Regional and Global Spillovers and Diversification Opportunities in the GCC Equity Sectors

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Abstract

This paper examines the international diversification benefits of bloc-wide equity sectors in the oil-rich Gulf Cooperation Council (GCC) countries by comparing alternative spillover models that encompass local, regional and global factors. Some GCC-wide equity sectors/subsectors are found to display segmentation from global markets during periods of high and extreme market volatility, and thus can serve as safe havens for international portfolio investors during such periods. The in- and out-of-sample portfolio analyses further suggest that supplementing global portfolios with positions in the GCC markets yields significant international diversification benefits, consistently offering much improved risk-adjusted returns across the alternative spillover models.

JEL Classification: C32, G11, G15

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1. Introduction

The 2007/2008 financial crisis which originated in the U.S., the prolonged debt crisis and the economic uncertainty that wrapped the Eurozone have sent severe shocks throughout the world's financial markets. These difficult times have also underscored the importance of emerging markets as potential risk diversifiers and return enhancers when the developed markets are in crises. As Balli et al. (2014) note, a number of factors including aging populations in mature markets and growing interest for alternative investments have led to significant shifts in global wealth to emerging market economies. To that end, the under-studied emerging and frontier stock markets in the oil-rich Gulf Cooperation Council (GCC) countries offer several unique features that make them a viable alternative as a diversifier in international portfolios.[1] This paper proposes a dynamic model of risk exposures of key equity sectors/subsectors in GCC stock markets with respect to local and global shocks and examines the potential diversification benefits of these fast growing markets for international portfolio investors.

Most GCC countries impose varying restrictions on foreign ownership in their stock markets in order to shield themselves from the adverse effects of regional and global shocks (Table 1). Foreign ownership restrictions, along with a number of other institutional issues, have therefore prevented most of the GCC markets from being classified as emerging markets. On the other hand, government revenues and corporate profitability in the GCC countries are influenced by oil prices and exports which are largely driven by global economic growth factors.[2] Information may also flow to these 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). Furthermore, 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 U.S. monetary policy. Therefore, it can be argued that the information and shocks relevant to changes in the U.S. and other international stock markets may affect the GCC stock

[1] Frontier, also called pre-emerging, markets refer to the less developed and less liquid subset of emerging stock markets that are too small to be considered emerging. MSCI has recently promoted two GCC markets, i.e. Qatar and UAE, from frontier to emerging market status.
[2] Saudi Arabia is placed first in the global oil exporter ranking, while UAE and Kuwait are ranked 6th and 10th, respectively.

markets from multiple channels. To that end, whether or not the GCC markets indeed exhibit segmentation from global financial shocks and thus can serve as a hedge or safe haven for international portfolio investors can be best described as an empirical issue to explore.

Motivated by the finding that industry-based diversification yields more efficient portfolios than country-based diversification (Moerman, 2008), this study focuses on sector portfolios and examines a wide range of defensive and growth equity sectors including energy, financials, industrials, basic materials and utilities in addition to several sub-sectors including industrial and commercial services, transportation, banking and real estate. 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 detail than before. [3] Nevertheless, the sector-based approach offers an interesting dimension of diversification as it covers different aspects of the macroeconomy, particularly in the context of regime-based models utilized in this study.

The main goal of this paper is to explore the diversification benefits of the cash- and oil-rich stock markets in the GCC bloc by examining the risk exposures of GCC-wide equity sectors with respect to regional and global factors. By doing so, this study contributes to the literature on return/volatility spillovers and international diversification in several aspects. First, it develops a dynamic two-factor model of GCC-wide equity sector returns with regional and global market shocks as risk factors. The two-factor specification follows Baele and Inghelbrecht (2010) who show that the restricted single factor specification, which is generally utilized in the literature, leads to incorrect inferences regarding financial integration. Second, it investigates the regional and global market exposures of the GCC-wide equity sectors using regime-switching spillover models in which the global, regional, and sectoral returns are allowed to have common synchronized and unsynchronized (general) return processes. While there have been several studies that examine the transmission of returns among individual GCC country sectors (Hammoudeh et al. 2009), how the volatility spillovers occur among various sectors and across different market regimes is yet to be explored. Third, unlike

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

in most studies in the literature (e.g. Bekaert and Harvey, 1995; Ang and Bekaert, 2002, 2004; Baele, 2005; Baele and Inghelbrecht, 2009, 2010), this paper does not make prior assumptions on the number of market regimes describing the return processes, but instead it determines the number of regimes by formal statistical testing. Furthermore, we allow all model parameters to vary across different regimes. By doing so, we provide a more realistic representation of the structural changes in risk exposures as revealed by the data. 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 based on the static and regime-based models.

The regime specification tests yield 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 global shocks during the low and high volatility regimes, we find that the regional risk exposure to global shocks turns negative during the extreme volatility regime which proxies for 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. Similarly, the sectors/subsectors including industrials, industrial and commercial services, transportation, financials and real estate are found to have negative risk exposures with respect to global shocks during the high and/or extreme volatility regimes. This finding suggests that some GCC-wide equity sectors/subsectors can serve as safe havens for international portfolio investors during periods of high or extreme volatility, depending on the particular sector to be utilized in the portfolio. Finally, examining the performance of portfolios constructed using the covariance matrices based on the alternative spillover models; we find that supplementing the world portfolio with positions in the accessible GCC-wide equity sectors leads to more efficient portfolios with much improved risk-adjusted returns. This finding is consistent across the constant parameter and the regime-based spillover models and supported by both the in- and out-of-sample tests.

The remainder of the paper is organized as follows. Section 2 reviews the literature on the spillovers and international diversification, with a focus on the GCC stock markets. Section 3 presents the methodology which specifies the alternative two-factor spillover models. 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 financial integration and contagion across global stock markets. A number of studies in this strand of the literature have focused specifically on international diversification benefits of emerging and frontier markets for investors in advanced markets (e.g. Chiou, 2008; Middleton et al., 2008; Bekaert et al., 2009; You and Daigler, 2010, Berger et al., 2011, 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), Arouri and Rault (2012) and Chau et al. (2014) have examined the stock markets in the Middle East and North Africa (MENA) region including the GCC countries. These studies generally suggest that MENA stock markets offer significant diversification potential for global investors. However, this strand of the literature has mostly ignored structural breaks and time variations 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.

An emerging strand of the literature on international diversification has also looked at the cash- and oil-rich Gulf Arab stock markets (e.g., Hassan et al., 2003;Yu and Hassan, 2008; Cheng et al., 2010; Mansourfar et al., 2010). Table 2 provides a summary of these studies which specifically examine the financial integration of GCC stock markets with world markets. This literature in general suggests that the developing stock markets of the GCC member countries are to a varying degree segmented from international markets, and thus diversification benefits can be achieved by allocating a part of global portfolios to investments from these oil-rich countries. Focusing specifically on a number of frontier markets including the GCC nations of Kuwait, Oman, Saudi Arabia and UAE, Berger et al. (2011) and Demirer (2013) find little evidence of financial integration of these markets with global markets. However, as Berger et al. (2011) also note, the literature has largely ignored structural changes and time variations in the integration of these markets with global markets by assuming time-invariant parameters in their models, thus providing an incomplete assessment of global spillovers and the potential benefits of these markets for temporal international diversification.

On the other hand, a well-established literature exists on financial integration and return/risk spillovers across stock markets due to the relevance of this information 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 domestic and GCC specific shocks rather than by global factors, implying potential international diversification benefits of these markets. Hammoudeh and Eleisa (2004) analyze the linkages among daily GCC market and oil returns and find that the GCC markets are not closely linked with each other and the oil market, with the exception of Saudi Arabia. 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, using overlapping trading days with western stock and oil markets.

More recently, Balli et al. (2013) find that GCC-wide equity sectors are mostly driven by their own volatilities and highlight the dominance of regional shocks over global shocks on the volatility of returns in these markets. However, Khalifa et al. (2014) find evidence of regime-specific volatility transmission patterns between GCC and global markets, with stronger linkages observed with the global equity markets than with the oil market. However, Khalifa et al. (2014) focus on the GCC national stock indices and examine volatility transmissions only, and thus provide an incomplete assessment of diversification potential of these markets. More recently, Syed Abul et al. (2014) utilize copula models to explore the dependence patterns of the bivariate distribution of returns among the seven GCC stock markets. They document significantly greater conditional dependence across all 21 pairs of GCC market returns in the lower tail of return distributions, suggesting asymmetric correlation dynamics.

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 and Rault (2012) argue that international diversification benefits can be achieved by allocating a part of the global portfolios to investments in the oil-exporting countries. In contrast, our study first develops a two-factor model of returns with regional and global shocks as risk factors and extends the analysis of return/risk spillovers to a regime-based context in which market regimes are identified by formal statistical testing, rather than by making prior assumptions on the regime structure. We then extend the spillover analysis to explore the portfolio diversification benefits across the market regimes, given the regional and global spillovers. The two-factor model allows us to examine the portfolio diversification benefits from the perspective of both regional and international portfolio investors. Finally, the in- and out-of-sample performance of the portfolios constructed based on the static and regime-based models are compared across alternative portfolio strategies that include positions in the GCC-wide equity sectors.

