Pattern of Volatility Transmission with Regime Switching: CASE OF GCC

Pattern of Volatility Transmission with Regime Switching: CASE OF GCC

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Abstract

This paper examines volatility transmission patterns with seven stock markets of countries of the Gulf Cooperation Council (GCC), (Saudi Arabia, Kuwait, Bahrain, Oman, Qatar, Dubai and Abu-Dhabi), and these markets with the two global markets (S&P 500 index, and Oil-WTI prices), using the Multi-Chain Markov Switching (MCMS) model. This method is able to distinguish and differentiate between well diverse transmission patterns including volatility spillover, interdependence, and independence, given changes from high to low volatility regimes and vice-versa. The results display that there are different transmission patterns between the GCC and the global factors, and there is strong relationship between some of the GCC markets and the global equity markets rather than the oil markets. These patterns of volatility transmission are also highly sensitive to the regimes of the selected markets which are characterized by turmoil or tranquility. For the first global market (Oil-WTI), the results show a strong interdependence between Oil and S&p500, Kuwait, Abu-Dhabi, Dubai and Saudi Arabia markets. Furthermore, there is spillover from Oil-WTI to Abu-Dhabi, Dubai and Saudi Arabia markets. And the significant result display that there is independence between Dubai and Bahrain, and Kuwait and Dubai markets. For the second global market (the U.S. S&P 500 index), the results show strong interdependence with WTI, Dubai, Qatar and Oman. There is also spillover from the S&P 500 index to Kuwait, Abu Dhabi, Dubai and Bahrain. More remarkable result that we find spillover from Qatar to the S&P 500 index. Finally, we display results in terms of inference on the regimes of high and low volatility, allowing for the interpretation of the financial shocks and the dates in which they are transmitted from one market to another.

Keywords: GCC markets, Global Markets, Multi-chain MS model, Transmission

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Chapter One: Introduction

The major element of the cross volatility transmission pattern among Gulf Cooperation Council stock market – Saudi Arabia, Kuwait, UAE (Dubai and Abu Dhabi), Oman, Bahrain and Qatar is Information flow. For instance, Information on oil prices plays an essential role in impacting the GCC economies, influencing movement and volatility in their financial markets. The main oil producers in the world are the GCC countries. Saudi Arabia own one-third of the world's oil reserves. So, the oil prices are affecting the most of companies' profitability around the world and GCC economies. Therefore, their stock price indices also influenced by fluctuation in the oil markets.

Some of The GCC economies are very connected with the U.S. economy and this because of peg their exchange rates to the U.S. dollar. Information related to changes in the U.S. stock market also affects the stock markets in the GCC countries through their monetary policies to that of the United States, and having mutual foreign trade and investment relationships.

Information among the GCC markets may also flow through macroeconomic linkages which include cross-country trade and customs relationships, direct investment, interrelated portfolios, exchange rate regime coordination, and monetary and fiscal policy arrangements (Kim, Hammoudeh, & Alesia, 2012). In addition to these macroeconomic linkages, there are regional and international macroeconomic announcements that bring shocks to these countries, thereby directly affecting the volatility of their stock markets (Mensi, Hammoudeh, & Young, 2013). During normal and crisis periods, the volatility in the GCC stock markets acts differently, and this is because of their dependence on the booms and slumps in oil revenues and the role of government spending in pushing their economies to smooth out declines in oil proceeds, especially in the slump periods. Yet, those markets as a group frequently perform similarly but they have different degrees over the same periods. Furthermore, changes in the oil price can be an essential major cause or main source of volatility in some of these oil-based GCC markets. Therefore, the oil price volatility can have a major effect on the market interdependence or spillover across these GCC markets and others. A significant increase in the cross-market linkages after a shock or a change in regime is called as volatility transmission.

1.2 Problem Statement

Examine the types of linkages across the selected markets through estimating volatility transmissions across the GCC stock markets and other global factor.

1.3 Problem Question

How can we examine and analyze volatility transmission patterns for pairs of the Gulf Cooperation Council (GCC) countries and pairs of these markets with the two global factors (S&P 500 index, Oil-WTI prices).

1.4 Research Objective

Examine and differentiate between different mechanisms of volatility transmission dynamics for pairs of the Gulf Cooperation Council (GCC) countries and pairs of these markets with the two global factors (S&P 500 index, Oil-WTI prices).

1.5 Research Methodology

Following the Multi-Chain Markov-Switching model (MCMS,) this is introduced by Otranto (2005). Using this approach is to record the different volatility transmission mechanisms (spillover, interdependence, independence and co-movements) between seven GCC stock markets and two global factors (Oil market, the U.S. S&P 500 index).

1.6 Research Hypotheses

1. No spillover effect from second market to first market:

$$H0: \beta 1(1,2) = \beta 1(2,2) = 0$$

2. No spillover effect from first market to second market:

$$H0: \beta 2(2,1) = \beta 2(2,2) = 0$$

3. No interdependence

$$H0: \beta 1(1,2) = \beta 1(2,2) = \beta 2(2,1) = \beta 2(2,2) = 0$$

The hypotheses labeled 1, To 4, are the ones which characterize the relationships between markets. The various situations can be summarized as follows: Gallo and Otranto (2007)

Spillover: it occurs when hypothesis 1 cannot be rejected and hypothesis 2 is rejected or the other way around.

Interdependence: hypotheses 1. 2 and 3 are rejected.

Independence: it occurs when hypothesis 3 cannot be rejected

1.7 Significant Of Research

This research is very important for the investors and portfolio managers in the GCC countries and other countries, as they can be used in risk management and diversify their portfolio though different selective choice for diversification gain between the S&P500, WTI and GCC markets.

The rest of the paper is organized as follows. 2 review the existing literature and Section 3 discusses the methodology. Section 4 describes the data and Section 5 presents the empirical analysis of the results. Section 6 concludes the paper.

Chapter Two: Literature Review

There has been wide flow of the literature that usually examines volatility transmission and contagion spillover in many markets since the 1997 Asian crisis. Within the literature on The Gulf Cooperation Council (GCC) countries stock and oil markets, there are few studies that examine the movements of stock returns, volatility interdependence, volatility spillover and the co-movement. The literature in this study can be categorized into four groups. The first group focus on the international market, second group focuses on (GCC) market, and the third group focus the GCC markets relative to the international market and the fourth group focus on the international factors relative to the GCC market.

The first group is focus on the international markets. **Gallo and Otranto (2007)** analyze the stock market indices of 5 Asian countries which are the Hang Seng index (Hong Kong-HSI hereafter), the KOSPI index (South Korea-KS11), the KLSE composite index (Malaysia-KLSE), the Straits Times index (Singapore-STI), and the Thailand SET index (Thailand, SETI). Starting from daily data spanning a period between November 29, 1993 and April 26, 2004; the results show reasonable market characterizations over the long run with a spillover from Hong Kong to Korea and Thailand, interdependence with Malaysia and co-movement with Singapore. **Jammazi and Nguyen (2014)** investigate the relationships between oil price and Stock market cycles in five oil-dependent countries over the period from January 1989 to December 2007 .They use a Markov-switching EGARCH model. The data comprise of monthly returns on stock market indices of five major industrial countries, namely DJIA (United States), DAX30 (Germany), FTSE100 (United Kingdom), TSX (Canada), and NIKKEI225 (Japan). For crude oil, they used the monthly returns on two international price benchmarks: the West Texas Intermediate (WTI) and the Europe Brent. The results indicate that stock returns in all the considered markets exhibit a regime-switching behavior. The high-volatility regime is dominant in Canada and Japan, while the low-volatility regime appears in Germany, the United States and the United Kingdom. They also find that the conditional volatility of the studied stock markets was regime-dependent, but its responses to oil price shocks are not the same. **Sukcharoen, Zohrabyan, Leatham, and Ximing Wu (2014)** study the relationship between the oil price and stock market index of numerous countries between 1982 and 2007 by using copula model. The data use in this study included daily oil price series, exchange rates, and industry price indices, as well as their respective market values, from both developed and developing countries. The countries consider in their study include Canada, French, Germany, Hong Kong, Italy, Japan, Netherlands, Switzerland, United Kingdom, United States, China, Czech Republic, Finland, Hungary, Poland, Russia, Spain, and Venezuela. The results show a weak dependence between oil prices and stock indices for most cases, which are consistent with the results from previous studies. Exceptions are for the stock index returns of large oil consuming and producing countries (United States and Canada), which are shown to have a relatively strong dependence with the oil price series.

The second group which is dealing with the GCC markets, **Assaf (2003)** study the dynamic interactions among stock market returns from six (GCC) countries (Bahrain, Kuwait, Oman, Qatar, Saudi Arabia and United Arab Emirates), throughout weekly period from January1997 to April 2000. He uses vector autoregressive analysis (VEC) models, and he finds the following: (1) there is a strong evidence of interdependence among GCC stock; and also (2) there was a correlation effect within the GCC markets. **Nekhili and Muhammad (2010)** study the volatility spillovers among Gulf Arab emerging markets using Multivariate VAR-GARCH model. They use daily closing prices for GCC indices for the period January 6, 2003 to January 1, 2009. The results showed high own-volatility spillovers. **Almohaimeed and Nizar (2013)** investigate the volatility transmission effect and conditional correlations among crude oil, stock market and sector stock indexes in Saudi Arabia (Banking, Telecom, Industrial and Cement.). They used daily data from January 3, 2009 to March 21, 2012 .they applied VAR-BEKK model, the results show significant volatility transmission between oil prices and Saudi stock market. Also, the results show that the sector stock returns significantly react to oil prices changes. In the third group which is dealing with the GCC markets relative to the international market. **Arouri and Nguyen (2011)** investigate the dynamic connections through the stock markets of the Gulf region and the world stock market using a multivariate dynamic conditional correlation GARCH model (DCC-GARCH). Data are gathering from June 2, 2005 to April 2, 2008. The results show that there is a significant co-movement among the Gulf markets, but these co-movements are still small. This result indicates a weak linkage between the stock markets of this region. Also the relations between Arab markets and the world market are smaller and insignificant. **Fayyad and Daly (2011)** investigate the relationship between oil price and stock market returns for seven countries (Kuwait, Oman, UAE, Bahrain, Qatar, UK and USA) by applying the Vector Auto Regression (VAR) analysis. They use daily data from September 2005 to February 2010. The results show the following: (1) the predictive power of oil for stock returns increased after a rise in oil prices and during the Global Financial Crises (GFC) periods. (2) The impulsive response of a shock to oil increased during the GFC period. (3) Qatar and the UAE in GCC countries and the UK in advanced countries showed more responsiveness to oil shocks than the other markets in the study. **Bouri and Azzi (2014)** they apply a multivariate model to reveal the dynamic mean and volatility interdependence across the markets of Morocco, Tunisia, Egypt, Lebanon, Jordan, Kuwait, Bahrain, Qatar, United Arabic Emirates (UAE), Saudi Arabia and Oman from June 2005 to January 2012. The Results show that, the Arab Middle East and North African equity markets are interconnected by their volatilities and not by their returns, which makes risk reduction possible.

In the fourth group which is dealing with the international factors relative to the GCC market, **Hammoudeh and Choi (2006)** examine the relationships among five GCC stock markets and their relations to three global factors – the WTI oil spot prices, the US 3-months Treasury bill rate, and the S&P Index. They use vector-error correction (VEC) model with weekly data from February 15, 1994 to December 28, 2004. The results show that there is interdependence between oil and the GCC markets. And the oil price is the main factor that affects the GCC markets. **Arouri, Lahiani and Nguyen (2011)**, investigate the return linkages and volatility transmission between world oil price and stock markets in (GCC) countries (Bahrain, Kuwait, Oman, Qatar, Saudi Arabia, and UAE) over the period 2005-2010 by using VAR-GARCH model, their results show the existence of substantial return and volatility spillovers between world oil prices and GCC stock markets. **Khalifa, Hammoudeh and Otranto (2012)** examine the volatility transmissions across (GCC) stock markets and the linkages between these markets and the United States stock and oil markets, using the Multi-chain Markov Switching model. They used weekly data over the period spanning January 5, 2004 to March 7, 2011. The results show a strong interdependence between the oil price, the U.S. S&P 500 index, Saudi Arabia and Abu Dhabi. There is also a strong spillover from the U.S. S&P 500 index to Oman and Kuwait, but interdependence with Dubai.

