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THE IMPACT OF U.S. ENERGY POLICY BILLS ON THE GCC STOCK MARKETS' CONDITIONAL VARIANCE

by
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To
My Beloved Family

The Impact of U.S. Energy Policy Bills on the GCC Stock Markets' Conditional Variance

Ranim Haidar

Abstract

This thesis investigates the impacts that bills on energy policy, introduced and discussed in the US Congress, have on the variance process of the five largest Gulf Cooperation Council stock markets. Since the US is the largest consumer of crude oil in the world and the GCC region is one of the most influential suppliers of crude oil, we investigate the hypothesis whether public news on US energy policy bills has a reversal impact on the GCC stock markets' conditional variance. Augmenting the Asymmetric Generalized Autoregressive Conditional Heteroskedasticity (AGARCH) model of Glosten et al. (1993) with indicators determined in terms of the dates when the US energy policy bills are introduced, we find that the conditional variance of the GCC markets tends to revert on days when the bills are introduced and discussed in the US Congress. This finding is consistent with the learning hypothesis in the financial economics literature. Furthermore, examining the robustness of our finding within the AGARCH model to endogenous effects, we find that the variance responses of the GCC markets to public news on the dates of bills are not solely driven by market specific effects.

Keywords: GCC Markets; Energy Policy; Volatility; Crude Oil

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CHAPTER ONE

INTRODUCTION

This chapter provides a short background to the research question, states the purpose of the thesis, gives some motivations, and summarizes the main findings.

1.1 -Background

The United States is the world's largest consumer of crude oil. According to the US Energy Information Administration (EIA), the US consumption of energy reached more than 94.5 quadrillion Btu[1] in 2009. The corresponding daily figure is 18.8 million barrel per day in 2009. Although, the US produces a negligible share of its total domestic consumption. The US production of energy comes mainly from crude oil, coal, natural gas, nuclear power, and diverse renewable sources. The country relies heavily on imports of crude oil. In 2009, the US imported 51% of its consumption of crude oil from the western hemisphere, 17% from the Gulf Cooperation Council (GCC) countries, and the rest from other countries. The four largest countries supplying the US with crude oil are Canada, Mexico, Venezuela and the Kingdom of Saudi Arabia standing for 21.2%, 10.3%, 9.1% and 8.6%, respectively.

While crude oil remains an important source of energy even in the near future, its consumption dropped by 5% in 2009, and its weight in the cost structure of industries has been questioned by both policymakers and environmentalists. As a matter

[1] The British thermal unit (**Btu**) is a traditional unit of energy equal to about 1,055.05585 joules. It is approximately the amount of energy needed to heat 1 pound of water from 39 °F to 40 °F.

of fact, the share of the renewable energy increased from its level of 2008 by 5%. It is difficult to say if this pattern will persist over time, even though there is a clear political willingness to reduce the country's dependence on foreign oil. In his speech of March 30, 2011, President Barack Obama stated: "The only way for America's energy supply to be truly secure is by permanently reducing our dependence on oil." Clearly, America is working on reducing its consumption of energy from fossil fuel by establishing new types of industries, and should eventually find new sources of energy that are cleaner and renewable.

1.2 -Research Questions

In an interdependent world, a strategic decision by one country leads to a strategic response of other countries. For instance, when the US reduces its consumption of crude oil, countries exporting oil must find an appropriate response to trade off the (negative) effects of the US strategic decision. This strategic response can be dramatic in the sense that the oil exporting country may reconsider the industrial structure of its entire economy. This restructuration may be long and hard for countries whose economy depends strongly on oil drilling. The GCC is a good example of countries that must assess the impact of the US energy policy on their economies.

The purpose of this thesis is to investigate how the GCC countries react to the US energy policy looking at the structure of its conditional variance process. The GCC area is the swing producer of crude oil within the OPEC[2]-cartel. The GCC have a great influence on the supply of crude oil to the world market. Therefore, we expect that the GCC stock markets variance to be sensitive to relevant (strategic) changes in the US

[2] OPEC stands for the Organization of Petroleum Exporting Countries.

energy policy. Within the Asymmetric Generalized Autoregressive Conditional Heteroskedasticity (A-GARCH) model of Glosten, Jagannathan and Runkle (1993), we measure the volatility effect of the introduction of bills on energy through a parameter associated with an indicator variable taking 1 when a bill is introduced in the US House of Representatives (Congress), and 0 otherwise. Under the Efficient Market Hypothesis (EMH)[3], the conditional variance of the GCC markets includes all available information at time t. Therefore, assessing how quickly and accurately these markets respond to public information is beneficial and relevant when managing risk, planning for the future and devising policies. While an isolated bill introduced in the Congress for discussion would most probably not impact the GCC market volatility in the way a proper shock will do, a sequence of bills may give rise to an information momentum that is discernable to policymakers and market participants. This view is consistent with sequential models conceding that stock prices adjust sequentially to information (e.g. Kyle, 1985; Easley and O'Hara, 1992).

1.3 -Motivation

The GCC countries produce 20% of the world output of crude oil and these countries are sitting on 37% of world proven reserves of crude oil. Furthermore, the economies of these countries are structured around the production and the processing of crude oil, which makes them vulnerable to both short- and long-run fluctuations in the demand of crude oil. A number of studies has shown a direct relationship between the price of crude oil and the production environment (e.g. Hammoudeh and Li, 2008; Arouri, Lahiani and Nguyen, 2011; and Fayyad and Daly, 2011). While these studies

[3]Investigating the weak-form efficiency in the GCC markets, Bley (2011) finds that these markets are slow at impounding historical information into prices.

show that the crude oil price tend to increase with political, military and social events taking place in and outside the region, they do not investigate the GCC stock markets' reaction to energy policy announcements.

It is important to investigate how these stock markets react to the US bills on energy on the day they are made public. Not only the US is currently the largest consumer of crude oil, it is also one of the most technologically advanced nations. A decrease in the US imports can be compensated by an increase in the imports from China and other emerging economies, but a technological shift in the production of energy may have durable negative effects on the welfare of the GCC countries. We expect a significant response in volatility in the GCC stock markets whenever a bill on energy is introduced and discussed in the Congress, holding everything else constant. Since stock markets are forward-looking a significant relationship suggests that the US energy policy is a credible strategic demand shift, and its effect is discernable in these markets whose economies depend essentially on the price of crude oil. In contrast, a non-significant relationship suggests that bills discussed in the Congress have diffuse short-run effects on these markets' volatility.

