Shock and Volatility Spillovers Among Equity Sectors of the Gulf Arab Stock Markets

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Abstract

Upon examining own volatility dependency for the three major sectors, namely Service, Industrial and Banking, in four GCC economies (Kuwait, Qatar, Saudi Arabia and UAE), the empirical findings suggest that Banking seems to be the least sensitive among the sectors to past own volatility, while Industrial is the most volatile to the onset of past shocks or news. Sector volatility spillovers show that Saudi Arabia has the least inter-sector spillovers, while tiny Qatar has the most. Saudi Arabia seems to be the most sensitive to geopolitics, while Kuwait is the least affected. The constant conditional correlations between the three sectors for all four GCC markets echo different economic advantages and varying roles in the economy. We also provide two examples using the estimates of the GCC equity sector markets for portfolio designs and hedging strategies.

1. Introduction

In developed countries, equity investing has been popular for many years. Investors invest in defensive stocks, such as those of the non-cyclical consumer goods sector, when the economy is teetering into recession. They invest in high tech sector's stocks when the economy is booming. In international investing, portfolio managers who follow the top down approach usually pick countries and then sectors. Even informed investors choose sectors without paying much attention to interactions and volatility transmission among sectors. In emerging markets such as the markets of the rich oil-producing countries, sector investing has not yet reached similar popularity and their markets lack organized sector indices. While there have been studies that examine the transmission of returns among individual sectors within a system, information is still needed on how volatility spillovers occur among sectors in multivariate settings. This knowledge is particularly useful because of the increase in globalization and contagion among world financial markets. The current transmission of high volatility among sectors of individual countries and among countries is a vivid and topical example.

More recent literature on MENA market volatility uses univariate GARCH models and examines volatility behavior at the market index level. Hammoudeh and Li (2008) examine sudden changes in volatility for five GCC stock markets at the market index using the iterated cumulative sums of squares (ICSS) algorithm, and analyze their impacts on the estimated persistence of volatility. They find that most of these stock markets are more sensitive to major global events than to local and regional factors.

Zarour and Siriopoulos (2008) use the CGARCH model developed by Engle and Lee (1993) to investigate the existence of volatility decomposition into short run and long run components. They apply this model to daily index returns data for nine emerging markets in the Middle East region, including three of our GCC countries. Hammoudeh and Choi (2007) employ the univariate GARCH approach with Markov-switching to study the volatility behavior for the transitory and permanent components of the individual GCC market indices, allowing for two volatility regimes to exist. While Malik and Hammoudeh (2007) use trivariate GARCH models, their systems include one individual GCC market index, the WTI oil price and S&P 500 index to analyze return volatility transmission for three GCC markets. The volatility transmission does not involve more than one GCC market within one system.

This paper uses a more recent multivariate technique that examines shock and volatility transmission among three sectors, namely banking, industrial and service, for Kuwait, Qatar and Saudi Arabia, and banking, insurance and service, for UAE which does not have data for the industrial sector. The technique is the vector autoregressive moving average GARCH (VARMA-GARCH) model developed by Ling and McAleer (2003) (see Chan et al. (2005) for an early application of the model). This method enables us to examine the conditional volatility and conditional correlation cross effects with meaningful estimated parameters and less computational complications, as compared with other methods such as the BEKK model of Engle and Kroner (1995). BEKK is a multivariate GARCH (1,1) model with dynamic covariances and dynamic correlations,

but typically is not attached to a VARMA model. The VARMA version of BEKK has not yet been analyzed theoretically (see McAleer et al. (2008) for further theoretical details). For more than four or five assets or commodities, BEKK typically does not converge because it has far too many parameters. In short, there is little argument in favour of BEKK, other than that it leads to a positive definite dynamic covariance matrix (see McAleer (2005) for further elaboration).