Awartani and Maghyereh (2013) investigate return and volatility spillover effects between the oil market and the GCC stock markets, they use weekly returns of West Texas Intermediate (WTI) oil future prices and the GCC stock indices from the 2nd of January 2004 to the 30th of March 2012. The results indicate that, return and volatility transmissions are bidirectional, albeit asymmetric. In particular, the oil market gives other markets more than it receives in terms of both returns and volatilities. The empirical evidence from the sample is consistent with a system in which oil is playing the dominant role in the information transmission mechanism between oil and equities in the GCC countries. **Jouini (2013)** investigate the long-run links between stock markets of the GCC and three global factors, comprising oil price, MSCI (Morgan Stanley Capital International) world index and US interest rate using weekly data from June 7, 2005 to October 21, 2008. The results show that the global factors have predictability effect on most GCC stock markets. **Jouini and Harrathi (2014)** discover the empirical evidence of the volatility interactions among (GCC) stock markets and world oil price over the weekly period start from June 24, 2005 to March 25, 2011, they use BEKK-GARCH model. Their findings show evidence of shock and volatility linkages among GCC stock and oil markets, and reveal that the spillover effects are more apparent for volatility patterns. They also indicate that the stock and oil markets exhibit asymmetry in the conditional variances.

Khalifa, Hammoudeh and Otranto (2014), examine volatility transmission patterns for pairs of six stock markets of countries of the GCC and pairs of these markets with the three global markets (S&P 500 index, Oil-WTI prices and MSCI-world),using the Multi-chain Markov Switching model. They used weekly data over the period from January 5, 2004 to March 7, 2011. The results show a strong interdependence between the oil price, the U.S. S&P 500 index, Saudi Arabia and Abu Dhabi. There is also a strong spillover from the U.S. S&P 500 index to Oman and Kuwait, but interdependence with Dubai. **Rehman & Hazazi (2014)** examine the existence of linkages between Saudi Stock Market Index (TASI) and the most important stock markets indices, namely, US, UK, Japan and (GCC). Data are collated on a weekly basis from

01/07/2004 to 31/12/2008 for the Period-I (This phase cover substantial economic boom period in Saudi Arabia) and from 01/01/2009 to 31/07/2013 for the Period-II (This duration summarizes major restructuring in the Saudi stock market sectors). Significant tests are used in the study, namely, the Pearson Correlation, Unit root, Johansen Co-integration, and Pairwise Causality tests. The results reveal that volatility of TASI returns have decreased over the years and the correlations between the stock markets have increased.

Rizvi and Masih (2014) investigate the correlation of international oil price shocks to the GCC capital markets. The data is taken from December 17th 2003 up to October 21st 2011 with 2048 observations of daily returns Brent crude oil and the equity indices of the six GCC member countries. They use discrete wavelet analysis (DWT) and the continuous wavelet analysis (CWT). Their findings are summarized country by country: Kingdom of Saudi Arabia: In case of an oil price shock, there is no determinable effect on the investments in the Saudi Stock Market in the short and the longer lag period. Bahrain: Any Oil price shock would be transmitted to Bahrain Stock market. Qatar: Post 2009, once the Qatar economy has started opening up to foreign investors, there are signs of a lead lag relationship between oil price shocks being transmitted to the Oil stock market. There are also strong signs of long term impact of oil price shocks as well. United Arab Emirates: Oil Price Shocks do not have a definite lead lag relationship with the local stock market.

Chapter Three: Research Methodology

GARCH family models are used in many studies to estimate the volatility spillover over financial markets. But, there are two points must be mentioned this regard. The First point, the conditional variance of returns which is considered as a proxy of volatility that is not observable can be estimated by the GARCH models. This measure is accurately linked to the squared returns. The latest econometric literature has suggested numerous measures of volatility, which needs for its computation a large collection of daily data Khalifa, Hammoudeh and Otranto (2014). The best alternative measure is the weekly range, as suggested in Parkinson (1980), Brunetti et al. (2003), and Brunetti and Lildholdt (2005). This measure does not need so much effort in computation as the realized volatility does.

The second point, choosing MCMS approach is a useful technique because of two important reasons. The First reason MCMS is consider the changes in the regimes of the volatility transmission patterns. The Second is analyzing the interactions between the selected markets. Furthermore, it provides the possibility to verify the different types of volatility transmission (spillover, interdependence, independence and co-movements) by classical statistical tests Khalifa, Hammoudeh and Otranto (2014). Therefore, we use this model (MCMS) which introduced by Otranto (2005) to examine and distinguish between different mechanisms of the volatility transmission dynamics. There are several studies based on MCMS model such as, (Otranto, 2005; Gallo and Otranto, 2007 and Gallo & Otranto, 2008), and their findings of those studies document that the MCMS model has better prediction performance than the VAR and other conventional MS models. As indicated, the MCMS model can differentiate between numerous inter-market linkages such as spillover, interdependence, independence and co-movement under different regimes, while other models do not.

In this context, we examine market characterizations depending on the following definitions. Spillover is a situation in which a switch in regime of a dominating market leads to a change in regime in the dominated market (with a lag). Interdependence is a situation in which a switch in regime of one of the markets leads a change in regime of the others. The volatility co-movement, on the other hand, is characterized by a contemporaneous change in regime of the markets. The volatility co-movement, on the other hand, is a contemporaneous change in regimes across markets. It is essential to note that the spillover, interdependence and co-movement relationships is not refer to the single period, however it is refer to the full time interval analyzed Khalifa, Hammoudeh and Otranto (2014).

3.1 The Model Specification

Let y_t be an n $n \times 1$ multivariate time series observed for n different variables. We suppose that it follows a VAR process:

$$y_t = \mu(s_t) + \sum_{m=1}^{p} \Phi(s_t) y_{t-m} + \varepsilon_t \qquad 3.1$$

$$\varepsilon_t \sim N \left\{0, \sum(s_t)\right\}$$

The vector μ_{s_t}contains n constants and is indicized by a multiple random variable $S_t = (s_{1,t}, s_{2,t}, . . . , s_{n,t})$. We call this variable the multiple regime (or multiple state) at time t. The univariate random variable $s_{j,t}$ (j = 1, . . . , n) represents the state at time t for the variable j and can assume k possible values; for the sake of simplicity we suppose k = 2 and denote these states by 0 and 1 (the extension to a generic k is simple but cumbersome in the notation). The difference with respect to the multivariate MS model is that the realization at time t of the dichotomous variable $s_{j,t}$ can be different from the realization of sit (i ≠ j). Otranto (2005)

The n × n matrix B = {β_{ij}} (i, j = 1, . . . , n) is a matrix of coefficients with elements on the diagonal equal to one. In practice, the intercept of the variable $y_{j,t}$ contained in the vector y_t, is equal to

$$\mu_{sj,_t} + \beta_{j1_{\mu_{s1,t}}} + \cdots + \beta_{jn}\mu_{sn,t}$$

in which it is possible to separate an 'autonomous' intercept $\mu_{s_{jt}}$ from the effect due to the other variables. Φ_h (h = 1, . . . , p) is a matrix of unknown coefficients. The *n*-vector of disturbances ε_t is uncorrelated along the time but correlated across the variables, to take into account their mutual influence. We suppose that ε_t is normally distributed with mean 0 and covariance matrix:

$$\Sigma(s_t) = \begin{bmatrix} \sigma_1^2(s_{1,t.}\ \cdot) & \rho(s_{1,t}, s_{2,t})\sigma_1(s_{1,t},\cdot)\sigma_2(\cdot, s_{2,t}) \\ \rho(s_{1,t}, s_{2,t})\sigma_1(s_{1,t},\cdot)\sigma_2(\cdot, s_{2,t}) & \sigma_2^2(\cdot, s_{2,t.}) \end{bmatrix} \qquad 3.2$$

In the variance-covariance matrix, the variances of each variable depend only on the variable's own state. The parameter $\rho(s_{1,t}, s_{2,t})$ denotes to the correlation coefficient between the two markets at a certain state $s_t = (s_{1,t}, s_{2,t})'$.This specification indicates that volatility is transmitted from one market to another, furthermore it is causing some changes in the covariance structure, while the movements in the variance depend just on the own state Otranto (2005).

The multi-chain Markov-Switching model has a major feature which is, the variables depend on separate but potentially related state variables. Practically, the state of variable $y_{1,t}$ can be made to depend on the lagged states of the other variable $y_{2,t}$ and vice versa. The change in the state of one variable can be transmitted to the other variable, because transition probability matrix captures the volatility transmission mechanism among the variables. In detail, let us consider a two-asset, two-state and two-lag model (p = 2). The state vector s_t can take one of four possible value pair of two assets at time t $(0,0),'$ $(0,1),'$ $(1,0),'$ $or(1,1)$ at anytime $0 \leq t \leq T$, where the first number of each cell is denotes to the state of the first asset and the second number denotes to the state of the second asset. So the interpretation of the two states will be, $s_t = (1,0),'$ and that is mean the first asset is in a high volatility state at time t, while the second asset is in the low volatility state.

The transition probability matrix $p = \{pr\ [s_t|s_{t-1}]\}$ is a 4 × 4 matrix and s_t is a vector. We also suppose that conditional on$(s_{t,t-1}, s_{2,t-1})$, the two states $s_{1,t}$ and $s_{2,t}$ are independent. That is

$$pr\left[s_{1,t,}\ s_{2,t}\middle|s_{1,t-1,}\ s_{2,t-1}\right] = pr\left[s_{1,t}\middle|s_{1,t-1,}\ s_{2,t-1}\right] \times pr\left[s_{2,t}\middle|s_{1,t-1}\,,s_{2,t-1}\right] \quad (3.3)$$

We can parameterize the right-hand side of equation 3.3 with logistic functions where each function explicitly depends on past states: Otranto (2005).

$$pr\left[s_{1,t} = h\middle|s_{1,t-1} = h, s_{2,t-1}\right] = \frac{exp\left[\alpha_1(h,.)+\beta_1(h,1)s_{2,t-1}\right]}{1+exp\left[\alpha_1(h,.)+\beta_1(h,1)s_{2,t-1}\right]} \quad (3.4)$$

$$pr\left[s_{2,t} = h\middle|s_{1,t-1}, s_{2,t-1} = h\right] = \frac{exp\left[\alpha_2(.,h) + \beta_2(1,h)s_{1,t-1}\right]}{1 + exp\left[\alpha_2(.,h) + \beta_2(1,h)s_{1,t-1}\right]}$$

For h = (0, 1) on the other word, 0= low volatility regimes and 1= high volatility regimes. In equation 3.4 the parameters $\alpha_1(h,.)$ and $\alpha_2(.,h)$ are the constants of the logistic function. Also we can note that coefficient $\beta_1(h,1)$ measures the influence of state of second market at time $t-1$ on the probability of the first market to stay in state h. likewise, $\beta_2(1,h)$ measures the influence of the state of the first market at time $t-1$ on the probability of second market to stay in state h. In this way, the estimation of the probabilities in equation 3.4 displays how the transition probabilities for the first market change according to the regime of the second market and vice versa. Therefore, the transition probability matrix makes the probability of staying at the same state for asset I (I=1, 2) conditional on the previous states of both assets.

Because each asset has only two states, the probabilities of switching to another state can be estimated by the following equation:

$$pr\left[s_{j,t} = k \middle| s_{j,t-1} = h, s_{i,t-1}\right] = 1 - pr\left[s_{j,t} = h \middle| s_{j,t-1,} s_{i,t-1}\right] \tag{3.5}$$

For $h, k = 0, 1$ where $h \neq k$ and $i, j = 1, 2, i \neq j$. Thus, the 4×4 transition probability matrix will be as follows:

$$\begin{bmatrix} p(00|00) & p(01|00) & p(10|00) & p(11|00) \\ p(00|01) & p(01|01) & p(10|01) & p(11|01) \\ p(00|10) & p(01|10) & p(10|10) & p(11|10) \\ p(00|11) & p(01|11) & p(10|11) & p(11|11) \end{bmatrix}$$

Where, for example, $p(00|00)$ means $pr(s_{1,t} = 0, s_{2,t} = 0 | s_{1,t} = 0, s_{2,t-1} = 0)$.Now we have a model of equations 3.1 and 3.2 and equations (3.3, 3.4 and 3.5) that can be estimated together in order to investigate the volatility dependence/independence structure, using a battery of tests.

