility with the MSCI world index in both periods, except for the services sector in pre-2014 period. The bank and services sectors experienced significant transmission with the S&P 500 in both periods, with a high coefficient in post-2014 period except Kuwait service sector in pre-2014 period.
- Volatility transmission between oil price and GCC stock markets is considered an important element for an efficient diversified portfolio and risk management. Investors in GCC stock markets need to manage their portfolios to include assets from various sectors to minimise risk while maintaining expected returns (Jouini & Harrathi 2014). Portfolio managers are required to determine optimal weights and hedge ratios to effectively hedge oil price change risk.
- Overall results for the analysis of optimal weight and hedge ratio are partially consistent with those of Jouini and Harrathi (2014); investors in GCC stock markets owned more oil stocks in pre-2014 period, while in post-2014 period they invested more in sector stocks in the corresponding portfolio to minimise the risk without reduce the expected return. These findings indicate changes in the behaviour of participants in financial markets, with more emphasis on building diversified portfolios of stock indices, including oil assets in the corresponding portfolio, to increase risk-adjusted performance.

6.3 Policy Implications

The analysis results presented in this thesis have significant and in-depth implications for understanding volatility patterns in GCC stock markets at the sectoral level. The findings will be helpful for policy makers and investors in GCC stock markets, as follows:

- This sector-level study of the causal relationships and volatility transmission patterns for GCC stock markets, as well as the effect of major global factors, including oil price and the MSCI and S&P 500 indices, has assisted in the development of well-established protection strategies for GCC stock markets to counteract their exposure to global factors. Further, the current sector-based analysis of these links has been informative and generated more accurate recommendations for portfolio management.

- The advanced econometrics analysis models used in this thesis—including family GARCH, VAR, CCF and multivariate GARCH-BEKK models—have provided a comprehensive overview of GCC stock markets at the sectoral level that will enable investors and policymakers to identify important factors affecting the performance of GCC stock market sectors, make sound future investment decisions and more effectively anticipate the behaviour of financial markets.
- The GCC stock markets, as part of the global financial economy, are affected by most representative global economic benchmarks, including oil prices, the MSCI world index and the S&P 500 index through relationships with varying degrees of sensitivity—from interdependence to independence—that have important and detailed implications for policymakers and investors regarding asset allocation and portfolio risk.
- The bank sectors in most GCC stock markets showed significant causal and volatility transmission relationships with oil prices in both the pre-and post-2014 periods. Oil price volatility can affect the profitability of banks through increased or decreased volumes of oil-related business and lending. Moreover, oil-related government income has a direct impact on GCC countries' fiscal spending, which in turn affects banks' profitability via private sector activities related to lending (Hesse & Poghosyan 2016).
- The real estate sectors in most GCC countries experienced significant volatility transmission from oil prices before the oil slump pre-mid-2014. After this time, there was weaker volatility spillover across GCC real estate sectors with oil price, which may be explained by GCC governments' initiatives to diversify their economies in response to the risk of dependency on oil revenues. Moreover, GCC governments began introducing new legislation to ensure the stability and growth of their real estate sectors.
- There was a significant causal effect on the Saudi sectors as a result of changes in the WTI oil price for the periods pre-2014 and post-2014. This may be explained by the strong correlation between worldwide oil price changes and the Saudi economy, as Saudi Arabia is a major oil exporter. Furthermore, the GARCH-BEKK model results showed that in the pre-2014 period all Saudi sectors were

affected by shocks and volatility in the oil price and MSCI index, but only Saudi banks and real estate were affected by shocks and volatility in the S&P 500. These results can be explained by the tight and important interdependency of financial and trade linkages between the US and Saudi Arabia (Gencer & Hurata 2017).

- The Abu Dhabi and Dubai bank sectors showed a significant causal relationship with the S&P 500 in the post-2014 period. The GARCH-BEKK model results showed that all Abu Dhabi sectors were affected by volatility in oil prices, while the services sector in Abu Dhabi was affected by shocks and volatility from the MSCI. In the pre-2014 period in Dubai, banks and the real estate sector were affected by oil price volatility, and most other sectors were affected by shocks and volatility in the MSCI. In the post-2014 period, Dubai's banks were affected by shocks and volatility from oil prices, but to a greater extent by shocks and volatility in the S&P 500. These correlations can be explained by the influence of innovations in international markets, especially the US market, on the UAE (Almohamad, Mishra & Yu 2018).
- There was no sign of a significant effect from shocks and volatility on any sector in Bahrain, which may be due to its economic diversification into non-oil sectors. However, the bank sector exhibited a relationship with the MSCI index in both the pre-and post-2014 periods; whereas Bahrain's service and industrial sectors showed a significant relationship with the MSCI world index only in the pre-2014 period. The S&P 500 had a significant effect on most of Bahrain's sectors in both periods, which could be due to its exposure to global financial markets and the direct and indirect impacts from other GCC markets (Alqahtani & Chevallier 2020).
- The MSCI had a significant causal effect on Qatar's sectors in the post-2014 period, while no significant effect was seen from the WTI oil price. This may be explained by Qatar's major dependency on gas supply, as one of the largest gas exporters in the world (Alrub et al. 2018).
- The Oman sectors experienced a strong effect of WTI oil price in both periods, with the exception of the bank sector post-2014. This could be a direct result of the reduction in oil revenues, since Oman is an oil exporting country, and an indirect result of the tight links with other GCC stock markets, especially, which is the largest and the leading stock market in GCC region (Almohamad, Mishra

