Effects of Oil Prices, Food Prices and Macroeconomic News on GCC Stock Markets

A Thesis Submitted for the Degree of Doctor of Philosophy

by

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Abstract

This thesis is based on three papers examining Gulf Cooperation Council (GCC) financial markets. The member countries of the GCC are Bahrain, Kuwait, Oman, Qatar, Saudi Arabia and the United Arab Emirates. These countries have transitioned from developing to frontier markets over the past ten years, but there is considerable debate about whether GCC economies are efficient or affected by shocks in oil and other commodity markets. The first paper (chapter 2) considers GCC stock market returns and examines how they are affected by oil price shocks using a bivariate VAR-GARCH(1,1) approach. The conclusion of this essay is that GCC economies are more affected by shocks than are other countries considered for comparison purposes. The second paper (chapter 3) discusses how food prices are affected by oil price shocks, and it examines possible parameter shifts between food and oil that result from four recent events, including renewable fuel policies and the financial crisis. The third paper (chapter 4) uses an empirical approach to compare a least squares model and a non-linear Markov switching model to measure the effect of newspaper sentiment on stock market performance. The results indicate that all information is important to stock market investors and that non-linear models are better predictors of stock market performance then linear models when using data from newspaper articles. Chapter 5 offers some final conclusions and remarks.

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Dedication

I am thankful to God, the most Gracious, the most Merciful for leading me to be an independent researcher and ask God to bless everyone who supported me with this effort. I wish them success in the future. This thesis is dedicated to my kind father and mother, as well as my lovely brothers, sisters and Essa, for their unconditional love and support throughout my life.

Publications and Conferences

I presented material from **Chapter Three** entitled “GCC Countries and Oil Shocks” at the Annual Conference of the Qatar Foundation (in a poster session) in March 2015 in Qatar. A forthcoming chapter is drawn from this work and will be published by Elsevier in the Handbooks of Frontier Markets 1st Edition, ISBN: 9780128092002.

I presented material from **Chapter Four** entitled “Volatility Spillover from Food and Energy Markets” at the 12th INFINITI Conference on International Finance (2014) in Prato, Italy, as well at Sussex University (2014) additionally in DIW Berlin, German Institute for Economic Research as paper number 1466 (2015). This research has also been awarded a prize for the best research in the social sciences at the Qatar Foundation Annual Research Conference (2013). A paper based on this chapter is forthcoming at the International Economics Journal.

Research from **Chapter Five**, “Investor sentiment in the GCC: How it affects stock markets”, was presented at the Research Student Poster Conference at Brunel University, as well at the 2016 Academic OASIS–PALM BEACH International Conference in the US.

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Chapter 1

Introduction

Stock price movements and volatility have the potential to deeply impact both the lives of everyday people and the economy. A rise or fall in all stock prices has the potential to cause widespread economic disruption if, for example, it results in significantly depressed market values. The US stock market crash of 2008 rapidly devolved into a global financial crisis, resulting in dramatic reductions in the values of commodities and stocks worldwide and leading to a number of bank failures in Europe. In this new age of globalization, nations are gradually and continually becoming a single entity as they find distance to be increasingly unimportant. Modelling stock market movements and analysing market volatility have attracted considerable attention in the field of finance. The transmission of shocks from one market to another, volatility, represents a risk or an opportunity in terms of levels and averages. This thesis consists of three papers, all of which are connected to the desire to better understand the stock markets of Gulf Cooperation Council (GCC) countries in terms of the challenges they face from energy prices, food prices and investor sentiment.

The primary aim of this introduction is to provide background knowledge on the nature, significance and challenges of the GCC stock markets. We begin by describing the GCC member countries.The GCC is a structure for regional cooperation established by a 1981 treaty among six of the southern Gulf nations: Bahrain, Kuwait, the Kingdom of Saudi Arabia (KSA), Oman, Qatar and the United Arab Emirates (UAE) (Al-Saud, 1997). This GCC treaty resulted from the similarities among these countries in terms of geographic proximity; political systems; Islamic norms, values, and beliefs; and common aims and objectives. Most importantly, they all use Arabic as an official language. The GCC was established by a charter stipulating the following objectives for its member states: regulation, assimilation and inter-relations in all spheres of life to strengthen connections among their peoples by imposing common regulations in all areas, including the economy. The charter was also intended to foster technical and procedural progress in areas such as the food industry while establishing scientific research and educational centres, creating joint ventures (especially in oil and gas), and supporting cooperation and inclusion in the private sector (Al-Kuwari, 2013).

The GCC stock markets are fairly new. Kuwait was the first country to pass a law creating a stock market in 1962. Later, Bahrain, Oman, the KSA, Qatar, and the UAE followed, with stock markets initiated in 1987, 1988, 1994, 1995, and 2000, respectively. Table 1.1 figures 1.1, and 1.2 refer to the liquidity ratios, the ratio between the liquid assets and the liabilities of the stock indices from the period of 2007 till 2016.

In this new dispensation of globalization age, the whole wide-world is gradually and continually becoming a single entity and village where nations are very close to one another, as they find distance unimportant. The Gulf Cooperation Council could therefore be described as a regional cooperation structure between six (6) of the Southern Gulf Nations including the United Arab Emirates (UAE), Kuwait, Oman, Saudi Arabia, Qatar and Bahrain (Al-Khouri, 2010). Similarly, Abotorabiardestani (2015) also agreed that the Gulf Cooperation Council came into lime-light by a treaty signed amongst Bahrain, Kuwait, Oman, Qatar, Saudi Arabia and the United Arab Emirates for the purpose of special relations and common goals for enhanced cooperation. Takagi (2012) affirm that Gulf Cooperation Council (GCC) is formally referred to as the Cooperation Council for the Arab States of the Gulf which was founded in 1981 around with the purpose of a tense political situation in the region. These countries agreed to issue a unified currency by 2005. However, implementation of the single currency has been postponed several times for political and inflation reasons (Al-Kraidi, E. 2009). Ministries of the six GCC countries meet every few months to discuss support for and to coordinate policies in the socio-economic and cultural domains. Takagi (2012) conclude that despite the differences amongst the six-Arab States, their primary aims is to come together in unity for the pursuit of common security objectives which include oil, food, stock and news. Although, the Gulf Cooperation Council (GCC) countries share a common vision for economic growth and development, while specifically set out the common visions in national development plans that embraces the need for diversification of the productive base in order to reduce dependence on the hydro-carbon sector as example, and to create more means of employment opportunities for young, vibrant and growing populations from all over the world (International Monetary Fund, [IMF], 2011).

Extant literature show that Gulf Cooperation Council (GCC) countries are also referred to as Gulf Monarchies with six Member State as described above and they are still undergoing impressive and dramatic change (Kinninmont, 2015). Although, Kinninmont, (2015) submit that the last ten years has seen rapid growth in their economies, educational systems, populations, as well as growth in the area of communication process. Kinninmont conclude that the Gulf Cooperation Council (GCC) countries are progressively important foreign policy players and investors, which means that a growing range of economies have a direct interest in their wealth and stability. According to Takagi (2012) it is a known fact that the GCC's economies are connected with the world economy and they remain economies with potential gains but the Gulf Cooperation Council (GCC) have a record that seem negative and disappointing on many fronts with respect to integration. The author emphasizes further that the experience of the Gulf Cooperation Council (GCC) economies points to a number of failures and weaknesses in the last two decades, though the failures and weaknesses were associated with growth, trade investment and unemployment.

Al-Yousif (2004) also submit that it is easy to initiate growth but it is more of difficult task to sustain and this is correct in the case of the GCC economies that have achieved very high rates of economic growth following the multiplying rate of oil prices in 1970s, and the worst economic growth record in the last twenty years by international principles. Historically, the Gulf Cooperation Council (GCC) economies are minor open economies that have depended all countries around the world for sales of oil products that represent their main income avenue and to use proceeds from that to purchase all they need in terms of labour and capital (Al-Yousif, 2004).Table 1.2 and Figure 1.3 is a time series figure to describe the trend of oil rents per gdp in the GCC Area from 1975 to 2014. The GCC states ratio of oil rents per GDP is compared to the average world ratio. Thus, trade liberalization has a number of benefits that can, in the proper economic policy setting, lead to a supportable economic development of the region. One benefit includes the provision of the Gulf Cooperation Council (GCC) nations with marketing outlets for setting up industries that currently gives them advantages and the opportunities for projecting the opportunities in their domestic businesses. Consequently, efficiency and productivity are further enhanced to the point that they can now have access to capital goods that are highly modern (World Bank, 2000).

Al-Kuwari (2013) writes that the establishment of the GCC can be traced to a contract that was initiated on the 35th of May, 1981 in the kingdom of Saudi Arabia where countries like Bahrain, Kuwait, Oman, Qatar, Saudi Arabia and United Arab Emirates (UAE) were included in the contract as a result of the similarities among these nations in terms of geographic vicinity, similar political systems and being Islamic norms, values, beliefs, and common aims and objectives. The most important of it all is the official language which is 'Arabic'. The Gulf Cooperation Council (GCC) actually was established on a charter which mentions that the charter's objectives must have coordination, integration and inter-relations between her Member States in all spheres of life in order to firm up the connections between their peoples by integrating the same regulations across all segments, including for example, economy (i.e. including oil, stock exchange, food, finance, trade, customs, tourism, legislation, administration) to also foster technical and procedural progress in industry such as mining, agri-

Table 1.1: Liquidity Ratios

Total Debt to Total Equity										
	2007	2008	2009	2010	2011	2012	2013	2014	2015	Curr.
AD.	124.9	106.9	106.4	106.0	104.3	93.3	80.2	78.7	86.6	91.0
Bah.	225.0	230.4	184.4	176.1	124.1	109.2	110.3	118.8	104.1	73.3
Dub.			77.6	62.3	59.7	59.2	44.8	45.4	46.6	56.5
Kuw.	60.5	65.8	79.3	71.2	69.8	62.1	58.8	60.3	61.3	64.9
Saudi			63.5	63.1	63.1	58.7	57.5	60.2	63.5	64.1
Oman	67.9	106.9	74.9	58.4	62.5	66.1	64.3	73.5	103.3	106.1
Qatar	87.2	128.1	140.1	113.0	123.6	108.6	97.4	83.9	88.0	93.2

Total Debt to Total Assets										
	2007	2008	2009	2010	2011	2012	2013	2014	2015	Curr.
AD.	26.4	21.9	23.7	22.7	21.0	19.7	17.0	17.0	18.3	18.6
Bah.	225.0	230.4	184.4	176.1	124.1	109.2	110.3	118.8	104.1	73.3
Dub.			18.2	16.7	16.6	16.2	12.2	12.3	13.1	13.8
Kuw.	26.7	38.2	28.8	28.5	27.4	25.0	23.6	24.1	24.1	25.0
Saudi			19.0	19.3	19.2	17.3	16.0	16.9	16.6	16.7
Oman	15.6	21.2	15.2	12.3	11.7	12.1	12.4	13.6	18.9	19.2
Qatar	23.4	28.6	29.1	25.3	26.7	25.9	23.4	20.9	21.4	22.2

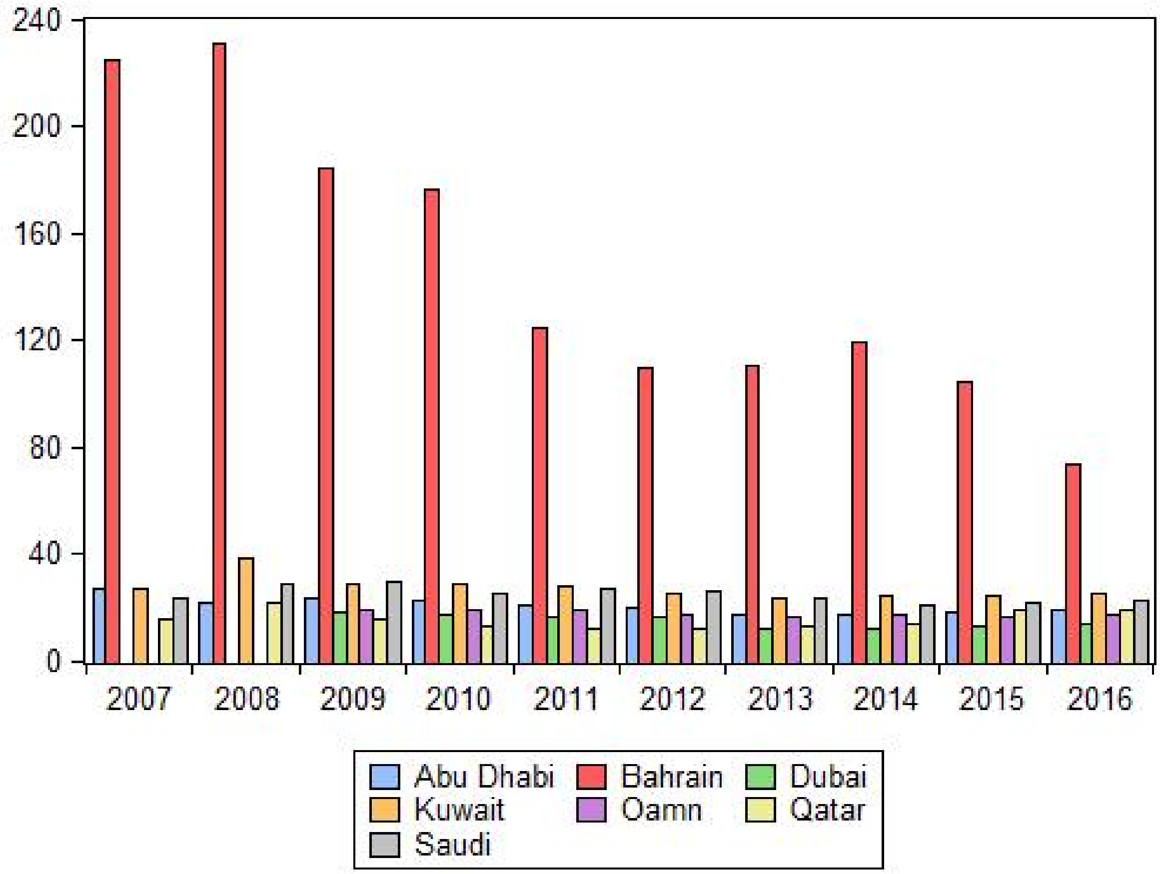

Figure 1.1: debt to asset ratio

Note: Debt to Equity Ratio Within the GCCBased on Bloomberg .

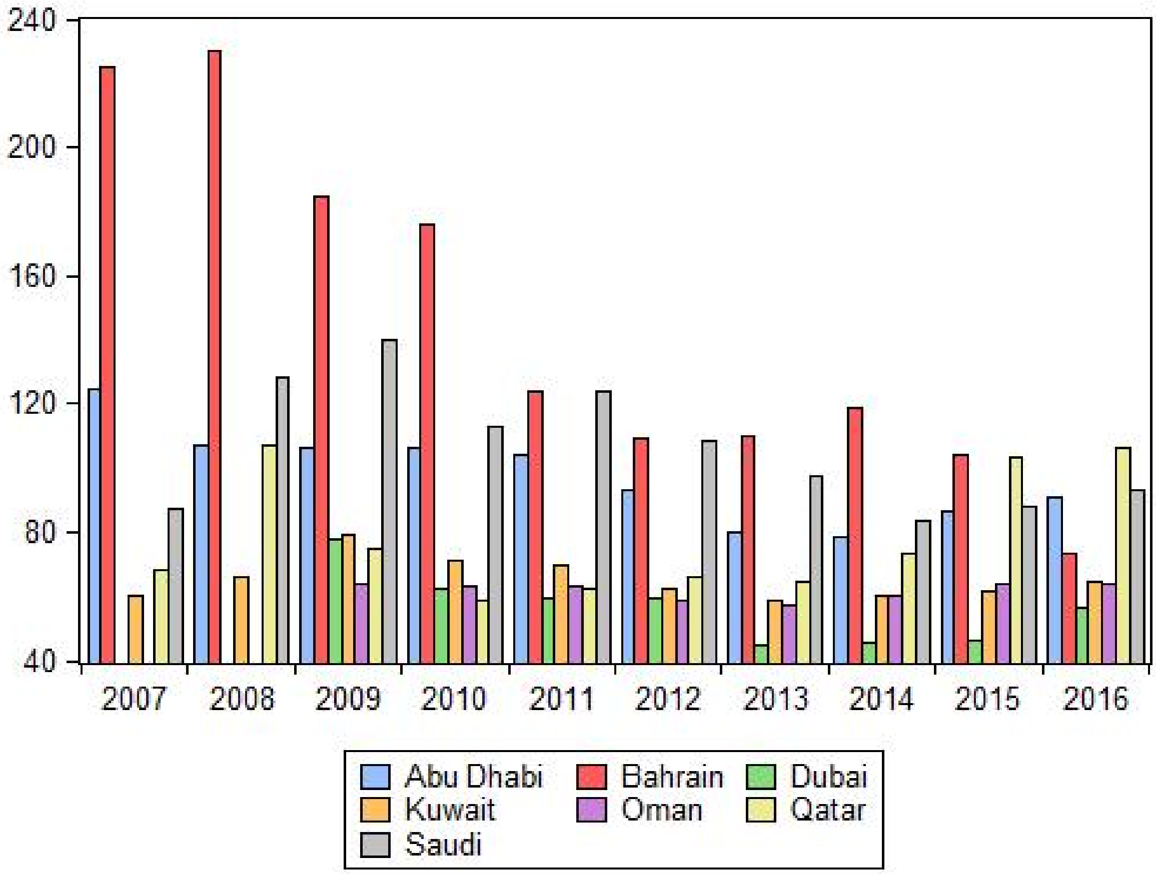

Figure 1.2: debt to asset ratio

Note: Debt to Equity ratio Within the GCC Based on Bloomberg .

culture, water and animal resources while establishing scientific research and educational centres, as well as setting up joint ventures (especially in oil and gas), and supporting private sector's cooperation and inclusion. The Gulf Cooperation Council (GCC) members are also members of the bloc refers to as the Greater Arab Free Trade Area (GAFTA). This is doubtful to affect the existing framework of the Gulf Cooperation Council (GCC) in a way as the Gulf Cooperation Council (GCC) economies has a more orderly timeframe as compared to Greater Arab Free Trade Area (GAFTA) and it seek out greater coalition. The Gulf Cooperation Council (GCC) comprises of the fastest growing countries in the world, principally due to the rise in the revenues of their oil and natural gas products together with a strong building and investment outburst supported by reserves amongst others. Most of these countries which were affected during the global economic meltdown have suddenly come out of crises and are now developing at a very rapid rate.

In terms of the structure of Gulf Cooperation Council (GCC) economies, it is made up of three constituent parts that include the "Supreme Council, the Ministerial Council and the Secretariat General" (Al-Kuwari, 2013). The Secretariat is located at Riyadh city. The constitution of the Gulf Cooperation Council (GCC) specifically reflected the importance of seeking for means of supporting the unity and cooperation of the Arab economies. Hence, the constitution requires the union to provide at least the means with which cooperation, coordination and integration in socio-economic and cultural affairs will be a reality. The Supreme Council as the name implies and the highest authority of the Gulf Cooperation Council (GCC) economies comprises the Heads of State of the six-member countries. The Supreme Council is designed to meet once a year in ordinary session, but the emergency sessions are structured in a way that they can meet whenever they wish to as long as a minimum of two states are involved. Also, the chairmanship of the Supreme Council is held by each Member State in turn while resolutions are carried by majority vote within the economies.

Notably, the Supreme Council is responsible for making and determining the overall policy of the Gulf Cooperation Council (GCC) and for confirming the suggestions given to the council by either of the “Ministerial Council or the Secretariat General”. Still on this issue, the Supreme Council as well as the Ministerial Council is composed of the Foreign Ministers of the GCC countries (Bahrain, Kuwait, Oman, Qatar, Saudi Arabia and United Arab Emirates [UAE]). Meetings are held by this council once every three months in what is called “ordinary session”. Sessions that are emergency in nature are convened at any time by the Foreign Ministers of any two countries of the GCC. Most significantly, policies are developed by the Ministerial Council, who also makes suggestions on the manners of building supports and coordination amongst the Gulf Cooperation Council (GCC) countries in the socio-economic and cultural domains. Finally, the office of the Secretariat prepares accounts and budgets, reports and studies for the Gulf Cooperation Council (GCC). The Secretariat General drafts rules and regulations which are charged with the sole responsibility of assisting Member States of the Gulf Cooperation Council (GCC) on how they can successfully implement decisions accepted by all segments of their councils. A total of three years are set aside for all secretary generals subject to renewal by the Supreme Council on the recommendation of the Ministerial Council. In summary, the Gulf Cooperation Council (GCC) countries, its definitions and descriptions along with composition with specific benefits and challenges have been successfully reviewed. The Gulf Cooperation Council (GCC) can be summed up as one of the most important regional entities in the global village with the provision of a framework for stability in terms of oil and gas to facilitating great wealth (Al-Kuwari, 2013).

The importance of oil to the Gulf Cooperation Council (GCC) cannot be overemphasized. Nonetheless, for well over five decades now, the international trade has increased at a faster rate than entire output of the world (Muhammad, et al., 2012). Specifically, between the 1948 and 1999, merchandize exports grew by six per cent (6%) in real terms when compared to an annual average world output growth of 3.7 per cent (Al-Yousif, 2004; WTO, 1998). According to Al-Yousif (2004), this growth means that the countries involved depend more

Table 1.2: Oil Rents Per GDP in the Gulf States

date	Bahrain	Kuwait	Oman	Qatar	Saudi	UAE	World
1980	76.813	75.519	60.200	77.481	78.856	50.461	5.543
1981	68.942	55.405	53.580	56.461	66.153	36.164	4.707
1982	43.722	42.322	46.655	46.816	47.504	28.997	3.876
1983	33.674	50.119	45.322	43.727	39.678	25.845	3.280
1984	36.233	51.505	41.790	54.184	37.843	25.386	3.134
1985	32.734	44.104	40.466	41.666	29.587	25.164	2.698
1986	23.297	26.691	27.161	23.901	24.878	15.536	1.034
1987	29.942	31.149	37.881	29.147	29.343	23.118	1.327
1988	21.057	31.091	28.024	23.739	26.714	18.052	0.930
1989	25.641	39.585	33.532	30.789	30.558	23.768	1.410
1990	31.736	35.412	39.938	39.420	41.845	30.008	1.830
1991	23.758	10.135	34.307	33.498	39.084	27.208	1.314
1992	22.221	32.133	31.439	31.300	37.729	23.809	1.202
1993	17.656	41.414	28.601	28.409	33.543	19.266	1.098
1994	14.932	39.976	26.942	25.952	30.720	17.200	0.955
1995	15.718	39.901	29.360	27.496	32.015	17.332	0.975
1996	18.677	41.983	34.236	35.168	35.057	19.449	1.215
1997	16.980	40.472	30.960	28.097	31.710	17.078	1.150
1998	10.439	30.091	19.454	23.207	22.755	10.743	0.655
1999	13.726	33.829	26.098	26.727	27.352	12.932	0.906
2000	18.091	48.552	40.897	36.692	41.911	20.055	1.666
2001	14.677	42.952	33.208	30.043	34.586	15.533	1.357
2002	14.145	36.004	30.697	26.999	32.620	14.087	1.323
2003	14.935	40.829	31.325	30.047	38.736	16.667	1.485
2004	16.967	47.932	35.821	33.818	44.527	20.067	1.939
2005	20.193	57.048	41.552	37.942	52.789	24.365	2.655
2006	20.724	56.371	40.056	34.214	53.250	24.928	2.983
2007	19.541	53.614	37.508	31.304	50.733	23.349	2.907
2008	22.570	59.599	38.143	33.001	59.226	27.099	3.674
2009	14.635	41.853	29.005	24.095	38.557	17.661	2.155
2010	17.118	51.140	33.762	28.219	43.997	20.562	2.673
2011	21.185	58.586	40.085	29.919	48.830	25.002	3.274
2012	17.911	57.674	36.108	25.967	46.159	24.077	3.205
2013	18.387	54.881	34.424	23.548	43.668	22.475	3.030
2014	15.271	53.039	27.968	19.501	38.711	18.979	2.513

Note: Oil Rents Per GDP, source bloomberg

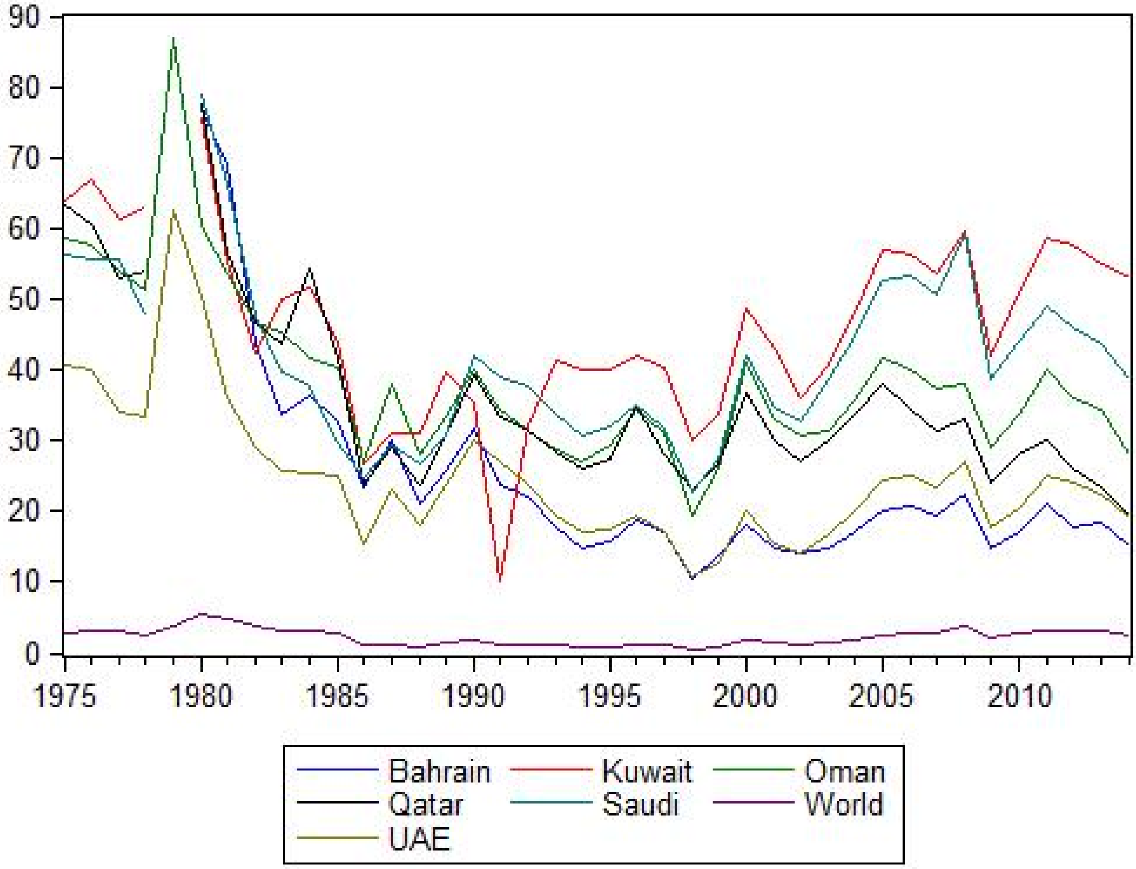

Figure 1.3: Oil Rents Per GDP Within the GCC Based on IMF Statistics

on trade than they had following World War II, perhaps the global economy is seen as becoming more integrated in a single village. Notably, it is a known fact that oil is the mainstay of the GCC economies. For instance, a change in the price of oil may produce quite abstruse effects on the economies of the Gulf Cooperation Council (GCC). As oil is a key source of energy, a rise in its market price may boosts profits for oil firms while increases costs for goods producing corporations, if other cost-cutting methods are not executed. Since most of the Gulf Cooperation Council (GCC) oil corporations are owned by their, the resulting boost in oil export revenues serves as a means of promoting investment in education, training, infrastructure, education and tourism, among other sectors of the economies. For example, a major increase in the price of oil may bring the disaster of raising the cost of imported capital goods, and therefore it hampers growth in the Gulf Cooperation Council (GCC) markets.

This track of perception is similar to the macro-view that oil prices can influence the real sector of the economy mainly through its influence on consumption as companies shift a portion of their costs to consumers, production, and government budgets (Ravichandran and Alkhathlan, 2010). Extant literature shows linkage in the fluctuations in key macroeconomic measures to stock market performance. The overall findings are in line with what Hamilton (2003), Hamilton and Herrera (2004), Cunado and Perez de Garcia (2005) have documented. That is, oil price shocks affect key macro-economic variables in both developed and developing economies with different forces and through different strategies. Given the innovation of the Gulf Cooperation Council (GCC) stock markets and the lack of high frequency macro-economic data, this area of exploration has not been fully exploited. Existing literature examines divergent effects that unimagined change in the price of oil can subsequently have on the share prices of oil and non-oil corporations as expectations about future dividends are factored into investors' portfolio decisions.

Raw petroleum is an important part of the GCC economies, and their governments rely on revenues from oil to finance their budgets (Callen et al., 2014). Changes in the cost of oil might thus have clear impacts on these economies.

As oil is the principle wellspring of economic vitality, an increase in its value benefits oil producers while increasing costs for manufacturers, provided that neither cost-cutting measures nor policies to encourage training, infrastructure, education, and tourism, among other factors, are implemented. The GCC economies are small, open economies that depend on the rest of the world buying oil products, which represent their main sources of income; they use the proceeds from these sales to finance their labour and capital needs (Al-Yousif, 2004). Thus, trade liberalization has a number of benefits that can, with appropriate economic policy, lead to sustainable economic development in the region. From another perspective, Al-Kuwari (2013) contends that no country can ignore the fact that the GCC represents a nexus of countries that help stabilize the world's supply of oil and gas. Thus, the global oil and gas industry provides opportunities for the GCC region to demonstrate its capacity to influence the balance between the demand for and supply of oil. In fact, according to some reports these economies accounted for nearly one-half of global oil reserves (40%), Qatar alone holds 15% of the worlds gas reserves, and nearly 15% of global oil production, and nearly 20% of all oil exports to distant parts of the world (Sturm et all 2008). Other statistics from the IMF database reveal the influence of oil on the GCC region. For example, in these countries, gross domestic product (GDP) from oil activities is the largest in the world relative to population, amounting to more than $1.4 trillion, with the KSA responsible for 43% and Bahrain for 1.9% of this figure (IMF, 2013).

In summary, decreases in oil prices will always have severe and strategically important negative consequences for the GCC economies, while breakthroughs and progress in the global oil industry generally increase GDP and sustain the GCC countries' competitiveness and roles as major stabilizers of the global supply of oil products.

This thesis comprises three papers that are connected to our aspiration to understand the effects of oil prices, food prices and macroeconomic news on the GCC stock markets. The first paper, which is presented in the second chapter, empirically evaluates the effect of oil on the securities exchange volatility of

GCC nations and compares the effects on the GCC with those on four developing nations. A recent body of literature discusses how economies are affected by oil shocks. For example, Wang et al. (2013) apply a structural vector autoregression (SVAR) model to examine how both oil-importing and oil-exporting countries are affected by oil shocks. They find that oil supply uncertainty can negatively affect the stock markets of both types of countries. However, there is limited evidence of how particular GCC stock markets are affected by oil shocks. Therefore, this paper uses data from 2004 to 2015 to compare the effects of oil shocks on GCC and non-GCC stock markets using a generalized autoregressive conditional heteroscedasticity (GARCH) framework for comparison purposes. The results indicate that GCC stock markets are more affected by oil price shocks than those of non-GCC countries. Thus, this thesis helps fill a gap by empirically exploring the volatility of GCC stock markets in relation to oil and comparing their stock market with other countries. This research serves as a baseline that can be used to derive models to explain portfolio diversification with the stocks discussed. Moreover, policymakers should consider the research produced in this field to produce more appropriate policies.

The second paper, which is presented in the third chapter, tests for and determines the dates of potential structural breaks in the relationship between energy and food spot prices, including volatility spillovers between them, using a GARCH model to examine four recent breaks in the relationship. These four breaks refer to the financial crisis, an environmental policy to promote ethanol, a period of food price volatility and a period of oil price volatility. The investigation of the crisis period includes the addition of a dummy variable to the Value at Risk Generalized Autoregressive conditional Heteroskedasticity (VAR-GARCH) model. This paper systematizes the investigation of the effects of well-known recent spillovers between food and energy prices in both the primary (mean) and second (instability) moments by applying a VAR-GARCH model with a BEKK representation. The key feature of this study is its long-term approach, as the sample period is from 2003 to 2014. The findings of this study offer another interpretation of ethanol and Brent oil as energy costs and cacao, espresso, corn, soybeans, soybean oil, sugar, beef, and wheat as food prices. This research extends our knowledge of volatility in energy and food commodity markets in relation to breaks. Progress in this area requires a better understanding of policy, and portfolio analysis needs to be developed to diversify portfolios in terms of energy and food.

The third paper comprehensively compares the accuracy of linear and non-linear model returns forecasts using data for GCC stock exchanges and newspaper articles on macroeconomic news in these countries. In such an empirical examination, daily newspaper articles must be ordered using a quantitative measure. For example, Birz and Lott (2011) recently studied the relationship between news and macroeconomic factors in the US, as measured by newspaper headlines, which were interpreted as providing statistical information. Birz and Lott adopt the headline classification developed by Lott and Hassett (2006), calculating the News Confidence Index, which is similar to the Confidence Board's Consumer Confidence Survey categorization of responses (i.e., as positive or negative responses). Negative responses were sorted by subtracting the negative values from the positive values, and the overall response was generated.This procedure must be uncorrupted by the objectives of the study. The articles obtained from Bloomberg for each week are classified as positive, negative, mixed, or impartial. The use of articles from Bloomberg to construct a dataset for a non-money-related study minimizes bias in our analysis. This paper provides a novel approach to examining the type of relationship and the degree of transmission between daily newspaper article sentiment and stock prices in GCC securities markets. Its unique characteristics provide rich insights into the distinctive attributes of GCC nations. In this study, dynamic regression models outperform the alternative, indicating the benefits of non-linear models.

Chapter 2

Oil Shocks Affecting GCC Countries and Stock Prices

2.1 Introduction

The recent oil boom between 2002 and 2008 generated a large volume of revenue for all the GCC economies, as can be seen in Table 1.2 and Figure 1.3. According to Saif (2009), the revenues from oil in this region were close to U.S. $327 billion between 2002 and 2006. Figure 1.3 and Table 1.2 refer to oil rents per GDP in the gulf states. In fact, however, the revenues from the five years prior to 2002 were less than half of those between 2002 and 2006. This huge revenue increase was responsible for improving the development of these economies, leading to further improvement in indices such as growth and investment in the GCC states (Saif, 2009). This paper aims to shed light on how the GCC economies are affected by oil shocks in comparison to other economies using a multivariate BEKK model. Despite their huge oil revenues, the GCC countries faced the same challenges during the oil boom as in preceding periods. Efforts at diversifying their economies while limiting their over-dependence on oil proved unsuccessful despite the multi-track methods that these economies pursued. Furthermore, the labour market was also negatively affected due to these economies' continued dependence on less expensive labour at the expense of GCC nationals, which negatively influenced productivity and performance.

The GCC represents a nexus of countries that have helped to stabilize the supply of oil and gas throughout the world. In other words, the global oil and gas industry provides opportunities for the GCC region to demonstrate its capacity to influence the balance between the demand and supply of oil. In fact, according to a report by the International Monetary Fund (IMF) in 2013, these economies boast close to half of the global reserve of oil (45%) and close to 15% of the reserves of natural gas. In addition, they also represent close to 15% of the total global production of oil and close to 20% of all exports of oil to distant parts of the world (IMF, 2013). Other statistics from the IMF database on the influence of oil on the GCC region include, for example, the fact that the sum of the GCC's GDP as a result of oil activities is the largest in the world in relation to population at more than $1.4 trillion. Saudi Arabia is responsible for 43% of this figure and Bahrain 1.9% (International Monetary Fund, 2013).