3. Methodology

Clearly, major regional and global shocks and extreme events can lead to structural breaks and regime changes in stock market returns. In the case of the GCC countries, it can be argued that at certain times (e.g. excepting the 2006 GCC regional stock market crash, while accounting for the 2007/2008 global financial crisis and its aftermath), the GCC and the global stock markets behave in a more integrated pattern, which necessitates that the regime-switching processes describing their returns be synchronized. In other times (e.g. the 2006 Dubai debt crisis or a regional market shock like the 2010 Arab Spring), 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 respect to global markets in a regime-specific fashion, which warrants a regime-based diversification analysis that also takes into account the time variations in the linkages across these markets and the differences among the GCC equity sectors.

Given the dynamic nature of risk/return spillovers, we develop in this section a two-factor MS spillover model for nine GCC-wide equity sector/sub-sector indices from the six GCC countries under consideration. Numerous studies in the literature have utilized MS models in several contexts including stock market return distributions (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 (e.g. Hammoudeh and Choi, 2007; Balcilar and Genc, 2010; Balcilar et al. 2013, 2014; Khalifa et al., 2014). In contrast to these studies, 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 (2010), the model allows for time-varying asset exposures and volatilities that can be driven by structural changes as well as fluctuations in risk factors. Ang and Bekaert (2002, 2004), Honda (2003), Giamouridis and Vrontos (2007), Buckley et al. (2008), Guidolin and Hyde (2008), Guidolin and Timmermann (2008), Flavin and Panopoulou (2009), Catão and Timmermann (2010), Guidolin and Ria (2011), and Bae et al. (2014) examine the implications of regime switching for portfolio diversification and asset allocation and conclude that incorporating the regime switching behavior in the return series improves the portfolio performance. Furthermore, we allow for all model parameters to vary across different regimes, thus offer a more accurate representation of the return dynamics by endogenously modeling the structural changes and the various market regimes.

Second, unlike most international diversification studies in the literature (e.g. Bekaert and Harvey, 1995; Ang and Bekaert, 2002, 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 by making assumptions on possible regime structure in the return processes. In the strand of the literature that adopts data-driven selection of the number of regimes, Hamilton (1996) and Maheu and McCurdy (2000) use residual based tests in order determine the number of regimes. Guidolin and

Timmermann (2006) use likelihood ratio tests with the approach adopted in Davies (1987). Sims and Zha (2006), Maheu et al. (2009) and Cakmakli et al. (2011) select the number of regimes based on the log likelihood, marginal density, or predictive likelihoods. On the other hand, Krolzig (1997), Rydén et al. (1998) and Psaradakis and Spagnolo (2003) suggest selecting the number of regimes and the type of the MS model using AIC and, using Monte Carlo experiments, Psaradakis and Spagnolo (2003) show that AIC is generally successful in selecting the correct model (see also Smith et al. 2006).

Finally, the regime transitions are governed by a latent switching variable, which may be sector-specific, associated with regional or global factors or common to all of these factors. Fourth, the volatility of sectoral, regional and global returns is 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) and global shocks. As Baele and Inghelbrecht (2010) note, the two-factor specification allows one to distinguish between partial (global) and regional integration and also outperforms the single factor model in modelling cross-market correlations. Additionally, the global shocks are allowed to drive GCC regional returns. Therefore, the model accommodates partial integration at both the regional and global levels and accommodates structural breaks and temporal variations in market linkages.

Similar to Baele and Inghelbrecht (2010), we decompose the excess return, $R_{k,t}$, of GCC sector index *k* for day *t* as follows

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

where $S_{k,t} \in \{1,2,3\}$, $k = 1, 2, \ldots, n$, are the latent regime variables for sector *k*, following a three-state Markov process.[4] In this specification $\mu_{k,S_{k,t},t-1}$ is the regime-dependent expected excess return

[4] A battery of tests for the optimal number of regimes supports 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 document that the three-regime specification better describes stock return dynamics than models with fewer regimes.

for sector k at time t-1, while $m_{\text{reg},t-1}$ and $m_{w,t-1}$ are the t-1 conditional excess returns for the GCC region and the world index, respectively.[5] The unexpected return is decomposed into three components: the sector-specific idiosyncratic shock that is conditionally heteroscedastic and specified as $\varepsilon_{k,t} \sim iid\left(0, \sigma^2_{S_{k,t}}\right)$ as well as two additional components due to regional (GCC-specific) and global market shocks represented by the random variables $e_{\text{reg},t}$ and $e_{w,t}$, respectively. The conditional exposures of the GCC sector returns with respect to the regional and global shocks are specified by the regional and global beta terms, $b^{\text{reg}}_{k,S_{k,t}}$ and $b^{w}_{k,S_{k,t}}$, 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 global shocks where the regime-switching is stochastic and governed by a Markov process. By doing so, this specification easily lends itself as a robust tool for 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

$$R_{\text{reg},t} = m_{\text{reg},S_{\text{reg},t},t-1} + f^{w}_{\text{reg},S_{\text{reg},t}} m_{w,t-1} + b^{w}_{\text{reg},S_{\text{reg},t}} e_{w,t} + e_{\text{reg},t} \quad \textbf{(2)}$$

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

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. Note that that the return processes describing the regional and global excess returns are indexed by their own regime variables, providing a flexible framework regarding the synchronization (or otherwise) of regimes across the different markets. The excess return process in Equation (2) is a generalization of the one-factor volatility spillover model of Bekaert and Harvey (1997). $m_{\text{reg},S_{\text{reg},t},t-1}$ is the regime-dependent regional expected return at time t-1 that can be explained

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

by the region-specific information available at time *t*-1. Similarly, $\mu_{w,S_{w,t},t-1}$ represents the regime-dependent world expected return at time *t*-1. Finally, the parameter $\beta^{w}_{\text{reg},S_{\text{reg},t}}$ 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 GCC region at large. Note that the model allows the spillover effects 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 $S_{w,t}$. Similarly, the GCC region's exposure with respect to the global shocks is time-varying as the beta ($\beta^{w}_{\text{reg},S_{\text{reg},t}}$) term is governed by the state variable $S_{\text{reg},t}$.

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 make inferences regarding the potential diversification benefits of the GCC equity sectors. For this purpose, we examine the performance of dynamic portfolios based on 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 widely employed 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*

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

$$\varepsilon_{l.t} | \psi_{t-1} \sim iid(0, \sigma^2_{l.t}) \quad \textbf{(5)}$$

$$\sigma^2_{l,t} = \omega_l + \alpha_l \varepsilon^2_{l,t-1} + \gamma_l \sigma^2_{l,t-1} \quad \textbf{(6)}$$

where l=k, reg, w (k=1,2,…,n), denoting sector k, GCC region, and global markets, respectively. $\sigma^2_{l,t}$ 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 $\phi_l^{reg} = \phi_l^{w} = \beta_l^{reg} = \beta_l^{w} = 0$ 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 $R_{w,t}$ at time t-1. Similarly, for the return process describing the GCC region (l=reg), we set $\phi_l^{reg} = \beta_l^{reg} = 0$ and obtain $\varepsilon_{reg,t} = R_{reg,t} - \mu_{reg,t-1} - \phi_{reg}^{w}\mu_{w,t-1} - \beta_{reg}^{w}\varepsilon_{w,t}$. However, it must be noted 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.[6] Following the approach adopted in Bekaert and Harvey (1997), Ng (2000), and Bekaert et al. (2005), we obtain the conditional variances and covariances across the sectoral, regional, and global 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 flexible regime-switching in the sectoral, regional and global return processes. No particular structure is 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, the specification in Baele (2005) 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 sector-specific equations. On the other hand, the model described in Equations (1)-(3) allows for multiple market regimes describing the sectoral, regional as well as the global market return processes and thus provides a more realistic approach.

[6] 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 the global market, 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 driving spillovers.

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. By doing so, the model accommodates partial integration of the GCC equity sectors with the GCC region at large and the global market, and thus provides a more comprehensive framework. 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 $p_{ij}^{l} = P(S_{l,t+1} = i \mid S_{l,t} = j)$. Thus, p_{ij}^{l} for sector or market l is the probability of being in regime i at time t+1 given that the sector/market was in regime j at time t, where the regimes i and j take values in {1,2,3}. Finally, the transition probabilities satisfy $\sum_{i=1}^{3} p_{ij}^{l} = 1$.

