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OIL PRICE AND FINANCIAL MARKETS IN THE MAIN OPEC COUNTRIES

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ABSTRACT

This paper assesses the impact of oil prices on stock markets of the four major OPEC countries, namely Emirate Arab United, Kuwait, Saudi, Arabia and Venezuela, over the period spanning from 03/09/2000 to03/12/2010. We aim at complementing the results from existing analyses, mainly focused on oil-importingcountries, by using a novel technique, namely the evolutionary co-spectral analysis as defined by Priestley andTong (1973). We find that co-movements between oil and stock markets can be either positive or negative.This interdependence is a medium-lived phenomenon, revealed on a three years and one quarter horizon, being weak in the short-run (ten months). Oil price shocks in periods of world turmoil or during fluctuations of the global business cycle (downturn or expansion, as for instance the 2008 financial crisis) have a significant impact on the relationship between oil and stock market prices in oil-exporting countries.

KEYWORDS
Oil Prices, Stock Markets, Evolutionary Co-spectral Analysis

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1. INTRODUCTION

In the last decades, much research has been devoted to the impact of oil price on macroeconomic variables in developed countries (Ferderer, 1996, Londarev and Balaz, 2006; Gronwald, 2008; Cologni and Manera, 2008 and Kilian, 2008). Among these studies, there is a growing literature on the relationship between oil price and stock markets. Although a theoretical model on the relationship between oil and financial markets does not exists, empirical research documents that oil price fluctuations affect corporate performance, output and earnings, and then stock returns.

While most of the existing studies focuses on the relationship between oil and financial markets in oil-importing countries, our paper tackles this issue in oil-exporting countries to investigate new aspects of the relationship between oil and financial markets. In fact, higher oil prices provide additional income and wealth to oil-producing countries. If this surplus income is transmitted back to the economy, then higher oil prices would be expected to lead to higher levels of economic activity as well as stock markets prices. Nevertheless, a decrease in the oil prices exhibits a negative relationship with economic growth of oil producers and can generate political and social instability (Yang and *al.*, 2002), putting downward pressure on financial returns. Therefore, as underlined by Bashar (2006) and Arouri and *al.* (2010), the relationship between stock markets and oil prices in oil-exporting countries can be ambiguous and is worthy of investigation.

Our sample consists of the major OPEC countries (Emirate Arab United, Kuwait, Saudi Arabia and Venezuela), with monthly data on oil and stock prices ranging from 03/09/2000 to 03/12/2010. We measure the interaction between oil price and stock markets indices according the evolutionary co-spectral analysis as defined by Priestley and Tong (1973). We choose this technique as it presents several advantages. First, this kind of analysis does not impose any restrictions or pre-treatment of the data (as volatility analysis, for instance, which requires the series to be stationary, or cointegration techniques which can be only applied to time series data integrated of order one). Second, it does not have an “end-point problem”: no future information is used, implied or required as in band-pass or trend projection methods. In addition, the evolutionary co-spectral analysis gives a robust frequency representation of non-stationary process. Finally, the most important advantage of frequency analysis consists of providing information about the time horizon of the interdependence between two series: the analysis delivers as result whether the variables under investigation present short, medium or long-term interdependence. This additional information allows understanding which cycles and periods are more synchronized than others.

Our study clearly shows changes in co-movements between oil prices and stock markets, thus partially contradicting the results of the studies that find a negative relationship between oil prices and stock market return. Overall, our analysis shows two main findings. Oil price shocks in periods of world turmoil or during fluctuations of the global business cycle (downturn or expansion) have a significant impact on the relationship between oil and stock market prices in oil-exporting countries. Oil prices and stock market prices co-movements experience higher and multiple peaks, which coincide with very important events (as oil price crisis which that has occurred in 2008). Interestingly, in the aftermath of the financial crisis, according to some recent research (Kilian and Murphy 2013, Hupmenn and Holtz, 2012), OPEC countries did not exert market power in the oil market, whose price can more easily follow financial stocks. In any scenario, the interdependency between oil and stock markets is not very strong in the short-run (ten months), but it is revealed more clearly in the medium run (three years and one quarter). We choose to study only medium-term and short-term as they are generally overlooked by the literature. Moreover, the time span of the model is relatively short, so the short and medium term seems more consistent, without being less attractive to investors.