1.4 -Main Findings

Presented below are the main findings of this thesis:

- The stock prices in the GCC markets reflects the available relevant public information, however, this is not done in a fast manner, but rather at a slow and gradual pace.

- Bills introduced in the US Congress are important in capturing some deterministic effects of returns.

- There is a strong momentum effect in volatility, which is persistent, and also asymmetric in three of five GCC markets. This asymmetry means that negative news affect volatility in a greater way than good news of the same magnitude.

- Although, there may be other determinants affecting volatility on the day the bills are introduced, however we show that on that day, even coincidentally, the volatility of the GCC markets follows two behaviors: either it accelerates in the direction it was following before the introduction of the bills in the US Congress, or it reverts.

- The effects of the bills introduced in the US Congress are in most cases positive and significant, and this shows that the GCC markets react to some kind of information on the days the bills on energy are introduced in the US.

1.5 -Limitation

This thesis only examines the effect of the US energy policy on the volatility of stock indices of selected markets in the GCC region, and it doesn't include the energy policies of other prominent economic powers in the world like European Union and China.

The energy policy of the USA was approximated by bills introduced in the Congress and did not include bills introduced in the House of Senates nor information released by the Department of Energy (DOE). Therefore, our findings give good indications on market reaction to global news. The rest of the thesis is organized as follows. Chapter 2 gives a short review of previous studies investigating either the relationship between crude oil price and stock markets or the relationship between stock markets and economic policies. Chapter 3 presents the GCC prices data and the bills on energy that were introduced in the US Congress. Moreover, this chapter states which variables are used. Chapter 4 describes statistically the returns data, introduces the econometric models (ARMA and A-GARCH), and reports the empirical results. Finally, Chapter 5 concludes that the bills introduced in the US Congress have an effect on the volatility of several GCC markets.

CHAPTER TWO

REVIEW OF PREVIOUS STUDIES

Stock markets are forward-looking economic entities. They capture the investment and the financial risk, and determine the present value of future cash flows. In the one-factor pricing model, stock markets aggregate all types of economic risk. In contrast, in multifactor pricing models the economic risk is multidimensional in the sense assets are differently related to pricing factors. The list of pricing factors having an impact on stock prices is not exhaustive. One factor that has drawn much of attention in the financial economics literature is the crude oil price factor.

We review in this chapter some of the studies that investigate how variation in crude oil impact stock prices.

2.1 -Impact of Oil Shocks on the US Stock Market

Jones and Kaul (1996) investigate the impact of crude oil price shocks on the equity prices in Canada, Japan, the UK and the US. Using the dividend valuation model, they identify that the stock markets in the US and Canada are directly affected by the changes in oil price. Similarly, Sadorsky (1999) documents that there is a significant relationship between oil price changes and aggregate equity market returns in the US.

However, the above two studies do not differentiate between the nature of oil shock in the markets. Kilian and Park (2009) show that the response of US real stock returns depend on whether the oil price shock is demand or supply driven, and document that high oil prices lead to lower stock prices only when we have demand shocks. They also find that high oil prices can accompany high equity prices especially at the start of an economic boom. Both shocks account for 22% of the long run variation in US equity returns.

Park and Ratti (2008) show that oil price shocks have a major impact on real stock returns at the same time the shock is happening or in the coming short period. This impact accounts for 6% of the volatility in returns, and they consider that this impact is far greater than that of interest rates.

2.2 -Impact of Oil Shocks on the GCC Stock Markets

Most of the GCC countries depend mainly on oil export returns to promote economic activities and growth. This dependency on oil export makes the relation between oil price shocks and the stock market indices in these countries very interesting. Several researchers conducted analysis on this relationship and came up with the following conclusions.

Hammoudeh and Aleisa (2004) find that there are spillovers from the oil market to equity markets in several GCC markets and mainly in Bahrain.

Arouri and Rault (2009) find that there is a bi-directional causal relationship between KSA and the oil market as changes in stock market prices cause a change in oil prices and oil price shocks will cause a change in stock market prices. In other markets, only oil shocks were found to cause stock price changes.

These results were also documented by Bashar (2006) who shows that only the market of Saudi Arabia can predict the price increases that happen in the oil market, but he adds Oman to the equation.

Others tried to examine the effect of other variables on the equity markets in the GCC.

Hammoudeh and Choi (2005) show that the S&P 500 shocks impact the GCC markets over the short term as these markets will follow the US index. In addition, they show that a hike in oil prices will benefit most of the GCC markets and is accountable for approximately 30 percent of Oman's and 19 percent of Saudi Arabia's total variations, while the other variations in the stock markets of the GCC countries could be attributed by a small fraction to global factors and mainly due to domestic or GCC shocks.

Malik and Hammoudeh (2005) study the volatility and the ways shocks are transmitted between US equity, global crude oil market, and equity markets of Saudi Arabia, Kuwait, and Bahrain. The results show that the Saudi market is indirectly influenced by news emanating from the US equity market, and by volatility in the oil market. The Kuwaiti market on the other hand is found to be directly affected by these two factors, and the Bahraini market is indirectly affected by the news and directly by volatility in the oil market.

However, the study finds that only in KSA, there is a major volatility spillover from the Saudi market to the global oil market, showing the prominent role of the kingdom in the oil market. Thus there is a two way transmission channel of volatility between KSA's equity market and the oil market.

2.3 -Impact of Information Shocks on the US Markets

Macroeconomic announcements in the US have considerable effects on the wide spectrum of financial markets both in terms of returns and volatility. However, markets seem not to respond to these statistical releases by themselves, but rather to the unexpected component of these releases which really creates the shock to these markets.

The effects of the announcements differ from one financial market to the other, and each type of announcement also has a different impact based on the macroeconomic variable it tries to capture.

Raj and Schrim (1998) explain that the impact of trade balance news differs between the US stock market and the foreign exchange market according to the magnitude and sign on the surprise component in the issued news.

Joong, McKenzie and Faff (2004) show that the release of non-farm payroll figures and retail sales has a great impact on the US T-Bond market.

Balduzzi, Elton and Green (2001) explain that the market's reaction to employment data issued in the US reflects the markets' participants' expectations towards the Federal Reserve monetary policy.

Fleming and Remolona (1999) show that the reaction would be stronger if the market was witnessing a high degree of uncertainty amongst the participants.

Bomfim (2003) shows that the releases related to the consumer price index, producers price index, and interest rate decisions have an important weight on returns and volatility.

Charles, Lamont and Lumsdaine (1998) document that volatility declines before releases of major macroeconomic data.

Joong *et al*. (2004) explain that if the announcements contained an unexpected component, then volatility will surge in the market as participants will be eager to reflect this new information in their holdings, and this volatility will persist until the new information is digested in the asset prices.