The broad objective of this paper is to examine conditional volatility and conditional correlation cross effects for the three majors sectors in the four GCC stock markets using the VARMA-GARCH model. This method enables an examination of the conditional volatility and conditional correlation cross effects with meaningful estimated parameters and less computational complication compared with several other methods. A complementary objective is to use the estimated results to compute the weights of the sectors in an optimal portfolio of each GCC country, and the optimal hedge ratios that minimize overall risk for holding the sectors in portfolios without affecting the expected returns in the individual country.

The empirical results indicate that optimal portfolio weights of investors own much more banking stocks than service or industrial stocks in Saudi Arabia and Qatar and more than service or insurance stocks in UAE in order to minimize risk without lowering expected returns. Investors in Kuwait hold more industrial stocks. The values for the hedge ratios for the GCC sectors are smaller than those for US equity sectors, reflecting the possibility of greater hedging effectiveness in GCC markets than in the USA, thereby leading to

more sophisticated hedging techniques and strategies. These empirical results are important for the GCC countries which have recently embarked on establishing equity funds for both individual and institutional investors.

The remainder of the paper is organized as follows. Section 2 provides a description of the data and summary statistics. Section 3 presents the empirical VARMA-GARCH model. Section 4 discusses the empirical results, and Section 5 provides the economic implications for designing optimal portfolios and formulating optimal hedging strategies. Section 6 gives some concluding comments.

2. Data Description

The data cover the three major sector daily indices for four of the six GCC countries, namely Saudi Arabia, Kuwait, Qatar and UAE. The sectors are the Service, Industrial and Banking sectors for the first three countries, and Service, Insurance and Banking for UAE, which does not have an index for the Industrial sector. Bahrain was excluded because this kingdom changed its index series in 2003, so that there are currently no adequate series for its sectors. Furthermore, reasonable sectoral data do not exist for Oman.[1]

The sample covers the daily period from December 31, 2001 until December 31, 2007 for Saudi Arabia, Kuwait and Qatar. The sample period for UAE starts with the same date

[1] Aksel Kibar of Abu Dhabi Investment Company indicated in a private communication that: "It is a fact that these two markets [Bahrain and Oman] are very illiquid. Sometimes stocks do not trade for weeks."

but ends on December 10, 2007. It should be noted that the GCC countries do not share the same week-end, and their week-ends are different from week-ends in western markets. Therefore, we cannot pool variables across countries on a daily basis. The data set also includes a dummy variable for the 2003 Iraq War, and is intended to capture the impact of geopolitics on sector return and volatility.

Table 1 provides the descriptive statistics for the daily indices of the three sectors in each of the four GCC countries over the sample periods. The average daily index return varies among the sectors within the same country, and for the same sector across the four countries. In Saudi Arabia, the Industrial sector gives the greatest average return relative to the other two sectors. This is consistent with the empirical findings reported in Hammoudeh and Al-Qudhea (2006). It is not surprising that the Industrial sector in Saudi Arabia yields the highest average return because the country has the largest economy, defined in terms of GDP, in the Middle East and North Africa (MENA) region. Its economy can thus support a relatively large industrial base.

In Kuwait and tiny Qatar, the Service sector and Banking sector, respectively, yield the greatest returns. Qatar is competing with Dubai and Bahrain in having the best financial center in the region, but it does not have a solid industrial base. In UAE, both the Service and Banking sectors give the same highest return which is much higher than the return in the Insurance sector. Stocks of the Insurance sector are not as liquid as those of the other sectors. Overall, among the three sectors in the four countries, the Service sector in Kuwait returns the highest average yield, while the Insurance sector in UAE gives the

lowest. In terms of sector risk, as defined by the standard deviation, most of the risk is in the Service sector for Saudi Arabia, Kuwait and UAE, but in the Industrial sector for Qatar, whose highly concentrated industries are based on the volatile oil and natural gas. Thus, in Kuwait and UAE, sector risk is commensurate with return.

Most of the returns are skewed to the left, implying that there is a greater chance that the sectors go down than up in a given period of time. This result suggests that investors invest in these sectors for the long haul to override the intermittent declines. The kurtosis is mixed, with some indices having a kurtosis that is higher than the normal distribution, while for others it is lower.