This paper is organized as follows. Section 2 presents the literature review. Section 3 details our empirical methodology. Section 4 presents data and results, while Section 5 concludes.

2. RELATED LITERATURE

The relationship between oil price and real economic activity has been widely investigated. Hamilton (1983) concludes that positive oil price shocks are a substantial cause for economic recession in the US. After this work, the impact of oil prices dynamic has motivated many studies, among them the ones focusing on the links between oil and stock prices. Most papers, devoted to oil-importing countries, show a negative relationship between oil prices and stock markets activities.[1] In the following, we present the main empirical literature related to our paper.

The first strand and the widely one is interested to the linkage between stock market and oil crude price in the case of oil-importing countries. Using a multi-factor approach, Syed and Sadorsky (2006) study the impact of oil price changes on emerging stock market. They argued that oil price risk impacts stock price returns. Narayan and Narayan (2012) use the EGARCH method to model daily data of crude oil prices and conclude that shocks influence constantly and asymmetrically the volatility over the long-term period. Asymmetric effect indicates that positive shocks affect oil price differently than negative shocks. Chiou and Lee (2009) examine the asymmetric effects of WTI daily oil prices on Standard&Poor 500 stock returns. Using the Autoregressive Conditional Jump Intensity model with expected, unexpected and negative unexpected oil price fluctuations, they find that high fluctuations in oil prices have asymmetric unexpected effects on stock returns. Malik and Ewing (2009) rely on bivariate GARCH models to estimate the volatility transmission between weekly WTI oil prices and equity sector returns and find evidence of spillover mechanisms. Choi and Hammoudeh (2010) extend the time-varying correlations analysis by considering commodity prices of Brent oil, WTI oil, copper, gold and silver, and the S&P 500 index. They show that commodity correlations have increased since 2003, limiting hedging substitutability in portfolios. Finally, Arouri and Nguyen (2010) used a GARCH model to inspect the effect of oil prices on European sector returns rather than only on aggregate stock market index returns. They concluded that oil prices tend to exercise a significant influence on various European sectors; however, the magnitude and the direction of the effect differ from one sector to another.

The use of copula processes has also been used in this strand of the literature. Aloui et al. (2011) examines the extent of the current global crisis and the contagion effects it induces by conducting an empirical investigation of the extreme financial interdependences of some selected emerging markets with the US. They use copula process capturing the dynamic patterns of fat tail as well as linear and nonlinear interdependences. Using daily return data from Brazil, Russia, India, China (BRIC) and the US, their empirical results show strong evidence of time-varying dependence between each of the BRIC markets and the US markets, but the dependency is stronger for commodity-price dependent markets than for finished-product export-oriented markets. Using weekly data from January 2, 1990 to December 28, 2009,Wu et al. (2012) examine the economic value of comovement between WTI oil price and U.S. dollar index futures. They use Copula-GARCH models and they conclude that dependence structure between oil and exchange-rate returns becomes negative and decreases continuously after 2003.

The second strand of literature focuses on a comparison between the nature of correlation between crude price and stock market, for both oil-importing and oil-exporting countries. A few papers tackle this issue. Bjornland (2009) shows that a 10% increase in oil price result in 2.5% of stock market index increase in Norway, an oil-exporting country. Yoon and Ratti (2011) and Park and Ratti (2008) argue that the negative effect of oil price on stock markets only holds for oil-importing countries, but their analysis is limited to a few countries (Norway, Korea, Saudi Arabia and Russia). Filis et al. (2011) investigate time-varying correlations between Brent oil prices and stock markets on both oil-importing and oil-exporting countries. Using multivariate asymmetric DCC-GARCH approach, they find that the conditional variances of oil and stock prices do not differ for oil-importing and oil-exporting economies. However, time-varying correlations depend on the origin of the oil shocks: the response from aggregate demand-side shocks is much greater than supply-side shocks originated by OPEC's production cuts. Wang et al. (2012) use VAR analysis impulse response analysis to investigate the impact of oil demand and supply shocks in several oil-importing and oil-exporting countries. The author show that stock markets of oil-importing countries react to oil supply shocks, but the effect is short lived. Demand shock affect stock market of both group of countries.

