Regional and Global Spillovers and Diversification Opportunities in the GCC-Wide Equity Sectors across Market Regimes

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December 2013

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Abstract

This paper examines the international diversification benefits of bloc-wide equity sectors of the stock markets of oil-rich Gulf Cooperation Council (GCC) countries by comparing alternative spillover models for local, regional and global factors. Both the return and volatility spillover effects are found to display time variations with regime-specific patterns based on low, high and extreme volatility market states. We also find that the highly segmented GCC-wide equity sectors can serve as safe havens for international investors during periods of high and extreme market volatility. The in- and out-of-sample portfolio analyses further suggest that supplementing global portfolios with positions in these markets yield significant diversification benefits, offering much improved risk-adjusted returns consistently across the alternative spillover models examined.

JEL Classification: C32, G11, G15

Keywords: Multivariate regime switching; Time-varying parameters; International diversification; GCC-wide equity sectors.

1. Introduction

The recent financial crisis which originated in the U.S. and the prolonged debt crisis and economic uncertainty in the Eurozone have sent severe shocks through the world financial markets. They have also underscored the importance of emerging markets as potential risk diversifiers and return enhancers. A number of studies in the literature have highlighted the importance of shock and volatility spillovers across global markets and the significance of diversification benefits from investing in emerging markets (e.g. Chiou, 2008; Middleton et al., 2008; Bekaert et al., 2009; You and Daigler, 2010, Khalifa et al., 2013; among others). An emerging strand of the literature on international diversification has also focused on the cash- and oil-rich Gulf Arab stock markets (e.g. Yu and Hassan, 2008; Cheng et al., 2010, and Mansourfar et al., 2010). The literature on the spillovers for the Gulf Cooperation Council (GCC) stock markets suggests that these markets are generally segmented from international markets, and thus diversification benefits can be achieved by allocating part of global portfolios to investments from these oil-exporting countries. However, the literature has largely ignored the time variation in the interaction of these markets with global markets by assuming time-invariant parameters in their models, thus providing an incomplete assessment of the potential benefits of these developing markets for temporal international diversification.

Most GCC countries impose restrictions on foreign ownership in their stock markets in order to shield themselves from the adverse effects of regional and global return and volatility spillovers. Foreign ownership restrictions, along with a number of other institutional issues, have therefore prevented these markets from being classified as emerging markets. However, MSCI has recently promoted two of these markets, i.e. Qatar and UAE, from the frontier to the emerging market status, which has the implication of increasing international investments into these markets. Considering the fact that more GCC nations, which are currently classified as frontier markets, are in the process of implementing structural reforms that would pave the way towards achieving the emerging market status, it can be expected that there will be greater interest espoused by international investors towards these under-studied and emerging stock markets.

Despite the seemingly segmented nature of the GCC stock markets from the global stock markets, several factors in fact link their economies to the world economy. Government revenues and corporate profitability in these countries are influenced by the oil prices and exports which are largely driven by global economic growth factors.[1] The dependence of the oil-exporting GCC economies on the global demand for oil imports, and thus on economic growth trends in the importing nations, further strengthens the linkages of these markets with the global stock markets. Information may also flow to the GCC markets through international macroeconomic linkages which include cross-country trade and customs relationships, foreign direct investments, interrelated portfolios and monetary and fiscal policy arrangements (Mensi and Hammoudeh, 2013). Finally, the GCC economies are interlinked with the U.S. market as their exchange rates are pegged to the U.S. dollar, which requires coordination with the monetary policy in the U.S. Hence, it can be argued that the information and shocks relevant to changes in the U.S. and other international stock markets affect the GCC stock markets from multiple channels.

Clearly, regional and global shocks and events can lead to structural breaks and regime changes in the stock market returns of the GCC countries. At certain times (e.g. the 2007/2008 global financial crisis and its aftermath), the GCC and the global stock markets have become more integrated which necessitates that the regime-switching process describing their return processes be synchronized. Other times (e.g. the Dubai debt crisis or a regional market shock like the so-called Arab Spring or other geopolitical events like in

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[1] Saudi Arabia places first in the oil exports global rank, while UAE and Kuwait rank 6th and 10th, respectively.

Bahrain), the GCC markets have moved independently from international markets, calling for an unsynchronized regime-switching specification. Therefore, despite the evidence in the literature that these markets are largely segmented from the global markets, it is possible that they exhibit segmentation or integration with the global markets in a regime-specific fashion, which necessitates a regime-based diversification analysis that also takes into account the time variation in the linkages across markets.

The main goal of this paper is to explore the portfolio diversification benefits of the cash and oil-rich stock markets in the GCC by examining the return and volatility spillovers of these markets at the GCC-wide sector level, employing a dynamic model with several novelties. The GCC-wide equity sectors include the financials, basic materials, industrial goods and services, energy, telecom and utilities sectors considered as potential diversifiers. The sector focus is motivated for several reasons. First, investors who seek more attractive risk-return tradeoffs in their portfolios go beyond investing in the aggregate equity market index and explore investment opportunities in sectors that suit best the state of the economy and their investment objectives. For example, at times when the economy is teetering into recession, investors opt for defensive sectors such as non-cyclical consumer goods. On the other hand, in a bull market state, growth sectors are preferred. Second, as Choi and Sias (2009) note, analysts are usually assigned on an industry basis with many professional managers making industry/sector recommendations just as they make individual security recommendations. From an international investment perspective, portfolio managers who follow the top down approach usually pick countries and then sectors, and not just the aggregate market index. Therefore, it is important that investors pay attention to the interactions and volatility spillovers among the local sectors and the regional and global markets.

As Hammoudeh et al. (2009) note, sector investing in the GCC stock markets has not yet reached the level of sophistication their developed counterparts have reached. Investing in the GCC sectors became opportune after the GCC countries have recently reorganized and classified their sectors with much greater details than before.[2] While there have been several studies that examine the transmission of returns among individual GCC sectors (Hammoudeh et al. 2009), how the volatility spillovers occur among various sectors and across different market regimes is yet to be explored. Such an insight is particularly of interest to international investors interested in the increase in globalization and contagion among the world financial markets and the desire for achieving diversification gains.

This paper contributes to the literature on return/volatility spillovers and international diversification in several aspects. First, it investigates the risk exposure of the GCC-wide equity sectors with respect to regional and global factors, using regime switching spillover models in which global, regional, and sectoral returns are allowed to have common synchronized and unsynchronized (general) return processes. Second, unlike in most international diversification studies in the literature (e.g. Bekaert and Harvey, 1995; Ang and Bekaert, 2000, 2004; Baele, 2005), we utilize regime-switching models with more than two regimes where all model parameters are allowed to vary across different regimes. Third, we determine the market regimes by formal statistical testing rather than by making assumptions on the possible regime structure in the return processes. Finally, unlike most spillover studies in the literature (e.g. Baele and Inghelbrecht, 2009, 2010), we supplement our analysis by comparing the in- and out-of-sample performance of the portfolios constructed based on the static and regime-based models. Therefore, this study contributes to the literature on both risk-return spillovers and international diversification using a dynamic model that takes into

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[2] The new sector classification follows the Thomson Reuters Business Classification System.

account parameter-time variations, market regime-switching and synchronization (or lack thereof) of regimes across the GCC and global markets.

Our findings suggest that the risk exposure of the GCC equity sectors with respect to the regional and global shocks display time-varying characteristics with regime-specific spillover effects observed for all equity sectors as well as for the GCC region at large. The regime specification tests identify three market regimes characterized as the low, high and extreme volatility market regimes. Although the GCC as a region is found to have a positive risk exposure to the global shocks during the low and high volatility regimes, we find that the regional risk exposure to the global shocks turns negative during the extreme volatility regime, which was the case during and in the aftermath of the global crisis in late 2008 and around the second bailout package for Greece in late 2011. Similarly, the industrials, the industrial and commercial services, the transportation, the financials and the real estate sectors are found to have negative risk exposures with respect to global shocks during the high and/or extreme volatility regimes, suggesting that GCC-wide sectors can serve as a safe haven for international investors during periods of high or extreme volatility and depending on the particular sector to be utilized in the portfolio. On the other hand, the constant parameter GARCH and the alternative common state MS models fail to capture the dynamic nature of the return and risk spillovers. They also fail to provide a complete assessment of the international diversification potential of these markets. Finally, examining the performance of the constructed portfolios, using the covariance matrices based on the alternative spillover models, suggests that supplementing the world portfolio with positions in the GCC-wide equity sectors lead to more efficient portfolios with much improved risk- adjusted returns. This finding is consistent across the examined alternative spillover models and supported by both the in- and out-of-sample tests.

The remainder of the paper is organized as follows. Section 2 briefly reviews the literature on the spillovers and international diversification, with a focus on emerging stock markets. Section 3 presents the data and the methodology. Section 4 provides the empirical findings for the global and regional spillover models. Section 5 examines the performance of the optimal portfolios and the diversification benefits of the GCC markets within a regime-specific framework. Finally, Section 6 concludes the paper.

2. Literature Review

The literature offers numerous studies on the integration of global stock markets with a focus on international diversification. A number of studies have examined the diversification benefits of emerging markets for investors in advanced markets (e.g. Chiou, 2008; Middleton et al., 2008; Bekaert et al., 2009; You and Daigler, 2010, among others). On the other hand, fewer studies including Lagoarde-Segot and Lucey (2007), Yu and Hassan (2008), Cheng et al. (2010), Mansourfar et al. (2010) and Arouri et al. (2012) have focused on the stock markets in the Middle East and North Africa (MENA) region. These studies generally suggest that MENA stock markets offer significant diversification potential for global investors. However, this strand of the literature has mostly ignored the time variation in the risk exposures of developing stock markets with respect to the global and regional factors, and thus provided an incomplete assessment of international diversification benefits of these markets.

On the other hand, a well-established literature exists on financial integration and return and volatility spillovers across stock markets because of its relevance to portfolio diversification. Numerous studies including Bekaert and Harvey (1997), Ng (2000), Baele (2005), Bekaert and Harvey (2005), Hardouvelis et al. (2006), and Baele and Inghelbrecht (2009, 2010) have looked into the effect of the local and global risk factors on asset prices in different contexts. Focusing on the oil-rich GCC stock markets, Hammoudeh and Choi

(2006) find that the volatility of the GCC returns is largely explained by their own domestic and other GCC shocks rather than by the global factors, suggesting that that the potential benefits accrue from international diversification. On the other hand, Malik and Hammoudeh (2007) document significant volatility transmissions from the oil market to the stock markets in Saudi Arabia, Kuwait, and Bahrain with a bidirectional spillover relationship only for Saudi Arabia and the oil market. More recently, Balli et al. (2013) find that GCC-wide equity sectors are mostly driven by their own volatilities and highlight the dominance of the regional shocks over the global shocks on the volatility of returns in these markets. However, taking a regime-based perspective, Khalifa et al. (2013) find evidence of regime-specific volatility transmission patterns between the GCC and global markets, with stronger connections with the global equity markets than with the oil markets. They also note the time and regime dependency of the optimal hedge ratios and the portfolio weights for each selected pair of the markets is conditional on the regime of the same market and the regimes of the other market.

Focusing on the portfolio diversification aspects, Yu and Hassan (2008) show that GCC markets are largely segmented from international markets, while Cheng et al. (2010) observe that these markets offer returns uncorrelated with global markets. Similarly, Mansourfar et al. (2010) find that the oil-producing GCC countries provide greater international diversification benefits than the non-oil producing MENA countries. More recently, Arouri et al. (2012) argue that international diversification benefits can be achieved by allocating part of the global portfolios in the oil-exporting countries. However, none of these studies has extended the diversification analysis to a regime-based context of spillovers and diversification.

In contrast, our study first extends the analysis of the single regime return-risk spillovers to a regime-based context in which the market regimes are identified by formal statistical testing, rather than making prior assumptions on the regime structure. We also allow all model paramters to be time-varying, while other studies assume constant parameters and fail to assess the true effect of the regional and global shocks on the return and volatility in the GCC markets. Furthermore, we extend the spillover analysis to explore the portfolio diversification benefits across the market regimes, given the regional and global spillovers. The portfolio diversification benefits are examined from the perspective of both the regional and international investors. Finally, the in- and out-of-sample performance of the portfolios constructed based on the static and regime-based models are compared across portfolios that include the GCC-wide equity sectors and the GCC national equity markets.

3. Methodology and data

This section develops a Markov Switching (MS) spillover (factor) model for nine GCC-wide equity sector and sub-sector indices from the six GCC countries. Numerous studies in the literature have utilized the MS models in several contexts including international stock market returns (e.g. Hamilton, 1988; Tyssedal and Tjostheim, 1988; Schwert, 1989; Pagan and Schwert, 1990; Kim, et al., 1998; Kim and Nelson, 1998), volatility spillovers (e.g. Ang and Bekaert, 2002; Baele, 2005; Baele and Inghelbrecht, 2009, 2010), and GCC stock market dynamics (Hammoudeh and Choi, 2007; Balcilar and Genc, 2010; Balcilar et al. 2013a, 2013b; Khalifa et al., 2013).

The MS model utilized in this study has several novelties as indicated earlier. First, unlike Bekaert and Harvey (1995), Ng (2000), Baele (2005) and Baele and Inghelbrecht (2009, 2010), the MS model examines both the time-varying return and volatility spillovers from the regional and global markets to the GCC-wide sectors. Furthermore, the model allows for all model parameters to vary across different regimes, thus offers a more accurate representation of the return dynamics by endogenously modeling the structural changes and the various market regimes such as low, high as well as extreme volatility regimes. Second, unlike most international diversification studies in the literature (e.g. Bekaert and Harvey, 1995; Ang and Bekaert, 2000, 2004; Baele, 2005), we utilize regime switching models with more than two regimes where the number of regimes is identified by formal statistical testing rather than making assumptions on possible regime structure in the return processes. Third, the regime transitions are governed by a latent switching variable, which may be sector-, region- or world-specific or common to all of these factors. Fourth, the total volatility for the GCC-wide sector, the regional and the world indices are decomposed into regime-specific systematic and idiosyncratic components. In order to correctly specify the risk spillovers and thus to disentangle the systematic and idiosyncratic components, we allow the GCC-wide sectors to be exposed to both regional (i.e. GCC bloc-specific) shocks and global shocks. Additionally, the global shocks are allowed to affect the GCC regional returns. Therefore, the model accommodates partial integration at both the regional and global levels and allows it to be time-varying.

Following studies including Bekaert and Harvey (1997), Ng (2000) and Bekaert et al. (2005), we construct a MS dynamic spillover factor model in order to examine the diversification potential of the GCC stock markets. Let $R_{k,t}$ denote the excess return on the GCC sector index *k* for period *t*, which is represented by the following process

$$R_{k,t} = \mu_{k,S_{k,t},t-1} + \phi^{\text{reg}}_{k,S_{k,t}} \mu_{\text{reg},t-1} + \phi^{w}_{k,S_{k,t}} \mu_{w,t-1} + \beta^{\text{reg}}_{k,S_{k,t}} \varepsilon_{\text{reg},t} + \beta^{w}_{k,S_{k,t}} \varepsilon_{w,t} + \varepsilon_{k,t} \qquad \textbf{(1)}$$

where $S_{k,t} \in \{1,2,3\}$, *k* = 1, 2, …, *n*, are latent regime variables, for sector *k*, following a three-state Markov process.[3] In this specification $\mu_{k,S_{k,t},t-1}$ is the regime-dependent expected

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[3] We test for the optimal number of regimes and find that the data support three regimes against the linear (one regime) and the two--regime alternatives. Several studies including Cakmakli et al. (2011), Guidolin and Timmermann (2006), and Maheu et al. (2009) also find that that the three-regime model better describes the stock return dynamics than models with fewer regimes.

excess return for sector k at time t-1, while the components $\mu_{\text{reg},t-1}$ and $\mu_{w,t-1}$ represent, respectively, the conditional excess returns for the GCC region and the world index based on the information available at time t-1[4]. Here, the random variables $\varepsilon_{\text{reg},t}$ and $\varepsilon_{w,t}$ denote the regional (GCC region) and the global market shocks, respectively. The sector-specific idiosyncratic shock is conditionally heteroscedastic and specified as $\varepsilon_{k,t} \sim iid(0,\sigma^2_{S_{k,t}})$. The conditional exposures of the GCC sector returns to the regional and global shocks are specified by the regional and global beta terms, $\beta^{\text{reg}}_{k,S_{k,t}}$ and $\beta^{w}_{k,S_{k,t}}$, respectively. To that end, the process specified for the GCC-wide sector returns in Equation (1) generalizes the two-factor spillover model of Ng (2000), Bekaert et al. (2005), and Baele (2005). However, our specification also allows for regime-specific risk exposures with respect to the regional and the global shocks where the regime-switching is stochastic and governed by a Markov process. Such a specification easily lends itself as a robust tool to examining diversification opportunities during different market regimes.