& Yu 2018). However, in general Oman's sectors were not influenced by the MSCI world index, with the exception of the industrial sector, which showed a bidirectional relationship with the MSCI index in the pre-2014 period. All sectors in Oman had a significant relationship with the S&P 500 index in both periods, but this this was not significant for the bank sector in the post-2014 period. Kuwait's bank and services sectors experienced a significant effect of shock and volatility spillover from both the WTI oil price and the S&P 500 in both periods. In addition, Kuwaits' sectors experienced a significant volatility spillover effect from shock and volatility in the MSCI index in both periods, with the exception of the service sector in the pre-2014 period.

- A decrease in investment in oil sectors in GCC stock markets as a result of shocks in oil prices and increases in non-oil sectors may signal future performance of stock market sectors. These findings may help policy makers to forecast the future performance of GCC stock markets.
- GCC countries must focus on the lack of diversification in their economies and develop non-oil sectors to increase economic growth and ensure that the region's exposure to shocks in the oil sector and associated risks is addressed.
- The significant links between oil price and stock indices may also help GCC governments and authorities to make deep and judicious decisions regarding the regulation of stock index markets and oil price policies, since they are highly sensitive to regional political events.

6.4 Recommendations for Further Research

Recommendations for further research arising from this study include the following:

- The selected GCC stock markets were shown to have different responses to the set of selected global factors: WTI oil price, MSCI world index and S&P 500 index. This is an indication that variation in GCC countries' economic growth affects volatility transmission patterns. Therefore, further research with a larger set of GCC stock market sectors and global factors might provide further explanation and insight into volatility transmission links between GCC stock markets at the sectoral level and global factors.

- The selected GCC stock markets sectors were shown to vary in their sensitivity to shocks before and after the oil price slump in mid-2014. Therefore, the research including a wider segment of stock market sectors may provide in-depth understanding of various sectors' behaviour and the extent to which the oil price factor affects GCC stock markets at the sectoral level, which may be useful to investors and policy makers.
- The research findings highlight the importance of taking into account the selected global factors when assessing the attractiveness of GCC stock market sectors. Consequently, the oil price, along with other global factors that affect returns and volatility in stock markets sectors should be considered when formulating performance expectations in GCC stock markets for the purpose of investment and portfolio asset allocation.
- The research results are also important for formulating more accurate risk expectations at the sectoral level. Risk transfer from oil and other global factors to the selected GCC stock market sectors depended on the extent to which these sectors were exposed to global factors. This conclusion might be strengthened by including more domestic and international factors to better forecast risk in GCC stock markets according to the factors under study.
- The findings of this research can be considered a starting point for further empirical analysis of how the oil slump in mid-2014 has affected GCC stock markets with a larger dataset, and how they can recover from this disaster while oil prices continue to be volatile.

This research provides a comprehensive and in-depth investigation of volatility transmission between GCC stock markets and selected global factors, including oil price, and the MSCI and S&P 500 indices. Going beyond the existing studies and market level analysis, by others including Hammoudeh and Choi (2006), Arouri and Rault (2012) and Jouini and Harrathi (2014), to name a few, this research provides a deep sector-level analysis of GCC stock markets. Studying the volatility of GCC stock markets at the sector level provides a better understating of volatile behaviour. It also eliminates the masking of individual sector reactions that may occur when studying stock markets as a single block. This research extends the previous literature in several ways. First, studying volatility patterns at the sectoral level provides an up-to-date and detailed explanation of the volatility behaviours of GCC stock markets through certain possible transmission mechanisms: interdependence, spillover and independence. This classification of the mechanisms provides an understanding of the natural volatility transmission in financial markets, enables the prediction of the volatility in linked markets, and allows selection of the dominant sector whose behaviour is expected to drive change in other sectors. Second, assessing the impact of the oil slump crisis in mid-2014 on portfolio management through analysing the optimal weight and hedge ratio of GCC stock markets at the sectoral level provides in-depth and detailed implications for both policymakers and investors regarding asset allocation and portfolio risk.