Some estimation problems could arise if some event is never verified in the data analyzed. For example, if there are not events satisfying$\left(s_{1,t} = 0 \middle| s_{1,t-1} = 0, s_{2,t-1} = 1\right)$, one of the two parameters in the first equation in 3.4 is not identified. In this case, it is convenient to put $\alpha_1(1,.)$ identically equal to a very small value (for example, -10) and to estimate only $\beta_1(1,1)$, so that $p\left(s_{1,t} = 0 \middle| s_{1,t-1} = 0, s_{2,t-1} = 1\right) = 0$ and $p\left(s_{1,t} = 1 \middle| s_{1,t-1} = 0, s_{2,t-1} = 1\right) = 1$. In this case, we say that the spillover effect is present from the second variable to the first one and it is deterministic. The existence of statistical significance of all parameters in equation 3.4 will provide evidence in favor of the case of interdependence. If the coefficient $\beta_1(h,1)=0$ but $\beta_2(1,h)=$ is different from zero, then the state of second market at time $t-1$ does not influence the probability of first market to stay in the same regime, but not vice versa. This is evidence in favor of the dominant status of first market or a spillover from First market, and thus shows an asymmetric relationship between the markets.

At the end, the non-significance of all the coefficients $\beta_1(h,1)$ and $\beta_2(h,1)$ would display evidence for independence between markets. The statistical significance of $\alpha_1(h,.),\alpha_2(.,h),\beta_1(h,1),\beta_2(h,1)$ are used together to test the co-movements between the two markets.

We follow the approach developed in Gallo and Otranto (2008) to evaluate the nature of the dependency of the two markets after estimating the model. Specially, we verify the following four null hypotheses, using the classical Wald statistics Gallo & Otranto (2008).

1. No spillover effect from second market to first market:

$$H0\colon \beta 1(0,1)=\beta 1(1,1)=0$$

2. No spillover effect from first market to second market:

$$H0\colon \beta 2(1,0)=\beta 2(1,1)=0$$

3. No interdependence

$$H0\colon \beta 1(0,1)=\beta 1(1,1)=\beta 2(1,0)=\beta 2(1,1)=0$$

The hypotheses labeled 1, To 3, are the ones which characterize the relationships between markets. The various situations can be summarized as follows: Gallo and Otranto (2007)

Spillover: it occurs when hypothesis 1. Cannot be rejected and hypothesis 2. is rejected or the other way around.

Interdependence: hypotheses 1. 2. and 3 are rejected.

Independence: it occurs when hypothesis 3 Cannot be rejected

Finally, the main characteristic of the Markov-switching models is the possibility to derive smoothed probabilities of the states to make inference on the latent bivariate variable$s_t = (s_{1,t\,,}\, s_{2,t})'$.

Using the Hamilton filtering and smoothing (see, for example Hamilton, 1994), it is possible to estimate for each time *t* the probability of a certain state $i (i = 0{,}1)$ conditional on the full data set. Generally, the probabilities are close to 0 or 1 if the model has a good fitting, so we can assign each observation to a certain regime or to another.

In particular, for the MCMS model, we will get the (smoothed) probabilities of each state, $p(s_{1,t} = i, s_{2,t} = j|I_T), (i, j = 0{,}1)$ where (I_T) represents the full information available. To obtain the probabilities of the state of a single variable, it will be sufficient to sum up over all the probability values of the other variable. For example, if we are interested in the smoothed probabilities of the first variable Otranto (2005), it will be obtained as

$$Ps_{1,t=}i|I_T = P(s_{1,t} = i, s_{2,t} = 0|I_T) + P(s_{1,t} = i, s_{2,t} = 1|I_T)\ (i = 0{,}1).$$

Chapter Four: Data and Descriptive Statistics

We investigate the historical features of the stock market indices of the seven GCC markets {Saudi Arabia (SASEIDX Index), Kuwait (KWSEIDX Index), Bahrain (BHSEASI Index), Oman (MSM30 Index) , Qatar (DSM Index) , Dubai (DFMGI Index) and Abu-Dhabi (ADSMI Index)}, and the two global factors (the light crude oil WTI, and the U.S. S&P 500 index), using weekly data from January 15, 2005 to March 15, 2015 ,(518 observations). The data was taken from Bloomberg and used R program for data analysis. Using the weekly data make researcher to get over the problem of different time zones between the stock market of the GCC countries, the Oil-WTI (the light crude oil), and the United States' S&P 500 index and to also have suitable time for regime-switching to occur than the daily data do Khalifa, Hammoudeh and Otranto (2014).

The GCC indices are the Saudi Arabian Tadawul All-Share Index (Saudi Arabia-TASI, hereafter), the Kuwait Stock Exchange Index, (Kuwait-SE), the Dubai General Index (Dubai-DFM), the Abu Dhabi General Index (Abu Dhabi-ADX), the Qatar Doha Securities Market (Qatar-QD), the Oman MSM30 Index (Oman-MSM30),and Bahrain All Share Index (BAX). Whenever a market becomes more unstable and its shocks are transmitted to other markets, the choice of using weekly frequency is always essential in identifying the direction of a temporal relationship. The development of the nine time series under consideration is shown in Figure.1 and Figure 2, which display several peaks describing the high volatility periods (financial crisis) which have short period, in contrast to the longer periods of low volatility. The figures also display the existence of identical pattern for the markets during the period of the financial crisis 2007–2011 which displays a high volatility period starting in 2008/2009 and pattern of symmetric peaks and bottoms across markets.

Fig.1. Evolution of volatility proxy or Oil, U.S.S&P 500 Index and the GCC markets over the full period

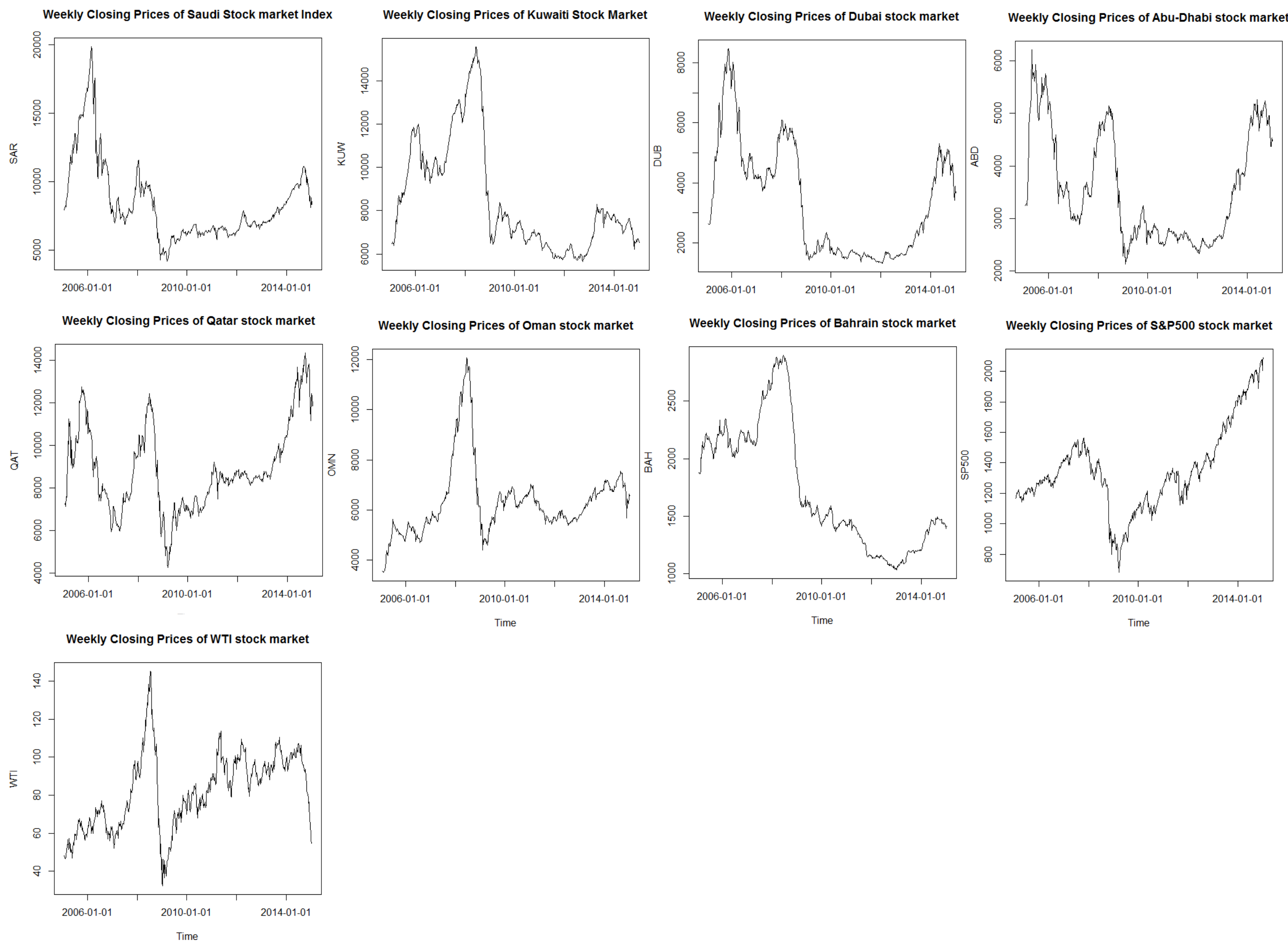


Fig.2. Evolution of return proxy or Oil, U.S.S&P 500 Index and the GCC markets over the full period

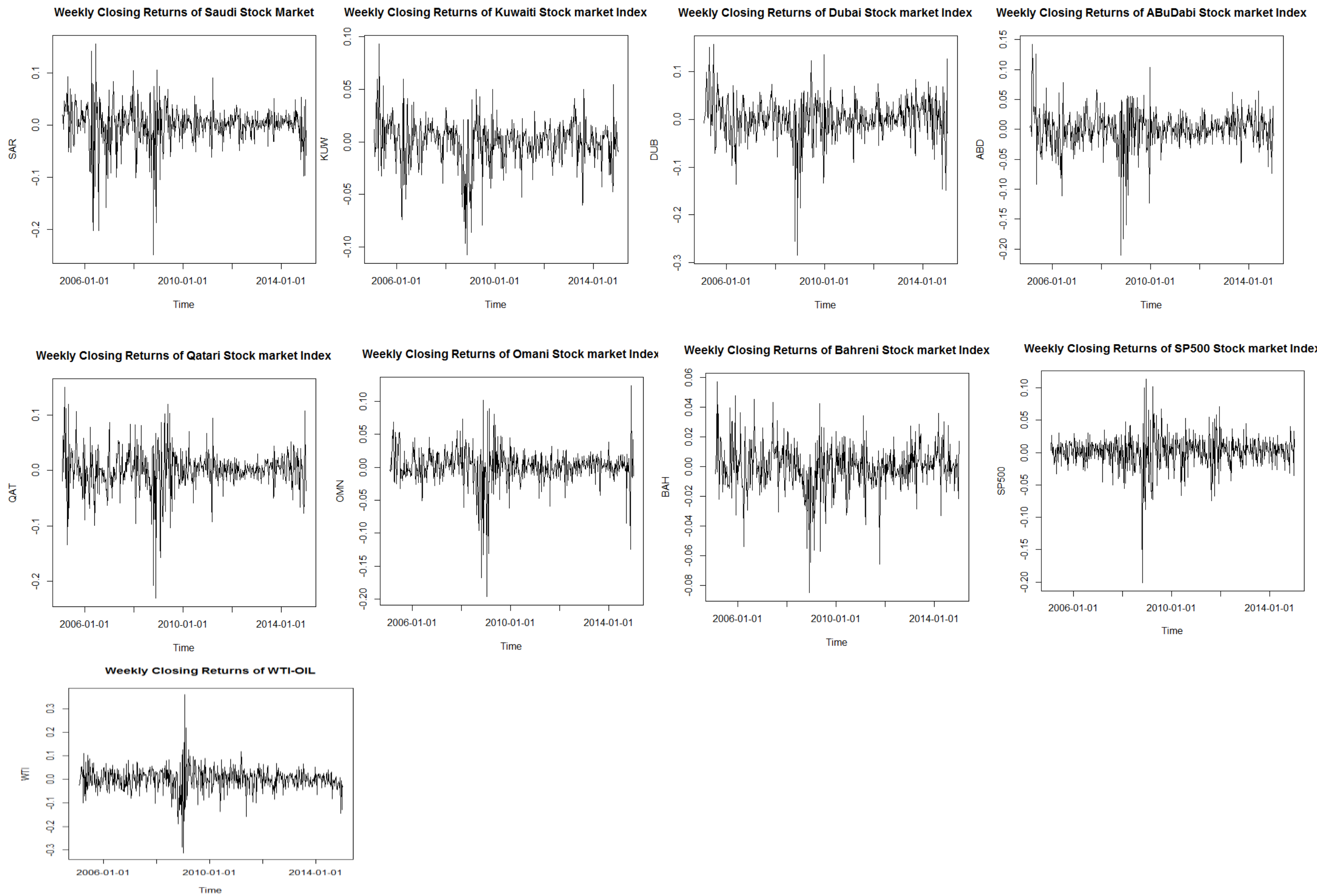


Table 1 display the correlation between the markets and as it show below there is strong connection between the GCC market and the global factors.

