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On the Time Varying Relationship between Oil Price and G7 Equity index: a Multivariate Approach

Khaled Guesmi*, Zied Fiti**, Ilyes Abid***, Gazi Salah Uddin****

Abstract

The aim of this paper is to investigate the interaction between G7 stock markets and oil prices during the period 1998-2013. We employ a multivariate approach based on c-DCC-FIAPARCH framework that incorporates the features of asymmetries, persistence, that are typically observed in stock markets and oil prices. We show that the origin of oil price shock is the main driver of the relationship between stock and oil markets. More specifically, our results show, in one hand, that G7 equity market has a high correlation with oil market in the presence of aggregate demand oil price shocks (Asian crisis, housing market boom, Chinese growth, subprime crisis). In other hand, our results highlight that G7 equity market did not react to precautionary demand shocks (09/11 US terrorist attacks, and second Iraq war in 2003).

JEL classification: C10; E44; G15.

Keywords: Oil Prices, Stock markets, Aggregate demand shocks, Precautionary demand.

1. Introduction

Previous studies were conducted within the last decade regarding asset classes, focusing on the commodity and financial market. Specifically, the recent financial crisis and synchronization in the financial market have drawn the concerns of the investors, academics and the finance practitioners. This study links with growing sectors of literature that depict the influence of oil price shocks on macroeconomic variables, specifically in advanced economics (Balaz and Londarev, 2006; Gronwald, 2008; and Cologni and Manera, 2009). From a theoretical perspective, the value of a share is reflected by the sum of future cash flows, which are discounted by a certain hurdle rate. The said discounted cash flows are vibrated by several economic factors, simultaneously, which can be influenced by the price of oil. Therefore, variation in stock prices can be explained—in a great extent—by the fluctuations in oil prices.

* Department of Finance, IPAG Lab, IPAG Business School, France
khaled.guesmi@ipag.fr

** EDC Paris Business School, OCRE Lab, Paris-France.
University of Tunis, High Institute of Management, GEF-2A Lab, Tunis-Tunisia.
Zied.ftiti@edcparis.edu

*** ISC Paris Business School, Department of Finance
22 Boulevard du Fort de Vaux, 75017 Paris, France
iabid@iscparis.com

**** Linköping University, Sweden and IPAG Business School, France
Gazi.salah.uddin@liu.se

Several previous studies have been conducted taking samples from two segments, namely, developing & developed countries and oil importing & exporting countries. Surprisingly enough, no conclusion could be drawn regarding the relationship of oil and stock. Within the context of European countries, Arouri and Nguyen (2010) examined the relationship between oil prices and 12 stock sectors *(*Automobile and Parts*,* Financials*,* Food and Beverages*,* Oil and Gas*,* HealthCare*,* Industrials*,* Basic Materials*,* Personal and Household Goods*,* Consumer Services, Technology, Telecommunications and Utilities), considering Stoxx600 in European countries. End of the day, they suggested that, depending on the activity sector, the reactions of stock returns to oil price changes differ in a great manner. Digging the four developed countries—Canada, UK, Japan and the USA-- Jones and Kaul (1996) suggested that the price of oil plays an important role in the formation of returns of financial assets in the USA and Canada; whereas, for other countries, the influence of oil for the same was less obvious. Restoring to Autoregressive Conditional Jump Intensity Model, Chiou and Lee (2009) pointed out that, high fluctuations in oil prices (WTI-daily) have asymmetric unexpected effects on stock returns in the United States. Additionally, studies conducted by Malik and Ewing (2009) confirmed that, there is a significant spill over transmission mechanism of shocks, volatility between oil prices (WTI-weekly) equity and equity sector return. Likewise, taking the figures from the USA oil companies and using a VAR model, Huang et al. (1996) established a significant relationship between oil prices and stock returns of some oil companies; yet, they could not institute any significant relationship between these investigated markets. On the flip side, Sadorsky (1999) implemented a VAR model augmented with GARCH impacts using recent numbers and found that the USA equity market reacts significantly to fluctuations in oil prices. Filis et al. (2011) used the DCC-GARCH model and concluded that the conditional variances of oil (Brent) and stock prices do not differ for oil-importing and oil-exporting economies; and, demand-side shocks are stronger than the supply-side shocks.

