Crude Oil Price Uncertainty and Stock Markets in Gulf Corporation Countries: A Var-Garch Copula Model

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Abstract

The main objectives of this study are twofold. The first objective is to examine the volatility spillover between the GCC stock markets and Oil prices, over the period 2005-2012, in a multivariate setting, using the VAR (1)-GARCH (1,1) model which allows for transmission in returns and volatility. The second is to investigate the dependence structure and to test the degree of the dependence between financial returns using copula functions. Five candidates, the Gaussian, the Student?s t, the Frank, the Clayton and the Gumbel copulas, are compared. Our empirical results for the first objective suggest that there exist moderate cross market volatility transmission and shocks between the markets, indicating that the past innovation in stock market have great effect on future volatility in oil market and vice versa. 0

Index terms— subprime financial crisis, return spillover, volatility spillover; oil market, var-garch (1, 1)-copula model.

1 Introduction

oday, crude oil is the most important commodities and is regarded as one of the single most important driving forces of the global economy. Changes in the oil prices have significant effects on economic growth and welfare around the world; hence, crude oil prices have received considerable attention from both finance practitioners and market participants.

Several researches on crude oil price dynamics found that crude oil prices experienced very large fluctuations and could suffer increasingly drastic fluctuations in the future.

Shocks in oil price have continuously augmented in size and frequency. First, the greater instability in the oil prices initially appeared during the world oil crises of 1973 and 1979. Then, after 2003, oil prices began to increase very sharply, hitting a record high of 147 UD\$/barrel in July 2008. Affected by the Author: Al majmaa Universit.y. e-mail: s.jaghoubi@mu.edu.sa global financial crisis in late 2008, oil prices plummeted to 34 UD\$/barrel in February 2009, which have recently started to rise again. During June 2014, the world market price of crude oil declined from \$115 per barrel to its low point of approximately \$43pb in January 2015.

In this context, understanding the possibly shock transmission and the relationship between oil prices and stock market of the emerging countries is of crucial importance for policy making and risk management.

In recent decades, numerous researches have been devoted to the study of the relationship between oil prices and economic activity. Essentially, these studies have established that shocks in oil prices have significant effects on macroeconomic variables in most developed and emerging countries [Cunado and Perez Garcia de (2005), Balaz and Londarev (2006), Gronwald (2008), Cologni and Manera (2008), Kilian (2008) and Lardic et Mignon (2006]. However, relatively little attention has been given to the relationship between oil prices and stock markets. In particular, previous empirical investigations of the relationship between crude oil and stock returns are mainly devoted to developed markets, and sometimes to Pacific Basin countries and very few studies have focused on the stock markets in some emerging markets of the GCC countries. These studies have mainly examined the interaction between short-term impact of oil prices and stock returns.

Giving the increasing role of the GCC countries in the global oil market, studying the effects of oil prices on the stock markets of the GCC is interesting for several reasons. First, the GCC countries are major participants in the global oil market, their stock markets are may be impacted by changes in oil prices. Second, the GCC markets differ from markets often covered by previous empirical studies by the fact that they are relatively poorly integrated into the global financial market and are extremely sensitive to regional political events. Finally, GCC markets are very promising for international portfolio diversification. Thus, studying the influence of oil price shocks on the returns of financial assets in the GCC allows both investors and authorities to understand the evolution of stock markets in response to changing oil prices.

the GCC and the crude oil returns and to explore the dependence structure between each pair of market indexes (OIL/GCC). We combine two models which are the VAR-GARCH model and the Copula approach to have a joint VAR-GARCH-Copula model with possibly skewed, fat tailed return innovations and non-linear property. The Vector Autoregressive-Generalized Autoregressive Conditional Heteroskedasticity model (VAR-GARCH) was introduced by Ling and McAleer (2003) and later used by **??**rouri et al. (2011 **??**rouri et al. (, 2012)). One of the main advantages of this model is that is allows us to investigate the shocks transmission, the dynamics of conditional volatility and the volatility spillovers between series. It also provides meaningful estimates of the unknown parameters with less computational complication than several other multivariate specifications. The specific aspect of this model allows us to observe the impact of crude oil events or news in the GCC equity index returns and vice versa. Besides, to take into account the stylized facts observed on financial markets such as non-linear dependency, asymmetry and heavy tails, the multivariate dependence structure between markets is modeled by several copulas which are perfectly suitable for non-normal distributions and nonlinear dependencies.