3.3. Synchronized MS dynamic spillover specification

As noted earlier, the GCC countries are linked through a political and economic union and their economies are highly sensitive to oil exports which have been affected by the choppy behavior of oil prices (e.g. Baumeister and Kilian, 2014 and 2015). This makes these economies particularly sensitive to the global economic growth trends that drive the demand for oil imports and oil prices globally. Therefore, it can be argued that an alternative specification in which one assumes a common state for the GCC equity sectors, the GCC region and the world market is also applicable. This specification clearly assumes that the GCC markets are highly integrated with the global markets which may be the case during a particular market state like the 2007/2008 global financial crisis period when financial markets across the globe experienced simultaneous crashes and high volatility. 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 common, three-state regime process, S_t. The transition probabilities of the common regime are then defined as $p_{ij} = P(S_{t+1} = i \mid S_t = j)$ with $\sum_{i=1}^{3} p_{ij} = 1$. In this case, Equations (1)-(3) form a system of multivariate MS (MV-MS) model and are estimated simultaneously.

3.4. Conditional covariances and variance ratios

In order to provide further insight into the risk exposures of the GCC equity sectors with respect to regional and global shocks as well as their time variations, we decompose the total volatility of each GCC-wide sector into three components: (1) a component due to global shocks, (2) a component due to regional shocks, and (3) a sector-specific or idiosyncratic component. Following Equations (1)-(3), we use the following equations in order to estimate the sector-specific, regional and global components

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

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

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

where the term ξ refers to the unexplained component of excess returns specified in Equations (1)-(3). Calculation of the conditional variances and covariances based on Equations (7)-(9) 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 asset *l* 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 of sector/market *l* as $\mathbf{P}^{l} = [p^{l}_{ij}]$, *i, j* = 1,2,3, we then obtain the predictive probabilities as $p^{l}_{t|t-1} = \mathbf{P}^{l} p^{l}_{t-1|t-1}$, where $p^{l}_{t-1|t-1}$ is the vector of probabilities of asset *l* at time *t*-1 given 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 termed as filtered probabilities and can be calculated using

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

where $f_{(i)}(R_{l,t}|\psi_t,\theta)$ is the likelihood function of $R_{l,t}$ of asset l being in regime i and θ is the parameter vector.

A novelty of the MS spillover model utilized in this study is that it allows for the computation of the time-varying conditional moments using the predictive probabilities. We specify an AR(1) model in order to obtain the conditional means. Defining β_i^l as the risk exposure parameters in Equations (1)-(3) of asset l in regime i and x_t^l as the vector of independent variables, the conditional means are obtained as

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

Once the conditional means are obtained, the sectoral, regional and global market shocks are then estimated as $\varepsilon_{l,t} = R_{l,t} - \mu_{l,t}$, where $l = w, \text{reg}, k$ (k=1,2,…,n). In this specification, the conditional mean term is computed as the weighted average of conditional means in each market regime with weights equal to the predictive probability of the respective regimes. Similarly, the conditional variances of $\varepsilon_{l,t}$ are given by

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

In order to complete the estimation of the spillover model, we next obtain the variances and the covariances of the unexplained component of excess returns defined in Equations (7)-(9). We assume that the sectoral, regional, and global market shocks are uncorrelated. Bekaert et al. (2009) show that a two-factor, 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.[7] Given the nine GCC-wide sectors and sub-sectors as well as the regional and global market returns, the procedure requires the estimation of 55 time-varying covariances and

[7] The synchronized common state model jointly estimates all equations along with the correlations among the idiosyncratic shocks.

11 time-varying variances for the unexplained component of excess returns. They are estimated using the following equations:[8]

$$h_{w,t} = E[x^2_{w,t} \mid y_{t-1}] = \sum_{i=1}^{3} \pi^{w}_{i,t|t-1} \sigma^2_{w,i} \quad \textbf{(13)}$$

$$h_{\text{reg},t} = E[x^2_{\text{reg},t} \mid y_{t-1}] = \sum_{i=1}^{3} \pi^{\text{reg}}_{i,t|t-1} \left[(\beta^{w}_{\text{reg},i})^2 \sigma^2_{w,t} + \sigma^2_{\text{reg},i} \right] \quad \textbf{(14)}$$

$$h_{k,t} = E[x^2_{k,t} \mid y_{t-1}] = \sum_{i=1}^{3} \pi^{k}_{i,t|t-1} \left[(\beta^{w}_{k,i})^2 \sigma^2_{w,t} + (\beta^{\text{reg}}_{k,i})^2 \sigma^2_{\text{reg},t} + \sigma^2_{k,i} \right] \quad \textbf{(15)}$$

$$h_{k,w,t} = E[x_{k,t} x_{w,t} \mid y_{t-1}] = \sum_{i=1}^{3} \sum_{s=1}^{3} \pi^{k}_{i,t|t-1} \pi^{w}_{s,t|t-1} \left[\beta^{w}_{k,i} \sigma^2_{w,i} \right] \quad \textbf{(16)}$$

$$h_{\text{reg},w,t} = E[x_{\text{reg},t} x_{w,t} \mid y_{t-1}] = \sum_{i=1}^{3} \sum_{s=1}^{3} \pi^{\text{reg}}_{i,t|t-1} \pi^{w}_{s,t|t-1} \left[\beta^{w}_{\text{reg},i} \sigma^2_{\text{reg},i} \right] \quad \textbf{(17)}$$

$$h_{k,\text{reg},t} = E[x_{k,t} x_{\text{reg},t} \mid y_{t-1}] = \sum_{i=1}^{3} \sum_{s=1}^{3} \pi^{k}_{i,t|t-1} \pi^{\text{reg}}_{s,t|t-1} \left[\beta^{w}_{k,i} \beta^{w}_{\text{reg},s} \sigma^2_{w,t} + \beta^{\text{reg}}_{k,i} \sigma^2_{\text{reg},t} \right] \quad \textbf{(18)}$$

$$h_{k,j,t} = E[x_{k,t} x_{j,t} \mid y_{t-1}] = \sum_{i=1}^{3} \sum_{s=1}^{3} \pi^{k}_{i,t|t-1} \pi^{j}_{s,t|t-1} \left[\beta^{w}_{k,i} \beta^{w}_{j,s} \sigma^2_{w,t} + \beta^{\text{reg}}_{k,i} \beta^{\text{reg}}_{j,s} \sigma^2_{\text{reg},t} \right] \quad \textbf{(19)}$$

Given the variances and covariances in Equations (13)-(19), we obtain the time-varying correlations of each GCC sector with regional as well as global shocks. The GCC region's correlations with the world index are also directly obtained from Equations (13)-(19). In short, Equations (11)-(19) yield time-varying, but regime-independent moments and allow us to examine alternative portfolio strategies without having to assume a particular market regime. This procedure enables a more realistic approach to portfolio analysis as it is not possible to know, in practice, what particular regime the market is in at any given point in time.

The variance ratios are then calculated as the percentage of the conditional variances of the unexpected sector returns explained by the conditional variances of the regional and the global unexpected returns

$$VR^{w}_{k,t} = \frac{\sum_{i=1}^{3} \pi^{k}_{i,t|t-1} (\beta^{w}_{k,i})^2 \sigma^2_{w,t}}{h_{k,t}} \times 100 \quad \textbf{(20)}$$

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

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

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

where $VR_{k,t}^{w}$, $VR_{k,t}^{\text{reg}}$, and $VR_{k,t}^{k}$ are the percentage of conditional variances explained by 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).[9] 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.[10] 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, i.e. 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 using Equation (8) for the MS spillover model and using Equation (4) for the GARCH spillover model, given the relevant restriction.[11] 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 similarly in 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

[9] This estimation approach is also used in Baele (2005), Baele and Inghelbrecht (2009, 2010), and Balli et al. (2013).

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

[11] Ng (2000) orthogonalizes the global and regional shocks and does not relate the global shocks to 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 at large.

finding indicates that the assumption of 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 sum to unity. The 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 that are obtained from the transition probabilities and the filtered probabilities of the Hamilton filter. The number of regimes in both models is selected using the likelihood ratio (LR) tests with the upper bound for the *p*-values obtained according to Davies (1987). We also supplement the LR tests with AIC. The power of the linearity tests, including the Davies (1987) approach, may be low when the number of regimes is high.[12] In order to check the robustness of the model selection, we use the bootstrap testing approach of Di Sanzo (2009) which tests for linearity in Markov-Switching models.[13]

The parameters of the univariate GARCH spillover model are estimated using the quasi maximum likelihood procedure. A final choice in the 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 the student *t* distribution. Thus, the idiosyncratic shocks are distributed as $e_{l,t} \sim t(v_{S_{l,t}})$ where $v_{S_{l,t}}$ ($l = w, \text{reg}, k$) is the degrees of freedom of the student *t* distribution. We allow the degrees of freedom of the student *t* distribution to switch with regimes, leading the tails of the distribution to vary across regimes.