3. Empirical Model

As indicated above, the univariate GARCH approach has been used in modeling volatility in the general indices of the GCC stock markets. Our objective is to apply recent techniques in modeling volatility to upgrade the use of the univariate GARCH approach to a multivariate system. This approach will enable us to examine the conditional volatility and correlation dependency, and interdependency of equity sectors of the GCC markets. With this approach, we will be able to focus more on the estimation of meaningful, interpretable parameters with minimal computational difficulties than for several other models. We use the VARMA-GARCH model developed by Ling and McAleer (2003) to focus on the interdependence of conditional variances and conditional correlations among these sectors.

The equity sectors for each GCC stock market in the VARMA-GARCH system are indexed by *i*, and *n* is the total number of sectors. Based on information criteria, the mean equation for the i^{th} sector in this system is AR(1), and is given by:

$$R_{i,t} = a_i + b_i R_{i,t-1} + \varepsilon_{i,t} \quad , \tag{1}$$

$$\varepsilon_{i,t} = h_{i,t}^{1/2} \eta_{i,t} \ ,$$

where $R_{i,t}$ is the return of the i^{th} sector of the nx1 vector R_t, defined as the log differences. The innovation $\eta_{i,t}$ is an *i.i.d.* random shock, and $h_{i,t}$ is the conditional variance of the ith sector at time *t*. Ling and McAleer (2003) specified the interdependent conditional variance as:

$$h_{i,t} = c_i + \sum_{j=1}^{n} \alpha_{ij} \varepsilon_{j,t-1}^2 + \sum_{j=1}^{n} \beta_{ij} h_{j,t-1} \ , \tag{2}$$

which is a generalization of the Bollerslev (19900) univariate GARCH process, where $h_{i,t}$ is the conditional variance at time *t*, $h_{j,t-1}$ refers to own past variance for $i=j$, and past conditional variances of the sectors in the market or system for $i \neq j$, $\Sigma \alpha_{ij} \varepsilon^2_{j,t-1}$ is the short run persistence (or the ARCH effects of past shocks), and $\Sigma \beta_{ij} h_{j,t-1}$ is the contribution to the long run persistence (or the GARCH effects of past volatilities).

From (2), the conditional variance for the i^{th} sector is impacted by past shocks and past conditional variances of all the sectors in the market, thereby capturing interdependencies or spillovers. Therefore, this specification allows for the cross-sectional dependency of conditional volatilities among all the sectors. The past shock and volatility of one sector are allowed to impact the future volatilities not only of itself but also of all the other sectors in the system.

The parameters of the VARMA-GARCH system defined above are obtained by using the maximum likelihood estimation (MLE) when the distribution of $\eta_{i,t}$ is standard normal, and by quasi-maximum likelihood estimation (QMLE) when the distribution is not standard normal. Ling and McAleer (2003) established the structural and statistical properties of VARMA-GARCH, using the second and fourth moments. The *i.i.d.* property of $\eta_{i,t}$ implies that conditional correlation matrix of $\varepsilon_t = [\varepsilon_{1,t}, \varepsilon_{2,t,} \cdots, \varepsilon_{n,t}]'$ may be modeled as constant over time (see Engle (2002) and McAleer et al. (2008) for dynamic extensions of the constant conditional correlation model). The constant correlation matrix is given by $\Gamma = E(\eta_t \eta_t')$, where $\eta_t = [\eta_{1,t}, \eta_{2,t}, \cdots, \eta_{n,t}]'$.

4. Empirical Results

We will discuss the empirical results in terms of own sector volatility and shock dependence, inter-sector volatility, shock spillover and political risk for the three sectors in each of the four GCC countries. As is the case with the BEKK version of the

multivariate GARCH model, we are also constrained by the number of sectors that can be included in the system to achieve computational convergence.