Analogously, the processes for the regional and global excess returns, $R_{\text{reg},t}$ and $R_{w,t}$, are specified as

$$R_{\text{reg},t} = \mu_{\text{reg},S_{\text{reg},t}t-1} + \phi^{w}_{\text{reg},S_{\text{reg},t}}\mu_{w,t-1} + \beta^{w}_{\text{reg},S_{\text{reg},t}}\varepsilon_{w,t} + \varepsilon_{\text{reg},t} \quad \textbf{(2)}$$

$$R_{w,t} = \mu_{w,S_{w,t},t-1} + \varepsilon_{w,t} \quad \textbf{(3)}$$

where the regional and global shocks are specified as $\varepsilon_{l,t} \sim iid\left(0,\sigma^2_{S_{l,t}}\right)$, l = reg and w with the regime variables, $S_{l,t}$, l = reg and w, each taking values in {1,2,3} and following a three-state, first order Markov process. The return process in Equation (2) is a generalization of the one-factor volatility spillover model of Bekaert and Harvey (1997). $\mu_{\text{reg},S_{\text{reg},t},t-1}$ is the regime-

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[4] $\mu_{\text{reg},t-1}$ and $\mu_{w,t-1}$ represent the conditional expected excess returns obtained from the respective MS models for the GCC region and the world market.

dependent expected regional return that can be explained by the sector- as well as region-specific information available at time *t*-1. Similarly, $\mu_{w,S_{w,t},t-1}$ represents the regime-dependent expected global return at time *t*-1. The parameter $\beta^{w}_{\mathrm{reg},S_{\mathrm{reg},t}}$ measures the conditional exposure of the GCC region with respect to the global shocks and captures the extent to which the global risk spillover is common to the overall GCC region. The spillover effects are specified to vary with the particular state of both the global economy and the region as the global shocks are time-varying and governed by the state variable $S_{w,t}$. Additionally, the extent of the GCC region's exposure with respect to the global shocks is time-varying as the beta ($\beta^{w}_{\mathrm{reg},S_{\mathrm{reg},t}}$) term is governed by the state variable $S_{\mathrm{reg},t}$.

As stated earlier, one of the contributions of this study is to investigate the risk exposure of the GCC-wide equity sectors with respect to the regional and global factors within a regime-switching return and volatility spillover specification. This also allows one to explore the diversification benefits of the GCC equity sectors. For this purpose, we examine the performance of the dynamic portfolios for alternative regional and global spillover specifications. In particular, we examine three alternative spillover specifications: the constant coefficient GARCH, the unsynchronized MS dynamic spillover, and synchronized MS dynamic spillover specifications.

3.1. Constant coefficient GARCH specification

As the benchmark model, we use a spillover specification based on a constant coefficient GARCH model which is the most commonly used specification in the literature (Bekaert and Harvey, 1997; Ng, 2000; Bekaert et al. 2005; Balli et al., 2013). Under this specification, we use a GARCH(1,1) model for the conditional volatility and assume constant spillover coefficients, leading to the following model for the excess return on the equity index *l* at time *t*,:

$$R_{l,t} = \mu_{l,t-1} + \phi_l^{\text{reg}} \mu_{\text{reg},t-1} + \phi_l^{w} \mu_{w,t-1} + \beta_l^{\text{reg}} \varepsilon_{\text{reg},t} + \beta_l^{w} \varepsilon_{w,t} + \varepsilon_{l,t} \tag{4}$$

$$\varepsilon_{l,t} \big| \psi_{t-1} \sim iid(0,\sigma_{l,t}^2) \tag{5}$$

$$\sigma_{l,t}^2 = \omega_l + \alpha_l \varepsilon_{l,t-1}^2 + \gamma_l \sigma_{l,t-1}^2 \tag{6}$$

where l=k, reg, w, k=1,2,…,n, denoting sector k, GCC region, or the world markets, respectively. $\sigma_{l,t}^2$ is the conditional variance, and ψ_{t-1} denotes the information set available at time t-1. In order to account for the fat tails in the return distribution, we use a student t distribution for $\varepsilon_{l,t}$ and estimate its degrees of freedom. In this specification, we set $\phi_l^{\text{reg}} = \phi_l^{w} = \beta_l^{\text{reg}} = \beta_l^{w} = 0$ when l=w and obtain $\varepsilon_{w,t} = R_{w,t} - \mu_{w,t-1}$. where $\mu_{w,,t-1}$ is the conditional mean of $R_{w,t}$. For the return process describing the GCC region, i.e. l=reg, we set $\phi_l^{\text{reg}} = \beta_l^{\text{reg}} = 0$ and obtain $\varepsilon_{\text{reg},t} = R_{\text{reg},t} - \mu_{\text{reg},t-1} - \phi_{\text{reg}}^{w}\mu_{w,t-1} - \beta_{\text{reg}}^{w}\varepsilon_{w,t}$. Note that the constant coefficient GARCH(1,1) specification is used for comparison purposes only. Since our primary focus is to examine the diversification potential of the GCC equity sectors, the conditional returns are specified as AR(1) processes.[5] Following the approach adopted in Bekaert and Harvey (1997), Ng (2000), and Bekaert et al. (2005), we obtain the conditional variances and covariances, and the correlation of the GCC equity indices with the global and regional indices, as well as the percentage of the conditional variances explained by the regional and global exposures.

3.2. Unsynchronized general MS dynamic spillover specification

This specification is given in Equations (1)-(3) and allows for a flexible regime switching in the sectoral, regional and global return processes. No particular structure is

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[5] Studies including Ng (2000), Baele (2005) and Balli et al. (2013) use the same specification. This specification captures the time evolution of the spillovers from the regional and global markets, but does not help explain the factors leading to them. Bekaert and Harvey (1995, 1997), De Santis and Gerard (1997), Bekaert et al. (2005) and Baele and Inghelbrecht (2009) use various regional and global factors to explain the implications of the partial integration as a source for potential spillovers.

imposed on how the regime of each market evolves. Baele (2005) utilizes a similar MS model for 13 European markets with spillovers emanating from the United States and Europe. However, this model is limited in the sense that it assumes a single regime (linear) model for the aggregate U.S. and European market shocks and only allows regime switching in the sectoral-specific equations. On the other hand, the model described in Equations (1)-(3) allows for multiple market regimes in the sector, as well as the GCC region and the world equations, and thus provides a more realistic approach.

The unsynchronized general specification does not assume a particular structure for the regime processes $S_{k,t}$, k = 1, 2,…, n, $S_{\text{reg},t}$, and $S_{w,t}$ for the sector, regional, and global markets, respectively. This specification is general in the sense that each process may follow a completely unsynchronized or a partially synchronized regime, rather than a common state for all markets. The level of the market risk and the parameters describing the global and regional risk exposures follow unrelated regime-switching processes, while the risk exposure intensities of the sectors vary according to the current state of a particular sector. Thus, the random variables $S_{l,t}$, $l = k$, reg and w, k = 1, 2, …, n, are defined as three-state, first order Markov chains. The specification is then completed by defining the transition probabilities of the Markov chains as $p_{ij}^{l} = P(S_{l,t+1} = i \mid S_{l,t-1} = j)$. Thus, p_{ij}^{l} for market l is the probability of being in regime i at time t+1, given that the market was in regime j at time t, where i and j take values in {1,2,3}. The transition probabilities satisfy $\sum_{i=1}^{3} p_{ij}^{l} = 1.$

3.3. Synchronized MS dynamic spillover specification

The GCC countries are linked through a political and economic union, having economies highly sensitive to oil exports. This makes these economies particularly sensitive to the global economic growth that drives the demand for oil imports. Therefore, it can be argued that an alternative specification in which one assumes a common state for all GCC equity sectors, the GCC region and the world is also applicable. This specification clearly assumes that the GCC markets at large are highly integrated with the global markets, which may be the case during a particular market state. For example, the financial markets across the globe experienced simultaneous crashes and high volatility during the 2007-2008 global financial crisis, which is consistent with the common state specification for all markets. This is represented in the model as $S_{k,t} = S_{\text{reg},t} = S_{w,t} = S_t$ which posits that all GCC sectors, the GCC region, and the world index follow a single common three-state regime process S_t. The transition probabilities of the common regime are defined as $p_{ij} = P(S_{t+1} = i \mid S_{t-1} = j)$ with $\sum_{i=1}^{3} p_{ij} = 1$. In this case, Equations (1)-(3) form a system of multivariate MS (MV-MS) model and must be estimated simultaneously.

3.4. Conditional covariances and variance ratios

In order to examine the risk exposures of the GCC equity sectors as well as their time evolution, we decompose the total volatility of each GCC-wide sector into three components: (1) a component due to global volatility, (2) a component due to regional volatility, and (3) a sector-specific or idiosyncratic component. Each of these components requires estimating the conditional means, variances, and covariances of the unexpected parts of the sectoral, regional, and global excess returns. Following Equation (1)-(3), we write these unexpected parts as

$$\xi_{k,t} = \beta^{\text{reg}}_{k,S_{k,t}} \varepsilon_{\text{reg},t} + \beta^{w}_{k,S_{k,t}} \varepsilon_{w,t} + \varepsilon_{k,t} \quad \textbf{(7)}$$

$$\xi_{\text{reg},t} = \beta^{w}_{\text{reg},S_{\text{reg},t}} \varepsilon_{w,t} + \varepsilon_{\text{reg},t} \quad \textbf{(8)}$$

$$\xi_{w,t} = \varepsilon_{w,t} \quad \textbf{(9)}$$

Calculating the conditional variances and covariances based on Equations (7)-(8) requires the estimation of predictive probabilities, $p^{l}_{i,t|t-1} = P(S_{l,t} = i \mid \psi_{t-1})$, i.e. the probability of being in regime *i* at time *t* given the data through *t*-1. Defining the vector of predictive probabilities as $p^l_{t|t-1} = [p^l_{i,t|t-1}]$, *i*=1,2,3, and the matrix of transition probabilities as $\mathbf{P}^l = [p^l_{ij}]$, *i, j* = 1,2,3, we can then obtain the predictive probabilities as $p^l_{t|t-1} = \mathbf{P}^l p^l_{i,t-1|t-1}$, where $p^l_{i,t-1|t-1}$ is the vector of probabilities at *t*-1 given the data through *t*-1, that is, $p^l_{t-1|t-1} = [p^l_{i,t-1|t-1}] = [P(S_{l,t-1} = i \mid \psi_{t-1}]$. This last set of probabilities is known as the set of filtered probabilities and it can be calculated from

$$p^l_{i,t|t} = \frac{p^l_{i,t|t-1} f_{(i)}(R_{l,t} \mid \psi_t, \theta)}{\sum_{i=1}^{3} p^l_{i,t|t-1} f_{(i)}(R_{l,t} \mid \psi_t, \theta)} \tag{10}$$

where $f_{(i)}(R_{l,t} \mid \psi_t, \theta)$ is the likelihood function of $R_{l,t}$ in regime *i* and θ is the parameter vector. A novelty of the MS spillover model is that it allows one to compute the time-varying conditional moments by using the predictive probabilities. We specify an AR(1) model in order to obtain the conditional means. Defining β^l_i as the parameters in Equations (1)-(3) for regime *i* and x^l_t as the vector of independent variables, the conditional means are obtained as

$$\mu_{l,t} = R[\big|R_{l,t} \mid \psi_{t-1}] = \sum_{i=1}^{3} p^{w}_{i.t|t-1}[\beta_i x^l_t], \qquad l = w, \text{reg}, k \tag{11}$$

Once the conditional means are obtained, the idiosyncratic shocks are obtained as $\varepsilon_{l,t} = R_{l,t} - \mu_{l,t}$, where $l = w, \text{reg}, k$, *k*=1,2,…,*n*. Similarly, the conditional variances of $\varepsilon_{l,t}$ are given by

$$\sigma^2_{l,t} = E[\varepsilon^2_{l,t} \mid \psi_{t-1}] = \sum_{i=1}^{3} p^l_{i,t|t-1} \sigma^2_{l,i}, \qquad l = w, \text{reg}, k \tag{12}$$

In order to complete the estimation of the spillover model, one must obtain the variances and the covariances of the unexpected parts defined in Equations (7)-(9). We assume that the idiosyncratic sectoral, regional, and world shocks are uncorrelated. Bekaert et al. (2009) show that a time-varying coefficient spillover model with global and regional shocks is sufficiently rich to eliminate most of the idiosyncratic shock correlations even when the equations are estimated independently.[6] Given the nine GCC-wide sectors and sub-sectors returns, the GCC regional market returns and the world return, we have 55 time-varying covariances and 11 time-varying variances that need to be estimated for the unexpected parts of the excess returns. They are estimated using the following equations: [7]

$$h_{w,t} = E[\xi^2_{w,t} \,|\, \psi_{t-1}] = \sum_{i=1}^{3} p^{w}_{i,t|t-1} \sigma^2_{w,i} \qquad \textbf{(13)}$$

$$h_{\text{reg},t} = E[\xi^2_{\text{reg},t} \,|\, \psi_{t-1}] = \sum_{i=1}^{3} p^{\text{reg}}_{i,t|t-1} \left[(\beta^{w}_{\text{reg},i})^2 \sigma^2_{w,t} + \sigma^2_{\text{reg},i} \right] \qquad \textbf{(14)}$$

$$h_{k,t} = E[\xi^2_{k,t} \,|\, \psi_{t-1}] = \sum_{i=1}^{3} p^{k}_{i,t|t-1} \left[(\beta^{w}_{k,i})^2 \sigma^2_{w,t} + (\beta^{\text{reg}}_{k,i})^2 \sigma^2_{\text{reg},t} + \sigma^2_{k,i} \right] \qquad \textbf{(15)}$$

$$h_{k,w,t} = E[\xi_{k,t} \xi_{w,t} \,|\, \psi_{t-1}] = \sum_{i=1}^{3} \sum_{s=1}^{3} p^{k}_{i,t|t-1} p^{w}_{s,t|t-1} \left[\beta^{w}_{k,i} \sigma^2_{s,i} \right] \qquad \textbf{(16)}$$

$$h_{\text{reg},w,t} = E[\xi_{\text{reg},t} \xi_{w,t} \,|\, \psi_{t-1}] = \sum_{i=1}^{3} \sum_{s=1}^{3} p^{\text{reg}}_{i,t|t-1} p^{w}_{s,t|t-1} \left[\beta^{w}_{\text{reg},i} \sigma^2_{s,i} \right] \qquad \textbf{(17)}$$

$$h_{k,\text{reg},t} = E[\xi_{k,t} \xi_{\text{reg},t} \,|\, \psi_{t-1}] = \sum_{i=1}^{3} \sum_{s=1}^{3} p^{k}_{i,t|t-1} p^{\text{reg}}_{s,t|t-1} \left[\beta^{w}_{k,i} \beta^{w}_{\text{reg},s} \sigma^2_{w,t} + \beta^{\text{reg}}_{k,i} \sigma^2_{\text{reg},t} \right] \qquad \textbf{(18)}$$

$$h_{k,j,t} = E[\xi_{k,t} \xi_{j,t} \,|\, \psi_{t-1}] = \sum_{i=1}^{3} \sum_{s=1}^{3} p^{k}_{i,t|t-1} p^{j}_{s,t|t-1} \left[\beta^{w}_{k,i} \beta^{w}_{j,s} \sigma^2_{w,t} + \beta^{\text{reg}}_{k,i} \beta^{\text{reg}}_{j,s} \sigma^2_{\text{reg},t} \right] \qquad \textbf{(19)}$$

Given the variances and covariances in Equations (13)-(19), we obtain the time-varying correlations of each sector with the regional shocks and the global shocks. The GCC region's correlations with the world index are also directly obtained from Equations (13)-(19). Equations (11)-(19) obtain time-varying but regime-independent moments, allowing for a portfolio analysis without assuming a particular known regime.

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[6] The synchronized common state model jointly estimates all equations, along with the correlations between the idiosyncratic shocks.

[7] The common state model with synchronized regimes is a special case of the general case and Equations (13)-(19) still apply with simplifications.

In order to examine the exposure of the GCC wide-sectors/subsectors with respect to the regional and the global shocks, we calculate the percentage of the conditional variances of the unexpected sector returns explained by the conditional variances of the regional and the global unexpected returns. These variance ratios measure the relative extent of the risk exposure of the GCC-wide equity indices to the regional and global market shocks. The part of the conditional variance of the unexpected returns not explained by regional and global shocks is due to the idiosyncratic shocks. The three variance ratios are defined as

$$VR_{k,t}^{w} = \frac{\sum_{i=1}^{3} p_{i,t|t-1}^{k} (\beta_{k,i}^{w})^2 \sigma_{w,t}^2}{h_{k,t}} \times 100 \qquad \textbf{(20)}$$

$$VR_{k,t}^{\text{reg}} = \frac{\sum_{i=1}^{3} p_{i,t|t-1}^{k} (\beta_{k,i}^{\text{reg}})^2 \sigma_{\text{reg},t}^2}{h_{k,t}} \times 100 \qquad \textbf{(21)}$$

$$VR_{k,t}^{k} = \frac{\sum_{i=1}^{3} p_{i,t|t-1}^{k} \sigma_{k,i}^2}{h_{k,t}} \times 100 \qquad \textbf{(22)}$$

where $VR_{k,t}^{w}$, $VR_{k,t}^{\text{reg}}$, and $VR_{k,t}^{k}$ are the variance proportions due to the global, regional and sector specific shocks, respectively.

3.5. Estimation method

For the benchmark GARCH and the general unsynchronized regime MS models, we adopt the three-step estimation procedure of Bekaert and Harvey (1997) and Ng (2000).[8] Given the recursive structure of the global, regional and sector specific shocks in Equations (7)-(9) for the MS models, the three-step approach does not possess a simultaneous equation bias.[9] As described earlier, the model structure is sufficiently rich to eliminate the cross correlations across the idiosyncratic shocks in Equations (7)-(9). In the three-step estimation procedure, the first equation, Equation (3) (or Equation (4) for the GARCH specification with relevant restrictions) is estimated and the global market shocks are obtained. In the second step, the global shock from the first step is related to the GCC regional shocks via Equation

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[8] This estimation approach is also used in Baele (2005), Baele and Inghelbrecht (2009, 2010), and Balli et al. (2010).

[9] An analogue recursive structure is imposed on the GARCH spillover models with the assumptions we make. See the conditions below Equations (4)-(6).

(8) for the MS spillover model and Equation (4) given the relevant restriction for the GARCH spillover model.[10] The third step of the estimation procedure relates the global and regional market shocks to the GCC-wide sectors in Equation (7) for the general MS spillover model and Equation (4) for the GARCH spillover model. This three-step estimation procedure yields consistent, but not necessarily efficient, parameter estimates since we do not correct for the likely estimation errors from the first and second steps.