In summary, oil price failures will always create very serious and strategic negative consequences for the (GCC) economies, while breakthroughs and progress in the global oil industry have generally helped the GCC region improve and sustain its national GDPs as well as its competitiveness as a major stabilizer of the supply of oil products around the world. For instance, the 1986 failure transitioned almost all of the GCC countries from the state of creditor to the state of borrower (Al-Sadoon, 2009). During that period, the GCC countries experienced severe recession and hyper-inflation that forced many of the member countries to sell off their foreign assets. One would think that these economies would have learned a lesson from this period of chaos. Not so, however, as many of the governments of the GCC states have continued to maintain their trust in an oil economy that has been threatened by numerous global macro-environmental problems (Al-Kuwari, 2013).

The aim of this chapter is to use a multivariate Garch Model to determine how the stock markets in three GCC countries respond to oil shocks. The same procedure is also applied to other developing markets as a benchmark for comparison with the GCC stock markets.

2.2 Litereture Review

The relationship between oil and stock prices has been analysed extensively in the recent literature. The aim of this paper is to shed light on the volatility spillover dynamics running from the oil market into stock market volatility for eight selected Middle East/African frontier markets.[1] The methodology adopted in this paper is based on the VAR-GARCH approach of Engle and Kroner (1995), which allows testing for the presence of volatility spillovers in both directions (i.e., from oil prices to stock prices, and vice versa).

The effects of crude oil prices on US financial and economic variables are well documented in the literature. Hamilton (1996) uses an impulse response approach to show that US recessions were triggered by increases in oil prices. Ghouri (2006), using a linear model, finds that West Texas Intermediate (WTI) oil prices are inversely related to monthly US stock market returns.

Hammoudeh et al. (2004), applying a GARCH methodology, report little evidence of spillover effects from oil prices to US stock prices. Elyasiani et al. (2012) compare specific industry sectors in the US stock market and find that, at the industry level, there is strong evidence that global oil price volatility constitutes an asset price risk factor for most indices. Mollick and Assefa (2013) investigate the effects of oil on the S&P 500, Dow Jones, NASDAQ and Russell 2000 index returns. These authors also apply a GARCH approach and show that US stock returns and WTI oil returns are, to some extent, negatively affected by both oil prices and the pre-financial crisis exchange rate. Moreover, their findings reveal that, after the onset of the 2007 financial crisis, stock returns were positively affected by oil prices and less affected by the exchange rate.

Nazliogu et al. (2015) use an impulse response function methodology to examine the relationship between WTI and financial stress indices. Their analysis was conducted by dividing the sample into pre-2008 and post-2008 crisis periods and reveals evidence of significant spillovers in mean and variance.

[1] Note that Middle East countries account for 31% of all crude oil production, whereas approximately 69% of all crude oil is produced by only ten countries (International Energy Agency).

Another recent study by Salisu and Oloko (2015) implements a VARMA-BEKK-AGARCH approach, showing that stock prices in the US are more strongly affected by the oil price since the financial crisis than during the pre-crisis period.

Huang et al. (1996) use a VAR framework to investigate causality between oil future prices and US stock prices and find weak evidence in terms of return volatility spillovers for the period from 1979 to 1983. Using a similar approach, Kilian and Park (2009) investigate the relationship between oil and stock prices in the US by considering US oil refiners' acquisition costs and find that US stock prices react differently depending on whether shocks are demand or supply driven. In contrast, Kang et al. (2014) replace stock prices with bond prices, revealing that demand and supply shocks originating from oil prices account for strong variation in the US bond market.

Balcilar and Ozdemir (2013) report evidence of non-linearity between stock prices and oil prices and use a Markov switching model to argue that oil future prices might be a reliable predictor of the S&P 500 index. Alsalman and Herrara (2013) apply a simultaneous equation method and find that an increase in oil prices can affect UK stock indices up to one year later. Conrad et al. (2014) use a modified dynamic conditional correlations-mixed data sampling (DCC-MIDAS) approach and observe a positive oil-stock correlation during recessions and a negative one during economic expansions.

Park and Ratti (2008) and Apergis and Miller (2009) study several developed countries and report that the stock market is affected by positive oil shocks only in Norway (an oil-exporting country). Arouri et al. (2011b) use a multi-factor asset pricing model for twelve weekly European industrial sector indices and provide evidence of substantial returns and volatility spillovers between oil and stock market prices. Arouri et al. (2011a) use a VAR-GARCH(1,1) model to test the relationship between daily oil and stock prices within the GCC region and show that oil prices tend to positively affect several stock markets in the GCC region, whereas the volatility from GCC stock markets to oil markets is nearly absent. Jouini (2013) models weekly stock returns in the KSA from 2007 until 2011 by means of a VAR-GARCH model and provides evidence of significant and bi-directional spillovers between the Saudi Market Index and oil prices. Jouini and Harrathi (2014) consider the empirical evidence on volatility interactions among GCC stock markets and oil prices for the period from 2005 to 2011 using a BEKK-GARCH model. Their findings suggest a volatility spillover running from stock price volatility into oil market volatilities and vice versa. Zarour (2006) uses a VAR process to show that, although all GCC stock markets are affected by oil price shocks, in the Saudi and Omani stock markets, returns also affect oil prices. Lescaroux and Mignon (2008) examine the short- and long-term relationships between WTI oil prices and macroeconomic and financial indicators for oil-exporting countries (including the GCC) and oil-importing countries based on causality tests, cross-correlations and cointegration techniques. Their analysis indicates strong Granger causality running from oil to share prices, especially for oil-exporting countries. Furthermore, oil prices are found to lead (counter-cyclically) share prices for most of the investigated countries.

Using a BEKK-GARCH model, Malik and Hammoudeh (2007) find significant volatility spillovers from oil to stock markets in the US and GCC countries. Filis et al. (2011) compare three oil-importing (Germany, the Netherlands and the US) and three oil-exporting (Brazil, Canada and Mexico) countries using a DCC-GARCH framework. Their results suggest that the relationship between oil and stock prices depends on the nature of the shocks (i.e., demand shocks caused by drastic events, such as war, might affect stock markets more significantly than supply-side shocks caused by production cuts). They also find a correlation between lagged oil prices and stock market returns. Finally, Wang et al. (2013) apply a structural VAR (SVAR) model to examine both oil-importing (China, France, Germany, India, Italy, Japan, Korea, the UK and the US) and oil-exporting (Canada, Saudi Arabia, Kuwait, Mexico, Norway, Russia and Venezuela) countries. Their findings indicate that oil supply uncertainty can depress the stock markets of both oil-exporting and oil-importing countries. The remainder of the paper is structured as follows. Section 2.2 discusses the econometric method, Section 2.3 presents the data and discusses the empirical results, and Section 2.4 concludes.

2.3 The Model

We model the joint process governing oil and stock prices using a bivariate VAR-GARCH(1,1) framework[2]. The model has the following specification:

$$\mathbf{x}_t = \alpha + \beta \mathbf{x}_{t-1} + \mathbf{u}_t, \tag{2.1}$$

where $\mathbf{x}_t = (Stock_t, Oil_t)$. The parameter vectors of the mean equation (1) are the constant $\alpha = (\alpha_1, \alpha_2)$ and autoregressive $\beta = (\beta_{11}, 0 \mid 0, \beta_{22})$ terms. The residual vector $\mathbf{u}_t = (e_{1,t}, e_{2,t})$ is bivariate and normally distributed, $\mathbf{u}_t \mid I_{t-1} \sim (\mathbf{0}, H_t)$, with a corresponding conditional variance-covariance matrix given by:

$$H_t = \begin{bmatrix} h_{11t} & h_{12t} \\ h_{12t} & h_{22t} \end{bmatrix}$$

$$H_t = C_0' C_0 + A_{11}' \begin{bmatrix} e_{1,t-1}^2 & e_{2,t-1} e_{1,t-1} \\ e_{1,t-1} e_{2,t-1} & e_{2,t-1}^2 \end{bmatrix} A_{11} + G_{11}' H_{t-1} G_{11}, \tag{2.2}$$

where

$$A_{11} = \begin{bmatrix} a_{11} & a_{12} \\ a_{21} & a_{22} \end{bmatrix}, G_{11} = \begin{bmatrix} g_{11} & g_{12} \\ g_{21} & g_{22} \end{bmatrix}.$$

Equation (3) models the dynamic process H_t as a linear function of its own past values H_{t-1} and the past values of the squared innovations $\left(e_{1,t-1}^2, e_{2,t-1}^2\right)$. The BEKK model guarantees, by design, that the covariance matrix in the system is positive definite. Given a sample of T observations, a vector of unknown parameters θ and a 2×1 vector of variables $\mathbf{x}_t$, the conditional density function for model (1) is as follows:

$$f\left(\mathbf{x}_t | I_{t-1}; \theta\right) = (2\pi)^{-1} \left|H_t\right|^{-1/2} \exp\left(-\frac{\mathbf{u}_t' \left(H_t^{-1}\right) \mathbf{u}_t}{2}\right). \tag{2.3}$$

[2]The model is based on the GARCH(1,1)-BEKK representation of Engle and Kroner (1995).

The log-likelihood function is:

$$L = \sum_{t=1}^{T} \log f\left(\mathbf{x}_t | I_{t-1}; \theta\right). \tag{2.4}$$

Standard errors are calculated using the quasi-maximum likelihood method of Bollerslev and Wooldridge (1992), which is robust to the distribution of the underlying residuals.

2.4 Empirical Analysis

2.4.1 Data and Hypotheses Tested

We use weekly data for four GCC stock markets (the KSA, Oman, Qatar and the UAE), three frontier stock markets (Algeria, Morocco and Namibia), and the US over the 1/6/2004–25/6/2015 period, for a total of 544 observations. WTI oil prices and stock prices were sourced from the US Energy Information Administration and Bloomberg, respectively. Weekly indices (Wednesday to Wednesday) were preferred to overcome the different stock markets closure days of the eight countries considered in this study. We define weekly returns as logarithmic differences of oil and stock prices. Descriptive statistics are reported in Table 2.1, and the data are plotted in Figs. 2.1 - 2.4. Namibia appears to be the most volatile stock market (of the eight considered), with a standard deviation equal to 0.014, whereas Oman is the least volatile stock market, with a standard deviation of 0.004. Oil prices exhibit high volatility, with a standard deviation equal to 0.013.

Following Caporale and Spagnolo (2003) and Al-Maadid et al. (2015), we use a multivariate BEKK-GARCH model to test for volatility spillovers by placing restrictions on the relevant parameters. We consider the following two null hypotheses: i) test of no stock price volatility spillover to oil price volatility (H_0: Stock $\rightarrow$ Oil : $a_{21} = g_{21} = 0$) and ii) test of no oil price volatility spillover to stock price volatility (H_0: Oil $\rightarrow$ Stock: $a_{12} = g_{12} = 0$).

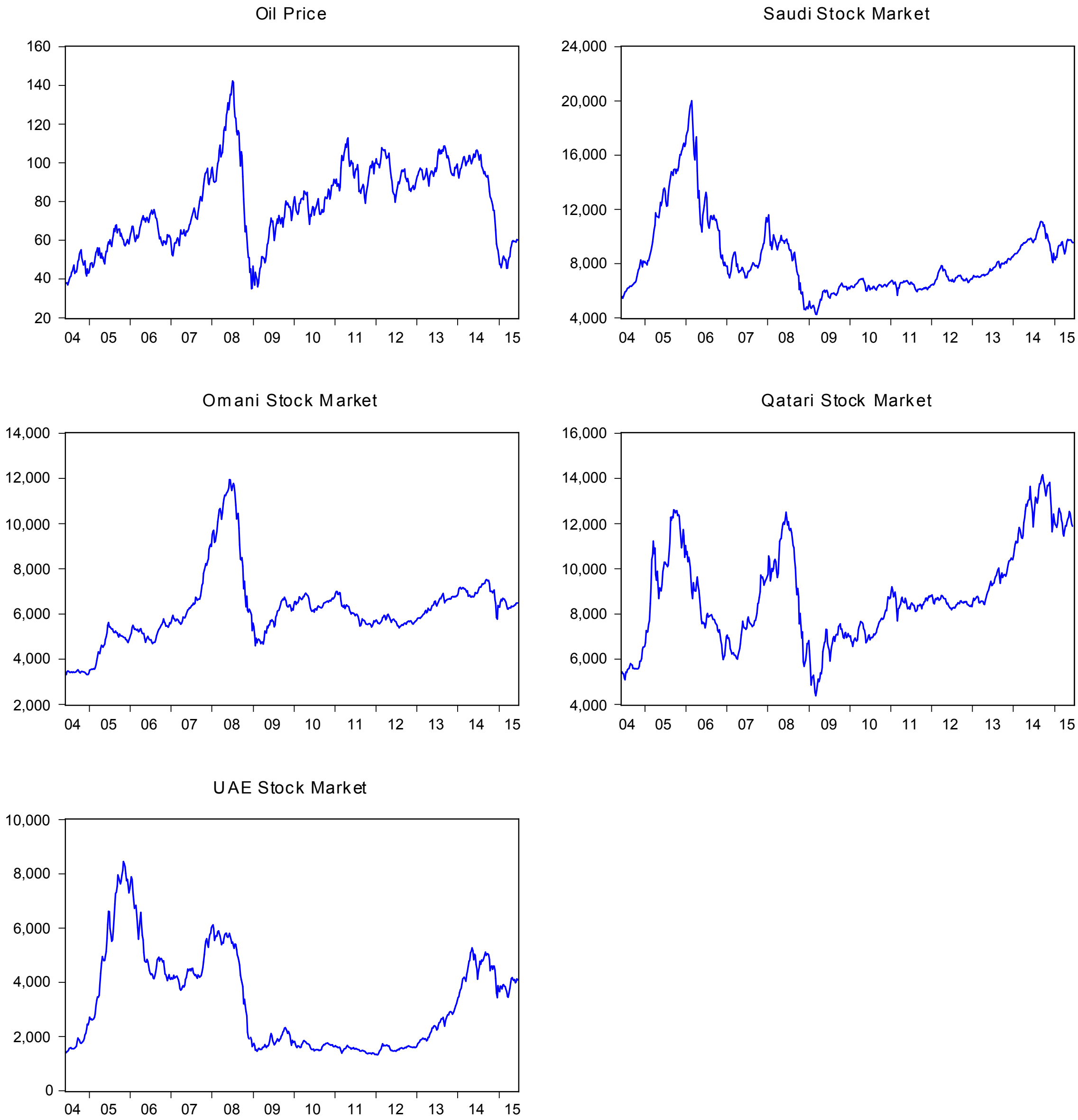

Figure 2.1: Real Prices of Oil and GCC Stock Markets

Table 2.1: Descriptive Statistics

	Oil	KSA	UAE	Qtr.	Oman	Alg.	Namb.	Moro.	USA
Mean	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Median	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Maximum	0.067	0.028	0.039	0.044	0.022	0.034	0.187	0.018	0.030
Minimum	-0.076	-0.103	-0.075	-0.059	-0.054	-0.041	-0.175	-0.035	-0.042
Std. Dev.	0.013	0.010	0.010	0.009	0.006	0.004	0.014	0.006	0.006
Skewness	-0.465	-3.168	-1.138	-0.883	-2.541	-2.314	0.631	-0.972	-0.923
Kurtosis	8.021	28.492	9.252	10.273	19.758	34.436	111.524	8.357	11.182
Jarque-Bera	620.4	1641.3	1053.3	1332.5	7296.3	2385.0	2280.7	767.2	1662.0
Probability	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Sum	0.252	-0.160	-0.225	0.070	-0.055	0.221	0.388	0.069	0.077
Sum Sq. Dev.	0.089	0.054	0.062	0.042	0.024	0.011	0.105	0.018	0.022

Note: Descriptive statistics for weekly data over the 9/6/2004–10/6/2015 period.

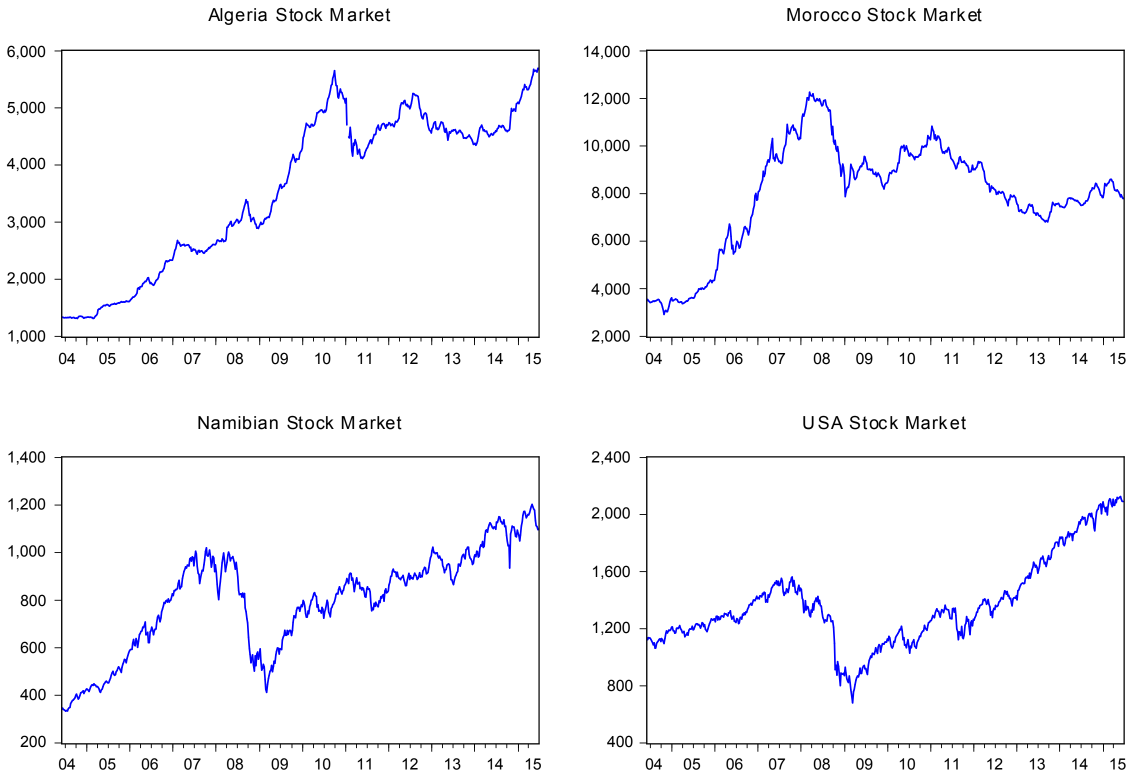

Figure 2.2: Real Prices of Non-GCC Stock Markets

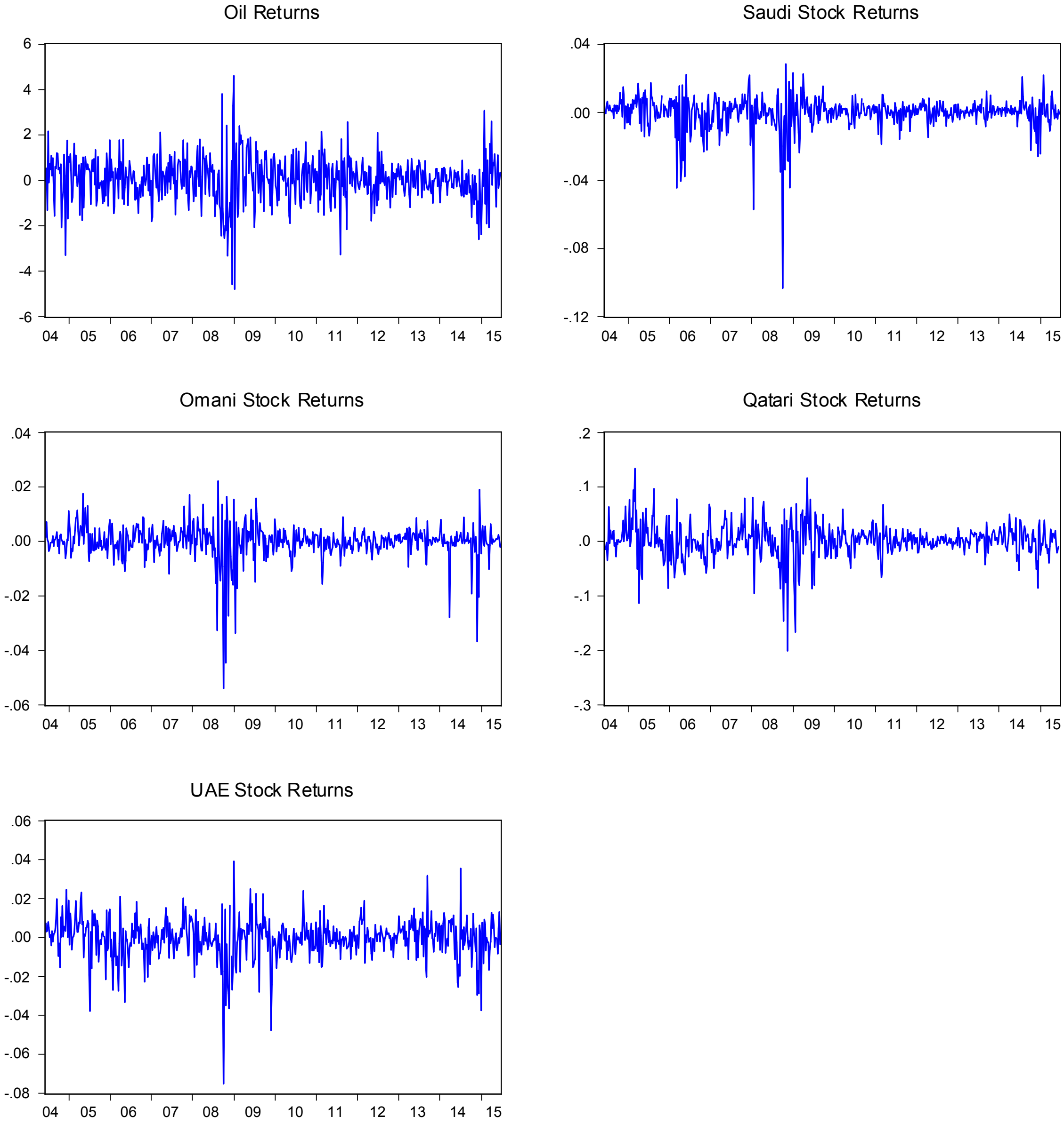

Figure 2.3: Returns of Oil and GCC Stock Markets

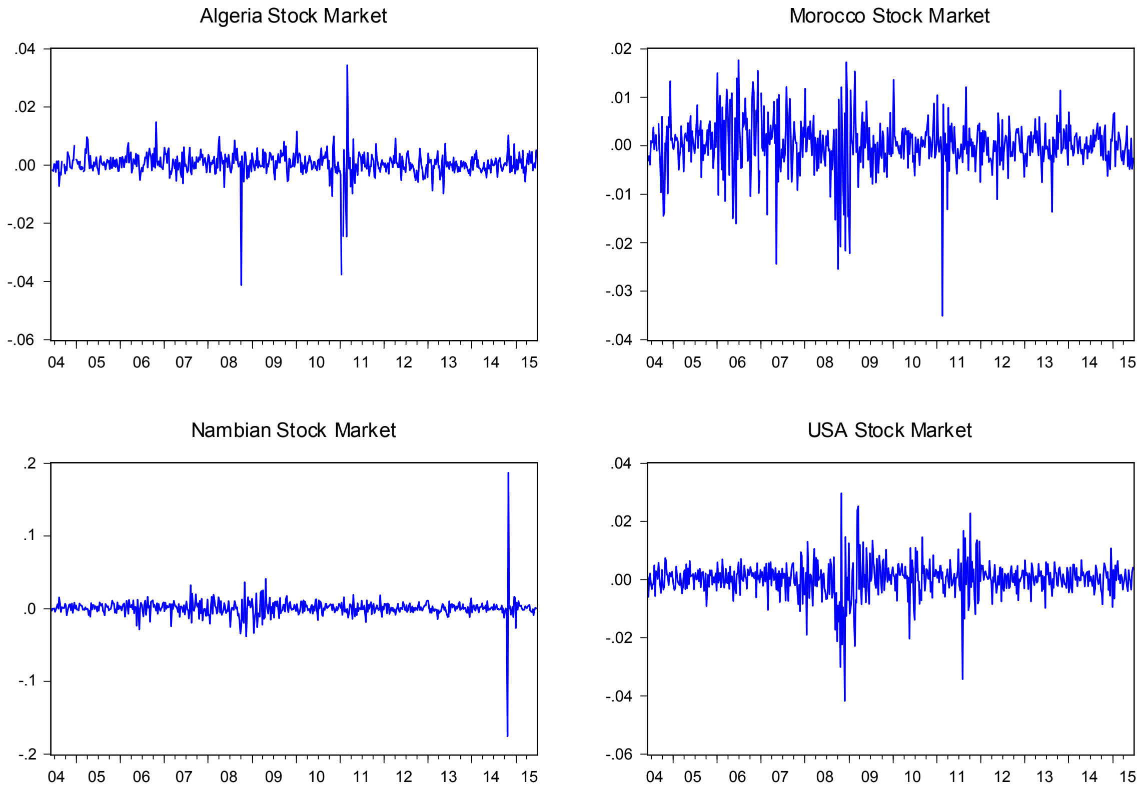

Figure 2.4: Returns Prices of Non-GCC Stock Markets

2.4.2 Discussion of the Results

To test the adequacy of the models, Ljung-Box portmanteau tests were performed on the standardized and standardized squared residuals. Overall, the results indicate that the VAR-GARCH(1,1) specification satisfactorily captures the persistence in the returns and squared returns of all the series considered (see Tables 2.2 and 2.3). The cross-market dependence in the conditional variance varies in magnitude and direction across the pair-wise estimations[3]. The estimated VAR-GARCH(1,1) model, with associated robust standard errors and likelihood function values, is presented in Tables 2.2-2.3.

We select the optimal lag length of the mean equation using the Schwarz Information Criterion. The parameter estimates for the conditional variance equations show that the estimated 'own-market' coefficients are statistically significant for all stock markets, and the estimates for g_{11} suggest a high degree of persistence. The results can be summarized as follows:

1) There is a volatility spillover from oil price volatility to stock market return volatility. The findings show a significant volatility shock spillover, measured by α_{12}, running from oil prices to stock market prices for Morocco and Qatar, with that of Qatar being the greatest (0.169) and that for Morocco being the least: $a_{12} = 0.018$. There is evidence of a significant conditional volatility spillover, as measured by $g_{12,}$, running from oil towards the UAE (0.130), Qatar (0.134) and Oman (0.259). These results are consistent with the findings reported by Arouri et al. (2011a), who report significant volatility spillovers between oil and stock markets in the GCC region.

2) There is a volatility spillover from stock market return volatility to oil price volatility. A significant volatility spillover running from stock market returns to oil prices only occurs in the UAE $(a_{21} = 0.103)$ and Morocco $(a_{21} = 0.012)$. These results are in line with those of Jouini (2013) and show that for most of the countries considered, a shock originating in the stock markets does not affect oil price volatility.

[3]Note that the signs of the cross-market volatilities are not relevant.

Table 2.2: Estimated VAR-GARCH(1,1) Model for GCC Countries

	KSA=>Oil		UAE=>Oil			Oil=>KSA		Oil=>UAE	
	Conditional Mean								
	Coef.	p-value	Coef.	p-value		Coef.	p-value	Coef.	p-value
α_1	0.080	(0.001)	0.021	(0.495)	α_2	0.076	(0.050)	0.053	(0.158)
β_{11}	0.027	(0.540)	0.142	(0.001)	β_{22}	-0.050	(0.245)	-0.010	(0.801)
	Conditional Variance								
c_{11}	0.235	(0.001)	0.450	(0.001)	c_{22}	0.247	(0.003)	0.263	(0.001)
c_{21}	-0.035	(0.811)	-0.139	(0.103)					
a_{11}	0.639	(0.001)	0.453	(0.001)	a_{22}	0.276	(0.001)	0.345	(0.001)
a_{21}	-0.055	(0.230)	0.103	(0.034)	a_{12}	0.017	(0.829)	-0.038	(0.536)
g_{11}	0.753	(0.001)	0.754	(0.001)	g_{22}	0.933	(0.001)	0.884	(0.001)
g_{21}	0.012	(0.776)	-0.010	(0.722)	g_{12}	0.051	(0.421)	0.130	(0.090)
Log-lik		-1424.658		-1595.544					
$Q_{Stock(10)}$	12.724	(0.235)	13.084	(0.219)	AIC		5.027		5.622
$Q_{Oil(10)}$	8.642	(0.566)	14.378	(0.156)	HQ		5.080		5.675
$Q^2_{Stock(10)}$	15.301	(0.122)	4.211	(0.973)	SBC		5.032		5.759
$Q^2_{Oil(10)}$	9.561	(0.479)	5.246	(0.874)					

	Qatar=>Oil		Oman=>Oil			Oil=>Qatar		Oil=>Oman	
	Conditional Mean								
	Coef.	p-value	Coef.	p-value		Coef.	p-value	Coef.	p-value
α_1	0.035	(0.042)	0.026	(0.064)	α_2	0.062	(0.120)	0.051	(0.191)
β_{11}	0.114	(0.004)	0.145	(0.000)	β_{22}	0.063	(0.225)	-0.043	(0.232)
	Conditional Variance								
c_{11}	0.168	(0.000)	0.216	(0.000)	c_{22}	0.268	(0.000)	0.156	0.000
c_{21}	-0.012	(0.853)	-0.042	(0.701)					
a_{11}	0.640	(0.000)	0.565	(0.000)	a_{22}	0.329	(0.000)	0.318	(0.000)
a_{21}	0.024	(0.289)	-0.112	(0.001)	a_{12}	-0.169	(0.00)	-0.153	(0.239)
g_{11}	0.785	(0.000)	0.703	(0.000)	g_{22}	0.902	(0.000)	0.942	(0.000)
g_{21}	-0.007	(0.598)	0.012	(0.645)	g_{12}	0.134	(0.007)	0.259	(0.009)
Log-lik		-1013.974		-1208.977					
$Q_{Stock(10)}$	9.618	(0.477)	13.958	(0.175)	AIC		4.895		4.283
$Q_{Oil(10)}$	14.534	(0.150)	14.606	(0.147)	HQ		3.655		4.336
$Q^2_{Stock(10)}$	7.000	(0.726)	6.3577	(0.784)	SBC		5.032		4.336
$Q^2_{Oil(10)}$	6.237	(0.795)	10.365	(0.409)					

Note: See next page.

Note for Tables 2.2 and 2.3: Standard errors (S.E.) are calculated using the quasi-maximum likelihood method of Bollerslev and Wooldridge (1992), which is robust to the distribution of the underlying residuals. $Q_{(10)}$ and $Q^2_{(10)}$ are the Ljung-Box test (Ljung and Box, 1978) of the significance of autocorrelations of ten lags in the standardized and standardized squared residuals, respectively. Parameter a_{12} measures the causality in the variance effect of oil price volatility towards stock return volatility. The covariance stationary condition is satisfied by all the estimated models. Note that in the conditional variance equation, the signs of the parameters are not relevant. Numbers are rounded to the third decimal.

To test the adequacy of the models, Ljung-Box portmanteau tests were performed on the standardized and standardized squared residuals. Overall, the results indicate that the VAR-GARCH(1,1) specification satisfactorily captures the persistence in the returns and squared returns of all the series considered (see Tables 2.2 and 2.3). The cross-market dependence in the conditional variance varies in magnitude and direction across the pair-wise estimations[4]. The estimated VAR-GARCH(1,1) model with associated robust standard errors and likelihood function values is presented in Tables 2.2-2.3.

We select the optimal lag length of the mean equation using the Schwarz Information Criterion. The parameter estimates for the conditional variance equations show that the estimated 'own-market' coefficients are statistically significant for all stock markets, and the estimates for g_{11} suggest a high degree of persistence. The results can be summarized as follows:

1) There is a volatility spillover from oil price volatility to stock market return volatility. The findings show a significant volatility shock spillover, measured by α_{12}, running from oil prices to stock market prices for Morocco and Qatar, with that of Qatar being the greatest (0.169) and that for Morocco being the least: $a_{12} = 0.018$. There is evidence of a significant conditional volatility spillover, as measured by $g_{12,}$, running from oil to the UAE (0.130), Qatar (0.134) and Oman (0.259). These results are consistent with the findings reported by Arouri et al. (2011a), who report significant volatility spillovers between oil and stock markets in the GCC region.

2) There is a volatility spillover from stock market return volatility into oil price volatility. A significant volatility spillover running from stock market returns to oil prices only occurs in the UAE $(a_{21} = 0.103)$ and Morocco $(a_{21} = 0.012)$. These results are in line with those of Jouini (2013) and show that for most of the countries considered, a shock originating in the stock markets does not affect oil price volatility.

Conditional correlations, as reported in Figs. 2.5 and 2.6, capture the co-movements across oil prices and stock markets, clearly confirming higher (and

[4]Note that the signs of the cross-market volatilities are not relevant.

Table 2.3: Estimated VAR-GARCH(1,1) Model without GCC Countries

	Algeria=>Oil		Namibia=>Oil			Oil=>Algeria		Oil=>Namibia	
	Conditional Mean								
	Coef.	p-value	Coef.	p-value		Coef.	p-value	Coef.	p-value
α_1	0.041	(0.001)	0.016	(0.317)	α_2	0.068	(0.106)	0.072	(0.067)
β_{11}	0.150	(0.001)	-0.032	(0.454)	β_{22}	-0.119	(0.220)	-0.037	(0.629)
	Conditional Variance								
c_{11}	0.186	(0.001)	0.110	(0.001)	c_{22}	0.241	(0.001)	0.251	(0.000)
c_{21}	0.142	(0.023)	-0.105	(0.159)					
a_{11}	0.358	(0.001)	0.299	(0.001)	a_{21}	-0.003	(0.672)	0.017	(0.422)
a_{12}	0.141	(0.248)	-0.085	(0.433)	a_{22}	0.376	(0.001)	0.359	(0.001)
g_{11}	0.749	(0.001)	0.929	(0.001)	g_{22}	0.908	(0.001)	0.915	(0.001)
g_{21}	-0.252	(0.103)	0.002	(0.871)	g_{12}	-0.251	(0.103)	0.038	(0.447)
Log-lik		-1424.658		-1277.908					
$Q_{Stock(10)}$	8.665	(0.564)	9.951	(0.445)	AIC		3.602		4.241
$Q_{Oil(10)}$	12.658	(0.243)	13.858	(0.180)	HQ		3.602		4.394
$Q^2_{Stock10)}$	0.660	(1.000)	6.815	(0.742)	SBC		3.739		4.478
$Q^2_{Oil(10)}$	4.460	(0.924)	8.786	(0.553)					

	Morocco=>Oil		USA=>Oil			Oil=>Morocco		Oil=>USA	
	Conditional Mean								
	Coef.	p-value	Coef.	p-value		Coef.	p-value	Coef.	p-value
α_1	0.103	(0.001)	0.016	(0.317)	α_2	0.063	(0.093)	0.072	(0.067)
β_{11}	-0.039	(0.359)	-0.032	(0.455)	β_{22}	0.020	(0.545)	-0.037	(0.629)
	Conditional Variance								
c_{11}	0.344	(0.001)	0.110	(0.001)	c_{22}	0.255	(0.001)	0.251	(0.001)
c_{21}	-0.027	(0.691)	-0.105	(0.159)					
a_{11}	0.532	(0.001)	0.299	(0.001)	a_{22}	0.311	(0.001)	0.359	(0.001)
a_{21}	0.026	(0.493)	0.017	(0.442)	a_{12}	-0.018	(0.033)	-0.085	(0.433)
g_{11}	0.759	(0.001)	0.929	(0.001)	g_{22}	0.920	(0.001)	0.915	(0.001)
g_{21}	-0.012	(0.027)	0.002	(0.872)	g_{12}	0.077	(0.005)	0.038	(0.447)
Log-lik		-1227.91		-1206.651					
$Q_{Stock(10)}$	3.450	(0.969)	7.405	(0.687)	AIC		5.315		4.267
$Q_{Oil(10)}$	14.874	(0.137)	15.192	(0.125)	HQ		5.368		4.320
$Q^2_{Stock(10)}$	0.062	(1.000)	8.784	(0.553)	SBC		5.451		4.404
$Q^2_{Oil(10)}$	11.308	(0.334)	7.490	(0.679)					

Notes: See notes to Table 2.2.