Volatility and shocks dependence

Most of the three sector indices in the individual GCC countries show significant and positive sensitivity to past own volatility in the long run, but to considerably varying degrees. This implies that past own volatility can be used in predicting future volatility for those sectors. The Banking sector seems to be the least volatile among the sectors for most countries. This should not be surprising as Banking is a dominant sector in most GCC economies, flooded with petrodollars and flushed with liquidity. Given the current global financial crisis, this relative banking stability is a crucial strength of the GCC economies.

For Saudi Arabia, own volatilities (β s) are, to some extent, similar across sectors, with the Service sector exhibiting the greatest relative β volatility dependency (0.686), as displayed in Table 2. The situation is different in Kuwait. In contrast to Saudi Arabia, the volatility discrepancy across sectors in Kuwait is relatively high (Table 3). While the Kuwaiti Service sector is the most volatile (0.868), higher even than in Saudi Arabia, Banking shows the highest stability (0.400), which is more stable than in Saudi Arabia (0.664). This implies that the Saudi Monetary Agency (SAMA) should pay closer attention to its banks. The banks in Kuwait are strongly supervised by its central bank. In Qatar, only the Industrial sector shows significant positive volatility, which is close to its

counterparts in Saudi Arabia and Kuwait (Table 4). In the UAE, which does not have an index for the Industrial sector, Insurance has the highest volatility, while Banking has the lowest own volatility (Table 5).

The sensitivity to past own shocks or news is also positive for all sector indices in the short run. But this α sensitivity is much smaller for all sectors across countries than the β own volatility, suggesting that past own volatilities are more important in predicting future volatility than past shocks or news. Among the individual GCC countries, Qatar has the highest shock sensitivity in the Service and Banking sectors. In Saudi Arabia, all three sectors have similar shock sensitivities, but with about one third of the sensitivity to past own volatility. Among the GCC sectors, the Industrial sector shows the least news sensitivity for most GCC countries. This suggests that this sector is more sensitive to past volatilities related to changes in the fundamentals such as the supply and demand for oil and natural gas, oil and natural gas products, petrochemicals, energy-intensive goods and other commodities than to news or noise. In contrast to past own volatility sensitivity, the Banking sector seems to be the most sensitive to past news. This is not surprising because of this sector's interconnectedness with the global financial sector.

Long run volatility and shock interdependency

The inter-sector volatility results are significant, as expected for the most sectors and countries. Still, the results show moderate volatility spillovers between the sectors within the individual countries, with the exception of the UAE, for which we have substituted the Insurance sector for the Industrial sector due to non-existence of data on the Industrial

sector. Interestingly, tiny Qatar, which exports both oil and natural gas products, has the most volatility spillover from the Industrial sector to the other two sectors. Moreover, Kuwait has more sector volatility transmission than Saudi Arabia, which relatively has the least inter-sector volatility spillovers.

Among the sectors, the volatility results are generally significant and as expected. Cross volatility, or spillover, is more widespread from the Industrial sector to the Service sector than the reverse. When a GCC economy grows or contracts, it first affects the demand for goods arising from the Industrial sector. In turn, this requires services for hauling and distribution of the goods, thereby leading to fluctuations in the Service sector. On the other hand, the demand arising from the Service sector for goods produced or generated in the Industrial sector is much less voluminous, giving rise to significantly less volatility spillover towards this sector. Surprisingly, the Banking sector shows cross-volatility independence. This may be due to the supervision of the GCC central banks and this sector's inter-connection with the global financial markets.

In terms of inter-sector shock spillovers, the shock contagion is weak, and even weaker than own sector shock sensitivity. As in the own shock case, Saudi Arabia has the weakest inter-sector shock spillover links, and Qatar has the strongest, excluding UAE, which does not have the same three sectors.