Bomfim (2003) tackles the federal open market committee activities relating to interest rate decisions, and concludes that the volatility in the stock market will be lower on the days before the committee’s meeting and higher on the day the meeting is to be held.

Bernanke and Kuttner (2005) research the effects of monetary policy changes on the equity markets and find out that an unanticipated 25-basis-point cut in the Fed target rate yields about 1% increase in broad stock markets, and that the impact of unanticipated interest rate actions has a primary role in explaining the excess returns of stock prices in the US.

Fratzscher (2004) explains that oral statements of central banks are an effective way of giving information to the market especially if they are not in line with the adopted policy, and even they become more important if the uncertainty is high.

Chang and Taylor (2003) show that an important announcement will lead to instantaneous changes in prices and declines in trading volumes. After this, volatility jumps back up again as investors digest the information and start adjusting their positions in the market accordingly. This phenomenon occurs in a relatively short period of time.

Indeed, Balduzzi *et al*. (2001) show that the impact of most indicators is quick and short lived across all markets.

All the above works show the effect of issuance of new information in the market and the effect of policy changes relating to interest rates on the financial markets. However, we have noted that there is no work that tackles the effect of the US energy policies on the oil and equity markets in the US, nor on other countries especially those considered to be net exporters of oil. This paper is the only paper tackling this issue and will focus on determining the short term effects of the US energy policy on the volatility of returns in selected GCC markets.

CHAPTER THREE

DATA AND VARIABLES

This chapter presents and describes the data and the variable.

3.1 -Prices Data

We use daily closing prices data for the Abu Dhabi, Kuwait, Muscat, Qatar and Saudi Arabia stock indices. We obtain these data from ZAWYA[4] Database. The data run from 1/1/2000 till 30/9/2010. Table 3.1 gives the covered period for each market.

Table 3.1. The sample period for each market

Stock Market	Start Date	End Date
Abu Dhabi (ABU)	16/9/2001	30/9/2010
Kuwait	21/3/2000	30/9/2010
Muscat	4/1/2000	30/9/2010
Qatar	14/5/2001	30/9/2010
Saudi Arabia	20/4/2000	29/9/2010

The market capitalization of the five GCC markets has increased from $102 billion in 2000 to $721 billion in 2010. The market capitalization of MUSCAT (Oman), Kuwait, United Arab Emirates, Qatar, and Saudi Arabia stock markets were in 2010 approximately $20 billion, $120 billion, $105 billion, $124 billion, and $353 billion, respectively. Similarly, the number of listed companies in the five stock markets increased from 359 in 2000 to 625 in 2010. In Oman, Kuwait, United Arab Emirates, Qatar, and Saudi Arabia, the number of listed companies in 2010 were 120, 215, 101,

[4] http://www.zawya.com/zisign-in.cfm

43, and 146 companies, respectively.

3.2 -Description of Data on Bills

The Thomas Library of Congress[5] database was used to retrieve the bills introduced at the Congress's Energy and Commerce Committee for the period extending from 1/1/2000 till 30/9/2010. The above listed bills, introduced by the 106th to the 111th Congress, totaled to 5384 bills. A filter was then applied to this data to select only the bills that might have an impact on the oil's consumption and therefore its price. Specifically, only the bills which contained selected terms (e.g. energy, nuclear, fuel, electricity, and gas) in their title were selected, and the result amounted to 799 bills. Based on these keywords, we obtain indicator variables taking 1 on the date a bill is introduced and 0, otherwise.

Although, the trading calendar in the GCC region differs from the trading calendar in the US. Weekends fall on Friday and Saturday in the GCC region, while the stock markets are closed on Saturdays and Sundays in the US and other western countries. Similarly, the commemorative days in the US differ from those in the GCC region. Since we have to match the day the bill is introduced in the Congress with the trading in each of the GCC markets under consideration, we matched the date of the bill with the following trading day if there was a match. Moreover, in general due to time differences when the bill is introduced in the Congress, stocks markets are already closed in the GCC region. Therefore, the matching day is the day after the bill was introduced.

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[5] http://thomas.loc.gov/home/LegislativeData.php

3.3 -The Time Patterns of Bills on Energy Policy

Figure 3.1 depicts the monthly pattern of the number of bills introduced in the Congress, where the number of bills is the sum of the indicators in the month.