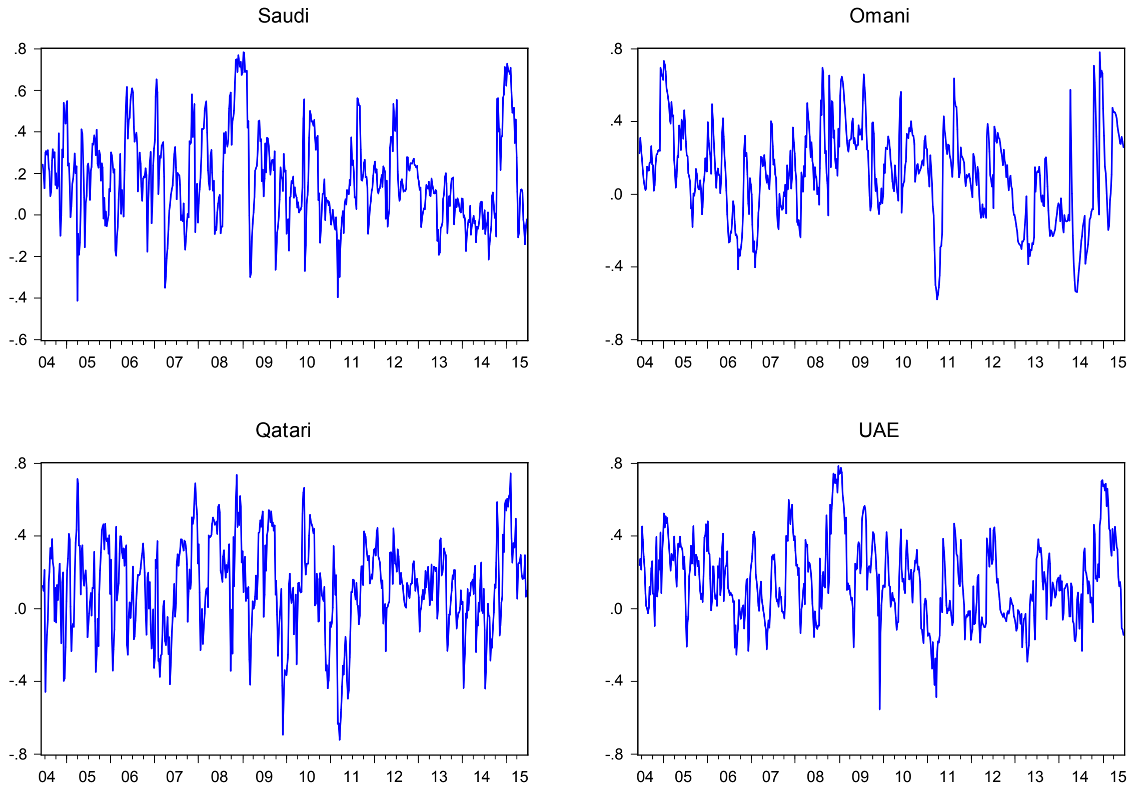

Figure 2.5: Correlations of Oil and GCC Stock Markets

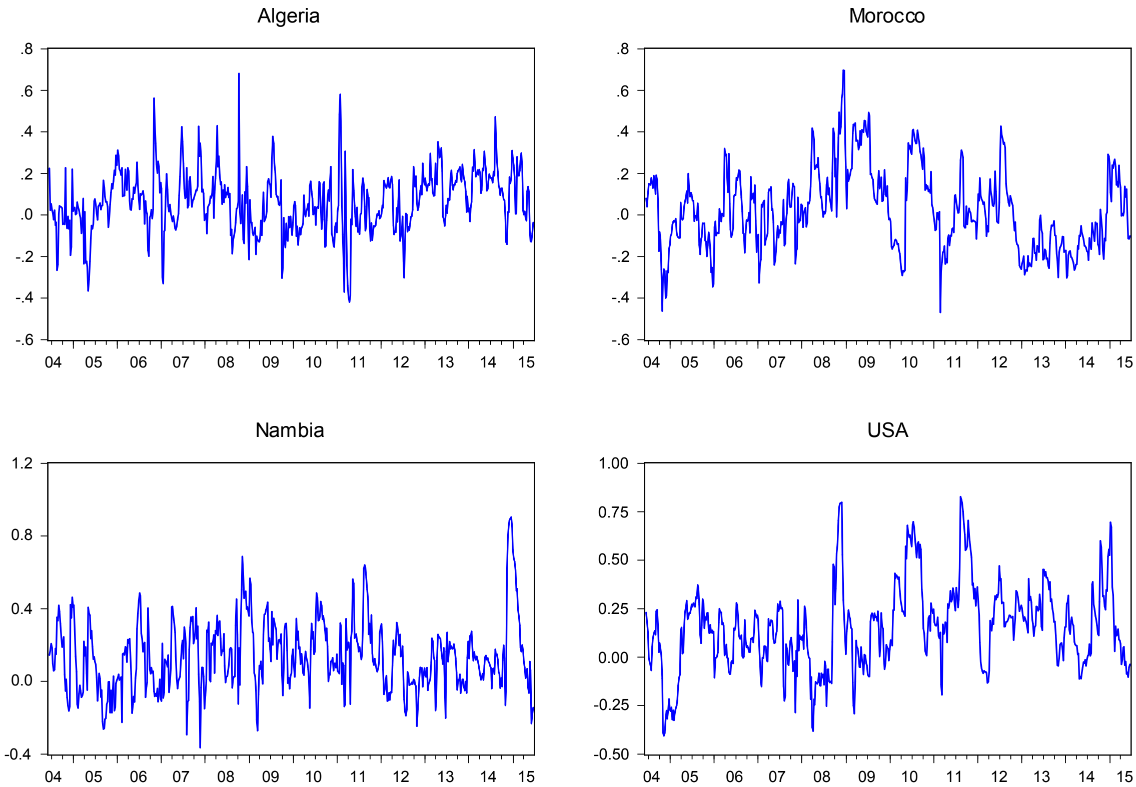

Figure 2.6: Correlations of Prices of Non-GCC Stock Markets

positive) degrees of co-movement in GCC countries compared to the other countries studied.

Compared to Hamiltion (1996), Huang et al. (1996), Hammoudah et al. (2004), Ghouri (2006), Balcilar and Ozdemir (2013), Mollick and Assefa (2013), and Salisu and Oloko (2015), our results show similarities between the GCC stock markets and the US stock markets, irrespective of whether stock prices or other market indices such as bond prices or stress indices and irrespective of the time series model used. Our results are also similar to those for the UK and Euro area as determined by Park and Ratti (2008), Arouri et al. (2011b), and Alsamlan and Herrara (2013). Our results add to the results of Arouri et al. (2011a) because we use an updated dataset, and our results using this dataset differ because we observe an apparant spillover from stock market returns in both the UAE and Morocco. Our results are also similar to those of Jouini (2013); however, he only tested the stock market in Saudi Arabia. Our results are also similar to those of Jouini and Harrathi (2014); however, the main contribution of our paper is that we use an updated dataset that includes the stock market crash of 2015, and we compare our results to those from other stock markets.

Overall, our results extend our knowledge of the strong co-movement between the oil and stock markets, especially in the GCC. Our analysis clearly shows that periods of turbulence in the oil markets generate higher correlations between the volatility of the stock and oil markets, especially in the GCC markets. However, this relationship is also clear in the Moroccan and US stock markets. Regarding volatility spillovers, despite being relatively mixed, the results indicate that oil price volatility can be considered an important determinant of stock price volatility, especially in the GCC, because these countries are clearly more exposed to oil price shocks.

2.5 Conclusions

This chapter has investigated the volatility spillovers between oil prices and eight selected stock market prices based on a VAR-GARCH model with a BEKK representation. We have provided empirical evidence on the levels of interdependence and volatility transmission between oil prices and several oil-exporting countries' stock market indices. Our findings have confirmed that stock markets and oil prices are highly and positively correlated. We have also found evidence of co-movement between oil and stock markets, especially in the GCC region, whereas the results for volatility spillovers are quite mixed.

This research can serve as a basis for future studies for regulators, market participants, and researchers. In particular, oil-exporting countries should beware of the effects of oil shocks in their own economies. The significant relationship can imply predictability in stock market returns. Consequently, general policies that are intended to stabilize stock price volatility in oil-exporting countries represent an avenue for future research. Indeed, the specific linkages between different markets must be taken into account when devising appropriate policy measures.

It is recommended that further research be undertaken in the following areas. First, research should be conducted using the same approach in this paper but using controls for fuel other than brent oil, such as natural gas or ethanol, and examining the period after of the current crises of 2015. Such an approach will likely provide interesting results. Second, future studies should use a sectoral analysis of the relationships between oil price changes and stock market returns in the GCC countries. A sectoral analysis of this link would be useful. Third, using a Markov switching model of the returns may confirm that there are two phases in stock and oil markets, one that is more stable and one that is more volatile.

Chapter 3

Spillovers between Food and Energy Prices and Structural Breaks

3.1 Introduction

In theory, there is a relationship between the prices of food and fuel for two reasons. The first is that fuel is used to transport food to consumers. The second is that some food is used as fuel; for example, biofuels often use sugar and corn to make ethanol, which is a type of fuel. Moreover, all of these are commodities traded on stock markets. Nazlioglou et al. (2013) examine volatility transmission between world oil and selected world agricultural commodity prices (wheat, corn, soybeans, and sugar). Using causality in variance tests and impulse response functions to examine daily data from 01 January 1986 to 21 March 2011, the authors find that food and oil prices exhibit the same characteristics as stock prices, and there is a relationship between food and fuel and vice versa. Our paper discusses this relationship more deeply by focusing on recent breaks and by using a multivariate BEKK model.

The world population is growing faster, and with decreasing arable land availability per capita, food security remains a major global challenge. In other words, the food security of the GCC economies rests almost completely on international trade. Bailey and Willoughby (2013) note that imports typically account for 80% to 90% of food consumption, and the GCC economies are not exceptional in this respect.

The GCC economies, which currently boast of a population of 40 million people, are among the world's wealthiest in oil but have unimaginably high dependence on imports to meet their food needs – nearly 90%.

According to a Food Industry report by Capital (2011), domestic production of food in the GCC region is inadequate to meeting current requirements, and the total value of all food imports in the GCC stood at $25.8 billion at the end of 2010. Because food is a basic necessity for every nation, including those in the GCC region, complete dependence on food imports from other parts of the world places the GCC region at risk should there be any collapse or temporary disruption in the global food export supply chain. Some studies have shown that the GCC region's high dependence on food exports can be attributed to the fact that the production of food crops is not an area of expertise for many of the GCC countries due to limited arable land and acute water shortage.Ahmed et al. (2015)

Research has shown that the typical quantity of rainfall needed to produce wheat is between 600 and 650 mm, while rainfall in the GCC region usually ranges between 50 and 250 mm per annum. Furthermore, most countries in the GCC region import more than 90% of their food because renewable freshwater resources in the region are among the lowest in the world (Bailey and Willoughby, 2013), while their soils have remained fragile with over 95 per cent of land on the Arabian Peninsula subject to some form of desertification. Moreover, climate change is likely to tighten these constraints, making large-scale domestic food production a mirage for most countries in this region (Met Office, 2011). It is against this background that many of the GCC countries depend on food imports, and they continue to be exposed to supply and price risks of these food items. Forecasts indicate that food imports to the GCC will reach $49 billion in value by the year 2020 if nothing drastic is done to invest massively in the purchase of agricultural land in other parts of the world (The Economist, 2009).

The world food crisis of 2007 to 2008 saw the prices of staple foods climb by more than 67%, leading to riots across the globe. The reaction at the time was to impose embargoes on the export of many staple foods to many GCC countries.

These events have alerted the GCC countries that the security of their food supply is liable to serious disruptions and imbalances in demand and supply within the global food industry. The GCC countries must implement highly proactive measures to stimulate domestic production through the establishment of agricultural investments in many locations with favourable conditions around the world, particularly nearby ones with enormous water and land resources, such as Sudan, Pakistan and Turkey. These water and land resources that are limited in the GCC countries continue to pose a major threat to the growth of food production initiatives in the region, as Shah (2010) notes. The total land area of GCC is 259 million ha, of which approximately 1.7% has been cultivated with the aid of groundwater irrigation. This portion of land has been found to the the only cultivable portion of the entire 259 million ha, owing to the region's severe biotic and abiotic stresses. All of these presently contribute to the limitations in the extent of food sufficiency for the GCC countries. More recently, several attempts have been made by many of the GCC countries to establish fossil-fuel powered water desalinization plants, which are responsible for nearly 15% of the available water in the region Shah (2010). Therefore, the GCC countries need to focus on creating a major regional hub where projects related to solar power for their food production activities can be implemented and monitored. This would potentially improve the sustainability of this region in terms of compliance with minimizing the level of carbon emissions as mandated by legislation. Against this background, Bailey and Willoughby (2013) summarize that it might remain a mirage for many of the GCC countries to achieve sustainable food self-sufficiency due to the enormous impact that the limited efforts made towards domestic production thus far have had on the economic resources of this region. The truth of the matter now is that, while GCC food security rests on international trade, it continues to leave many member countries exposed to price risk (related to the volatility of import prices) and supply risk (related to import disruption). According to Bailey and Willoughby (2013), events, such as the 2011 Arab rebellions, have also played some roles in the food industry of the GCC countries, including the sustained unstable political atmosphere in places such as Egypt, Syria and Iran that have reiterated the need to close the Strait of Hormuz, leading to a sustained rise in the prices of food on international markets importing from political unstable countries Ahmed et al. (2015). Moreover, repeated spikes in international food prices have sharpened these risks. In fact, the crises in the Middle East and North African region have been assigned responsibility for the disruption of alternative routes for imports to the GCC region. GCC governments can hedge supply risks through strategic storage and investments in port and rail infrastructure to create a regional import and transport network.

Finally, Bailey and Willoughby (2013) note that the investment being made in land in countries that are food insecure and those with weak governments and poor infrastructure will continue to worsen the global food supply to the GCC region in terms of supply and price risks. The authors recommend a focus on overseas investments with major trading partners. However, while the GCC's resource wealth mitigates price risk, over the long run, the ability of governments to manage price risk depends upon successful economic diversification. The food sector in the GCC is highly controlled by three leading companies, Almarai, Savola and Kuwait Food Company (Americana), which are jointly responsible for more than 75% of total earnings from food in the region.

3.2 Literature Review

The relationship between energy and food prices has been analysed extensively in the literature. Their behaviour in terms of trends and volatilities appears to be rather similar. The recent crises in the 2006–2008 period substantially affected these prices (e.g. wheat prices increased from \$3.8 to \$8.8 per bushel, and corn prices from \$2.6 to \$7). This sharp increase is a serious concern for the developing economies. According to the World Bank report (De Hoyos and Medvedev, 2009), the impact of the recent crises on global welfare was to lead between 75 and 160 million people into poverty. Furthermore, food-importing countries were exposed to political instability and internal conflicts. The higher price volatility has also generated additional uncertainty and had adverse effects on investment.

The links between energy and agricultural commodity prices were first analysed by Barnard (1983). The three-fold increase in the demand for bio-fuel in recent years led to the introduction in the US in 2005 of the so-called the Renewable Fuel Standard (RFS) policy. This policy aims to reduce pollution by requiring vehicles to use methyl tertiary butyl ether (MTBE) as an oxygenate to gasoline to improve combustion and reduce harmful vehicle emissions. The RFS policy is in effect in New York and Connecticut, states that had previously accounted for a total of 42 percent of national MTBE consumption. The RFS policy was approved in 2005 but was not enforced until June 2006. This new standard required motor fuels to contain a minimum amount of fuel coming from renewable sources, such as biomass (e.g., ethanol), solar power or wind energy. Since then, ethanol has been the only practical way to comply with the new standard. Therefore, in mid-2006, ethanol became the only available gasoline additive (Avalos, 2014). Abbott et al. (2009) described the link between food and fuel and argued that these two markets were historically independent until 2006, when ethanol usage became large enough to influence world energy prices. They stated that relating the agriculture and energy link, starting in 2008. The binding RFS policy among other factors: supply and utilization, macroeconomic factors, and exchange rates explains the enhancing ethanol price relative to oil and gasoline.

The higher demand for ethanol oil as a bio-fuel alternative to natural oil has led to more land being used for its production. The ‘food versus fuel claim’ posits that an increased demand for bio-fuel production may result in less land allocated to food production, which can lead to higher food prices. Bio-fuel production increased three-fold over the 2006–2012 period. De Gorter et al.

(2013) argued that food prices increased owing to RFS policies in rich countries only.

Most studies rely on standard supply and demand (e.g., Mcphail and Babcock, 2012) or equilibrium frameworks to model both fuel and food prices (e.g., Serra, 2011a; Zhang et al., 2010). These models have been criticized for not being sufficiently validated against historical data and are plagued by poor performance (Hertel and Beckman, 2011; Serra and Zilberman, 2013); in addition, equilibrium models mainly employ annual data, which is a clear limitation. For instance, Timilsina et al. (2011) developed a multi-country, multi-sector general equilibrium model and used recursive techniques to simulate various future oil price scenarios and assess the corresponding impact on bio-fuels production, agricultural output, land-use change and global food supply. One of the scenarios considered higher oil prices leading to an increase in bio-fuel price and a decrease in food supply. The effects of exchange rates have also been examined by other authors, such as Durevall et al. (2013), who estimated an error correction model for cereal, food and non-food consumer prices using monthly data and found that agriculture and food have a dominant role in Ethiopia's economy. Baquedano and Liefert (2014) also used a (single equation) error correction model to test for market long run relationship and price transmission from macroeconomic factors to consumer prices for wheat, rice, maize, and sorghum in the major urban centres of a selected number of countries in Asia, Latin America, the Caribbean, and Sub-Saharan Africa. Their results confirm that open economies are more vulnerable to international shocks. Hochman et al. (2014) adopted a multi-region framework dividing the world into regions, where demand for corn, rapeseed, rice, soybean, and wheat is shown to consist of demand food/feed, inventory, and (where applicable) bio-fuels. His results indicate that up to 25% of the price of corn can be affected by bio-fuel prices and up to 7% of the price of soybean by energy prices. He also examined the impact of shocks during periods when there are large inventories of food.

Very few papers examine the volatilities of energy and agricultural prices. For instance, Serra (2013) estimated volatilities to investigate the impact of bio-fuels on food and fuel prices up to 2013. McPhail and Babcock (2012) showed that ethanol, RFS and the blend wall lead to more inelastic demand for both corn and gasoline, which makes both the corn and gasoline markets more susceptible to supply shocks and leads to greater price volatility. They also estimated supply and demand elasticities for the US corn, ethanol, and gasoline markets using a three-stage least squares approach to provide empirical evidence for their theoretical set-up. Further, they developed a stochastic partial equilibrium model that explicitly accounts for important sources of volatility in the corn-ethanol-gasoline links, including stochastic corn yields and crude oil prices. Babcock and Fabiosa (2011) argued that only 8% of the increase in corn prices during the 2006–2009 period was the result of ethanol subsidies. They attributed the remainder to market forces and other factors, such as droughts, floods, a severe US recession, and two general commodity price surges. Ethanol policies, such as RFS, mandates and blend wall regulations, can affect the price variability of both corn and gasoline. Qiu et al. (2012) used a structural vector auto-regression (SVAR) model to show how supply/demand structural shocks affect food and fuel markets. Their results support the hypothesis that increased bio-fuel production may cause short-run food price increases but not long-run price shifts. However, agricultural products, such as corn, are affected by their own trade shocks. Their findings also suggest complementarity between ethanol and gasoline and the idea that demand and supply market forces are the main drivers of food price volatility.

The study of volatility can benefit from high frequency data both because high frequency volatility is easier to predict and because it has proven useful to forecast over longer horizons (Andersen et al., 2003). The most popular view is that the grain price boom from 2006 was the result of many factors, with bio-fuels being just one of them, and that bio-fuel policies account for only a fraction of the effects of bio-fuels (de Gorter et al., 2014). The food crisis caused the price of wheat, corn and soybeans to double between 2006 and mid-2008. Volatility issues and macroeconomic policies aimed at achieving more stable food and oil prices have become increasingly important (Wright and Parkash, 2011). Reviews of the literature investigating the economic impacts of bio-fuels have paid particular attention to structural models (Kretschmer and Peterson, 2010). Zhang et al. (2009), using weekly data, examined price volatility interactions between the US energy and food markets in the 1989–2007 period by estimating the BEKK model of Engle and Kroner (1995). Their results suggest that there is no relationship between fuel (ethanol, oil and gasoline) prices and agricultural commodity (corn and soybean) prices. However, they did not control for the 2006 food crisis and the 2005 RFS policy.

Headey (2011) and Serra (2013) argued that previous research has generally relied on a specification of the variance-covariance matrix that does not allow for asymmetric impacts of price increases and decreases on volatility. They found that the high volatility persistence of commodity prices may be due to failing to account for structural breaks. Serra et al. (2011) also used a standard BEKK model to analyse volatility interactions between crude oil, ethanol and sugarcane prices in Brazil using weekly prices during the 2000–2008 period. In a related study on the same topic Serra (2011) used semi-parametric MGARCH models. Both papers suggest that there is a relationship between sugar and energy prices. Wu et al. (2011) estimated a restricted asymmetric MGARCH model using US corn and oil prices from 1992 to 2009 to investigate volatility spillovers between oil and corn prices. They concluded that corn markets have become much more connected to crude oil markets after the implementation of the RFS policy of 2005. Du et al. (2011) used futures market prices for crude oil, corn and wheat from 1998 to early 2009 to estimate stochastic volatility in these returns. The correlation coefficient between the crude oil and corn markets is found to increase from 0.07 to 0.34 after October 2009, while that between the crude oil and wheat markets increased from 0.09 to 0.27, indicating a much tighter linkage between crude oil and agriculture commodity markets in the second period. Trujillo-Barrera et al. (2012) estimated a similar model using futures prices for crude oil, ethanol and corn from 2006 to 2011, and identified volatility spillovers from the crude oil futures market to the ethanol and corn futures markets.

Nazlioglua et al. (2013) employed a univariate GARCH model and impulse responses to examine volatility transmission between world oil and selected world agricultural commodity prices (wheat, corn, soybeans, and sugar). They considered two sub-periods, before and after the food crisis, $01/01/1986 - 31/12/2005$ and $01/01/2006 - 21/03/2011$. Their causality-in-variance tests suggest that there is no transmission between oil and the agricultural commodity markets in the pre-crisis period, and no oil market volatility spillovers to the agricultural markets (with the exception of sugar during the post-crisis period).

Gardebroek and Hernandez (2013) examined oil, ethanol and corn prices in the US between 1997 and 2011 and used a multivariate GARCH approach to estimate interdependence and volatility spillovers across these markets. Their results indicate a stronger interaction between the ethanol and corn markets in recent years and particularly after 2006, when ethanol became the sole alternative oxygenate for gasoline. However, they observed significant volatility spillovers only from corn to ethanol prices and not the reverse. They also did not find major cross-volatility effects from the oil to the corn markets. In another study using univariate GARCH(1, 1) and EGARCH models, Wang and Zhang (2014) examined price volatility interactions between China's energy and bulk commodity markets between 2001 and 2010. They split the sample before and after 2007 and found that there is greater volatility clustering between the food and oil markets after the 2007 oil shock.

Olson et al. (2014) used a univariate GARCH model for food prices only. They found evidence of different structural breaks for energy and food commodities (such as grains). The latter are more volatile than other commodities studied (metals) and display bidirectional (linear and non-linear) feedback effects vis-à-vis stock price indices. These findings suggest not only that shocks to commodity demand and supply may have an impact on aggregate price indices but also that non-commodity shocks, as embodied in aggregate price indices, may affect commodity prices linearly and non-linearly. Chen et al. (2014) identified a structural break in the crude oil market in July 2004. De Gorter et al. (2014) showed that grain prices have increased significantly since 2006 owing to several factors. Jebabli et al. (2014) focused on the recent financial crisis and its effects on volatility spillovers between food and energy prices. Fan and Xu (2011) stressed that the recent bubble in oil prices (2004–2008) and the resulting structural break should also be considered.

Mensi et al. (2014) examine the impact of three types of OPEC news announcements on volatility spillovers and persistence in the spot prices of oil and agriculture commodities using VAR BEKK GARCH and VAR-DCC GARCH models. OPEC announcements were found to influence oil markets as well as the oil-cereal relationship; however, the results are more mixed in the cereal markets for daily data from 1/1/2000 to 29/1/2014.

Han et al. (2015) uses a multivariate normal mixture model to capture the structural properties of energy and three food commodities (corn, soybeans and wheat). They use daily futures data from January 2000 to January 2014 and identify five breaks: (1) investment in commodity factors in 2004, (2) the food crisis (3) the RFS policy of 2005, (4) the financial crisis, and (5) the new European Union (EU) rules on bio-fuels and policies addressing the financial crisis. The results indicate that the financial crisis had the strongest impact on the food-energy nexus.

None of the papers mentioned above properly tested for and determined the dates of possible structural breaks in the energy-food spot prices volatility spillovers by the mean of a VAR-GARCH analysis. Caporin and McAleer (2012) favour a BEKK model over a DCC model in terms of high frequency data. This research provides a framework for the exploration of the impacts of well-known recent events on spillovers between food and energy prices in both the first (mean) and second (volatility) moments using a VAR-GARCH model with a BEKK representation. A key strength of this study is its long duration, as the sample period covers from 2003 to 2014. The empirical findings in this study provide a new understanding of ethanol and Brent oil prices as energy prices, and cacao, coffee, corn, soybeans, soybean oil, sugar, steer and wheat prices as food prices. The layout of the paper is as follows. Section 3.2 outlines the econometric model. Section 3.3 describes the data and presents the empirical findings. Section 3.4 summarizes the main findings and offers some concluding remarks.

3.3 The Econometric Model

We model the joint process governing energy prices (oil and ethanol) and food prices (corn, soybeans, sugar and wheat) using a bi-variate VAR-GARCH(1,1) framework[1]. The model has the following specification:

$$\mathbf{x}_t = \alpha + \beta \mathbf{x}_{t-1} + \gamma y_{t-1} + e_t, \tag{3.1}$$

where $\mathbf{x}_t = (Energy_t, Food_t)$. The residual vector $e_t = (e_{1,t}, e_{2,t})$ is bi-variate, and $\mathbf{u}_t \mid I_{t-1} \sim (\mathbf{0}, H_t)$, where the corresponding conditional variance covariance matrix given by:

$$H_t = \begin{bmatrix} h_{11t} & h_{12t} \\ h_{12t} & h_{22t} \end{bmatrix}, H_t = C_0' C_0 + A_{11}' \begin{bmatrix} e_{1,t-1}^2 & e_{2,t-1}e_{1,t-1} \\ e_{1,t-1}e_{2,t-1} & e_{2,t-1}^2 \end{bmatrix} A_{11} + G_{11}' H_{t-1} G_{11}. \tag{3.2}$$

The parameter vectors of the mean equation (1) are the constant $\alpha = (\alpha_1, \alpha_2)$ and the autoregressive term

$\beta = (\beta_{11}, \beta_{12} + \beta_{12}^{*} + \beta_{12}^{**} + \beta_{12}^{***} + \beta_{12}^{****} \mid \beta_{21} + \beta_{21}^{*} + \beta_{21}^{**} + \beta_{21}^{***} + \beta_{21}^{****}, \beta_{22})$. Campbell (1999) finds that there is a link between stock returns and predicted changes in industrial production in developed countries, where the predictability of changes in the business cycle. To control for the business cycle in global stock market spillovers, the S&P 100 Index (y_t) is included in the mean equation (this effect is measured by the parameters $\gamma = (\gamma_1 \mid \gamma_2)$. The parameter matrices for the variance Equation (2) are defined as C_0, which is restricted to be upper triangular, and two unrestricted matrices A_{11} and G_{11}.

To account for the possible effects of the recent crises, we include four dummy variables: the first (denoted by *) captures the 2006 food crisis (Na-

[1] The model is based on the GARCH(1,1)-BEKK representation proposed by Engle and Kroner (1995). The BEKK representation rather than the DCC is motivated by Caporin and McAleer (2012).

zlioglu et al., 2013); the second (denoted by $**$), following Fan and Zu (2000), captures the oil crisis from March 19, 2004 to June 6, 2008; the third (denoted by $***$) controls for the RFS policy implementation in June 2006, as suggested by Avalos (2014); and finally, the fourth (denoted by $****$) corresponds to the 2008 global financial crisis (originating on September 15, 2008, i.e. the day of the collapse of Lehman Brothers), as suggested by Jebabli et al. (2014). Therefore, the second moment will take the following form[2]:

$$A_{11} = \begin{bmatrix} a_{11} & a_{12} + a_{12}^{*} + a_{12}^{**} + a_{12}^{****} + a_{12}^{****} \\ a_{21} + a_{21}^{*} + a_{21}^{**} + a_{21}^{***} + a_{21}^{****} & a_{22} \end{bmatrix} \quad (3.3)$$

$$G_{11} = \begin{bmatrix} g_{11} & g_{12} + g_{12}^{*} + g_{12}^{**} + g_{12}^{****} + g_{12}^{****} \\ g_{21} + g_{21}^{*} + g_{21}^{**} + g_{21}^{***} + g_{21}^{****} & g_{22} \end{bmatrix} \quad (3.4)$$

Equation (3) models the dynamic process of H_t as a linear function of its own past values, H_{t-1}, and past values of the squared innovations $\left(e_{1,t-1}^2, e_{2,t-1}^2\right)$. The BEKK model guarantees, by construction, that the covariance matrix in the system is positive definite. Given a sample of T observations, a vector of unknown parameters θ and a 2×1 vector of variables $\mathbf{x}_t$, the conditional density function for model (1) is:

$$f\left(\mathbf{x}_t | I_{t-1}; \theta\right) = (2\pi)^{-1} \left|H_t\right|^{-1/2} \exp\left(-\frac{\mathbf{u}_t^{'}\left(H_t^{-1}\right)\mathbf{u}_t}{2}\right). \quad (3.5)$$

The log-likelihood function is:

$$L = \sum_{t=1}^{T} \log f\left(\mathbf{x}_t | I_{t-1}; \theta\right), \quad (3.6)$$

where θ is the vector of unknown parameters. The standard errors are calculated using the quasi-maximum likelihood method of Bollerslev and Wooldridge (1992), which is robust to the distribution of the underlying residuals.

[2]Parameters (a_{21}) in Equation (3) measures the causality effect of variable 2 on variable 1, whereas $(a_{21} + a_{21}^{*})$, $(a_{21} + a_{21}^{**})$, $(a_{21} + a_{21}^{***})$ and $(a_{21} + a_{21}^{****})$ measure the possible effects of the 2006 food crisis, the 2004–2008 oil bubble accumulation period, the mid-2006 RFS policy change, and the 2008 financial crisis, respectively.

3.4 Empirical Analysis

3.4.1 Data

We use daily data (from Bloomberg for ethanol and from Datastream for the other commodities) for two energy spot price series (crude oil and ethanol) and eight food price series (cacao, coffee, corn, soybeans, soybean oil, steer, sugar and wheat) over the 1/1/2003–6/6//2015 period for a total of 2253 observations. Furthermore, as stock markets can be used as proxies for the business cycle, we use the S&P stock market index in the US as a proxy for market globalization Campbell (1999). We define daily returns as the logarithmic differences of energy and food price indices.

Figure 3.1 shows real spot prices of food and energy. Figure 3.2 shows energy and food price changes. Note that the lines refer to the four breaks listed in the analysis. The recent literature has suggested several possible structural breaks affecting the spillovers between food and energy markets. Here, we consider the four breaks mentioned above. The descriptive statistics presented in Table 3.1 concern the two sub-periods before and after the 2006 food crisis. Post-crisis volatilities are significantly higher for oil coffee and corn commodity prices, as are the standard deviations (especially in the case of coffee, which increased 1.614 to from 2,124). All food prices (except cacao) reach a peak in the post-crisis sample. The mean values are quite similar. The increased volatility and larger extreme events (measured by maximum and minimum values) observed in the second sample affect, as one would expect, the Jarque-Bera statistics, which indicate a larger departure from normality in the post- than in the pre-crisis sample. Descriptive statistics for the remaining three breaks are available upon request. They show a similar pattern with higher energy and food price volatilities in the second sub-sample. The sample correlations, reported in Table 3.2, are all positive from oil towards the other commodities and negative from ethanol towards other commodities (except steer). Further, the correlation between food and energy prices before the food crises is weak; however, there are a significant positive correlations between cacao, corn, soybean oil, sugar and wheat and most of the other food and energy prices during the post-crisis period.