Geopolitics

With regard to sensitivity of the major sectors' indices to geopolitical events, as represented by the 2003 Iraq War, geopolitics partly elevated the mean return of the industrial sector in Saudi Arabia and the Insurance sector in UAE. The war increased prices of oil, refined products, petrochemicals, energy-intensive goods and other commodities, which Saudi Arabia produces the most. This country also received more than its share of domestic political violence during the sample period. Shipping premiums on freights going through the Gulf also increased substantially because of the war. Moreover, increased crowdedness and congestion increased insurance rates in Dubai and Abu Dhabi, the two major emirates in the seven-emirate UAE.

Constant conditional correlations (CCC)

As expected, all the CCCs between the three sectors for all GCC markets are positive, reflecting simultaneous growth in the overall economy. They are all below 0.64, echoing different advantages and varying-roles played by those sectors in the economy. The estimates demonstrate that the highest CCC for all the countries is between the Service and Industrial sectors, suggesting more mutual responses economic factors between those two sectors than other sectors. The Industrial and Service sectors are highly complementary to each other. While services create demand for other services, the industries initiate original services. The CCC between Industrial and Banking, and between Services and Banking, are very close, reflecting banks' mutual ties to all sectors in the economy.

5. Implications for Portfolio Designs and Hedging Strategies

We now provide two examples using the estimates of the GCC equity sector markets for portfolio design and hedging strategies.

5.1. Portfolio weights

The first example follows Kroner and Ng (1998) by considering a portfolio that minimizes risk without lowering expected returns. In this case, the portfolio weight of holdings of two equity sector indices in the same market is given by:

$$w_{12,t} = \frac{h_{22,t} - h_{12,t}}{h_{11,t} - 2h_{12,t} + h_{22,t}}$$

and

$$w_{12,t} = \begin{cases} 0, & if \quad w_{12,t} < 0 \\ w_{12,t}, & if \quad 0 \le w_{12,t} \le 1 \\ 1, & if \quad w_{12,t} > 1 \end{cases}$$

where $w_{12,t}$ is the weight of, say, the first sector index in one dollar portfolio of the two sector indices at time *t*, $h_{12,t}$ is the conditional covariance between sector indices 1 and 2, and $h_{22,t}$ is the conditional variance of the second sector index. Obviously, the weight of the second sector index in the one dollar portfolio is 1-$w_{12,t}$.

The average values of $w_{12,t}$ for the sectors in each GCC country are reported in Table 6. For instance, the average value of $w_{12,t}$ of a portfolio comprising the Service and

Industrial sector indices in Saudi Arabia is 0.48. [Hassan and Malik (2007) used the BEKK model and estimated the average weight between the financial and technology sectors at 0.66, while the average risk-minimizing hedge ratio between these sectors is 0.64.] This suggests that the optimal holding of the Service index in one dollar of Service/Industrial index portfolio for Saudi Arabia is 48 cents, compared with 52 cents for the Industrial index. These optimal portfolio weights suggest that investors in Saudi Arabia should own more industrial stocks than service stocks in their portfolios. This finding confirms the result in Hammoudeh and Al-Gudhea (2006). The result is more pronounced in Kuwait, where the holdings tilt more heavily toward industrial stocks. The case is opposite for Qatar, where the Service sector overwhelmingly dominates the Industrial sector, possibly because Qatar has the highest own volatility and volatility and shock spillovers in the Industrial sector.

Additionally, investors in Saudi Arabia, Qatar and UAE should also possess much more banking stocks than other sectors' stocks to minimize risk without lowering the expected returns. However, the current financial crisis is an exceptional period that happens once in a lifetime. The optimal portfolios in Kuwait favor industrial stocks over banking stocks.

5.2. Hedge ratios

As a second example, we follow the example given in Kroner and Sultan (1993) regarding risk-minimizing hedge ratios and apply it to the GCC markets. In order to

minimize risk, a long position of one dollar taken in one sector index in a given GCC stock market should be hedged by a short position of $\$\beta_t$ in another sector index in the same market at time *t*. The β_t is given by:

$$\beta_t = \frac{h_{12,t}}{h_{22,t}} \ ,$$

where β_t is the risk-minimizing hedge ratio for two sector indices, $h_{12,t}$ is the conditional covariance between sectors 1 and 2, and $h_{22,t}$ is the conditional variance of the second sector.