The paper is organized as follow. Section 2 reviews the relationship between the crude oil and stock markets. Section 3 outlines the methodology used. Section 4 presents the data and discusses the empirical results. The final section concludes.

2   II.

3   Literature Review

The literature on the subject is quite rich in the developed countries. One of the first studies to investigate the exposure of stock returns to oil price movements was **??**hen et al. (1986), who find that oil price have no significant effect on US stock returns for the period 1958 to 1984. [Bredin D, Elder, J. (2011)].

Recent research by Aloui and Jammazi (2009) applied a univariate regime-switching EGARCH model to examine the relationship between crude oil shocks and UK, French and Japanese stock markets. They concluded that there exist some nonlinearity in the relationship between oil prices and the stock market financial returns. In the same line, Odusami (2009) shows that unexpected shocks in oil prices have nonlinear and asymmetric effects on stock returns. Miller and Ratti (2009) investigate the existence of different regimes in the long term relationship between oil and the stock market in OECD countries over the past four decades. Kilian and Park (2009) employ a structural VAR to decompose the oil price shocks into aggregate demand shocks and supply shocks. In their model, the response of the stock market to these two types of shocks is very different, with the aggregate demand shock leading to a reduction in stock returns, while the aggregate supply shock (representing better global economic conditions) leads to an increase in returns.

More recently, Jammazi and Aloui (2010) combine wavelet analysis and models change regime Markov-type (MS-VAR) and find that the reaction of the stock markets of these three countries to shocks in oil prices is rather asymmetric.

Chang et al. (2010) employ a symmetric DCC-GARCH model to investigate the conditional correlations and volatility spillovers between crude oil (WTI and Brent markets) and FTSE100, NYSE, Dow Jones and S&P500 stock indices.

Some recent studies have focused on the case of European, Asian and Latin American emerging stock markets. The results of these studies suggest a significant link between short-term changes in oil prices and returns in emerging equity markets.

Using a VAR model, Papapetrou (2001) established the existence of a significant relationship between changes in oil prices and stock markets in Greece.

Basher and Sadorsky (2006) use a multifactorial asset pricing model and find the same results for other emerging stock markets.

In contrast to the work done on developed markets, relatively little attention has been given to smaller emerging markets, particularly in the GCC countries, where the creation of stock markets is relatively recent. Recent work in this area includes Hamoudeh et Eleisa (2004), Zarour (2006) and Onour (2008).

Hamoudeh et Eleisa (2004) estimate a vector autoregression model to study the relationship between oil prices and stock prices for five members (Bahrain, Kuwait, Oman, Saudi Arabia, and the United Arab Emirates) of the Gulf Cooperation Council (GCC). They find that there is bidirectional causality between the Saudi stock market and oil prices. Their results suggest also that the other GCC markets are not directly affected by oil prices.

In the same line, Zarour (2006) uses a VAR model to study the relationship between Oil prices and GCC stock markets and suggests that only the Saudi and Omani markets have predictive power of the increase in oil prices.

104　More recently, onour (2008) use more recent data and shows that long-term oil prices significantly affect stock
105　prices in the GCC countries.
106　This paper concentrates on modeling the joint evolution of conditional returns, volatility and correlation
107　between crude oil and GCC countries.