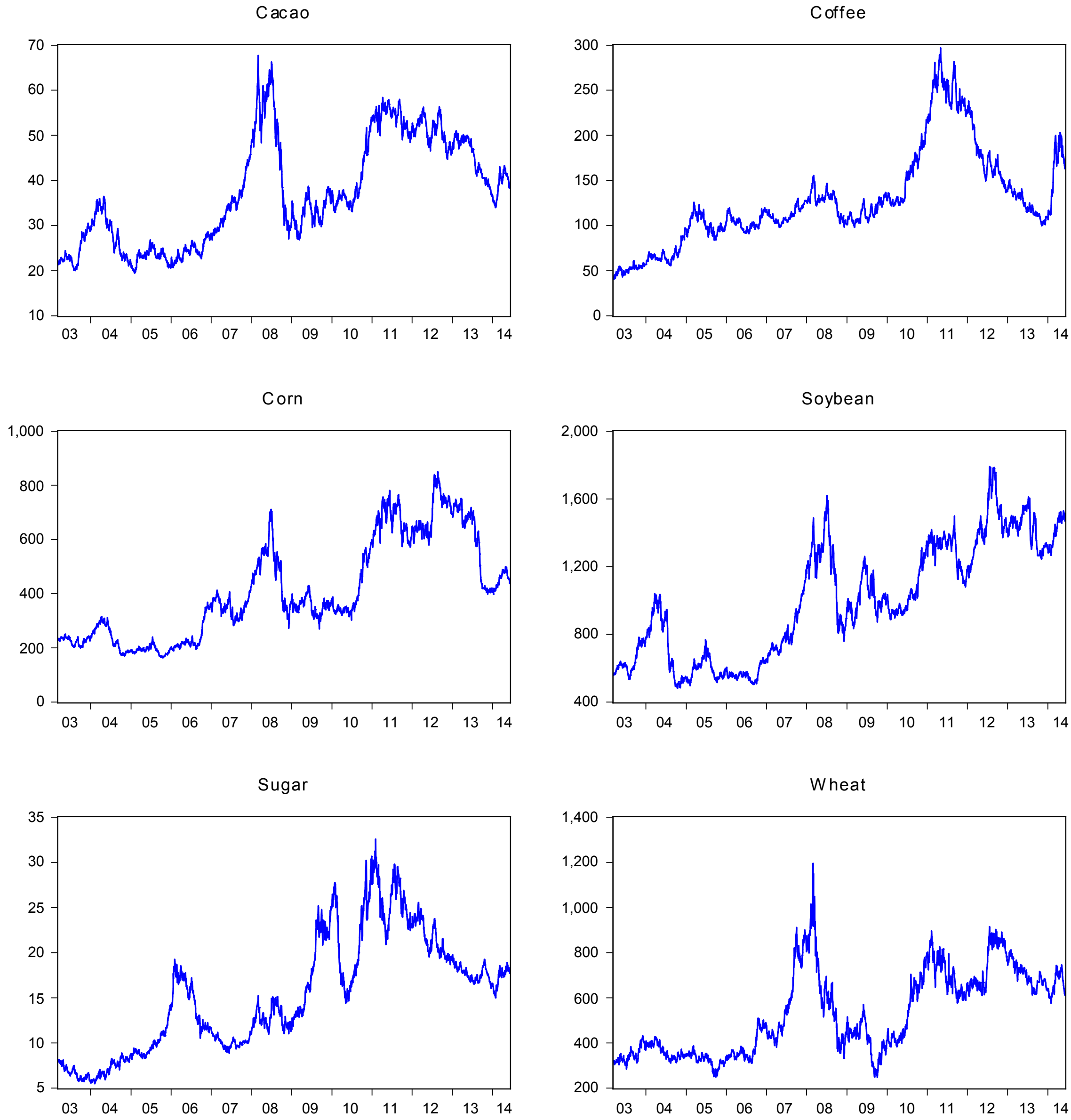

Figure 3.1: Food Prices

3.4.2 Hypotheses Tested

We test for mean and volatility spillovers by placing restrictions on the relevant parameters; specifically, we consider the following four sets of null hypotheses:

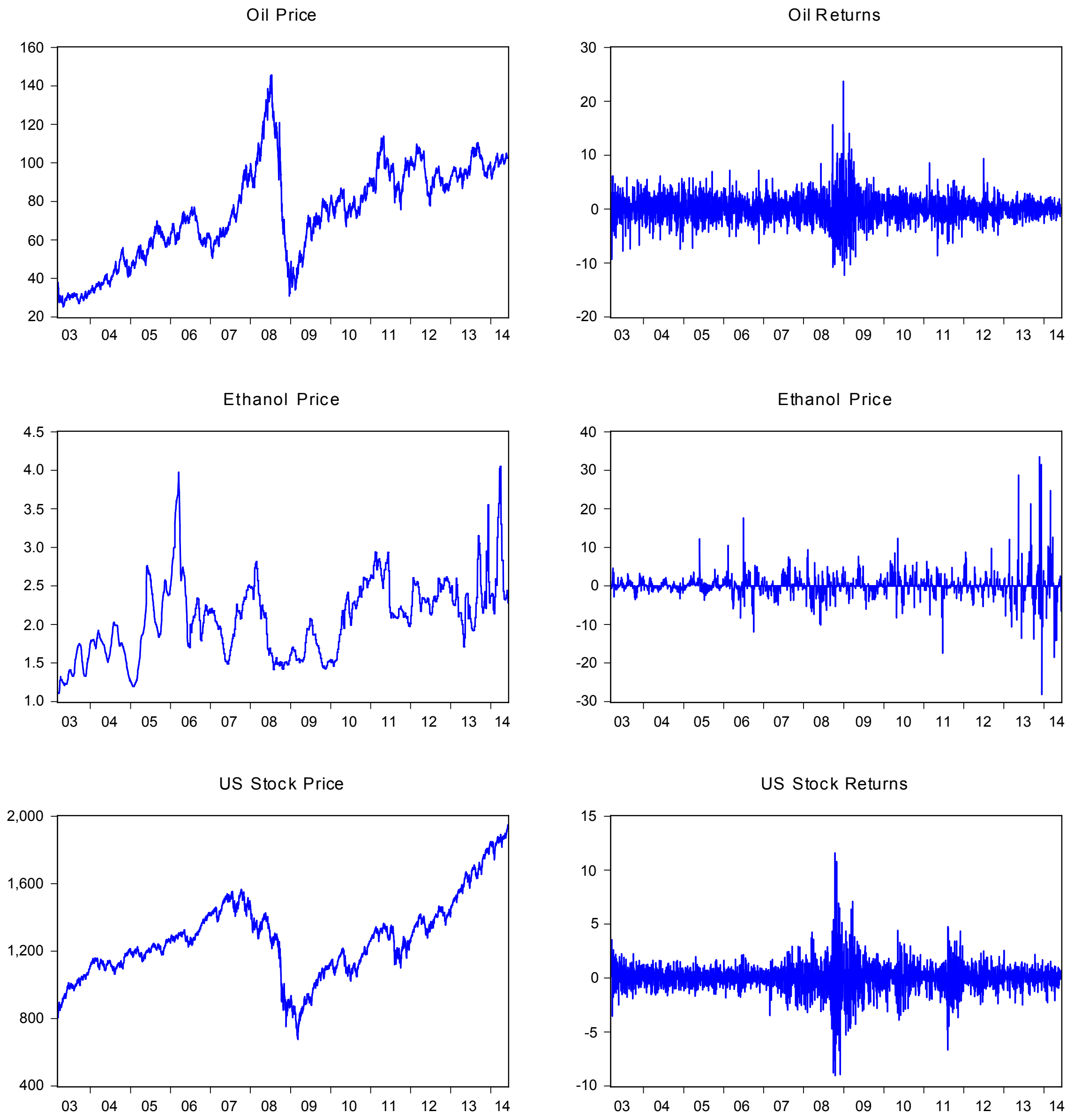

Figure 3.2: Oil, Ethanol and US Stock Prices and Returns

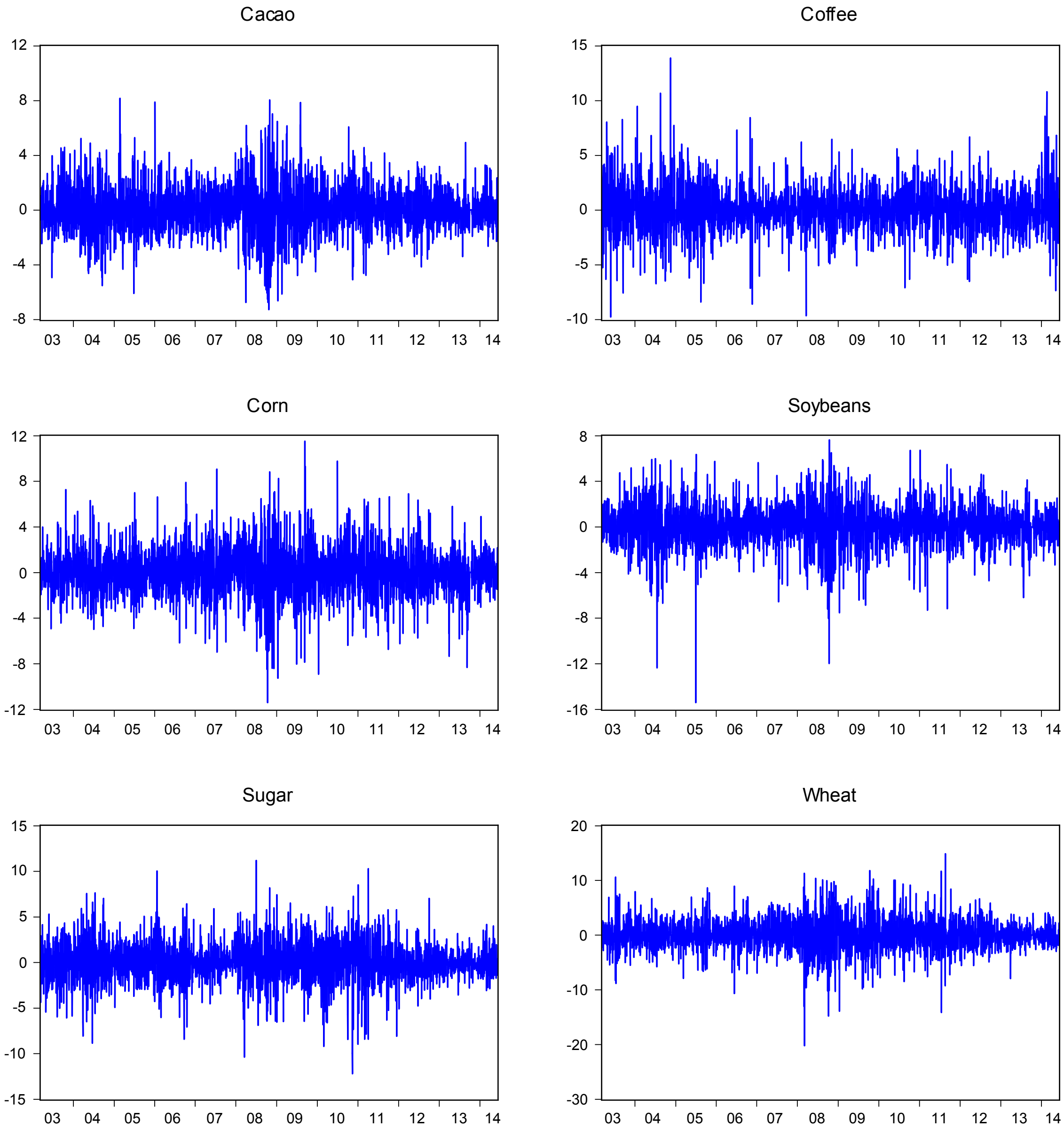

Figure 3.3: Food Returns

Table 3.1: Descriptive Statistics for Foods and Fuels

	Oil	Eth.	Cac.	Coef.	Corn	Soy	Soy Oil	Ste.	Sug.	Whe.
					Whole Sample 1/1/2003–6/6/2015					
Mean	0.059	-0.013	0.045	0.067	-0.002	0.034	0.045	0.044	0.076	0.024
Med.	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Max.	23.71	19.48	8.17	10.80	11.50	6.71	8.17	9.20	10.28	11.68
Min.	-12.24	-18.92	-6.63	-9.64	-11.41	-15.41	-6.631	-9.47	-12.20	-20.22
S.Dev.	2.325	2.294	1.637	1.873	2.039	1.740	1.637	1.713	2.098	2.667
Skew.	0.717	-0.291	0.239	0.098	-0.070	-0.799	0.239	-0.081	-0.205	-0.194
Kurt.	12.23	12.96	5.033	6.294	5.587	9.121	5.033	6.561	5.932	6.889
J-Bera	8192	9342	409	1022	630	3756	409	1192	822	1433
Obs.	2418	2418	2418	2418	2418	2418	2418	2418	2418	2418
					Pre-Food Crisis 1/1/2003–12/31/2005					
Mean	0.193	-0.056	0.047	0.049	-0.128	0.009	0.047	-0.028	0.182	-0.004
Med.	0.057	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.104	0.000
Max.	6.967	19.48	8.168	10.67	6.983	6.340	8.168	8.805	7.632	8.644
Min.	-7.428	-18.92	-6.078	-8.395	-4.981	-15.41	-6.078	-7.665	-8.836	-6.62
S.Dev.	2.114	2.986	1.782	2.398	1.614	2.143	1.782	1.833	2.088	2.122
Skew.	-0.040	-0.625	0.304	-0.027	-0.049	-1.341	0.304	-0.090	-0.077	0.164
Kurt.	3.700	14.70	4.325	4.288	3.905	11.642	4.325	6.770	4.703	4.518
J-Bera	8	2412	37	28	14	1425	37	248	50	42
Obs.	583	583	583	583	583	583	583	583	583	583
					Post-Food Crisis 1/1/2006–6/6/2015					
Mean	0.029	-0.003	0.045	0.071	0.027	0.040	0.045	0.060	0.052	0.030
Med.	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Max.	23.71	11.39	8.033	10.80	11.50	6.71	8.033	9.201	10.29	11.68
Min.	-12.25	-12.97	-6.630	-9.642	-11.41	-11.96	-6.630	-9.465	-12.20	-20.22
S.Dev.	2.370	2.105	1.603	1.732	2.124	1.634	1.603	1.684	2.101	2.777
Skew.	0.846	-0.043	0.217	0.175	-0.088	-0.488	0.217	-0.073	-0.233	-0.230
Kurt.	13.42	8.881	5.227	6.99	5.54	6.52	5.23	6.46	6.20	6.85
J-Bera	8523	2645	394	1227	495	1023	394	914	800	1151
Obs.	1835	1835	1835	1835	1835	1835	1835	1835	1835	1835

Note: Descriptive statistics for the whole sample 1/1/2003–6/6/2015, pre-food crisis 1/1/2003–31/12/2005, and post-food crisis 1/1/2006–6/6/2015 periods. Two-digits numbers are rounded to the second decimal place, One-digit numbers are rounded to the third decimal place.

Table 3.2: Correlations between Foods and Fuels

	Oil	Eth.	Sto.	Cac.	Cof.	Corn	Soy	Soy Oil	Ste.	Sug.	Whe.
Pre-Food Crisis 1/1/2003–31/12/2005											
Oil	1.000										
	—–										
Eth.	0.056	1.000									
	(0.18)	—–									
Stock	-0.180	0.025	1.000								
	(0.00)	(0.54)	—–								
Cac.	0.114	-0.066	0.046	1.000							
	(0.01)	(0.11)	(0.27)	—–							
Cof	0.039	-0.020	-0.065	0.050	1.000						
	(0.35)	(0.64)	(0.12)	(0.23)	—–						
Corn	0.158	-0.017	0.064	0.423	0.031	1.000					
	(0.00)	(0.69)	(0.12)	(0.00)	(0.46)	—–					
Soy	0.115	-0.075	0.035	0.642	0.025	0.496	1.000				
	(0.01)	(0.07)	(0.39)	(0.00)	(0.54)	(0.00)	—–				
Soy O.	0.114	-0.066	0.046	1.000	0.050	0.423	0.642	1.000			
	(0.01)	(0.11)	(0.27)	NA	(0.23)	(0.00)	(0.00)	—–			
Ste	-0.084	0.012	0.023	0.074	0.124	0.039	0.053	0.074	1.000		
	(0.04)	(0.77)	(0.58)	(0.07)	(0.00)	(0.34)	(0.20)	(0.07)	—–		
Sug.	0.045	0.001	-0.040	0.064	0.046	-0.067	0.016	0.064	0.036	1.000	
	(0.28)	(0.98)	(0.34)	(0.12)	(0.26)	(0.11)	(0.70)	(0.12)	(0.39)	—–	
Whe.	0.077	-0.041	-0.008	0.284	0.031	0.394	0.278	0.284	-0.045	0.106	1.000
	(0.07)	(0.33)	(0.84)	(0.00)	(0.46)	(0.00)	(0.00)	(0.00)	(0.27)	(0.01)	—–
Post-Food Crises 1/1/2006–6/6/2015											
Oil	1.000										
	—–										
Eth.	0.021	1.000									
	(0.30)	—–									
Stock	0.213	-0.013	1.000								
	(0.00)	(0.52)	—–								
Cac.	0.385	-0.038	0.197	1.000							
	(0.00)	(0.06)	(0.00)	—–							
Cof.	0.061	-0.004	-0.026	0.059	1.000						
	(0.00)	(0.86)	(0.20)	(0.00)	—–						
Corn	0.261	0.004	0.125	0.454	0.022	1.000					
	(0.00)	(0.84)	(0.00)	(0.00)	(0.27)	—–					
Soy	0.277	-0.022	0.120	0.667	0.023	0.535	1.000				
	(0.00)	(0.28)	(0.00)	(0.00)	(0.25)	(0.00)	—–				
Soy O.	0.385	-0.038	0.197	1.000	0.059	0.454	0.667	1.000			
	(0.00)	(0.06)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	—–			
Ste.	-0.003	0.022	-0.001	0.053	0.142	0.020	0.050	0.053	1.000		
	(0.88)	(0.28)	(0.96)	(0.01)	(0.00)	(0.34)	(0.01)	(0.01)	—–		
Sug.	0.206	-0.033	0.127	0.183	0.072	0.172	0.163	0.183	-0.014	1.000	
	(0.00)	(0.10)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.50)	—–	
Whe.	0.204	-0.011	0.097	0.352	0.010	0.498	0.362	0.352	-0.035	0.169	1.000
	(0.00)	(0.58)	(0.00)	(0.00)	(0.61)	(0.00)	(0.00)	(0.00)	(0.08)	(0.00)	—–

Correlations are reported to the third decimal place, p values are reported to second decimal place.

1. Tests of no spillovers from food to energy prices

$H_0$1a: Food $\rightarrow$ energy: $\beta_{12} = 0$

$H_0$1b: Food $\rightarrow$ energy after the first breakpoint: $\beta^{*}_{12} = 0$

$H_0$1c: Food $\rightarrow$ energy after the second breakpoint: $\beta^{**}_{12} = 0$

$H_0$1d: Food $\rightarrow$ energy after the third breakpoint: β^{***}_{12}

$H_0$1e: Food $\rightarrow$ energy after the fourth breakpoint: $\beta^{****}_{12} = 0$

2. Tests of no volatility spillovers from food to energy prices

$H_0$2a: Food $\rightarrow$ energy: $a_{21} = g_{21} = 0$

$H_0$2b: Food $\rightarrow$ energy after the first breakpoint: $a^{*}_{21} = g^{*}_{21} = 0$

$H_0$2c: Food $\rightarrow$ energy after the second breakpoint: $a^{**}_{21} = g^{**}_{21} = 0$

$H_0$2d: Food $\rightarrow$ energy after the third breakpoint: $a^{***}_{21} = g^{***}_{21} = 0$

$H_0$2e: Food $\rightarrow$ energy after the fourth breakpoint: $a^{****}_{21} = g^{****}_{21} = 0$

3. Tests of no spillovers from energy to food prices

$H_0$3a: Energy $\rightarrow$ food: $\beta_{21} = 0$

$H_0$3b: Energy $\rightarrow$ food after the first breakpoint: $\beta^{*}_{21} = 0$

$H_0$3c: Energy $\rightarrow$ food after the second breakpoint: $\beta^{**}_{21} = 0$

$H_0$3d: Energy $\rightarrow$ food after the third breakpoint: β^{***}_{21}

$H_0$3e: Energy $\rightarrow$ food after the fourth breakpoint: $\beta^{****}_{21} = 0$

4. Tests of no volatility spillovers from energy to food prices

$H_0$4a: Energy $\rightarrow$ food: $a_{12} = g_{12} = 0$

$H_0$4b: Energy $\rightarrow$ food after the first breakpoint: $a^{*}_{12} = g^{*}_{12} = 0$

$H_0$4c: Energy $\rightarrow$ food after the second breakpoint: $a^{**}_{12} = g^{**}_{12} = 0$

$H_0$4d: Energy $\rightarrow$ food after the third breakpoint: $a^{***}_{12} = g^{***}_{12} = 0$

$H_0$4e: Energy $\rightarrow$ food after the fourth breakpoint: $a^{****}_{12} = g^{****}_{12} = 0$

3.4.3 Empirical Results

Our interpretation of the results is divided into two parts: spillovers from energy prices to food prices and spillovers from food prices to energy prices. We start by investigating the volatility spillover from energy prices, oil and ethanol, to food commodities. We divide this interpretation of the results according to the spillover in mean (β) and spillover in variance (α and g). However, we further divide the interpretation of the results by significant breaks in the mean and variance equation. After enquiring into the spillover from energy to food, we examine causality from food to energy in the same way.

We select the optimal lag length of the mean equation using the Schwarz Information Criterion. Cross-market dependence in the conditional mean and variance vary in magnitude and direction across pairwise estimations. Note that the signs of cross-market volatilities are not relevant. In order to test the adequacy of these models, Ljung-Box portmanteau tests were performed on the standardized and squared residuals. The parameter estimates for the conditional means suggest statistically significant spillovers-in-mean at the standard 5% level.

The exogenous variable controlling for business cycle fluctuations is statistically significant in the estimated models, indicating a positive γ_1 (US stock returns) effect, as expected because it can be used as an indicator of the market mood. Regarding the volatility spillovers between oil and food prices, our results suggest strong linkages between food and energy markets. Concerning the conditional variance equations, the estimated "own-market" coefficients are statistically significant, and the estimates of g_{11} suggest a high degree of persistence. The estimated VAR-GARCH(1,1) models with associated robust standard errors and likelihood function values are presented in Tables 3.3–3.13. Overall, the results indicate that the VAR-GARCH(1,1) specification satisfactorily captures persistence in the returns and squared returns of all the series considered.

Table 3.3: Summary of Estimated VAR-GARCH(1,1) for Oil

Oil=$\gg$	Cacao	Coffee	Corn	Soy	Soybean Oil	Steer	Sugar	Wheat	Ethanol
β_{12}		x					x		x
β^{*}_{12}		x							
β^{**}_{12}		x							x
β^{***}_{12}									
β^{****}_{12}							-		x
a_{11}		x	x	x		x	x	x	
a_{21}		x	x	x	x				x
a^{*}_{21}		x							
a^{**}_{21}		x			x				x
a^{***}_{21}		x	x	x					
a^{****}_{21}		x	x	x	x				
g_{11}	x	x	x	x	x	x	x	x	
g_{21}	x	x	x	x	x	x	x		x
g^{*}_{21}		x		x					
g^{**}_{21}		x	x	x	x				x
g^{***}_{21}	x	x							
g^{****}_{21}		x	x		x	x			

Oil$\ll$	Cacao	Coffee	Corn	Soy	Soybean Oil	Steer	Sugar	Wheat	Ethanol
β_{21}		x	x	x		x	x		
β^{*}_{21}									
β^{**}_{21}						x			
β^{***}_{21}									
β^{****}_{21}			x	x		x			
a^{****}_{21}		x	x	x	x				
a_{21}		x	x	x	x				
a^{*}_{21}		x							
a^{**}_{21}		x			x				
a^{***}_{21}		x	x	x					
a^{****}_{21}		x	x	x	x				
g_{12}	x	x			x			x	
g^{*}_{12}		x			x			x	
g^{**}_{12}								x	
g^{***}_{12}	x							x	
g^{****}_{12}								x	

Note: Extended tables are in this chapter's appendix.

Table 3.4: Summary of Estimated VAR-Garch (1,1) for Ethanol

Eth.$\gg$	Cacao	Coffee	Corn	Soy	Soybean Oil	Steer	Sugar	Wheat	Oil
β_{12}								x	
β_{12}^{*}									
β_{12}^{**}									
β_{12}^{***}									
β_{12}^{****}									
a_{21}									
a_{21}^{*}									
a_{21}^{**}									
a_{21}^{***}	x								
a_{21}^{****}	x								
g_{21}	x		x	x	x	x			
g_{21}^{*}				x		x			
g_{21}^{**}			x	x		x			
g_{21}^{***}	x								
g_{21}^{****}	x		x	x	x	x			

Eth.$\ll$	Cacao	Coffee	Corn	Soy	Soybean Oil	Steer	Sugar	Wheat	Oil
β_{21}							x		x
β_{21}^{*}									
β_{21}^{**}							x		x
β_{21}^{***}									
β_{21}^{****}							x		x
g_{21}^{***}	x								
g_{21}^{****}	x		x	x	x	x			
a_{12}		x							x
a_{12}^{*}									
a_{12}^{**}		x							x
a_{12}^{***}									
a_{12}^{****}		x							
g_{12}	x			x		x			x
g_{12}^{*}				x					
g_{12}^{**}	x			x		x			x
g_{12}^{***}				x					
g_{12}^{****}	x			x		x			

Note for Tables 3.5–3.12 in the appendix: Standard errors (S.E.) are calculated using the quasi-maximum likelihood method of Bollerslev and Wooldridge (1992), which is robust to the distribution of the underlying residuals. Parameters that are not statistically significant at the 5% level are not reported. $Q_{(10)}$ and $Q^2_{(10)}$ are the Ljung-Box test (1978) of significance of autocorrelations of ten lags in the standardized and standardized squared residuals, respectively. The parameters β_{21} and a_{12} measure causality of oil (ethanol) on food commodities and causality in variance effect, respectively. The effects of the 1/1/2006, 20/3/2004, 6/6/2008 and 15/8/2004 crises are measured by $(\beta_{12} + \beta^{*}_{12})$, $(\beta_{12} + \beta^{**}_{12})$, $(\beta_{12} + \beta^{***}_{12})$ and $(\beta_{12} + \beta^{****}_{12})$, respectively. The same applies to the effects on food volatilities. The covariance stationary condition is satisfied by all the estimated models, all the eigenvalues of $A_{11} \otimes A_{11} + G_{11} \otimes G_{11}$ being less than one in modulus. Note that in the conditional variance equation, the sign of the parameters is not relevant. Numbers are rounded to the third decimal place.

Spillovers from Energy to Food

We start our discussion by investigating the effects of energy on food and oil energy on ethanol energy in the mean and variance equations. Regarding the mean equation, return spillovers from oil energy prices have a negative impact on coffee (β_{12}=-0.098) and on ethanol (-0.174). Causality in mean from oil energy has a positive effect on sugar (0.203). Return spillover from ethanol energy to wheat is positive. Return causality from oil to food prices is affected by the food crisis, the RFS policy and the financial crisis:

a) The food crisis increases return spillover from oil to coffee: ($\beta_{12} + \beta^{*}_{12} =$-0.098-0.168= -0.266).

b) The RFS policy break stabilizes volatility in the mean from oil to coffee ($\beta_{12} + \beta^{***}_{12} =$-0.098+0.127=0.029) and from oil to ethanol (-0.025).

c) The financial crisis decreases return causality from oil to sugar and from oil to ethanol ($\beta_{12} + \beta^{****}_{12} =$0.203-0.155=0.048) and (0.006), respectively.

Regarding the mean equation, there is return causality of some energy com-

Table 3.5: Estimated VAR-GARCH(1,1) Model, Oil-Cacao and Ethanol-Cacao

	Oil$\gg Cac.$		Eth. $\gg Cac.$			Cac.$\gg Oil$		Cac.$\gg Eth.$	
					Conditional Mean				
	Coef.	p-value	Coef.	p-value		Coef.	p-value	Coef.	p-value
a_1	0.027	(0.473)	-0.003	(0.943)	a_2	0.028	(0.391)	0.034	(0.323)
β_{11}	-0.004	(0.790)	0.105	(0.000)	β_{22}	-0.020	(0.374)	0.006	(0.664)
β_{12}	0.024	(0.432)	-0.020	(0.427)	β_{21}	0.0249	(0.120)	-0.051	(0.442)
β_{12}^{*}	0.035	(0.738)	0.138	(0.080)	β_{21}^{*}	-0.085	(0.252)	-0.057	(0.280)
β_{12}^{**}	-0.044	(0.500)	-0.041	(0.423)	β_{21}^{**}	-0.011	(0.848)	0.057	(0.399)
β_{12}^{***}	0.015	(0.892)	-0.216	(0.005)	β_{21}^{***}	0.181	(0.011)	0.082	(0.157)
β_{12}^{****}	-0.016	(0.837)	0.106	(0.063)	β_{21}^{****}	-0.020	(0.654)	0.025	(0.725)
γ_1	0.064	(0.008)	-0.011	(0.734)	γ_2	0.078	(0.000)	0.093	(0.000)
					Conditional Variance				
c_{11}	0.501	(0.000)	0.294	(0.000)	c_{22}	0.000	(0.999)	0.146	(0.000)
a_{11}	0.174	(0.000)	0.908	(0.000)	a_{22}	0.229	(0.000)	-0.198	(0.000)
a_{21}	-0.052	(0.231)	0.041	(0.005)	a_{12}	0.014	(0.441)	0.015	(0.753)
a_{21}^{*}	-0.017	(0.783)	0.043	(0.168)	a_{12}^{*}	0.102	(0.226)	-0.106	(0.016)
a_{21}^{**}	0.058	(0.241)	-0.042	(0.044)	a_{12}^{**}	-0.191	(0.042)	0.014	(0.769)
a_{21}^{***}	-0.044	(0.605)	-0.077	(0.018)	a_{12}^{***}	0.047	(0.576)	0.093	(0.106)
a_{21}^{****}	0.120	(0.200)	0.013	(0.582)	a_{12}^{****}	-0.062	(0.457)	0.000	(0.992)
g_{11}	0.978	(0.000)	0.410	(0.000)	g_{22}	0.912	(0.000)	-0.198	(0.000)
g_{21}	0.227	(0.000)	0.045	(0.044)	g_{12}	-0.140	(0.000)	-0.071	(0.003)
g_{21}^{*}	-0.067	(0.527)	0.157	(0.162)	g_{12}^{*}	0.102	(0.226)	0.016	(0.462)
g_{21}^{**}	-0.106	(0.314)	-0.072	(0.276)	g_{12}^{**}	0.064	(0.420)	0.053	(0.016)
g_{21}^{***}	-0.114	(0.027)	-0.267	(0.015)	g_{12}^{***}	0.056	(0.064)	0.001	(0.978)
g_{21}^{****}	-0.006	(0.915)	0.130	(0.082)	g_{12}^{****}	0.003	(0.937)	0.054	(0.007)
Log-lik		-19053.9		-10954.1					
$Q_{oil(10)}$	5.81						Arch(10)	3.689	(0)
$Q^2_{oil(10)}$	17.98						Arch(10)	2.329	(-0.01)
$Q_{Eth.(10)}$			17.57				Arch(10)	0.753	(-0.675)
$Q^2_{Eth.(10)}$			13.31				Arch(10)	1.434	(-0.159)
$Q_{corn(10)}$	10.33		16.42						
$Q^2_{corn(10)}$	12.33		13.49						

Table 3.6: Estimated VAR-GARCH(1,1) Model, Oil-Coffee and Ethanol-Coffee

	Oil≫ $Coffee$		Eth. ≫ $Coffee$			Coffee≫ Oil		Coffee≫ $Eth.$	
				Conditional Mean					
	Coef.	p-value	Coef.	p-value		Coef.	p-value	Coef.	p-value
a$_1$	0.026	(0.494)	-0.002	(0.948)	a$_2$	0.040	(0.245)	0.038	(0.382)
ß$_{11}$	-0.048	(0.037)	0.117	(0.000)	ß$_{22}$	0.025	(0.109)	0.025	(0.123)
ß$_{12}$	-0.098	(0.025)	-0.018	(0.336)	ß$_{21}$	0.113	(0.055)	-0.125	(0.162)
ß$^{*}_{12}$	-0.168	(0.074)	0.014	(0.879)	ß$^{*}_{21}$	0.035	(0.550)	-0.006	(0.879)
ß$^{**}_{12}$	0.127	(0.052)	-0.021	(0.608)	ß$^{**}_{21}$	-0.013	(0.843)	0.116	(0.183)
ß$^{***}_{12}$	0.154	(0.110)	0.033	(0.691)	ß$^{***}_{21}$	-0.083	(0.103)	0.083	(0.108)
ß$^{****}_{12}$	0.129	(0.114)	-0.043	(0.440)	ß$^{****}_{21}$	0.006	(0.932)	0.029	(0.697)
γ_1	0.063	(0.107)	-0.018	(0.534)	γ_2	0.108	(0.000)	0.159	(0.000)
				Conditional Variance					
c_{11}	0.003	(0.000)	0.329	(0.000)	c_{22}	0.994	(0.000)	0.000	(1.000)
a_{11}	0.232	(0.000)	0.412	(0.000)	a_{22}	0.260	(0.000)	-0.123	(0.000)
a_{21}	0.177	(0.000)	0.013	(0.434)	a_{12}	-0.203	(0.049)	0.152	(0.000)
a^{*}_{21}	-0.038	(0.002)	0.035	(0.804)	a^{*}_{12}	-0.014	(0.899)	0.047	(0.177)
a^{**}_{21}	-0.189	(0.019)	0.023	(0.682)	a^{**}_{12}	0.153	(0.110)	-0.122	(0.000)
a^{***}_{21}	0.182	(0.000)	-0.194	(0.102)	a^{***}_{12}	0.197	(0.021)	-0.026	(0.539)
a^{****}_{21}	0.093	(0.000)	0.227	(0.002)	a^{****}_{12}	0.047	(0.690)	-0.148	(0.001)
g_{11}	0.964	(0.000)	0.903	(0.000)	g_{22}	0.757	(0.000)	0.989	(0.000)
g_{21}	-0.116	(0.000)	0.005	(0.240)	g_{12}	0.397	(0.000)	-0.027	(0.222)
g^{*}_{21}	-0.038	(0.002)	0.067	(0.001)	g^{*}_{12}	-0.347	(0.000)	-0.021	(0.191)
g^{**}_{21}	-0.189	(0.019)	-0.002	(0.848)	g^{**}_{12}	-0.055	(0.234)	0.016	(0.444)
g^{***}_{21}	0.182	(0.000)	-0.039	(0.071)	g^{***}_{12}	0.002	(0.972)	-0.008	(0.738)
g^{****}_{21}	-0.275	(0.000)	-0.021	(0.290)	g^{****}_{12}	-0.050	(0.294)	0.056	(0.002)
Log-lik		-11183.7		-10907.1					
$Q_{oil(10)}$	4.79						Arch(10)$_{oil}$	1	(0.441)
$Q^2_{oil(10)}$	12.85						Arch(10)$_{caco.oil}$	2.402	(0.008)
$Q_{Eth.(10)}$			16.49				Arch(10)$_{eth.}$	1.001	(0.4399)
$Q^2_{Eth.(10)}$			16.12				Arch(10)$_{caco.eth}$	1.775	(0.059)
$Q_{corn(10)}$	11.75		9.76						
$Q^2_{corn(10)}$	11.57		9.98						

Table 3.7: Estimated VAR-GARCH(1,1) Model, Oil-Corn and Ethanol-Corn

	Oil $\gg Corn$		Eth. $\gg Corn$			Corn $\gg Oil$		Corn $\gg Eth.$	
				Conditional Mean					
	Coef.	p-value	Coef.	p-value		Coef.	p-value	Coef.	p-value
a$_1$	0.025	(0.498)	-0.077	(0.036)	a$_2$	0.0171	(0.536)	0.006	(0.873)
ß$_{11}$	-0.011	(0.375)	0.102	(0.000)	ß$_{22}$	0.001	(0.958)	-0.002	(0.922)
ß$_{12}$	0.026	(0.363)	-0.007	(0.776)	ß$_{21}$	-0.022	(0.005	-0.094	(0.188)
ß$^{*}_{12}$	0.174	(0.043)	-0.094	(0.183)	ß$^{*}_{21}$	-0.132	(0.015)	-0.158	(0.058)
ß$^{**}_{12}$	-0.092	(0.072)	-0.020	(0.689)	ß$^{**}_{21}$	-0.021	(0.302)	0.059	(0.449)
ß$^{***}_{12}$	-0.060	(0.437)	0.098	(0.115)	ß$^{***}_{21}$	0.039	(0.650)	0.196	(0.067)
ß$^{****}_{12}$	-0.039	(0.389)	-0.009	(0.874)	ß$^{****}_{21}$	0.133	(0.005)	0.063	(0.454)
γ_1	0.055	(0.042)	0.005	(0.858)	γ_2	0.034	(0.085)	0.018	(0.536)
				Conditional Variance					
c_{11}	0.143	(0.053)	0.181	(0.000	c_{22}	0.323	(0.000)	0.155	0.262
a_{11}	0.184	(0.000)	0.384	(0.000)	a_{22}	0.226	(0.000)	-0.119	(0.022)
a_{21}	-0.097	(0.001)	-0.007	(0.779)	a_{12}	0.002	(0.812)	0.055	(0.276)
a^{*}_{21}	-0.0169	(0.633)	-0.271	(0.000)	a^{*}_{12}	-0.002	(0.964)	0.131	(0.002)
a^{**}_{21}	0.008	(0.840)	0.146	(0.024)	a^{**}_{12}	0.038	(0.151)	-0.044	(0.350)
a^{***}_{21}	0.092	(0.023)	0.217	(0.000)	a^{***}_{12}	0.128	(0.000)	-0.294	(0.001)
a^{****}_{21}	0.088	(0.036)	0.134	(0.070)	a^{****}_{12}	-0.157	(0.000)	0.090	(0.042)
g_{11}	0.979	(0.000)	0.920	(0.000)	g_{22}	0.953	(0.000)	0.988	(0.000)
g_{21}	0.039	(0.003)	-0.002	(0.885)	g_{12}	-0.004	(0.221)	-0.031	(0.003)
g^{*}_{21}	-0.075	(0.000)	-0.019	(0.376)	g^{*}_{12}	0.050	(0.000)	-0.031	(0.003)
g^{**}_{21}	-0.024	(0.061)	0.011	(0.161)	g^{**}_{12}	0.006	(0.464)	0.007	(0.773)
g^{***}_{21}	-0.047	(0.103)	0.000	(0.994)	g^{***}_{12}	0.128	(0.000)	0.137	(0.000)
g^{****}_{21}	0.090	(0.000)	0.030	(0.004)	g^{****}_{12}	-0.157	(0.000)	-0.084	(0.315)
Log-lik	21004.99		-9578.517						
$Q_{oil(10)}$	5.058				Arch(10)$_{oil}$2.34			2.34	(0.010)
$Q^2_{oil(10)}$	17.48				Arch(10)$_{caco.oil}$1.595			1.595	(0.102)
$Q_{Eth.(10)}$			16.41		Arch(10)$_{eth.}$0.735			1.445	(0.154)
$Q^2_{Eth.(10)}$			12.73		Arch(10)$_{eth.caco}$3.38			2.090	(0.022)
$Q_{corn(10)}$	8.37		3.80						
$Q^2_{corn(10)}$	14.96		16.46						