Table.1. correlation between the selected markets

	SAR01	KWT	DUB	ABU	QTR	OMN	BHN	S_P500	WTI
SAR01	1	0.4642	0.8683	0.7663	0.5567	-0.0582	0.4548	0.2270	-0.1285
KWT	0.4642	1	0.7387	0.5380	0.1879	0.5583	0.9157	0.0160	0.0728
DUB	0.8683	0.7387	1	0.8740	0.5796	0.2245	0.7246	0.2759	-0.0852
ABU	0.7663	0.5380	0.8740	1	0.7967	0.3140	0.5106	0.4435	0.0928
QTR	0.5567	0.1879	0.5796	0.7967	1	0.3776	0.0861	0.6791	0.4707
OMN	-0.0582	0.5583	0.2245	0.3140	0.3776	1	0.4018	0.2440	0.6844
BHN	0.4548	0.915	0.7246	0.5106	0.0861	0.4018	1	-0.1661	-0.1660
S_P500	0.2270	0.0160	0.2759	0.4435	0.6791	0.2440	-0.1661	1	0.4653
WTI	-0.1285	0.0728	-0.0852	0.0928	0.4707	0.6844	-0.1660	0.4653	1

Table.2 shows the main descriptive statistics of the series. By observing the full period, we can notice a clear evidence of the existence of asymmetric patterns, especially during the financial crisis 2008 till 2009, through the observed facts in Table 2. Also we can see the skewness, with very high peaks clearly appear if we make comparison between the maximum values with the medians and the minimum values. Furthermore, we can observe that the observation is not normal distribution and that is clearly appearing from the significance of the Jarque – Bera test, the p vale is less than 0.05, and by the large kurtosis values.

Table 2 . Descriptive statistics of the volatility proxies over selected periods.

Statistic	SAR01	KWT	DUB	ABD	QTR	OMN	BHN	S_P500	WTI
Mean	9.45E-05	1.73E-05	0.000641	0.000622	0.000943	0.001180	-0.000548	0.001122	0.000240
Median	0.004834	0.002736	0.002445	0.002656	0.002098	0.001885	-0.000222	0.002324	0.002801
Maximum	0.155363	0.093126	0.156550	0.142059	0.150120	0.123794	0.056981	0.113559	0.359391
Minimum	-0.248982	-0.107237	-0.283905	-0.209986	-0.229730	-0.196173	-0.084813	-0.200837	-0.312180
Std. Dev.	0.040628	0.021672	0.043813	0.032039	0.038062	0.028054	0.015357	0.025552	0.051883
Skewness	-1.556492	-0.863967	-1.110263	-1.070258	-0.745786	-1.551003	-0.589480	-0.981664	-0.310451
Kurtosis	10.23825	6.571849	9.519092	10.99614	8.856176	13.72923	6.958837	12.22419	11.87395
Jarque-Bera	1339.956	339.8050	1023.682	1478.891	788.2143	2692.281	368.2622	1919.630	1707.944
Probability	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
Sum	0.048949	0.008985	0.331805	0.321997	0.488699	0.611035	-0.283918	0.581394	0.124360
Sum Sq. Dev.	0.853369	0.242819	0.992404	0.530709	0.748972	0.406892	0.121921	0.337563	1.391664
Observations	518	518	518	518	518	518	518	518	518

One of the essential feature of the MCMS approach for the full time period is that the existence of the structural breaks at different time periods and that is captured by a switch in the regime (with high probability), with the probability of evaluating whether this switch is contemporaneous or one series leads the other series. This will show clearly by analyze the smoothed probabilities in the next section.

Chapter Five: Empirical Results

We discuss in this section the relationships between the nine selected markets, and the inferences on the two regimes through the period from January 15, 2005 to March 15, 2015.

5.1 Bivariate relationships between Oil, S&P 500 Index and GCC variables

In the first global factor (Oil-WTI), there is bivariate interdependence between WTI and each of the S&P 500, Kuwait and Abu Dhabi, Saudi Arabia markets. Also, there is a spillover from the Oil to Dubai, Saudi Arabia and Abu Dhabi. And there is independence between Dubai and Bahrain, Kuwait and Dubai markets. This result indicates a weakening of the oil-domestic equity nexus for these GCC countries because of diverse reasons. In Qatar, the Qatar Investment Authority intervenes in the domestic market to prop up stock prices. In Bahrain, investors borrow from banks to buy stocks regardless of the oil price. Oman is not a major oil producer or exporter but receives financial support from the rich GCC countries. However, the oil-domestic market result contradicts Khalifa, Hammoudeh and Otranto (2014), who find independence between oil prices and GCC stock markets such as Saudi Arabia and Oman. These finding is supported by other studies in the literature (e.g., Arouri & Nguyen, 2011). The thesis's result are confirm with Hammoudeh, Yuan, and Smimou (2008), Malik and Hammoudeh (2007), Hammoudeh and Choi (2007) and Hammoudeh and Aleisa (2004) who discover interdependence between oil prices and GCC stock markets. It is well known that oil is the most important factor in the GCC economies and any change in the oil price will affect the GCC macro-economy but not necessary all GCC stock markets. General, our results send a strong signal to the portfolio managers of the weakening in the oil-GCC stock market nexus for some GCC markets including Oman, Qatar and Bahrain. These markets are highly segmented, dominated by inactive stocks and do not always reflect regional or global factors because of government interventions. Our conclusion thus refers to the possibility of combining oil and some GCC indices in the same portfolio to decrease risk exposure.

With respect to the second global market (the S&P 500 index) and the bivariate relationships with the GCC markets are different from those for the oil market. There is spillover to the Kuwait and Oman markets. There is interdependence between the S&P 500 and each of the WTI, Saudi Arabia, Dubai and Abu Dhabi markets.

Several implications can be drawn from the results provided above. The first implication is that the global markets matter. Our results show more diverse transmissions between each of the Oil-WTI, the U.S. S&P 500 index and each of the GCC markets than what is provided in the literature. The GCC markets are influenced by common global economic factors (e.g business cycle phases) through the interdependence with the global markets such as Oil, U.S. S&P500. This means that if there is a slowdown in the global economy, this will be reflected in a down turn in the U.S. S&P500 index, a decline in the demand for oil and consequently leading to a negative impact on Kuwait, Saudi Arabia and Abu Dhabi stock markets. *Any decrease in the oil price may have a negative or a slowdown impact on the macroeconomic performance of the GCC countries and this impact is noticeable through the historical data. Which means that scholars should distinguish between the impact of the oil price on the stock markets and the macroeconomic performance of those countries Khalifa, Hammoudeh and Otranto (2014),* The second implication is that there is a selective choice for diversification gains between the WTI, U.S. S&P 500 and the GCC markets, which is consistent with previous studies despite the increased sensitivity of the GCC markets to global shocks over time. However the diversification opportunities differ according to state of the financial market.