The common state synchronized dynamic MS model is indeed a multivariate MS model and is estimated as a system. We consider a general multivariate distribution for the idiosyncratic shocks in Equations (7)-(9), although it yields almost the same results with a diagonal specification. This finding indicates that the assumption of the uncorrelated shocks for the general univariate MS and the GARCH spillover models is indeed supported by the data given the model structure. We estimate the parameters of the general and the common state MS spillover models, given that the number of regimes is known, using the maximum likelihood estimation. The likelihood is evaluated using the filtering procedure of Hamilton (1990), followed by the smoothing algorithm of Kim (1994). The log-likelihoods of the MS models are functions of the parameters and the transition probabilities p_{ij}. The estimates are obtained by maximizing the log-likelihood subject to the constraint that the probabilities lie between 0 and 1 and they sum to unity. Various conditional moments of the MS spillover models in Equations (13)-(19) as well as the conditional variance ratios in Equations (20)-(22) are estimated, using the predictive probabilities which are obtained from the transition probabilities and the filtered probabilities of the Hamilton filter. The number of regimes in both models are selected using the likelihood ratio (LR) tests with the upper bound for *p*-values obtained according to Davies (1987). We also supplement the LR tests with AIC.

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[10] Ng (2000) orthogonalizes the global and regional shocks and does not relate the global shocks to the regional shocks as in Equation (8). Our specification sufficiently removes the correlation between the global and regional shocks, and the resulting orthogonalized shock essentially yields the same estimates. We prefer the specification in Equation (8) since it allows us to estimate the spillover of the global shocks to the GCC region commonly.

We estimate the parameters of the univariate GARCH spillover model using the quasi maximum likelihood procedure. A final choice in estimation of the models is the distribution of the idiosyncratic shocks. The normality tests reject the normal distribution for all excess returns, and therefore we estimate the GARCH, the general MS, and the common-state MS models using student *t* distribution. Thus, the idiosyncratic shocks are distributed as $\varepsilon_{l,t} \sim t(v_{S_{l,t}})$ where $v_{S_{l,t}}$ is the degrees of freedom of the student *t* distribution and $l = w, \text{reg}, k$. We allow the degrees of freedom of the student *t* distribution to switch with regimes, causing the tails of the distribution to vary across regimes.

4. Empirical Results

4.1. Data

The empirical analysis includes nine GCC-wide equity sector/subsector indices spread over the six GCC countries, namely Bahrain, Kuwait, Oman, Qatar, United Arab Emirates (UAE), and Saudi Arabia, obtained from Datastream. Since the GCC markets follow different trading days and weekends from the Western markets (i.e. Fridays are part of the weekends in the GCC countries and their markets are closed on those days), we utilize daily data for 3 trading days a week (Monday-Wednesday) when the GCC and the global markets are commonly open. This frequency avoids the weekend effects in both sets of markets. The whole sample period includes 1/1/2006-11/25/2013, which is equivalent to 1,237 observations. This period is dictated by the availability of the data on the GCC equity sectors which have been newly re- classified.

The new sector classifications are based on the Thomson Reuters Business Classification System (TRBC). As of November 2013, TRBC provides a five-level hierarchical classification starting with ten top level sectors. Those top level sectors for the GCC markets include the energy, basic materials, industrials, consumer cyclicals, consumer non-cyclicals, financials, healthcare, technology, telecommunication services, and utilities. Due to the limitations on the availability of sector level data for the GCC countries, we only include the five top sectors, i.e. energy, basic materials, industrials, financials, and utilities, in our analysis. Additionally, we include the industrial and commercial services, and transportation sub-sectors for the industrials sector; and the banking and investment services, and real estate sub-sectors for the financials sector. Thus, our spillover analysis includes nine GCC-wide sector/subsector indices. However, in the case of portfolio analysis, we consider only the subsectors of the industrials and financials top sectors as part of the portfolios.

In order to capture the effect of the regional shocks, we use the MSCI GCC index which covers the large and mid-capitalization firms across the six GCC countries. This index covers about 85% of the free float-adjusted market capitalization in each GCC country. For the world market, we use STOXX Global 1800 index which includes the developed markets only, having a total fixed number of 1,800 constituent firms.[11] This index excludes the GCC markets and is an appropriate representation of the global investor who is currently not invested in any of the GCC markets and is looking for diversification opportunities by allocating part of the global portfolio to GCC stocks. Taking the perspective of a developed market investor, we use the 3-month U.S. Treasury bill rate in order to calculate the excess returns.

Table 1 provides the descriptive statistics of the logarithmic returns for the GCC-wide sector indices, the regional MSCI GCC index and the global STOXX Global 1800 index. We observe negative mean returns for the variables in general, most likely as a result of the global financial crisis experienced during 2007/08. The GCC stock returns are generally less volatile compared to stocks in developed markets, possibly due to the institutional restrictions imposed on these markets to protect them from the negative effects from abroad. On the other

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[11] The STOXX Global 1800 index includes stocks of 600 European, 600 American and 600 Asia/Pacific region firms.

hand, most of the returns are found to exhibit negative skewness which suggests a greater likelihood of experiencing losses than gains in a given time period. The only exception is the energy sector returns which exhibit positive skewness, likely due to this sector's high correlation with oil prices. Similarly, the return distributions have kurtosis values higher than the normal distribution, implying the presence of extreme movements in either direction, thus supporting the use of the t- distribution in the estimation process.

4.2. Estimation results

4.2.1. Estimation procedures and model identification

The GARCH spillover model and the conditional mean and variance models in Equations (4)-(6) are jointly estimated by the QML method. The descriptive statistics reported in Table 1 suggests that the excess return series are generally not normally distributed and have fat tails. In order to incorporate this feature, all GARCH spillover models are estimated with a student *t* error distribution, and the degrees of freedom of the *t*-distribution are also estimated as an additional parameter.

The estimation of the general (unsynchronized) MS spillover model and its common state synchronized multivariate MS (MV-MS) version first requires the determination of the number of regimes. As noted earlier, this study determines the number of market regimes by employing formal statistical tests, rather than making prior assumptions on the regime structure. The empirical evidence obtained in Cakmakli et al. (2011), Guidolin and Timmermann (2006) and Maheu et al. (2009) suggests that more than two regimes might be required to adequately capture the dynamics of returns in stock markets. In the case of the GCC stock returns, Balcilar et al. (2013a, 2013b) for herding show that the 3-regime MS model best captures return dynamics in these markets. In the current application to the GCC-wide sector returns, our empirical strategy for building the MS models first specifies a student *t* error distribution. We next allow the variance of each idiosyncratic shock to depend on the regime in order to account for the volatility switching in the returns. This leads to the heteroscedastic MS models (MSH) which is an appropriate representation, given the time-varying volatility in the return series as displayed in Figures 1(a)-12(a). In the next step, we estimate the linear version of each model and then test the linear models against models with two and three regimes, MSH(2) and MSH(3), alternatives. If the linear model is rejected, we test MSH(2) against MSH(3) and determine the number of regimes. Finally, we estimate the MS spillover model given the number of regimes. In order to test for linearity and determine the number of regimes, we use both the likelihood ratio (LR) statistic and the Akaike Information Criterion (AIC). For the LR test, we report the *p*-values both based on the conventional χ^2 distribution with q degrees of freedom, where q is equal to the number of restrictions plus the nuisance parameters, and also based on the approximate upper bound for the significance level of the LR statistic as derived by Davies (1987).

Table 2 reports the log likelihoods, the LR tests and the AIC for each model under consideration. The results show that the linear models are rejected in favor of the MSH model by the Davies (1987) *p*-values for each series and the system of series (the MV-MS case). Indeed, all *p*-values given in Panel B of Table 2 are below the 1% significance level, and thus linearity is strongly rejected in each case. We reject the linearity against both the MSH(2) and MSH(3) models. Having established evidence supporting the nonlinearity, we next determine the number of regimes by testing MSH(2) against MSH(3). The LR test in Table 2 strongly rejects MSH(2) in favor of MSH(3) for all models with the p-values lower than 1% in each case. Furthermore, the AIC values reported in Panel C of Table 2 select the MSH(3) model uniformly in all cases. We therefore build the MS spillover models with three regimes and a *t*-distribution error term.

4.2.2. Global and regional spillover analysis

Table 3 reports the estimates for the GARCH spillover model in Equations (4)-(6). The constant coefficient GARCH models yield significant and positive estimates for both β_l^{reg} and β_l^{w} across all GCC sectors, indicating positive risk spillovers from global and regional shocks into these sectors in these benchmark models. The finding of a positive risk exposure to the regional and global risk factors is consistent with international asset pricing models and suggests that these risk factors carry a positive price of risk in the GCC equity sectors. However, this finding also implies that the GCC-wide sectors are driven by the same fundamental uncertainties that also drive the regional and global market returns, suggesting that these investments would not provide significant global diversification benefits, particularly during periods when diversification is needed the most. The largest spillover effect from the regional shocks is observed for the Real Estate sector. This finding points to the high integration of the real estate sector which is open to investors from the GCC countries, particularly Dubai in UAE. The lowest regional spillover effect is displayed by the banking sector, which is highly regulated and supervised within national borders due to its importance to the national economy and government. Most GCC countries have a few banks and do not allow foreign banks to have offices in their countries. Similarly, the real estate subsector is found to have the greatest risk exposure to the global shocks, whereas the lowest spillover effect of the global shocks is observed for the energy sector which may be due to the periodic regulatory effect of OPEC. Nevertheless, both the global and regional spillover effects are found to be positive according to the constant parameter model (the benchmark model) which does not take into account the time-variation and possible regime-specific patterns in the model parameters.

On the other hand, taking into account the effect of market regimes yields different results, showing insignificant and sometimes significant and negative spillover coefficients, particularly during periods of high volatility (regime 2). Table 4 presents the estimates for the general MS spillover model which considers the low, high and extreme volatility market regimes. Examining the regime-based parameter estimates, we conclude that the positive spillover effects observed in Table 3 for the benchmark GARCH model, where the spillover parameters are consistently found to be positive and significant, represent in fact the effects of the regional and global shocks during the low volatility regime. On the other hand, we observe in Table 4 for the general MS spillover model that the GCC-wide equity sectors exhibit heterogeneous risk exposures with respect to the regional and global shocks based on the particular prevailing market regime. For example, although the GCC as a region is found to have a positive risk exposure to the global shocks during the low and high volatility regimes, we see that the regional risk exposure to the global shocks turns negative during the extreme volatility regime, with an estimated value of -0.4586 for $\beta_{l,3}^{w}$.

Similarly, the industrials, industrial and commercial services, transportation, financials and real estate sectors and subsectors are found to have negative risk exposures with respect to the global shocks during the high volatility regime, whereas the same logic applies to the energy sector during the extreme volatility regime only. This means that these GCC sectors can serve as safe havens for international investors during periods of high or extreme volatility depending on the particular sector to be utilized in the portfolio. Oil for example can be a safe haven during crises or severe geopolitical tension. Examining the smoothed probability plots for the Global STOXX index's returns in Figure 1d, it is clear that the extreme volatility regime (regime 3) corresponds to the duration and the aftermath of the global crisis in late 2008 and the negotiations around the second bailout package for Greece in late 2011. This is a period of extreme market volatility for the global investors, which is not necessarily related to fundamentals in the GCC region. To that end, our regime-based models appropriately capture this unusual period and suggest that GCC-equity sectors/subsectors could have been used as safe havens by the international investors to offset losses they sustained in the Western markets. The regime-based aspects of financial integration and spillover effects have largely been ignored in the literature and our findings clearly suggest that a regime-based model can offer significant and better insights.

On the other hand, from the perspective of the local investors in the GCC markets, the finding of negative risk exposures of the energy, industrial and commercial services, banks and real estate to the regional shocks during the high and extreme volatility regimes suggests that these GCC sectors can also be used as safe havens in the portfolios for the local GCC investors in order to offset portfolio losses during periods of high and extreme volatility. Overall, the MS spillover model captures useful information that can be used for international and local diversification purposes which cannot be captured by the constant parameter model. The constant coefficient GARCH model clearly packages the results, thus hiding and compromising detailed information about the risk exposures of the sectors/subsectors over the regimes.

A similar argument can also be made for the common state multivariate MS (MV-MS) spillover model presented in Table 5. The assumption of a common regime for all GCC equity sectors, the GCC region and the world in a way overlooks the differences across the GCC sectors and the segmentation of the GCC markets from the global markets. It thus fails to capture the true spillover effects of the shocks into the GCC sectors. For example, the results in Table 5 show positive risk exposure of the GCC region at large to the global shocks, which is consistent with the constant parameter GARCH model. However, several GCC sectors including energy, industrials, financials and utilities are found to have negative risk exposures to the global shocks during the extreme volatility regime under the common regime specification, suggesting possible hedging benefits for global investors.

In order to measure the extent of the global and regional spillovers, we compute the variance ratios defined in Equations (20)-(22). This allows us to compare the spillover effects implied by the three classes of models. Equations (20)-(22) are easily modified for the GARCH spillover model. However, since the MS spillover models have three regimes with each regime characterized by different volatility dynamics, like the various moments in Equations (11)-(19), the variance ratios in Equations (20)-(22) are computed conditionally based on predictive probabilities. This formulation allows one to obtain regime independent variance ratio measures. Summary statistics for the estimated variance ratios of the global shocks ($VR_{k,t}^{w}$), the regional shocks ($VR_{k,t}^{\mathrm{reg}}$), and the idiosyncratic shocks ($VR_{k,t}^{k}$) are given in Table 6. First, we observe that the means of the variances of the GCC region accounted by the global shocks are 2.501%, 7.863%, and 4.055% for the GARCH, MS and MV-MS spillover models, respectively. This implies that more than 90% of the return variance for the GCC region is due to the regional shocks, whereas the global shocks account for less than 10%. This is consistent with the finding by Hammoudeh and Choi (2006) that the volatility of GCC returns are largely explained by their domestic shocks rather than by global factors. It thus further supports that these markets can be potential diversifiers for the global investors.

Among the three classes of models, the general MS spillover model has the highest global spillover implications for the GCC region. Figures 13(a)-15(a) displays the time series plots of $VR_{\mathrm{reg},t}^{w}$ and $VR_{\mathrm{reg},t}^{\mathrm{reg}}$ for the GARCH, MS and MV-MS spillover models, respectively. We observe a significant time variation in the global spillover values. The lowest spillover is implied by the MV-MS model. The lowest time variation in the variance ratios also observed for the MV-MS model. The general MS spillover model implies that the global shocks have accounted account for 10% to 40% of the return volatility in the GCC region during the 2008-2010 period. The variance ratio for $VR_{\mathrm{reg},t}^{w}$ reaches values above 40% at the end of 2011 and early 2012, implying that the global shocks accounted for more than 40% of the regional return variation during this recent period.

Table 6 provides the summary statistics for the variance ratio estimates for the GCC-wide equity sectors. Figures 13(b)-(d), 14(b)-(d), and 15(b)-(d) provide the plots for the GARCH, MS and MV-MS spillover models, respectively. For all sectors, the MV-MS model implies 2.5% to 5.0% global spillover effects with little time variations. This model implies the highest regional spillover ratios which range between 8.699% (industrial and commercial services) and 28.834% (financials). However, the time variation in the $VR_{k,t}^{w}$ values implied by the MV-MS model is low compared to the MS and GARCH spillover models. The general MS model implies that the global shock variance ratios vary between 1.179% (energy) and 5.535% (real estate), while the constant parameter GARCH model implies that the same ratio varies between 1.243% (basic materials) and 3.487% (real estate). The variance ratios of the regional shocks vary between 5.905% (basic materials) and 16.036% (financials) for the general MS model, whereas the regional variance ratios range between 3.788% (industrial and commercial services) and 16.199% (financials) for the standard GARCH model.

Among the three models we consider, the general MS spillover model implies a greater time variation for the global and regional spillovers to the GCC-wide equity sectors. We observe that the regional variance ratios based on the general MS model are higher before 2010, varying between 10% and 60% for all GCC wide sectors. The same model implies more than 20% global spillover during 2009-2010 and the second half of 2011 for all GCC-wide sectors. We observe that regional variance ratios generally decrease over time for all sectors, suggesting increasing importance of the global shocks and perhaps greater integration of these markets with global markets over time. Nevertheless, the variance ratio plots in Figure 14 clearly display the significant spillover effects of the global shocks on the financials, industrials and related sub-sectors; but with the energy, transportation and utilities sectors being relatively less affected by the global equity shocks. The oil-related sectors are subsidized in the GCC countries. The higher variance ratios for the finance-related (sub) sectors are consistent with Arouri and Rault (2012) who suggest a significant link between the financials stocks in the GCC to the Western financial centers. The relatively segmented nature of the subsidized energy related sectors can be utilized by global investors in their diversification strategies.

5. Diversification benefits of GCC-wide equity sectors

The evidence presented so far suggests that the alternative spillover models yield different conclusions than the benchmark GARCH model regarding the spillover effects of the global and regional shocks as well as the co-movements across the global and GCC returns. Most notable differences in the results relate to the time evolution of the spillovers and the correlations of returns. To that end, rather than making judgments on whether one model provides a more realistic assessment of the linkages among the sectoral, regional and global returns over another, we instead focus our attention on the potential diversification benefits of the GCC-wide equity sectors for the global investors. For this purpose, we compare the risk/return tradeoffs offered by alternative portfolios implied by each model and examine the in- and out-of-sample performance of these portfolios.

From the perspective of a global investor, we use the developed equity market index represented by the STOXX 1800 index as the benchmark portfolio to assess the diversification benefits. This benchmark portfolio represents the undiversified investor who is currently not invested in the GCC stock markets. We then create portfolios augmented with the seven GCC-wide equity sectors described above. As noted earlier, we exclude the broad industrial and financial top sectors as their sub-sectors are already included in the portfolio considerations.