Table 3.8: Estimated VAR-GARCH(1,1) Model, Oil-Soybeans and Ethanol-Soybeans

	Oil $\gg Soy$		Eth. $\gg Soy$			Soy $\gg Oil$		Soy $\gg Eth.$	
				Conditional Mean					
	Coef.	p-value	Coef.	p-value		Coef.	p-value	Coef.	p-value
a_1	0.026	(0.468)	-0.018	(0.597)	a_2	0.013	(0.590)	0.025	(0.491)
β_{11}	-0.008	(0.506)	0.119	(0.000)	β_{22}	-0.033	(0.002)	-0.041	(0.019)
β_{12}	-0.005	(0.846)	-0.009	(0.802)	β_{21}	-0.015	(0.042)	-0.009	(0.892)
β^{*}_{12}	0.156	(0.079)	-0.057	(0.542)	β^{*}_{21}	-0.053	(0.178)	0.142	(0.012)
β^{**}_{12}	-0.015	(0.665)	0.018	(0.754)	β^{**}_{21}	0.032	(0.322)	-0.095	(0.164)
β^{***}_{12}	-0.090	(0.308)	-0.098	(0.263)	β^{***}_{21}	-0.055	(0.248)	-0.028	(0.607)
β^{****}_{12}	-0.042	(0.368)	0.129	(0.080)	β^{****}_{21}	0.076	(0.029)	-0.105	(0.155)
γ_1	0.031	(0.241)	-0.007	(0.816)	γ_2	0.056	(0.000)	0.121	(0.000)
				Conditional Variance					
c_{11}	0.147	(0.000)	0.164	(0.000)	c_{22}	0.197	(0.056)	0.000	(1.000)
a_{11}	0.191	(0.000)	0.402	(0.000)	a_{22}	0.229	(0.000)	0.327	(0.000)
a_{21}	0.098	(0.022)	0.037	(0.394)	a_{12}	0.002	(0.807)	-0.060	(0.408)
a^{*}_{21}	-0.162	(0.102)	0.360	(0.028)	a^{*}_{12}	-0.031	(0.503)	0.074	(0.328)
a^{**}_{21}	-0.020	(0.689)	-0.145	(0.170)	a^{**}_{12}	0.039	(0.352)	0.055	(0.496)
a^{***}_{21}	0.044	(0.686)	-0.185	(0.059)	a^{***}_{12}	-0.054	(0.395)	-0.127	(0.030)
a^{****}_{21}	0.137	(0.048)	-0.358	(0.000)	a^{****}_{12}	0.012	(0.830)	0.118	(0.249)
g_{11}	0.980	(0.000)	0.909	(0.000)	g_{22}	0.956	(0.000)	0.733	(0.000)
g_{21}	-0.044	(0.001)	0.144	(0.000)	g_{12}	0.002	(0.471)	-0.181	(0.000)
g^{*}_{21}	0.148	(0.000)	-0.343	(0.001)	g^{*}_{12}	-0.098	(0.000)	0.315	(0.000)
g^{**}_{21}	-0.079	(0.000)	0.251	(0.000)	g^{**}_{12}	0.087	(0.000)	-0.186	(0.001)
g^{***}_{21}	-0.022	(0.285)	-0.185	(0.059)	g^{***}_{12}	0.0165	(0.300)	0.181	(0.000)
g^{****}_{21}	-0.038	(0.112)	0.540	(0.000)	g^{****}_{12}	(0.004	(0.619)	-0.324	(0.000)
Log-lik		-18387		-10577					
$Q_{oil(10)}$	4.14						Arch(10)$_{oil}$	2.169	(0.017)
$Q^2_{oil(10)}$	15.6						Arch(10)$_{soybean.oil}$	1.138	(0.329)
$Q_{Eth.(10)}$			13.46				Arch(10)$_{eth.}$	0.917	(0.516)
$Q^2_{Eth.(10)}$			5.8				Arch(10)$_{soy.eth.}$	1.279	(0.236)
$Q_{soy(10)}$	5.981		3.356						
$Q^2_{soy(10)}$	5.799		2.117						

Table 3.9: Estimated VAR-GARCH(1,1) Model, Oil-Soybean Oil and Ethanol-Soybean Oil

	Oil $\gg SoyOil$		Eth. $\gg SoyOil$			Soy Oil $\gg Oil$		Soy Oil $\gg Eth.$	
				Conditional Mean					
	Coef.	p-value	Coef.	p-value		Coef.	p-value	Coef.	p-value
a_1	0.0292	(0.461)	-0.011	(0.742)	a_2	0.026	(0.296)	0.026	(0.442)
$ß_{11}$	-0.067	(0.000)	0.110	(0.000)	$ß_{22}$	0.005	(0.732)	0.012	(0.470)
$ß_{12}$	-0.091	(0.111)	-0.019	(0.424)	$ß_{21}$	0.023	(0.243)	-0.028	(0.637)
$ß^{*}_{12}$	-0.046	(0.547)	0.150	(0.104)	$ß^{*}_{21}$	0.037	(0.414)	-0.057	(0.282)
$ß^{**}_{12}$	0.094	(0.139)	-0.049	(0.379)	$ß^{**}_{21}$	0.028	(0.428)	0.033	(0.590)
$ß^{***}_{12}$	0.134	(0.069)	-0.182	(0.036)	$ß^{***}_{21}$	-0.108	(0.002)	0.091	(0.119)
$ß^{****}_{12}$	0.0156	(0.765)	0.043	(0.449)	$ß^{****}_{21}$	0.038	(0.330)	-0.012	(0.851)
γ_1	0.057	(0.110)	-0.024	(0.435)	γ_2	0.081	(0.000)	0.093	(0.000)
				Conditional Variance					
c_{11}	0.148	(0.000)	0.281	(0.000)	c_{22}	0.169	(0.321)	0.145	0.002)
a_{11}	0.207	(0.000)	0.410	(0.000)	a_{22}	0.224	(0.000)	-0.187	(0.000)
a_{21}	0.250	(0.000)	0.033	(0.146)	a_{12}	-0.031	(0.115)	-0.029	(0.676)
a^{*}_{21}	0.031	(0.680)	0.101	(0.303)	a^{*}_{12}	-0.003	(0.949)	-0.110	(0.013)
a^{**}_{21}	-0.443	(0.000)	0.012	(0.859)	a^{**}_{12}	-0.079	(0.011)	0.056	(0.463)
a^{***}_{21}	0.054	(0.477)	-0.005	(0.955)	a^{***}_{12}	0.123	(0.017)	0.045	(0.366)
a^{****}_{21}	-0.379	(0.000)	-0.047	(0.497)	a^{****}_{12}	-0.051	(0.246)	0.088	(0.329)
g_{11}	0.965	(0.000)	0.910	(0.000)	g_{22}	0.956	(0.000)	0.974	(0.000)
g_{21}	-0.081	(0.000)	0.040	(0.000)	g_{12}	0.023	(0.002)	-0.029	(0.676)
g^{*}_{21}	0.036	(0.160)	0.025	(0.454)	g^{*}_{12}	-0.029	(0.034)	0.021	(0.305)
g^{**}_{21}	0.108	(0.000)	-0.017	(0.295)	g^{**}_{12}	0.015	(0.152)	0.038	(0.211)
g^{***}_{21}	-0.009	(0.692)	0.003	(0.918)	g^{***}_{12}	-0.007	(0.590)	-0.005	(0.820)
g^{****}_{21}	0.096	(0.000)	-0.039	(0.002)	g^{****}_{12}	0.005	(0.715)	0.039	(0.246)
Log-lik		-10371.5		-10308.1					
$Q_{oil(10)}$	4.85						Arch(10)$_{oil}$	1.204	(0.282)
$Q^2_{oil(10)}$	13.75						Arch(10)$_{soy.o.oil}$	1.2	(0.285)
$Q_{Eth.(10)}$			15.86				Arch(10)$_{eth.}$	0.89	(0.542)
$Q^2_{Eth.(10)}$			17.03				Arch(10)$_{soy.o.eth}$	1.644	(0.088)
$Q_{s.o(10)}$	15.79		17.03						
$Q^2_{s.o(10)}$	13.57		15.89						

Table 3.10: Estimated VAR-GARCH(1,1) Model, Oil-Sugar and Ethanol-Sugar

	Oil $\gg Sug.$		Eth.$\gg Sug.$			Sug. $\gg Oil$		Sug. $\gg Eth.$	
				Conditional Mean					
	Coef.	p-value	Coef.	p-value		Coef.	p-value	Coef.	p-value
a_1	0.049	(0.297)	-0.083	(0.024)	a_2	0.005	(0.903)	0.002	(0.958)
$ß_{11}$	-0.057	(0.001)	0.084	(0.000)	$ß_{22}$	-0.046	(0.076)	-0.078	(0.000)
$ß_{12}$	0.203	(0.000)	0.001	(0.948)	$ß_{21}$	0.078	(0.035)	-0.099	(0.000)
$ß^{*}_{12}$	-0.067	(0.260)	-0.107	(0.135)	$ß^{*}_{21}$	0.012	(0.863)	0.016	(0.563)
$ß^{**}_{12}$	-0.068	(0.314)	0.022	(0.598)	$ß^{**}_{21}$	-0.028	(0.542)	0.079	(0.005)
$ß^{***}_{12}$	-0.004	(0.950)	0.098	(0.123)	$ß^{***}_{21}$	-0.093	(0.126)	-0.013	(0.717)
$ß^{****}_{12}$	-0.155	(0.043)	0.007	(0.864)	$ß^{****}_{21}$	0.003	(0.944)	0.100	(0.025)
γ_1	0.063	(0.070)	-0.008	(0.766)	γ_2	0.046	(0.085)	0.059	(0.033)
				Conditional Variance					
c_{11}	0.160	(0.000)	0.307	(0.000)	c_{22}	0.000	(0.999)	0.062	(0.595)
a_{11}	0.189	(0.000)	0.440	(0.000)	a_{22}	0.218	(0.000)	0.157	(0.000)
a_{21}	-0.075	(0.191)	0.021	(0.195)	a_{12}	0.058	(0.126)	-0.010	(0.914)
a^{*}_{21}	0.028	(0.491)	-0.228	(0.071)	a^{*}_{12}	0.178	(0.010)	-0.018	(0.725)
a^{**}_{21}	0.149	(0.022)	-0.013	(0.911)	a^{**}_{12}	-0.109	(0.065)	-0.026	(0.757)
a^{***}_{21}	-0.032	(0.430)	0.265	(0.000)	a^{***}_{12}	-0.183	(0.000)	-0.048	(0.423)
a^{****}_{21}	0.020	(0.778)	-0.030	(0.741)	a^{****}_{12}	-0.075	(0.175)	0.076	(0.356)
g_{11}	-0.981	(0.000)	0.892	(0.000)	g_{22}	0.974	(0.000)	0.157	(0.000)
g_{21}	0.315	(0.000)	-0.015	(0.176)	g_{12}	0.058	(0.126)	-0.010	(0.914)
g^{*}_{21}	0.035	(0.607)	0.008	(0.770)	g^{*}_{12}	0.178	(0.010)	-0.018	(0.725)
g^{**}_{21}	-0.245	(0.000)	0.002	(0.951)	g^{**}_{12}	-0.109	(0.065)	-0.026	(0.757)
g^{***}_{21}	0.172	(0.000)	-0.003	(0.892)	g^{***}_{12}	-0.183	(0.000)	-0.048	(0.423)
g^{****}_{21}	-0.501	(0.000)	0.002	(0.936)	g^{****}_{12}	-0.075	(0.175)	0.076	(0.356)
Log-lik	-11727.362		-9589.101						
$Q_{oil(10)}$	4.520						Arch(10)$_{oil}$	1.12	(0.343)
$Q^2_{oil(10)}$	11.610						Arch(10)$_{sug.oil}$	1.564	(0.111)
$Q_{Eth.(10)}$		14.07					Arch(10)$_{eth.}$	0.625	(0.794)
$Q^2_{Eth.(10)}$		6.710					Arch(10)$_{sug.eth}$	1.679	(1.679)
$Q_{sug.(10)}$	9.430	8.370							
$Q^2_{sug(10)}$	9.150	10.86							

Table 3.11: Estimated VAR-GARCH(1,1) Model, Oil-Wheat and Ethanol-Wheat

	Oil $\gg Wheat$		Eth. $\gg Wheat$			Wheat $\gg Oil$		Wheat $\gg Eth.$	
				Conditional Mean					
	Coef.	p-value	Coef.	p-value		Coef.	p-value	Coef.	p-value
a_1	0.013	(0.759)	0.001	(0.986)	a_2	-0.012	(0.802)	-0.021	(0.689)
$ß_{11}$	-0.053	(0.004)	0.100	(0.000)	$ß_{22}$	-0.037	(0.098)	-0.038	(0.043)
$ß_{12}$	-0.060	(0.174)	0.038	(0.005)	$ß_{21}$	-0.009	(0.843)	-0.016	(0.843)
$ß^{*}_{12}$	-0.030	(0.660)	-0.063	(0.542)	$ß^{*}_{21}$	-0.207	(0.017)	-0.098	(0.073)
$ß^{**}_{12}$	0.063	(0.304)	-0.035	(0.239)	$ß^{**}_{21}$	0.131	(0.048)	0.017	(0.840)
$ß^{***}_{12}$	0.035	(0.571)	0.069	(0.492)	$ß^{***}_{21}$	-0.067	(0.470)	-0.016	(0.777)
$ß^{****}_{12}$	0.022	(0.718)	-0.046	(0.160)	$ß^{****}_{21}$	0.203	(0.020)	0.107	(0.211)
γ_1	0.085	(0.024)	-0.037	(0.253)	γ_2	0.026	(0.551)	-0.033	(0.489)
				Conditional Variance					
c_{11}	0.054	(0.266)	0.336	(0.000)	c_{22}	0.000	(0.999)	0.317	(0.000)
a_{11}	0.179	(0.000)	0.416	(0.000)	a_{22}	0.268	(0.000)	0.241	(0.000)
a_{21}	-0.064	(0.235)	0.001	(0.965)	a_{12}	0.033	(0.031)	0.058	(0.330)
a^{*}_{21}	0.021	(0.680)	-0.225	(0.087)	a^{*}_{12}	0.021	(0.493)	0.061	(0.381)
a^{**}_{21}	0.061	(0.397)	0.105	(0.002)	a^{**}_{12}	-0.122	(0.000)	-0.054	(0.408)
a^{***}_{21}	0.035	(0.223)	0.167	(0.177)	a^{***}_{12}	0.124	(0.000)	-0.218	(0.074)
a^{****}_{21}	0.062	(0.453)	0.027	(0.470)	a^{****}_{12}	-0.176	(0.000)	0.076	(0.618)
g_{11}	0.983	(0.000)	0.901	(0.000)	g_{22}	0.950	(0.000)	0.960	(0.000)
g_{21}	-0.014	(0.275)	0.023	(0.060)	g_{12}	0.033	(0.031)	-0.099	(0.078)
g^{*}_{21}	-0.028	(0.052)	0.071	(0.031)	g^{*}_{12}	0.021	(0.000)	-0.067	(0.067)
g^{**}_{21}	0.098	(0.000)	-0.033	(0.020)	g^{**}_{12}	-0.122	(0.000)	0.095	(0.087)
g^{***}_{21}	-0.091	(0.000)	-0.078	(0.012)	g^{***}_{12}	0.124	(0.000)	0.164	(0.001)
g^{****}_{21}	0.110	(0.000)	0.000	(0.994)	g^{****}_{12}	-0.176	(0.000)	0.010	(0.886)
Log-lik		21004.99		-12147.9					
$Q_{oil(10)}$	4.83						Arch(10)$_{oil}$	0.863	(0.567)
$Q^2_{oil(10)}$	7.33						Arch(10)$_{wheat.oil}$	1.646	(0.087)
$Q_{Eth.(10)}$			17.06				Arch(10)$_{eth.}$	0.287	(-0.984)
$Q^2_{Eth.(10)}$			2.51				Arch(10)$_{wheat.eth}$	2.012	(0.029)
$Q_{whe.(10)}$	6.08		6.42						
$Q^2_{whe.(10)}$	12.23		14.89						

Table 3.12: Estimated VAR-GARCH(1,1) Model, Eth.-Oil

	Eth.=≫ oil			Oil =≫ $Eth.$	
		Conditional Mean			
	Coef.	p-value		Coef.	p-value
a_1	-0.092	(0.009)	a_2	0.037	(0.473)
$ß_{11}$	0.091	(0.000)	$ß_{22}$	-0.066	(0.000)
$ß_{12}$	0.003	(0.796)	$ß_{21}$	-0.174	(0.010)
$ß^{*}_{12}$	-0.011	(0.912)	$ß^{*}_{21}$	0.055	(0.422)
$ß^{**}_{12}$	-0.062	(0.012)	$ß^{**}_{21}$	0.149	(0.025)
$ß^{***}_{12}$	0.044	(0.653)	$ß^{***}_{21}$	0.002	(0.986)
$ß^{****}_{12}$	-0.023	(0.375)	$ß^{****}_{21}$	0.180	(0.000)
γ_1	-0.004	(0.888)	γ_2	0.041	(0.236)
		Conditional Variance			
c_{11}	0.283	(0.000)	c_{22}	0.135	(0.001)
a_{11}	0.435	(0.000)	a_{22}	0.175	(0.000)
a_{21}	0.003	(0.854)	a_{12}	0.216	(0.000)
a^{*}_{21}	0.280	(0.013)	a^{*}_{12}	-0.023	(0.627)
a^{**}_{21}	-0.068	(0.242)	a^{**}_{12}	-0.194	(0.003)
a^{***}_{21}	-0.228	(0.040)	a^{***}_{12}	-0.160	(0.063)
a^{****}_{21}	0.003	(0.922)	a^{****}_{12}	-0.040	(0.622)
g_{11}	0.895	(0.000)	g_{22}	0.982	(0.000)
g_{21}	0.008	(0.301)	g_{12}	-0.105	(0.000)
g^{*}_{21}	-0.044	(0.299)	g^{*}_{12}	0.024	(0.244)
g^{**}_{21}	0.007	(0.649)	g^{**}_{12}	0.091	(0.000)
g^{***}_{21}	0.040	(0.381)	g^{***}_{12}	0.026	(0.557)
g^{****}_{21}	-0.011	0.340)	g^{****}_{12}	0.059	(0.107)
Log-lik	-9982				
$Q_{oil(10)}$	6.9		Arch(10)$_{oil}$	1.781	(0.058)
$Q^2_{oil(10)}$	15.74		Arch(10)$_{caco.oil}$	0.721	(0.705)
$Q_{Eth.(10)}$	16.09				
$Q^2_{Eth.(10)}$	6.46				

modities on some agri-food commodities, i.e., coffee, sugar and wheat. This provides mixed evidence of the effect of each of the above-mentioned structural breaks; however, during the financial crisis, oil causality in the mean decreases for sugar.

Regarding variance spillovers from oil to food prices, there is strong variance causality from oil energy to foods (in absolute value terms). We list these variance spillovers from largest to smallest: soybean oil ($\boldsymbol{\alpha_{21}}$=0.250), sugar (0.203), coffee (0.177), soybeans (0.173), and corn (0.097). There is also convincing variance spillover from ethanol towards cacao is (0.041).

The RFS policy change, oil crisis period and financial crisis have the following implications for energy-food spillover in the variance:

a) The introduction of the RFS policy leads to an increase in the variance spillovers from oil to coffee ($\boldsymbol{\alpha_{21}} + \boldsymbol{\alpha_{21}^{**}} = 0.177 + 0.182 = 0.359$). The same policy led to a decrease in variance causality from ethanol to cacao (-0.003).

b) The oil crisis period led to a compression of the variance spillover from oil to coffee (=0.177+-0.189=-0.012) and from ethanol to cacao (-0.001). An increase in the variance causality from oil to soybean oil (-0.193) is also observed over the same period.

c) The financial crisis caused the oil to food variance spillover increase for coffee ($\alpha_{21} + 21$=0.177+0.093=0.186) and soybeans (0.235). The same crisis decreased the volatility for oil to corn (-0.009), soybean oil (0.120), and sugar (0.048).

The results for causality provide strong evidence of variance spillovers from energy to food commodities. The variance spillover from oil to coffee increases with the implementation of the RFS policy, while the variance spillover from ethanol to cacao decreases over the same period. Variance causality runs from oil to coffee, soybean oil, and soybeans during the financial crisis period.

Spillovers from Food to Energy

The second part of the discussion of the results reports the effects of food prices on energy prices and discusses which breaks are significant in the mean and variance equation. Regarding return spillovers from food prices to energy prices, there is persistent evidence of return spillovers from food commodities to energy commodities. In the case of food commodity to oil energy spillovers, there is compelling evidence for cattle and steer (β_{21} = 0.362) and the following agricultural commodities: coffee (0.113), sugar (0.078), corn (-0.022), and soybeans (-0.015). Regarding causality in mean effect of food commodities on ethanol, evidence exists for the steer to ethanol (0.290) and sugar to ethanol (-0.099) relations. Of the breaks considered, the food, oil and financial crises were significant:

a) The food crisis exhibits positive causality in the mean from corn to oil ($\beta_{21} + \beta_{21}^{*} = -0.022 - 0.132 = -0.154$).

b) The energy bubble reduced spillovers in mean from sugar towards ethanol ($\beta_{21} + \beta_{21}^{**}$=-0.099+0.079= -0.02).

c) The 2008 financial crisis had a significant impact on return spillovers for most commodities. Return causality for corn (β_{21}+β_{21}^{****} =-0.022+0.133=0.111) and soybeans (-0.061) becomes persistent. During the financial crisis, spillovers in the mean become more stable for steer (0.029). In the case of ethanol, return spillover is only stable for steer (0.005) and sugar (0.001).

The results indicate that there is considerable variance spillover from food to fuel, which is an interesting addition to the food before fuel debate. The evidence indicates that the financial crisis caused the largest increases in return causality for the corn to oil and soybean to oil relations; however, the crisis decreased this effect in other commodities tested. One explanation for this link is that sugar and corn are used in ethanol fuel production.

For food variance spillovers to energy ($\alpha_{\mathbf{12}}$), effects are observed of coffee on oil ($\alpha_{\mathbf{12}}$=-0.203) and on ethanol (0.152), as well as of wheat on oil (0.033). The RFS policy change and the financial crisis were prominent in the variance spillover relationships:

a) The RFS policy change cause a decrease on the variance causality from coffee towards oil ($\alpha_{\mathbf{12}} + \alpha_{\mathbf{12}}^{***}$0.203+0.197=0.005).

b) The financial crisis reduced variance spillovers from coffee to ethanol

($\alpha_{12} + \alpha_{12}^{****}$=0.152-0.148=0.04). There is also a causal relationship from wheat to oil, which increases for all four breaks but most persistently during the financial crisis (-0.143).

The results for variance spillovers from food to energy confirm the importance of food in the fuel before food debate. The results are most affected by the financial crisis.

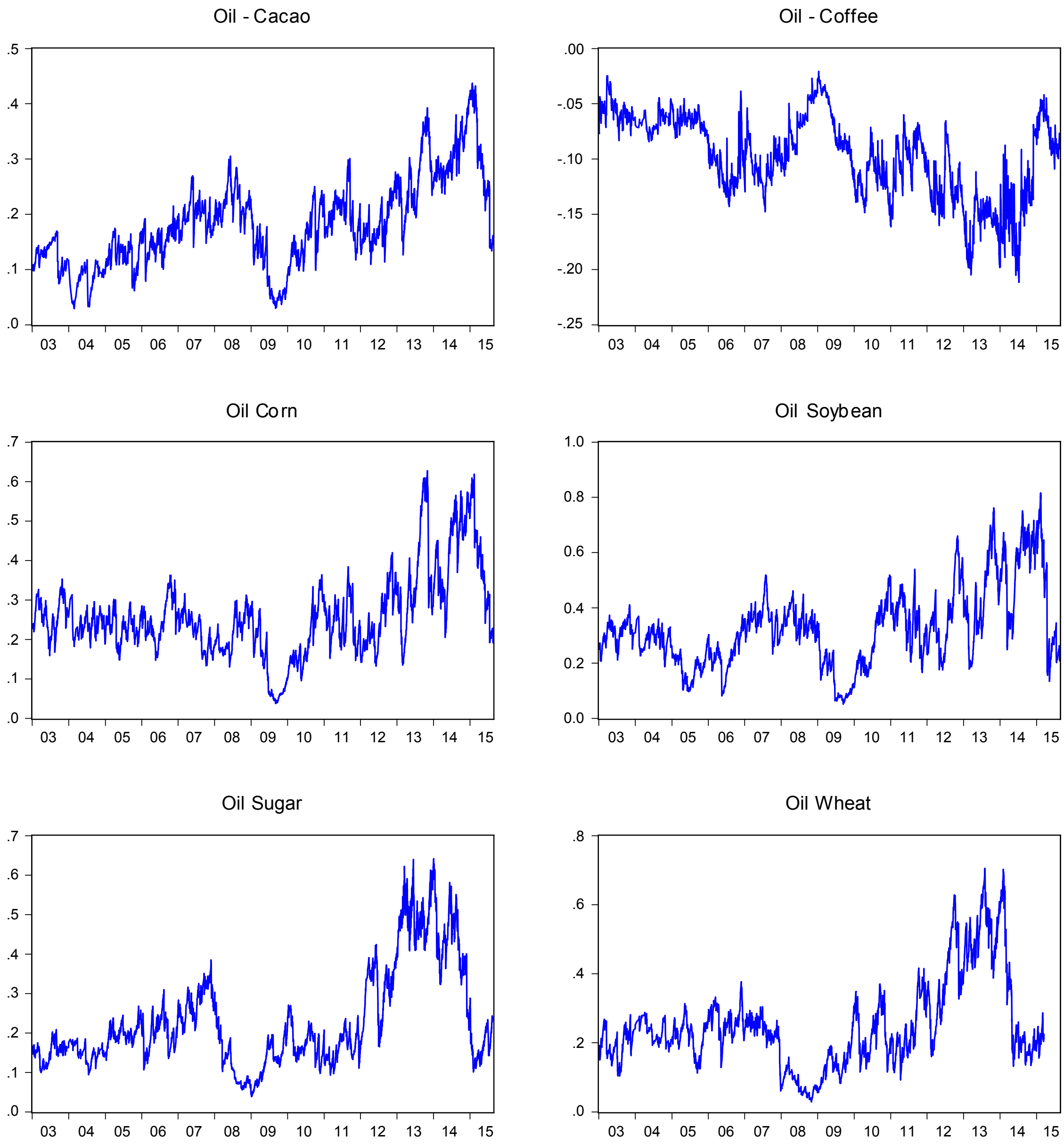

Figure 3.4: Conditional Correlations for Oil

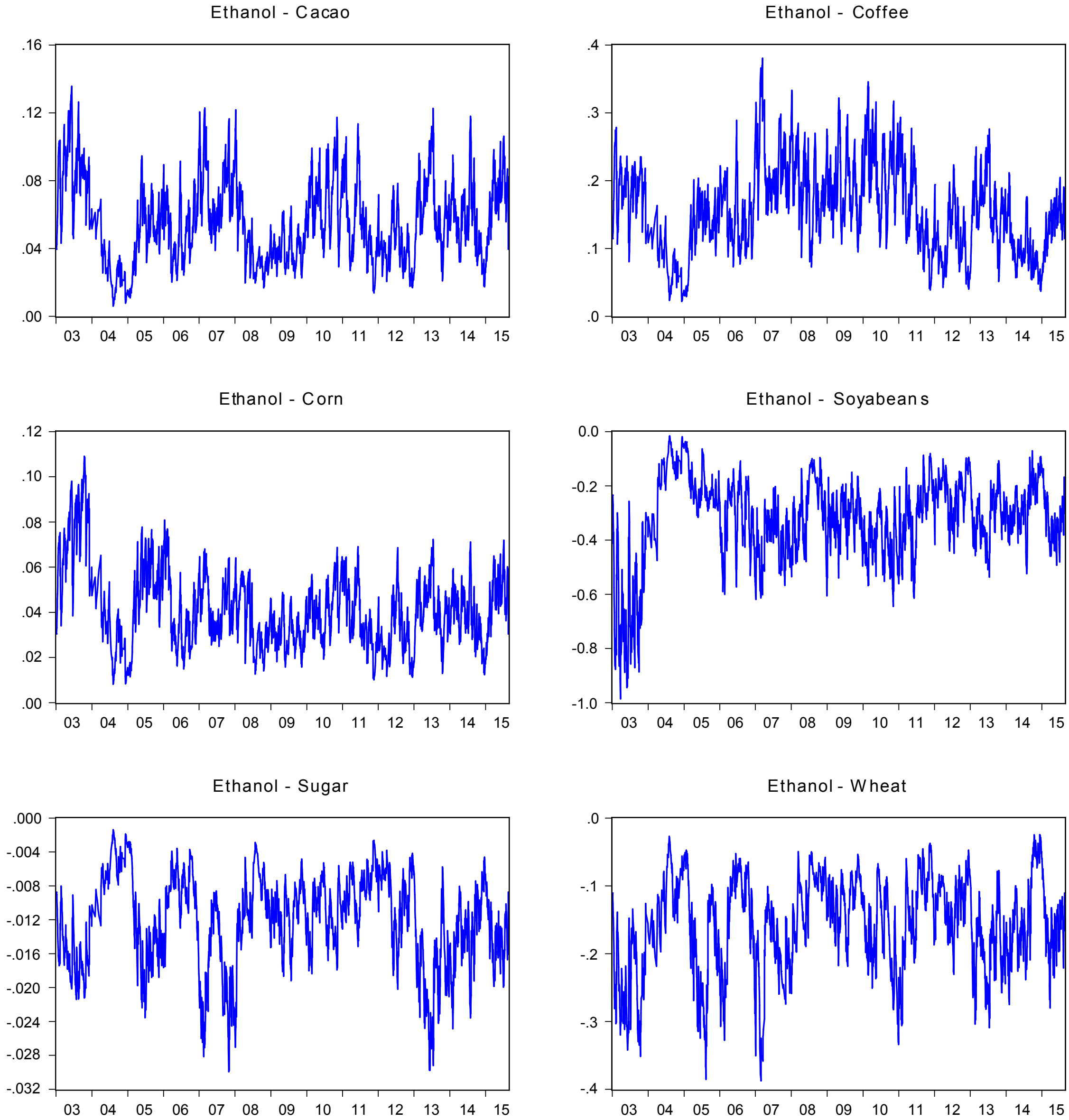

Figure 3.5: Conditional Correlations for Ethanol

3.5 Discussion of the Results

All four breaks considered had some effect on both mean and variance spillovers; however, the financial crisis was the most prominent break observed in the data. Further, the conditional correlation graphs illustrate the same patterns (Figures 3.4–3.6). The conditional correlation indicates that there is a change in the relationship between energy and food prices after the financial crisis, especially in the relations for some commodities: between oil energy and soybeans and soybean oil; between ethanol and cacao and soybeans; and between ethanol and oil. Our results can be compared to the literature as follows:

1) The observed effect of the food crisis on energy to coffee volatility (variance spillover) suggests the of the importance of the food crisis in the food-energy dynamics, which has also been reported by Nazlioglu et al. (2013). However, the food crisis did not affect the other commodities tested.

2) The reported results show that the oil bubble increased the volatility relationship from oil and sugar to ethanol in the variance and mean equations, and it decreased spillover effects in the variance from cacao, soybean, steer and oil to ethanol. This break is also described by Fan and Xu (2011). These results reveal another side of oil-food dynamics, and they contribute the observation that food energy volatility effects on ethanol decrease during that time. However, by examining the oil bubble break, we show that the relationship from food to energy prices strengthened during the energy bubble. This result emphasizes that food affects fuel, especially during periods of oil price turbulence.

3) Our results indicate that the 2006 RFS policy mainly affected the volatility in the variance of spillovers from wheat to oil prices because the link between ethanol and food prices becomes more important during these times (Abbott et al., 2009; de Gorter et al., 2013; Avalos, 2014). Further, the results support the view that fuel policies in the US affect both food and fuel volatilities.

4) Finally, we show that the financial crisis has stronger effects on the relationships between oil and food grain commodities. These results can be compared to those of Han et al. (2015); however, we identify different breaks and

distinguish between oil and ethanol commodities. Our results clearly show that all four breaks considered affected both mean and variance spillovers, with the 2008 financial crisis particularly affecting variance spillovers from oil to food prices.

3.6 Conclusions

This paper investigated mean and volatility spillovers between selected energy (ethanol and oil) and food (cacao, coffee, corn, soybeans, soybean oil, steer, sugar and wheat) prices by estimating a VAR-GARCH model with a BEKK representation. Moreover, it considered the effects of four recent events that might have shifted the model parameters by including dummy variables in both the conditional mean and variance equations. The analysis of these breaks revealed that food to fuel causality is affected by the oil bubble, captured by Brent prices, and the RFS policy passed in 2006. The results indicate that the policies of powerful countries, such as the US, can trigger spillovers from food to fuel prices. This research provides a foundation for future research aimed at stabilizing key food and fuel prices: specific linkages between different markets need to be taken into account in order to devise appropriate policy measures. The second pattern in our findings indicates that the financial crisis affected fuel and food causality in both directions because the global financial crisis had important effects on everything, including food and fuel. The present study should be particularly valuable to those seeking to diversify portfolios containing food and fuel. The extensive dataset analysed, the focus on both first- and second-moment linkages and the incorporation of structural breaks into a multivariate GARCH specification all represent original contributions to the existing literature. To sum up, our findings confirm that food and energy prices are tightly interconnected and provide evidence that recent turbulence in the world economy has affected these linkages.

Chapter 4

How are GCC Stock Markets Affected by Investor Sentiment?

4.0.1 Introduction

This paper provides new insight into how investor sentiment affects stock prices in the GCC region. Behavioural theorists argue that investors can be irrational and can exhibit herd-like behaviour depending on prevailing investor sentiment. The histories of stock markets are marked by numerous notable examples, such as the October 1987 market crash in the US, which have resulted from erroneous speculative beliefs. Changes in share prices are believed to be highly associated with investor sentiment following news of these crises. De Long et al. (1990) provide an interesting attempt to address such events, contending that market investors are overwhelmed by sentiment. In fact, several notable economists have already considered the importance of people's beliefs and expectations in shaping their economic choices (Camerer et al., 2011). The complete rejection of the role of psychology in the formation of market prices dates to the 1960s with the foundation of classical financial theory, which assumed that investors are extremely rational. However, the weakness of neoclassical models in predicting and, especially, explaining economic reality was the precursor to and foundation for work on investor sentiment and psychology. The main objective of the paper is to test how the GCC stock markets respond to news using linear and dynamic markov model.