4　Methodology

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109　It is often argued that the information flow across markets through returns (correlation in first moment) might
110　not be significant and visible; however they may have strong effect through volatility (correlation in second
111　moment). Volatility has been argued to be a better proxy of information by Clark (1973), Tauchen and Pitts
112　(1983) and **??**oss (1983). The ARCH model developed by Engle (1982), and later generalized by Bollerslev
113　(1986), is one of the most popular method used for modeling volatility of high-frequency financial time series
114　data (See Engle (2002) for a detailed recent survey). Multivariate GARCH (MGARCH) models such as BEEK
115　(full parameterization), CCC (constant conditional correlation) or DCC (dynamic conditional correlation) models
116　with dynamic covariances and conditional correlation have been found to be very useful in studying volatility
117　spillover effects than univariate models. These models are subject to a major delinquent that their estimation
118　becomes extremely difficult, especially when the number of variables considered is important owing to the rapid
119　proliferation of parameters to be estimated (see McALeer (2005) for more details). The other failure of these
120　models is that they do not allow for cross market volatility spillovers effect, while the latter are likely to occur with
121　the increasing integration between financial markets. The VAR(1)-GARCH **?? ??**rouri et al., (2011 **??**rouri et al.,
122　(, 2012)), includes the multivariate CCC-GARCH of Bollerslev (1990) as a special case where correlations between
123　system shocks are assumed to be constant to ease the estimation and inference procedure (see Engle (2002)
124　and McAleer et al. (2008) for more details about the CCC model). In this paper, we use a bivariate VAR(1)-
125　GARCH(1,1) copula model to explore the joint evolution of conditional returns, volatility and dependency among
126　GCC and the crude oil markets simultaneously.
127　The conditional mean equation of the VAR(1)-GARCH(1,1) system is giving by:? ?? ?? = ?? + ??? ???1 +
128　?? ?? ?? ?? = ? ?? 1/2 ?? ??

5　Where

129

130　-?? ?? = (?? ?? ?????? , ?? ?? ??????); ?? ?? ?????? and ?? ?? ?????? are the returns on the GCC and WTI
131　market indices at time t, respectively.
132　-?? ?? = (?? ?? ?????? , ?? ?? ??????); ?? ?? ?????? and ?? ?? ?????? are the residual of the mean
133　equations for the GCC and WTI markets returns, respectively.
134　-?? ?? = (?? ?? ?????? , ?? ?? ??????), refers to the innovation and is an i.i.d distributed random vectors.
135　? ?? 1/2 = diag (?? ?? ?????? , ?? ?? ??????); with ? ?? ?????? and ? ?? ?????? being the conditional
136　variances of ?? ?? ?????? and ?? ?? ?????? , respectively given by:? ?? ?????? = ?? ?????? + ?? ?????? (??
137　???1 ??????) 2 + ?? ?????? ? ???1 ?????? + ?? ???? (?? ???1 ??????) 2 +?? ?????? ? ???1 ?????? ? ??
138　?????? = ?? ?????? + ?? ?????? (?? ???1 ??????) 2 + ?? ?????? ? ???1 ?????? + ?? ?????? (?? ???1 ??????
139　) 2 + ?? ?????? ? ???1 ??????
140　Copulas are multivariate distribution functions with standard uniform marginal distributions. Amdimensional
141　copula is represented as follows:C (u) = C (?? 1 , ?, ?? ??)
142　Where ?? 1 , ? , ?? ?? are standard uniform marginal distributions.In such a context, copulas can be used to
143　link margins into a multivariate distribution function. The copula function extends the concept of multivariate
144　distribution for random variables which are defined over **??**0,1]. This is possible due to the Sklar (1959) theorem
145　which states that copulas may be constructed in conjunction with univariate distribution functions to build
146　multivariate distribution functions.
147　Sklar's Theorem: Let ?? ???? be a joint distribution function with margins ?? ?? and ?? ?? . Then there
148　exists a copula C such that for all x, y in R,C (?? ?? ,?? ??) = C (?? ?? (x), ?? ?? (y)) = F (?? ?? ?1 (?? ??
149　),?? ?? ?1 (?? ??)) C (?? ?? ,?? ??) = F (x, y)
150　If ?? ?? and ?? ?? are continuous, then C is unique; otherwise, C is uniquely determined on Ran ?? ?? ×Ran
151　?? ?? and C is invariant under strictly increasing transformations of the random variables.
152　Here we study five copulas with different dependence structure: the Gaussian copula, the Student-t copula,
153　the Frank copula, the Clayton and the Gumbel copula. From them, the Gaussian copula is the most popular in
154　finance and used as the benchmark.