In a recent study, Kilian and Murphy (2014) developed a structural model of the global market for crude oil. They chalked out unexpected increases in international oil consumption, which is aligned with global business cycle. The speculative demand shifts played an important role during the earlier oil price shock episodes of 1979, 1986 and 1990. Going one step ahead, Sukcharoen et al. (2014) studied the relationship between the oil price and stock market index of various countries between 1982 and 2007, excluding the oil and gas stock companies from the stock indices to remove the obvious direct association. To model the general dependency between stock returns and oil price returns, copula method was used. The findings suggested a weak dependency between oil prices and stock indices for most cases; yet, interestingly enough, the introduction of Euro in 1999 altered the said relationship in a significant manner. Using the VAR-VECM, Cunado and De Gracia (2014) examined the impact of oil price shocks on stock returns, considering data of 12 oil importing European economies. Their study considered both world oil production and world oil prices to disentangle oil supply and oil demand shocks. We have pointed out that depending on the underlying causes of the oil price change, the response of the European real stock returns to an oil price shock may vary considerably. Caporale et al. (2014) studied the time-varying impact of oil price uncertainty on stock prices in China, considering weekly data on ten sectorial indices, over the period of January 1997–February 2014. Conclusion drawn from the estimation of a bivariate-GARCH-in-mean model highlights that oil price volatility has a positive effects on stock returns during periods characterized by demand-side shocks, in almost all sectors; the Consumer Services, Financials, Oil and Gas sectors happen to be the exceptional ones.

The sleek side of this study is that, it is going to contribute to the growing literature on the relationship between the oil and stock market returns by detecting the transmission mechanisms of an oil price shock to the stock market returns, taking into account the samples from G7 countries (the USA, Japan, Germany, France, United Kingdom, Italy and Canada). On a more specific note, we have emphasized on the Corrected Dynamic Conditional Correlation Fractionally Integrated (c-DCC-FIAPARCH)[1] model to comprehend the relationship between WTI oil prices and stock market returns, using monthly data from February 1998 to February 2013.

The FIAPARCH model permits us to analyse the long-run causal links between oil and stock markets, the transmission of return and volatility shocks across these markets; and the co-movement of oil and stock markets over time with respect to different economic phases (bullish and bearish). The obtained results should be of particular interest to policymakers as unfavourable oil price fluctuations may have severe impacts on stock market performance through reducing corporate cash flows. On the other hand, investors, and portfolio and fund managers can use our results to build appropriate diversification and hedging strategies. If, for example, crude oil and stock markets exhibit long-range volatility dependence, profitable investment strategies can be constructed based on price persistence patterns. Also, these markets may not be included in diversification strategies if they establish a long-run equilibrium in the future.

The comparative advantage of this GARCH model is that, it captures the asymmetric response of volatility to positive and negative shocks of the investigated market. Additionally, we have considered the application of the Diebold and Yilmaz (2012) spillover index that measures percentage of variations in a stock, accounted for by the variations in another oil price; using a time-varying spillover index of a 50-month moving window. The discussed approach is based on a vector autoregressive (VAR) model and the focus is to compute the forecast error variance decompositions. The main findings of this study suggests

[1]This model is constructed by extending the APARCH model of Ding et al. (1993) to a process that is fractionally integrated, as defined by Baillie et al. (1996).

that the dynamic correlations between oil and the stock market in the G7 countries changes over the investigated sample period due to the change in economic and financial events. The spillovers among Canada, France and Germany explain about 10-15% of variations in oil shocks; whereas, in the case of Italy Japan, UK, and the USA, the horizon is between 10-12% (the exceptional years are 2003 and 2009-2010). As economic implications, our results consider that oil is not usually counter-cyclical. More specifically, our result highlight that oil demand shocks generating high demand is a driver of high correlation between oil and stock markets. From a macroeconomic point of view, funds to limit public expenditures in oil booms and release financial resources during crisis periods could also be established. Finally, the outcome of our oil-stock relationships study will contribute to the policy and investment decisions of various economic agents, predominantly for the advanced economics like G7 countries.

The structured of this paper is as follows; section-2 describes the Corrected Dynamic Conditional Correlation Fractionally Integrated (c-DCC-FIAPARCH) model and spillover index for variations in a variable, accounted for by the variations in another variable. Section-3 portrays the data and reports the related empirical results, along with discussion. Lastly, section-4 offers concluding remarks augmented with policy implication.