According to Brown and Cliff (2004), investor sentiment is defined as the optimism or pessimism of investors with respect to a norm, such as the performance of securities; for example, an optimistic investor anticipates that the expected returns of a stock are above average, whereas the opposite holds for a pessimistic investor. In addition, Black (1986) and Daniel et al. (1998) stress that investor sentiment refers to the tendency of some investors to trade based on noise rather than on information, whereas Baker and Wurgler (2006) contend that it represents investors' tendencies to develop speculative strategies, and that the measurement of implied volatility of options in a US index called the Market Volatility Index (ViX) can be used as a measure of investor sentiment is often practically called the "investor fear gauge". Accordingly, from the perspective of visual media, investor sentiment denotes the negative emotions of investors, such as fear and risk aversion, which exert negative pressure on financial market prices (Tetlock, 2007). For example, after a terrorist attack, stock prices go down. Tetlock argues that negative word categories are easy to interpret because they capture most of the variation in the pessimism factor, it seems likely that they convey the same semantic ideas to readers of the column and, therefore, exhibit the same relationship to stock market activity. In any case, it seems that people are not considered rational and that they thus drive the prices of securities beyond their true value. There has been considerable discussion regarding the predictability of stock market returns.

However, according to Fama (1970), when a market is not subject to transaction costs, all existing information concerning the expected level and volatility of future cash flows of a business is freely available, and investors are rational and homogeneous, the market is considered efficient. This is known as the Efficient Market Hypothesis (EMH). Supporters of the EMH contend that given an efficient stock market, all past and current available information is reflected in current prices, and thus, no investor can earn excess returns by developing trading rules based on different types of information (Fama, 1970).

As a result, only new information can cause changes in prices, and examining potential changes in endogenous or exogenous variables with the aim of forecasting future prices is unnecessary (Van Gysen et al., 2013). Nevertheless, in recent years, many researchers have argued that the EMH is characterized by empirical anomalies and instead contended that both endogenous and exogenous variables can be used to forecast stock market prices (Schwert, 2002; Latif et al., 2011). Such relationships have been addressed using both linear and non-linear econometric models, with the existing literature providing quite mixed results. Extensive research has been conducted in finance on the impact of macroeconomic news on stock market performance. However, little evidence has been collected for GCC stock markets.

This paper is organized as follows. Section 4.2 presents a three-part literature review in chronological order if the investor sentiment literature, the macroeconomic surprises literature and the Markov switching model literature. Section 4.3 outlines the econometric modelling approach. Section 4.4 describes the data and presents the empirical findings. We use data on stock prices in GCC countries categorized as potentially positive business news, potentially positive political news, negative business news and negative political news. Obtaining data classified by Bloomberg as potentially positive or potentially negative improves the objectivity of the results. We also include the days on which a macroeconomic forecast is available as a control variable. We then model the relationship between news prices and stock prices in this region. Section 4.5 summarizes the main findings and offers some concluding remarks

4.1 Literature Review

Over the past twenty years, a branch of finance called behavioural finance has emerged within which several empirical studies have been conducted on the role of investor sentiment in the formation of stock prices. This section reviews three bodies of literature on (1) investor sentiment (2) dynamic Markov switching models. It is presented in chronological order and highlights the data and models used within each area.

4.1.1 Investor Sentiment

Barberis et al. (1998) model how investors develop sentiments or form beliefs as a result of the information they obtain in the market. Investors continuously receive information from different corporate entities. They treat information as news, which determines their reactions to changes in the particular stocks in which they have invested. These researchers propose a model of investor sentiment or of the process of forming beliefs. By creating a parsimonious model of investor sentiment based on empirical evidence, Barberis et al. (1998) address how investors form different beliefs. This model is supported by evidence from experimental research. The experimental observations are based on investor experiences of failures of judgement in the presence of uncertainty, and they examine the training patterns adopted by investors in the experimental context. This model is also related to another frequently observed psychological phenomenon known as conservatism, which can be defined as the slow adoption of new models in the face of new evidence. Among the investors who participated in the study, underreaction was due to conservatism.

In the Barberis et al. (1998) study, a professional investor was placed in an experimental situation. The investor's behaviour was assessed as either an under- or overreaction to stock market news. Statistical evidence was then collected to examine investor behaviour in this particular experimental condition. In addition to assessing under- and overreactions, psychological data were collected to examine the investor's subsequent behaviour.

Previous research indicates that people pay the most attention to evidence when making predictions of the future, although they pay very little attention to empirical evidence overall. An investor can consider announcements on issues such as earnings and dividends as information or news, which can then determine investor behaviour in a particular situation. The model indicates that the pattern of news was very important to the development of an investor's beliefs. The investor developed strong beliefs if he continuously heard good news in the form of positive corporate information. Thus, an increase in stock prices would predict an overreaction of this investor's behaviour. However, the authors conclude that future work must identify an objective way of estimating the strength of news announcements.

Otoo (1999) uses the Michigan Survey Research Center (MSRC) and the Conference Board (CB) Measure of Sentiment questionnaires to measure sentiment. These questionnaire responses were subsequently converted to numerical values. This study highlights that investor sentiment is reinforced by a previous positive trend in the market.

The American Association of Individual Investors (AAII) notes that weekly changes in the expectations of its members reveal important information about the level of influence exercised by their expectations on overall market returns. Based on this survey, Fisher and Statman (2000) estimate the relevant regressions and find that the level of investor sentiment is negatively related to market returns. In addition, they confirm that optimism among investors arises from previous positive trends in the market. A similarly positive, albeit lower intensity, relationship has been reported between investment expectations and small-cap stock returns. This conclusion is consistent with the findings of Otoo (1999).

Fisher and Statman (2003) use two indicators of investor sentiment, namely, the MSRC and CB indices of Consumer Confidence, to examine the relationship between investment and performance expectations during the 1989–2002 period. These authors confirm the existence of a positive and statistically significant correlation between changes in consumer confidence and the performance of a number of market indices, implying that high returns are accompanied with positive public sentiments. They also examine the future performance of the market and report that high (low) levels of consumer confidence result in downward (upward) trends in the market within six to twelve months.

Baker and Wurgler (2006) perform a linear regression analysis. Specifically, they collect monthly returns data for common shares listed in the Center for Research in Security Prices (CRSP) database over the 1963–2001 period and create an aggregate sentiment index consisting of six sub-indices.Their results indicate that low-sentiment stocks are attractive to arbitrageurs and unattractive to optimists and speculators. Interestingly, cross-sectional patterns attenuate or completely reverse their findings during high-sentiment times. These patterns reveal that the impact of investment expectations on market returns varies by the type and profitability of shares; for instance, investment expectations appear to have stronger effect on the prices of securities for which it is difficult to appreciate their true value and apply an arbitrage strategy.

Lemmon and Portniaguina (2006) explore the time-series relationship between investor sentiment and size premium over the last two decades and consider whether it measures future macroeconomic conditions. They control for investor sentiment using two surveys of consumer confidence that have been conducted for the US: one is collected by the CB, the Consumer Confidence Index (CCI), and the other is independently constructed by the MSRC, the Index of Consumer Sentiment (ICS). Overall, the results are mixed; however, there is some evidence that investor sentiment is a good predictor of returns to small stocks and stocks with small shares of institutional ownership.

Schmeling (2009) reports similar results. Specifically, the author examines monthly data from the MSRC ICS for 18 countries and the overall market returns of both a portfolio of value stocks and a portfolio of growth stocks over the 01/1985–12/2005 period. The regression analysis reveals that the degree of consumer confidence depends on the market's past performance, but the returns are influenced by previous changes in consumer beliefs. Moreover, the author concludes that high investor expectations predict negative future market trends, and vice versa, while the effect of investor sentiment on returns is strongest among countries with weaker regulatory standards and investors who exhibit herd behavior.

Ho and Hung (2009) use a Capital Asset Pricing Model (CAPM) to examine whether incorporating investor sentiment as conditioning information helps model how risk-adjusted stock returns are affected by liquidity, value, momentum and size. To measure sentiment, they use US data (the CB CCI, the Investors Intelligence Survey Index (II), and the MSRC ICS). The size effect becomes less important in the conditional CAPM and is no longer significant in all other models examined. The model was a good fit for measuring value, liquidity and momentum but was not usually a good fit for measuring size. Birz and Lott (2011) study the relationships between news and macroeconomic factors and stock prices. The macroeconomic factors included in the study were measured from newspaper headlines, which were interpreted to provide statistical information. Birz and Lott adopt the headline classification developed by Lott and Hassett (2006), which allows news to be classified to develop a News Confidence Index; this process helps identify the net effect of economic news. The methodology used to calculate the News Confidence Index is similar to that used for the CB's consumer confidence survey responses (i.e., positive and negative responses). Negative responses were sorted by subtracting negative values from positive values, and the overall response was generated.

In addition to analysing newspaper articles, Lott and Hassett (2006) include four major macroeconomic factors in covered with the list of factors covered in the news: unemployment, GDP, durable goods and retail sales. Newspaper articles were selected from the day of and the day after the release of statistical information. A total of 389 newspapers were selected from LexisNexis. The articles included in their study were published after January 199 and were drawn from the top ten newspapers: the Houston Chronicle, the Chicago Tribune, Newsday, the New York Post, the New York Daily News, the Washington Post, the Los Angeles Times, USA Today, the New York Times and the Wall Street Journal. Their results indicate that macroeconomic surprises had no significant impact on stock prices or S&P 500 returns. Although they report that these factors had no impact on stock performance on the day of the news event, significant results were observed on the day after the news event. These results may reflect causation problems that arise because most analysts publish their recommendations based upon their knowledge of the previous day's impact (Birz and Lott, 2011).

Yu and Yuan (2011) examine how investor sentiment affects the market's mean-variance tradeoff. The results indicate that unlike during high-sentiment periods, the expected excess returns are positively related to the market's conditional variance during low-sentiment periods. They use data on US stocks the sentiment index developed by Baker and Wurgler (2006). Their findings indicate that during high-sentiment periods, sentiment traders make a positive mean-variance tradeoff negative.

Stambaugh et al. (2012) explore the role of investor sentiment in a wide-ranging set of anomalous cross-sectional stock returns. They use a monthly sentiment series created by Baker and Wurgler (2006) and consider a framework in which market-wide sentiment is combined with the argument that premium pricing should be more extensive than moderate pricing due to undervalue restriction. The results indicate that the long-short strategy and short legs of the scenario are more profitable in months following high levels of sentiment, while the long leg of the strategy exhibit similar returns following periods of increasing and decreasing sentiment. A few researchers have observed that some emerging economies make very important contributions to the global economy. These countries appear to determine the prosperity of the global economy and to be immune to global financial crises, which indicates that they are not fully integrated with the world's developed economies. Due to the large spillover effected observed in highly integrated developed economies, most investors have turned to investing in these emerging economies. For example, the so-called CIVETS countries (Colombia, Indonesia, Vietnam, Egypt, Turkey and South Africa) are included in this group of emerging countries and have recently opened their markets to developed economies. Fedorova et al. (2014) investigate whether and, if so, to what extent the economies of these countries are integrated with the Euro Area (EA) using announcements made in EA markets.

The EA is the main source of foreign direct investment (FDI) in the CIVETS countries. The model in Fedorova et al. (2014) is based on the hypothesis that returns on stocks in the CIVETS stock exchanges are influenced by different types of financial news released in EA countries. However, the CIVETS markets are heterogeneous with respect to size, political conditions, industrial regulations, economic ties and international trade. Therefore, the impact of news on market and volatility returns is assumed to differ across CIVETS countries.

Secondary data were collected from the stock exchanges of all of the CIVETS and EA countries. Daily returns were computed as logarithmic differences using data from daily closing sessions. Data on eight different macroeconomic factors were included from different news sources in the EA. These macroeconomic factors include consumer confidence (CC); the purchasing manager index (PMI); liquidity, as measured by M3 (M3); unemployment (UE); retail sales (RS); GDP; industrial production (IP); and the consumer price index (CPI). Four different types of tests were used to analyse the secondary data, including ARCH-LM, Ljung Box, Augmented Dickey-Fuller (ADF) and Jarque-Bera tests.

Fedorova et al. (2014) use an ARCH-LM and report that the ARCH effect was present for all of the proposed hypotheses. The Ljung-Box test showed that the null hypothesis was rejected in all CIVETS markets, except for Turkey. There was no unit root exhibited in the ADF. The null hypothesis was rejected for all CIVETS countries when the Jarque-Bera test was applied. The overall result of this study indicate that EA news affected stock returns and, to a certain extent, volatility, but no major effects were observed. The Indonesian market was found to be the most segmented because it exhibited very little impact from information spillover.

Chevapatrakul and Tee (2014) study the impact of contagion from news events on stock markets during the 2007–2009 crisis. The global recession resulted from a crisis in subprime lending. However, according to experts, it was also the result of crashes in many major global stock markets. These researchers track the timeline of a number of events during the financial crisis and observe that news related to the ad hoc bailouts of most individual banks in the UK had contagion effects on the performance of stock markets in most countries during that period.

To study contagion, Chevapatrakul and Tee (2014) adopt a two-stage approach. In the first stage, conditional volatility was studied by fitting the return series for the US and the UK, and a BEKK-GARCH model was used in the second stage. BEKK-GARCH models are natural extensions of univariate and multivariate GARCH models and allow conditional variance-covariance to be a function of the lagged values of both volatility and covariance. It considers spillover effects originating from the stock markets in which the crisis situation arose (i.e., the stock markets of the US and the UK) and the stock markets of other countries when conditional volatility is estimated. The conditions imposed on the BEKK-GARCH model make it mathematically tractable.

Weekly continuously compounded index returns in the stock markets of many countries were included in their study, including the Philippines, Thailand, Taiwan, Singapore, Mexico, Malaysia, South Korea, Japan, Indonesia, Hong Kong, Germany, France, Chile, Brazil, Argentina, the US and the UK. Stock market performance was proxied by returns from the MSCI. The sample was collected between March 9, 2005 and December 28, 2012. The period was carefully determined to include most of the news addressing the economic and financial crisis of 2007–2009, before and after the crisis. To examine how investors react to risk, the impact of the VIX index (CBOE Volatility Index) on the coexistence. An increase (decline) in the VIX is assumed to signal an increase in investor aversion to (tolerance of) global risk.

The results of that study suggest a difference between the US and the UK in terms of the contagion effects originating from the financial crisis. News related to ad hoc bailouts of individual banks in the UK market had a contagion effect on at least one of the lower quantiles (i.e., 2nd, 4th, 6th, 8th, and 10th quantiles) of the distribution throughout the crisis period for most countries, except for the US and Mexico. The US market experienced very minimal contagion from these events. No contagion effect was observed for other markets, including Thailand, Singapore, Korea, Chile, Brazil, Argentina, Japan and the UK. These results reveal that news led most of the markets at that time, which is an interesting finding.

4.1.2 Markov Switching Models

In recent years, an increasing number of empirical studies have made use of Markov switching models to analyse and predict financial data (Guidolin, 2012) Markov switching models (henceforth, MSMs), otherwise known as regime-switching models, were introduced by Goldfeld and Quandt (1973) and extended by Hamilton (1989). These are among the most widely utilized non-linear and dynamic models that influence the development of financial time series under different regimes (Kuan, 2002; Davig, 2004; Cerra and Saxena, 2005). The initial MSM was based on the mean performance of the estimated variables, while, by definition, a chain is considered to be Markov when the future states depend solely on the current state of affairs and are independent of past states (Hamilton, 1994). Hence, an analysis of the current state can capture all the information that may affect the future development of the series.

The broad use of regime-switching models in finance relies on the fact that they are more efficient in capturing any potential and sudden fluctuations that may arise in the financial market (Ang and Timmermann, 2011). It is also claimed that even the simplest MSMs can effectively derive the distribution of returns, including its skewness, kurtosis, serial correlation and volatility clustering (Haas et al., 2004). Hence, the extensive application of MSMs to a range of variables is evident. For example, such models are used by Lindgren (1978) and Rabiner (1989) to explain non-autoregressive and autoregressive processes, respectively, while Hamilton (1989) applies them to aggregate output. Moreover, Gray (1996) and Diebold et al. (1994) apply them to analyse interest rates and exchange rates, respectively, while Ceccheti et al. (1990) and Ang and Bekaert (2002) employ them to explain stock market returns.

The clear effectiveness of MSMs has led many researchers to combine the MSM of a conditional mean with models of conditional variance, such as GARCH and stochastic volatility models (Kuan, 2002). For instance, Li and Lin (2004) use Markov switching GARCH (SWARCH) models to estimate the VaR of the returns of a number of stock market indices, and they conclude that, in cases of kurtosis and heavy tails in the distributions of returns, there is considerable improvement in the assessment of the VaR compared to ARCH and GARCH models. Similar positive evidence regarding the success of regime-switching models is provided by other studies, including those by Jacquier et al. (1994), Hamilton and Lin (1996) and Lin et al. (2002).

MSMs are also widely used to estimate the role of investor sentiment. Using a Markov switching vector autoregressive (MSVAR) model, Chung and Yeh (2008) attempt to examine the impact of sentiment on the predictability of stock market prices. Their findings reveal that sentiment is significantly associated with the future predictability of the market, with the coefficients' values being greater after controlling for regimes. A similar model is used by Li (2015) to examine the impact of sentiment regarding monetary policy on stock prices. The results indicate that sentiment shocks result in greater stock market fluctuations and longer-duration stock market recessions, thereby indicating their asymmetric effects.

Chen (2011) also examines the asymmetric effects of investor sentiment by applies a regime-switching model to investigate the association between negative sentiment and market fluctuations. The model analysis reveals that when the market exhibits poor performance, investors become more pessimistic, and the likelihood of moving from a bull market to a bear market is greater. Finally, Wang et al. (2009) apply SWARCH models, among others, to examine the features of investors' structural variations and to assess their relationship with futures markets. The authors confirm that regime-switching models are more successful in predicting future performance, emphasizing that SWARCH models can efficiently capture volatility arising from investor sentiment.

The use of Markov switching models is also common in investigating macroeconomic surprises. For instance, Aray (2008) uses a simple MSM with two different regimes to investigate the impact of macroeconomic announcements on stock market performance and demonstrates that stock market returns are more responsive to macroeconomic announcements in the low-volatility regime than in the high-volatility regime. In addition, Melvin et al. (2009) examine the impact of macroeconomic surprises on the foreign exchange market by utilizing an MSM with endogenous transition probabilities, the authors reveal that the likelihood that the market enters and remains in the informed trading state is highly affected by surprise announcements from the Bank of England Monetary Policy Committee.

Abubaker (2015) proposes a New Keynesian Markov switching model to measure the effects of macroeconomic surprises. The author demonstrates that risk aversion is an integral component of the influence of macroeconomic shocks, especially in cases for which interest rates are at the zero lower bound, and contends that there is greater flexibility in responding to positive shocks than to negative ones. A similar approach is followed by Baele et al. (2011), who attempt to estimate the relationship between macroeconomic shocks and monetary policies and demonstrate that both output and inflation were characterized by low variability between 1980 and 2007.

4.2 Linear and Dynamic Models

To estimate the sensitivity of stock returns to investor sentiment while controlling for macroeconomic surprises to account for business cycle, it is appropriate to use a linear factor pricing model. Linear factor analysis can be viewed as a special case of consumption-based asset pricing (e.g., Cochrane, 2009; Mohanaty et al., 2011). We also control for oil prices, interest rates, and US SP 500 index values. Accordingly, the following return-generating process is assumed:

$$\text{y}_{tQt} = NBN_{Qt} + NPN_{Qt-1} + O_{t-1+}i_{tQ-1} + \text{y}_{tDt} + M_{tQ} + \epsilon_T \quad (4.1)$$

$\epsilon_T \sim (\theta, \sigma_i^2)$

y_{tQt}: Stock of $(_{Qt} = Country)$,

defined as the weekly return on the stock market index of country i at time t, derived as the log difference in the price level of the market portfolio for country i over week t weekly $(LnP_t - LnP_{t-1})$ for each of the seven stock markets.

NBN_{Qt}: investor sentiment from business news is defined as (negative business news news per country)/(all business news per country).

NPN_{Qt}: investor sentiment from political news is defined as (negative political news per country)/(all political news per country)

O_t: Oil price is defined as (Ln (Oil Price) - Ln (Oil Price$_{-1}$) for US Brent oil prices

M_{tQ}: GDP macroeconomic surprises are defined as (actual GDP - Forecasted GDP) (average), per country x

i_{tQ}: Interest Rate = 3-month deposit rate in country $_{Qt}$

y_{tDt}: US stock market

We propose using oil prices because they have been a great reliance of oil prices in the GDP of GCC countries (as can be seen in gifure 1.3 and table 1.2).

We use macroeconomic surprises because Green (2004) examines the impact of macroeconomic news releases on the informational role of trading bonds in the US. The results suggest that the release of public information in the form of announcements is followed by an increase in the role of trading and that the release of such public information increases the level of knowledge irregularity in the government bond market.

In addition, after examining the impact of inflation surprises on high-frequency trading in the foreign exchange market, Clarida and Waldman (2007) argue that positive inflation surprises increase currency values due to expectations that central banks will raise interest rates. This effect is much more pronounced for countries that follow more aggressive inflation-targeting strategies. Also Caporale et al. (2014) use macroeconomic surprises as a control variable for stock market fluctiations. We propose an alternative means of detecting causality dynamics between news and stock returns. The regime-switching model considered in this paperPositive and negative news are taken from bloomberg experts. Attached in the abstract are a picture of negative and positive news example. The expected GDP is the contribuiter composite in bloomberg. [1] allows for shifts in the mean, as well as for periods of high stock returns and low stock returns:

$$y_t = \mu(s_t) + \sum_{i=1}^{4} \gamma_i y_{t-i} + \beta(s_t) x_{t-1} + \varepsilon_t, \tag{4.2}$$

[1]The model is based on the Markov switching representation proposed by Hamilton (1989, 1990).

$\mu(s_t) = \sum_{i=1}^{2} \mu^{(i)} \mathbf{1}\{s_t = i\}$, $(t \in T)$, where $y_t =$ change in stock markets, and $x_t =$ news. As s_t is unobserved, the estimation of (1) requires restrictions on the probability process governing s_t; it is assumed that s_t follows a first-order, homogeneous, two-state Markov chain. This means that any persistence in the state is completely summarized by the value of the state in the previous period. Therefore, the regime indicators $\{s_t\}$ are assumed to form a Markov chain on S with transition probability matrix $\mathbf{P}' = [p_{ij}]_{2\times 2}$, where

$$p_{ij} = \Pr(s_t = j | s_{t-1} = i), \qquad i, j \in S, \tag{4.3}$$

and $p_{i1} = 1 - p_{i2}$ $(i \in S)$, where each column sums to unity, and all elements are non-negative. The probability law that governs these regime changes is flexible enough to allow for a wide variety of shifts, depending on the values of the transition probabilities. For example, values of p_{ii} $(i \in S)$ that are not very close to unity imply that structural parameters are subject to frequent changes, whereas values close to unity suggest that only a few regime transitions are likely to occur in a relatively short realization of the process, and $\{\varepsilon_t\}$ are i.i.d. errors with $\mathrm{E}(\varepsilon_t) = 0$ and $\mathrm{E}(\varepsilon_t^2) = 1$. Here, $\{s_t\}$ are random variables in $S = \{1, 2\}$ that indicate the unobserved state of the system at time t. It is assumed that $\{\varepsilon_t\}$ and $\{s_t\}$ are independent. Moreover, note that the independence between the sequences $\{\varepsilon_t\}$ and $\{s_t\}$ implies that regime changes take place independent of the history of $\{y_t\}$.

We are interested in documenting estimates of the low-high state stock returns, μ^l and μ^h, but mainly in investigating the extent to which news instruments are associated with the low-high state stock returns. Autoregressive terms (up to four lags) are also considered. Therefore, the parameter vector of the mean equation (1) is defined by $\mu^{(i)}$ $(i = 1, 2)$, which are real constants. The autoregressive terms ${}_{i=1}^{4}\gamma_i$, and $\beta = \left(\beta^l, \beta^h\right)$ measure the impact of news. The parameter vector is estimated by maximum likelihood. The density of the data has two components, one for each regime, and the log-likelihood function is constructed as a probability-weighted sum of these two components. The maximum likelihood estimation is performed using the EM algorithm described by

Hamilton (1989, 1990).

4.3 Hypotheses

We consider the following four sets of null hypotheses for each of the six countries under investigation. The aim of the hypothesis is to see which model best fits the data, the linear or the dynamic model. If the markov switching model fits best, then which regime (the higher or lower state) best reacts to investor sentiment and macroeconomic surprises.

We test the predictability of stock in country $_{Qt}$ with investor sentiment of countries $_{Qt}$, where stock $_{Qt}$ refers to all the six GCC stock markets, including how domestic investor sentiment affect domestic markets.

The first Hypothesis: Country $_{Qt}$ stock market is efficiently modeled using investor sentiment $\Rightarrow$ (1) using a linear model (2) using a dynamic model in a high regime μ^l (3) using a dynamic model low regime μ^h

The second Hypothesis: How each of the seven stock markets are affected by it's own investor sentiment and by neighbouring countries investor sentiment?

4.4 Empirical Analysis

4.4.1 Data

e define weekly returns as the logarithmic differences in stock prices, interest rates, and oil prices. Bloomberg classifies newspaper articles as potentially positive or potentially negative. We collect data on the GCC from September 2010 to December 2015. We then calculate separate ratios of positive to negative news for business news and political news seperatly. An example of positive business news and negative political news is copied from the Bloomberg database and is available on pages 144-145 in the appendix. Relying on Bloomberg experts to classify newspaper articles as potentially positive or potentially negative helps minimize bias in our study. We define investor sentiment as the ratio of negative to positive business and political news. News sentiment is measured weekly. The weekly sentiment, however, is a day previous of the stock market returns (in this case, Tuesday to Tuesday), because sometimes newspaper articles are delivered at the end of the day when the stock market has already been opened. We also use a week defined from Wednesday to Wednesday to adjust for different weekends in the GCC and in the US. Previous research has found that stock returns are sensitive to both negative and positive newspaper sentiment; however negative news sentiment has a more profound effect on returns (Veronesi, 1999; Tetlock, 2007; Wang et al., 2009). In this research, we use the percentage of negative to positive business news as a proxy for business investor sentiment; however, we also measure political sentiment as a ratio of negative to positive political news as another indicator for investor political sentiment. As for macroeconomic announcements, we use the news component of each release—i.e., the difference between the market's expectation (from Bloomberg's contribuiter composite) and the actual figure (from Bloomberg). We take the macroeconomic value minus the expected value from Bloomberg and divide it by the standard deviation of the macroeconomic surprise. $\mathrm{S}_{tQ} = (Actual_{tQ} - Forecast_{tQ})/\sigma_{Qt}$, where σ refers to the standard deviation of the $_t$th macroeconomic surprise in the same country $_Q$. Macroeconomic news is shown to be a good predictor of the state of the economy (Kim et al., 2004; Simpson et al., 2005; Caporale et al., 2014). Furthermore, we use interest rates, oil prices, US stock market values as control variables for the state of the economy.

The descriptive statistics presented in Table 4.1 show that the Dubai stock market has the greatest average return and the Omani stock market has the smallest average return. There is more business news than political news, and on average, the number of positive news releases is larger than that of negative releases.

Table 4.1: Descriptive Statistics

	AD st.	Dubai st.	KSA st.	Qatar st.	GCC st.	US st.	Oil	
Mean	0.003	0.004	0.001	0.002	0.001	0.003	0.000	
Med.	0.000	0.002	0.002	0.002	0.002	0.004	0.001	
Max.	0.022	0.041	0.023	0.021	0.017	0.026	0.033	
Min.	-0.026	-0.050	-0.031	-0.033	-0.018	-0.016	-0.035	
Std. Dev.	0.010	0.018	0.010	0.010	0.008	0.008	0.014	
Skew.	0.085	-0.140	-0.621	-1.000	-0.293	-0.265	-0.071	
Kurt.	2.958	3.233	4.023	5.677	2.993	4.020	2.839	
J-B	0.066	0.281	5.505	23.730	0.730	2.810	0.098	
Prb.	0.968	0.869	0.064	0.000	0.694	0.245	0.952	
	KSA bus.	KSA pol.	Qatar bus.	Qatar pol.	UAE pol.	UAE pol.	GCC bus.	GCC pol.
Mean	0.380	0.061	0.393	0.040	0.362	0.133	0.335	0.071
Med.	0.387	0.057	0.412	0.025	0.362	0.126	0.340	0.066
Max.	0.787	0.209	0.770	0.166	0.449	0.301	0.495	0.134
Min.	0.120	0.000	0.037	0.000	0.302	0.033	0.202	0.016
Std. Dev.	0.122	0.040	0.161	0.039	0.032	0.054	0.060	0.028
Skew.	0.422	1.079	0.032	1.324	0.378	0.508	0.245	0.317
Kurt.	4.615	5.016	2.433	4.134	3.054	3.487	3.087	2.607
J-B	7.057	18.531	0.692	17.645	1.221	2.694	0.527	1.183
Prb.	0.029	0.000	0.707	0.000	0.543	0.260	0.769	0.554
	KSA int.	Qatar int.	UAE int.	GCC int.	Sur. KSA	Sur. Qatar	Sur. UAE	Sur. GCC
Mean	0.000	-0.001	0.000	0.000	-0.014	0.204	0.192	0.471
Med.	0.001	0.000	0.000	-0.001	0.000	0.000	0.000	0.035
Max.	0.061	0.046	0.038	0.025	0.726	1.865	1.275	4.294
Min.	-0.065	-0.062	-0.040	-0.031	-0.605	-0.342	-0.073	-0.011
Std. Dev.	0.020	0.022	0.017	0.010	0.252	0.382	0.322	0.791
Skew.	-0.151	-0.244	-0.012	-0.219	1.113	2.277	1.547	2.602
Kurt.	6.538	3.344	3.425	3.931	5.739	9.031	4.412	11.852
J-B	26.798	0.758	0.385	2.250	26.479	121.367	24.586	224.035
Prb.	0.000	0.685	0.825	0.325	0.000	0.000	0.000	0.000

Note: In the Top table: AD refers to Abu Dhabi; st., to stock returns; KSA, to the Kingdom of Saudi Arabia; and GCC, to the average of all stock markets returns. In the middle table, bus. refers to average business news per week; pol., to average political news per week. In the bottom table, int. refers to interest rate returns; Sur., to macroeconomic news surprises, Std. Dev., to the standard deviation; Skew. to skewnewss; Kurt. to kurtosis; J-B to the Jarque-Berra test; and Prb.to the propability of the Jarque-Berra to statistics. Numbers are rounded to three decimal places.

Table 4.2: Descriptive Statistics

	Bah st.	Kuwait st.	Oman st.	Bah int.	Kuwait int.	Oman int.	Sur. Bah	
Mean	0.000	0.000	0.000	0.000	0.000	-0.003	0.257	
Med.	0.000	0.000	0.002	0.000	0.000	0.000	-0.000	
Max.	0.035	0.053	0.073	0.888	0.088	0.799	0.799	
Min.	-0.047	-0.053	-0.113	-0.977	0.119	-1.245	0.000	
Std. Dev.	0.009	0.014	0.017	0.263	0.020	0.161	1.047	
Skew.	-0.335	-0.309	-1.815	0.038	-0.483	-1.688	4.944	
Kurt.	6.603	5.372	15.663	4.201	15.382	23.038	30.056	
J-B	128.721	57.568	1662.919	13.874	1478.223	3664.760	7952.167	
Prb.	0.000	0.000	0.000	0.000	0.000	0.000	-0.000	
	Sur. Kuwait	**Sur. Oman**	**Bah bus.**	**Bah pol.**	**Kuwait pol.**	**Kuwait pol.**	**Oman bus.**	**Oman pol.**
Mean	1.877	0.041	0.393	0.040	0.362	0.133	0.335	0.071
Med.	0.000	0.000	0.400	0.000	0.315	0.000	0.195	0.000
Max.	52.627	1.905	1.000	0.750	1.000	0.423	1.000	0.500
Min.	0.000	-0.655	0.037	0.000	0.000	0.000	0.000	0.000
Std. Dev.	6.223	0.237	0.285	0.142	0.193	0.079	0.252	0.077
Skew.	4.433	3.863	0.311	2.039	0.473	2.178	0.898	3.087
Kurt.	27.244	25.373	2.295	7.391	3.185	8.006	3.071	13.454
J-B	6386.060	5368.909	8.469	344.148	8.887	422.035	30.942	1412.733
Prb.	0.000	0.000	0.014	0.000	0.012	0.000	0.000	0.000

Note: In the top table, Bah refers to Bahrain; st., to stock returns. The bottom table (bus.) refers to average business news per week and (pol.) refers to average political news per week. Sur., refers to macroeconomic news surprises; Std. Dev, to the standard deviation; Skew., to skewnewss; Kurt., to kurtosis; J-B, to the Jarque-Berra test; and Prb., to the propability of the Jarque-Berra statistics. Numbers are rounded to three decimal places.

Table 4.3: Summary the Results of Both Models for the Qatar, Oman, Saudi and Abu Dhabi Stock Exchanges

	Linear Results	Higher Regime	Lower Regime
		Qatar	
Qatar	Bus. news-*** Pol. news-***	Bus. news - ***	Pol. news +*
Oman	Pol. news-***	no effect	Pol. news -**
Kuwait		Bus. news - ***	no effect
Bahrain		Pol. news -**	Pol. news (greater) -***
UAE	Bus. news -	no effect	Pol. news +**
KSA		one regime, Pol. news +***, Bus. news -*	
		Oman	
Oman		none	Bus. news -*
Qatar		Bus. news -***	Pol. news +**
Kuwait			Pol. news -***
UAE	Bus. news -***	Pol. news -**	Bus. news -***
Saudi			Bus. news +***
Bahrain		one regime, negative business news -***	
		Saudi	
Qatar	Bus. -** and Pol. news -*	Bus. news - **	Bus. news -*** (greater)
Oman	Pol. news -**	none	Bus. news +**
Kuwait	Pol. news -*	Bus. news -**	Pol. news +***
Bahrain		one regime, Pol. news -***	
Saudi		one regime, Pol. news +***	
UAE	Bus. news -***	one regime, Pol. news -*	
		Abu Dhabi	
Kuwait		Pol. news -***	Bus. news - *** . Pol. news +***
Oman	Bus. news-*		
Qatar			
UAE	Bus. news -***	none	Bus. news
Saudi		none	none
Bahrain	Pol. news -*	none	Pol. news -***

Note: This is the summary table for both results (Linear and Dynamic) for Oman, Saudi and Abu Dhabi. The Markov switching model provides a better fit to the data for the Qatar, Oman, Saudi and Abu Dhabi stock exchanges, except for news from the KSA to the Qatar exchange, Bahrain to the Oman exchange, Bahrain and the KSA to the Saudi exchange, and Oman to the Abu Dhabi exchange, where a linear model provides a better fit for this data. Here, '-' indicates a negative effect, '+' indicates a positive effect. * refers to significance at the 10% level, ** to significance at the 1% level and *** to significance at the 0.1% level.

4.5 Discussion of the Results

The linear model results suggest that the GCC stock markets are affected by domestic business news and business news from the UAE. The Kuwait market is particularly sensitive to all news from the GCC region. The Qatar and Saudi markets are sensitive to new from Oman, and the Qatar, Abu Dhabi, and Kuwait markets are sensitive to their domestic business news. The markov switching results suggest the following in all the markets: 1. The Qatari stock market in the high regime is sensitive to business news from Qatar and Kuwait and to political news from Bahrain. In the low regime, it is sensitive to political news from Oman, is greatly affected by political news from the UAE, and is more affected by political news from Bahrain. Regarding overall sensitivity, negative news leads to negative returns. KSA news sentiment leads to only one regime, with political news having mixed effects on the Qatari stock market.

2. The Omani stock market is sensitive to business news from Qatar and to political news from UAE in the high regime. In the low regime, the Omani stock market is sensitive to political news from Kuwait and Qatar. It is also sensitive to business news from the UAE, the KSA, and Oman. However, the sensitivity is quite mixed. Bahraini news leads to only one regime, with business news sentiment affecting the Omani stock market.