The second column of Table 6 reports the average values of β_t for the GCC markets. The values of the hedge ratios for the GCC sectors are smaller than those for the US equity sectors (Hassan and Malik, 2007), reflecting the possibility of greater hedging effectiveness in GCC markets than in the USA. By following this hedging strategy, one dollar long in the Service index, for example, in the Saudi market should be shorted by 66 cents in the industrial sector in that market. The most expensive hedge in the Saudi market and the other GCC markets is by hedging the Service index with short positions in the Banking sector. However, the most (hedging) effective to hedge long positions is between the Insurance and Banking in UAE, where a one dollar long position is the former can be hedged by a 23 cent short position in the latter.

6. Conclusion

The results suggest that past own volatility is the stronger driver in determining future volatility. This implies that a sector's fundamentals have more influence on volatility than shocks or news. In countries like the oil-rich GCC countries, changes in the fundamentals for oil and natural gas, as well as for their products and energy-intensive goods, matter more when it comes to sector volatility. This is not surprising, given these countries' heavy dependence on oil and natural gas exports. It is important for the GCC countries to accumulate foreign assets in boom times and invest them prudently in the region to stave off the negative impacts of fluctuations in bust periods and the migration of foreign capital.

The GCC markets differ in terms of optimal portfolio holdings that minimize risk without lowering expected returns, thereby allowing investors to hold more stocks in certain sectors than others and effecting some diversification between sectors and countries. For example, investors in Saudi Arabia, Qatar and UAE should possess much more banking stocks than service, industrial or insurance stocks, while in Kuwait they should favor industrial over banking stocks. These results should be relevant for the GCC countries, which have recently embarked on establishing equity funds for both individual and institutional investors.

Since the values for ratios of hedging long positions with short positions in the GCC sectors are smaller than those for the US equity sectors, which reflect the possibility of greater hedging effectiveness in the GCC markets than in the USA, the GCC countries

should develop hedging techniques and strategies, such as futures, options and swaps, that reduce volatility. The high volatility of the GCC markets in 2008 makes such a conclusion imperative.

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Table 1. Descriptive Statistics for GCC Sector Returns

Sector	Service	Industrial	Banking
Saudi Arabia			
Mean	0.0007	0.0014	0.0007
S.D.	0.0265	0.0229	0.0163
Skewness	-0.8801	-0.6010	-0.5906
Kurtosis	5.2299	5.0387	7.9321
Kuwait			
Mean	0.0015	0.0010	0.0011
S.D.	0.0100	0.0093	0.0097
Skewness	-0.1055	-0.3479	0.4375
Kurtosis	2.4901	2.8554	3.2788
Qatar			
Mean	0.0009	0.0011	0.0014
S.D.	0.0143	0.0168	0.0155
Skewness	-0.3276	-0.0230	0.1107
Kurtosis	4.7814	3.0792	2.8739
Sector	**Service**	**Insurance**	**Banking**
UAE			
Mean	0.0009	0.0004	0.0009
S.D.	0.0143	0.0101	0.0093
Skewness	0.2640	0.1611	-0.1254
Kurtosis	6.9276	6.3911	5.9536

Notes:
(1) The numbers are log differences, or returns.
(2) UAE does not have an index for the Industrial sector.