2. Methodology

2.2 FIAPARCH Model

In this paper, we employ the DCC-GARCH model of Engle (2002) in order to estimate dynamic conditional correlations between our studied time series: stock markets and crude oil. The corrected dynamic conditional correlation fractionally integrated asymmetric power ARCH. The FIAPRCH process in an extend version of the APARCH model of Ding et al. (1993) incorporating to fractionally to specify the conditional variance process in which volatility reacts asymmetries to positive and negative shocks, long range volatility dependence is easily captured, and the appropriate power of returns can be determined to set up the best predictable structure of conditional volatility. The conditional variance-covariance matrix of DCC GARCH model is expressed as follows:

$$H_t = D_t R_t D_t \tag{1}$$

where
$$\begin{cases} D_t = diag\left(\sqrt{h_{1,t}},\dots,\sqrt{h_{k,t}}\right) \\ R_t = diag\left(q_{11,t}^{-1/2},\dots,q_{kk,t}^{-1/2}\right) Q_t \; diag\left(q_{11,t}^{-1/2},\dots,q_{kk,t}^{-1/2}\right) \\ Q_t = \left(1-\theta_1-\theta_2\right)\bar{Q} + \theta_1 \eta_{t-1}\eta'_{t-1} + \theta_2 Q_{t-1} \\ \eta_t^{*} = diag\left\{Q_t\right\}^{1/2} \eta_t \end{cases}$$

D_t : Diagonal matrix of time-varying standard deviations calculated from a GARCH model, having ($k \times k$) dimension. R_t: Symmetric matrix of dynamic conditional correlations, having ($k \times k$) dimension.

$Q_t = \left(q_{ijt}\right)$: Symmetric positive matrix that is supposed to vary through a GARCH process.

$\bar{Q}$: Unconditional variance matrix of standardized residuals $\eta_{i,t}$, with ($k \times k$) dimension.

θ_1 and θ_2 are scalar parameters which capture the shocks effects on dynamic correlations. These parameters are nonnegative and satisfy the condition that $\theta_1 + \theta_2 < 1$.

In this work, we adopt the univariate FIAPARCH approach, developed by Tse (1998) as an extension to the APARCH model proposed by Ding et al. (1993). This approach allows us to model the conditional volatility of each of the system variables and to compute their time-varying standard deviations. We select the FIAPARCH model for many reasons. Firstly, this model proposes a nonlinear representation of the volatility[2]. Secondly, this model proposes a nonlinear representation of the long memory[3] of conditional volatility. The following equation (Eq.2) shows that the FIAPARCH model is expressed as a power transformation of the conditional standard deviation:

$$h_{i,t}^{\kappa_i/2} = \chi_i + \left\{1-\left(1-\tau_i\left(L\right)\right)^{-1}\phi_i\left(L\right)\left(1-L\right)^{\varphi_{v_i}}\right\}\left(\left|\varepsilon_{i,t}\right| - \eta_i \varepsilon_{i,t}\right)^{\kappa_i} \qquad (2)$$

[2] The FIAPARCH model allows for asymmetric responses of volatility to positive and negative shocks

[3] The co-movement between oil and G7 stock markets is typically time varying and exhibits both asymmetric volatility effects and long-memory patterns. We apply the univariate FIAPARCH of Tse (1998) to model the conditional volatility of each of the system variables and then compute their time-varying standard deviations. The FIAPARCH process is the extension of the APARCH model of Ding et al. (1993) and allows for the asymmetric responses of volatility to positive and negative shocks as well as the long memory property of conditional volatility.

where,

$h_{i,t}$: Conditional variance; ω_i: Mean of the process, f_{v_i}: Fractional degree of integration of $h_{i,t}$; $t_i(L)$ and $j_i(L)$ represent the lag polynomials of orders P and K.