3. The Saudi market in the high regime is affected by sentiment in Qatari and Kuwaiti business news. In the lower regime, it is more strongly affected by business news from Qatar. In the lower regime, business news from Oman and political news from Kuwait have mixed effects on the Saudi stock market. The Saudi market is affected by political news from Bahrain, the KSA, and the UAE.

4. The Abu Dhabi stock market is affected by sentiment in Kuwait in the high regime. In the lower regime, it is affected by sentiment in business news in Kuwait and the UAE. Mixed results are obtained with respect to political news from Bahrain and Kuwait. The Abu Dhabi stock market has one regime in Qatar, Saudi, and Bahrain. The higher regime is affected by sentiment in business news in Kuwait, Oman, and the UAE. In the lower regime, it is affected by sentiment in Kuwait and the UAE, it exhibits mixed effects for political news

Table 4.4: Summary of the Results of Both Models for the Dubai, Bahrain and Kuwait Stock Exchanges

	Linear Results	Higher Regime	Lower Regime
		Dubai	
Kuwait		Bus. news -**	Bus. news -***, Pol. news +***
Qatar		one regime	
Oman	Bus. news -***	Bus. news -***	
UAE		Bus. news -**	Bus. news -*** (greater)
Saudi		one regime	
Bahrain		one regime	
		Bahrain	
Oman	Pol. news +***	none	none
Qatar	Bus. news -***	Pol. news -*	none
Kuwait	Bus. news +***	no regime	
Saudi	Bus. news -***, Pol. news +***	one regime	
Bahrain	Bus. news +**	Bus. news -***	none
UAE	Bus. news +*	no regime	
		Kuwait	
Kuwait	Bus. news-***	Bus. news - **	Bus. news -* (greater)
Qatar	Pol. news -***	Pol. news -***	Bus. news -*
Oman	Bus. news -***	none	none
Saudi		one regime	
Bahrain	Pol. news-**	one regime	
UAE	Bus. news -**	Bus. news	none

Note: The Markov switching model provides a better fit to the data for the Dubai and Kuwait stock exchanges, except for news from Qatar, the KSA, and Bahrain to the Dubai exchange and for the KSA and Bahrain to the Kuwait exchange. The linear model provides a better fit to the data for Bahrain, except for domestic news. Here, '-' indicates a negative effect, and '+' indicates a positive effect. * refers to significance at the 10% level, ** to significance at the 1% level and *** to significance at the 0.1% level.

from Kuwait.

6. The linear model provides a better fit for the data for the Bahraini stock market, which is not affected by the Omani, Kuwaiti, or Saudi stock markets. The higher regime is affected only by Qatari and Bahraini news sentiment.

7. The Kuwaiti stock market has one regime that is affected by Omani news and one regime affected by the Saudi and Bahraini stock markets. The higher regime is affected by sentiment in UAE and Kuwaiti business news and by sentiment in Kuwaiti political news. In the lower regime, it is only affected by Qatari and Kuwaiti business news. (In the lower regime, Kuwaiti sentiment has a greater affect.)

As a summary of the results, Markov switching in the mean model results suggest that Oman and Qatar's stock markets are more open to domestic news and to news from neighbouring countries. However, these markets are only susceptible to business news from Qatar and the UAE, while they are affected by both political and business domestic news.Qatar is affected by both GCC business news and its own domestic business news, while Abu Dhabi is affected by news from the GCC and Qatar. The Dubai market is not affected by any news. The Markov switching results show that during lower regimes, stock markets are more prone to investor sentiment. The markov switching models and linear models yield similar results.

These results provide new insight into how investor sentiment affects stock prices in the GCC countries. Investors can exhibit herd-like behavior in some regimes. These results are similar those found by De Long et al. (1990) and Camerer et al. (2011). Our results also support Schwert (2002) and Latif (2011) in that in some cases, both endogenous and exogenous variables can be used to forecast stock returns, which is the oppositie of Fama's (1970) efficient market hypothesis. Compared to Barberies (1998) and Baker and Wurglur (2006), our paper gathers data in a more objective way because we use Bloomberg experts' classifications; however, our results are quiet similar. Our results contradict those of Schemelling because in most cases, positive investor sentiment leads to positive investor returns. Moreover, we added macroeconomic surprises to control for gains and loss in the economy. Our results are quite similar to those of Birz and Litt, although we use data from the GCC rather than analysing newspaper headlines. According to Yu and Yuan (2011), during lower regimes, it is easier to predict stock market performance.

Table 4.5: Linear Results for the Bahrain & Qatar Stock Markets

Bahrain Stock Market												
	Bahrain		Qatar		Oman		Kuwait		KSA		UAE	
Variable	Coe.	Prob.	Coe.	Prob.	Coe.	Prob.	Coe.	Prob.	Coe.	Prob.	Coe.	Prob.
C	-1.952	0.000	-0.674	0.001	-1.805	0.000	-1.611	0.000	-1.799	0.000	-1.985	0.000
int.	1.779	0.000	0.802	0.000	1.669	0.000	1.455	0.000	1.588	0.000	1.753	0.000
Oil	0.455	0.510	0.507	0.426	0.203	0.768	-0.077	0.911	0.522	0.432	0.784	0.259
Surp.	-0.127	0.380	-0.221	0.123	-0.127	0.374	-0.175	0.213	-0.157	0.254	-0.114	0.426
US. Stock	1.509	0.300	1.482	0.290	1.419	0.324	1.844	0.195	1.314	0.348	1.124	0.439
Bus News	0.054	0.033	-0.091	0.000	-0.010	0.830	0.032	0.000	-0.040	0.026	0.020	0.097
Pol News	0.000	0.995	0.051	0.534	0.471	0.000	-0.107	0.149	0.071	0.000	0.140	0.014
R^2	0.271	0.169	0.169	0.154	0.287	0.169	0.308	0.169	0.331	0.169	0.276	0.169
Adj. R^2	0.254	0.374	0.151	0.361	0.270	0.374	0.291	0.374	0.315	0.374	0.259	0.374
S.E. of R/ Akaike	0.323	0.603	0.332	0.659	0.319	0.581	0.315	0.552	0.309	0.518	0.322	0.596
Sum R^2/Schwarz	26.148	0.699	30.364	0.749	25.568	0.677	24.837	0.648	24.007	0.614	25.964	0.692
Log-like/ Hannan-Quinn	-70.780	0.642	-85.902	0.695	-67.886	0.619	-64.144	0.590	-59.763	0.556	-69.869	0.635
F-stat/Durbin Wat.	15.563	0.121	9.319	0.199	16.865	0.141	18.592	0.193	20.680	0.252	15.969	0.141
Prob(F-stat)	0.000		0.000		0.000		0.000		0.000		0.000	

Qatar Stock Market												
	Bahrain		Qatar		Oman		Kuwait		KSA		UAE	
Variable	Coe.	Prob.	Coe.	Prob.	Coe.	Prob.	Coe.	Prob.	Coe.	Prob.	Coe.	Prob.
C	0.000	0.999	0.010	0.010	0.001	0.804	0.001	0.814	0.000	0.970	0.010	0.012
int.	0.003	0.488	-0.001	0.822	0.003	0.480	0.003	0.491	0.004	0.323	0.003	0.436
Oil	0.102	0.009	0.088	0.017	0.120	0.002	0.111	0.006	0.102	0.009	0.074	0.049
Surp.	-0.012	0.089	-0.016	0.018	-0.014	0.037	-0.012	0.081	-0.011	0.105	-0.014	0.029
US. Stock	0.079	0.336	0.099	0.201	0.066	0.411	0.077	0.351	0.080	0.334	0.109	0.166
Bus News	0.000	0.944	-0.005	0.000	-0.001	0.725	0.000	0.218	0.001	0.561	-0.003	0.000
Pol News	-0.004	0.270	-0.012	0.006	-0.022	0.001	-0.003	0.533	-0.001	0.214	-0.003	0.372
R^2	0.073	0.002	0.174	0.002	0.112	0.002	0.074	0.002	0.074	0.002	0.158	0.002
Adj. R^2	0.051	0.019	0.154	0.019	0.091	0.019	0.052	0.019	0.052	0.019	0.138	0.019
S.E. of R/ Akaike	0.018	-5.148	0.017	-5.262	0.018	-5.190	0.018	-5.148	0.018	-5.148	0.017	-5.244
Sum R^2/Schwarz	0.083	-5.051	0.074	-5.166	0.080	-5.094	0.083	-5.052	0.083	-5.052	0.076	-5.147
Log-like/ Hannan-Quinn	671.052	-5.109	685.843	-5.224	676.571	-5.152	671.134	-5.110	671.131	-5.110	683.449	-5.205
F-stat/Durbin Wat.	3.309	1.569	8.794	1.703	5.283	1.649	3.338	1.624	3.337	1.630	7.863	1.585
Prob(F-stat)	0.004		0.000		0.000		0.004		0.004		0.000	

Note: Coe. refers to coefficient; Prob., to probability. The results for the Akaike, Schwarz, and Hannan-Quinn criteria, as well as the Durbin Watson statistic, are placed in placed next to the standard error of the R, sum of the R^2, log-likelihood, and F-stat, respectively, to save space in the table. Bus News refers to business news, and Pol News refers to political news.

Table 4.6: Linear Results for the Kuwait & Oman Stock Markets

Kuwait Stock Market

	Bahrain		Qatar		Oman		Kuwait		KSA		UAE	
Variable	Coe.	Prob.	Coe.	Prob.	Coe.	Prob.	Coe.	Prob.	Coe.	Prob.	Coe.	Prob.
C	0.013	0.004	0.014	0.002	0.014	0.002	0.014	0.002	0.014	0.003	0.014	0.003
int.	-0.015	0.002	-0.015	0.002	-0.015	0.003	-0.015	0.003	-0.015	0.003	-0.011	0.038
Oil	0.011	0.693	0.015	0.599	0.015	0.589	0.024	0.401	0.010	0.726	0.003	0.906
Surp.	0.000	0.674	0.000	0.671	-0.001	0.485	-0.001	0.589	-0.001	0.535	-0.001	0.423
US. Stock	0.185	0.002	0.185	0.002	0.178	0.003	0.174	0.004	0.177	0.004	0.196	0.001
Bus News	0.001	0.384	0.000	0.898	-0.004	0.029	-0.001	0.042	0.001	0.156	-0.001	0.014
Pol News	-0.005	0.044	-0.011	0.001	-0.004	0.474	0.000	0.994	-0.001	0.095	-0.002	0.404
R^2	0.102	-0.001	0.122	-0.001	0.112	-0.001	0.102	-0.001	0.094	-0.001	0.111	-0.001
Adj. R^2	0.080	0.014	0.101	0.014	0.091	0.014	0.081	0.014	0.072	0.014	0.090	0.014
S.E. of R/ Akaike	0.013	-5.765	0.013	-5.788	0.013	-5.777	0.013	-5.765	0.013	-5.756	0.013	-5.775
Sum R^2/Schwarz	0.045	-5.668	0.044	-5.692	0.044	-5.680	0.045	-5.669	0.045	-5.660	0.044	-5.679
Log-like/ Hannan-Quinn	750.635	-5.726	753.656	-5.749	752.177	-5.738	750.731	-5.727	749.549	-5.717	752.033	-5.737
F-stat/Durbin Wat.	4.732	1.324	5.836	1.423	5.292	1.340	4.767	1.358	4.342	1.363	5.240	1.358
Prob(F-stat)	0.000		0.000		0.000		0.000		0.000		0.000	
	Oman											

Oman Stock Market

	Bahrain		Qatar		Oman		Kuwait		KSA		UAE	
Variable	Coe.	Prob.	Coe.	Prob.	Coe.	Prob.	Coe.	Prob.	Coe.	Prob.	Coe.	Prob.
C	0.012	0.023	0.016	0.007	0.012	0.023	0.013	0.020	0.013	0.018	0.019	0.001
int.	-0.023	0.050	-0.027	0.019	-0.022	0.059	-0.025	0.038	-0.026	0.029	-0.020	0.093
Oil	0.004	0.914	-0.001	0.979	0.004	0.926	0.004	0.918	0.002	0.955	-0.019	0.639
Surp.	-0.014	0.589	-0.007	0.783	-0.014	0.591	-0.014	0.617	-0.014	0.581	-0.005	0.840
US. Stock	0.108	0.214	0.113	0.192	0.111	0.204	0.113	0.198	0.109	0.214	0.134	0.116
Bus News	-0.001	0.624	-0.002	0.160	-0.003	0.365	0.000	0.907	0.000	0.759	-0.002	0.001
Pol News	-0.001	0.782	-0.001	0.912	-0.002	0.806	0.000	0.956	0.000	0.841	-0.003	0.383
R^2	0.034	0.001	0.038	0.001	0.034	0.001	0.030	0.001	0.030	0.001	0.085	0.001
Adj. R^2	0.011	0.019	0.015	0.019	0.011	0.019	0.007	0.019	0.007	0.019	0.063	0.019
S.E. of R/ Akaike	0.019	-5.040	0.019	-5.044	0.019	-5.040	0.019	-5.036	0.019	-5.036	0.019	-5.094
Sum R^2/Schwarz	0.093	-4.944	0.092	-4.947	0.093	-4.944	0.093	-4.939	0.093	-4.939	0.088	-4.997
Log-like/ Hannan-Quinn	657.153	-5.001	657.645	-5.005	657.213	-5.002	656.581	-4.997	656.631	-4.997	664.093	-5.055
F-stat/Durbin Wat.	1.473	1.888	1.639	1.888	1.494	1.893	1.282	1.900	1.299	1.901	3.867	1.872
Prob(F-stat)	0.188		0.137		0.181		0.266		0.258		0.001	

Note: See note for Table 4.4.

Table 4.7: Linear Results for the Saudi & Abu Dhabi Stock Markets

	Saudi Stock Market											
	Bahrain		Qatar		Oman		Kuwait		KSA		UAE	
Variable	Coe.	Prob.	Coe.	Prob.	Coe.	Prob.	Coe.	Prob.	Coe.	Prob.	Coe.	Prob.
C	-0.009	0.388	-0.007	0.479	0.001	0.943	-0.009	0.422	-0.011	0.345	0.008	0.431
int.	0.011	0.366	0.015	0.215	0.002	0.890	0.011	0.356	0.012	0.318	0.008	0.509
Oil	0.082	0.062	0.077	0.076	0.097	0.028	0.075	0.091	0.083	0.061	0.048	0.247
Surp.	-0.007	0.696	-0.005	0.773	-0.005	0.766	-0.002	0.899	-0.008	0.674	0.001	0.933
US. Stock	0.125	0.182	0.123	0.180	0.112	0.222	0.132	0.157	0.118	0.209	0.155	0.077
Bus News	0.001	0.532	-0.003	0.028	-0.002	0.595	0.000	0.486	0.000	0.917	-0.004	0.000
Pol News	-0.002	0.578	-0.009	0.078	-0.017	0.027	-0.008	0.085	0.000	0.934	-0.002	0.474
R^2	0.039	0.001	0.074	0.001	0.064	0.001	0.049	0.001	0.039	0.001	0.157	0.001
Adj. R^2	0.017	0.021	0.052	0.021	0.042	0.021	0.026	0.021	0.016	0.021	0.136	0.021
S.E. of R/ Akaike	0.021	-4.903	0.020	-4.939	0.020	-4.929	0.020	-4.913	0.021	-4.902	0.019	-5.033
Sum R^2/Schwarz	0.106	-4.807	0.102	-4.843	0.103	-4.833	0.105	-4.817	0.106	-4.806	0.093	-4.937
Log-like/ Hannan-Quinn	639.505	-4.864	644.195	-4.901	642.861	-4.890	640.820	-4.875	639.382	-4.863	656.276	-4.994
F-stat/Durbin Wat.	1.719	1.591	3.332	1.612	2.867	1.584	2.166	1.570	1.678	1.584	7.766	1.580
Prob(F-stat)	0.117		0.004		0.010		0.047		0.127		0.000	

	Abu Dhabi Stock Market											
	Bahrain		Qatar		Oman		Kuwait		KSA		UAE	
Variable	Coe.	Prob.	Coe.	Prob.	Coe.	Prob.	Coe.	Prob.	Coe.	Prob.	Coe.	Prob.
C	0.000	0.985	0.003	0.456	0.000	0.971	0.000	0.909	0.000	0.918	0.014	0.003
int.	0.007	0.488	0.004	0.682	0.012	0.267	0.008	0.437	0.010	0.368	-0.002	0.877
Oil	0.103	0.006	0.100	0.008	0.109	0.004	0.112	0.003	0.106	0.005	0.081	0.023
Surp.	0.008	0.296	0.006	0.397	0.007	0.329	0.007	0.330	0.008	0.305	0.002	0.739
US. Stock	0.054	0.494	0.058	0.459	0.044	0.574	0.047	0.548	0.057	0.467	0.080	0.280
Bus News	0.001	0.615	-0.002	0.141	-0.005	0.066	0.000	0.210	0.000	0.865	-0.003	0.000
Pol News	-0.005	0.089	-0.006	0.142	-0.009	0.188	-0.001	0.722	-0.001	0.333	-0.001	0.800
R^2	0.068	0.002	0.072	0.002	0.083	0.002	0.061	0.002	0.065	0.002	0.158	0.002
Adj. R^2	0.045	0.018	0.050	0.018	0.061	0.018	0.039	0.018	0.043	0.018	0.138	0.018
S.E. of R/ Akaike	0.017	-5.248	0.017	-5.252	0.017	-5.265	0.017	-5.241	0.017	-5.245	0.016	-5.350
Sum R^2/Schwarz	0.075	-5.152	0.075	-5.156	0.074	-5.168	0.076	-5.145	0.075	-5.149	0.068	-5.253
Log-like/ Hannan-Quinn	684.017	-5.209	684.566	-5.214	686.129	-5.226	683.153	-5.203	683.654	-5.207	697.131	-5.311
F-stat/Durbin Wat.	3.041	1.616	3.232	1.624	3.782	1.658	2.741	1.656	2.915	1.644	7.843	1.637
Prob(F-stat)	0.007		0.004		0.001		0.013		0.009		0.000	

Note: See note for Table 4.4.

Table 4.8: Linear Results for the Dubai Stock Market

	Dubai Stock Market											
	Bahrain		Qatar		Oman		Kuwait		KSA		UAE	
Variable	Coe.	Prob.	Coe.	Prob.	Coe.	Prob.	Coe.	Prob.	Coe.	Prob.	Coe.	Prob.
C	0.003	0.714	0.008	0.331	0.003	0.676	0.004	0.598	0.004	0.603	0.030	0.000
int.	0.002	0.932	-0.001	0.951	0.012	0.517	0.006	0.749	0.008	0.653	-0.014	0.428
Oil	0.177	0.006	0.175	0.006	0.187	0.003	0.195	0.003	0.184	0.004	0.138	0.021
Surp.	0.012	0.366	0.009	0.469	0.011	0.407	0.010	0.420	0.011	0.388	0.001	0.922
US. Stock	0.078	0.563	0.076	0.570	0.053	0.688	0.059	0.658	0.075	0.576	0.122	0.332
Bus News	0.002	0.402	-0.002	0.254	-0.010	0.027	-0.001	0.212	0.000	0.821	-0.006	0.000
Pol News	-0.007	0.172	-0.009	0.242	-0.011	0.311	-0.003	0.649	-0.002	0.293	0.000	0.978
R^2	0.055	0.003	0.060	0.003	0.082	0.003	0.058	0.003	0.062	0.003	0.173	0.003
Adj. R^2	0.033	0.030	0.038	0.030	0.060	0.030	0.036	0.030	0.040	0.030	0.153	0.030
S.E. of R/ Akaike	0.030	-4.171	0.030	-4.176	0.029	-4.199	0.030	-4.174	0.030	-4.178	0.028	-4/304
Sum R^2/Schwarz	0.221	-4.075	0.220	-4.080	0.215	-4.103	0.220	-4.078	0.219	-4.082	0.193	-4.208
Log-like/ Hannan-Quinn	545.057	-4.132	545.742	-4.138	548.725	-4.138	-548.725	-4.161	545.462	-4.140	562.238	-4.265
F-stat/Durbin Wat.	2.455	1.544	2.690	1.555	3.732	1.565	2.594	1.555	2.783	1.548	8.764	1.573
Prob(F-stat)	0.025		0.015		0.001		0.019		0.012		0.000	

Note: See note for Table 4.4.

4.6 Conclusions

This paper provides an innovative approach to examining empirical evidence of the level of interdependence and transmission between newspaper article sentiment and stock prices among the GCC stock markets. Limited research has been conducted on this issue. This original contribution provides meaningful insights into the different characteristics of the GCC countries. The main finding is that the Markov switching model provides slightly more explanatory power regarding the importance of news and macroeconomic surprises in the GCC stock markets. The results indicate the importance of news sentiment for predicting stock market performance. Qatar appears to be an influential country, as its news must be taken into account when predicting the stock market returns of neighbouring countries. Qatar and Oman are most affected by news from neighbouring countries; these countries are also affected by sentiment from neighbouring countries, especially in the lower regimes. Qatar and the UAE are also very affected by other countries' business news. The scope of this study was limited, however, as it is a general empirical study using index

Table 4.9: Markov Switching Results for the Qatar Stock Market

	Qatar		Oman		Kuwait		Bahrain		UAE		KSA	
Var.	Coe.	Prb.	Coe.	Prb.	Coe.	Prb.	Coe.	Prb.	Coe.	Prb.	Coe.	Prb.
						Regime 1						
C	-0.053	0.000	0.005	0.001	0.007	0.000	-0.036	0.000	0.007	0.003	-0.001	0.806
Bus.(1)	0.027	0.658	-0.004	0.888	-0.092	0.006	-0.013	0.870	-0.060	0.137	-0.015	0.233
Pol.(1)	0.069	0.051	0.000	0.957	0.000	0.864	-0.315	0.002	0.000	0.896	0.009	0.098
						Regime 2						
C	0.010	0.000	-0.040	0.000	-0.041	0.000	0.004	0.018	-0.050	0.000	-0.057	0.000
Bus.(2)	-0.134	0.000	0.021	0.803	-0.313	0.182	0.014	0.468	0.006	0.956	-0.226	0.100
Pol.(2)	-0.024	0.261	-0.544	0.038	0.118	0.234	-0.009	0.046	0.057	0.049	0.044	0.015
						Common						
int.	-0.009	0.212	-0.009	0.301	-0.010	0.179	-0.008	0.273	-0.006	0.433	-0.006	0.432
oil	0.105	0.001	0.092	0.019	0.099	0.002	0.091	0.005	0.080	0.013	0.100	0.002
US sto.	0.037	0.575	-0.076	0.374	0.051	0.476	0.119	0.074	0.116	0.087	0.101	0.136
surp.	-0.016	0.008	-0.012	0.057	-0.012	0.044	-0.013	0.020	-0.014	-0.012	0.035	0.432
LOG(SIGMA)	-4.170	0.000	-4.168	0.000	-4.149	0.000	-4.289	0.000	-4.244	0.000	-4.245	0.000
						Transition Matrix Parameters						
	1	2	1	2	1	2	1	2	1	2	1	2
P11-C	0.605	0.395	0.960	0.040	0.976	0.024	0.473	0.527	0.984	0.016	0.979	0.021
P21-C	0.021	0.979	0.499	0.501	0.454	0.546	0.028	0.972	0.345	0.655	0.360	0.640
D-W		1.824		1.801		1.838		2.086		1.738		1.777
Log-like.		744.253		567.961		736.895		647.857		696.029		699.439
Schwarz		-5.018		-4.867		-4.966		-5.167		-5.177		-5.142
						Constant Expected Durations						
	1	2	1	2	1	2	1	2	1	2	1	2
	2.534	47.383	25.055	2.003	42.382	2.205	1.898	35.822	61.853	2.897	47.130	2.779

Note: Markov in mean results; Coe refers to coefficient; Prb., to probability.

Table 4.10: Markov Switching Results for the Saudi Stock Market

	Qatar		Oman		Kuwait		Bahrain		KSA		UAE	
Var.	Coe.	Prb.	Coe.	Prb.	Coe.	Prb.	Coe.	Prb.	Coe.	Prb.	Coe.	Prb.
						Regime 1						
C	0.007	0.000	-0.092	0.000	0.006	0.000	0.003	0.151	0.000	0.903	0.011	0.000
Bus.(1)	-0.054	0.031	0.345	0.022	-0.089	0.016	0.018	0.417	-0.010	0.479	-0.072	0.116
Pol.(1)	-0.010	0.567	0.570	0.105	-0.012	0.568	-0.005	0.354	0.009	0.011	-0.018	0.083
						Regime 2						
C	-0.029	0.001	0.003	0.043	-0.074	0.000	-0.031	0.000	-0.080	0.000	-0.001	0.892
Bus.(2)	-0.314	0.000	-0.006	0.776	-0.046	0.792	-0.340	0.005	0.071	0.275	-0.508	0.000
Pol.(2)	0.012	0.844	0.020	0.636	0.280	0.006	0.052	0.192	0.070	0.000	0.096	0.005
						Common						
int.	0.135	0.012	-0.109	0.076	-0.066	0.199	0.015	0.836	0.058	0.404	0.045	0.480
oil	-0.012	0.792	0.031	0.447	0.011	0.736	-0.019	0.680	-0.007	0.850	-0.046	0.212
US sto.	0.127	0.126	0.134	0.145	0.173	0.025	0.241	0.006	0.134	0.141	0.191	0.023
surp.	-0.009	0.525	-0.008	0.689	-0.008	0.590	-0.009	0.523	-0.012	0.397	-0.010	0.476
LOG(SIGMA)	-4.158	0.000	-4.072	0.000	-4.096	0.000	-4.144	0.000	-4.194	0.000	-4.233	0.000
						Transition Matrix Parameters						
	1	2	1	2	1	2	1	2	1	2	1	2
P11-C	0.936	0.064	0.952	0.048	0.119	0.881	0.981	0.019	0.917	0.083	0.942	0.058
P21-C	0.676	0.324	0.550	0.450	0.042	0.958	0.297	0.703	0.429	0.571	0.311	0.689
D-W		1.738		1.549		1.604		1.965		1.784		1.760
Log-like.		706.768		540.965		706.042		621.865		671.569		678.531
Schwarz		-4.822		-4.707		-4.816		-4.948		-4.926		-5.039
						Constant Expected Durations						
	1	2	1	2	1	2	1	2	1	2	1	2
	15.720	1.479	20.629	1.819	1.135	23.747	52.776	3.362	12.025	2.333	17.226	3.215

Note: See note for Table 4.8.

Table 4.11: Markov Switching Results for the Abu Dhabi Stock Market

	Kuwait		Qatar		UAE		KSA		Bahrain			
	Coe.	Prb.	Coe.	Prb.	Coe.	Prb.	Coe.	Prb.	Coe.	Prb.	Coe.	Prb.
Regime 1												
C	-0.014	0.021	0.008	0.035	0.009	0.029	0.009	0.040	0.005	0.003		
Bus. (1)	-0.750	0.000	-0.022	0.479	-0.310	0.000	-0.010	0.438	0.004	0.803		
Pol. (1)	0.524	0.000	0.004	0.839	0.013	0.527	-0.005	0.405	-0.007	0.111		
Regime 2												
C	0.006	0.000	-0.002	0.705	0.015	0.026	-0.047	0.000	-0.023	0.026		
Bus. (2)	-0.011	0.726	-0.256	0.000	-0.095	0.170	-0.171	0.388	-0.071	0.444		
Pol. (2)	-0.057	0.003	-0.017	0.597	0.006	0.602	0.040	0.116	-0.388	0.001		
Common												
Surp.	-0.012	0.261	0.003	0.697	0.004	0.580	0.004	0.546	-0.002	0.739		
Int.	-0.001	0.879	0.001	0.832	0.002	0.634	0.001	0.849	-0.003	0.566		
Oil	0.116	0.000	0.071	0.037	0.068	0.055	0.085	0.035	0.067	0.094		
s&p	-0.017	0.784	0.034	0.639	0.055	0.451	0.048	0.510	0.070	0.345		
LOG(S)	-4.263	0.000	-4.207	0.000	-4.295	0.000	-4.233	0.000	-4.259	0.000		
Transition Matrix Parameters												
P11-C	0.007	0.957	2.205	0.000	1.376	0.029	3.518	0.000	3.474	0.000		
P21-C	-2.784	0.000	-0.667	0.516	-1.789	0.004	-0.259	0.682	0.363	0.648		
D-W	1.665		1.831		1.826		1.781		1.990			
Log-like.	758.315		748.144		696.085		696.942		647.285			
Schwarz c.	-5.118		-5.046		-5.177		-5.123		-5.162			
Constant Transition Probabilities												
	1	2	1	2	1	2	1	2	1	2		
	0.502	0.498	0.901	0.099	0.798	0.202	0.971	0.029	0.970	0.030		
	0.058	0.942	0.339	0.661	0.143	0.857	0.436	0.564	0.590	0.410		
Constant Expected Durations												
	1	2	1	2	1	2	1	2	1	2		
	2.007	17.183	10.071	2.948	4.961	6.982	34.715	2.296	33.261	1.696		

Note: See note for Table 4.8.

Table 4.12: Markov Switching Results for the Dubai Stock Market

	Kuwait		Qatar		Oman		UAE		KSA		Bahrain	
Var.	Coe.	Prb.	Coe.	Prb.	Coe.	Prb.	Coe.	Prb.	Coe.	Prb.	Coe.	Prb.
						Regime 1						
C	-0.032	0.006	-0.002	0.613	-0.050	0.000	0.043	0.000	0.007	0.313	0.086	0.003
Bus. (1)	-1.165	0.000	-0.274	0.000	-0.020	0.913	-0.280	0.027	-0.042	0.046	-2.446	0.000
Pol. (1)	0.837	0.000	-0.020	0.647	0.056	0.866	-0.005	0.853	0.007	0.460	-0.065	0.661
						Regime 2						
C	0.011	0.000	0.021	0.002	0.014	0.000	0.015	0.001	-0.088	0.000	0.003	0.232
Bus. (2)	-0.113	0.043	-0.079	0.217	-0.133	0.005	-0.444	0.000	0.107	0.616	0.023	0.510
Pol. (2)	-0.032	0.338	0.015	0.695	0.067	0.310	0.024	0.275	0.032	0.267	-0.007	0.412
						Common						
surp.	-0.009	0.431	0.004	0.777	0.011	0.335	0.005	0.680	0.006	0.578	-0.007	0.586
int.	0.002	0.780	0.111	0.057	0.013	0.208	0.006	0.463	0.010	0.267	-0.004	0.668
oil	0.157	0.002	0.111	0.057	0.104	0.108	0.110	0.050	0.149	0.010	0.131	0.071
s	0.005	0.927	0.027	0.842	-0.004	0.920	0.106	0.357	0.081	0.479	0.125	0.356
LOG(S)	-3.704	0.000	-3.714	0.000	-3.688	0.000	-3.815	0.000	-0.026	0.189	-3.645	0.000
						Transition Matrix Parameters						
P11-C	0.116	0.794	1.610	0.001	0.051	0.925	1.572	0.000	3.287	0.000	-23.958	0.957
P21-C	-3.218	0.000	-1.822	0.000	-2.734	0.000	-2.300	0.000	-0.146	0.778	-3.978	0.000
D-W	1.617		1.856		1.751		1.848		1.700		1.602	
Log-like.	610.544		602.073		458.330		567.537		556.087		517.233	
Schwarz c.	-4.070		-4.010		-3.866		-4.169		-4.073		-4.065	
						Constant Transition Durations						
	1	2	1	2	1	2	1	2	1	2	1	2
	0.529	0.471	0.833	0.167	0.513	0.487	0.828	0.172	0.964	0.036	0.000	1.000
	0.039	0.961	0.139	0.861	0.061	0.939	0.091	0.909	0.464	0.536	0.018	0.982
						Constant Expected Durations						
	1	2	1	2	1	2	1	2	1	2	1	2
	2.123	25.973	6.004	7.187	2.052	16.387	5.816	10.973	27.772	2.157	1.000	54.415

Note: See note for Table 4.8.

Table 4.13: Markov Switching Results for the Bahrain Stock

	Bahrain		Qatar		Kuwait		Oman		KSA		UAE	
Var.	Coe.	Prb.	Coe.	Prb.	Coe.	Prb.	Coe.	Prb.	Coe.	Prb.	Coe.	Prb.
						Regime 1						
C	0.010	0.079	0.001	0.077	0.013	0.001	-0.001	0.036	-0.001	0.094	0.001	0.557
Bus. (1)	0.001	0.539	0.000	0.311	-0.003	0.191	-0.002	0.109	-0.001	0.338	-0.001	0.086
Pol. (1)	-0.005	0.261	-0.007	0.001	-0.006	0.857	-0.001	0.819	0.000	0.569	-0.004	0.010
						Regime 2						
C	0.000	0.864	-0.005	0.485	-0.002	0.062	0.014	0.000	0.014	0.000	0.017	0.000
Bus. (2)	-0.002	0.003	-0.008	0.004	0.000	0.504	-0.002	0.757	0.000	0.911	-0.001	0.399
Pol. (2)	-0.004	0.008	-0.061	0.023	0.000	0.945	-0.029	0.008	-0.002	0.423	-0.004	0.269
						Common						
oil	0.026	0.136	0.132	0.000	-0.073	0.084	0.128	0.000	0.007	0.697	0.144	0.000
int	-0.045	0.345	0.013	0.412	-0.001	0.933	0.012	0.530	-0.054	0.231	-0.001	0.909
s	-0.006	0.108	-0.081	0.046	0.133	0.000	-0.028	0.495	-0.004	0.292	-0.052	0.236
sp	0.127	0.000	-0.003	0.323	0.011	0.541	-0.005	0.276	0.141	0.000	-0.005	0.218
LOG(S)	-4.947	0.000	-4.871	0.000	-4.827	0.000	-4.900	0.000	-4.888	0.000	-4.913	0.000
P11-C	1.102	0.076	3.777	0.000	2.487	0.114	3.465	0.000	3.393	0.000	3.462	0.000
P21-C	-2.928	0.000	0.232	0.781	-4.470	0.000	-1.184	0.033	-1.121	0.056	-1.147	0.044
P11-C	0.000	0.009	-0.001	0.009	-0.001	0.009	-0.001	0.009	0.000	0.009	0.000	0.009
P21-C	0.009	0.019	0.009	0.021	0.008	0.020	0.008	0.019	0.009	0.018	0.008	0.017
D-W	1.844	875.567	1.695	951.769	1.847	949.002	1.931	951.368	1.787	867.830	1.850	873.336
Log-like.	875.567		951.769		949.002		951.368		867.830		873.336	-6.655
Schwarz c.	-6.687		-6.508		-6.490		-6.470		-6.448		-6.490	
						Constant Transition Probabilities						
	1	2	1	2	1	2	1	2	1	2	1	2
	0.960	0.040	0.993	0.007	0.439	0.561	0.782	0.218	0.954	0.046	0.985	0.015
	0.265	0.735	0.022	0.978	0.025	0.975	0.027	0.973	0.654	0.346	0.481	0.519
						Constant Expected Durations						
	1	2	1	2	1	2	1	2	1	2	1	2
	25.029	3.772	138.365	44.639	1.782	39.234	4.578	37.226	21.642	1.529	65.642	2.078

Note: See the note for Table 4.8.