The in-sample portfolios are constructed by first estimating each model over the sample period 1/1/2006-8/14/2012 and then computing the in-sample covariance matrix (Σ_t)

of the 8 return series from the moments obtained using Equations (13)-(19). The in-sample analysis contains 1,036 portfolio points for the period 1/1/2006-8/14/2012. On the other hand, the out-of-sample portfolios are constructed following a recursive procedure. We first estimate the model using data over the period 1/1/2006-8/14/2012 and obtain the predicted covariance matrix Σ_{T+1} for 8/15/2012. The first out-of-sample portfolio is then constructed for 8/15/2012. We then adjust the portfolio holdings on a daily basis and update the sample period by adding the next observation and updating the predicted covariance matrix for the next day. Continuing recursively in this fashion, we obtain 200 out-of-sample portfolio points over the period 8/15/2012-11/25/2013. Excess returns are then calculated using the 3-month U.S. Treasury bill rate.

Performance comparisons are made across the five alternative portfolios given the estimates of the covariance matrix Σ_t. Note that the portfolio weights are w_t and the portfolio return is $r_{p,t} = w_t' \mu_t$, where μ_t is the return vector. We restrict the portfolio weights w_t to sum to 1 so that short-selling is not allowed.

Portfolio 1: Undiversified global investor represented by STOXX 1800 with its historical return and risk obtained from the respective model.

Portfolio 2: Diversified minimum-variance portfolio, i.e. the world portfolio augmented with the GCC-wide equity sectors, with the historical return and risk obtained from the respective model.

Portfolio 3: Diversified minimum-variance portfolio with the same return as the STOXX 1800 index.[12]

Portfolio 4: Diversified minimum-variance portfolio with the same risk as the STOXX 1800 index. [13]

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[12] If the STOXX 1800 return is outside the range of returns for efficient portfolios, we replace it with the minimum or maximum efficient portfolio return, depending upon whether the STOXX 1800 return is below or above the range of efficient portfolio returns.

Portfolio 5: Diversified tangency portfolio with the maximum Sharpe ratio.

Table 7 reports the summary statistics of the daily returns for the dynamic in-sample portfolios constructed using the covariance matrices obtained from the GARCH, MS, and MV-MS alternative spillover models. As expected, the diversified minimum-variance portfolio augmented with the GCC-wide equity sectors (Portfolio 2) yields the lowest level of risk, consistently across the three alternative spillover models. Similarly, the undiversified global investor who does not hold any positions in GCC stock markets (Portfolio 1) sustains the greatest level of portfolio risk in all alternative model specifications. Not surprisingly, the diversified tangency portfolio (Portfolio 5) offers the best risk/return tradeoff indicated by the greatest Sharpe ratio values. In general, all augmented portfolios with the exception of Portfolio 2 yield better Sharpe ratios compared to the undiversified portfolio (Portfolio 1), suggesting that supplementing the global portfolio with positions in the GCC equity sectors yields more efficient portfolios. On another note, comparing the results across the three alternative spillover models, we observe that the dynamic portfolios constructed using the covariance matrices obtained from the general MS model yield better risk-adjusted returns. The general model allows the GCC-wide equity sectors, the aggregate GCC region market, and the world market to follow their independent regimes. These regime-switching is not restricted to be synchronized, although they can be so. The portfolio analysis shows that, restricting the regimes of the GCC-wide equity sectors, the GCC-region, and the world is suboptimal and would result in a lower risk-adjusted portfolio.

The summary statistics for the dynamic out-of-sample portfolios reported in Table 8 further support our findings for the in-sample portfolios reported in Table 7. Consistently across all three spillover models, we observe that the portfolios supplemented with positions in the GCC-wide equity sectors yield significantly more efficient portfolios compared to the

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[13] If the STOXX 1800 risk is outside the range of risks for efficient portfolios, we replace it with the minimum or maximum efficient portfolio risk, depending on whether the STOXX 1800 risk is below or above the range of efficient portfolio risks

undiversified global investor portfolio (Portfolio 1). The best Sharpe ratio is once again observed for the diversified tangency portfolio (Portfolio 5). We find that the undiversified global investor experiences the greatest return volatility, while the inclusion of GCC sector positions reduces the portfolio risk in all cases. Once again, we observe that the dynamic portfolios constructed using the covariance matrices obtained from the general (unsynchronized) MS spillover model dominate the portfolios based on the GARCH and MV-MS models in terms of the risk-adjusted returns. Overall, both in- and out-of-sample results clearly suggest that GCC-wide equity sectors offer significant diversification benefits for global investors, regardless of the model specifying the spillover effects.

In order to provide further insight to the dynamic nature of the portfolios discussed in Tables 7 and 8, we provide in Figure 16 the stacked plots of the in- and the out-of-sample portfolio weights corresponding to the diversified tangency portfolio (Portfolio 5) based on the best performing the general MS spillover model. The figure clearly points to the highly time-varying nature of the portfolio weights in both cases. We observe that the GCC-wide equity sector allocation in the diversified portfolio exceeds 60 percent for prolonged periods, underscoring the potential diversification benefits of these markets. Finally, we find that the GCC-wide sectors including utilities, banks and basic materials are allocated higher weights suggesting that global investors should explore these particular sectors in their diversification strategies.

6. Conclusion

This paper extends the literature on the global integration of financial markets and international diversification for developing markets. It examines the risk exposure of the GCC-wide equity sectors with respect to regional and global factors, using three alternative spillover models (i.e., GARCH, MS, and MV-MS) with several different characteristics.

More specifically, we compare the inferences from different spillover models, ranging from the constant parameter GARCH model which is considered as the benchmark model to regime switching spillover models in which the global, regional, and sectoral returns are allowed to have common synchronized and unsynchronized (general) regime-switching processes. Furthermore, unlike in most international diversification studies in the literature, we determine the market regimes by formal statistical testing rather than making assumptions on the possible regime structure. We utilize regime-switching models with more than two regimes for which all model parameters are allowed to vary across the different regimes. Finally, unlike most spillover studies in the literature, we supplement our analysis by comparing the in- and out-of-sample performance of the portfolios constructed based on the static and regime-based models.

Our findings suggest that the risk exposure of the GCC-wide equity sectors with respect to the regional and global shocks display time-varying characteristics with regime-specific spillover effects observed for all those equity sectors and the GCC region to global shocks at large. The regime specification tests identify three market regimes characterized as low, high and extreme volatility market regimes. Although the GCC as a region is found to have a positive risk exposure to the global shocks during the low and high volatility regimes, we find that the regional risk exposure to the global shocks turns negative during the extreme volatility regime. This was the case during and aftermath of the global crisis in late 2008 and around the second bailout package for Greece in late 2011.

Similarly, the GCC-wide industrials, industrial and commercial services, transportation, financials and real estate sectors and subsectors are found to have negative risk exposures with respect to the global shocks during the high volatility regime and the energy sector during the extreme volatility regime, suggesting that the GCC-wide sectors can serve as a safe haven for international investors during periods of high or extreme volatility depending on the particular sector to be utilized in the portfolio. As discussed earlier, the GCC markets are to some extended segmented from the global markets through a set of restrictions that limits foreign ownership. On the other hand, the constant parameter GARCH which serves as the benchmark model and the common state MS models fail to capture the dynamic nature of the return and risk spillovers. These models also fail to provide a complete assessment of the international diversification potential of these markets.

Finally, examining the performance of portfolios constructed using the covariance matrices based on the alternative spillover models suggests that supplementing the world portfolio with positions in the GCC-wide equity sectors/subsectors particularly during the times of extreme volatility, lead to more efficient portfolios with much improved risk-adjusted returns. This finding is consistent across the alternative spillover models examined and supported by both the in- and out-of-sample tests. Finally, the GCC-wide sectors including utilities, banks and basic materials should be allocated greater weights in a diversified portfolio like Portfolio 5. This suggests that global investors should well explore these particular sectors to gain more diversification benefits.

In conclusion, the findings clearly suggest that taking into account the regime-specific and time-varying nature of the return and risk spillovers across stock markets provides valuable insight to the diversification benefits offered by developing markets, particularly during periods of market stress. By doing so, our dynamic models are able to successfully capture the significant diversification potential offered by the cash- and oil- rich GCC stock markets, an assessment that would not be possible to capture by time-invariant spillover, single regime models. The much improved risk-adjusted performance of the world portfolio augmented with positions in the GCC-wide sectors clearly supports the findings from the dynamic spillover analysis in that the partial segmentation of these markets can indeed be utilized to achieve significant international diversification benefits.

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Table 1. Descriptive Statistics

	Mean	S.D.	Min	Max	Skewness	Kurtosis	JB	*Q*(1)	*Q*(4)	ARCH(1)	ARCH(4)
ENERGY	-0.05%	1.39%	-8.30%	14.80%	0.48%	15.38%	12279.50***	21.42***	21.42***	58.81***	66.73***
BMTLS	-0.02%	1.61%	-7.96%	7.10%	-0.29%	5.36%	1505.44***	8.08***	8.08***	147.51***	173.84***
INDUSTRY	-0.07%	1.26%	-7.04%	7.29%	-0.54%	5.51%	1630.23***	1.66	1.66	327.35***	344.42***
INDCOMS	-0.03%	1.89%	-11.93%	9.45%	-0.32%	5.22%	1434.18***	0.89	0.89	140.89***	162.69***
TRANS	-0.09%	1.43%	-8.34%	8.59%	-0.26%	6.21%	2010.53***	0.58	0.58	324.60***	333.47***
FIN	-0.04%	1.06%	-5.79%	4.82%	-0.90%	6.63%	2447.08***	9.96***	9.96***	244.62***	263.32***
BANK	-0.03%	1.01%	-5.83%	4.50%	-0.85%	6.74%	2502.81***	6.08**	6.08**	239.30***	251.17***
RESTATE	-0.10%	1.75%	-9.42%	8.33%	-0.56%	4.72%	1221.27***	4.35**	4.35**	223.70***	256.93***
UTIL	-0.07%	1.73%	-11.07%	8.89%	-0.64%	6.31%	2148.17***	6.41**	6.41**	188.93***	205.88***
GCC	-0.06%	1.15%	-11.70%	4.64%	-1.57%	13.93%	6538.81***	19.70***	19.70***	49.47***	161.62***
WORLD	-0.05%	1.58%	-10.85%	7.48%	-1.22%	8.63%	3861.63***	0.18	0.18	62.68***	392.74***
TB3	-0.02%	1.46%	-16.68%	10.95%	-1.58%	24.37%	243.80***	1234.90***	1234.90***	1229.36***	1226.63***

Note: This table reports the descriptive statistics for daily returns based on 3 trading days per week. The sample period covers 1/1/2006-11/25/2013 with 1,237 observations. GCC-wide equity sectors include ENERGY, BMTLS (basic materials), INDUSTRY (industrials), INDCOMS (industrial and commercial services), TRANS (transportation), FIN (financials), BANK (banking), RESTATE (real estate), and UTIL (utilities). Other indices considered are GCC (Morgan Stanley GCC index), WORLD (SOXX Global 1800 developed market index) and TB3 (the 3-month US Treasury bill rate). In addition to the mean, standard deviation (S.D.), minimum (min), maximum (max), skewness, and kurtosis statistics, the table reports the Jarque-Berra normality test (JB), the Ljung-Box first [*Q*(1)] and the fourth [*Q*(4) autocorrelation tests, and the first [ARCH(1)] and the fourth [ARCH(4)] order Lagrange multiplier (LM) tests for the autoregressive conditional heteroskedasticity (ARCH). ***, ** and * represent significance at the 1%, 5%, and 10% levels, respectively.

Table 2: Model Selection Criteria and Tests

Panel A: log L

	Linear	MSH(2)	MSH(3)
WORLD	-2007.181	-1694.142	-1663.891
GCC	-2342.106	-1860.115	-1835.189
ENERGY	-2046.543	-1732.139	-1681.271
BMTLS	-2220.911	-1844.921	-1829.446
INDUSTRY	-1863.901	-1659.920	-1585.668
INDCOMS	-2431.799	-2246.790	-2222.780
TRANS	-2072.677	-1845.246	-1817.446
FIN	-1599.692	-1308.438	-1272.386
BANK	-1574.469	-1288.117	-1257.041
RESTATE	-2266.673	-2142.874	-2034.375
UTIL	-2328.971	-2052.072	-2015.071
MV-MS	-19,884.437	-19,685.253	-19,110.962

Panel B: Likelihood Ratio Tests

	H_0: Linear, H_1: MSH(2)	H_0: Linear, H_1: MSH(3)	H_0: MSH(2), H_1: MSH(3)
WORLD	626.078*** (0.000) [0.000]	686.578*** (0.000) [0.000]	60.500*** (0.000) [0.000]
GCC	963.981*** (0.000) [0.000]	1013.833*** (0.000) [0.000]	49.852*** (0.000) [0.000]
ENERGY	628.807*** (0.000) [0.000]	730.543*** (0.000) [0.000]	101.736*** (0.000) [0.000]
BMTLS	751.981*** (0.000) [0.000]	782.930*** (0.000) [0.000]	30.949*** (0.001) [0.000]
INDUSTRY	407.962*** (0.000) [0.000]	556.466*** (0.000) [0.000]	148.505*** (0.000) [0.000]
INDCOMS	370.019*** (0.000) [0.000]	418.038*** (0.000) [0.000]	48.019*** (0.000) [0.000]
TRANS	454.862*** (0.000) [0.000]	510.461*** (0.000) [0.000]	55.599*** (0.000) [0.000]
FIN	582.508*** (0.000) [0.000]	654.612*** (0.000) [0.000]	72.103*** (0.000) [0.000]
BANK	572.705*** (0.000) [0.000]	634.856*** (0.000) [0.000]	62.151*** (0.000) [0.000]
RESTATE	247.597*** (0.000) [0.000]	464.596*** (0.000) [0.000]	216.999*** (0.000) [0.000]
UTIL	553.797*** (0.000) [0.000]	627.799*** (0.000) [0.000]	74.002*** (0.000) [0.000]
MV-MS	1148.582*** (0.000) [0.000]	398.368*** (0.000) [0.000]	1546.950*** (0.000) [0.000]

Panel C: AIC

	Linear	MSH(2)	MSH(3)
WORLD	3.251	2.758	2.722
GCC	3.796	3.033	3.008
ENERGY	3.321	2.832	2.769
BMTLS	3.603	3.014	3.009
INDUSTRY	3.026	2.715	2.614
INDCOMS	3.945	3.665	3.645
TRANS	3.364	3.015	2.989
FIN	2.598	2.146	2.107
BANK	2.557	2.113	2.083
RESTATE	3.677	3.497	3.340
UTIL	3.778	3.350	3.309
MV-MS	32.274	32.086	31.278

Notes: log *L* is the value of the log likelihood of the model based on the values of the estimated parameter and AIC is the Akaike Information Criterion. The linear model is the spillover regression model obtained from Equations (1)-(3) with one regime restriction. MSH(*m*) is the Markov-switching spillover model given in Equations (1)-(3) with regime dependent (heteroscedastic) variance, $\varepsilon_{l,t} \sim iid(0, \sigma^2_{s_{l,t}})$, *l* = *w*, reg and *k* and j regimes. H_0 specifies the model under the null hypothesis that is tested against the alternative model under H_1. The test statistics are computed as the likelihood ratio (LR) test. The LR test is nonstandard since there are unidentified parameters under the null. The χ^2 *p*-values (in parentheses) with degrees of freedom are equal to the number of restrictions plus the numbers of parameters unidentified under the null. The *p*-values of the Davies (1987) test are given in brackets. The models are estimated over the full sample period 1/1/2006-11/25/2013 with 1,236 observations. ***, ** and * represent significance at the 1%, 5%, and 10% levels, respectively.