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Appendices

Appendix 1: VAR model estimation for Saudi Arabia sectors, WTI, MSCI and S&P 500, 2010–17

Full period	WTI	MSCI	S&P 500	SB	SRE	SR
WTI [-1]	-0.08997	0.0061	0.3971	0.0239**	-0.0084*	0.0277*
[-2]	0.0019	0.0103	0.0838	-0.0216		
MSCI [-1]	-0.0020	0.1290	0.0143	-0.0.0869***	0.0001	0.0693***
[-2]	-0.0050	-0.0072	0.0212	0.0262		
S&P 500 [-1]	0.0193	-0.0193	-0.0650	-0.0188	0.0068	-0.0020
[-2]	-0.0141	-0.0335	0.0162	0.0427*		
SB [-1]	0.0010	0.0066	0.0057	0.0768**	0.0056	0.0419
[-2]	0.0005	0.0175	0.0129	-0.0243		
SRE [-1]	0.0146	-0.0364	0.0156	0.0050	0.0784**	0.0393
[-2]	-0.0035	-0.0451	-0.0250	0.0918	-0.0197	-0.1106**
SR (-1)	0.0111	0.0086	0.0104	-0.0259	0.0233	0.1441***
[-2]	0.0218	-0.0579*	-0.0074	0.0110	0.0276	-0.0492
Pre-2014	WTI	MSCI	S&P 500	SB	SRE	SR
WTI [-1]	-0.0964	-0.0096	0.5275	0.0176*	0.0313*	-0.0382*
[-2]	-0.0470	0.0464	0.1469	0.0715	-0.0556	0.0485
MSCI [-1]	0.0101	0.1123	0.0057	-0.0576	0.0220	0.0083
[-2]	-0.0004	0.0160	0.0284	0.0449	-0.0239	-0.0046
S&P 500[-1]	0.0471	-0.0082	-0.0810	0.0379*	0.0254*	-0.0180*
[-2]	-0.0339	-0.0535	0.0234	0.1275**	0.0118	-0.0299
SB [-1]	0.03118	0.0527	0.0353	0.0586**	0.0103	0.0626*
[-2]	-0.0112	0.0251	0.0635	0.1118**	-0.0569*	-0.1125
SRE [-1]	0.0474	0.0230	0.0543	-0.0382	0.0627*	0.0649
[-2]	-0.0236	-0.0169	0.0396	0.1001	-0.0197	-0.1059*
SR [-1]	0.0168	0.0463	0.0332	-0.0425	0.0180	0.1003***
[-2]	0.0182	-0.0336	0.0506	0.0196	0.0065	-0.0573
Post-2014	WTI	MSCI	S&P 500	SB	SRE	SR
WTI [-1]	-0.1014	0.0608	0.0605	0.0355**	-0.0712*	0.0860
[-2]	0.0272	-0.1182	0.0033	-0.1875	0.0299	0.0848
MSCI [-1]	-0.0158	0.1652	0.0235	-0.1365***	-0.0215	-0.1439***
[-2]	-0.0082	-0.0796	-0.0149	-0.0035	-0.0097	0.0425
S&P 500[-1]	-0.0012	-0.0577	-0.0450	0.0035**	-0.0172*	0.0139
[-2]	-0.0019	0.0357	-0.0273	-0.0226	0.0371	-0.0466
SB [-1]	-0.0093	-0.1226	-0.0850	0.1040	-0.0055	0.0200
[-2]	0.0036	0.0051	-0.1118	0.0089	-0.0205	-0.0520
SRE [-1]	-0.0137	-0.2022	-0.0976	0.0575	0.0837	0.0066
[-2]	-0.0007	-0.1087	-0.1895	0.0685	-0.0299	-0.0873
SR [-1]	0.0030	-0.1080	-0.0433	-0.0220	0.0268	0.1761***
[-2]	0.0157	-0.1152	-0.1284	-0.0168	0.0457	-0.0387

Note: ***, **, * indicate statistical significance at the 1%, 5% and 10% levels, respectively.