2.2 Examining the Oil-Stock spillover

In this study, we consider the oil-stock link through the application of the Diebold-Yilmaz (2012) spillover index. The spillover index is to measure percentage of variations in a variable (stock) accounted for by the variations in another variable (crude oil) applying a 50-month moving window. The fundamental procedure in this approach is based on a vector autoregressive (VAR) model, and its enables us to estimate the forecast error variance decompositions. This approach is sensitive to the ordering of the endogenous variables. A VAR (p) model depicting the oil-stock dynamics in G7 countries is given by

$$\Psi_t = \sum_{i=1}^{p} \Theta_i \Psi_{t-i} + \boldsymbol{\varepsilon}_t\,,\ \boldsymbol{\varepsilon}_t \sim \mathbf{N}(\mathbf{0}, \boldsymbol{\Sigma}) \tag{3}$$

where $\boldsymbol{\varepsilon}_t$ is the error vector and $\boldsymbol{\Sigma}$ is the associated variance-covariance matrix. Diebold and Yilmaz (2012) recommend measuring the total spillover by

$$S(H) = \frac{\sum_{\substack{j=1 \\ i \neq j}}^{N} \tilde{\theta}_{ij}(H)}{N} \cdot 100 \tag{4}$$

In our case, we are interested in the directional spillover received by variable *i* from all other variables. This is given by

$$S_{i,\circ}(H) = \frac{\sum_{\substack{j=1 \\ i \neq j}}^{N} \tilde{\theta}_{ij}(H)}{\sum_{j=1}^{N} \tilde{\theta}_{ij}(H)} \cdot 100$$

3. Data and Empirical Results

3.1 Data description

The aim of this paper is to study the relationship between G7 stock markets and oil price. The analysis period covers February 1998 to February 2013. Our sample is based on G7 countries because their financial markets are the well-established one in the world. The choice of the data range is explained through two criteria: i) the availability of the data and, ii) we choose this range because it includes major economic crisis and political events[4] corresponding to two type of oil shocks: aggregate demand-side oil price shocks and precautionary demand shocks. Therefore, this choice allows making important conclusion regarding the link between dynamic of oil prices and financial market returns.

For the stock markets, we use the following indexes: S&P 500 for the US market, FTSE 100 for UK, DAX 30 for Germany, CAC 40 for France, FTSE MIB for Italy, NIKKEI 225 for Japan, and S&P/TSX Composite for Canada. These entire indexes are expressed in US currency and then divided by US consumer price index (CPI) in order to get the inflation-adjusted real values for stock index.

As a proxy of the world oil price series, we use the West Texas Intermediate (WTI) crude oil. This series is divided by the US CPI to get the inflation-adjusted real oil prices. In our empirical framework, all series are expressed on the growth rates which are calculated as follows

$$x_t = \ln(X_t) - \ln(X_{t-1})$$

where,

X_t represents one of our series (stokc index or crudite oil price) at date t. x_t is the growth rate of the series X_t.

All data are collected from the DataStream database with monthly[5] frequency.

[4] These events correspond to the different monetary and financial crises such as Financial Asian crisis (started in july 1997) and Latin American crisis (1998) and Middle East crisis (The second golf war in 2003), the Russian economic crisis (1998) and the terrorist attack in US (2001) and subprime crisis in 2007-2008.

[5] The use of monthly frequency is a common feature among the studies focusing on the relationship between financial market and oil prices fluctuations, which is a relatively long-run phenomenon (see Creti et al. 2014). Besides, using monthly data thus allows us not only to have sufficient data points to make reliable statistical inferences, but also to compare our results with those of previous studies.

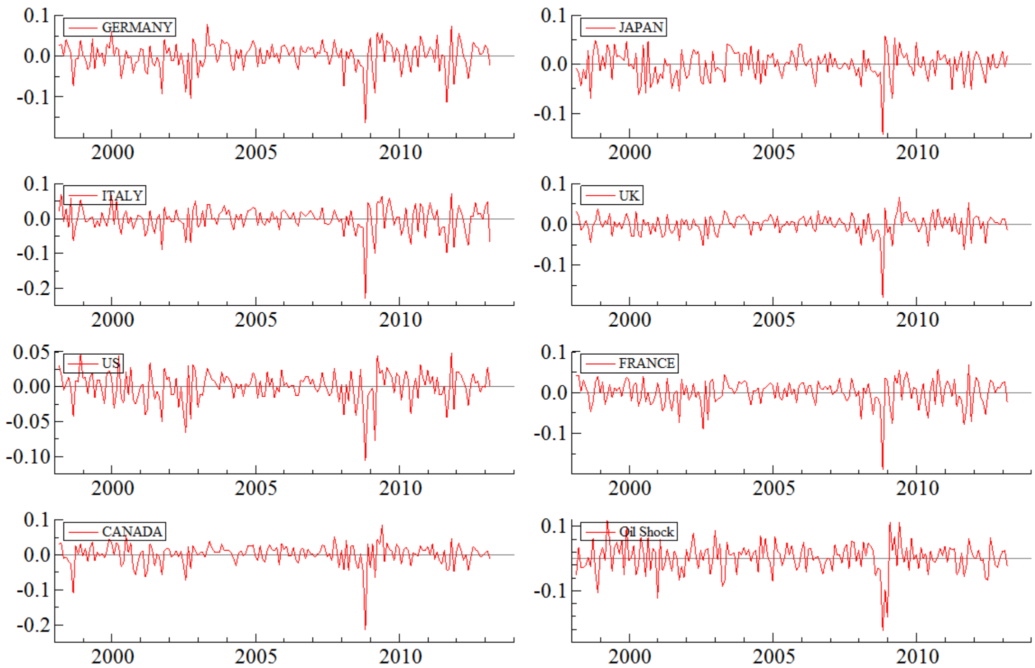
Table 1. Descriptive statistics of return series during the period 1998-2013