Table 3: Estimates of the Constant Coefficient GARCH Spillover Model

Parameter	WORLD	GCC	ENERGY	BMTLS	INDUSTRY	INDCOMS	TRANS	FIN	BANK	RESTATE	UTIL
$\phi_{l,0}$	0.055^{***}	0.056^{***}	0.007	0.038^{*}	0.024	0.008	0.002	0.031^{**}	0.033^{**}	-0.006	0.003
	(0.021)	(0.019)	(0.021)	(0.022)	(0.019)	(0.036)	(0.024)	(0.015)	(0.016)	(0.028)	(0.027)
$\phi_{l,1}$	0.043	0.052^{*}	0.053^{**}	-0.003	-0.061^{**}	-0.056^{**}	-0.046^{*}	-0.036	-0.023	-0.027	-0.001
	(0.030)	(0.030)	(0.026)	(0.025)	(0.024)	(0.027)	(0.027)	(0.024)	(0.025)	(0.026)	(0.028)
ϕ_l^{reg}			0.062^{***}	0.050^{***}	0.076^{***}	0.046^{*}	0.079^{***}	0.047^{***}	0.039^{***}	0.081^{***}	0.069^{***}
			(0.017)	(0.018)	(0.016)	(0.024)	(0.020)	(0.013)	(0.013)	(0.025)	(0.023)
ϕ_l^{w}		0.128^{***}	0.081^{***}	0.110^{***}	0.090^{***}	0.123^{***}	0.088^{***}	0.109^{***}	0.102^{***}	0.172^{***}	0.099^{***}
		(0.022)	(0.020)	(0.022)	(0.020)	(0.032)	(0.024)	(0.016)	(0.015)	(0.029)	(0.026)
β_l^{reg}			0.209^{***}	0.211^{***}	0.260^{***}	0.191^{***}	0.235^{***}	0.222^{***}	0.188^{***}	0.358^{***}	0.228^{***}
			(0.017)	(0.019)	(0.015)	(0.023)	(0.019)	(0.015)	(0.012)	(0.021)	(0.024)
β_l^{w}		0.164^{***}	0.079^{***}	0.122^{***}	0.126^{***}	0.176^{***}	0.115^{***}	0.119^{***}	0.102^{***}	0.235^{***}	0.106^{***}
		(0.021)	(0.020)	(0.023)	(0.019)	(0.033)	(0.022)	(0.016)	(0.015)	(0.027)	(0.027)
ω_l	0.016^{***}	0.019^{***}	0.085^{***}	0.063^{***}	0.039^{***}	0.209^{***}	0.037^{***}	0.030^{***}	0.033^{***}	0.138^{***}	0.033^{**}
	(0.003)	(0.006)	(0.011)	(0.011)	(0.009)	(0.027)	(0.007)	(0.004)	(0.005)	(0.018)	(0.015)
α_l	0.125^{***}	0.219^{***}	0.378^{***}	0.215^{***}	0.223^{***}	0.194^{***}	0.172^{***}	0.249^{***}	0.262^{***}	0.265^{***}	0.141^{***}
	(0.007)	(0.014)	(0.026)	(0.016)	(0.013)	(0.016)	(0.010)	(0.016)	(0.017)	(0.018)	(0.035)
γ_l	0.870^{***}	0.847^{***}	0.649^{***}	0.806^{***}	0.764^{***}	0.771^{***}	0.822^{***}	0.736^{***}	0.721^{***}	0.697^{***}	0.859^{***}
	(0.005)	(0.007)	(0.014)	(0.009)	(0.016)	(0.011)	(0.007)	(0.011)	(0.011)	(0.011)	(0.032)
v_l	5.506^{***}	2.932^{***}	3.940^{***}	3.147^{***}	5.369^{***}	3.728^{***}	4.925^{***}	5.046^{***}	4.769^{***}	6.187^{***}	4.535^{***}
	(0.657)	(0.093)	(0.238)	(0.127)	(0.679)	(0.224)	(0.648)	(0.525)	(0.437)	(0.899)	(0.595)
log *L*	-1650.765	-1820.89	-1704.19	-1870.793	-1601.708	-2249.293	-1828.397	-1308.395	-1281.729	-2056.674	-2027.84
AIC	2.681	2.959	2.774	3.043	2.608	3.656	2.975	2.133	2.09	3.344	3.297

Note: The table reports the parameter estimates of the constant coefficient GARCH spillover model described in Equations (4)-(6). In each case, we parameterize $\mu_{l,t-1}$ as $\mu_{l,t-1} = \phi_{l,0} + \phi_{l,1} R_{l,t-1}$, where *l*=*k* (sector), *reg* (region) and *w* (world). The error distribution is assumed to be student t distribution, i.e. $\varepsilon_{l,t} \sim t(v_l)$, where v_l is the degrees of freedom of the student *t* distribution The parameters are estimated using the QML method. Models are estimated over the full sample period 1/1/2006-11/25/2013 with 1,236 observations. The standard errors of the estimates are given in parentheses. ***, ** and * represent significance at the 1%, 5%, and 10% levels, respectively.

Table 4: Estimates of the General MS Spillover Model

Parameters	WORLD	GCC	ENERGY	BMTLS	INDUSTRY	INDCOMS
$\phi_{l,0,1}$	0.0731*** (0.0000)	0.0605*** (0.0227)	0.0165 (0.0225)	0.0075 (0.0228)	0.0594*** (0.0219)	-0.0058 (0.0663)
$\phi_{l,0,2}$	-0.0546*** (0.0000)	-0.1030 (0.0901)	-0.0499 (0.0637)	-0.0113 (0.0649)	-0.1728 (0.1282)	-0.0015 (0.046)
$\phi_{l,0,3}$	-0.0328*** (0.0000)	0.1119 (0.5014)	0.1102 (0.1231)	0.0084 (0.0196)	-0.1107 (0.1212)	-0.0215 (0.3290)
$\phi_{l,1,1}$	0.0280*** (0.0000)	0.0623* (0.0372)	0.0009 (0.0027)	-0.0104 (0.0405)	-0.0794** (0.0357)	-0.0349 (0.0518)
$\phi_{l,1,2}$	0.0733*** (0.0000)	0.0691 (0.0492)	0.1387*** (0.0105)	0.0127 (0.0891)	0.0763 (0.0992)	-0.0301 (0.2762)
$\phi_{l,1,3}$	0.0287*** (0.0000)	0.2718** (0.1183)	-0.0721 (0.2389)	0.0124 (0.0769)	-0.2061*** (0.0649)	-0.1235 (0.1071)
$\phi_{l,1}^{reg}$			0.0318 (0.0341)	0.0251 (0.0272)	0.0495* (0.0276)	-0.0367 (0.0423)
$\phi_{l,2}^{reg}$			0.2293*** (0.0291)	-0.3644*** (0.0739)	0.0846* (0.0432)	0.0381 (0.0902)
$\phi_{l,3}^{reg}$			-0.2635*** (0.0156)	0.2873*** (0.0634)	0.2139*** (0.0557)	0.2508*** (0.0773)
$\phi_{l,1}^{w}$		0.1349*** (0.0279)	0.0730*** (0.0263)	0.1045*** (0.0254)	0.0882*** (0.0246)	0.0990** (0.0449)
$\phi_{l,2}^{w}$		0.1371** (0.0532)	0.2773*** (0.0537)	0.0457 (0.1166)	0.0202 (0.0805)	-0.1828 (0.1939)
$\phi_{l,3}^{w}$		0.6920*** (0.2322)	-0.1219 (0.0868)	0.2724** (0.1147)	0.2386*** (0.0650)	0.3613** (0.1678)
Spillover parameters						
$\beta_{l,1}^{reg}$			0.1250*** (0.0391)	0.1402*** (0.0253)	0.2232*** (0.0280)	0.1217*** (0.0383)
$\beta_{l,2}^{reg}$			0.4184*** (0.0432)	0.4157*** (0.0643)	**0.0279** (0.0455)	**-0.0421** (0.0844)
$\beta_{l,3}^{reg}$			**-0.2149***** (0.0511)	0.2757*** (0.0583)	0.4304*** (0.0487)	0.4866*** (0.0917)
$\beta_{l,1}^{w}$		0.1673*** (0.0264)	0.0852*** (0.0292)	0.1143*** (0.0242)	0.1084*** (0.0236)	0.1548*** (0.0394)
$\beta_{l,2}^{w}$		0.4141*** (0.0686)	**0.0375** (0.0522)	**0.0133** (0.0631)	**-0.1197** (0.1132)	**-0.6211***** (0.1306)
$\beta_{l,3}^{w}$		**-0.4586**** (0.4118)	**-0.0095** (0.0019)	0.3635*** (0.1050)	0.2518*** (0.0633)	0.3594*** (0.1118)
Distribution parameters						
$v_{l,1}$	6.1269*** (0.0000)	4.3453*** (1.1494)	6.9788** (2.8139)	4.2430*** (1.0319)	7.5631*** (2.3049)	4.4771*** (1.3076)
$v_{l,2}$	10.2239*** (0.0000)	4.3094*** (1.0681)	3.7862*** (0.7816)	15.8549 (90.8741)	32.2671 (36.0564)	7.6100 (12.8119)
$v_{l,3}$	123.9222*** (0.0000)	8.9023 (21.9013)	11.5918 (8.0965)	8.0723** (3.4656)	23.5933* (16.6925)	8.6582 (6.4955)
Standard deviations						
$\sigma_{l,1}$	0.4623*** (0.0000)	0.4644*** (0.1810)	0.4787*** (0.1726)	0.4967*** (0.1603)	0.5114*** (0.1672)	0.7811*** (0.3302)
$\sigma_{l,2}$	0.9624*** (0.0000)	1.2538*** (0.5395)	1.0811*** (0.4328)	0.7199 (0.6219)	1.0683*** (0.4985)	0.9686 (1.3085)
$\sigma_{l,3}$	2.5904*** (0.0000)	3.6952*** (1.7908)	1.1098*** (0.5660)	2.0313*** (0.8041)	1.5931*** (0.4964)	2.1464*** (1.0783)
Model Statistics						
$\tau_{l,1}$	41.9862	57.9675	35.6968	37.7164	60.9767	33.5468
$\tau_{l,2}$	40.091	17.2023	4.2228	1.5565	12.3569	2.7472
$\tau_{l,3}$	70.1367	6.4116	1.4662	4.9343	11.3514	6.6795
$n_{l,1}$	0.4484	0.5518	0.5622	0.6092	0.6630	0.5809
$n_{l,2}$	0.4268	0.3509	0.3348	0.0979	0.1113	0.1105
$n_{l,3}$	0.1248	0.0973	0.1029	0.2929	0.2257	0.3086
AIC	2.7215	3.0084	2.7690	3.0088	2.6143	2.7215
log *L*	-1663.8914	-1835.1889	-1681.271	-1829.4463	-1585.6675	-2222.7802

Notes: The table reports the parameter estimates of the general MS spillover model in Equations (1)-(3). In each case, we parameterize $\mu_{l,S_{l,t},t-1}$ as $\mu_{l,S_{l,t},t-1} = \phi_{l,0,S_{l,t}} + \phi_{l,1,S_{l,t}} R_{l,t-1}$, where *l*=*k* (sector), *reg* (region) and *w* (world). $n_{l,m}$ is the percentage of observations in regime *m* (ergodic probability of the regime), $\tau_{l,m}$ is the duration of regime *m*. The error distribution is assumed to be the student *t* distribution, i.e., $\varepsilon_{l,t} \sim t(v_{l,S_{l,t}})$, where $v_{l,S_{l,t}}$ is the degree of freedom . The parameters are estimated using ML. The standard errors of the estimates are given in parentheses. ***, ** and * represent significance at the 1%, 5%, and 10% levels, respectively.

Table 4 (continued)

Parameters	TRANS	FIN	BANK	RESTATE	UTIL
$\phi_{l,0,1}$	0.0104 (0.1134)	0.0414** (0.0165)	0.0141 (0.0167)	0.0159 (0.0336)	-0.0249 (0.0295)
$\phi_{l,0,2}$	-0.0197 (1.0318)	0.0035 (0.0059)	0.0147 (0.0503)	-0.1808 (0.3884)	-0.1068 (0.1174)
$\phi_{l,0,3}$	-0.1863 (0.3154)	-0.0463 (0.0761)	-0.0365 (0.0765)	-0.1705 (0.1215)	0.1036 (0.2024)
$\phi_{l,1,1}$	-0.0780 (0.0805)	-0.0487 (0.0379)	-0.0777** (0.0370)	0.0576 (0.0360)	0.0067 (0.0287)
$\phi_{l,1,2}$	0.0698 (0.2953)	0.0815 (0.0725)	0.2141** (0.0866)	-0.3967*** (0.1466)	0.0784 (0.0721)
$\phi_{l,1,3}$	-0.0867 (0.0897)	-0.1231** (0.0562)	-0.0590 (0.0627)	-0.1069** (0.0532)	-0.0409 (0.0577)
$\phi_{l,1}^{\mathrm{reg}}$	0.0510 (0.0567)	0.0385* (0.0226)	0.0556** (0.0225)	-0.0135 (0.0366)	0.0717** (0.0350)
$\phi_{l,2}^{\mathrm{reg}}$	0.0957 (0.0878)	0.0771** (0.0353)	-0.0484 (0.0915)	0.0227 (0.0218)	0.3397*** (0.0778)
$\phi_{l,3}^{\mathrm{reg}}$	0.1924*** (0.0611)	0.1542*** (0.0420)	0.1342*** (0.0360)	0.2824*** (0.0608)	-0.3028*** (0.1121)
$\phi_{l,1}^{w}$	0.1142*** (0.0298)	0.1150*** (0.0184)	0.1233*** (0.0186)	0.1317*** (0.0342)	0.0761** (0.0339)
$\phi_{l,2}^{w}$	-0.1936 (0.1622)	0.0241 (0.0824)	-0.0422 (0.0877)	0.0412 (0.1373)	0.6003*** (0.0736)
$\phi_{l,3}^{w}$	0.1626 (0.1050)	0.2441*** (0.0427)	0.2070*** (0.0470)	0.3453*** (0.0809)	-0.0117 (0.0316)
			Spillover parameters		
$\beta_{l,1}^{\mathrm{reg}}$	0.2209*** (0.0529)	0.2144*** (0.0216)	0.2057*** (0.0248)	0.2942*** (0.0366)	0.1098*** (0.0354)
$\beta_{l,2}^{\mathrm{reg}}$	**0.0258** (0.1459)	**0.0163** (0.0333)	**-0.0483***** (0.0128)	**-0.1646***(0.1916)	0.5889*** (0.0394)
$\beta_{l,3}^{\mathrm{reg}}$	0.4289*** (0.1254)	0.3816*** (0.0390)	0.3184*** (0.0442)	0.4618*** (0.0670)	**0.1065** (0.0791)
$\beta_{l,1}^{w}$	0.1034*** (0.0266)	0.1073*** (0.0182)	0.0947*** (0.0179)	0.1542*** (0.0348)	0.0863*** (0.0331)
$\beta_{l,2}^{w}$	**-0.1114** (0.2523)	**-0.0096** (0.0469)	**0.0261** (0.0597)	**-0.5185***** (0.1241)	**0.1068** (0.0752)
$\beta_{l,3}^{w}$	0.2214*** (0.0731)	0.2198*** (0.0510)	0.2063*** (0.0567)	0.4913*** (0.0733)	**0.1816** (0.1377)
			Distribution parameters		
$v_{l,1}$	7.0914** (3.5912)	7.9520*** (2.7749)	6.2198*** (1.6114)	56.0270 (62.1973)	6.5341*** (2.3726)
$v_{l,2}$	33.3381 (228.3765)	5.5546** (2.4933)	7.7159 (6.2977)	11.5213 (26.7204)	7.4512 (10.1250)
$v_{l,3}$	20.0215 (38.9102)	5.3085*** (1.8746)	5.0318*** (1.4106)	16.9258 (28.5638)	11.6050 (2471)
			Standard deviations		
$\sigma_{l,1}$	0.6002*** (0.2295)	0.3947*** (0.1240)	0.3765*** (0.1177)	0.8605*** (0.1609)	0.6545*** (0.2264)
$\sigma_{l,2}$	1.2800 (1.1179)	0.8262*** (0.3644)	0.5317*** (0.2057)	1.6218* (1.1679)	1.4783*** (1.8134)
$\sigma_{l,3}$	1.8568*** (0.5664)	1.0796*** (0.4787)	1.1079*** (0.3026)	1.9762*** (0.9667)	2.0298*** (2.6396)
			Model Statistics		
$\tau_{l,1}$	41.9862	57.9675	35.6968	37.7164	60.9767
$\tau_{l,2}$	40.091	17.2023	4.2228	1.5565	12.3569
$\tau_{l,3}$	70.1367	6.4116	1.4662	4.9343	11.3514
$n_{l,1}$	0.6285	0.6596	0.6398	0.6846	0.6027
$n_{l,2}$	0.1207	0.0566	0.1047	0.0391	0.2190
$n_{l,3}$	0.2508	0.2838	0.2555	0.2763	0.1783
AIC	2.7215	3.0084	2.7690	3.0088	2.6143
log L	-1663.8914	-1835.1889	-1681.271	-1829.4463	-1585.6675

Notes: See the notes in Table 4 above.

Table 5: Estimates of the Common State MS Spillover Model

Parameters	WORLD	GCC	ENERGY	BMTLS	INDUSTRY	INDCOMS
$\phi_{l,0,1}$	0.0068 (0.0102)	-0.1016*** (0.0295)	-0.0534 (0.0533)	0.0010 (0.0044)	-0.0416*** (0.0103)	-0.0089 (0.0146)
$\phi_{l,0,2}$	0.0160 (0.0312)	-0.0769 (0.1816)	-0.0349 (0.0840)	0.0055 (0.0151)	-0.0503 (0.0590)	-0.0056 (0.0127)
$\phi_{l,0,3}$	-0.0099 (0.0137)	0.0681 (0.1162)	0.0451 (0.0790)	-0.0000092	0.0448 (0.0526)	0.0090 (0.0246)
$\phi_{l,1,1}$	0.0213 (0.0168)	0.0680* (0.0372)	0.0529** (0.0269)	-0.0178 (0.0483)	-0.0695 (0.0455)	-0.0698 (0.0939)
$\phi_{l,1,2}$	0.0155 0.0405)	0.0404 (0.1144)	0.1119 (0.0931)	-0.0040 (0.0083)	-0.0672 (0.1431)	-0.0415 (0.0834)
$\phi_{l,1,3}$	-0.0045*(0.0103)	-0.0473* (0.0263)	-0.0543*(0.0957)	0.0106 (0.0275)	0.1057** (0.0429)	0.0668 (0.2886)
$\phi_{l,1}^{\text{reg}}$		0.1544*** (0.0315)	0.1592*** (0.0268)	0.1853*** (0.0298)	0.1845*** (0.0244)	0.1953*** (0.0646)
$\phi_{l,2}^{\text{reg}}$		0.4424*** (0.1423)	0.1131** (0.0542)	0.2509*** (0.0592)	0.1283*** (0.0407)	0.2214*** (0.0726)
$\phi_{l,3}^{\text{reg}}$		-0.2880 (0.1973)	-0.1273*** (0.0475)	-0.2306*** (0.0598)	-0.2020*** (0.0301)	-0.1958** (0.0970)
$\phi_{l,1}^{w}$			0.1693*** (0.0326)	0.1773*** (0.0350)	0.1728*** (0.0231)	0.2259*** (0.0657)
$\phi_{l,2}^{w}$			0.1083 (0.1869)	0.2768*** (0.0864)	0.2096* (0.1196)	0.0507 (0.0961)
$\phi_{l,3}^{w}$			-0.2883*** (0.0831)	-0.2351*** (0.0776)	-0.0995* (0.0565)	-0.2725*** (0.0950)
Spillover parameters						
$\beta_{l,1}^{\text{reg}}$			0.3125*** (0.0451)	0.3605*** (0.0543)	0.4131*** (0.0519)	0.2443*** (0.0844)
$\beta_{l,2}^{\text{reg}}$			0.3106*** (0.0501)	0.3202*** (0.0612)	0.3253*** (0.0494)	0.5669*** (0.0712)
$\beta_{l,3}^{\text{reg}}$			-0.0885** (0.0354)	-0.2184*** (0.0589)	-0.1598*** (0.0291)	-0.2025*** (0.0483)
$\beta_{l,1}^{w}$		0.2767*** (0.0335)	0.1576*** (0.0283)	0.1702*** (0.0320)	0.1707*** (0.0288)	0.3193*** (0.0551)
$\beta_{l,2}^{w}$		0.4177*** (0.0844)	0.1094 (0.1311)	0.3470*** (0.0812)	0.1974*** (0.0586)	0.0866 (0.1585)
$\beta_{l,3}^{w}$		0.0326 (0.0626)	-0.2612** (0.1022)	-0.0676*(0.0932)	-0.2303** (0.0937)	-0.1393 (0.4398)
Standard deviations						
$\sigma_{l,1}$	0.8531*** (0.1947)	0.7408*** (0.1821)	0.5853*** (0.1550)	0.6805*** (0.2293)	0.5301*** (0.1568)	1.2179*** (0.3741)
$\sigma_{l,2}$	0.9201*** (0.3139)	2.0087*** (0.7266)	1.1608*** (0.3689)	1.3028*** (0.4413)	0.8807*** (0.3040)	1.3381** (0.8489)
$\sigma_{l,3}$	1.8773*** (0.5627)	2.7080*** (1.0029)	2.0067*** (0.6484)	2.4923*** (0.8367)	1.7924*** (0.5454)	2.9368*** (0.9540)

Notes: The table reports the parameter estimates of the common state multivariate MS (MV-MS) spillover model given in Equations (1)-(3), with a 3-regime common state variable S_t that takes on values in {1, 2, 3}. In each case, we parameterize $\mu_{l,S_t,t-1}$ as $\mu_{l,S_t,t-1} = \phi_{l,0,S_t} + \phi_{l,1,S_t} R_{l,t-1}$, where $l=k$, reg, and w denotes sector k, GCC regional, or world markets, respectively. n_m is the percentage of observations in regime m (ergodic probability of the regime), τ_m is the duration of regime m. The error distribution is assumed to be the student t distribution with v_{S_t} degrees of freedom. The parameters are estimated using the system ML. The standard errors of the estimates are given in parentheses. The models are estimated over the full sample period 1/1/2006-11/25/2013 with 1,236 observations. The asterisks ***, ** and * represent significance at the 1%, 5%, and 10% levels, respectively.