Appendix 2: VAR model estimation for Abu Dhabi sectors, WTI, MSCI and S&P 500, 2010–17

Full period	WTI	MSCI	S&P 500	ADB	ADRE	ADS
WTI [-1]	-0.0935	0.0080	0.3913	0.0894**	-0.0114	-0.0366
[-2]	-0.0012	0.0095	0.0825	-0.0592	0.0194	-0.0487
MSCI [-1]	-0.0033	0.1264	0.0125	0.0143	-0.0055	0.0083
[-2]	-0.0043	-0.0026	0.0224	0.0238	0.0166	-0.0195
S&P 500[-1]	0.0170	-0.0214	-0.0629	0.0405*	-0.0133	0.0095
[-2]	-0.0097	-0.0309	0.0185	0.0205	0.0071	0.0005
ADB [-1]	-0.0031	-0.0088	-0.0004	-0.0325	0.2292***	-0.0077
[-2]	0.0094	-0.0192	-0.0446	-0.0006	0.0452***	-0.0236
ADRE [-1]	0.0419	0.0668	-0.0721	0.0341	0.0591	0.0183
[-2]	0.0055	0.0284	0.2555	0.0500	0.0233	0.0278
ADS [-1]	-0.0001	-0.0546	-0.0148	0.0527	0.0150	-0.0702***
[-2]	-0.0061	0.0330	0.0074	0.0359	0.0084	-0.0548*
Pre-2014	WTI	MSCI	S&P 500	ADB	ADRE	ADS
WTI [-1]	-0.1284	-0.0068	0.5500	-0.0374	-0.0278	-0.0107
[-2]	-0.0429	0.0492	0.1475	-0.0397	-0.0110	-0.0011
MSCI [-1]	0.0028	0.1112	0.0107	-0.0116	-0.0027	0.0036*
[-2]	-0.0035	0.0158	0.0298	0.0060	0.0174	-0.0324
S&P 500[-1]	0.0394	0.0013	-0.0720	0.0114	-0.0198	0.0002
[-2]	-0.0276	-0.0507	0.0266	0.0068	0.0076	-0.0118
ADB [-1]	0.0165	0.0204	0.0058	-0.0590	0.1635***	-0.0436***
[-2]	0.0198	-0.0456	-0.0288	0.08755**	0.0443	-0.0442
ADRE [-1]	0.0583	0.0494	0.0261	-0.0038	0.0660**	-0.0033
[-2]	0.0242	0.0101	0.2600	0.0526	0.0210	-0.0307
ADS [-1]	0.0086	-0.0449	-0.0546	0.0684	0.01814	-0.0814***
[-2]	0.0181	0.0132	0.0128	0.0449	-0.0077	-0.0950
Post-2014	WTI	MSCI	S&P 500	ADB	ADRE	ADS
WTI [-1]	-0.1029	0.0423	0.0529	-0.1181	0.0103	-0.0934
[-2]	0.0169	-0.1425	0.0031	-0.0724	0.0813	-0.1458
MSCI [-1]	-0.0120	0.1663	0.0184	0.0175	-0.0088	0.0173
[-2]	-0.0064	-0.0500	-0.0104	0.0349	0.0181	0.0057
S&P 500[-1]	-0.0039	-0.0584	-0.0422	0.0564**	0.0061	0.0307*
[-2]	0.0009	0.0425	-0.0168	0.0271	0.0117	0.0275
ADB [-1]	-0.0156	-0.0207	-0.0086	-0.0611*	0.3670***	0.0857**
[-2]	0.0070	0.0461	-0.0666	-0.0868	0.0534	0.0152
ADRE [-1]	-0.0116	0.1170	-0.2944	0.0446	0.0418	0.0673
[-2]	-0.0145	0.0612	0.1652	0.0504	0.0369	-0.0207
ADS [-1]	-0.0036	-0.0916	0.0759	0.0301	0.0068	-0.0622
[-2]	-0.0263	0.1208	-0.0378	0.0183	0.0635	0.0635

Note: ***, **, * indicate statistical significance at the 1%, 5% and 10% levels, respectively.

Appendix 3: VAR model estimation for Dubai sectors, WTI, MSCI and S&P 500, 2010–17