Fig.3. WTI with GCC market

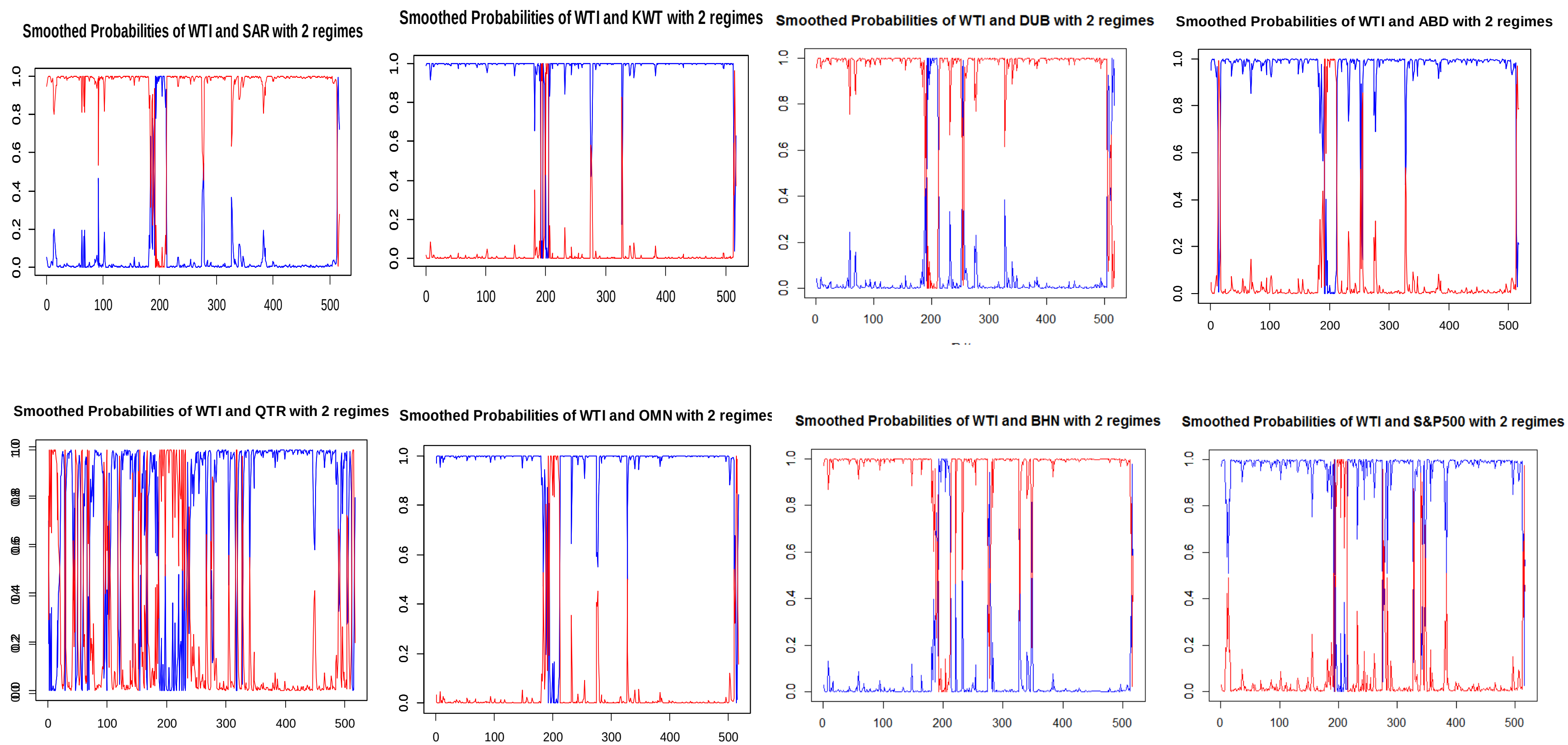


Fig.4. S&P500 with GCC market

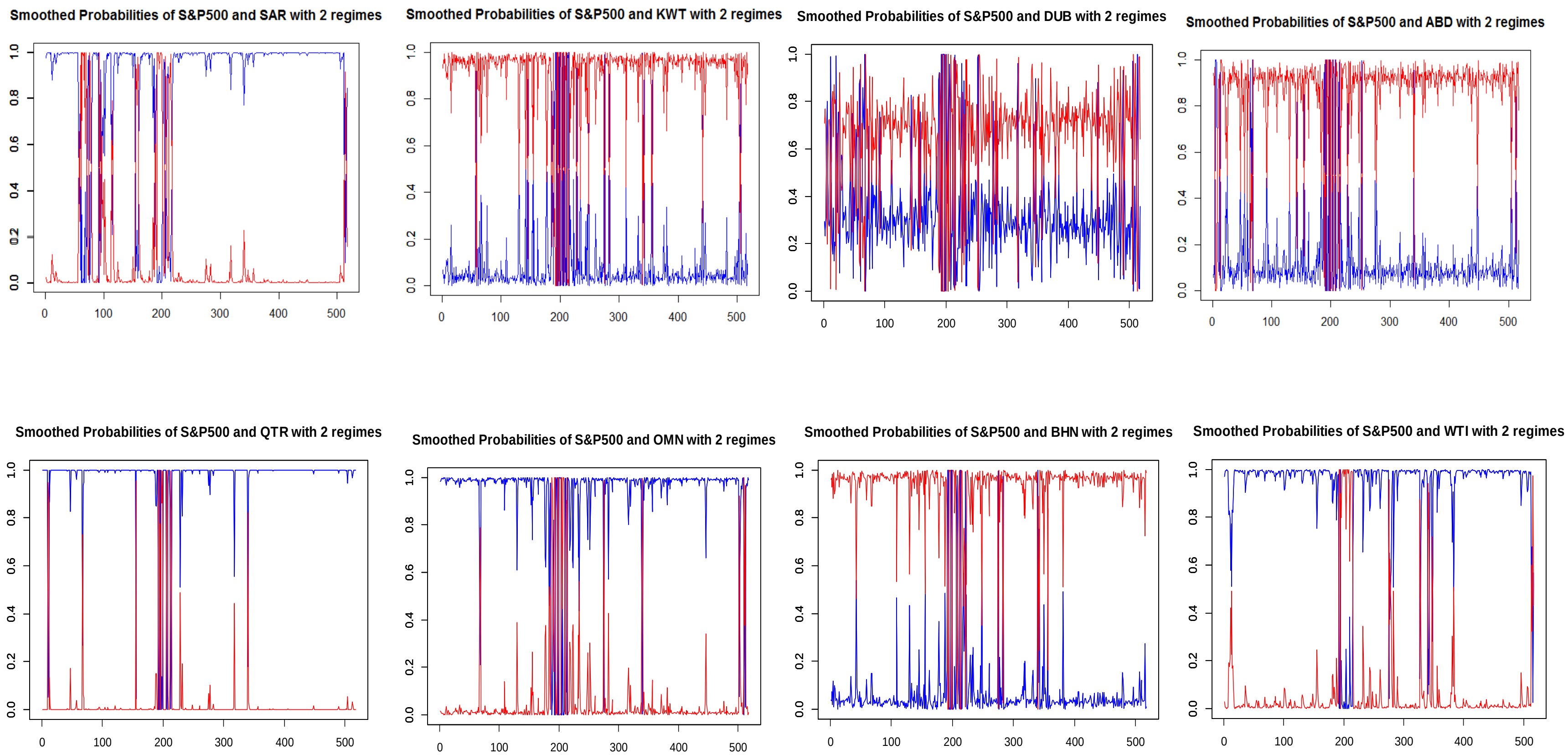
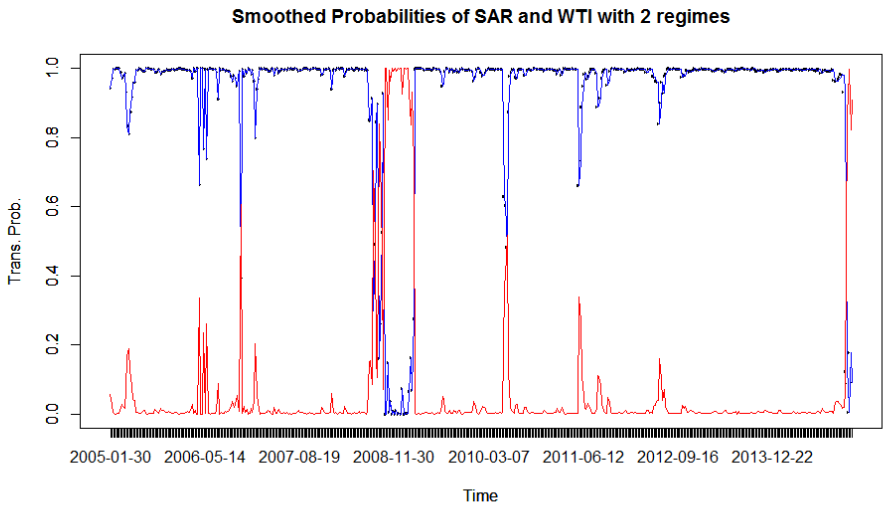


Fig. 5. Smoothed probabilities of state 0 for Saudi Arabia (variable A) and the WTI (variable B).



5.2 Inference on the regimes: the case of the Saudi Arabia and WTI

One of the most remarkable features of the MCMS model is the possibility to have an inference on the regime for each time t, by using the smoothed probabilities (Hamilton, 1994). We show this kind of analysis only for the pair Saudi Arabia (variable A) and WTI (variable B) in figure 5, given the combinations of the states. Since Saudi Arabia is the largest GCC in oil revenues, and the size of the economy. However, the results for the other 35 pairs are available in the appendix. In general, these probabilities are close to 0 or 1, so that the inference on the regimes is fairly precise.

The first most frequent state is the one in which both variables are in the tranquility state (1, 1), in the figure above, the state (1, 1) characterizes a long period from 2005 to 2006. The second frequent state is the one in which both variables are in the turmoil state, that is (2, 2). This state extend from 2008 to 2009 which the period of the global financial crisis. This is consistent and appropriate with the most dramatic effects of the 2008/2009 financial crisis were transmitted and transfer very quickly to the markets. This period of high volatility plagued and affects all global financial markets. The turmoil period ends in mid of 2009 when Saudi Arabia and WTI switches to the tranquility period.

The cases in which the two variables are in the different states, (1, 2) or (2, 1), which one of the two variables is in a high volatility and the other in low volatility. In these cases, the two variables have a very short duration. These cases are a small percentage with respect to the full data set, but they indicate a week interdependence behavior of the two series.

The numbers in transition probability matrix confirm the fact that, when both variables are in the same state, this state has a high probability to be confirmed at the next time. All the results are consistent with the estimated transition probability matrix Saudi Arabia and WTI:

Table 3 Transition Probability Matrix Saudi Arabia And WTI

	[,1]	**[,2]**
[1,]	0.955540431	0.04445957
[2,]	0.005125373	0.99487463

From table 3, it is evident that the states (1,1) and (2,2) are highly persistent, with a high probability to stay in the same regime also at the next time. The most important difference between these states is that from state (1,1), it is possible to switch to most other regimes, while from state (2,2) the only possibility to switch is to pass by state (1,2). When the state is (1,2) or (2,1), the most possible situation is a switch to the (1,1) regime, but there is a nonzero probability to exchange the state between variables (the case of contemporaneous spillover).

Chapter six: Conclusions

The thesis examines the different patterns of volatility transmission: interdependence, spillover, independence and co-movements between the oil-WTI price, the U.S. S&P 500 index, and seven GCC stock markets under different groups of states. The model is the multi-chain Markov-switching (MCMS) which able to differentiate among the different volatility transmissions mechanisms, and is better than the GARCH family models which do not provide all those different patterns of transmission. The MCMS model captures and show the nonlinearity in the relationships between the pairs of variables in a period that is characterized by global crises. Differentiating between the volatility transmissions patterns focus on the integration of the GCC markets with the world markets, the relationships are stated in Table 3 according to the transition probability matrix in the appendix**.** Examination of volatility transmission through combination of different states provides investor's different ways to hedge, protection and control against high volatility regimes.

Table.4. Transmission patterns (spillovers, interdependence, and independence) between index pairs.
Where: interdp, meaning interdependence, indep, meaning independence.

Market index	SAR	KWT	DUB	ABD	QTR	OMN	BHRN	S&P500	WTI
SAR	-	Interdp.	Spillover	Interdp	Spillover	Interdp	Interdp	Spillover	Interdp
KWT	Spillover	-	**No Spill**	Spillover	Spillover	Spillover	Spillover	Spillover	Spillover
DUB	Interdp	**Indep.**	-	Spillover	Interdp	Interdp	**No Spill**	Interdp	Spillover
ABD	Spillover	Interdp	Interdp	-	Interdp	Interdp	Spillover	Spillover	Spillover
QTR	Interdp	Interdp	Spillover	Spillover	-	Interdp	Spillover	Interdp	Spillover
OMN	Spillover	Interdp	Spillover	Spillover	Spillover	-	Interdp	Interdp	Interdp
BHRN	Spillover	Interdp	**Indepe.**	Interdp	Interdp	Spillover	-	Spillover	Spillover
S&P500	Interdp	Interdp	Spillover	Interdp	Spillover	Spillover	Interdp	-	Spillover
WTI	Spillover	Interdp	Indepe	Interdp	Interdp	Spillover	Interdp	Interdp	-

The results provide evidence of diverse patterns of volatility transmission between the global factors such as the WTI oil price, the U.S. S&P 500 index and the GCC markets. The first bivariate transmission pattern (interdependence), the results show that there is strong interdependence between the U.S. S&P 500 index and WTI, Dubai, Oman and Qatar markets, and there is more integration of these GCC markets with the world factors than is provided in the existing literature. Furthermore, there is interdependence between Oil and each of the S&P 500, Kuwait and Abu Dhabi, Bahrain and Saudi Arabia markets. Within the GCC countries, there is bivariate interdependence between Saudi Arabia and Kuwait also there is interdependence between Kuwait and Oman and Abu Dhabi. Table 4 displays all the transmission patterns between the GCC markets and global factors.

The second pattern of volatility transmission is the spillover, the result show that there is a strong spillover from the U.S. S&P 500 index to each of Kuwait, Saudi Arabia, Abu Dhabi, and Bahrain. Also, there is Spillover from Oil to Abu Dhabi, Saudi Arabia and Dubai, which also emphasizes the sensitivity of Dubai's market to the global factors. Also there are independence from Dubai to Bahrain and from Kuwait to Dubai.

The inference on regimes for the pairs (Saudi market and WTI) indicates that these markets spent most of the time in the tranquility state before the occurrence of the global financial crisis, which suggests that the Saudi market can be stable and steady in the absence of global crises. However, the Saudi market can be in the turmoil state during periods of global financial crises but staying in this state ends when the crisis disappear.

6.1 Recommendations

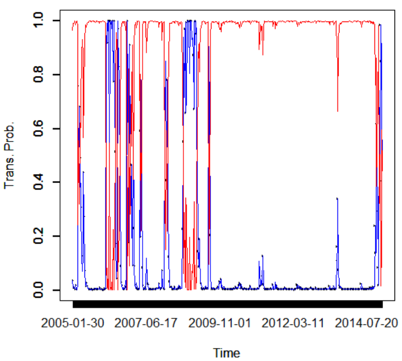
The impact of macroeconomic variables on the volatility spillover between the GCC markets under regime switching is a crucial issue that should also be explored further.

6.2 Limitations

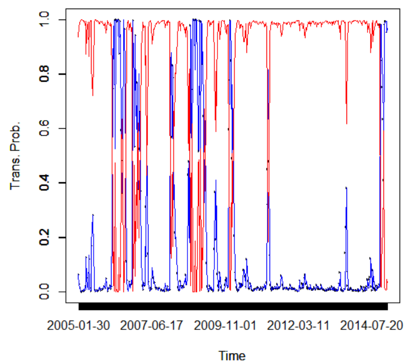
Although this research was carefully prepared, I am still aware of its limitations and shortcomings. First of all the time was not enough to cover all the aspect of the research carefully. It would be better if it was done in a longer time. Also the model it need longer time to understand it well since it new and a few researchers who use it.