[12] We thank an anonymous referee for pointing out this issue and suggesting the use of the bootstrap linearity test of Di Sanzo (2009).
[13] Di Sanzo (2009) shows that this text works well and outperforms the Hansen (1996) and the Carrasco et al. (2004) tests.

4. Empirical Results

4.1. Data

The empirical analysis includes a total of 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 observe dissimilar weekends from the Western markets (i.e. , Fridays and Thursdays are part of the weekend in the GCC countries and their markets are closed on those days), we utilize daily data for three-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 sample period includes 1/1/2006-11/25/2013 with 1,237 observations. This period is dictated by the availability of the data for the GCC equity sectors which have recently been 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. 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 financial sector.

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.[14] The world market is represented by the STOXX Global 1800 index which includes the developed markets only, having a total fixed number of 1,800 constituent firms.[15] 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 excess returns.

[14] MSCI GCC index covers about 85% of the free float-adjusted market capitalization in each GCC country.
[15] The STOXX Global 1800 index includes stocks of 600 European, 600 American and 600 Asia/Pacific region firms.

Table 3 provides the descriptive statistics of the logarithmic returns for the return series examined. We observe negative mean returns for the return series in general, most likely as a result of the 2007/2008 global financial crisis. 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 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 which exhibits positive skewness possibly due to this sector's high correlation with global 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 procedure 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. Given the non-normality and the fat tails implied by the descriptive statistics reported in Table 3, all GARCH spillover models are estimated with a student *t* error distribution with the degrees of freedom of the *t*-distribution also estimated as an additional parameter. As noted earlier, a novelty of this study is that we determine 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. (2013, 2014) show that the three-regime MS model best captures the return dynamics in these markets. In our case, a battery of tests comparing linear, 2-regime MS and 3-regime MS models strongly rejects alternative specifications in favor of the 3-regime heteroscedastic MS model, MSH(3). The selection of the MSH(3) specification is consistently supported by the tests based on the likelihood ratio (LR) statistic and the Akaike Information Criterion (AIC). The bootstrap test suggested by Di Sanzo (2009), which is performed with 1000 bootstrap draws, also strongly rejects the linear models in favor of the MS(3) models and selects the MS(3) models over the MS(2) models. The details of the test results are not reported to save space and are available upon request.

The three-regime specification is in contrast to Baele and Inghelbrecht (2010) who argue that the third regime exhibits spike-like behavior implying short-lived events. However, as will be discussed later, the third regime in our case proxies periods of extreme fundamental uncertainty including the 2007/2008 crisis period as well as the Greek bailout discussions in the Eurozone area. Furthermore, the findings indicate significantly different spillover effects during the third regime with important diversification implications.

4.2.2. Global and regional spillover analysis

The estimates for the constant parameter GARCH spillover model (the benchmark model) which are not reported here yield significant and positive estimates for both risk exposures β_l^{reg} and β_l^{w} across all GCC sectors/subsectors, indicating positive risk spillovers from the global and regional shocks into these sectors in these benchmark models. The finding of a positive risk exposure with respect 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/subsectors. It also implies that the GCC-wide sectors are driven by the same fundamental uncertainties that also drive the regional and global market returns. The largest spillover effect from both the regional and global shocks is observed for the Real Estate sector/subsectors. 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 which also allows investments from non GCC citizens. The lowest regional spillover effect is observed for the banking sector which is highly regulated and supervised within the national borders due to its importance to the national economy and the government. Most GCC countries have a few banks and do not allow foreign banks to have offices in their countries. Similarly, the energy sector is found to have the lowest exposure to global shocks, possibly due to the periodic regulatory effect of OPEC and this sector is also considered ‘sovereign” by the GCC governments. Nevertheless, both the global and regional spillover effects are found to be positive according to the constant parameter (benchmark) model, which does not take into account time-variations and possible regime-specific patterns in the model parameters.

Taking into account the effect of market regimes yields different results, yielding insignificant and sometimes significant and negative spillover coefficients, particularly during periods of high market stress (regimes 2 and 3). 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 in this model, we conclude that the positive spillover effects 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 that the GCC-wide equity sectors exhibit heterogeneous risk exposures with respect to the regional and global shocks based on the 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 global shocks turns negative during the extreme volatility regime, with an estimated value of -0.4586 for $b^{w}_{l,3}$.

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) proxies 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. Clearly, this is a period of significant market uncertainty for global investors as indicated by a standard deviation estimate of 2.5904% for world returns in regime 3 compared to 0.4623% in regime 1 and 0.9264% in regime 2. The periods covered by the extreme volatility regime all correspond to the 2006 domestic stock market crash and the recent global financial crisis period and its aftermath. The extreme volatility regime for the world returns covers the sub-periods that correspond to early 2006 to mid-2006, mid-2008 to mid-2009 and mid-2011 to early 2012. Thus, for the GCC region, the extreme volatility regime is observed from early 2006 to mid-2006, from mid-2008 to mid-2009, and to mid-2011, which broadly correspond to the crash in the GCC stock markets in 2006 and the extreme volatility regime of the global markets starting in 2008. For individual sectors, the extreme volatility regime periods are more pronounced than those for the overall GCC and global markets, due to the less aggregated nature of sector returns. The extreme volatility periods for the individual sectors cover early early-2006 to mid-2006, most of 2007-2010 period, mid-2011 to 2012, and mid-2013 to 2014. These periods more or less correspond to the regional and global financial crises as well.

The negative risk exposure of the GCC region with respect to the global market shocks in this regime then implies that the GCC stock markets could serve as a safe haven for investors in advanced markets during the extreme volatility regime, which is highly persistent with an average duration of 70.13 days. This finding is further supported by the smoothed probability plot for the GCC region at large, presented in Figure 2.[16] The smoothed probabilities for the GCC region as well as for the GCC-wide sectors suggest that the extreme volatility periods for the world market largely fall into the low volatility regime (Regime 1) for the GCC stock indexes. It also highlights the advantage of the general MS spillover model that allows us to capture the distinct market regimes for global and local returns as each return process is designed to follow its own regime process. As Figure 2 and the estimates of the smoothed probabilities for individual sectors (not reported) indicate, there are periods where all markets share the same regime as well as periods where some markets are governed by different regime dynamics.

Similarly, the industrials, industrial and commercial services, transportation, financials and real estate sectors are found to have negative risk exposures with respect to the global shocks during the high volatility regime, whereas the same applies to the energy sector during the extreme volatility regime only. Comparing the risk exposure values across sectors, we observe that real estate as well as industrial and commercials services have the largest negative exposures to the global market shocks, suggesting that these particular GCC sectors have the best potential as a safe haven for international portfolio investors during periods of high global market stress. Similarly, the finding of a negative risk exposure of the energy sector with respect to both the regional and global shocks in Table 4 suggests that this GCC sector can serve as a safe haven for both GCC and global investors during crises or severe geopolitical tension. 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

[16] The smoothed probability plots for the individual sectors are not reported save space and are available upon request.

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 local GCC portfolios and help offset portfolio losses during periods of high and extreme volatility.

Overall, the general MS spillover model captures useful information that can be used for international and local diversification purposes which cannot be captured by the constant parameter (benchmark) model. The benchmark model clearly packages the results, thus hiding and compromising detailed information about the risk exposures of the sectors/subsectors across the regimes. A similar argument can also be made for the common state multivariate MS (MV-MS) spillover model which, similarly to the constant parameter GARCH model, yields positive risk exposure of the GCC region at large with respect to global shocks.[17] 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, providing further support to the findings in Table 4. Nevertheless, we conclude that the assumption of a common regime for the sectoral, regional and global markets in a way overlooks the differences across the GCC sectors and the possible segmentation of these markets from the global markets. It thus fails to appropriately capture the risk exposures of the GCC sectors with respect to the market shocks.

In order to gain further insight into the extent of the global and regional spillovers, we next compute the variance ratios defined in Equations (20)-(22) and compare the spillover effects implied by the three alternative models. These are easily modified for the GARCH spillover (benchmark) model. However, since the two MS spillover models have three regimes with each regime characterized by different volatility dynamics, similarly to the various moments in Equations (11)-(19), the variance ratios in Equations (20)-(22) are computed conditionally based on the predictive probabilities. This formulation allows one to obtain regime independent variance ratio measures. Table 5 presents the summary statistics for the estimated variance ratios due to the global ($VR_{k,t}^{w}$), regional ($VR_{k,t}^{\mathrm{reg}}$), and idiosyncratic shocks ($VR_{k,t}^{k}$). We observe that more than 90% of the return

[17] The results for the MV-MS model are available upon request.

variance for the GCC region is due to the regional shocks, with the global shocks accounting for only 2.501%, 7.863% and 4.055% of the variance of GCC returns based on the GARCH, MS and MV-MS models, respectively. This finding is consistent with Hammoudeh and Choi (2006) and suggests that the volatility of the GCC returns is largely explained by domestic shocks rather than by global factors. It also reiterates the relative segmentation of these markets from global markets and further supports that these markets can be potential diversifiers for global investors. On the other hand, the dominance of regional shocks over global shocks means that local GCC investors will need to supplement domestic portfolios by foreign assets in order to reduce portfolio risks.