Full period	WTI	MSCI	S&P 500	DB	DRE	DS
WTI [-1]	-0.0924	0.0084	0.3927	0.00236*	-0.0333*	-0.0019
[-2]	0.0025	0.0103	0.0815	-0.0767	0.0172	-0.0021
MSCI [-1]	-0.0032	0.1272	0.0116	-0.0190	0.0134	-0.0099
[-2]	-0.0042	-0.0047	0.0223	-0.0152	0.0095	0.0111
S&P 500 [-1]	0.0162	-0.0209	-0.0637	0.0004	-0.0094	0.0029
[-2]	-0.0108	-0.0339	0.0185	0.0353	-0.0025	-0.0004
DB [-1]	0.0350	0.0219	-0.0279	0.0746**	0.0405*	-0.0165
[-2]	-0.0134	0.0319	0.0636	0.0502	-0.0161	-0.0006
DRE [-1]	0.0553	-0.0433	-0.0568	0.1484***	0.0162	-0.0348
[-2]	-0.0202	0.0994	0.1490	0.0355	-0.0024	-0.0086
DS [-1]	0.0598	-0.0676	-0.0422	0.1290**	-0.0309	0.0851***
[-2]	-0.0085	0.1649	0.1781	0.0243	-0.0399	0.0988
Pre-2014	WTI	MSCI	S&P 500	DB	DRE	DS
WTI [-1]	-0.0973	0.0045	0.5333	0.0172	-0.0761**	-0.0021
[-2]	-0.0329	0.0463	0.1529	-0.0250	-0.0480	0.0128
MSCI [-1]	0.0090	0.1119	0.0074	-0.0415	0.0256	-0.0151
[-2]	-0.0031	0.0147	0.0292	-0.0094	-0.0036	0.0159
S&P 500[-1]	0.0461	-0.0048	-0.0797	0.0010	-0.0249	0.0039
[-2]	-0.0289	-0.0521	0.0276	0.0141	-0.0183	0.0026
DB [-1]	0.0319	0.0201	0.0333	0.0378	0.0447*	-0.0117
[-2]	0.0079	0.0243	0.0960	0.0568	-0.0276	0.0026
DRE [-1]	0.0826	-0.0778	0.0323	0.0342	0.0615	-0.0272
[-2]	0.0304	0.0866	0.1636	0.0096	0.0202	-0.0073
DS [-1]	0.1456	-0.0771	-0.0049	0.1233	-0.0886	0.1400***
[-2]	-0.0272	0.1791	0.1795	0.0009	-0.0412	0.1181
Post-2014	WTI	MSCI	S&P 500	DB	DRE	DS
WTI [-1]	-0.1034	0.0522	0.0554	-0.0704	0.0300	0.0167
[-2]	0.0241	-0.1094	-0.0074	-0.2495	0.1873	-0.0387
MSCI [-1]	0.0106	0.1663	0.0131	0.0051	-0.0109	-0.0087
[-2]	-0.0053	-0.0540	-0.0096	-0.0334	0.0381	-0.0035
S&P 500[-1]	-0.0029	-0.0600	-0.0461	-0.0141**	0.0102**	0.0054
[-2]	0.0009	0.0368	-0.0157	0.0343	0.0348	0.0008
DB [-1]	0.0276	0.0311	-0.1809	0.1113*	-0.0300	-0.0343
[-2]	-0.0355	0.0530	-0.0025	0.0215	0.0117	-0.0062
DRE [-1]	0.0237	0.0453	-0.2934	0.3076***	-0.0573	-0.0719
[-2]	-0.0677	0.1312	0.0709	0.1021	-0.0471	-0.0281
DS [-1]	-0.0033	-0.0317	-0.2096	0.1633*	0.0970	-0.1165**
[-2]	-0.0079	0.1358	0.0842	0.1067	0.0135	-0.0492

Note: ***, **, * indicate statistical significance at the 1%, 5% and 10% levels, respectively.

Appendix 4: VAR model estimation for Qatar sectors, WTI, MSCI and S&P 500, 2010–17