6　? The Gaussian copula

155

156　The multivariate Gaussian copula applied to a joint distribution function with correlation matrix R, is defined
157　by:?? ?? (?? 1 , ? ? . ?? ??) = ? ?? ?? ?1 (?? 1), ? ? ? , ? ?1 (?? ??)?
158　Where ?? ?? is the distribution function of joint variables, these variables are normal, standardized and have
159　a correlation matrix R.
160　? The Student-t copula The Student-t copula is defined by:?? ?? (?? 1 , ? , ?? ??) = ?? ??,?? ,? ??? ?? ?1
161　(?? 1), ? , ?? ?? ?1 (?? ??)?

162   Where ?? ??,?? ,? is the multivariate student distribution function with a degree of freedom v and variance-
163   covariance matrix ?.

7   ? Archimedean copula

165 We present as follow the characteristics of the best known models. The variables u and v are cumulative
166 distribution functions. The parameter ?? measures the degree of dependence between risks.
167   ? The Clayton Copula:C (u, v,??) = (?? ??? + ?? ??? ? 1) ?1 ??
168   where ?? > 0? The Gumbel Copula: C (u, v,??) = exp [?[(?Ln (u)) ?? + ??Ln (v)) ?? ?] 1 ??
169   where ??? 1 ? The Frank Copula:C (u, v,??) = - 1 ?? Ln [1+ (exp (??? ??) ?1)(exp (??? ??) ?1) exp
170 (???)?1
171   ] where ??? 0
172   According to the VAR-GARCH-Copula model that we consider, return, volatility and dependence are jointly
173 modeled to explore the possibly spillover effects and the dependence structure between each pair of indexes
174 (oil/CCG). Thus, the past shock and volatility of one market are allowed to affect the future volatility not only
175 of itself but also of all other markets in the system.

8   IV.

9   Empirical Results and Discussion

10   a) Data And Descriptive Statistics

179 We use daily market data from sex equity indices for the GCC countries, for a sample period of January 1, 2005
180 to December 31, 2012. We choose this period to investigate the impact of the 2007 Subprime crisis on the six
181 emerging countries of the GCC. The countries used in our sample are Bahrain (BHRALSH), United Arab Emirates
182 (ABUGNRL), Kuwait (KWSEIDX), Oman (OMANMSN), Qatar (QTRMRKT) and Saudi Arabia (TDWTASI).
183 The total number of observations is 2013 for the full sample. We briefly overview summary statistics, then discuss
184 the correlation.
185   The descriptive statistics for daily returns shown in Table 1 suggest that the mean daily stock returns range
186 between -0.003107 and 0.028438 and the standard deviation between 0.275243 and 1.133865. Jarque-Bera tests
187 on log returns data indicate that the normality hypothesis cannot be accepted for these stocks, Furthermore, the
188 GCC stock market returns and oil prices show the properties of asymmetry, leptokurtosis, and tail dependence;
189 hence, the normality assumption has been severely challenged.
190   Panel B of Table 1 presents the obtained results of the ADF, PP, and KPSS stationary tests. Both ADF and
191 PP tests reject hypothesis of unit root for all the daily returns. For the KPSS, the null hypothesis of stationnarity
192 cannot be rejected at the 1% level. Therefore, the investigation of ARCH behavior in crude oil market, indicated
193 by Engl's LM test, shows evidence of the presence of ARCH effect.