Figure 3 presents the plots of variance ratio estimates based on the general MS spillover model obtained from Equations (20)-(22).[18] Among the three classes of models, the general MS spillover model suggests the largest global spillover effects for the GCC region with global shocks accounting for a larger percentage of sectoral and regional returns compared to the GARCH and MV-MS models. Furthermore, the time series plots of $VR_{\text{reg},t}^{w}$ and $VR_{\text{reg},t}^{\text{reg}}$ for the general MS spillover model presented in Figure 3(a) suggest significant time variations in the global spillover values, with the global shocks accounting account for 10% to 40% of the return volatility in the GCC region during the 2008-2010 period. The variance ratio for $VR_{\text{reg},t}^{w}$ 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.

In the case of the GCC-wide sectors shown in Figures 3 (b)-(j), we observe that among the three models we consider, the general MS spillover model implies greater time variations for the global and regional spillovers to the GCC-wide sectors. The global shock variance ratios are found to vary between 1.179% (energy) and 5.573% (industrial and commercial services), whereas the variance ratios for the regional shocks vary between 5.905% (basic materials) and 16.036% (financials). We also observe that the regional shock variance ratios based on the general MS model are higher before 2010, varying between 10% and 60% for all GCC wide sectors. Not surprisingly, the variance ratios due to global shocks are found to exceed 20% during 2009-2010 and the second

[18] The variance ratio plots for the other spillover models are not included in the paper for brevity and are available upon request.

half of 2011 for all GCC-wide sectors. On the other hand, the 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. Significant spillover effects of the global shocks are observed on financials, industrials and related sub-sectors; with energy, transportation and utilities relatively less affected by global market shocks probably because of heavy government subsidies. Prices of goods and services in the oil-related sectors in the GCC countries are considerably below world prices because of those subsidies. The relatively segmented nature of the subsidized energy related sectors can be utilized by global investors in their diversification strategies if they are accessible. The higher variance ratios for the finance-related (sub) sectors are consistent with Arouri and Rault (2012) who suggest a significant link between the financial services in the GCC and the Western financial centers.

5. Diversification benefits of GCC-wide equity sectors

Having presented evidence on the risk exposures of GCC-wide equity sectors with respect to regional and global shocks, we next divert our attention to the potential diversification benefits of these sectors for investors. For this purpose, we compare the risk/return tradeoffs offered by alternative portfolios implied by each spillover 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 in order to assess the relative 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 earlier. 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 computing the in-sample covariance matrix (Σ_t) of the eight sector 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 each model using data over the period 1/1/2006-8/14/2012 and obtain the predicted covariance matrix S_{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 three-month U.S. Treasury bill rate.

Performance comparisons are made across five alternative portfolios given the estimates of the covariance matrix S_t. We restrict the portfolio weights to sum up to 1 and do not allow short-selling.

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 models.

Portfolio 3: Diversified minimum-variance portfolio with the same return as the STOXX 1800 index.[19]

Portfolio 4: Diversified minimum-variance portfolio with the same risk as the STOXX 1800 index. [20]

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

Table 6 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

[19] 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.

[20] If the STOXX 1800 risk is outside the range of risk values 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

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 yield 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. Note that the general MS model allows the sectoral, regional and global market returns to follow their independent regimes and provides the flexibility for the regime-switching to be synchronized or vice versa. The comparison of portfolio performances across the alternative models in Table 6 clearly suggests that restricting the regimes of the GCC-wide equity sectors, the GCC-region, and the world is suboptimal, leading to lower risk-adjusted returns.

The summary statistics for the dynamic out-of-sample portfolios reported in Table 7 further support our findings for the in-sample findings in Table 6. 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 undiversified global investor portfolio (Portfolio 1). The highest Sharpe ratio is once again observed for the diversified tangency portfolio (Portfolio 5). We also 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 MS spillover model dominate the portfolios based on the GARCH and MV-MS models in terms of risk-adjusted returns.

Figure 4 presents the portfolio weights in the tangency portfolio based on the general MS spillover model. We observe that the GCC-wide equity sector allocation in the best performing portfolio (Portfolio 5) exceeds 60 percent for prolonged periods, thus underscoring the potential diversification benefits of the GCC sectors. Furthermore, the GCC-wide sectors including utilities, energy, banks, and basic materials are allocated higher weights, implying the significance of these particular GCC sectors in global diversification strategies. Overall, both in- and out-of-sample results support earlier findings on the spillover effects with respect to global shocks and suggest that GCC-wide equity sectors can offer significant diversification benefits for global investors, regardless of the model specifying the spillover effects. While our findings suggest enhanced risk/return tradeoffs and potential safe haven benefits of the developing GCC markets for global investors, as Balli et al. (2014) note, investors in mature economies have been slow to diversify their portfolios internationally, suggesting a home bias in these markets. Our findings therefore provide compelling evidence that emerging market stock markets can still provide international diversification benefits despite the globalization of capital markets, thereby underscoring the importance of financial reforms that will make these markets more easily accessible to investors in developed markets.

6. Conclusion

This paper extends the literature on international financial integration and portfolio diversification by developing dynamic two-factor models of GCC-wide equity sector returns, with the regional and global market shocks as the risk factors. In the first part of the analysis, we examine the regional and global market exposures of the GCC-wide equity sectors using three alternative spillover models: (i) the constant parameter GARCH model; (ii) the unsynchronized (general) regime-switching model (MS); and (iii) the common synchronized regime-switching model (MV-MS). We also compare the inferences from these alternative spillover models regarding regimes, risk exposures and portfolio diversification. In contrast to most spillover studies in the literature, we determine the market regimes by formal statistical testing rather than making assumptions on the possible regime structure. We find that the three-regime specification best describes the returns, in which the third regime proxies periods of extreme market uncertainty. Finally, we supplement our analysis with a comparison of the in- and out-of-sample performance of alternative portfolio strategies based on the static and regime-based models.

Our findings suggest that the risk exposures 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 equity sectors as well as for the GCC region 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 global shocks during the low and high volatility regimes, we find that the regional risk exposure to global shocks turns negative during the extreme volatility regime which proxies the duration and aftermath of the global crisis in late 2008 and around the second bailout package announcement for Greece in late 2011.

Similarly, the GCC-wide industrials, industrial and commercial services, transportation, financials and real estate sectors/subsector are found to have negative risk exposures with respect to global shocks during the high volatility regime and the energy sector during the extreme volatility regime. This finding suggests that the GCC-wide sectors can serve as a safe haven for international portfolio investors during periods of high market stress, depending on the particular sector utilized in the portfolio. On the other hand, we find that the constant parameter GARCH and the common state MS models (MV-MS) fail to capture the dynamic nature of return and risk spillovers, thus they fail to provide a complete assessment of the international diversification potential of these markets. This is further supported by the in- and out-of-sample portfolio tests which imply inferior risk-adjusted returns for portfolios based on these two models, compared to the unsynchronized MS model.

The comparison of the portfolios constructed using the covariance matrices based on alternative spillover models suggests that supplementing the world portfolio with positions in the GCC-wide equity sectors/subsectors leads to more efficient portfolios with much improved risk-adjusted returns. This finding is consistent across the alternative spillover models and is also supported by both in- and out-of-sample tests. Finally, we observe that the GCC-wide sectors including utilities, energy, banks and basic materials carry greater weights in the most efficient global portfolio, suggesting that global investors should well explore the accessibility of these particular sectors in their international diversification strategies. Some of these sectors may be considered "sovereign" by the GCC governments, and thus may not be open to foreign investors.