Figure 3.1. The monthly pattern of the bills on energy

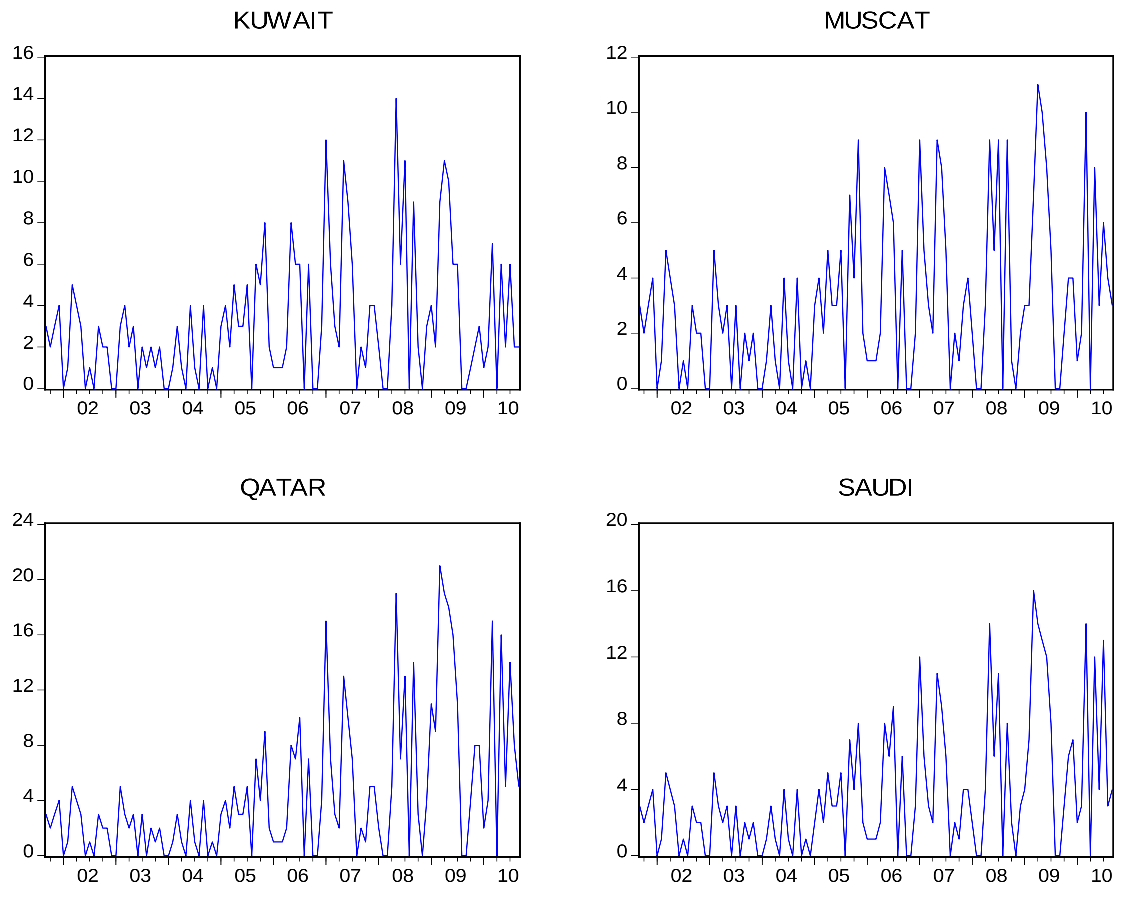


Figure 3.1 shows that the number of bills in the Congress starts increasing from 2005, with a discernable positive trend. This trend covers both the presidency of Georges W. Bush (a Republican with a reputation of favoring fossil fuel as the main source of energy) and the presidency of Barack Obama (a Democrat with a reputation of promoting environmental friendly sources of energy).

3.4 -Log and Simple Returns

Let p_{it} be the logarithmic stock price at time t of a stock (index) i that does not pay a dividend, then the logarithmic (log) return or the continuously compounded return is given by $r_{it} = p_{it} - p_{it-1}$. An alternative formula for return is the rate of (simple) return given by $\mathrm{r}_{\mathrm{it}}^{*} = (\mathrm{P}_{\mathrm{it}} - \mathrm{P}_{\mathrm{it-1}})/\mathrm{p}_{\mathrm{it}}$, where P_{it} is the price at this level. Let us take an example. Suppose the price of a stock is \$100 at time $t-1$ and \$110 at time t. The logarithmic return is 9.53% and the simple return is 10%, suggesting that r_{it}^{*} is greater than r_{it}. The difference arises because $\mathrm{r}_{\mathrm{it}} = \ln(1 + \mathrm{r}_{\mathrm{it}}^{*})$. The difference between r_{it} and $\mathrm{r}_{\mathrm{it}}^{*}$ has empirical implications.

Most studies in the financial economics literature use log returns instead of simple returns when dealing with the time series properties of high frequency stock returns data. This is because it is much easier to statistically manipulate r_{it} than r_{it}^{*} when dealing with multi-period returns since the gross simple returns are multiplicative while the log returns are additive. Nonetheless, while the sum of weighted simple returns in a portfolio equals the portfolio return, the sum of weighted log returns does not equal the portfolio return. The equality does not hold in the latter because the log of sum is not the same as the sum of logs. That is, $ln\left(1 + r_{pt}^{*}\right) \neq \sum_{i=1}^{n} w_i r_{it}$, where w_{i} is the weight in asset i included in portfolio p with n assets, and $\mathrm{r}_{\mathrm{pt}}^{*} = \sum_{\mathrm{i=1}}^{\mathrm{n}} \mathrm{w}_{\mathrm{i}} \mathrm{r}_{\mathrm{it}}^{*}$.

3.5 -Excess Returns

In an economy with n assets, it is possible to obtain a portfolio with no systematic risk. Such a portfolio is known as a Zero-Beta Portfolio (ZCB). The ZCB resembles to the “riskless” asset rate of return, r_{ft}. The possibility to earn a risk-free return suggests that investors require a risk premium to hold risky assets, which are proportionally combined in the market portfolio. Therefore, whenever such a risk-free asset rate of return exists, it is more convenient to work with excess return, which is given by $R_{it}^{*} = r_{pt}^{*} - r_{ft}$ and $R_{it} = r_{it} - r_{ft}$ for the simple and the log return, respectively. However, we use gross return in this thesis, as our main objective is to investigate the impact of bills on the conditional variance of GCC markets.

3.6 -The Return Process

The economic environment determines the dynamic of the returns process across assets and over time, which means that the economic path passes through different states of nature and asset returns are random. For instance, in good states of nature asset returns tend to be above their long-run average, while in bad states of nature asset returns tend to be below their long-run averages. Since these states of nature occur randomly, probabilities must be assigned to each state of nature. The randomness property of asset prices suggests that future returns are uncertain.

The probability distribution of the asset returns is governed by the probability law that has, since the seminal dissertation of Bachelier (1990), been expressed differently in the financial economics literature. The normal (Gaussian) distribution is, however, the benchmark probability law. Asset returns are said to be normally distributed when the return process can be completely described in terms of its mean, μ_i and its variance, σ_i^2. So, the process of R_{it} can be written as $R_{it} \sim N(\mu_i, \sigma_i^2)$. In contrast, when asset returns are not normally distributed, the process of R_{it} is leptokurtic, which means that the third moment of the normal distribution (the skewness, S) is not zero, and the fourth moment (kurtosis, K)of the normal distribution is not 3.

3.7 -The Return Dynamics

The return dynamics is a function of the information set at time t, Ω_t. With all information included in Ω_t and given an equilibrium model, abnormal returns are immediately eliminated as soon as they appear in efficient markets (see Fama, 1993; and Malkiel, 1992). The idea that R_{it} is equal to R_{it-1} in the absence of information implies that R_{it} and R_{it-1} are uncorrelated, which also suggests that R_{it} is a process that is identically and independently distributed (iid). It follows that $(R_{it} - \mu) = \varepsilon_{it}$ is equal to $(R_{it-1} - \mu) = \varepsilon_{it-1}$ and $E(\varepsilon_{it}\varepsilon_{it-1}) = 0$ under the assumption that σ_{it}^2 is equal to σ_{it-1}^2.

Although, a basic observation of financial returns data at high frequency is that R_{it} is not Gaussian nor linear. The nonlinearity of the return process follows from the observation that ε_{it} is serially correlated, and σ_{it}^2 is a time-varying process. Different explanations are provided to rationalize the observation that the return process is nonlinear. One explanation is that many aspects of economic behavior are not linear because economic agents exhibit different degrees of risk aversion, and face a tradeoff between risk and return. Another explanation is that economic agents or market participants are asymmetrically informed, and therefore must act strategically (see, Gossman and Stiligtiz, 1980; Kyle, 1985; Glosten and Milgrom, 1985; Delong *et al*. 1990; and Easleyand O'Hara, 1992).