Table 5: (continued)

Parameters	TRANS	FIN	BANK	RESTATE	UTIL
$\phi_{l,0,1}$	-0.0729*** (0.0274)	-0.0196** (0.0099)	-0.00016954	-0.1013*** (0.0335)	-0.0587 (0.0439)
$\phi_{l,0,2}$	-0.0932 (0.2535)	-0.0275 (0.0516)	-0.0285 (0.0176)	-0.0734 (0.1047)	-0.0336 (0.1364)
$\phi_{l,0,3}$	0.0560 (0.0727)	0.0606** (0.0247)	0.0252 (0.0620)	0.0705 (0.0559)	-0.0774 (0.2778)
$\phi_{l,1,1}$	-0.0545** (0.0244)	0.0062 (0.0084)	-0.0407 (0.0281)	-0.0892*** (0.0325)	0.0317 (0.0343)
$\phi_{l,1,2}$	-0.0784 (0.0664)	-0.0803 (0.0821)	-0.0439 (0.0624)	-0.1790*** (0.0670)	0.0449 (0.0650)
$\phi_{l,1,3}$	0.0369 (0.1196)	0.0579 (0.0651)	0.0921* (0.0524)	0.0496 (0.1434)	-0.0280 (0.0339)
$\phi^{reg}_{l,1}$	0.1601*** (0.0321)	0.1055*** (0.0214)	0.1043*** (0.0228)	0.1896*** (0.0376)	0.1091*** (0.0381)
$\phi^{reg}_{l,2}$	0.2789*** (0.0598)	0.1785*** (0.0489)	0.1084*** (0.0340)	0.2671*** (0.0538)	0.1159** (0.0472)
$\phi^{reg}_{l,3}$	-0.3388*** (0.0430)	-0.0554 (0.0365)	-0.1085*** (0.0251)	-0.1333 (0.0992)	-0.1241 (0.0944)
$\phi^{w}_{l,1}$	0.1151*** (0.0321)	0.1728*** (0.0173)	0.1557*** (0.0171)	0.2510*** (0.0342)	0.2110*** (0.0362)
$\phi^{w}_{l,2}$	0.1356** (0.0659)	0.2011*** (0.0666)	0.2437*** (0.0560)	0.4169*** (0.0894)	0.3143 (0.1938)
$\phi^{w}_{l,3}$	-0.1325 (0.1796)	-0.2200*** (0.0601)	-0.1683*** (0.0371)	-0.3190*** (0.0707)	-0.4325*** (0.0762)
			Spillover parameters		
$\beta^{reg}_{l,1}$	0.3391*** (0.0522)	0.3946*** (0.0272)	0.3415*** (0.0260)	0.5992*** (0.0502)	0.3868*** (0.0553)
$\beta^{reg}_{l,2}$	0.4399*** (0.0506)	0.2743*** (0.0426)	0.2879*** (0.0365)	0.4436*** (0.0613)	0.4802*** (0.0608)
$\beta^{reg}_{l,3}$	-0.1940*** (0.0462)	-0.0726*** (0.0192)	-0.0678** (0.0275)	-0.1926*** (0.0620)	-0.0310 (0.0586)
$\beta^{w}_{l,1}$	0.1326*** (0.0347)	0.1470*** (0.0189)	0.1460*** (0.0231)	0.2294*** (0.0378)	0.2323*** (0.0383)
$\beta^{w}_{l,2}$	0.2787*** (0.0717)	0.2427*** (0.0547)	0.1612*** (0.0475)	0.4915*** (0.0827)	-0.0894 (0.1308)
$\beta^{w}_{l,3}$	-0.0581 (0.2007)	-0.1603** (0.0791)	-0.0626 (0.0729)	-0.3187* (0.1675)	-0.2385** (0.1195)
			Standard deviations		
$\sigma_{l,1}$	0.6847*** (0.2073)	0.3510*** (0.0924)	0.3579*** (0.0961)	0.8430*** (0.2064)	0.8305*** (0.2098)
$\sigma_{l,2}$	1.1072*** (0.3803)	0.5692*** (0.2247)	0.5846*** (0.1945)	1.0506*** (0.4293)	1.4153*** (0.5731)
$\sigma_{l,3}$	2.1065*** (0.6561)	1.7210*** (0.6692)	1.4601*** (0.4532)	2.5637*** (0.8464)	2.5127*** (0.7365)
			Model Statistics		
τ_1	τ_2	τ_3	n_1	n_2	n_3
4.5726	2.884	1.5142	0.5603	0.2252	0.2145
v_1	v_2	v_3	AIC	log L	
6.2308*** (1.9275)	10.1984*** (4.1286)	12.9436 (38.8422)	31.2783	-19110.9620	

Note: See notes to Table 4 above.

Table 6: Summary Statistics for the Variance Ratios

	Variance due to Global Shocks				Variance due to Regional Shocks				Variance due to Idiosyncratic Shocks			
	Mean	S.D.	Min	Max	Mean	S.D.	Min	Max	Mean	S.D.	Min	Max
	The GARCH Spillover Model											
GCC Region	2.501	2.866	0.018	17.558					97.499	2.866	82.442	99.983
ENERGY	0.789	0.902	0.009	7.015	8.764	7.534	0.030	45.089	90.447	7.761	52.233	99.946
BMTLS	1.243	1.426	0.061	10.603	6.079	5.782	0.190	51.629	92.678	6.019	48.146	99.675
INDUSTRY	2.174	2.228	0.061	15.539	14.443	10.702	1.362	57.461	83.384	10.937	41.609	98.091
INDCOMS	1.468	1.516	0.055	10.252	3.788	4.543	0.136	40.455	94.745	4.965	59.053	99.721
TRANS	1.418	1.764	0.054	14.177	9.328	7.986	0.682	53.622	89.254	8.268	46.211	98.944
FIN	2.914	2.953	0.054	22.753	16.199	11.237	0.614	64.599	80.886	11.444	35.134	99.220
BANK	2.333	2.376	0.053	18.057	12.994	9.861	0.307	56.171	84.673	10.092	43.591	99.607
RESTATE	3.487	3.344	0.070	22.798	14.270	11.363	0.752	60.661	82.244	11.896	37.997	98.241
UTIL	0.847	1.000	0.023	8.725	6.239	4.821	0.546	33.751	92.914	4.917	65.948	99.234
	The General MS Spillover Model											
GCC Region	7.863	9.000	0.480	37.312					92.137	9.000	62.688	99.520
ENERGY	1.179	2.376	0.011	13.880	13.911	13.487	2.366	59.296	84.910	13.115	40.375	96.694
BMTLS	4.264	5.215	0.595	22.587	5.905	5.650	0.972	37.051	89.832	7.738	58.396	98.034
INDUSTRY	3.397	4.356	0.345	20.337	11.056	8.595	1.294	52.354	85.546	9.684	46.586	97.671
INDCOMS	5.573	6.899	0.672	45.032	5.983	6.809	0.881	35.902	88.444	10.063	44.809	97.823
TRANS	2.211	2.992	0.205	14.144	8.215	7.301	1.018	46.133	89.574	8.070	53.041	98.496
FIN	4.881	6.072	0.011	29.144	16.036	11.468	0.490	60.840	79.083	13.065	35.703	99.469
BANK	4.416	5.447	0.330	25.878	15.551	10.925	2.664	59.952	80.033	11.652	30.453	96.354
RESTATE	5.535	7.093	0.579	31.945	9.546	8.184	1.807	47.185	84.918	10.948	48.343	96.077
UTIL	1.249	1.759	0.087	8.925	8.195	9.297	1.300	51.158	90.556	9.407	48.742	98.207
	The Common State MV-MS Spillover Model											
GCC Region	4.055	0.660	2.961	5.179					95.945	0.660	94.820	97.039
ENERGY	2.866	0.467	1.970	3.222	13.531	0.876	11.976	14.332	83.602	1.266	82.446	85.462
BMTLS	2.649	0.691	2.172	4.073	13.085	1.616	10.217	14.413	84.266	1.067	83.264	85.895
INDUSTRY	3.757	0.147	3.393	3.912	24.826	3.562	18.410	27.684	71.417	3.691	68.403	78.003
INDCOMS	2.626	1.087	0.708	3.543	8.669	4.583	5.101	17.300	88.705	3.507	81.992	91.357
TRANS	2.054	0.591	1.703	3.261	17.245	1.541	16.100	20.276	80.701	2.120	76.463	82.176
FIN	4.149	0.324	3.711	4.775	28.834	7.723	15.467	35.449	67.018	7.548	60.402	79.757
BANK	3.295	0.564	2.488	3.866	28.627	4.808	20.443	32.747	68.078	5.320	63.388	76.853
RESTATE	5.023	1.450	3.999	7.885	24.374	4.062	16.728	27.405	70.603	2.623	68.595	75.387
UTIL	2.525	0.785	1.114	3.188	14.149	1.402	13.335	17.021	83.325	0.763	81.865	84.415

Note: This table reports the mean, the standard deviation (S.D.), the minimum, and the maximum for the percentage variance ratios for the GARCH, MS, and MV-MS spillover models. The variance ratios are computed over the full sample period 1/1/2006-11/25/2013, which is equivalent to 1,236 observations. The GARCH Spillover Model is the benchmark model.

Table 7: Summary Statistics for In-sample Portfolios

	Portfolio Return				Portfolio Risk				Sharpe Ratio of Portfolio			
	Mean	S.D.	Min	Max	Mean	S.D.	Min	Max	Mean	S.D.	Min	Max
	The GARCH Spillover Model											
Portfolio 1	0.002	1.316	-7.183	8.970	1.171	0.689	0.470	4.985	0.003	0.984	-4.377	3.743
Portfolio 2	-0.057	0.993	-6.035	6.465	0.543	0.255	0.272	1.811	-0.043	1.481	-7.283	6.499
Portfolio 3	0.388	1.060	-5.943	8.970	0.732	0.540	0.272	4.792	0.481	1.253	-5.819	6.499
Portfolio 4	1.105	1.347	-4.700	14.797	1.093	0.619	0.470	4.792	1.060	1.123	-2.462	14.373
Portfolio 5	1.065	1.218	-4.700	14.390	1.016	0.637	0.344	4.838	1.263	1.205	-2.180	14.378
	The General MS Spillover Model											
Portfolio 1	0.002	1.316	-7.183	8.970	**1.101**	0.657	0.498	2.572	**0.006**	1.096	-5.222	4.640
Portfolio 2	-0.053	1.029	-6.349	6.681	**0.442**	0.173	0.256	1.215	**-0.048**	1.863	-9.789	7.432
Portfolio 3	0.417	1.062	-5.943	8.970	**0.640**	0.506	0.256	2.572	**0.610**	1.526	-9.043	7.432
Portfolio 4	1.172	1.416	-4.700	14.797	**0.960**	0.519	0.440	2.572	**1.292**	1.412	-3.628	19.927
Portfolio 5	1.073	1.255	-4.700	14.797	**0.828**	0.465	0.292	2.572	**1.547**	1.545	-3.628	19.927
	The Common State MV-MS Spillover Model											
Portfolio 1	0.002	1.316	-7.183	8.970	1.164	0.252	0.957	1.607	0.003	1.102	-7.125	5.582
Portfolio 2	-0.060	1.042	-5.757	7.146	0.600	0.155	0.479	0.878	-0.065	1.511	-12.006	8.141
Portfolio 3	0.402	1.068	-5.757	8.970	0.752	0.305	0.479	1.607	0.470	1.302	-12.006	6.171
Portfolio 4	1.268	1.390	-4.716	13.041	1.150	0.261	0.669	1.607	1.104	1.126	-4.923	11.297
Portfolio 5	1.147	1.278	-4.700	14.797	1.036	0.399	0.513	2.755	1.247	1.228	-4.673	11.424

Notes: This table reports the mean, the standard deviation (S.D.), the minimum, and the maximum for the dynamic in-sample portfolios constructed using covariance matrices obtained from the GARCH, the MS, and the MV-MS spillover models. The models are estimated for the sample period 1/1/2006-8/14/2012, and the 1036 portfolios are constructed for the same period. **P1** is the undiversified world portfolio represented by the STOXX 1800 developed market index. **P2** is the diversified minimum variance portfolio which includes the STOXX 1800 index and the seven GCC-wide equity sectors ENERGY, BMTLS (basic materials), INDUSTRY (industrials), INDCOMS (industrial and commercial services), TRANS (transportation), FIN (financials), BANK (banking), RESTATE (real estate), and UTIL (utilities). **P3** is the diversified minimum variance portfolio with a target return equal to the efficient global return. **P4** is the diversified minimum variance portfolio with a target risk equal to the efficient global risk. **P5** is the diversified tangency portfolio with the maximum Sharpe ratio. The GARCH Spillover Model is the benchmark model.

Table 8: Summary Statistics for the Out-of-sample Portfolios

	Portfolio Return				Portfolio Risk				Sharpe Ratio of Portfolio			
	Mean	S.D.	Min	Max	Mean	S.D.	Min	Max	Mean	S.D.	Min	Max
The GARCH Spillover Model												
Portfolio 1	0.038	0.593	-1.703	2.146	0.684	0.123	0.492	1.141	0.032	0.889	-2.654	3.517
Portfolio 2	0.059	0.467	-2.254	2.864	0.332	0.061	0.252	0.605	0.178	1.359	-6.762	5.631
Portfolio 3	0.263	0.485	-1.318	2.864	0.393	0.136	0.252	0.904	0.618	1.197	-2.909	7.087
Portfolio 4	0.806	0.705	-1.232	5.064	0.665	0.112	0.421	1.070	1.205	1.034	-2.249	7.195
Portfolio 5	0.738	0.634	-1.104	4.739	0.645	0.789	0.317	10.683	1.385	1.125	-1.062	7.481
The General MS Spillover Model												
Portfolio 1	0.038	0.593	-1.703	2.146	0.602	0.120	0.498	1.021	0.039	1.003	-3.025	4.137
Portfolio 2	0.060	0.449	-2.212	2.478	0.287	0.050	0.247	0.541	0.212	1.501	-7.324	6.520
Portfolio 3	0.262	0.472	-1.318	2.478	0.341	0.124	0.247	0.889	0.700	1.331	-3.661	7.864
Portfolio 4	0.818	0.692	-1.216	4.436	0.586	0.111	0.379	0.988	1.382	1.126	-2.296	7.840
Portfolio 5	0.731	0.650	-1.104	5.061	0.502	0.199	0.267	1.776	1.587	1.246	-1.227	8.449
The Common State MV-MS Spillover Model												
Portfolio 1	0.038	0.593	-1.703	2.146	1.013	0.138	0.957	1.607	0.030	0.597	-1.774	2.226
Portfolio 2	0.058	0.527	-2.359	3.977	0.511	0.082	0.479	0.878	0.120	0.946	-4.924	5.922
Portfolio 3	0.274	0.518	-1.318	3.977	0.600	0.233	0.479	1.607	0.425	0.839	-2.503	5.922
Portfolio 4	0.921	0.833	-1.137	7.419	1.002	0.152	0.669	1.607	0.920	0.768	-1.188	5.642
Portfolio 5	0.814	0.724	-1.104	5.430	0.840	0.245	0.499	1.869	1.026	0.859	-1.004	7.022

Notes: This table reports the mean, the standard deviation (S.D.), the minimum, and the maximum for the dynamic out-of-sample portfolios; constructed using one-step ahead predicted covariance matrices obtained from the recursively estimated GARCH, MS, and MV-MS spillover models. The out of sample models are recursively estimated for the sample period 8/15/2012-11/25/2013, and 200 portfolios are constructed for the same period. **P1** is the undiversified world portfolio represented by the STOXX 1800 developed market index. **P2** is the diversified minimum variance portfolio which includes the STOXX 1800 index and the seven GCC-wide equity sectors ENERGY, BMTLS (basic materials), INDUSTRY (industrials), INDCOMS (industrial and commercial services), TRANS (transportation), FIN (financials), BANK (banking), RESTATE (real estate), and UTIL (utilities). **P3** is the diversified minimum variance portfolio with a target return equal to the efficient global return. **P4** is the diversified minimum variance portfolio with a target risk equal to the efficient global risk. **P5** is the diversified tangency portfolio with the maximum Sharpe ratio. The GARCH Spillover Model is the benchmark model.