In conclusion, the findings clearly suggest that taking into account the regime-specific and the time-varying nature of the return and risk spillovers across the GCC stock markets provides valuable insight to the diversification benefits offered by these developing markets, particularly during periods of high 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 the time-invariant single regime model as well as by the common two-regime spillover model. The much improved risk-adjusted performance of the world portfolio augmented with positions in the GCC-wide sectors clearly supports the findings from the general 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. GCC market characteristics

	S. Arabia	UAE	Kuwait	Qatar	Bahrain	Oman
Sectors						
	Financials	Financials	Financials	Financials	Financials	Financials
	Petrochemicals	Energy	Consumer Services	Industrial	Hotel & Tourism	Industrial
	Cement	Consumer	Basic Material	Transportation	Industrial	Insurance
	Retail	Consumer Staples	Consumer Goods	Real Estate	Insurance	
	Energy & Utilities	Construction	Healthcare	Insurance	Services	
	Agriculture	Industrial	Technology	Telecom.		
	Telecom.	Insurance	Telecom.	Consumer Goods		
	Insurance	Real Estate	Insurance			
	Multi-Investment	Telecom.	Real Estate			
	Construction	Transportation	Industrial			
	Real Estate	Industrial	Oil & Gas			
	Transportation	Healthcare	Utilities			
	Media	Financial Services				
	Hotel & Tourism	Services				
Max. % of foreign investment	0	49	49	25	100	25-100
Foreign investment through mutual funds	Yes	Yes	Yes	Yes	Yes	Yes

Note: Kuwait and Saudi Arabia allow GCC citizens to invest in their markets although Saudi Arabia limits it to certain companies and within limited percentages. In Kuwait and Saudi Arabia, non-GCC nationals are not allowed to invest directly although new laws are underway to allow foreign investors in these markets. In Bahrain, there are no restrictions on foreign investors although ownership is restricted to 49% for most companies expect for several bank stocks that are available for 100% foreign ownership. In UAE and Qatar, GCC nationals are allowed to invest within certain limits. UAE requires at least 51% of the share capital of a UAE company to be held by UAE nationals and foreign investors are only able to hold up to 49% of the share capital of a UAE company. UAE (Abu Dhabi) completely restricts real estate, general transport and labor supply to UAE nationals. In all GCC countries, investors are not allowed to invest in sovereign sectors such as the oil and gas sectors for all GCC. Kuwait and Saudi Arabia do not allow foreign ownership in the banking sector. In Qatar’s free zones, 100% foreign ownership is allowed. See Demirer (2013) and K&L Gates (2014) for more information.

Table 2. Literature on financial integration of GCC stock markets

Authors	Data	Methodology	Key findings
Hassan et al. (2003)	Monthly data for various sample periods.	GARCH-M models	Impact of county risk factors on volatility and predictability of Middle Eastern and African stock markets
Hammoudeh and Eleisa (2004)	Daily GCC market indices and oil price for Feb.1994-Dec. 2001.	Cointegration tests and VEC models.	The Saudi market leads, followed by Bahrain and United Arab Emirates. Oman has the weakest link.
Hammoudeh and Choi (2006)	Daily GCC market indices and oil price for Feb. 1994- Dec. 2004.	Cointegration tests and VEC models.	GCC return volatility is largely explained by local shocks, implying potential international diversification benefits.
Lagoarde-Segot and Lucey (2007)	Weekly MENA stock market indices for 1998-2005.	Portfolio analysis using rolling block-bootstrapping.	Significant international diversification benefits of MENA stock markets.
Malik and Hammoudeh (2007)	Daily GCC stock indices for Feb. 1994-Dec. 2001.	Multivariate GARCH models.	Significant volatility transmissions from the oil market to GCC stock markets.
Yu and Hassan (2008)	Daily GCC stock indices for Jan. 1999-Dec. 2005.	ARMA and VEC models of market integration and spillovers.	GCC markets are largely segmented from international markets.
Cheng et al. (2010)	Daily MENA market indices until Feb. 2008.	International CAPM and factor models.	MENA markets offer returns uncorrelated with global markets.
Mansourfar et al. (2010)	Daily GCC stock indices until Sep. 2008.	Portfolio optimization.	Oil-producing GCC countries provide greater international diversification benefits than the non-oil producing MENA countries.
Berger et al. (2011)	25 emerging and frontier market indices including UAE, Kuwait, S. Arabia until 2009.	Principal component analysis and structural break models.	Frontier markets have low integration with world markets, offering significant diversification benefits.
Arouri and Rault (2012)	Monthly GCC market indices until Dec. 2007.	Seemingly unrelated regressions using panel data.	International diversification benefits can be achieved by allocating part of the global portfolios to investments in the oil-exporting countries.
Balli et al. (2013)	Weekly GCC-wide sector indices for 2005-2012.	Time-varying spillover models.	Regional shocks dominate global shocks on the volatility of returns in GCC-wide equity sectors.
Demirer (2013)	Daily GCC sector indices until Nov. 2008.	Regression analysis and portfolio models.	Significant linkages among GCC markets. Diversification benefits can be with advanced markets.

Khalifa et al. (2014)	Weekly GCC national indices for 2004-2011.	Multi-chain Markov switching volatility transmission models.	Stronger linkages of GCC markets with the global markets than with the oil market.
Chau et al. (2014)	Daily stock indices for 6 MENA countries for June 1, 2009- June 29, 2012.	GARCH models for market volatility.	MENA stock markets have become more integrated with international markets after the Arab Spring.
Syed Abul et al. (2014)	Daily GCC returns for Jan 2004-Dec 2013.	Copula models	The lower tail dependence for GCC markets is significantly greater than the upper tail dependence.

Note: The table only lists some of the more relevant studies in the literature related to the focus of this study. MENA refers to Middle East and North Africa.

Table 3. 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 three trading days per week. The sample period covers 1/1/2006-11/25/2013 with 1,237 observations. The GCC-wide equity sectors/subsectors 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 (MSCI GCC index), WORLD (SOXX Global 1800 developed market index) and TB3 (the three-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 4: Estimates of the General MS Spillover Model

Parameters	WORLD	GCC	ENERGY	BMTLS	INDUSTRY	INDCOMS
$f_{l,0,1}$	0.0731*** (0.0000)	0.0605*** (0.0227)	0.0165 (0.0225)	0.0075 (0.0228)	0.0594*** (0.0219)	-0.0058 (0.0663)
$f_{l,0,2}$	-0.0546*** (0.0000)	-0.1030 (0.0901)	-0.0499 (0.0637)	-0.0113 (0.0649)	-0.1728 (0.1282)	-0.0015 (0.046)
$f_{l,0,3}$	-0.0328*** (0.0000)	0.1119 (0.5014)	0.1102 (0.1231)	0.0084 (0.0196)	-0.1107 (0.1212)	-0.0215 (0.3290)
$f_{l,1,1}$	0.0280*** (0.0000)	0.0623* (0.0372)	0.0009 (0.0027)	-0.0104 (0.0405)	-0.0794** (0.0357)	-0.0349 (0.0518)
$f_{l,1,2}$	0.0733*** (0.0000)	0.0691 (0.0492)	0.1387*** (0.0105)	0.0127 (0.0891)	0.0763 (0.0992)	-0.0301 (0.2762)
$f_{l,1,3}$	0.0287*** (0.0000)	0.2718** (0.1183)	-0.0721 (0.2389)	0.0124 (0.0769)	-0.2061*** (0.0649)	-0.1235 (0.1071)
$f_{l,1}^{reg}$			0.0318 (0.0341)	0.0251 (0.0272)	0.0495* (0.0276)	-0.0367 (0.0423)
$f_{l,2}^{reg}$			0.2293*** (0.0291)	-0.3644*** (0.0739)	0.0846* (0.0432)	0.0381 (0.0902)
$f_{l,3}^{reg}$			-0.2635*** (0.0156)	0.2873*** (0.0634)	0.2139*** (0.0557)	0.2508*** (0.0773)
$f_{l,1}^{w}$		0.1349*** (0.0279)	0.0730*** (0.0263)	0.1045*** (0.0254)	0.0882*** (0.0246)	0.0990** (0.0449)
$f_{l,2}^{w}$		0.1371** (0.0532)	0.2773*** (0.0537)	0.0457 (0.1166)	0.0202 (0.0805)	-0.1828 (0.1939)
$f_{l,3}^{w}$		0.6920*** (0.2322)	-0.1219 (0.0868)	0.2724** (0.1147)	0.2386*** (0.0650)	0.3613** (0.1678)
			Spillover parameters			
$b_{l,1}^{reg}$			0.1250*** (0.0391)	0.1402*** (0.0253)	0.2232*** (0.0280)	0.1217*** (0.0383)
$b_{l,2}^{reg}$			0.4184*** (0.0432)	0.4157*** (0.0643)	**0.0279** (0.0455)	**-0.0421** (0.0844)
$b_{l,3}^{reg}$			**-0.2149***** (0.0511)	0.2757*** (0.0583)	0.4304*** (0.0487)	0.4866*** (0.0917)
$b_{l,1}^{w}$		0.1673*** (0.0264)	0.0852*** (0.0292)	0.1143*** (0.0242)	0.1084*** (0.0236)	0.1548*** (0.0394)
$b_{l,2}^{w}$		0.4141*** (0.0686)	**0.0375** (0.0522)	**0.0133** (0.0631)	**-0.1197** (0.1132)	**-0.6211***** (0.1306)
$b_{l,3}^{w}$		**-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			
$s_{l,1}$	0.4623*** (0.0000)	0.4644*** (0.1810)	0.4787*** (0.1726)	0.4967*** (0.1603)	0.5114*** (0.1672)	0.7811*** (0.3302)
$s_{l,2}$	0.9624*** (0.0000)	1.2538*** (0.5395)	1.0811*** (0.4328)	0.7199 (0.6219)	1.0683*** (0.4985)	0.9686 (1.3085)
$s_{l,3}$	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			
$t_{l,1}$	41.9862	57.9675	35.6968	37.7164	60.9767	33.5468
$t_{l,2}$	40.0910	17.2023	4.2228	1.5565	12.3569	2.7472
$t_{l,3}$	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	3.6453
log *L*	-1663.8914	-1835.1889	-1681.2710	-1829.4463	-1585.6675	-2222.7802

Notes: The table reports the parameter estimates of the general MS spillover model in Equations (1)-(3). The standard errors of the estimates are given in parentheses. In each case, we parameterize $m_{l,S_{l,t},t-1}$ as $m_{l,S_{l,t},t-1} = f_{l,0,S_{l,t}} + f_{l,1,S_{l,t}} R_{l,t-1}$, 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. $e_{l,t} \sim t(v_{l,S_{l,t}})$, where $v_{l,S_{l,t}}$ is the degree of freedom . The parameters are estimated using ML. ***, ** and * represent significance at the 1%, 5%, and 10% levels, respectively.