Appendix A (Saudi Arabia with GCC)

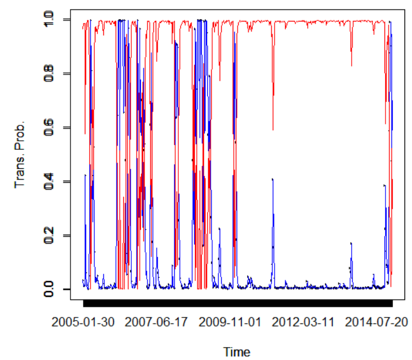
Smoothed Probabilities of SAR and KWU with 2 regimes



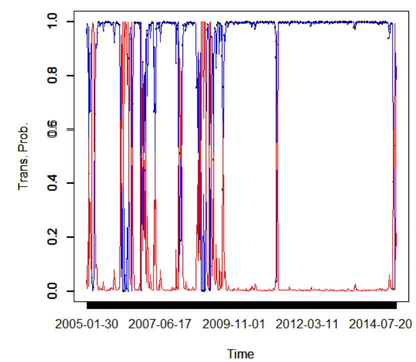
Smoothed Probabilities of SAR and DUB with 2 regimes



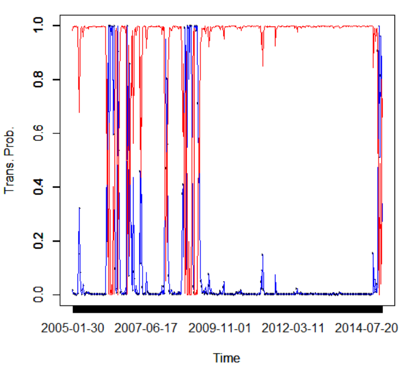
Smoothed Probabilities of SAR and ABU with 2 regimes



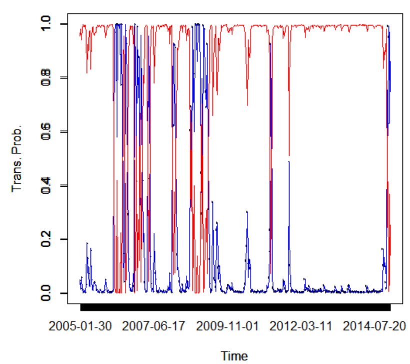
Smoothed Probabilities of SAR and QTR with 2 regimes



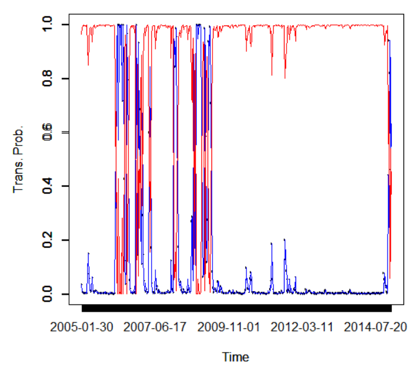
Smoothed Probabilities of SAR and OMN with 2 regimes



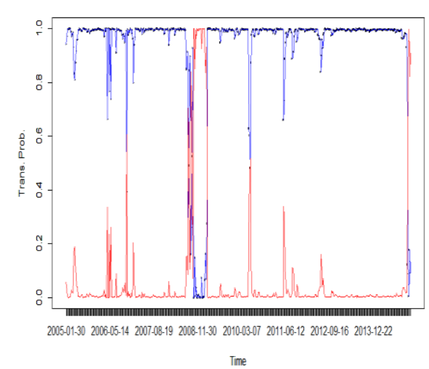
Smoothed Probabilities of SAR and BHN with 2 regimes



Smoothed Probabilities of SAR and S&P500 with 2 regime

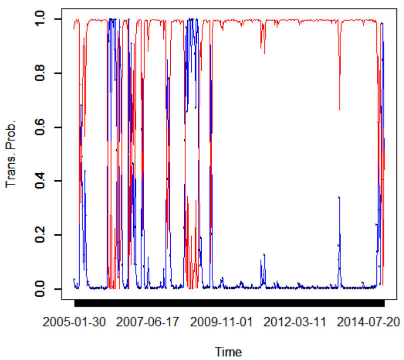


Smoothed Probabilities of SAR and WTI with 2 regimes

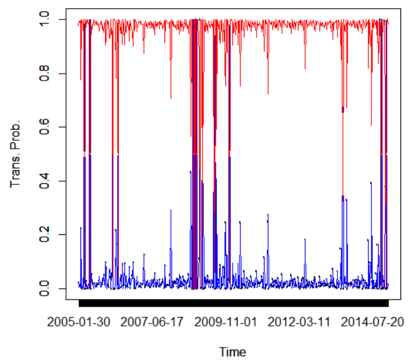


Appendix B (Kuwait with GCC)

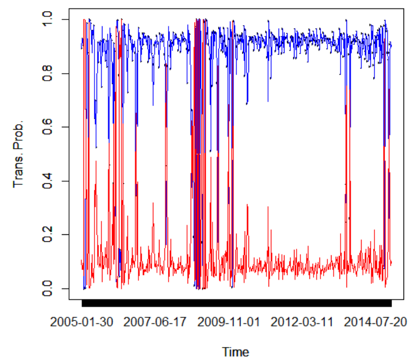
Smoothed Probabilities of KUW and SAR with 2 regimes



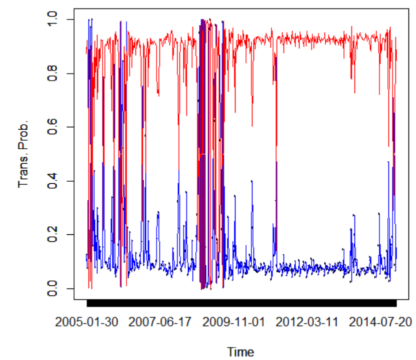
Smoothed Probabilities of KUW and DUB with 2 regimes



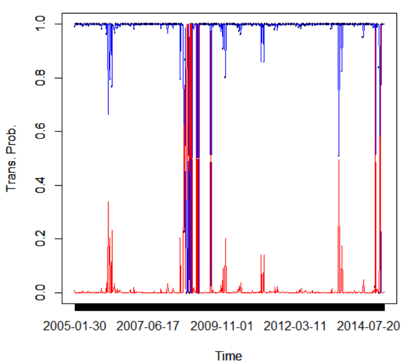
Smoothed Probabilities of KUW and AUD with 2 regimes



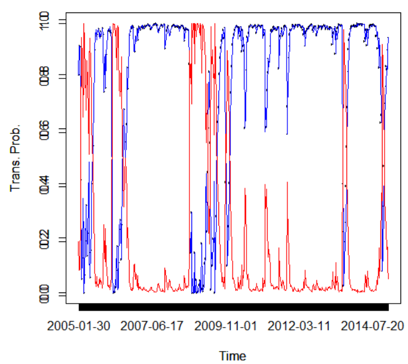
Smoothed Probabilities of KUW and QTR with 2 regimes



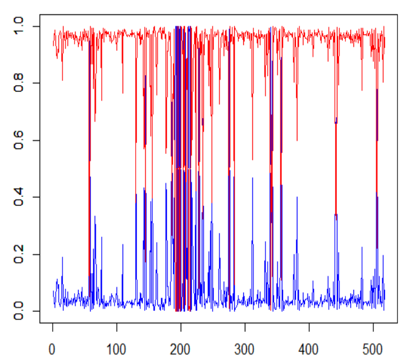
Smoothed Probabilities of KUW and OMN with 2 regimes



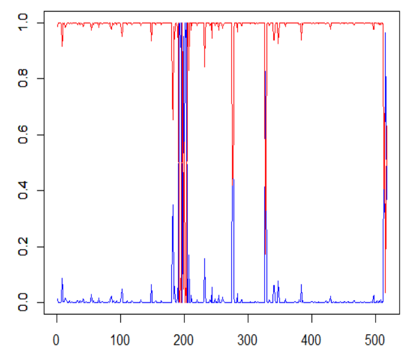
Smoothed Probabilities of KUW and BHN with 2 regimes



Smoothed Probabilities of KWT and S&P500 with 2 regimes

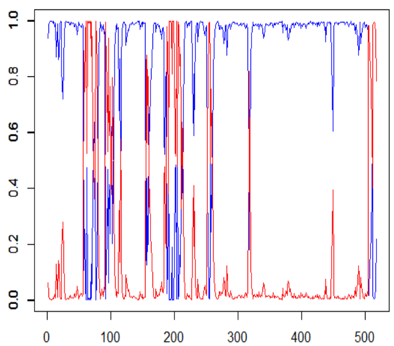


Smoothed Probabilities of KWT and WTI with 2 regimes

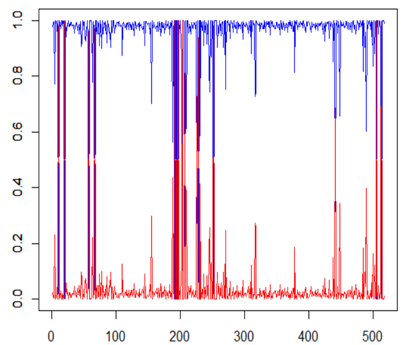


Appendix C (Dubai with GCC)

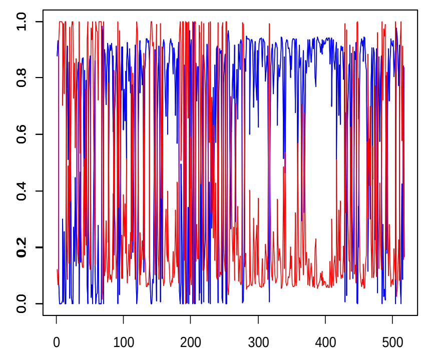
Smoothed Probabilities of DUB and SAR with 2 regimes



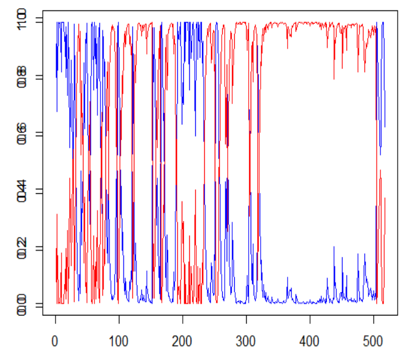
Smoothed Probabilities of DUB and KWT with 2 regimes



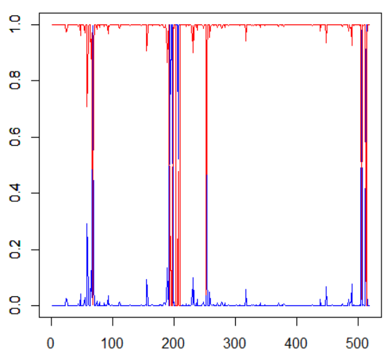
Smoothed Probabilities of DUB and ABD with 2 regimes



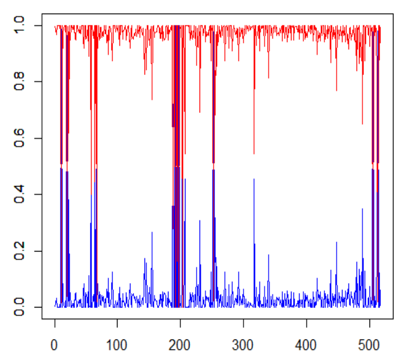
Smoothed Probabilities of DUB and QTR with 2 regimes



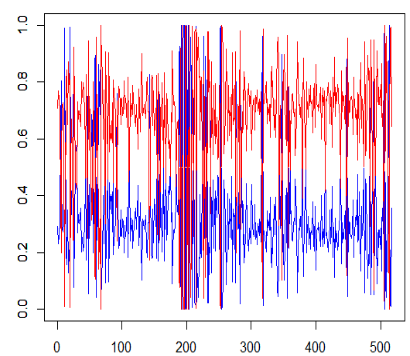
Smoothed Probabilities of DUB and OMN with 2 regime



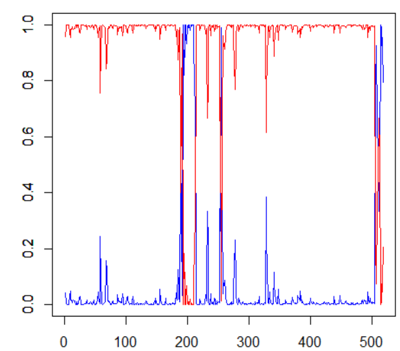
Smoothed Probabilities of DUB and BHN with 2 regimes



Smoothed Probabilities of DUB and S&P500 with 2 regimes

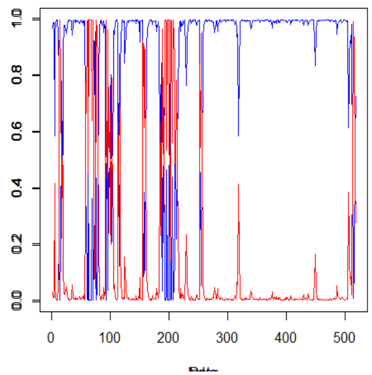


Smoothed Probabilities of DUB and WTI with 2 regime

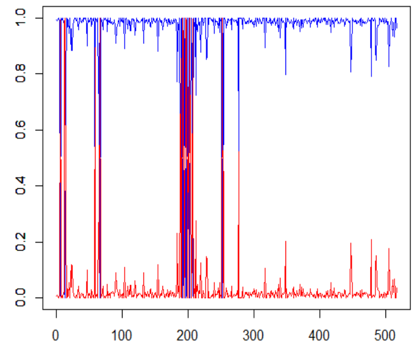


Appendix D (Abu-Dhabi with GCC)

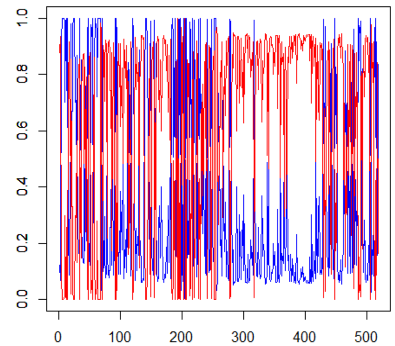
Smoothed Probabilities of ABD and SAR with 2 regime