Full period	WTI	MSCI	S&P 500	QB	QRE	QS
WTI [-1]	-0.0905	0.0108	0.3938	-0.0388	0.0308	0.0057
[-2]	0.0045	0.0092	0.0810	-0.1033	0.0045	0.0214
MSCI [-1]	-0.0026	0.1264	0.0124	0.0594**	-0.0123	-0.0081
[-2]	-0.0070	-0.0030	0.0207	-0.0102	0.0043	-0.0084
S&P 500 [-1]	0.0160	-0.0217	-0.0612	-0.0601**	0.0392**	0.0187
[-2]	-0.0113	-0.0327	0.0177	-0.0202	-0.0279	0.0552
QB [-1]	0.0168	-0.0191	0.0065	0.0337	0.0341*	0.0614**
[-2]	0.0132	-0.0106	-0.0124	0.0249	-0.0412	0.0050
QRE [-1]	0.0003	-0.0229	0.0029	0.0045	0.0339	0.1184***
[-2]	0.0105	0.0757	-0.0083	0.0900	-0.0685	0.0154
QS [-1]	0.0054	-0.0186	0.0071	0.0747**	0.0058	0.0505*
[-2]	0.0162	0.0037	-0.0003	0.0561	-0.0376	0.0401
Pre-2014	WTI	MSCI	S&P 500	QB	QRE	QS
WTI [-1]	-0.0989	-0.0091	0.5372	-0.1483**	0.0708**	0.0441
[-2]	-0.0391	0.0554	0.1408	-0.0362	-0.0645	0.0071
MSCI [-1]	0.0111	0.1068	0.0019	0.0568	-0.0104	0.0425
[-2]	-0.0048	0.0166	0.0277	0.0104	-0.0003	-0.0131
S&P 500[-1]	0.0435	-0.0096	-0.0759	-0.0665*	0.0558**	0.0162
[-2]	-0.0268	-0.0460	0.0230	-0.0387	-0.0384	0.0720
QB [-1]	0.0218	-0.0297	-0.0091	0.1227***	0.0434**	0.0065
[-2]	0.0042	-0.0021	-0.0036	0.0077	-0.0055	0.0034
QRE [-1]	-0.0229	-0.0506	0.0314	0.0838	0.0380	0.0190
[-2]	-0.0009	0.0615	-0.0074	0.0130	-0.0259	0.0906
QS [-1]	-0.0096	-0.0380	-0.0048	0.1274***	-0.0073	-0.0302
[-2]	0.0212	0.0022	0.0245	0.0253	0.0033	0.0464
Post-2014	WTI	MSCI	S&P 500	QB	QRE	QS
WTI [-1]	-0.0928	0.0680	0.0444	0.1681	-0.0345	-0.0708
[-2]	0.0266	-0.1263	-0.0231	-0.2705	0.1569	-0.0150
MSCI [-1]	-0.0121	0.1793	0.0260	0.0648	0.0044	-0.0692*
[-2]	-0.0085	-0.0624	-0.0146	-0.0710	0.0189	0.0129
S&P 500[-1]	-0.0028	-0.0630	-0.0406	-0.0487	0.0029	0.0463
[-2]	-0.0015	0.0299	-0.0199	0.0166	0.0014	-0.0066
QB [-1]	0.0158	0.0166	0.0216	-0.1339**	0.0208	0.1617***
[-2]	0.0165	-0.0511	-0.0280	0.0346	-0.1210	0.0610
QRE [-1]	0.0119	0.0535	-0.0658	-0.1621	0.0279	0.2495***
[-2]	0.0197	0.0971	0.0316	0.2417	-0.1507	-0.0528
QS [-1]	0.0149	0.0406	0.0341	-0.0088	0.0155	0.1295**
[-2]	0.0086	-0.0210	-0.0358	0.1142	-0.1227	0.0653

Note: ***, **, * indicate statistical significance at the 1%, 5% and 10% levels, respectively.

Appendix 5: VAR model estimation for Bahrain sectors, WTI, MSCI and S&P 500, 2010–17

Full period	WTI	MSCI	S&P 500	BB	BS	BI
WTI [-1]	-0.0893	0.0047	0.3930	0.0321	-0.0511	0.0429
[-2]	0.0010	0.0108	0.0826	-0.0079	0.0114	0.0333
MSCI [-1]	-0.0038	0.1276	0.0135	0.0131	0.0201	0.0132
[-2]	-0.0049	-0.0061	0.0239	-0.0028	0.0313	-0.0036
S&P 500[-1]	0.0919	-0.0208	-0.0694	-0.0187	-0.0206	0.0347**
[-2]	-0.0149	-0.0306	0.0198	0.0220	0.0262	-0.0186
BB [-1]	0.0002	-0.0139	-0.0248	-0.0552**	0.0142	0.0006
[-2]	0.0021	0.0439	-0.0009	-0.0502	0.0541	0.0107
BS [-1]	-0.0062	0.0359	-0.0118	0.0191	-0.0087	-0.0128
[-2]	-0.0053	-0.0213	-0.0157	0.0042	0.0131	0.0143
BI [-1]	0.0312	0.0042	-0.0389	0.0555	0.0158	-0.0155
[-2]	-0.0066	-0.0243	-0.0197	0.0110	0.0817	0.0639
Pre-2014	WTI	MSCI	S&P 500	BB	BS	BI
WTI [-1]	-0.0959	-0.0077	0.5279	-0.0038*	-0.0576*	-0.0145
[-2]	-0.0445	0.0470	0.1448	0.0166	-0.0103	0.0251
MSCI [-1]	0.0079	0.1114	0.0057	0.0159	-0.0054	-0.0009
[-2]	-0.0041	0.0160	0.0292	-0.0345	-0.0116	-0.0084
S&P 500[-1]	0.0464	-0.0081	-0.0841	-0.0151	-0.0103	0.0252
[-2]	-0.0314	-0.0504	0.0302	0.0301	0.0190	-0.0354
BB [-1]	0.0027	-0.0086	-0.0023	-0.0645**	0.0431	-0.0154
[-2]	0.0089	0.0571	0.0080	-0.0806**	0.0379	0.0028*
BS [-1]	-0.0133	0.0393	-0.0147	0.0081	0.0029	0.0044
[-2]	-0.0033	-0.0087	-0.0238	-0.0053	0.0361	0.0012
BI [-1]	0.0225	-0.0011	0.0025	0.0541	-0.0031	-0.0141
[-2]	0.0280	-0.0483	-0.0610	-0.0122	0.0235	0.0740*
Post-2014	WTI	MSCI	S&P 500	BB	BS	BI
WTI [-1]	-0.0948	0.0436	0.0246	0.1412	-0.0936	0.1604*
[-2]	0.0247	-0.1135	0.0247	-0.1247	0.0400	0.0610
MSCI [-1]	-0.0132	0.1724	0.0326	-0.0060	0.1184**	0.0392
[-2]	-0.0107	-0.0682	0.0104	0.1273	0.1508	-0.0014
S&P 500[-1]	0.0001	-0.0623	-0.0518	-0.0462	-0.0529	0.0670**
[-2]	-0.0043	0.0339	-0.0242	-0.0279	0.0383	0.0210
BB [-1]	-0.0049	-0.0347	-0.0872	-0.0296	-0.0846	0.0335
[-2]	-0.0090	0.0013	-0.0176	0.0726	0.0954	0.0149
BS [-1]	-0.0028	0.0210	-0.0028	0.0807**	-0.0437	-0.0570
[-2]	-0.0046	-0.0578	0.0070	0.0324	-0.0518	0.0345
BI [-1]	0.0361	0.0247	-0.1429	0.0371	0.0319	0.0416**
[-2]	-0.0339	0.0410	0.0661	0.1161	0.2932	0.0412