Table 2. Estimates of VARMA-GARCH for Saudi Arabia

Variables	Service	Industrial	Banking
	Mean Equation		
C	0.0003	-0.0002	-0.0004
AR(1)	0.0503 [b]	0.0511 [b]	0.1530
D03	0.0009	0.0022 [a]	0.0014
	Variance Equation		
C	3.39E-06 [b]	8.97E-06 [a]	3.62E-06
$\varepsilon^2_{service}(t-1)$	0.2398 [a]	-0.1176 [a]	-0.0344
$\varepsilon^2_{industrial}(t-1)$	-0.1009 [a]	0.2069 [a]	0.0011
$\varepsilon^2_{banking}(t-1)$	-0.0770 [c]	0.0339	0.2152
$h_{service}(t-1)$	0.6862 [a]	0.2266 [a]	0.0965
$h_{industrial}(t-1)$	0.1956 [a]	0.6049 [a]	0.0723
$h_{banking}(t-1)$	0.0583	0.1148	0.6654
D03	1.47E-05 [a]	2.71E-05 [a]	1.56E-06
	Constant Conditional Correlations		
Service	1.00		
Industry	0.62 [a]	1.00	
Banking	0.53 [a]	0.51 [a]	1.00
Log Likelihood	13400.05		
AIC	-17.14		
#Obs.	1561		

Notes: $\varepsilon^2_j(t-1)$ represents the past unconditional shock of the jth sector in the short run, or news, j = Service, Industrial, Banking $h_{jj}(t-1)$ denotes the past conditional volatility dependency or interdependency. *D03* is the dummy for the 2003 Iraq War. The September 11, 2001 dummy variable, *D01*, gives similar results when it replaces *D03*.

Table 3. Estimates of VARMA-GARCH for Kuwait

Variables	Service	Industry	Banking
	Mean Equation		
C	0.0015 [a]	0.0005	0.0008 [c]
AR(1)	0.1569 [a]	0.0785 [a]	0.0071
D03	-7.94E-04	2.61E-04	-3.13E-05
	Variance Equation		
C	4.63E-06 [b]	3.93E-06 [c]	3.15E-06
$\varepsilon^2_{service}(t-1)$	0.1132 [a]	-0.0039	-0.1315 [a]
$\varepsilon^2_{industrial}(t-1)$	0.0214	0.1167 [a]	0.0182
$\varepsilon^2_{banking}(t-1)$	-0.0432 [b]	-0.0316	0.1977 [a]
$h_{service}(t-1)$	0.8683 [a]	0.0818	0.5835 [a]
$h_{industrial}(t-1)$	-0.3297 [b]	0.6515 [a]	0.2782
$h_{banking}(t-1)$	0.3913 [b]	0.2178	0.4001 [b]
D03	-4.50E-07	2.63E-06	4.33E-06
	Constant Conditional Correlations		
Service	1.00		
Industry	0.64 [a]	1.00	
Banking	0.45 [a]	0.48 [a]	1.00
Log Likelihood	16023.28		
AIC	-20.59		
#Obs.	1553		

Notes: $\varepsilon^2_j(t-1)$ represents the past unconditional shock of the jth sector in the short run, or news, j = Service, Industrial, Banking $h_{jj}(t-1)$ denotes the past conditional volatility dependency or interdependency. *D03* is the dummy for the 2003 Iraq War. The September 11, 2001 dummy variable, *D01*, gives similar results when it replaces *D03*.

Table 4. Estimates of VARMA-GARCH for Qatar

Variables	Service	Industry	Banking
	Mean Equation		
C	0.0009 [b]	0.0009 [b]	0.0006
AR(1)	0.2113 [a]	0.1860 [a]	0.2820 [a]
D03	-6.84E-04	-6.11E-04	-8.83E-05
	Variance Equation		
C	8.92E-06 [c]	-6.52E-06 [b]	3.36E-05 [a]
$\varepsilon^2_{sevice}(t-1)$	0.3170 [a]	0.0546 [a]	-0.0211
$\varepsilon^2_{industry}(t-1)$	-0.0649 [b]	0.1010 [a]	-0.1002 [b]
$\varepsilon^2_{banking}(t-1)$	0.0690 [c]	-0.1091 [a]	0.3536 [a]
$h_{service}(t-1)$	-0.0730	-0.1593	0.2306
$h_{industry}(t-1)$	0.9179 [a]	0.6068 [a]	0.8242 [a]
$h_{banking}(t-1)$	0.3697 [b]	0.9164 [a]	0.0056
D03	-8.70E-06	7.59E-06 [c]	-7.96E-06
	Constant Conditional Correlations		
Service	1.00		
Industry	0.52 [a]	1.00	
Banking	0.53 [a]	0.50 [a]	1.00
Log Likelihood	14381.93		
AIC	-18.43		
#Obs.	1557		