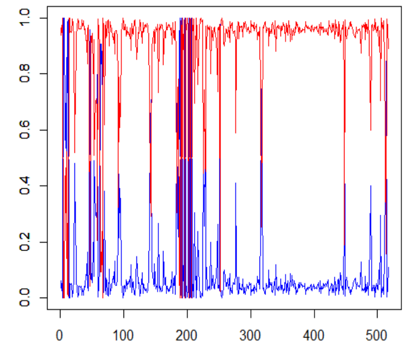
Smoothed Probabilities of ABD and BHN with 2 regimes



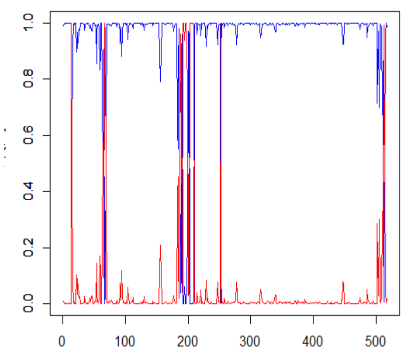
Smoothed Probabilities of ABD and DUB with 2 regime



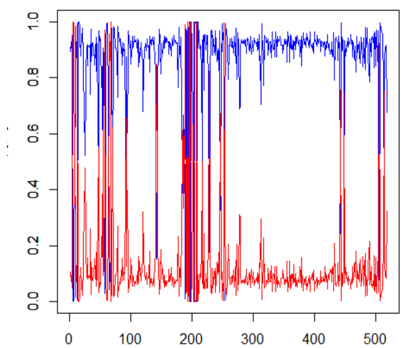
Smoothed Probabilities of ABD and QTR with 2 regimes



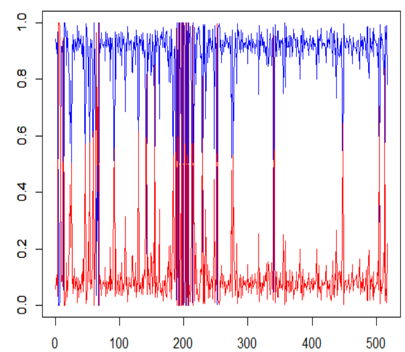
Smoothed Probabilities of ABD and OMN with 2 regimes



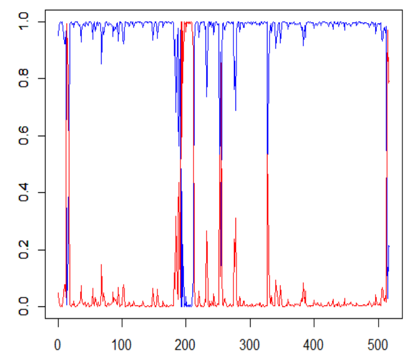
Smoothed Probabilities of ABD and KWT with 2 regime



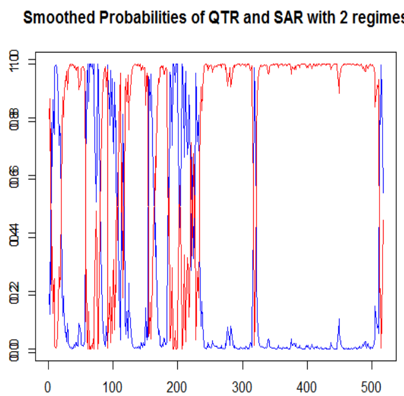
Smoothed Probabilities of ABD and S&P500 with 2 regimes

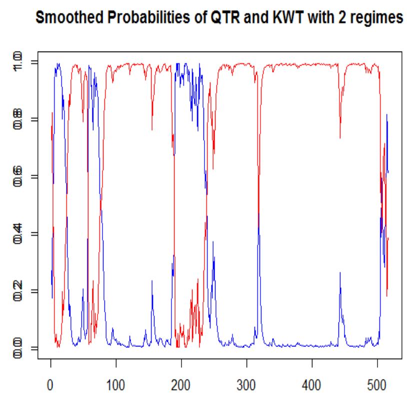


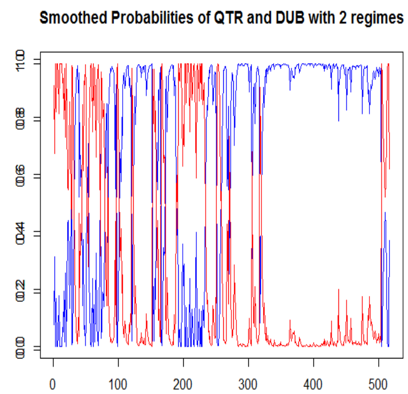
Smoothed Probabilities of ABD and WTI with 2 regimes

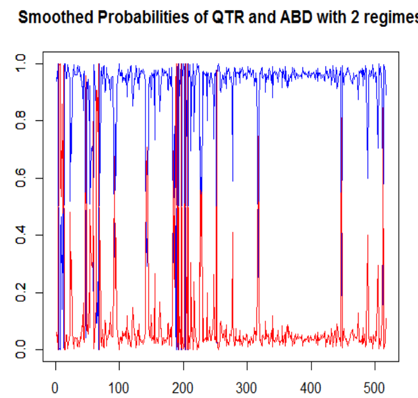


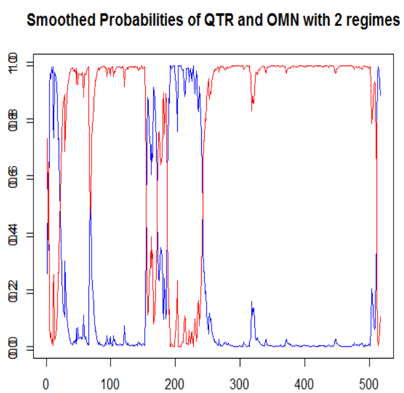
Appendix E (Qatar with GCC)

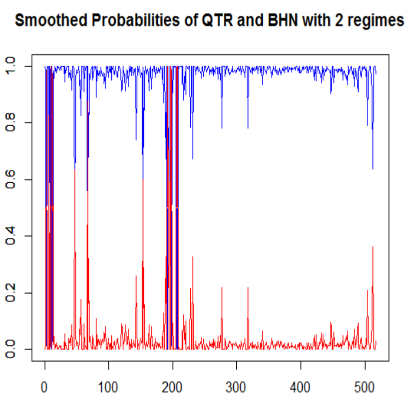


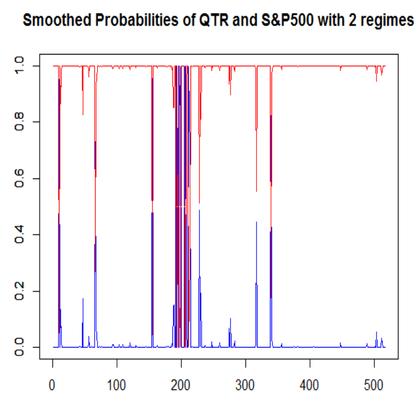


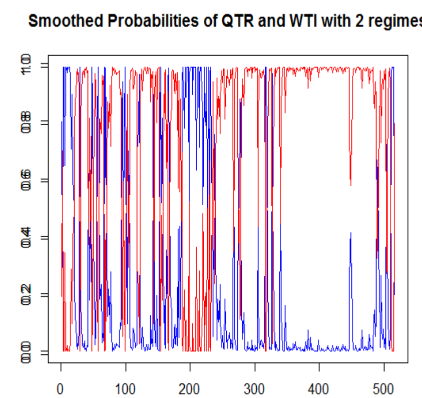






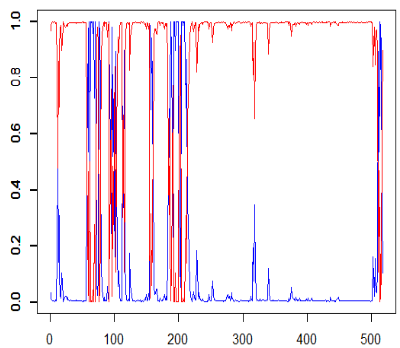




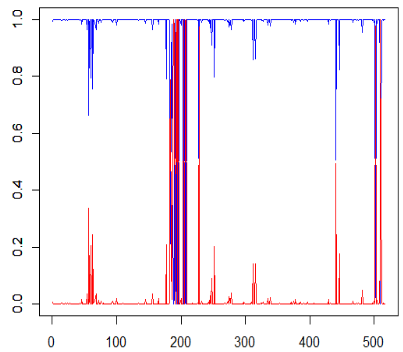


Appendix F (Oman with GCC)

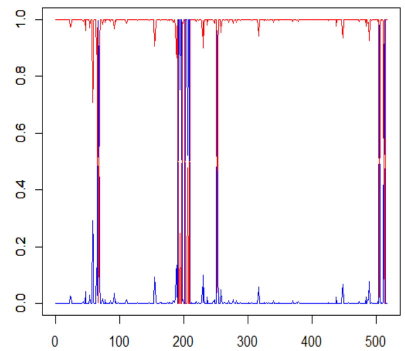
Smoothed Probabilities of OMN and SAR with 2 regimes



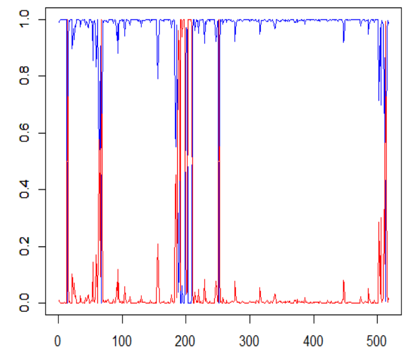
Smoothed Probabilities of OMN and KWT with 2 regimes



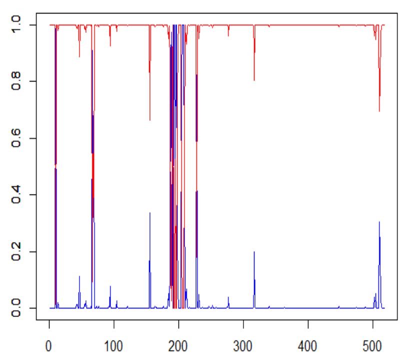
Smoothed Probabilities of OMN and DUB with 2 regimes



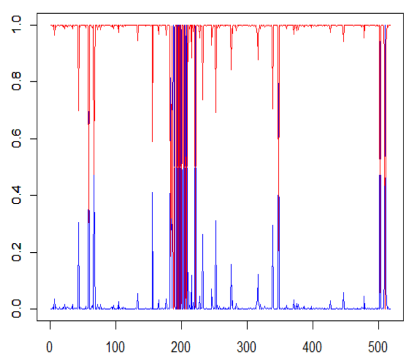
Smoothed Probabilities of OMN and ABD with 2 regimes



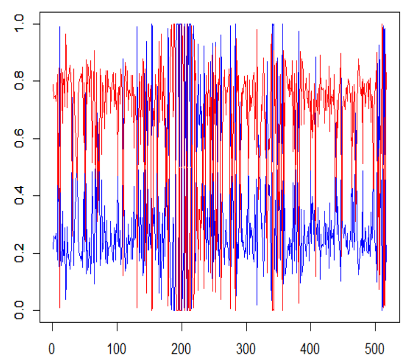
Smoothed Probabilities of OMN and QTR with 2 regimes



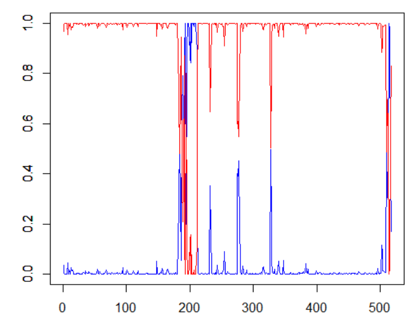
Smoothed Probabilities of OMN and BHN with 2 regimes



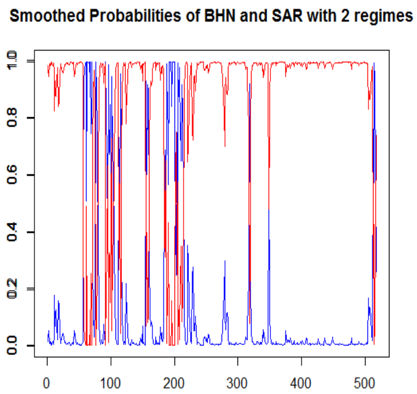
Smoothed Probabilities of OMN and S&P500 with 2 regimes