Table 4.14: Markov Switching Results for the Kuwait Stock Market

	Kuwait		Qatar		Oman		KSA		Bahrain		UAE	
Var.	Coe.	Prb.	Coe.	Prb.	Coe.	Prb.	Coe.	Prb.	Coe.	Prb.	Coe.	Prb.
						Regime 1						
C	0.002	0.050	-0.020	0.007	0.002	0.071	-0.040	0.000	0.002	0.222	0.005	0.013
Bus. (1)	-0.042	0.088	-0.131	0.072	-0.020	0.337	0.125	0.013	0.004	0.814	-0.061	0.062
Pol. (1)	-0.002	0.855	0.019	0.767	-0.007	0.809	0.069	0.000	-0.004	0.238	-0.002	0.782
						Regime 2						
C	-0.029	0.000	0.002	0.099	-0.024	0.000	-0.003	0.421	-0.018	0.001	-0.014	0.029
Bus. (2)	-0.232	0.078	-0.006	0.754	-0.026	0.790	0.007	0.535	-0.138	0.159	-0.138	0.172
Pol. (2)	0.173	0.210	-0.034	0.008	-0.198	0.312	0.001	0.928	-0.044	0.380	-0.001	0.889
						Common						
oil	0.010	0.672	0.003	0.955	-0.003	0.892	0.015	0.604	-0.016	0.595	-0.025	0.345
S	0.204	0.000	0.209	0.012	0.238	0.002	0.137	0.016	0.224	0.000	0.229	0.000
int.	-0.032	0.426	0.008	0.862	0.012	0.761	0.127	0.005	0.018	0.675	0.025	0.584
surp.	-0.001	0.493	-0.001	0.528	-0.001	0.495	0.000	0.763	-0.001	0.337	-0.001	0.242
LOG(S)	-4.494	0.000	-4.492	0.000	-4.449	0.000	-4.448	0.000	-4.465	0.000	-4.488	0.000
						Transition Matrix Parameters						
	1	2	1	2	1	2	1	2	1	2	1	2
P11-C	0.963	0.037	0.636	0.364	0.960	0.040	0.737	0.263	0.982	0.018	1.000	2.000
P21-C	0.564	0.436	0.032	0.968	0.370	0.630	0.024	0.976	0.226	0.774	0.973	0.027
D-W	1.540		1.622		1.498		1.478		1.591		1.495	
Log-like.	830.256		833.037		633.838		760.276		699.124		757.028	
Schwarz c.	-5.628		-5.648		-5.469		-5.614		-5.600		-5.655	
						Constant Expected Durations						
	1	2	1	2	1	2	1	2	1	2	1	2
	27.192	1.775	2.746	31.530	24.867	2.704	3.798	41.943	54.125	4.416	36.835	3.525

Note: See note for Table 4.8.

Table 4.15: Markov Switching Results for the Oman Stock Market

	Oman		Qatar		Kuwait		UAE		KSA		Bahrain	
Var.	Coe.	Prb.	Coe.	Prb.	Coe.	Prb.	Coe.	Prb.	Coe.	Prb.	Coe.	Prb.
Regime 1												
C	0.006	0.004	0.009	0.000	0.003	0.096	0.009	0.001	0.006	0.022	0.002	0.149
Bus. (1)	0.008	0.770	-0.096	0.003	-0.008	0.858	-0.136	0.002	-0.008	0.603	-0.008	0.685
Pol. (1)	-0.002	0.942	0.001	0.960	-0.013	0.547	0.006	0.560	0.000	0.912	-0.007	0.278
Regime 2												
C	-0.018	0.001	-0.031	0.000	-0.037	0.033	0.094	0.000	-0.058	0.000	0.080	0.000
Bus. (2)	-0.131	0.061	-0.022	0.818	-0.094	0.684	-2.427	0.000	-0.092	0.233	-2.142	0.000
Pol. (2)	0.226	0.118	0.214	0.035	-0.730	0.003	-0.550	0.022	0.066	0.001	0.015	0.602
Common												
int.	-0.012	0.084	-0.014	0.016	-0.008	0.154	-0.005	0.352	-0.013	0.035	-0.004	0.528
surp.	-0.044	0.007	-0.018	0.291	-0.038	0.019	-0.004	0.839	-0.016	0.490	-0.010	0.664
s	0.009	0.878	0.031	0.712	0.080	0.283	0.102	0.190	0.043	0.610	0.118	0.153
oil	0.000	0.886	-0.013	0.696	-0.020	0.544	-0.029	0.431	0.003	0.881	-0.022	0.579
LOG(S)	-4.224	0.000	-4.133	0.000	-4.069	0.000	-4.122	0.000	-4.124	0.000	-4.093	0.000
Transition Matrix Parameters												
	1	2	1	2	1	2	1	2	1	2	1	2
P11-C	0.892	0.108	0.942	0.058	0.980	0.020	0.980	0.020	0.910	0.090	0.983	0.017
P21-C	0.625	0.375	0.524	0.476	1.000	0.000	1.000	0.000	0.551	0.449	1.000	0.000
D-W	1.789		1.943		1.822		1.836		1.932		2.012	
Log-like.	579.238		730.027		729.314		674.208		666.203		620.717	
Schwarz c.	-4.970		-4.917		-4.912		-5.005		-4.885		-4.938	
Constant Expected Durations												
	1	2	1	2	1	2	1	2	1	2	1	2
	9.265	1.599	17.250	1.907	49.213	1.000	50.535	1.000	11.067	1.816	58.500	1.000

Note: See note for Table 4.8.

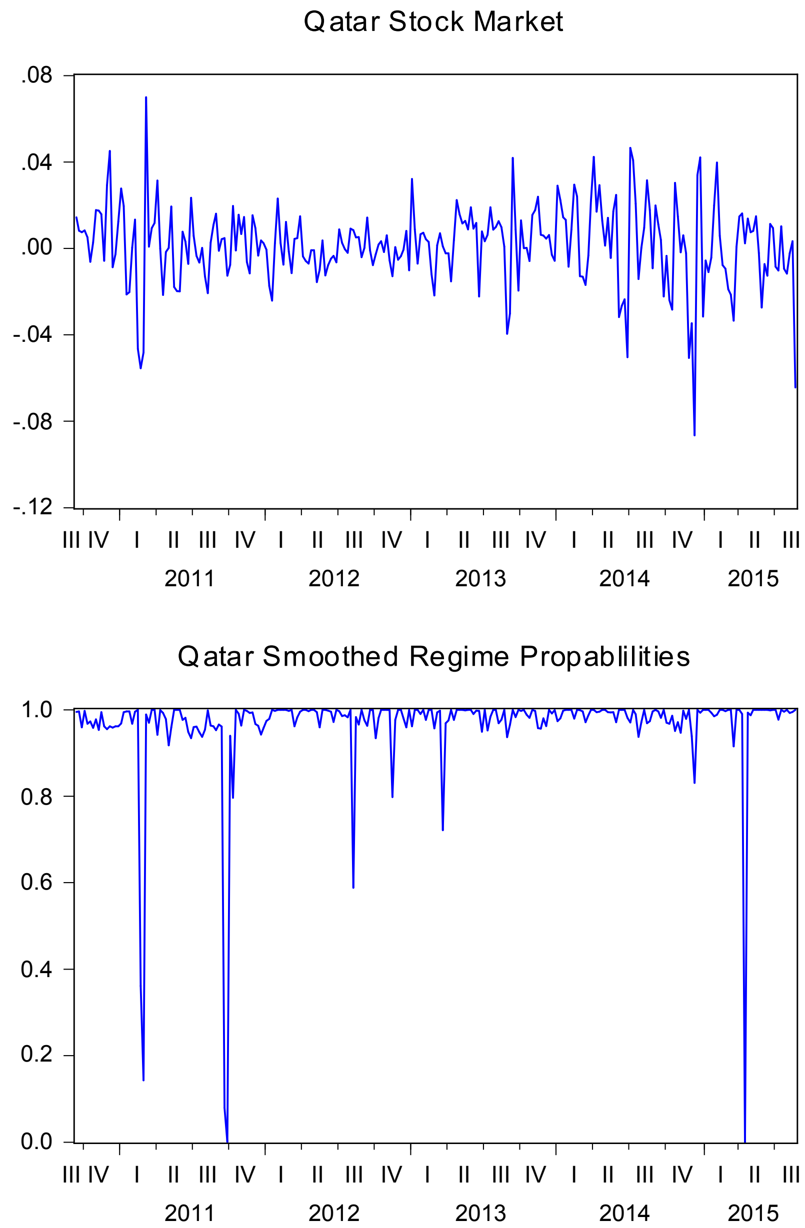

Figure 4.1: Qatar Stock Returns and Smoothed Probabilities

Note: Weekly returns of the Qatari Stock Market and smoothed regime probabilities of domestic news.

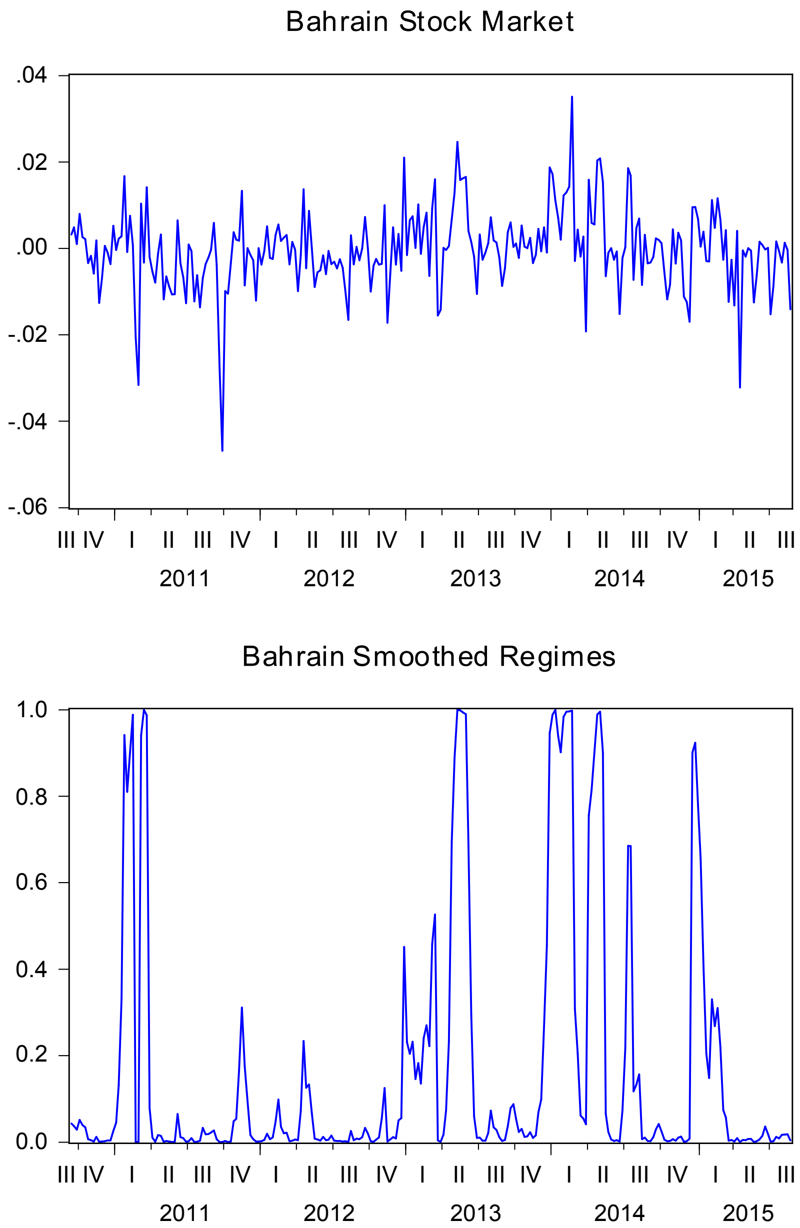

Figure 4.2: Bahrain Stock Returns and Smoothed Probabilities

Note: Weekly returns of the Bahrain Stock Market and smoothed regime probabilities of domestic news.

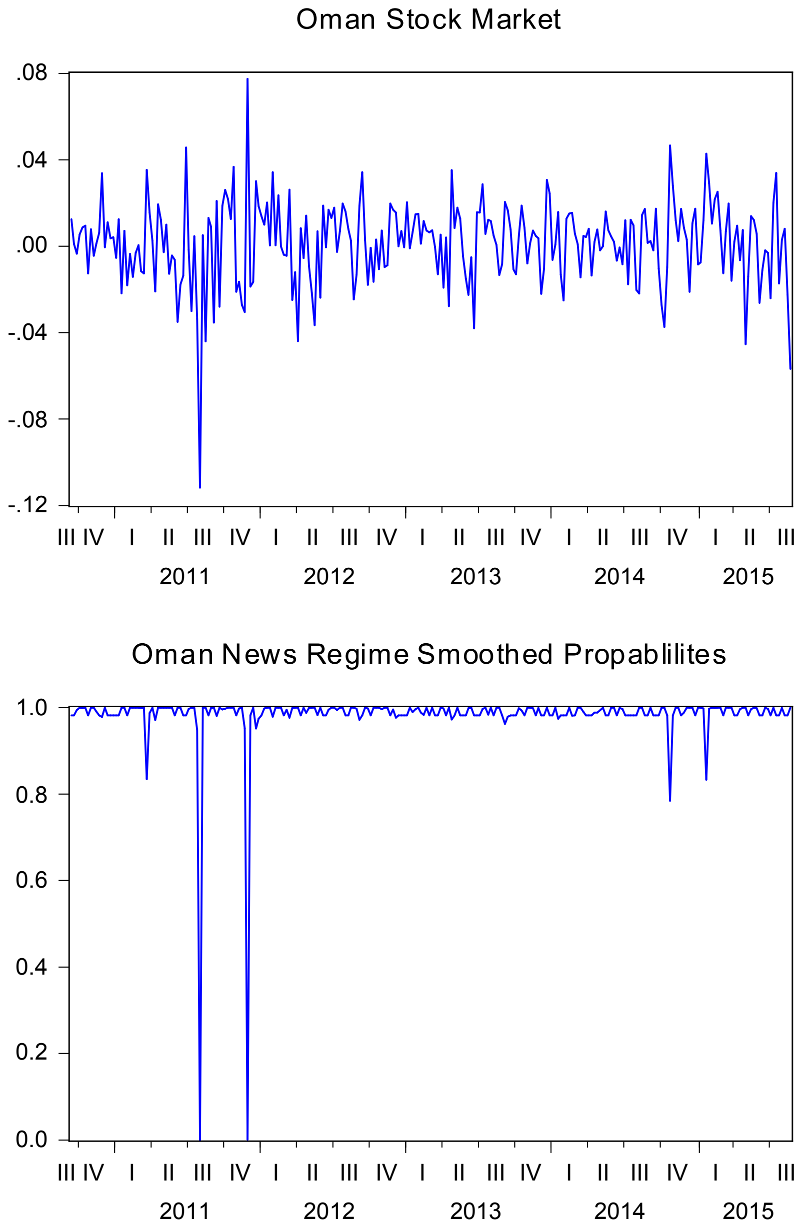

Figure 4.3: Oman Stock Returns and Smoothed Probabilities

Note: Weekly returns of the Omani Stock Market and smoothed regime probabilities of domestic news.

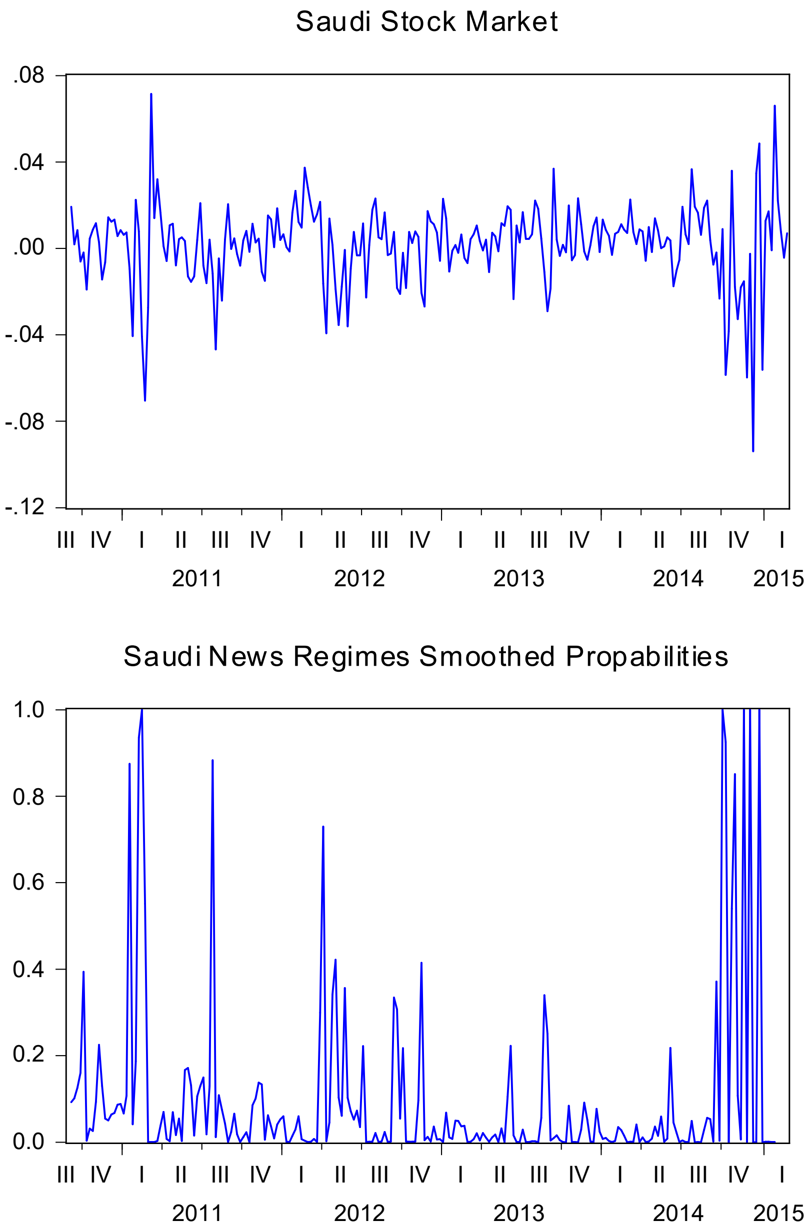

Figure 4.4: Saudi Stock Returns and Smoothed Probabilities

Note: Weekly returns of the Saudi Stock Market and smoothed regime probabilities of domestic news.

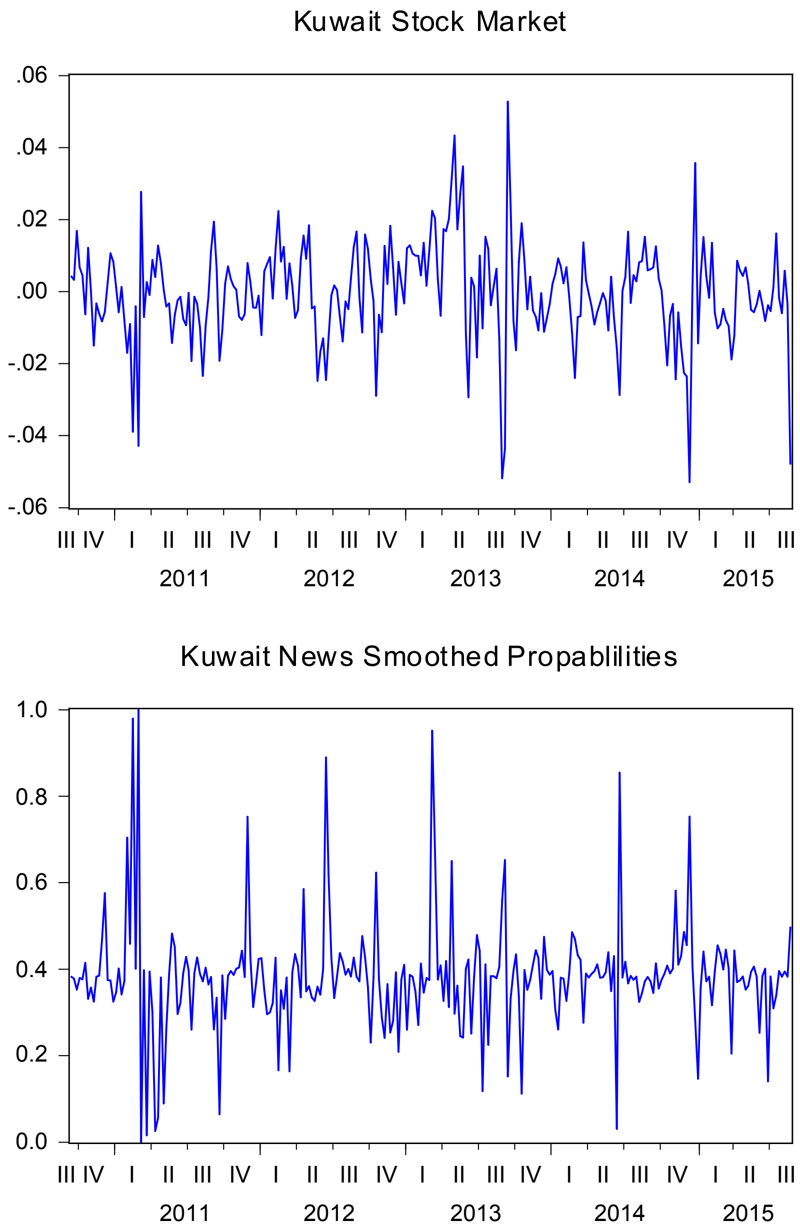

Figure 4.5: Kuwait Stock Returns and Smoothed Probabilities

Note: Weekly returns of the Kuwait Stock Market and smoothed regime probabilities of domestic news.

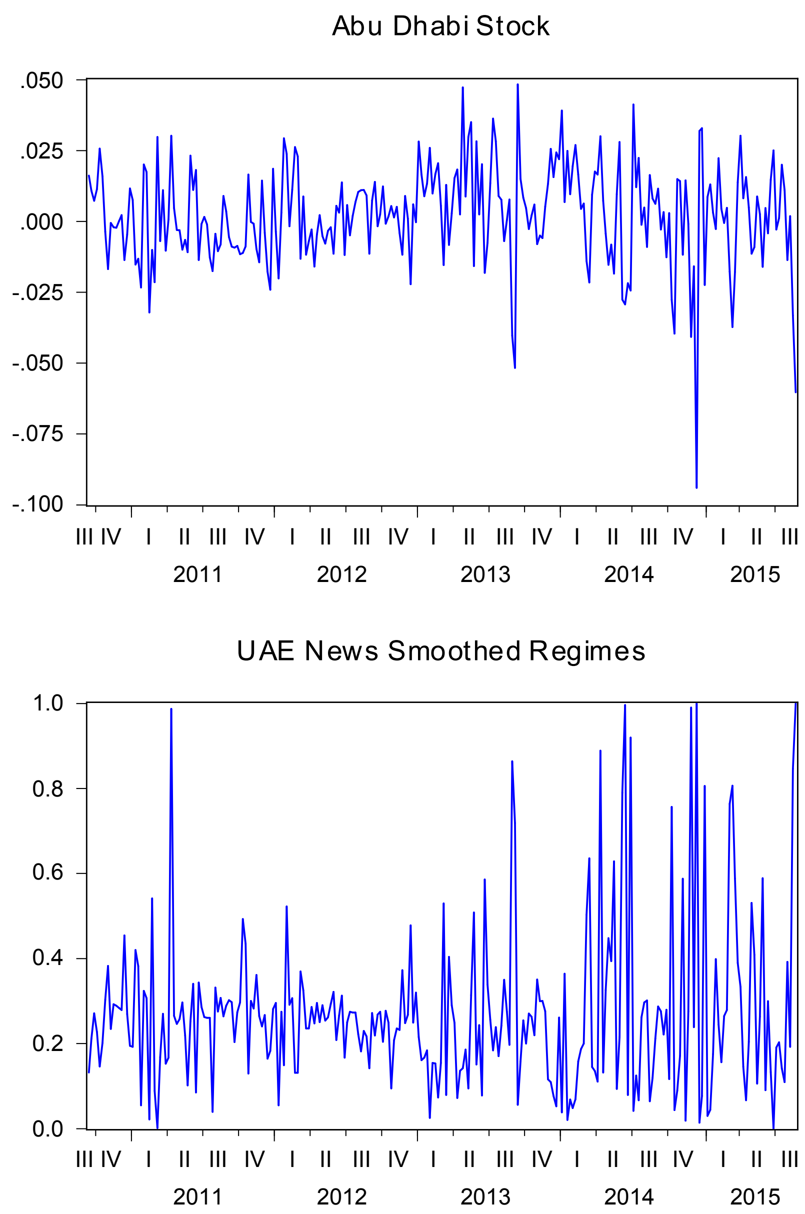

Figure 4.6: AD Stock Returns and Smoothed Probabilities

Note: Weekly returns of the Abu Dhabi Stock Market and smoothed regime probabilities of domestic news.

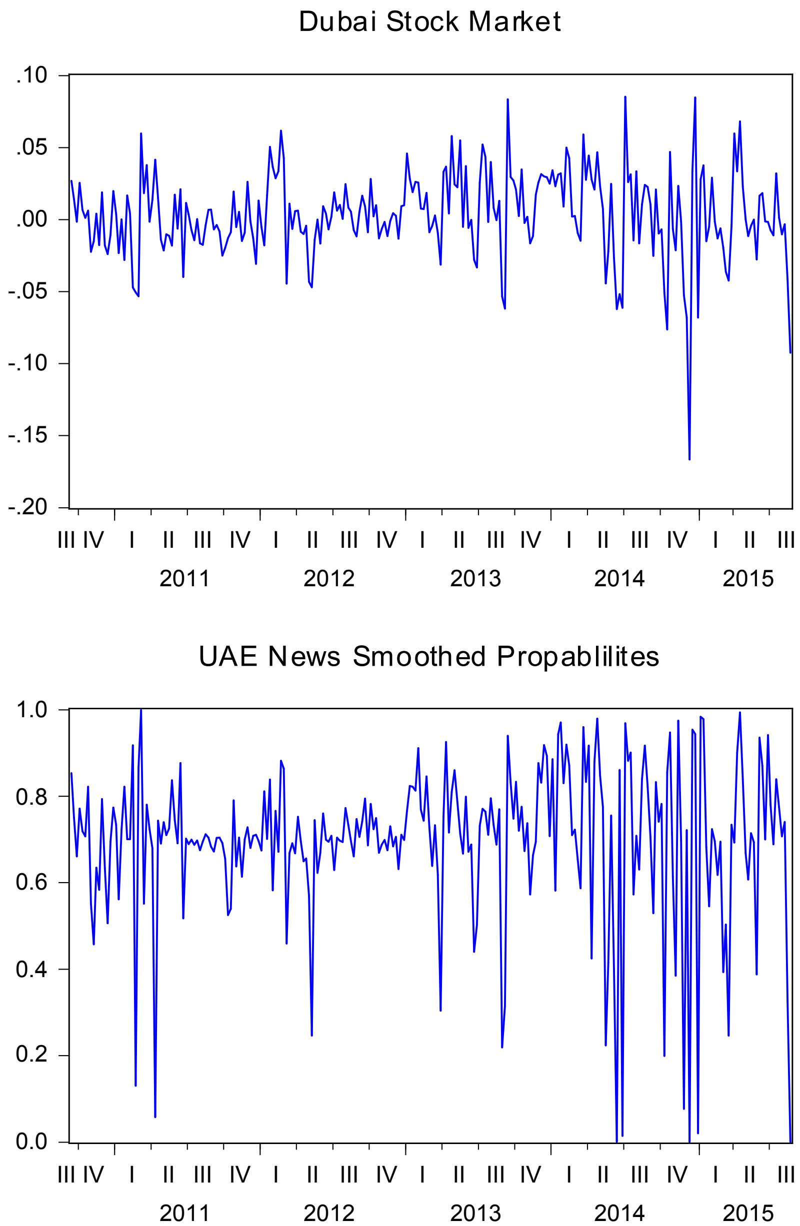

Figure 4.7: Dubai Stock Returns and Smoothed Probabilities

Note: Weekly returns of the Dubai Stock Market and smoothed regime probabilities of domestic news.

values over five years. It is recommended that further research be undertaken to determine why the GCC stock markets behave in these ways and to conduct the same analysis at the sectoral level and for individual stocks. Further in-depth research could potentially explore why and how other countries' sentiment can affect the stock markets of the GCC. According to other studies, the GCC stock markets are not weak-form efficient. This information can be used to realize gains in the stock market and is also important information for news agencies and stock market investors.

This research can serve as a basis for future studies for news agents, regulators, market participants, and researchers. It is recommended that further research be undertaken using the same approach as in this paper but employing a sectoral analysis of the relationships between oil price changes and stock market returns in the GCC countries, which would be quite interesting.

Chapter 5

Conclusion

This thesis has successfully highlighted the nature of and challenges facing the GCC. This was achieved through a clear-cut presentation of conceptual and empirical clarification, with the main objectives of the paper being to address the GCC's composition, benefits, and challenges with specific reference to the importance of oil, food, stocks and news. In other words, this paper highlights the economic position of the Gulf States in recent decades following the establishment of the GCC, with reference those four factors. GCC economies presently depend exclusively on crude oil exports. Global oil demand affects their real GDP, budget balances and current accounts. Although capital revenues, such as oil income, must be employed for capital expenditures, their history shows that this is not the case in GCC states whose capital investment expenditures directly depend on budget surpluses.

The significant influence of oil prices on GCC stock markets; the role of news, as obtained from numerous research databases and media sources; and the role of food, among other factors, have been examined. The truth of the matter is that the GCC states remain particularly underdeveloped in the areas of food production and food security. Obstacles include the region's lack of water, hot weather and small markets, excluding the KSA, as well as the lack of tools for planning, coordinating and enforcing economic policies across the GCC countries. This thesis recommends that oil, food and stocks in the GCC region be enhanced with the aim of achieving diversification by channeling its foreign alliances and economic relationships towards newly industrializing countries. This will allow the GCC to remain an oil-exporting region, while providing an even greater share of the world's oil than at present, among other factors. The scope of this study was limited in terms of the empirical framework. Further research could assess the long-term effects of newspaper articles and how particular policies affect stock prices in the GCC.

This thesis is divided into three sections. Chapter two (following the introduction) evaluates the literature and elaborates on oil and instability in the GCC nations' securities exchanges, empirically comparing their situations to those of four developing nations in Africa.

Al-Kuwari (2013) contends that no country in this global world can ignore the fact that the GCC represents a nexus of countries that help to stabilize supplies of oil and gas worldwide. In other words, the global oil and gas industry provides opportunities for the GCC region to demonstrate its capacity to influence the balance between the demand for and supply of oil. In fact, according to a report by the IMF, in 2013, these economies accounted for nearly one-half of global oil reserves (45%), nearly 15% of gas reserves, and close to 15% of global oil production while simultaneously being responsible for close to 20% of all oil exports to distant parts of the world (IMF, 2013). Other statistics from the IMF database on the influence of oil indicate that the region's GDP from oil activities remains the largest in the world relative to their populations, totalling more than $1.4 trillion, with the KSA responsible for 43% of this figure and Bahrain for 1.9% (IMF, 2013).

In summary, declines in oil prices will always have severe and strategically important negative consequences for the GCC economies, while breakthroughs and progress in the global oil industry have generally helped the GCC region improve and sustain national GDPs and competitiveness as a major stabilizer of the supply of oil products around the world. It is widely understood that raw petroleum is the mainstay of the GCC economies. Adjustments to the cost of oil, however, have highly ambiguous impacts on these economies. As oil is the principle wellspring of growth, an increase in its value benefits oil producers while increasing costs for manufacturers, provided that other cost-cutting measures are not implemented. As a large share of GCC oil firms are government owned, the distribution of oil revenues serves as a method for encouraging interest in training, infrastructure, instruction, and tourism, among other areas. The chapter examines the volatility spillover between oil and stock markets in the GCC using a bivariate BEKK model. Overall, these results are in line with those of previous studies and suggest strong co-movement between oil and stock markets, especially in the GCC. It provides clear empirical evidence regarding the levels of interdependence and volatility transmission between oil prices and several oil-exporting countries' stock market indices based on a VAR-GARCH model with a BEKK representation. The findings confirm that stock markets and oil prices are highly and positively correlated. We also found evidence of co-movement between oil and stock markets, especially in the GCC region, whereas the results for volatility spillovers are quite mixed, especially in the GCC markets. However, such results are also observed in the Moroccan and US stock markets. The results indicate that oil price volatility can be considered an important determinant of stock price volatility, especially in the GCC, because these countries are clearly more exposed to oil price shocks. Consequently, general policies intended to stabilize stock price volatility in oil-exporting countries cannot be formulated. Indeed, the specific linkages between different markets must be taken into account to devise appropriate policy measures.

Chapter three investigates breaks in the mean and volatility spillovers between energy (ethanol and oil) and seven selected food prices (cacao, coffee, corn, soybeans, soybean oil, sugar and wheat) by estimating a VAR-GARCH model with a BEKK representation (Caporin and McAleer (2012) favour BEKK models over DCC models for high-frequency data) for the period from 2003 to 2014. Moreover, it examines the possible effects of four recent events that might shifted in the model parameters by including dummy variables in both the conditional mean and variance equations. Of the four breaks considered, food to fuel causality is affected by the Brent oil bubble and the RFS policy enacted in 2006. This means that policies in powerful countries such as the US can trigger spillovers from food to fuel prices. This research can provide a foundation for future studies seeking to stabilize key food and fuel prices. Specific linkages between markets need to be taken into account to devise appropriate policy measures. The second pattern revealed in our findings is that the financial crisis affected fuel and food causality in both directions in the fuel-food relationship; this result reflect the global impact of the financial crisis, which had important effects on all sectors, including food and fuel. The study presented in Chapter 3 should prove particularly valuable for those seeking to diversify portfolios containing food and fuel. The extensive dataset analysed, the focus on both first- and second-moment linkages and the incorporation of structural breaks into the multivariate GARCH specification all represent original contributions to the existing literature. In summary, our findings confirm that food and energy prices are tightly interconnected and provide evidence that some of the recent turbulence in the world economy has affected their linkages.

Chapter four provides an innovative approach to examining empirical evidence regarding the level of interdependence and transmission between newspaper article sentiment and stock prices in the GCC stock markets. This study was motivated by the importance of these issues for investors and by the limited research that has been conducted on this matter, especially in for the GCC region. This original contribution provides meaningful insights into the different characteristics of the GCC countries. The main finding is that the MSMs provide slightly more explanatory power for the importance of news and macroeconomic surprises in GCC stock markets. The results indicate the importance of news sentiment in predicting stock market performance. Qatar appears to be an influential country, as its news must be taken into account to predict stock market returns of neighbouring countries. Qatar and Oman are the countries most affected by political news from neighbouring countries; however, they are also affected by sentiment from neighbouring countries, especially in lower regimes. Qatar and the UAE are also affected by other countries' business news.

Based on this study, in some regimes, the GCC stock markets are not weak-form efficient. News sentiment information can be used to realize gains in the stock market. This unique result provides meaningful insights into the distinctive attributes of the GCC nations.

The key strengths of these three studies include long historical data series and the empirical approaches employed, which best fit the data; the findings presented in this thesis provide a new understanding of how stock markets in the GCC are affected by oil shocks.

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Chapter 6

Appendix

6.1 Positive Business News Sentiment Example:

(NS8) Qatar Peninsula: Qatar's trade surplus touches QR10.9bn

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Qatar Peninsula: Qatar's trade surplus touches QR10.9bn 2015-12-27 20:43:24.273 GMT

http://thepeninsulaqatar.com/business/qatar-business/363900/qatar-s-trade-surplus-touches-qr10-9bn

PageExcerpt: DOHA: The value of Qatar's total export of goods, including exports of goods of domestic origin and re-exports, stood at QR21.3bn in November, a 36.7 percent decrease on year-on-year and a 5.9 percent on month-on-month decline. On other hand, the ...

6.2 Negative Political News Sentiment Example:

GCC Takes Rejects Egypt Accusations Against Qatar 2015-02-19 11:06:53.9 GMT

By Salma El Wardany (Bloomberg) – Claim by Egypt's Arab League ambassador suggesting Qatar supports terrorism is "void, defies truth and overlooks" efforts by that country, other Gulf Cooperation Council members and Arab states to fight terrorism, GCC Secretary-General Abdul Latif Al Zayani says in statement on organization's website.

* Al Zayani expressed his "rejection of the accusations" by Egypt's permanent representative to the Arab League: statement * NOTE: Qatar Recalls Ambassador to Egypt Over Terrorism Accusation Link