CHAPTER FOUR

EMPIRICAL MODELS AND RESULTS

This chapter describes the returns data, presents the econometric models, and reports the empirical results.

4.1 -Descriptive Statistics

In the previous chapter, we stated that the return process is described by the properties of its average, variance, skewness and kurtosis, its behavior over time and across assets, and the probability law that governs its dynamic path. We also stated that the return process can be nonlinear in its mean and variance. While the non-Gaussianity of the return process suggests that the mean and the variance of the return process are not unique, the nonlinearity in mean and variance suggests that both the return and the squared return process can be serially correlated. These features are readily observable looking at the daily pattern of the logarithmic return and the squared returns. Figure 4.1 portrays the daily pattern of the return for the Saudi market only.

The vertical axis of Figure 4.1 measures the daily return in percent and the horizontal axis reads the daily observations over the sample period from April 20, 2001 to September 30, 2010. The daily pattern of the Saudi market is much similar to the patterns of the four other GCC markets. Figure 4.1 shows that the return process of the Saudi market is stationary around a long-run return mean. Furthermore, negative and positive large returns tend to cluster, while normal returns are more common than large returns. However, it is difficult based on Figure 4.1 to determine if the clustering of returns leads to strong dependence in the return process. In the favor of Figure 4.1, we can also portray the volatility pattern of the Saudi stock market using absolute returns as a proxy for volatility.

Figure 4.1. The daily return pattern of the Saudi stock market over the sample period

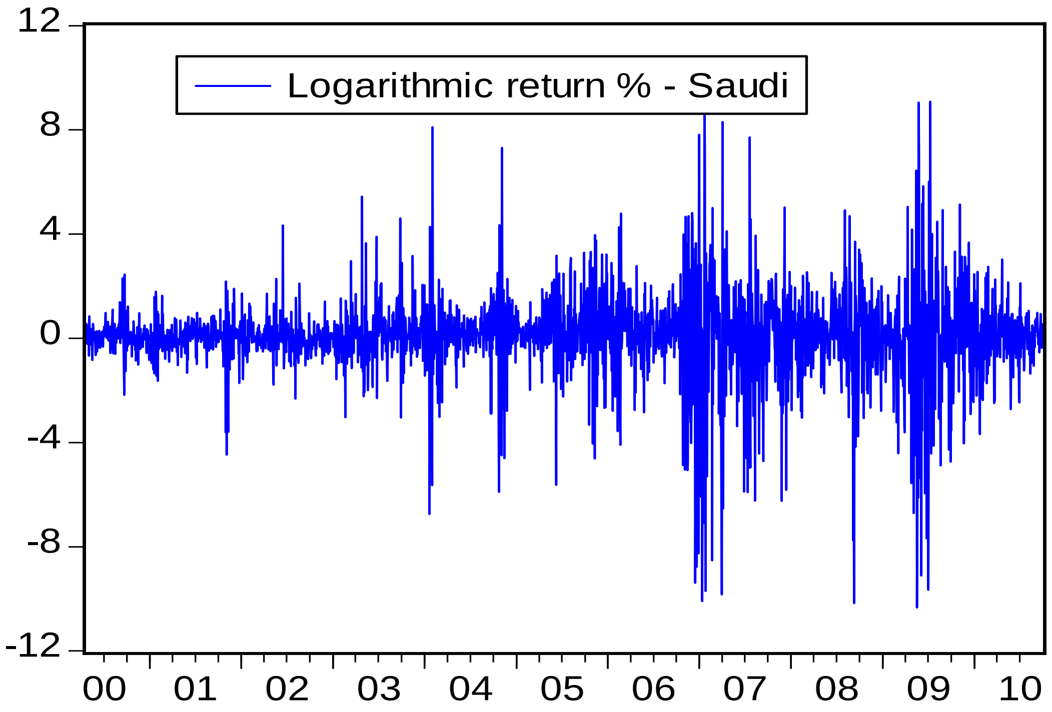
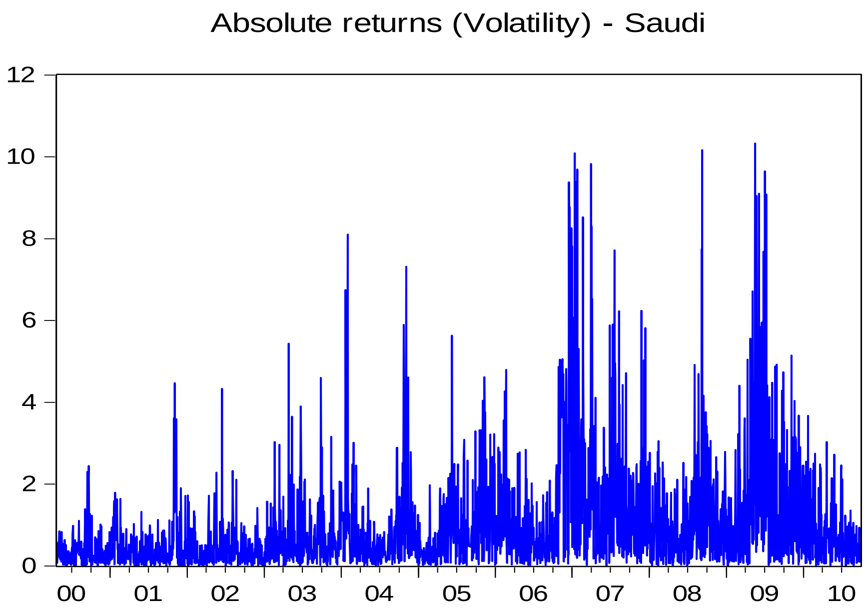


Figure 4.2 shows that small volatilities tend to follow small volatilities, and large volatilities tend to follow large volatilities. This is a common feature in stock markets around the world, and it is known as volatility clustering. Thus, volatility is changing from day to day. With time-varying volatility, volatility is unpredictable. However, due to volatility clustering, the so-called ARCH[6] effects are strongly present in the volatility process of the Saudi stock.

[6]ARCH effects denote that the returns are persistent and have a long distributional lag.

Figure 4.2. The daily volatility pattern of the Saudi stock market over the sample period



Figures 4.1 and 4.2 show that at any time point along the time line past returns and volatilities are strongly linked to the return and the volatility at that point. However, there are few points along the time line where this is not true. At those points we have a large price change combined with a high volatility. This discontinuity in the return and volatility process means that not only changes are nonlinear, but also changes may not be normally distributed. The descriptive statistics in Tables 4.1 and 4.2 show to which extent what we said about Figures 4.1 and 4.2 can be verified.