Note: ***, **, * indicate statistical significance at the 1%, 5% and 10% levels, respectively.

Appendix 6: VAR model estimation for Oman sectors, WTI, MSCI and S&P 500, 2010–17

Full period	WTI	MSCI	S&P 500	OB	OS	OI
WTI [-1]	-0.0889	0.0079	0.3963	-0.1048	0.0485*	0.0604*
[-2]	0.0009	0.0115	0.0855	0.0526	0.0611	-0.0798
MSCI [-1]	-0.0033	0.1304	0.0142	0.0492	-0.0688	-0.0456**
[-2]	-0.0040	-0.0047	0.0236	0.0129	0.0599	-0.0768
S&P 500[-1]	0.0176	-0.0217	-0.0658	-0.0586	0.0626**	0.0628
[-2]	-0.0133	-0.0309	0.0152	-0.0052	-0.0340	0.0043
OB [-1]	0.0122	0.0415	0.0402	0.1964***	0.0686	-0.0116
[-2]	0.0108	0.0147	-0.0328	0.0504	-0.0553	0.0006
OS [-1]	0.0137	0.0258	0.0302	-0.0038	0.2086	0.0240
[-2]	-0.0019	0.0083	-0.0306	0.0082	0.0429	0.0184
OI [-1]	0.0142	0.0251	0.0204	0.0175	0.0397	0.2316***
[-2]	0.0030	-0.0003	-0.0249	0.0153	0.0025	0.0668
Pre-2014	WTI	MSCI	S&P 500	OB	OS	OI
WTI [-1]	-0.0925	-0.0030	0.5284	-0.0179	-0.1226	-0.0182*
[-2]	-0.0424	0.0517	0.1592	-0.0286	0.1611	-0.0491
MSCI [-1]	0.0093	0.1159	0.0067	0.0425*	-0.0611*	-0.0829*
[-2]	-0.0039	0.0184	0.0353	-0.0152	0.0741	-0.0624
S&P 500[-1]	0.0445	-0.0114	-0.0813	-0.0905**	0.1184*	0.0596**
[-2]	-0.0303	-0.0555	0.0208	-0.0385	-0.0175	0.0827
OB [-1]	0.0218	0.0573	0.0661	0.1647***	0.0033	-0.0145
[-2]	-0.0042	0.0085	-0.0231	0.0644	-0.1049	-0.0187
OS [-1]	0.0117	0.0399	0.0587	-0.0356	0.2115***	-0.0007
[-2]	-0.0096	0.0138	-0.0280	0.0332	0.0103	0.0158
OI [-1]	0.0189	0.0392	0.0434	-0.0225	0.0411	0.1688***
[-2]	-0.0056	-0.0053	-0.0283	0.0439	-0.0260	0.0074
Post-2014	WTI	MSCI	S&P 500	OB	OS	OI
WTI [-1]	-0.1008	0.0716	0.0568	-0.3701*	0.6297*	0.2040
[-2]	0.0158	-0.1079	0.0255	0.2487	-0.2978	-0.2629
MSCI [-1]	-0.0131	0.1723	0.0238	0.0410	-0.0711	0.0342
[-2]	-0.0055	-0.0691	-0.0084	0.0548	0.0279	-0.1385
S&P 500[-1]	-0.0016	-0.0602	-0.0453	0.0287	-0.1310	0.0664
[-2]	-0.0006	0.0364	-0.0265	0.0702	-0.0985	-0.1580
OB [-1]	0.0011	0.0037	-0.0298	0.1686**	0.3004**	0.0131
[-2]	0.0172	0.0534	-0.0339	-0.0268	0.1207	0.0418
OS [-1]	0.0109	-0.0104	-0.0389	0.01615	0.2310***	0.0723
[-2]	0.0019	-0.0002	-0.0212	-0.0298	0.1021	0.0051
OI [-1]	0.0060	-0.0086	-0.0373	0.0203	0.0986	0.3631
[-2]	0.0071	0.0335	0.0009	-0.0704	0.1045	0.1732

Note: ***, **, * indicate statistical significance at the 1%, 5% and 10% levels, respectively.