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12   b) Return And Volatility Dependecy

197 Our objective is to examine both own conditional volatility and shocks and conditional crossmarket volatility
198 transmission and shocks between the GCC stock returns and the oil returns. We experiment on GARCH terms
199 up to p=1 and q=1. The optimal lag order for the VAR model is selected using the AIC and SIC information
200 criteria. The estimations of the bivariate VAR (1)-GARCH (1,1) for the two sub-period, are presented as follows
201 . We will discuss the empirical results of bivariate VAR(1)-GARCH (1,11) models in terms of own volatility and
202 shock dependence, cross market volatility and shock spillover for the GCC stock returns and the Oil index, both
203 for the pre-crisis and the post-crisis.
204   During the pre-crisis period and for the Bahrain, the sensitivity to past own conditional volatility and cross
205 market volatility transmission are significant at the level of 1%, showing that future volatility can be predicted
206 by both the past own conditional volatility in the long run and the cross market volatility spillover. We found
207 the same result for the rest of the GCC returns (United Arab Emirates, Oman, Qatar and Saudi Arabia) with
208 exception for Kuwait. In addition, only own shocks or news are significant for these returns, exception for the
209 United Arabe Emirates and the Saudi Arabia which the impact of the past shocks is significant indicating a short
210 run persistence.
211   Considering now the WTI return, only the past own volatility and the past own news are significant, exception
212 for the Oman and the Saudi Arabia, displaying that cross market volatility transmission and shocks cannot be
213 used to predict either the future volatility in the long run and the short run persistence.
214   After the occurrence of the Subprime crisis, the behavior of these markets changes considerably. Indeed, both
215 the own past volatility and shocks remain significant but their persistence diverge. Moreover, own volatility
216 and shock dependence and cross market volatility and shock spillover for the United Arab Emirates remain

significant at level of 1% however the effect of past volatility is bigger than the effect of past shocks. This implies that fundamentals matter more than news.

For the oil market, cross shocks (or spillover) are more widespread inter-markets after the crisis.

For the oil market, cross shocks (or spillover) are more widespread inter-markets after the crisis. Indeed, cross market volatility and shock transmission become significant after the crisis, for the Bahrain stock market return with the oil market. This implies that past own shocks and volatility and cross market volatility and shock dependence can be used to predicting future volatility and news.

We show the same results for the Emirates Arab Unis/oil market returns which indicates significant cross volatility. Besides, the WTI stock market becomes more sensitive to past volatility of the Emirates Arab Unis than past shocks related to changes in news or noise. However, the shock spillover of the Saudi Arabia becomes non-significant after the crisis. For the rest of the GCC-OIL market returns, the past own volatility and news remain significant.

13   c) Estimates Copula Parameters

We now present results from our copula estimation. We consider five bivariate copulas, the bivariate normal, biivariate Student-t, bivariate Gumbel, bivariate Clayton and the bivariate Frank. We will examine the relationship between each pair of stock-oil return separately, for the two sub period.

Table 8.A bellow, reports parameters estimates of bivariate copulas for each pair, before the occurrence of the financial subprime crisis. We note that the parameter?? ??and ?? measure the degree of dependence between returns and DoF is the degree of freedom in the Student-t copula. For all pairs, the dependence parameters; the correlation coefficient ? in both Gaussian and Student-t copulas, the degree of freedom DoF in the Student-t copula and the asymmetric dependence parameter ?? in the Clayton, Gumbel and Frank copulas are positive.

The Qatar / WTI pair returns has the highest correlation coefficient with ? $= 0.062$. The DoF of the Student-t copulas are 6, indicating the presence of extreme co-movements and tail dependence. The tail dependence parameter ?? for post crisis period, are from 1.01 to 0.189. The Bahrain / WTI pair has the highest tail dependence after the crisis, followed by the Kuwait pair. Moreover, the dependence structure between each stock index returns and exchange rate returns is largely changed from a symmetric structure with or not symmetric tail dependence to an asymmetric structure with non-zero and asymmetric upper and lower tail dependence.