Figure 1: Smoothed Probability of the General MS Spillover Model for WORLD

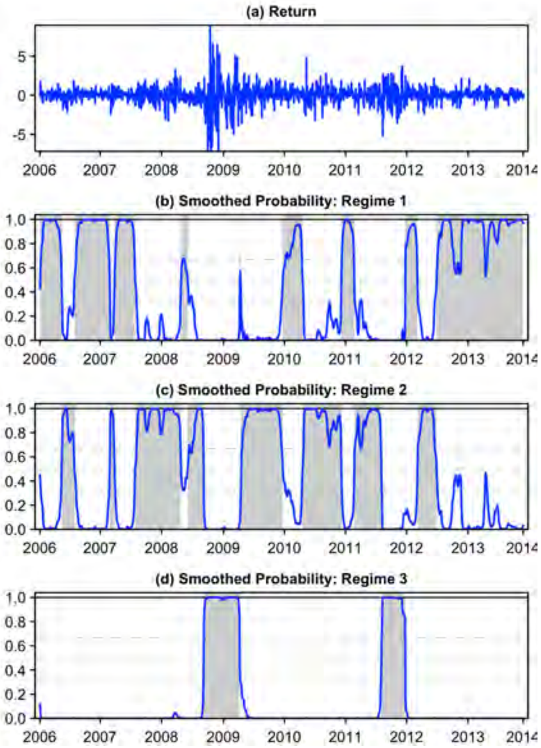


Figure 2: Smoothed Probability of the General MS Spillover Model for the GCC region

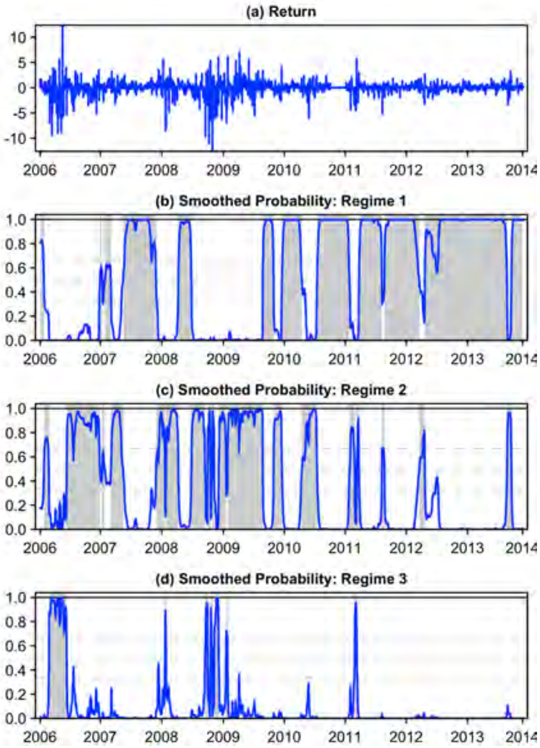


Figure 3: Smoothed Probability of General MS Spillover Model for ENERGY

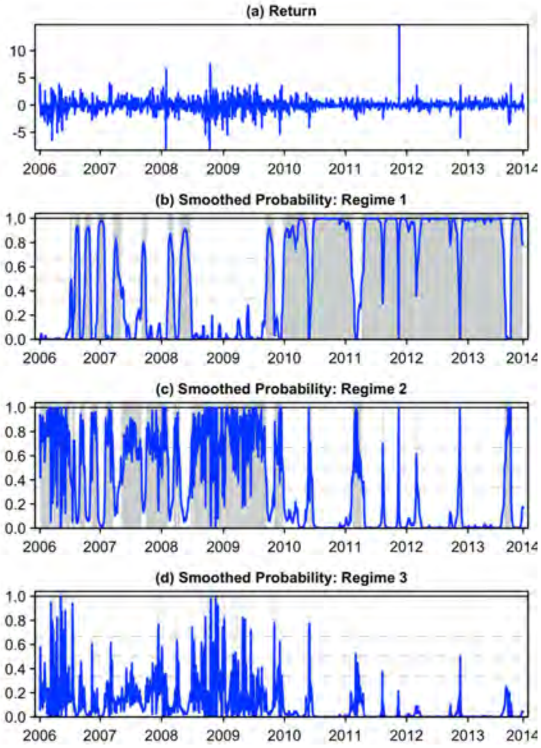


Figure 4: Smoothed Probability of General MS Spillover Model for BMTLS

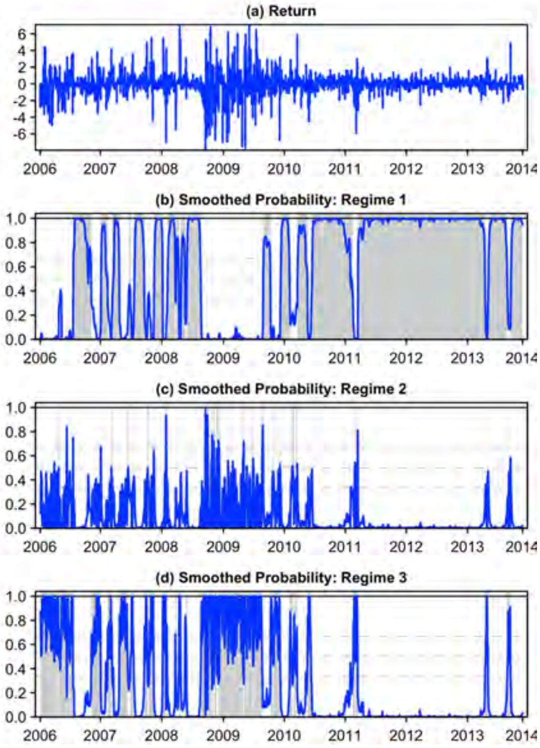
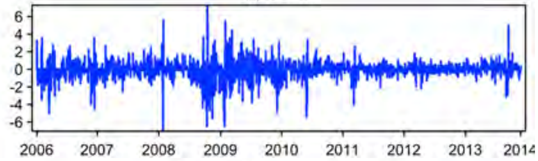
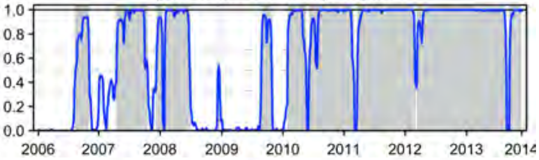


Figure 5: Smoothed Probability of General MS Spillover Model for INDUSTRY

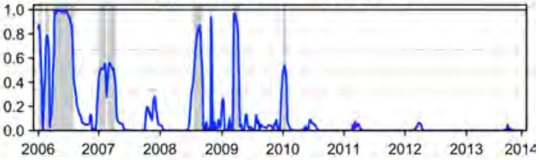
(a) Return



(b) Smoothed Probability: Regime 1



(c) Smoothed Probability: Regime 2



(d) Smoothed Probability: Regime 3

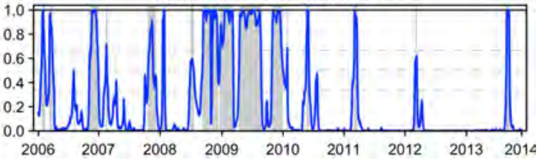
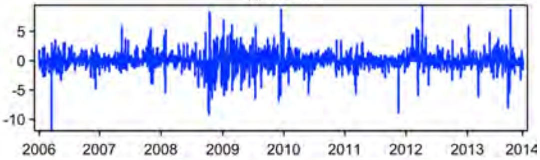
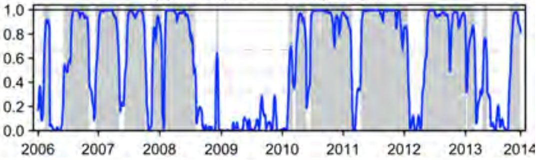


Figure 6: Smoothed Probability of General MS Spillover Model for INDCOMS

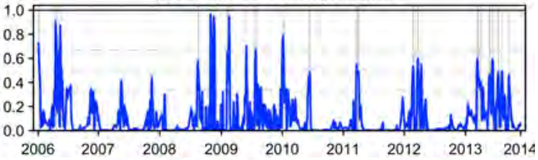
(a) Return



(b) Smoothed Probability: Regime 1



(c) Smoothed Probability: Regime 2



(d) Smoothed Probability: Regime 3

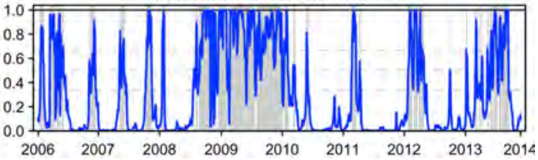
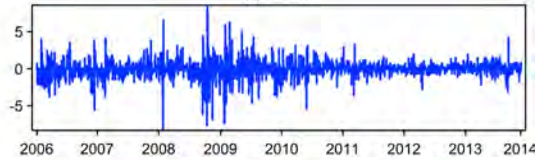
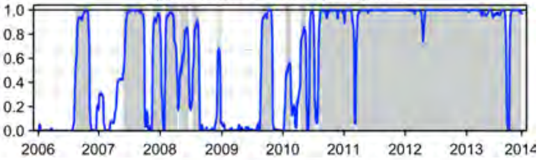


Figure 7: Smoothed Probability of General MS Spillover Model for TRANS

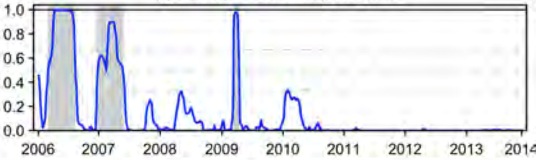
(a) Return



(b) Smoothed Probability: Regime 1



(c) Smoothed Probability: Regime 2



(d) Smoothed Probability: Regime 3

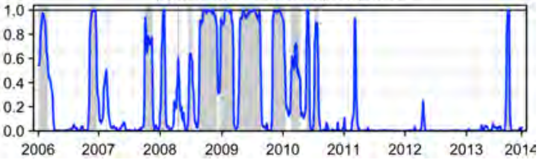
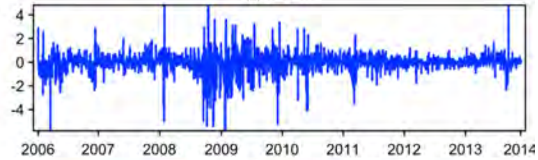
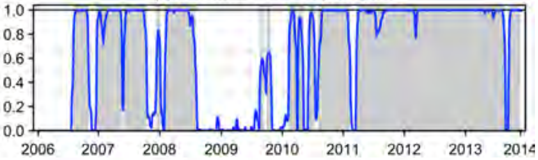


Figure 8: Smoothed Probability of General MS Spillover Model for FIN

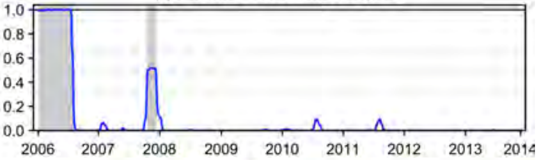
(a) Return



(b) Smoothed Probability: Regime 1



(c) Smoothed Probability: Regime 2



(d) Smoothed Probability: Regime 3

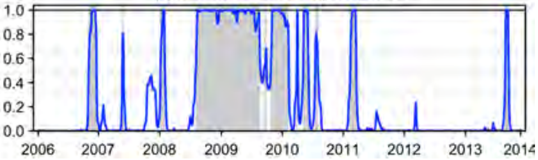


Figure 9: Smoothed Probability of the General MS Spillover Model for the BANK sector

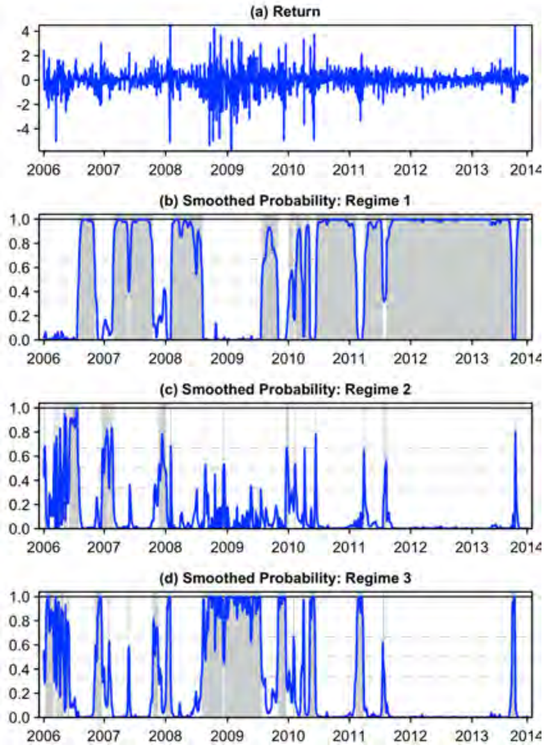


Figure 10: Smoothed Probability of the General MS Spillover Model for the RESTATE sector