Appendix 7: VAR model estimation for Kuwait sectors, WTI, MSCI and S&P 500, 2010–17

Full period	WTI	MSCI	S&P 500	KB	KS	KI
WTI [-1]	-0.1113	0.0409	0.2695	0.0287*	0.0326*	-0.0523
[-2]	0.0276	-0.0437	0.0434	0.0455	-0.0544	0.0235
MSCI [-1]	-0.0137	0.1588	0.0395	-0.1159**	0.0181	0.0313
[-2]	-0.0020	-0.0354	-0.0153	-0.0081	0.0028	0.0087
S&P 500[-1]	0.0121	-0.0674	-0.0309	-0.0530	-0.0049	-0.0247
[-2]	-0.0114	-0.0059	-0.0172	0.0075	0.0066	-0.0399
KB [-1]	0.0017	0.0339	-0.0034	-0.0341	0.0149	0.0970*
[-2]	-0.0118	-0.0171	0.0241	-0.0094	0.0045	0.0535
KS [-1]	0.0019	-0.0129	-0.0011	0.0217	0.0145	0.0263
[-2]	-0.0050	-0.0424	-0.0091	0.0003	0.1024	0.0340
KI [-1]	0.0071	-0.0193	0.0138	0.0376	0.0209	0.0864***
[-2]	-0.0068	-0.0140	0.0090	0.0818	-0.0101	0.0258
Pre-2014	WTI	MSCI	S&P 500	KB	KS	KI
WTI [-1]	-0.1686	0.0197	0.5866	-0.1474	0.0302*	-0.0147
[-2]	0.0276	-0.0437	0.0434	0.0455	-0.0544	0.0235
MSCI [-1]	-0.0181	0.1362	0.0656	-0.1382***	-0.0020	0.0561
[-2]	-0.0020	-0.0354	-0.0153	-0.0081	0.0028	0.0087
S&P 500[-1]	0.0548	-0.0849	-0.0160	-0.0096	-0.0379	0.0324
[-2]	-0.0114	-0.0059	-0.0172	0.0075	0.0066	-0.0399
KB [-1]	0.0247	0.0141	0.0125	-0.1530***	-0.0041	0.1581
[-2]	-0.0118	-0.0171	0.0241	-0.0094	0.0045	0.0535
KS [-1]	0.0167	0.0024	-0.0269	-0.0152	0.0311	0.0326
[-2]	-0.0050	-0.0424	-0.0091	0.0003	0.1024	0.0340
KI [-1]	-0.0265	-0.0432	-0.0123	-0.0421	0.0401	0.1317***
[-2]	-0.0068	-0.0140	0.0090	0.0818	-0.0101	0.0258
Post-2014	WTI	MSCI	S&P 500	KB	KS	KI
WTI [-1]	-0.0987	0.0637	0.0637	0.1136*	0.0296*	-0.0493
[-2]	0.0276	-0.0437	0.0434	0.0455	-0.0544	0.0235
MSCI [-1]	-0.0133	0.1744	0.0221	-0.1059**	0.0347	0.0178
[-2]	-0.0020	-0.0354	-0.0153	-0.0081	0.0028	0.0087
S&P 500[-1]	-0.0013	-0.0560	-0.0458	-0.0868	0.0227	-0.0650
[-2]	-0.0114	-0.0059	-0.0172	0.0075	0.0066	-0.0399
KB [-1]	-0.0059	0.0501	-0.0112	0.0386	0.0363	0.0574
[-2]	-0.0118	-0.0171	0.0241	-0.0094	0.0045	0.0535
KS [-1]	-0.0020	-0.0267	0.0190	0.0440	-0.0066	0.0215
[-2]	-0.0050	-0.0424	-0.0091	0.0003	0.1024	0.0340
KI [-1]	0.0173	0.0013	0.0375	0.0946	-0.0044	0.0569
[-2]	-0.0068	-0.0140	0.0090	0.0818	-0.0101	0.0258

Note: ***, **, * indicate statistical significance at the 1%, 5% and 10% levels, respectively.