	Canada	France	Germany	Italy	Japan	U.K	U.S	Oil return.
Mean	0.002	0.000	0.001	-0.002	-0.001	-0.001	0.000	0.003
Std, Dev	0.031	0.032	0.034	0.0367	0.0287	0.025	0.022	0.047
Skewness	-2.193	-1.585	-1.194	-1.561	-0.842	-2.135	-1.074	-0.935
Kurtosis	14.932	9.316	6.157	10.108	5.387	15.916	6.072	6.467
Jarque-Bera	1219.10+	376.70+	118.17+	454.61+	64.36+	1395.69+	105.96+	117.07+

Notes: This table shows the basic statistics and the stochastic properties for stock and oil returns. + indicate that the null hypothesis of normality and no ARCH effect is rejected at the 1% level.

Table 1 presents the descriptive statistics for stock market return of G7 countries with the return of real oil price series. Among the equity market index, the Canada exhibits the highest average return. The return on the oil price differential is the most volatile compared to the equity market data. Moreover, the returns are negatively skewed for all return series. The kurtosis coefficient is greater than 3 for all the return series. Therefore, we conclude that all studied series; both oil and equity returns, are not normally distributed. This result is confirmed by the Jarque-Bera test (JB). Fig. 1 displays the stock market return of each countrie with the differential of oil price. According these figure, we observe that all series are stationary and they exihibit a high volatility.

Fig. 1. Stock returns and Oil price differential in G7 countries



3.2 Empirical results

Table 2 presents the results of FIAPARCH model. Table 1 shows that the power term of returns k is highly significant at the 1% level for all countries. This finding suggests that the volatility persistence is predictable. Table 1 highlights that the estimated asymmetry coefficient h is significant and positive. This finding implies that negative shocks have greater impact on volatility than positive shocks. We carried out a likelihood ratio test to examine the relevance of the restricted FIGARCH specification whereby $k_i = 2$ and $h_i = 0$.

Table 2. Estimation results for the FIAPARCH-c-DCC parameters

	USA	**Japan**	**Germany**	**France**	**UK**	**Italy**	**Canada**
c	0.032 (3.331)***	0.004 (3.971)***	0.001 (3.211)***	0.022 (2.315)***	0.022 (2.715)* **	0.001 (2.615)***	0.0444 (3.764)*
f_v	0.0011 (54.21)***	1.065 (41.41)***	0.075 (30.41)***	0.881 (15.02)***	0.894 (11.02)***	0.981 (12.02)***	0.824 (7.411)***
h	0.102 (1.78)**	0.107 (1.229)*	0.208 (1.229)*	0.170 (1.992)***	-0.013 (1.491)	0.160 (1.592)*	0.105 (3.797)***
k	0.536 (13.58)***	0.846 (15.58)***	0.741 (13.118)***	0.962 (17.08)***	0.805 (12.080)***	0.862 (10.08)***	0.790 (9.048)***
t	0.321 (4.064) ***	0.228 (1.064)	0.328 (1.564)*	0.895 (19.139)***	0.0283 (3.130)***	0.028 (0.239)	0.704 (5.230)***
j	0.034 (1.662) **	1.031 (1.332)*	0.231 (1.732)**	2.721 (1.701)**	2.828 (1.701)**	1.828 (1.501)*	5.959 (3.739)***
Skewness	-0.517	-0.577	-0.317	-0.617	-0.484	-0.517	-0.768
Kurtosis	5.806	3.806	3.706	4.508	3.434	3.806	5.378