Table 4 (continued)

Parameters	TRANS	FIN	BANK	RESTATE	UTIL
$f_{l,0,1}$	0.0104 (0.1134)	0.0414** (0.0165)	0.0141 (0.0167)	0.0159 (0.0336)	-0.0249 (0.0295)
$f_{l,0,2}$	-0.0197 (1.0318)	0.0035 (0.0059)	0.0147 (0.0503)	-0.1808 (0.3884)	-0.1068 (0.1174)
$f_{l,0,3}$	-0.1863 (0.3154)	-0.0463 (0.0761)	-0.0365 (0.0765)	-0.1705 (0.1215)	0.1036 (0.2024)
$f_{l,1,1}$	-0.0780 (0.0805)	-0.0487 (0.0379)	-0.0777** (0.0370)	0.0576 (0.0360)	0.0067 (0.0287)
$f_{l,1,2}$	0.0698 (0.2953)	0.0815 (0.0725)	0.2141** (0.0866)	-0.3967*** (0.1466)	0.0784 (0.0721)
$f_{l,1,3}$	-0.0867 (0.0897)	-0.1231** (0.0562)	-0.0590 (0.0627)	-0.1069** (0.0532)	-0.0409 (0.0577)
$f_{l,1}^{reg}$	0.0510 (0.0567)	0.0385* (0.0226)	0.0556** (0.0225)	-0.0135 (0.0366)	0.0717** (0.0350)
$f_{l,2}^{reg}$	0.0957 (0.0878)	0.0771** (0.0353)	-0.0484 (0.0915)	0.0227 (0.0218)	0.3397*** (0.0778)
$f_{l,3}^{reg}$	0.1924*** (0.0611)	0.1542*** (0.0420)	0.1342*** (0.0360)	0.2824*** (0.0608)	-0.3028*** (0.1121)
$f_{l,1}^{w}$	0.1142*** (0.0298)	0.1150*** (0.0184)	0.1233*** (0.0186)	0.1317*** (0.0342)	0.0761** (0.0339)
$f_{l,2}^{w}$	-0.1936 (0.1622)	0.0241 (0.0824)	-0.0422 (0.0877)	0.0412 (0.1373)	0.6003*** (0.0736)
$f_{l,3}^{w}$	0.1626 (0.1050)	0.2441*** (0.0427)	0.2070*** (0.0470)	0.3453*** (0.0809)	-0.0117 (0.0316)
			Spillover parameters		
$b_{l,1}^{reg}$	0.2209*** (0.0529)	0.2144*** (0.0216)	0.2057*** (0.0248)	0.2942*** (0.0366)	0.1098*** (0.0354)
$b_{l,2}^{reg}$	**0.0258** (0.1459)	**0.0163** (0.0333)	**-0.0483***** (0.0128)	**-0.1646***(0.1916)	0.5889*** (0.0394)
$b_{l,3}^{reg}$	0.4289*** (0.1254)	0.3816*** (0.0390)	0.3184*** (0.0442)	0.4618*** (0.0670)	**0.1065** (0.0791)
$b_{l,1}^{w}$	0.1034*** (0.0266)	0.1073*** (0.0182)	0.0947*** (0.0179)	0.1542*** (0.0348)	0.0863*** (0.0331)
$b_{l,2}^{w}$	**-0.1114** (0.2523)	**-0.0096** (0.0469)	**0.0261** (0.0597)	**-0.5185***** (0.1241)	**0.1068** (0.0752)
$b_{l,3}^{w}$	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		
$s_{l,1}$	0.6002*** (0.2295)	0.3947*** (0.1240)	0.3765*** (0.1177)	0.8605*** (0.1609)	0.6545*** (0.2264)
$s_{l,2}$	1.2800 (1.1179)	0.8262*** (0.3644)	0.5317*** (0.2057)	1.6218* (1.1679)	1.4783*** (1.8134)
$s_{l,3}$	1.8568*** (0.5664)	1.0796*** (0.4787)	1.1079*** (0.3026)	1.9762*** (0.9667)	2.0298*** (2.6396)
			Model Statistics		
$t_{l,1}$	46.6609	57.5342	57.2934	53.5067	40.0389
$t_{l,2}$	26.3547	69.0514	4.0708	2.9413	1.6722
$t_{l,3}$	16.3190	26.5905	10.0670	10.9394	1.3322
$n_{l,1}$	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	2.9894	2.1074	2.0826	3.3404	3.3092
log L	-1817.4460	-1272.3864	-1257.0411	-2034.3749	-2015.0714

Notes: See notes in Table 4 above.

Table 5: 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, general 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 6: 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 general MS, and the MV-MS spillover models. The models are estimated for the sample period 1/1/2006-8/14/2012, and 1,036 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 including 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 7: 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 including 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