Table 4.1 gives some statistics on the five time series. The daily annualized average return ranges 12.78% and 26.28%, and the daily annualized standard deviation ranges from 16.64% to 31.31%. Moreover, the Jarque-Bera[7] statistics show that returns are leptokurtic.

[7]Jarque-Bera is the goodness of fit measure of the departure from normality based on sample kurtosis and skewness. Its null hypothesis states that data are normally distributed.

Table 4.1. Summary statistics

	ABU	KUWAIT	MUSCAT	QATAR	SAUDI
Mean	0.035	0.063	0.036	0.072	0.044
Median	0.045	0.116	0.044	0.087	0.118
Maximum	7.629	5.047	8.039	9.422	9.391
Minimum	-8.679	-4.777	-8.699	-10.398	-10.328
Std. Dev.	1.248	0.871	1.074	1.561	1.639
Skewness	-0.089	-0.626	-0.756	-0.482	-0.902
Kurtosis	10.179	6.885	18.650	9.740	11.687
Jarque-Bera	5,067*	1,799*	27,347*	4,572*	8,937*
Observations (N)	2,358	2,591	2,655	2,367	2,725

One asterisk (*) means that the coefficient is significant at 5%.

Table 4.2 reports the autocorrelation coefficients of the time series.

Table 4.2. Simple and squared autocorrelation of the time series

	ABU	KUWAIT	MUSCAT	QATAR	SAUDI
Panel A: Simple Logarithmic Returns					
Lag 1	0.274	0.222	0.270	0.248	0.065
Lag 2	-0.019	0.045	0.031	0.029	-0.040
Lag 3	-0.014	0.055	-0.012	-0.011	0.043
Lag 4	0.010	0.088	-0.067	-0.026	0.035
Lag 5	0.023	0.087	-0.025	0.014	0.053
Lag 6	0.035	0.058	0.023	0.006	-0.015
Lag 7	-0.003	0.028	-0.020	-0.018	-0.051
Lag 8	0.020	0.039	-0.008	0.046	0.033
Lag 9	0.008	0.047	-0.024	0.003	0.015
Lag 10	0.002	0.065	0.027	0.000	-0.041
Ljung-Box Stat	307.370*	381.930*	450.650*	242.450*	121.230*
Panel B: Squared Logarithmic Returns					
Lag 1	0.369	0.287	0.527	0.322	0.244
Lag 2	0.272	0.281	0.410	0.288	0.291
Lag 3	0.228	0.269	0.360	0.274	0.336
Lag 4	0.209	0.222	0.307	0.257	0.193
Lag 5	0.175	0.171	0.284	0.174	0.306
Lag 6	0.180	0.177	0.219	0.123	0.263
Lag 7	0.172	0.168	0.187	0.195	0.210
Lag 8	0.210	0.111	0.212	0.219	0.226
Lag 9	0.097	0.137	0.191	0.185	0.225
Lag 10	0.090	0.149	0.187	0.252	0.222
Ljung-Box Stat	1,608*	1,616*	4,815*	2,813*	3,875*

One asterisk (*) means that the coefficient is significant at 5%.

Panel A of Table 4.2 shows that the five markets exhibit a positive first order autocorrelation coefficient suggesting that at any point in time the return at that time is strongly and positively related to the return at the previous time point. The Ljung-Box statistic for the simple returns shows that the null hypothesis[8] that returns are uncorrelated up to lag $N^{0.5}$ cannot be accepted for any of the five markets. Similarly, the Ljung-Box statistics for the squared returns reject the null hypothesis of the absence ARCH effects in the time series. Furthermore, the autocorrelation function of the squared returns decay slowly toward zero, suggesting that volatility is time-varying and persistent. Hence, Table 4.2 shows that returns and volatility are strongly correlated across the five stock markets.

4.2 -Modeling the Return Process

On the basis of the Auto-Correlation Function (ACF) of Table 4.2, we use the Auto Regressive Moving Average model of order 2 [ARMA (2, 2)] to estimate the parameters that characterize the return process.

$$r_{it} = \phi_0 + \phi_{11} r_{it-1} + \phi_{12} r_{it-2} + \varepsilon_t + \phi_{21} \varepsilon_{it-1} + \phi_{22} \varepsilon_{it-2} + \sum_j^5 \vartheta_j b_{ij,t}, \quad (1)$$

Where i is the stock market, ϕ_0 is the drift of r_{it}, ϕ_{11} and ϕ_{12} are the autoregressive coefficients measuring feedbacks in the return process, ϕ_{21} and ϕ_{22} are the moving average coefficient measuring feedbacks in the error term process, ε_t is the error term, $b_{ij,t}$ is an indicator variable for ENERGY, FUEL, GAS, ELECTRICITY and NUCLEAR, and ϑ_j are deterministic coefficients associated with $b_{ij,t}$. The indicator

[8] Null Hypothesis states that the data are independently distributed.

variable takes either 1 or 0, where $b_{ij,t} = 1$ when a bill falling in the five categories was introduced a day before in the US Congress.

Equation (1) is consistent with Table 4.2 showing that the return process of the five series exhibit historical patterns. Modeling the feedback effects of the return process yields an innovation process that is uncorrelated given all available information at time$(t-1)$, Ω_{t-1}. That is, the expected return of the error term equals zero, and the covariance between the error term at time t and the error term time $\mathrm{t}-1$ equals zero.

However, the modeling of (1) does not eliminate the clustering effect of the squared error terms given by ε_t^2. Neither does it convert the return process into a symmetric process. Therefore, at any point on the time line, the squared error at that time is a function of at least the squared error term at the previous point in time.

4.3 -Modeling the Variance Process

Let ε_t follow a fat-tail distribution since Table 4.1 shows that the normal distribution does not govern the process of the five time series. Many studies have shown that the Student's t-distribution fits quite well the process of the error term exhibiting GARCH effects (see for example, Wilhelmsson, 2006). With ε_{it} following a t-distribution with the number of degrees of freedom given by v the log-likelihood[9] is given by

$$l_{it}(\theta) = -\frac{1}{2} ln\left[\frac{\Gamma(v-2)\Gamma(v/2)^2}{\Gamma((v-2)/2)^2}\right] - \frac{1}{2} ln(\sigma_{it}^2)\left(\frac{(v+1)}{2}\right) ln\left[1 + \frac{\varepsilon_{it}^2}{\sigma_{it}^2(v-2)}\right], \qquad (2)$$

[9] The log likelihood identifies the parameters that are optimal in describing the mean and the variance process.