*Note: ***, ** and * denote significance at 1%, 5% and 10% level respectively. The Student's t-statistics are in brackets.*

Fig. 2 displays the dynamic correlation between, computed from equations (1) and (2) between each stock market index and the Crude oil prices. The dynamic correlation exhibits several episodes. Indeed, during the period 1998-2001, we observe an increase in the correlation between oil price and stock market return of G7. This interdependence rise is explained by the growth of housing market which leads the OPEC to incite oil production. Therefore, we conclude that for the interdependence between stock market and oil price rise when we have aggregate demand side oil shock.

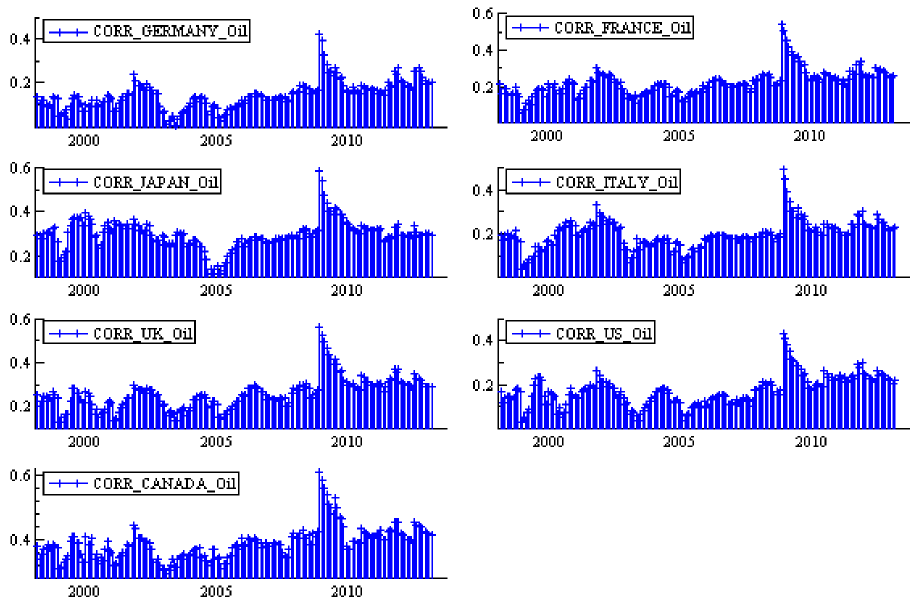
Since the end of 2001, we observe a decrease in the dynamic correlation. This pattern is explained by the shock in the oil market caused by the terrorist attack in US. This correlation remains low until 2006. So, our finding highlights that the interdependence between stock market and oil market is low in presence of oil precautionary demand. As our results indicate, the period of 2001-2006, the interdependence is low (less than 0.2). This period is characterized by many oil demand shocks such as; 09/11 US terrorist attacks, and second war in Iraq 2003.

Since 2006 the correlation between oil price and stock market rise significantly and we reach a pick in 2008. This result is explained by the oil shock demand resulting from the Chinese growth in 2006-2007 causing a high oil demand. This event has impact in the world trade caused euphoria in all stock markets regardless the country of origin. Our results confirm the finding of Filis et al. (2011) that suggesting that demand-side oil price shocks are originated by world economic growth.

Fig.2 show that correlation peaks (more than 50%) is observed for all countries during the period of 2008-2009. This period coincides with the subprime financial crisis. According a report in 2009 of the international Energy Agency, this financial turmoil is considered as an aggregate demand-side oil price shock. According the Filis et al (2011), the decrease of oil price during this period is caused its high level of correlation with stock market, as these later are in recession phase.

Our analysis distinguishes the following main results. First, we show that aggregate demand-side oil price shocks[6] generate a significant higher interdependence between stock and oil markets. Second, we highlight that important precautionary demand-side oil price shocks[7] have not a significant impact on the interaction between two markets. As consequence, we put out the importance of the nature of shock in the determination of the level of correlation between oil and stock markets.

Fig. 2. Dynamic conditional correlations between G7 equity markets and oil price, during the period 1998-2013.