From our results, we find The Gumbel copula which is limited to the description of a positive dependence structure. Thus, it allows only positive dependence structures or upper tail dependence, for which the parameter belongs to the interval ??1,+?).We find also the Frank copula. Consequently, the degree of the dependence varies when the financial Subprime crisis occurs. Indeed, as we see in tables above, it increased after the crisis, expect of ABUGNRL/WTI and TDWTASI/WTI pairs which remain symmetric, with zero tail dependence. The degree of the dependence becomes stronger and moves from a negative to a positive one.

Our findings may have important implications in the risk management. First, symmetric dependence structure with zero tail dependence can specify different levels of correlation between the marginal; however, it must possess radial symmetry which doesn't allow to extreme values correlation. Thus, in this case, the dependence has the linear correlation coefficient as measure of dependence. Second, asymmetric dependence structure can have upper tail dependence, lower tail dependence, or both; as such, they can better describe the reality of the behavior of financial markets. Additionally, it indicates the potential of simultaneous extreme events in both the stock and foreign exchange market. This property of dependence structure is important to international investors who invest in foreign stock markets.

V.

14   Conclusion

This paper examines the dynamics relationship between the GCC and the oil stock market returns after the occurrence of the financial subprime crisis, using daily data from January 2005 to December 2012. Based on the VAR(1)-GARCH(1,1) model, the results show that there exist moderate cross market volatility transmission and shocks between the markets, indicating that the past innovation in stock market have great effect on future volatility in oil market and vice versa.

Copula models are used to specify the dependence structure and to examine the degree of the dependence between these two financial markets when the Subprime crisis takes place. We employ five bivariate copulas; the bivariate normal, bivariate Student-t, bivariate Gumbel, bivariate Clayton and the bivariate Frank to directly model the underlying dependence structure. We find that, during the pre-crisis period, the major of stock-oil market returns have asymmetric dependence structure with asymmetric upper and lower tail dependence.. However, the degree of the dependence become stronger and moves from a negative to a positive one when the financial crisis occurs.

Figure 1: C

Figure 2:

1

ADF, PP, and KPSS are the acronym of Augmented Dickey-Fuller (1979) unit root test statistic, Phillips-Perron (1988) unit root test
statistic, and Kwiatkowski, Phillips, Schmidt, Shin (1992) stationarity test statistic, respectively.
denotes the rejection of the null hypothesis of normality, unit root, stationarity, and homoscedasticity at 10% level.

Figure 3: Table 1 :

2

Variables		BHRALSH		WTI	
Meanequation		Pre-crisis	Post-crisis	Pre-crisis	Post-crisis
C		0.0081[0.5088]	-0.016**[0.0260]	0.0697**[0.0243]	0.026[0.2296]
AR(1)		0.1924*[0.0000]	0.104*[0.0003]	-0.0857**[0.0415]	-0.087*[0.0048]
Variance equation					
C		0.0065[0.2066]	0.0016*[0.0000]	0.0952**[0.0192]	0.018***[0.0909]
?? ????????????? ??	(?? ? ??)	0.2590*[0.0000]	0.109*[0.0000]	-0.0748[0.3479]	0.14*[0.0030]

*[Note: ©20 15 Global Journals Inc. (US) Notes: ?? ?? 2 (?? ? 1) represents the past unconditional shocks of the ?? ??? market in the short run, or news.? ?? (t-1) denotes the past conditional volatility dependency. J= BHRALSH, WTI. *, **, ***indicate statistical significance level at the 1%, 5% and 10%.]*

Figure 4: Table 2 :