Notes: $\varepsilon^2_j(t-1)$ represents the past unconditional shock of the jth sector in the short run, or news, j = Service, Industrial, Banking $h_{jj}(t-1)$ denotes the past conditional volatility dependency or interdependency. *D03* is the dummy for the 2003 Iraq War. The September 11, 2001 dummy variable, *D01*, gives similar results when it replaces *D03*.

Table 5. Estimates of VARMA-GARCH for UAE

Variables	Service	Insurance	Banking
	Mean Equation		
C	0.0001	-0.0003	0.0005 [a]
AR(1)	0.1488 [a]	-0.0045	0.1527 [a]
D03	-4.32E-05	9.12E-04 [a]	-3.34E-05
	Variance Equation		
C	4.10E-07	1.16E-07 [b]	1.43E-06 [a]
$\varepsilon^2_{sevice}(t-1)$	0.2076 [a]	-0.0024	0.0303
$\varepsilon^2_{insurance}(t-1)$	0.0136	0.0387 [a]	0.0224
$\varepsilon^2_{banking}(t-1)$	0.1247 [a]	-0.0456 [a]	0.2581 [a]
$h_{service}(t-1)$	0.4490 [a]	0.1903 [a]	0.0133
$h_{insurance}(t-1)$	1.3025 [a]	0.8767 [a]	2.0340 [a]
$h_{banking}(t-1)$	0.5616 [a]	0.3400 [a]	0.3216 [a]
D03	4.80E-06 [a]	5.27E-07 [a]	-2.25E-06 [a]
	Constant Conditional Correlations		
Service	1.00		
Insurance	0.14 [a]	1.00	
Banking	0.41 [a]	0.18 [a]	1.00
Log Likelihood	17723.78		
AIC	-20.68		
#Obs.	1711		

Notes: $\varepsilon^2_j(t-1)$ represents the past unconditional shock of the jth sector in the short run, or news, j = Service, Industrial, Banking $h_{jj}(t-1)$ denotes the past conditional volatility dependency or interdependency. *D03* is the dummy for the 2003 Iraq War. The September 11, 2001 dummy variable, *D01*, gives similar results when it replaces *D03*. The table uses the data for the NBAD indices, which are superior to the NBAD Emirates indices.

Table 6. Optimal Portfolio Weights and Hedge Ratios

Saudi Arabia

Portfolio	Weight of First Sector in 1$ Portfolio (Kroner and Ng,1998))	Short/Long Beta (Kroner and Sultan, 1993)
Service/Industrial	0.48	0.66
Service/Banking	0.18	0.87
Industrial/Banking	0.14	0.96

Kuwait

Portfolio	Weight of First Sector in 1$ Portfolio (Kroner and Ng, 1998)	Short/Long Beta (Kroner and Sultan,1993)
Service/Industrial	0.41	0.72
Service/Banking	0.49	0.47
Industrial/Banking	0.56	0.46

Qatar

Portfolio	Weight of First Sector in 1$ Portfolio (Kroner and Ng, 1998)	Short/Long Beta (Kroner and Sultan, 1993)
Service/Industrial	0.70	0.43
Service/Banking	0.59	0.50
Industrial/Banking	0.38	0.58

UAE

Portfolio	Weight of First Sector in 1$ Portfolio (Kroner and NG, 1998)	Short/Long Beta (Kroner and Sultan, 1993)
Service/Insurance	0.41	0.18
Service/Banking	0.24	0.63
Insurance/Banking	0.39	0.23

Notes: $w_{12,t}$ is the portfolio weight of sector index 1 relative to sector index 2 in a two-asset holding at time t, while average β_t is the risk-minimizing hedge ratio for the two sector indices.