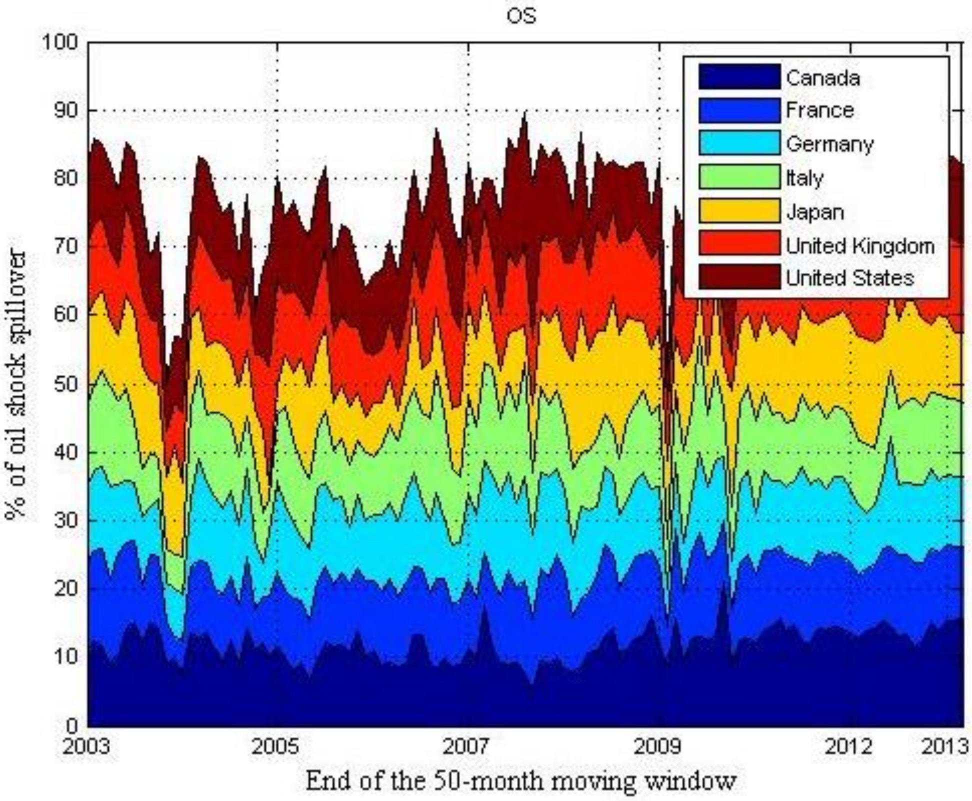


[6] Such as, housing market boom, Chinese economic growth, and the latest global financial crisis.

[7] Such as, i.e., second war in Iraq, terrorist attacks.

Fig.3 display the spillover effects computed from equations (3) and (4) between stock market index and the Crude oil prices. Fig. 3 shows that the oil-stock spillovers among the G7 countries are reported. The main interesting features of this approach is that the study period Canada, France and Germany explain about 10-15% of variation in oil shock, whereas Italy, Japan, United Kingdom and United States about 10-12% of variation in oil shock except in around 2003 and 2009-2010.

Figure 3. Spillover Effects



4. Conclusion

The paper analyses the interaction between oil and stock market in G7 countries, from February 2000 to February 2013. We use FIAPARCH-c-DCC model, developed by Tse (1998), in order to specify the dynamic correlation between oil price and stock return. This model allows the volatility to have asymmetric responses for positive or negative shock as well as the long memory property of conditional volatility.

The study provides homogeneity of the interdependence patterns between oil prices and stock markets for all G7 countries. Our results highlight two main findings. Firstly, we show the stock market reactions to the oil market depend on the origin of the oil price shocks. Indeed, our results show, in one hand, that G7 equity market has a high correlation with oil market in the presence of aggregate demand oil price shocks (Asian crisis, housing market boom, Chinese growth, subprime crisis). In other hand, our results highlight that G7 equity market did not react to precautionary demand shocks (09/11 US terrorist attacks, and second Iraq war in 2003).

Our results highlight some policy implications. Contradictory to previous literature, our results support that oil is not always counter-cyclical with respect to stock markets. Our findings prove that oil prices and stock markets has a high correlation, only in the case of demand oil shocks is originate from high demand. On the macroeconomic side, funds to limit public expenditures in oil booms and release financial resources during crisis periods could also be established.

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