3

Variables		ABUGNRL		WTI	
Meanequation		Pre-crisis	Post-crisis	Pre-crisis	Post-crisis
c		0.0028[0.9354]	-0.014[0.1961]	0.0758**[0.0195]	0.024[0.2795]
AR(1)		0.1790*[0.0005]	0.241*[0.0000]	-0.089**[0.0318]	-0.088*[0.0038]
Variance equation					
c		0.2572*[0.0000]	-0.002*[0.0003]	0.0845**[0.0129]	0.020*[0.0030]
?? ????????????? ??	(?? ? ??)	0.2666*[0.0000]	0.296*[0.0000]	0.038[0.1429]	0.050**[0.0283]
?? ?????? ??	(?? ? ??)	0.0746*[0.0000]	0.002*[0.0005]	0.095*[0.0000]	0.093*[0.0000]
?? ????????????? (t-1)		0.3833*[0.0000]	0.76*[0.0000]	-0.0116[0.3322]	0.002[0.7012]
?? ?????? (t-1)		-0.055*[0.0000]	0.009*[0.0000]	0.8188*[0.0000]	0.888*[0.0000]

*[Note: ?? (t-1) denotes the past conditional volatility dependency. J= ABUGNRL, WTI. *, **, ***indicate statistical significance level at the 1%, 5% and 10%.]*

Figure 5: Table 3 :

14 CONCLUSION

4

Variables		KWSEIDX		WTI	
Meanequation		Pre-crisis	Post-crisis	Pre-crisis	Post-crisis
	c	0.0731*[0.0000]	0.026*[0.0000]	0.0699**[0.0251]	0.024[0.2725]
AR(1)		0.1842*[0.0000]	0.234*[0.0000]	-0.0830***[0.0527]	-0.09*[0.0030]
Variance equation					
	c	0.0044*[0.0227]	0.012*[0.0000]	0.1017*[0.0035]	0.022*[0.0022]
?? ????????????? ?? (?? ? ??)		0.2231*[0.0000]	0.49*[0.0000]	-0.1021[0.1065]	-0.058[0.1023]
?? ?????? ?? (?? ? ??)		0.0026*[0.2253]	-0.0005[0.6308]	0.1079*[0.0000]	0.095*[0.0000]
?? ????????????? (t-1)		0.7757*0.0000]	0.209*[0.0000]	0.0339[0.6264]	0.004[0.9114]
?? ?????? (t-1)		-0.0013[0.2778]	0.006*[0.0000]	0.7804*[0.0000]	0.886*[0.0000]

*[Note: Notes: ?? ?? 2 (?? ? 1) represents the past unconditional shocks of the ?? ??? market in the short run, or news.? ?? (t-1) denotes the past conditional volatility dependency. J= KWSEIDX, WTI. *, **, ***indicate statistical significance level at the 1%, 5% and 10%.]*

Figure 6: Table 4 :

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Global Journal of Management and Business Research	Variables Meanequation c AR(1) Variance equation c ?? ????????????? ?? (?? ? ??) ?? ?????? ?? (?? ? ??)	OMANMSN Pre-crisis Post-crisis 0.0284***[0.0767] 0.008[0.4123] 0.1480*[0.00	
	?? ??????????? (t-1)	0.9351*[0.0000]	0.801*[0.0000]
	?? ?????? (t-1)	-0.0032*[0.0039]	0.0014**[0.0102]

*[Note: Notes: ?? ?? 2 (?? ? 1) represents the past unconditional shocks of the ?? ??? market in the short run, or news.? ?? (t-1) denotes the past conditional volatility dependency. J= OMANMSN, WTI. *, **, ***indicate statistical significance level at the 1%, 5% and 10%.]*

Figure 7: Table 5 :