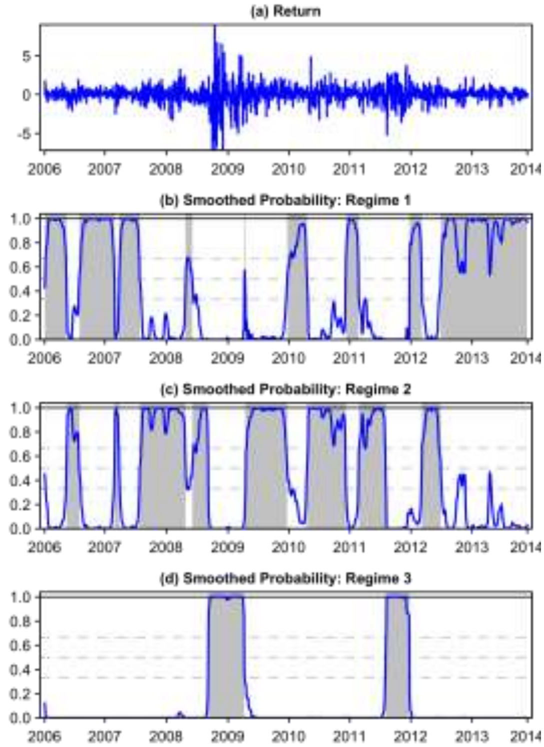
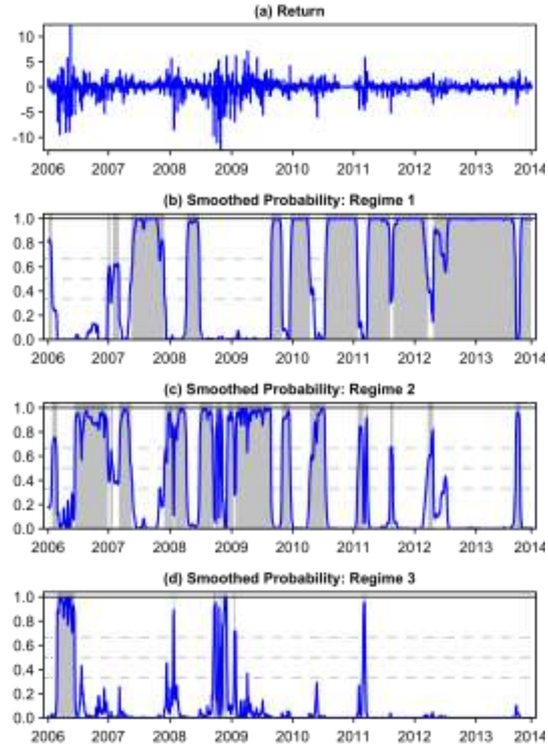
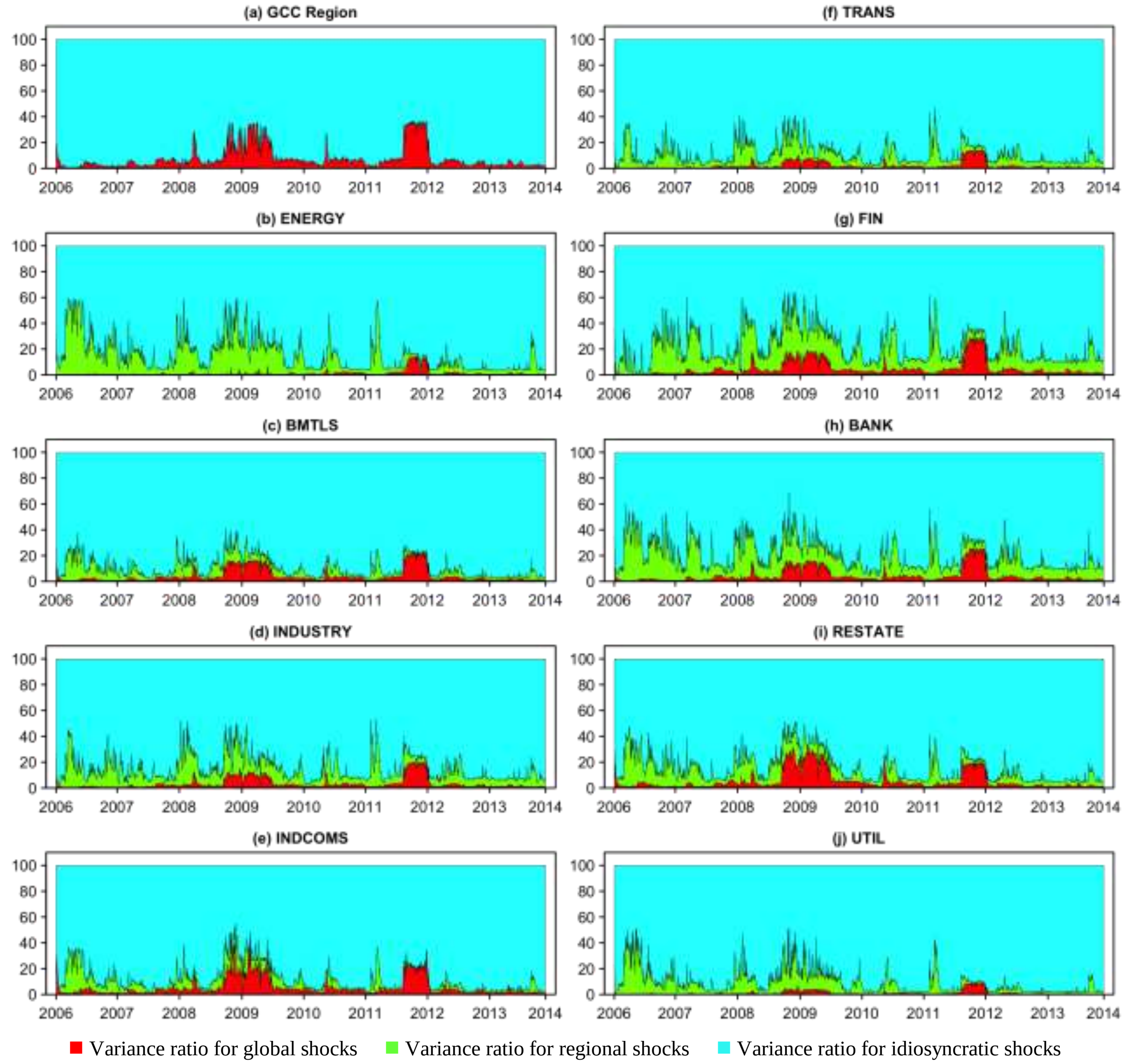


Figure 2: Smoothed Probability of the General MS Spillover Model for the GCC region



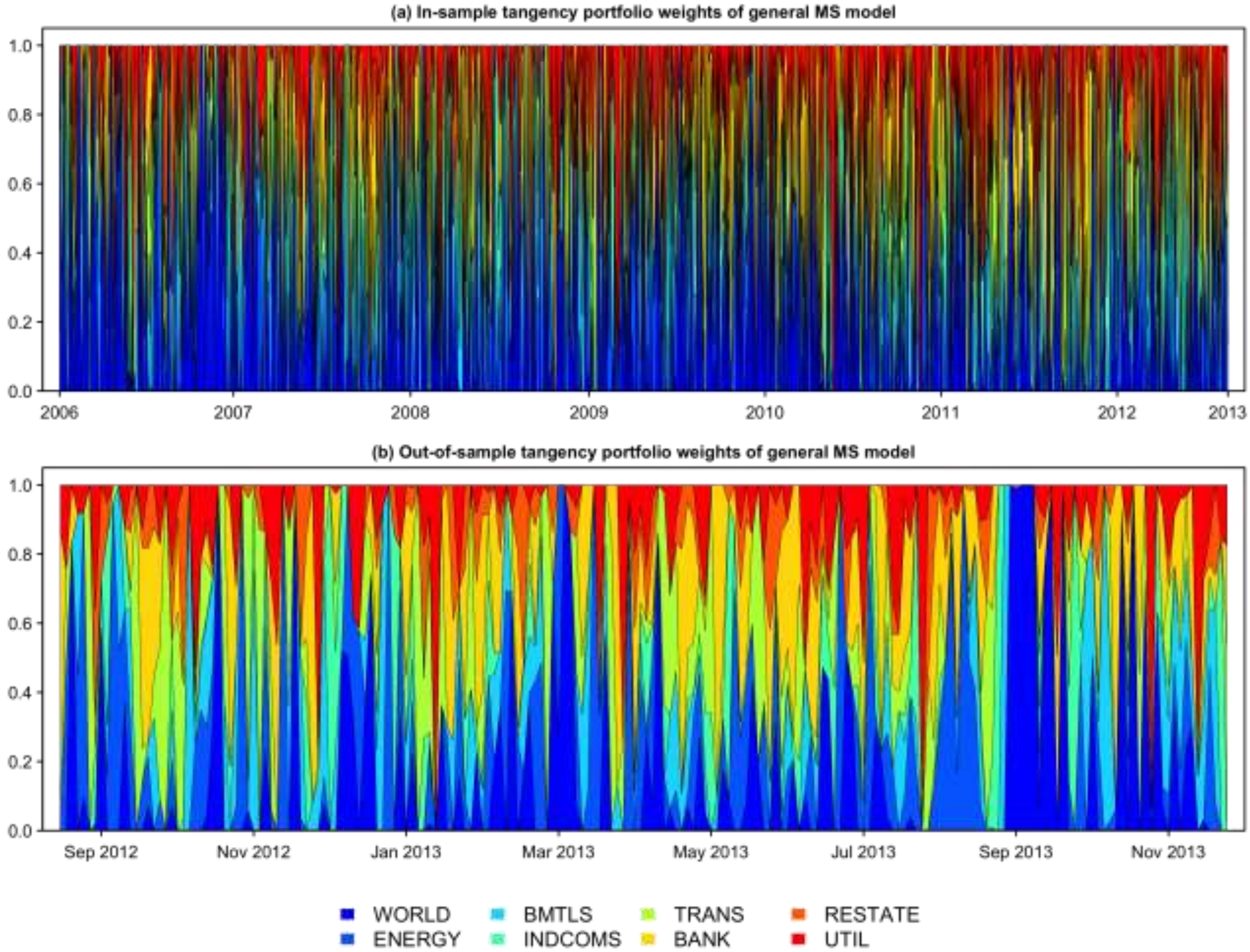
Note: Figure (a) plots the market return. Figures (b)-(d) plot the smoothed regime probabilities for the 3-regime nonlinear general MS spillover model in Equations (1)-(3) The shaded regions in Figures (b)-(d) correspond to the maximum smoothed probability among the three smoothed probabilities. Regime 1 is the low volatility, Regime 2 is the high volatility and Regime 3 is the crash or extreme volatility.

Figure 3: Variance Ratio Estimates from the General MS Spillover Model



Note: This figure presents stacked plots of the percentage variance ratios for the general MS spillover model in Equations (1)-(3). Variance ratios are obtained from Equations (20)-(22). For the GCC region, the total variance is decomposed into components due to global shocks and idiosyncratic shocks. For the GCC-wide sectors, the total variance is decomposed into components due to global shocks, regional shocks and idiosyncratic shocks. The variance ratios are computed over the full sample period 1/1/2006-11/25/2013 with 1,236 observations.

Figure 4: In-sample and Out-of-sample Tangency Portfolio Weights of the General MS Spillover Model



Note: This figure presents stacked plots for the dynamic tangency portfolio weights (Portfolio 5) based on the general MS spillover model. The in-sample dynamic portfolios are constructed over the period 1/1/2006-8/14/2012 and include 1,036 portfolios. The out-of-sample dynamic portfolios are constructed for the sample period 8/15/2012-11/25/2013 and include 200 portfolios. Each portfolio includes the STOXX 1800 developed market index and the GCC-wide equity sectors/subsectors including ENERGY, BMTLS, INDCOMS, TRANS, BANK, RESTATE, and UTIL.