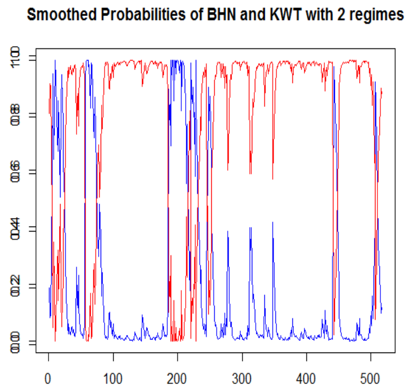


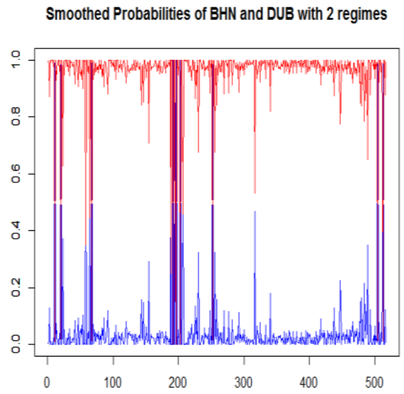
Smoothed Probabilities of OMN and WTI with 2 regimes

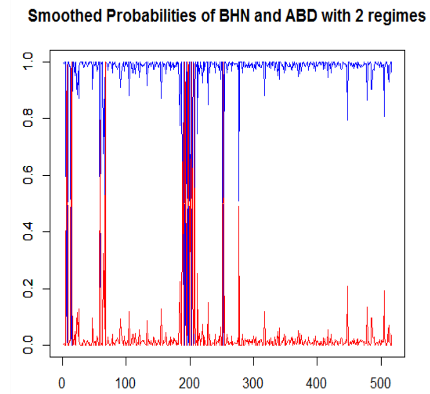


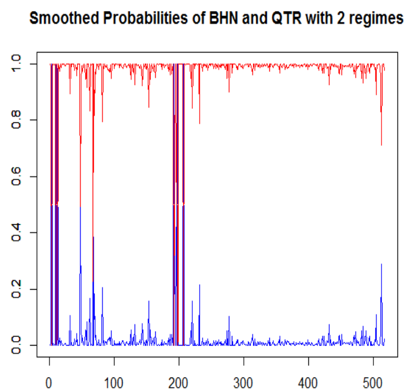
Appendix G (Bahrain with GCC)

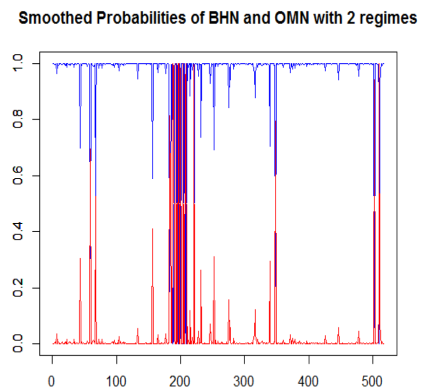


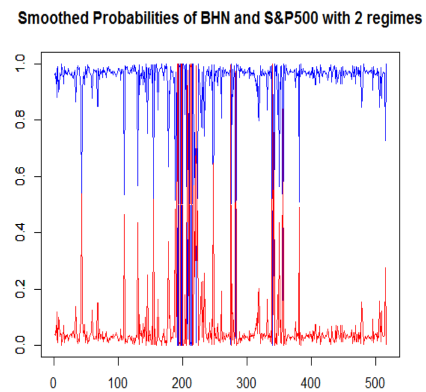


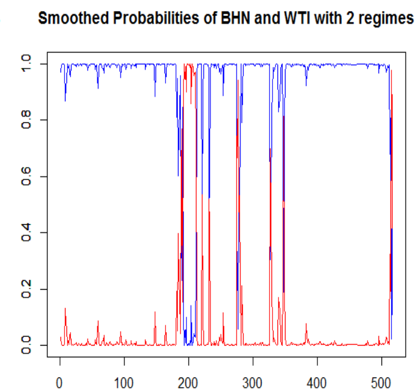












Appendix H (Matrix of SAR with GCC)

SAR with KWT		
	(,1)	(,2)
(1,)	0.98	0.01
(2,)	0.11	0.88

SAR with DUB		
	(,1)	(,2)
(1,)	0.98	0.01
(2,)	0.07	0.92

SAR with ABD		
	(,1)	(,2)
(1,)	0.97	0.02
(2,)	0.11	0.88

SAR with QTR		
	(,1)	(,2)
(1,)	0.83	0.16
(2,)	0.02	0.97

SAR with OMN		
	(,1)	(,2)
(1,)	0.98	0.01
(2,)	0.13	0.66

SAR with BHN		
	(,1)	(,2)
(1,)	0.98	0.01
(2,)	0.09	0.90

Appendix I (Matrix of KWT with GCC)

KWT with SAR		
	(,1)	(,2)
(1,)	0.98	0.01
(2,)	0.11	0.88

KWT with DUB		
	(,1)	(,2)
(1,)	0.94	0.05
(2,)	0.99	0.000

KWT with ABD		
	(,1)	(,2)
(1,)	0.42	0.57
(2,)	0.09	0.90

KWT with QTR		
	(,1)	(,2)
(1,)	0.17	0.82
(2,)	0.19	0.80

KWT with OMN		
	(,1)	(,2)
(1,)	0.44	0.55
(2,)	0.02	0.98

KWT with BHN		
	(,1)	(,2)
(1,)	0.94	0.05
(2,)	0.01	0.98

KWT with S&P500		
	(,1)	(,2)
(1,)	0.95	0.07
(2,)	0.67	0.32

KWT with WTI		
	(,1)	(,2)
(1,)	0.92	0.07
(2,)	0.67	0.32

Appendix J (Matrix of DUB with GCC)

DUB with SAR		
	(,1)	(,2)
(1,)	0.91	0.08
(2,)	0.00	0.09

DUB with KWT		
	(,1)	(,2)
(1,)	0.00	0.99
(2,)	0.00	0.94

DUB with ABD		
	(,1)	(,2)
(1,)	0.69	0.30
(2,)	0.17	0.82

DUB with QTR		
	(,1)	(,2)
(1,)	0.96	0.03
(2,)	0.06	0.82

DUB with OMN		
	(,1)	(,2)
(1,)	0.98	0.01
(2,)	0.30	0.96

DUB with BHN		
	(,1)	(,2)
(1,)	0.94	0.00
(2,)	0.99	0.00

DUB with S&P500		
	(,1)	(,2)
(1,)	0.68	0.31
(2,)	0.60	0.39

DUB with WTI		
	(,1)	(,2)
(1,)	0.99	0.007
(2,)	0.06	0.39

Appendix K (Matrix of ABD with GCC)

ABD with SAR		
	(,1)	(,2)
(1,)	0.87	0.12
(2,)	0.02	0.97

ABD with KWT		
	(,1)	(,2)
(1,)	0.42	0.57
(2,)	0.09	0.9

ABD with DUB		
	(,1)	(,2)
(1,)	0.82	0.17
(2,)	0.30	0.96

ABD with QTR		
	(,1)	(,2)
(1,)	0.94	0.05
(2,)	0.43	0.56

ABD with OMN		
	(,1)	(,2)
(1,)	0.80	0.19
(2,)	0.01	0.9

ABD with BHN		
	(,1)	(,2)
(1,)	0.37	0.62
(2,)	0.03	0.9

ABD with S&P500		
	(,1)	(,2)
(1,)	0.27	0.72
(2,)	0.11	0.88

ABD with WTI		
	(,1)	(,2)
(1,)	0.91	0.08
(2,)	0.00	0.99

Appendix L (Matrix of QTR with GCC)

QTR with SAR		
	(,1)	(,2)
(1,)	0.97	0.02
(2,)	0.05	0.9

QTR with KWT		
	(,1)	(,2)
(1,)	0.99	0.00
(2,)	0.02	0.97

QTR with DUB		
	(,1)	(,2)
(1,)	0.93	0.06
(2,)	0.03	0.96

QTR with ABD		
	(,1)	(,2)
(1,)	0.56	0.43
(2,)	0.05	0.94

QTR with OMN		
	(,1)	(,2)
(1,)	0.99	0.00
(2,)	0.01	0.98

QTR with BHN		
	(,1)	(,2)
(1,)	0.15	0.84
(2,)	0.03	0.96

QTR with S&P500		
	(,1)	(,2)
(1,)	0.98	0.01
(2,)	0.56	0.43

QTR with WTI		
	(,1)	(,2)
(1,)	0.99	0.05
(2,)	0.13	0.86

Appendix M (Matrix of OMN with GCC)

OMN with SAR		
	(,1)	(,2)
(1,)	0.98	0.01
(2,)	0.10	0.89

OMN with KWT		
	(,1)	(,2)
(1,)	0.44	0.55
(2,)	0.02	0.97

OMN with DUB		
	(,1)	(,2)
(1,)	0.98	0.01
(2,)	0.30	0.69

OMN with ABD		
	(,1)	(,2)
(1,)	0.80	0.19
(2,)	0.01	0.98

OMN with QTR		
	(,1)	(,2)
(1,)	0.98	0.01
(2,)	0.33	0.60

OMN with BHN		
	(,1)	(,2)
(1,)	0.96	0.03
(2,)	0.78	0.21

OMN with S&P500		
	(,1)	(,2)
(1,)	0.77	0.22
(2,)	0.42	0.57

OMN with WTI		
	(,1)	(,2)
(1,)	0.99	0.00
(2,)	0.06	0.93

Appendix N (Matrix of BHN with GCC)

BHN with SAR		
	(,1)	(,2)
(1,)	0.98	0.02
(2,)	0.10	0.89

BHN with KWT		
	(,1)	(,2)
(1,)	0.98	0.02
(2,)	0.05	0.94

BHN with DUB		
	(,1)	(,2)
(1,)	0.9	0.00
(2,)	0.99	0.00

BHN with ABD		
	(,1)	(,2)
(1,)	0.33	0.6
(2,)	0.03	0.96

BHN with QTR		
	(,1)	(,2)
(1,)	0.97	0.02
(2,)	0.81	0.18

BHN with OMN		
	(,1)	(,2)
(1,)	0.21	0.78
(2,)	0.03	0.96

BHN with S&P500		
	(,1)	(,2)
(1,)	0.39	0.6
(2,)	0.05	0.94

BHN with WTI		
	(,1)	(,2)
(1,)	0.9	0.09
(2,)	0.00	0.99

Appendix O (Matrix of WTI with GCC)

WTI with SAR		
	(,1)	(,2)
(1,)	0.99	0.00
(2,)	0.05	0.99

WTI with KWT		
	(,1)	(,2)
(1,)	0.79	0.25
(2,)	0.00	0.99

WTI with DUB		
	(,1)	(,2)
(1,)	0.99	0.00
(2,)	0.6	0.93

WTI with ABD		
	(,1)	(,2)
(1,)	0.91	0.08
(2,)	0.00	0.99

WTI with QTR		
	(,1)	(,2)
(1,)	0.86	0.139
(2,)	0.05	0.94

WTI with OMN		
	(,1)	(,2)
(1,)	0.93	0.06
(2,)	0.00	0.99

WTI with S&P500		
	(,1)	(,2)
(1,)	0.79	0.20
(2,)	0.01	0.98

WTI with BHN		
	(,1)	(,2)
(1,)	0.99	0.00
(2,)	0.09	0.90

Appendix P (Matrix of S&P500 with GCC)

S&P500 with SAR		
	(,1)	(,2)
(1,)	0.85	0.15
(2,)	0.01	0.98

S&P500 with KWT		
	(,1)	(,2)
(1,)	0.92	0.07
(2,)	0.68	0.31

S&P500 with DUB		
	(,1)	(,2)
(1,)	0.68	0.31
(2,)	0.60	0.39

S&P500 with ABD		
	(,1)	(,2)
(1,)	0.88	0.11
(2,)	0.72	0.27

S&P500 with QTR		
	(,1)	(,2)
(1,)	0.43	0.56
(2,)	0.02	0.98

S&P500 with OMN		
	(,1)	(,2)
(1,)	0.61	0.38
(2,)	0.03	0.97

S&P500 with BHN		
	(,1)	(,2)
(1,)	0.94	0.05
(2,)	0.6	0.39

S&P500 with BHN		
	(,1)	(,2)
(1,)	0.79	0.20
(2,)	0.01	0.98

References

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