Where $\Gamma(.)$ is the gamma function, and σ_{it}^2 is the conditional variance given by

$$\sigma_{it}^2 = \omega + (\alpha + \gamma d_{it-1})\varepsilon_{it-1}^2 + \beta\sigma_{it-1}^2 + \sum_{j=1}^{5} \delta_j b_{ij,t} \varepsilon_{it-1}^2, \qquad (3)$$

where θ includes the coefficients of equation (1) and (3), $\mathrm{d_{it-1}}$ equal 1 for $\varepsilon_{it-1} < 0$ and 0 otherwise, ω is a positive coefficient associated with the unconditional variance, α is a positive coefficient associated with feedbacks in positive and negative squared errors, γ is a positive coefficient associated with feedbacks in negative squared errors, β is a coefficient associated with feedbacks in the conditional variance, δ_j are coefficients associated with feedbacks in policy-related squared errors, and $\mathrm{b_{ij,t}}$ is an indicator taking 1 when a bill is introduced in the Congress of the US and 0 otherwise.

Equation (3) is the asymmetric GARCH model of Glosten *et al*. (1993), which through γ measures to which past negative shocks increase variance. The model is augmented with an additional indicator, $b_{ij,t}$ serving the purpose of measuring the effects of bills on the conditional variance.

4.4 -Estimates of the Empirical Models

Table 4.3 reports the goodness of fit of models (1) and (3). Based on the Ljung-Box statistics on simple and squared standardized residuals, we examine whether the combination of (1) and (3) fits well the data. The simple standardized residuals are given by $\mathrm{z_{it}} = \varepsilon_{\mathrm{it}}/\sigma_{\mathrm{it}}$.

Panel A of Table 4.3 shows that regressing return on a constant, the five policy indicators, past returns and past innovations removes the historical patterns present in the logarithmic returns in four out of five cases. The Ljung-Box statistic under the null hypothesis of uncorrelated standardized residual is only rejected in the case of Qatar. This is probably because the jumps are not accounted for. Similarly, Panel B of Table 4.3 shows that the combination of the mean and the variance equation captures much of historical patterns in volatility, as we are unable to reject the null hypothesis based on the Ljung-Box statistic at lag 36.

With the goodness of fit of Table 4.3 our estimates of equations (1) and (3) are robust to serial correlation and heteroskedasticity. Table 4.4 reports the estimates of the mean and the variance model.

Table 4.3. The Autocorrelation Function of the Standardized Residuals

	ABU	KUWAIT	MUSCAT	QATAR	SAUDI
Panel A: Simple standardized residuals					
Lag 1	0.044	0.033	0.043	0.079	0.061
Lag 2	0.052	-0.024	0.026	0.050	-0.003
Lag 3	0.026	0.011	0.036	0.029	0.013
Lag 4	0.031	-0.002	0.028	0.021	-0.010
Lag 5	0.031	0.026	0.022	0.049	0.023
Lag 6	0.002	0.018	0.018	-0.003	-0.003
Lag 7	-0.011	0.000	0.036	0.017	-0.023
Lag 8	0.017	0.000	0.016	0.032	0.026
Lag 9	0.006	0.007	0.011	0.010	0.007
Lag 10	0.011	0.038	0.031	0.059	-0.018
Ljung-Box Statistic	52.062	43.930	49.466	76.715*	33.644
Panel B: Squared standardized residuals					
Lag 1	-0.008	-0.004	-0.002	-0.004	0.009
Lag 2	-0.012	-0.020	-0.008	-0.026	-0.004
Lag 3	-0.028	-0.002	-0.007	-0.026	-0.011
Lag 4	-0.015	-0.008	-0.012	-0.021	-0.013
Lag 5	0.004	-0.002	-0.013	-0.012	-0.010
Lag 6	-0.015	-0.013	-0.013	-0.027	-0.015
Lag 7	-0.016	0.011	-0.010	-0.025	-0.006
Lag 8	-0.018	-0.014	-0.010	-0.011	0.024
Lag 9	-0.017	-0.003	-0.005	-0.002	-0.020
Lag 10	0.003	0.020	0.026	0.003	0.003
Ljung-Box Statistic	25.116	18.480	8.636	26.574	31.816

One asterisk (*) means that the coefficient is significant at 5%.

The goodness of fit of our models can also be measured looking at v, the estimated parameter for the degree-of-freedom of the error term under the assumption the error term follows a t-distribution. The degree-of-freedom parameters range from 3.711 to 7.030, suggesting that the error terms are fat-tailed. A test on the standardized errors (which is not reported) reveals that they are not normally distributed. Despite the fact that the standardized error terms are not Gaussian, our estimates are still efficient and consistent, even though unstable.

Table 4.4. Estimates of the Augmented A-GARCH (1,1) model

	ABU	KUWAIT	MUSCAT	QATAR	SAUDI
	Mean Equation				
ϕ_0	0.092*	0.081*	0.093*	0.101*	0.056*
ϑ_{ENERGY}	-0.034	-0.028	0.009	-0.087	-0.057
ϑ_{FUEL}	-0.074	-0.075*	-0.080	0.047	-0.037
ϑ_{GAS}	-0.020	-0.022	0.162	-0.170*	0.087
$\vartheta_{ELECTRICITY}$	0.083	-0.015	-0.087	0.037	-0.011
$\vartheta_{NUCLEAR}$	0.162	0.035	-0.046	0.167	0.051
ϕ_{11}	0.720	1.200*	-0.062	0.933*	0.905*
ϕ_{12}		-0.203*	0.089		0.031
ϕ_{21}	-0.672*	-0.868*	0.417	-0.886*	-0.672*
ϕ_{22}		-0.128*	-0.006		-0.221*
	Variance Equation				
ω	0.015*	0.047*	0.019*	0.038*	0.022*
α	0.263*	0.085*	0.253*	0.429*	0.151*
γ	0.140*	0.249*	0.006	0.077	0.133*
β	0.756*	0.719*	0.757*	0.641*	0.814*
δ_{ENERGY}	-0.111	0.297	0.075	0.311	0.084
δ_{FUEL}	-0.219*	-0.002	-0.096	0.075	-0.115
δ_{GAS}	0.112	-0.165*	0.133	-0.354*	0.066
$\delta_{ELECTRICITY}$	0.077	-0.046	-0.026	0.133	-0.206*
$\delta_{NUCLEAR}$	0.426	0.213	-0.134	0.710	0.180
v	3.711*	7.030*	4.379*	4.273*	3.924*
Log likelihood	-2,965	-2,759	-2,638	-3,428	-3,996

ENERGY, FUEL, GAS, ELECTRICITY and NUCLEAR are policy-indicators. $v$is the degree of freedom of the error term in equation (2). One asterisk (*) means that the coefficient is significant at 10%.