6

Variables		QTRMRKT		WTI	
Meanequation		Pre-crisis	Post-crisis	Pre-crisis	Post-crisis
	c	0.0198[0.4867]	0.016[0.2538]	0.073**[0.0190]	0.024[0.2905]
AR(1)		0.307*[0.0000]	0.149*[0.0000]	-0.085**[0.0465]	-0.087*[0.0049]
Variance equation					
	c	-0.004[0.7211]	0.004*[0.0001]	0.128*[0.0081]	0.024*[0.0030]
?? ????????????? ?? (?? ? ??)		0.4959*[0.0000]	0.154*[0.0000]	-0.057[0.1059]	0.009[0.6717]
?? ?????? ?? (?? ? ??)		-0.008[0.2697]	0.001[0.4534]	0.099*[0.0001]	0.104*[0.0000]
?? ????????????? (t-1)		0.527*[0.0000]	0.849*[0.0000]	-0.0009[0.6914]	0.015[0.1241]
?? ?????? (t-1)		0.045*[0.0021]	0.001[0.1531]	0.757*[0.0000]	0.867*[0.0000]
Notes: ?? ??					

*[Note: 2 (?? ? 1) represents the past unconditional shocks of the ?? ??? market in the short run, or news.? ?? (t-1) denotes the past conditional volatility dependency. J= QTRMRKT, WTI. *, **, ***indicate statistical significance level at the 1%, 5% and 10%.]*

Figure 8: Table 6 :

7

Variables		TDWTASI		WTI	
Meanequation		Pre-crisis	Post-crisis	Pre-crisis	Post-crisis
	c	0.091*[0.0012]	0.036**[0.0278]	0.074**[0.0188]	0.024[0.2842]
AR(1)		0.065[0.1397]	0.089**[0.0161]	-0.089**[0.0332]	-0.089*[0.0040]
Variance equation					
	c	-0.014[0.1046]	0.005*[0.0000]	0.087**[0.0108]	0.025*[0.0008]
?? ????????????? ?? (?? ? ??)		0.119*[0.0000]	0.104*[0.0000]	0.034**[0.0269]	0.028[0.1423]
?? ?????? ?? (?? ? ??)		0.016***[0.0564]	0.002[0.2999]	0.095*[0.0000]	0.102*[0.0000]
?? ????????????? (t-1)		0.870*[0.0000]	0.877*[0.0000]	-0.007[0.1933]	0.005[0.6246]
?? ?????? (t-1)		0.029*[0.0054]	0.003*[0.0022]	0.816*[0.0000]	0.879*[0.0000]

Notes: ?? ?? 2 (?? ? 1) represents the past unconditional shocks of the ?? ??? market in the short run, or conditional volatility dependency. J= TDWTASI, WTI. *, **, ***indicate statistical significance level at the

Figure 9: Table 7 :

8

ABUGNRL/WTI	Student	0.012	6	7.98	18.25	14.40
KWSEIDX/WTI	Frank		0.189	-12.95	-2.63	-6.53
OMANMSN/WTI	Student	0.052	6	10.88	21.15	17.30
QTRMRKT/WTI	Student	0.062	9	5.28	15.55	11.70
TDWTASI/WTI	Student	0.011	9	0.28	10.56	6.70

Figure 10: Table 8 .

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Volume XV Issue X Version I Year 2015 ( ) C   [1] [2]

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.1 Pairs

Copula The correlation coefficient ? in Student-t copulas are negative for these pairs: BHRALSH/WTI, ABUGNRL/WTI and KWSEIDX/WTI. The DoF of the Student-t copulas are 40, indicating the presence of strongly extreme co-movements and tail dependence. These market returns have elliptical symmetric dependence structure (the case of the Student-t copulas) with the oil return.

However, we observe asymmetric tail dependence for the rest of the GCC-Oil market returns. Indeed, the asymmetric dependence parameter ?? in the Clayton, Gumbel and Frank copulas are positive. The Oman-WTI pair has the highest tail dependence, followed by the Qatar-WTI pair and the Kuwait-WTI pair.

In order to appreciate both, the dependence structure and the degree of this dependence, after the Subprime crisis; we estimate the copula parameters in the post-crisis period.

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