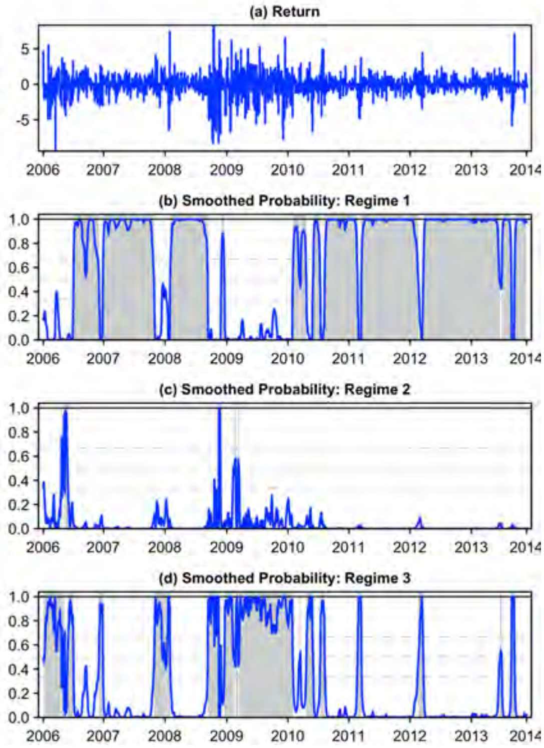


Figure 11: Smoothed Probability of General MS Spillover Model for UTIL

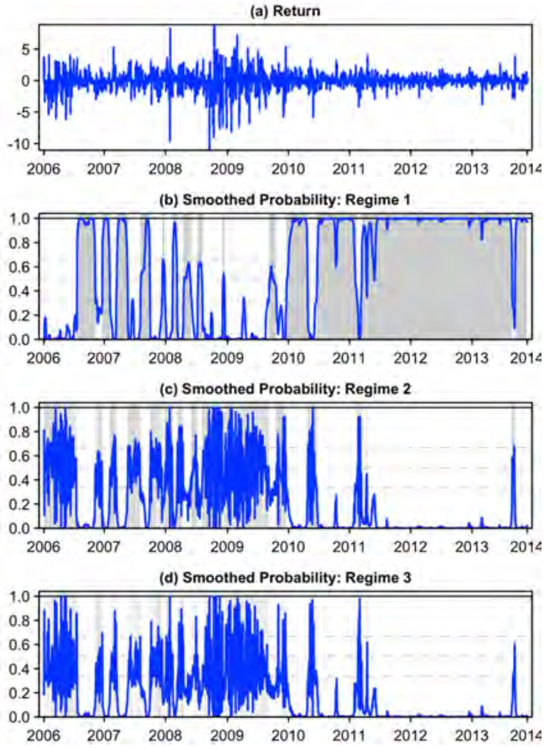


Figure 12: Smoothed Probability of Multivariate MS (MV-MS) Spillover Model

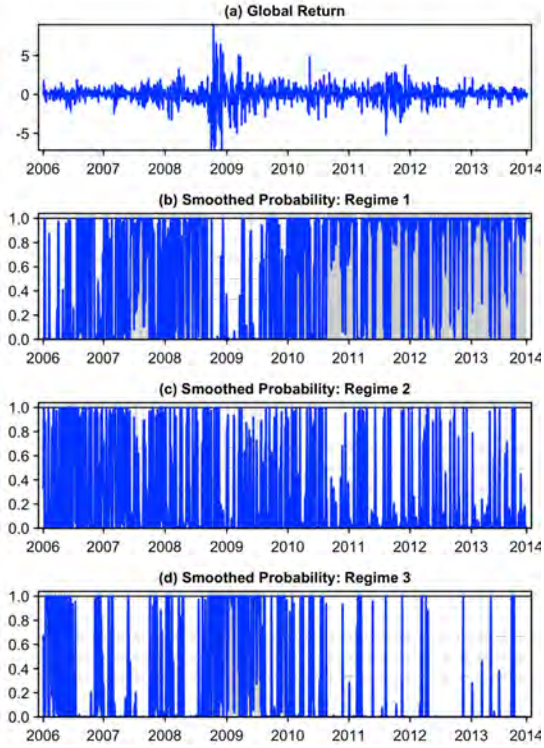
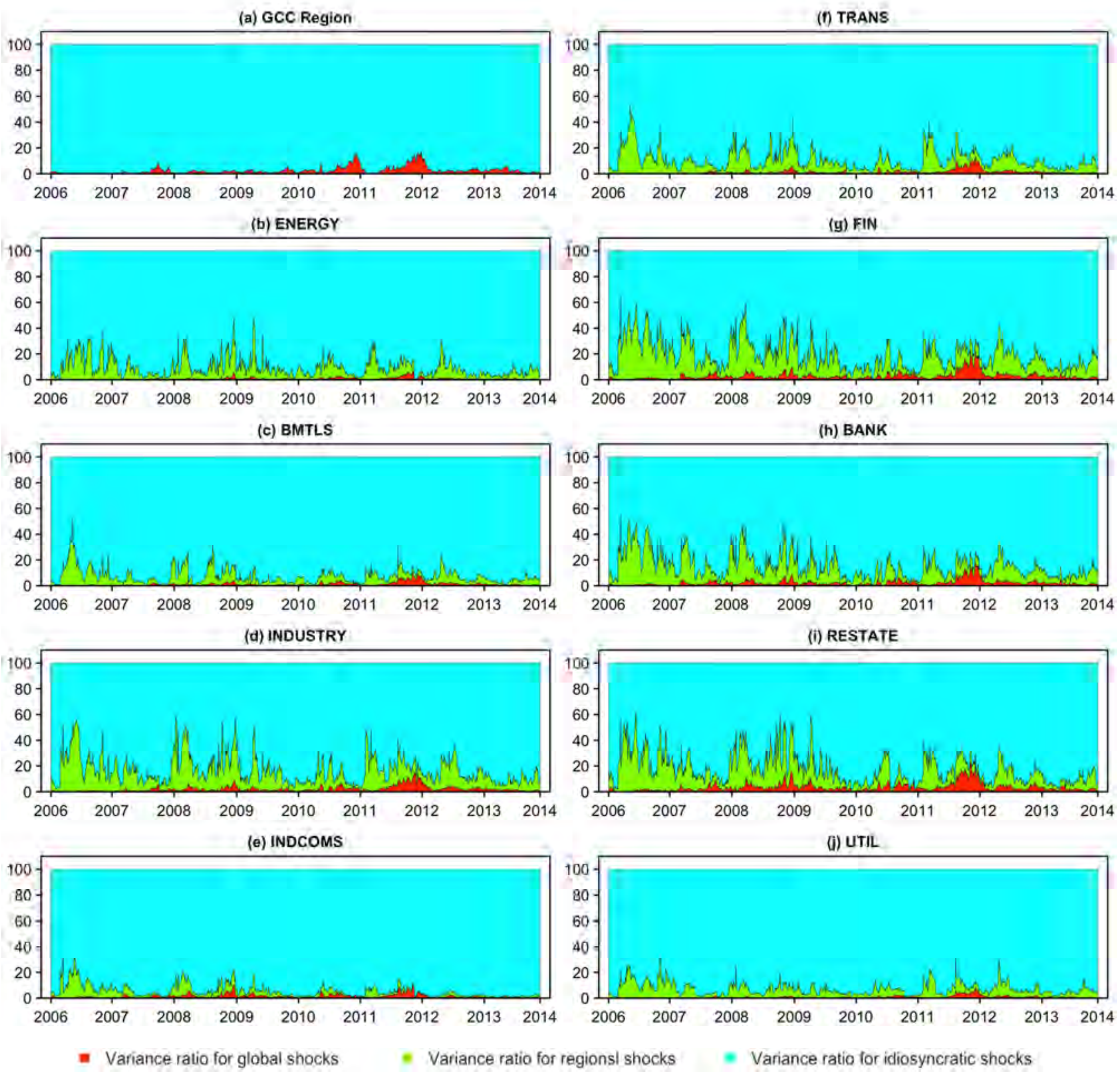
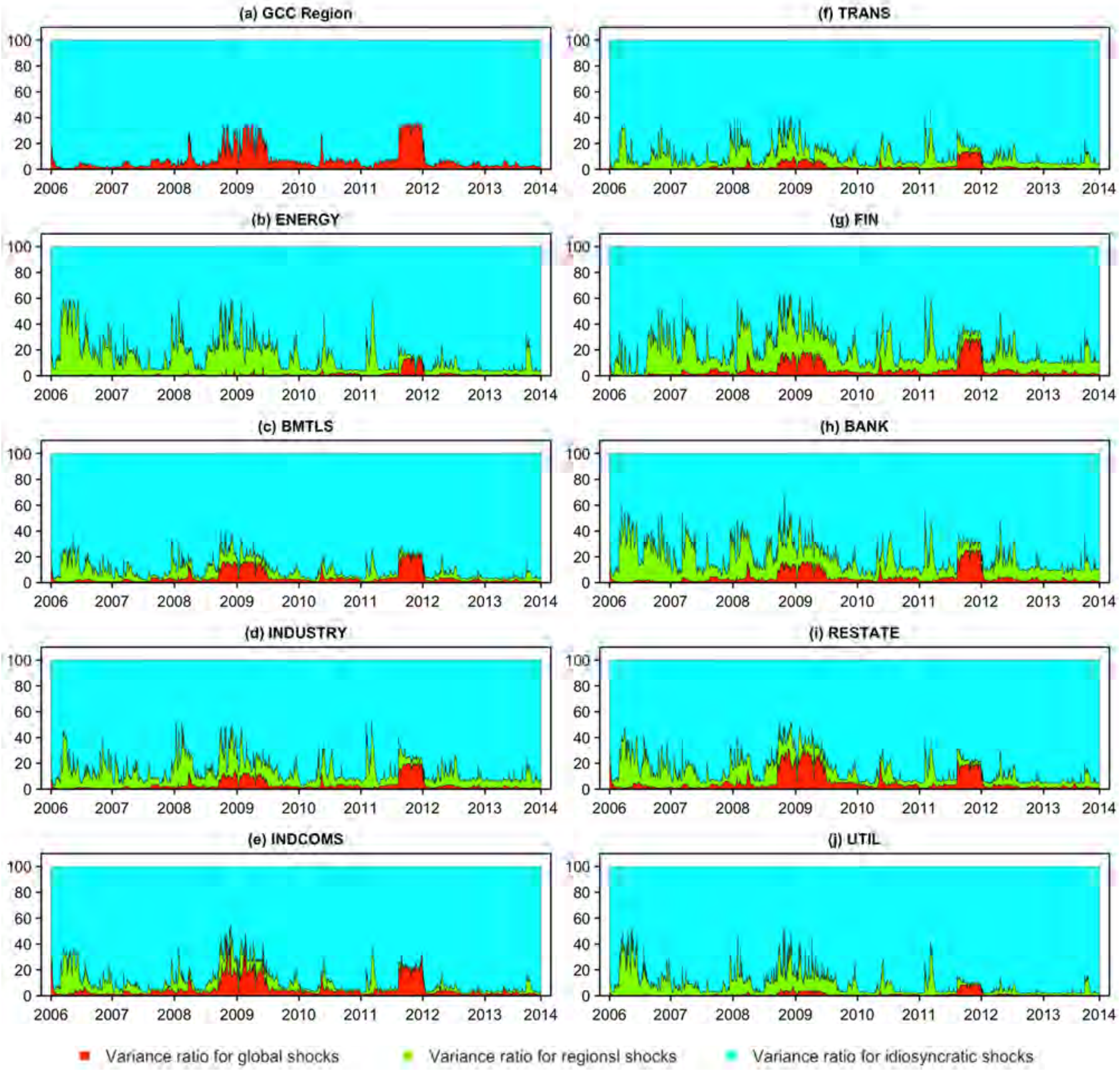


Figure 13: Variance Ratio Estimates from the GARCH Spillover Model



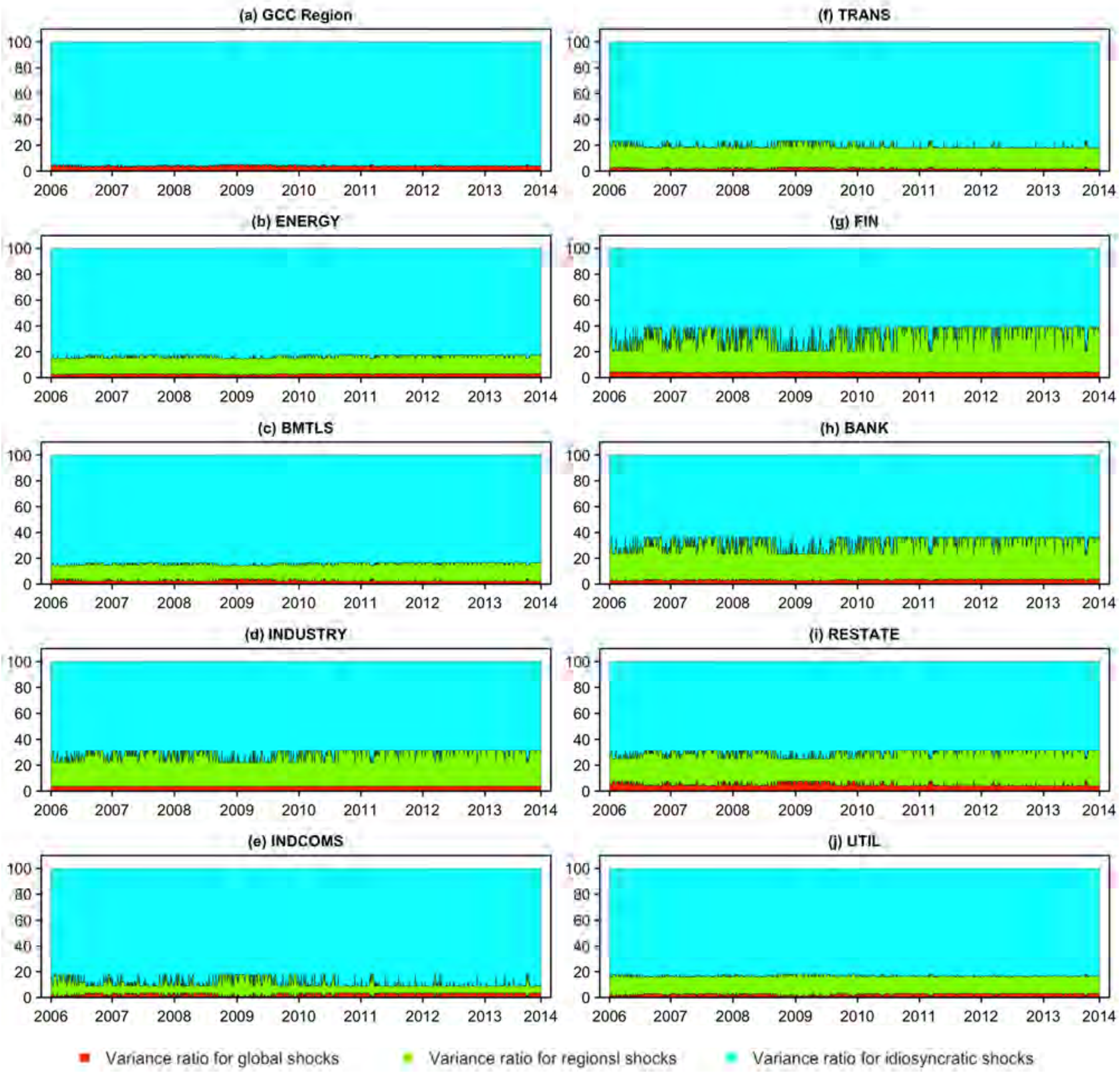
Notes: Figure gives stacked plots of percentage variance ratios for the GARCH spillover model in Equations (4)-(6). Variance ratios for the GARCH spillover model are obtained by analogues equations to Equations (20)-(22). For the GCC regions total variance is decomposed into variance due to global shocks and idiosyncratic shocks. For the GCC wide markets, variance is decomposed into variance due to global shocks, regional shocks, and idiosyncratic shocks. Variance ratios are computed over the full sample period 1/1/2006-11/25/2013 with 1236 observations.

Figure 14: Variance Ratio Estimates from the General MS Spillover Model



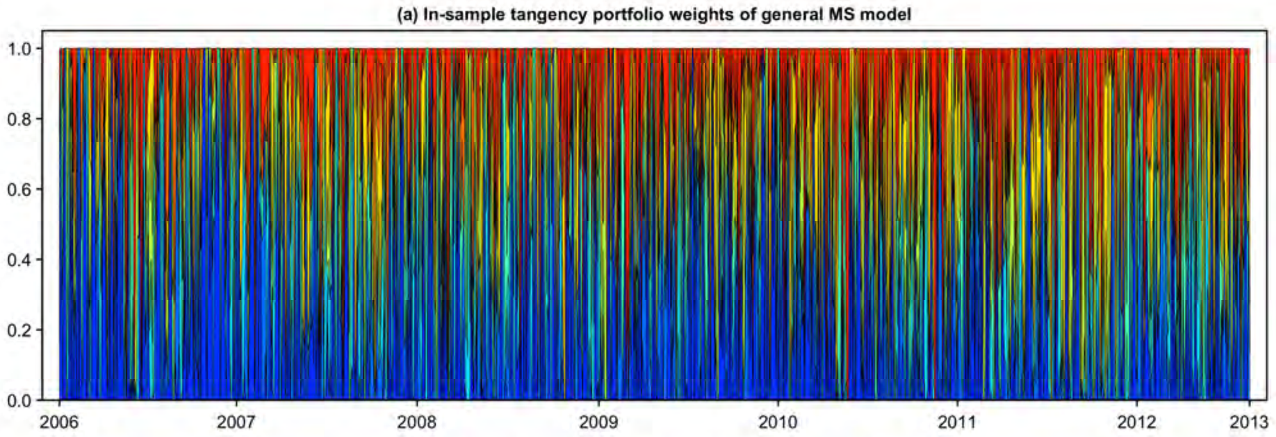
Note: Figure gives stacked plots of percentage variance ratios for the general MS spillover model in Equations (1)-(3). Variance ratios are obtained from Equations (20)-(22). For the GCC regions total variance is decomposed into variance due to global shocks and idiosyncratic shocks. For the GCC wide markets, variance is decomposed into variance due to global shocks, regional shocks, and idiosyncratic shocks. Variance ratios are computed over the full sample period 1/1/2006-11/25/2013 with 1236 observations.

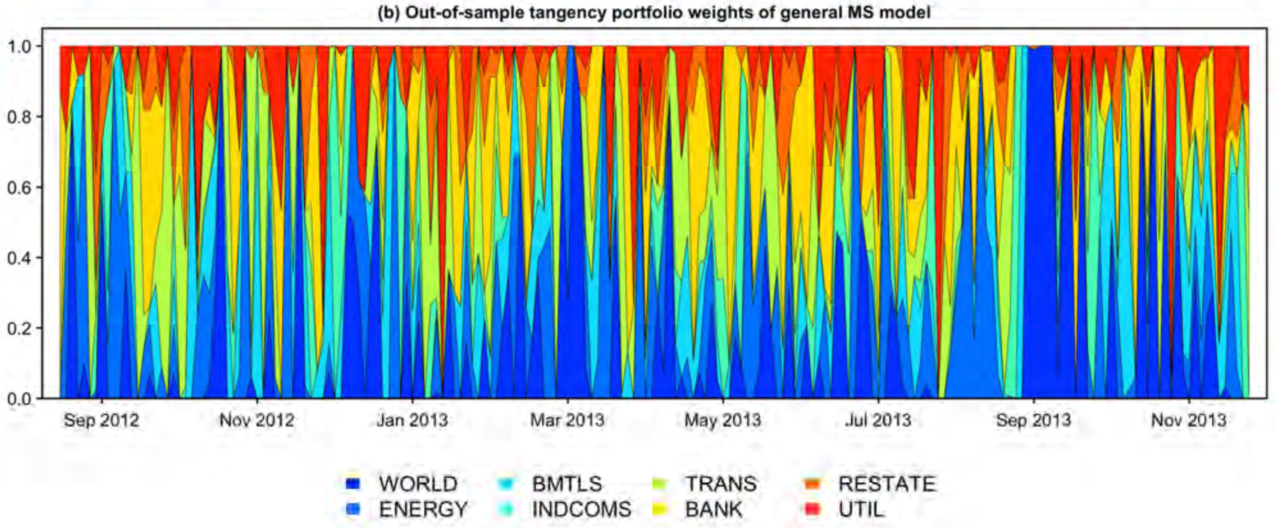
Figure 15: Variance Ratio Estimates from the Common State MV-MS Spillover Model



Note: The figure gives stacked plots of percentage variance ratios for the common state multivariate MS (MV-MS) spillover model in Equations (1)-(3), with a 3-regime common state variable S_t which takes values in {1, 2, 3}. The variance ratios are obtained from Equations (20)-(22). For the GCC region's total variance is decomposed into the variance due to the global shocks and the variance due to the idiosyncratic shocks. For the GCC-wide equity sectors, the variance is decomposed into variances due to the global shocks, the regional shocks, and the idiosyncratic shocks. The variance ratios are computed over the full sample period 1/1/2006-11/25/2013, which is equivalent to 1236 observations.

Figure 16: In-sample and Out-of-sample Tangency Portfolio Weights of the General MS Spillover Model


(a) In-sample tangency portfolio weights of general MS model


(b) Out-of-sample tangency portfolio weights of general MS model

Note: This figure presents stacked plots for the dynamic tangency portfolio weights (Portfolio 5 obtained by maximizing the Sharpe ratio) arising from the general MS spillover models. The in-sample dynamic portfolios are constructed over the period 1/1/2006-8/14/2012 and include 1036 portfolios. The out-of-sample dynamic portfolios are constructed for the sample period 8/15/2012-11/25/2013 and include 200 portfolios. The portfolios are based on excess returns over the U.S. 3-month Treasury bill rate. Each portfolio includes the developed equity market index and seven GCC-wide equity sectors These are the STOXX 1800 developed market and the GCC-wide equity sectors, ENERGY, BMTLS, INDCOMS, TRANS, BANK, RESTATE, and UTIL.