We divide Table 4.4 in three parts. The first part reports the estimates of the mean equation. The second part reports the estimates of the traditional AGARCH (1,1) model. The third part reports the hypothetical estimates of our thesis.

The estimates of the mean equation show that a model ignoring past returns and past innovations will be misspecified. Consistent with Bley (2011), Table 4.4 shows that the GCC markets are slow at incorporating public available information. In addition, we find that including policy-indicators is not only beneficial in capturing some of the deterministic effects of returns, but also in removing some of the historical patterns in returns. We don't report it, but we find that whenever the policy-indicators were removed from equation (1), the autocorrelation coefficients of the standardized residuals increased.

The estimates of the AGARCH are in line with previous studies. The coefficients are positive, suggesting a strong momentum effect in volatility. Not only volatility is persistent, but it also asymmetric in three of five markets. The asymmetric effect is not fully investigated here, but the coefficients are large in the cases where they are significant. That is, negative news has greater impact on volatility than positive news of the same magnitude.

The significant estimates of the squared residuals associated with the policy-indicators are negative in all the cases. A negative estimate suggests that the volatility of the GCC market tends to increase when it was decreasing at the time the policy was introduced. This reversal pattern indicates that these markets adjust to information.

However, it is not a face value that $b_{ij,t}$ captures solely policy-related effects since $b_{ij,t}$ is not uniquely determined. The reversal pattern of Table 4.4 can be simply by coincidence. Any other effect can produce such a pattern. Furthermore, the AGARCH model is complicated by unstandardized residuals. While the policy-effects are diffuse, we can further investigate how significant are these effects in a model that regresses squared standardized residuals on the policy indicators, and past policy-based standardized residuals. Thus, we estimate the following model,

$$z_{it}^2 = \sum_{j=1}^{5} \vartheta_{1j} b_{ij,t} + \sum_{j=1}^{5} \vartheta_{2j} b_{ij,t} z_{it-1}^2 + e_{it}, \qquad (4)$$

where e_{it} is the error term. Table 4.5 reports the estimates of equation (4).

Table 4.5. Estimates of the standardized residual model

	ABU	KUWAIT	MUSCAT	QATAR	SAUDI
$\vartheta_{1\ ENERGY}$	0.375*	0.676*	0.456*	0.566*	0.513*
$\vartheta_{1\ FUEL}$	0.519*	0.418*	0.532*	-0.042	0.428*
$\vartheta_{1\ GAS}$	-0.195	0.456*	1.172*	-0.307*	0.355
$\vartheta_{1\ Electricity}$	0.267*	1.086*	0.974*	0.772*	0.123
$\vartheta_{1\ NUCLEAR}$	0.156	0.754*	0.642*	0.426*	0.802*
$\vartheta_{2\ ENERGY}$	0.070*	0.033	-0.072*	-0.036	0.178
$\vartheta_{2\ FUEL}$	-0.270*	0.100	0.050*	-0.057	-0.081
$\vartheta_{2\ GAS}$	0.158*	-0.076	0.217	0.153*	-0.139
$\vartheta_{2\ Electricity}$	0.073	-0.065*	-0.167	-0.063	0.180*
$\vartheta_{2\ NUCLEAR}$	0.539	-0.070	0.009	0.259	-0.258*

ENERGY, FUEL, GAS, ELECTRICITY and NUCLEAR are policy-indicators taking 1 or 0. One asterisk (*) means that the coefficient is significant at 10%, at least.

We estimate (4) using the Bollerslev-Wooldridge's Heteroskedasticity Consistent Covariance Matrix. The robust estimates of Table 4.5 are divided into two parts. Part I groups the deterministic effects of the policy-related indicators, and Part II groups the effects of the policy-related indicators through the squared standardized residuals. We found previously that the squared standardized residuals are uncorrelated. Therefore, repackaging these standardized residuals differently should not lead to a different result under the null hypothesis.

The deterministic effects of the policy-related indicators are in most of cases positive and significant, which suggests that these markets react to some kind of information on the days the bills on energy are introduced in the US. The five categories show that on the days when bills on energy are discussed in the Congress, the residuals tend to be large, even when the market specific variance is controlled for.

Signing past squared standardized residuals with the policy-related indicators and relating them to current squared standardized residuals shows that there is still some information in squared standardized residuals when we repackaged them differently. The significant coefficients are both negative and positive. Negative coefficients suggest that on days of news the variance tends to increase when in fact it was decreasing prior to the news, while a positive coefficient suggests that on day of news the variance tends to increase more when in fact it was already increasing prior to news.

Even though we find that when bills on energy policy are introduced and discussed in the Congress, the variance of the GCC markets tend either to revert or to accelerate, a number of other undetermined effects could have played a determinant role. However, whatever these effects could be and to which extent the bills on energy policy have dominant effects on these markets, we document in this thesis that the GCC market volatilities either revert or further increase coincidentally on these days.

CHAPTER 5

SUMMARY AND POLICY IMPLICATIONS

The purpose of this thesis was to investigate the impact of bills on energy policy in the US on the conditional volatility of selected GCC stock markets. We concentrate on bills that were introduced in the US Congress, even though these bills were not yet adopted. Using the bills at the introductory phase is consistent with the information and the learning hypothesis. Within the Asymmetric GARCH model, we find that bills introduced in the US Congress have an effect on the volatility of several GCC markets. Even though the volatility changes could not be solely attributed to the US energy policy, we document a significant change in volatility on days when bills on energy policy are introduced in the US Congress.

Given the link between the US policies on energy and the gulf markets, policy makers in the GCC region should show concerns about the measures adopted in the USA.

The USA is on a track to reduce its dependency on oil, and the frequency of the introduced bills in the Congress in this regard is lately increasing, which shows an increased and persistent support for such a goal.

If it succeeds in achieving this goal, it will gain a competitive advantage over other competing nations in the international arena. Therefore, other countries have already started to follow similar objectives.

Thus, the GCC policymakers should pay close attention to the achievements or breakthrough inventions in the field of alternative energy. In response, the GCC countries will have to adopt a long term policy that should aim at reducing their dependence on the revenues of oil to move the wheels of their economies.

CHAPTER VI

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