[1] One of the first paper exhibiting this relationship is Sadorsky (1999), who shows that oil prices shocks have symmetric effects on the economy, positive shocks have a greater impact on stock markets and economic activity than do negative oil price shocks. Since this seminal paper, other studies have either confirmed this finding (as for instance Basher et al, 2010; Chen, 2009; Elder and Serletis, 2010; Jones and Kaul, 1996; Kilian and Park (2009); Masish et al., 2011; Wei, 2003) or pointed out that the impact of oil price on stock markets can be weakly significant (Aspergis and Miller, 2009; Miller and Ratti, 2009).

Concerning specifically oil-exporting countries, there are a few empirical models on the Gulf Cooperation Council (henceforth GCC) countries as they have gone through structural reforms and attracted foreign investors. However, results are sensitive to the countries selection and the time span of the analysis. Al-Janabi and al. (2010) use bootstrap test for causality to study non-normal financial data with time-varying volatility. They show that oil prices do not affect stock markets. Hammoudeh et al. (2004) come to the same conclusion. They examine the long-run interaction between five GCC stock markets (Bahrain, Kuwait, Oman, Saudi Arabia, and UAE) and three global factors (oil spot price indices, US 3-month Treasury bill rate, and S&P index). They apply cointegration tests and VEC model to weekly data from February 1994 to December 2004. Arouri and Rault (2011), using a boostrap panel cointegration model, provide evidence that the stock market performance of the Gulf markets is affected by positive oil price shocks. Similar results were also documented by Bashar (2006) and Hammoudeh and Aleisa (2004). Arouri et al. (2012) study six GCC with a wide range of cointegration techniques. They find that the relationship between oil and stock-prices is positive and evident in the short-term, but not in the long-term. When causality exists, it runs from oil prices to stock markets in most cases. The effects of oil price changes on stock returns in the GCC countries are asymmetric: negative oil price changes have larger impact on stock returns than positive oil price changes. Asymmetric effects are also found by Awartani and Maghyereh (2013), who investigate the dynamic spillover of return and volatility between oil and equities in the GCC countries during the period 2004 to 2012. The authors find that the oil market gives other markets more than it receives in terms of both returns and volatilities, especially in the aftermath of 2008 financial crisis.

Our paper takes a novel perspective in assessing the links between oil prices and stock markets in oil-exporting countries. We use a technique which has not yet been used so far in that context: the evolutionary co-spectral analysis, which is a time frequency approach. Contrary to time series models, our approach allows for a representation of non-stationary series without any risk of misspecification. Indeed, differently from traditional time series model-such as ARMA, Multivariate or Copula-GARCH, evolutionary spectral analysis does not depend on assumption on the data. The evolutionary spectral analysis does not show an "end-point problem": no future information is used, implied or required as in band-pass or trend projection methods. The most important contribution with respect to traditional time series analysis consists of the decomposition of series on two dimensions that is frequency and time occurrence of the dependence. This allows studying time series according to different horizons, for instance short and medium-term. Therefore, we aim at complementing the existing studies to uncover whether the results of the previous literature are robust to model specification, in particular in the dynamic dimension of the oil-stock market relationship for the most important OPEC countries.

3. EMPIRICAL METHODOLOGY

We measure the dynamic interaction between oil price series and stock market index according to a frequency approach based on the theory of evolutionary co-spectral analysis of Priestley and Tong (1973). Co-movements between series will be captured by the coherence function. We then propose a time-varying measure of this variable.

3.1 Theory of the evolutionary Co-spectral (Priestley and Tong : 1973)

According to Priestley (1965), a non-stationary discrete[2] process or a continuous[3] process can be written as equation (1). Priestley and Tong (1973) extend the theory of the evolutionary spectral analysis of Priestley (1965–1966), presented in detail by Ftiti (2010), to the case of a bivariate non-stationary process. In this sub-section, we summarize this theory. Consider, for example, a bivariate continuous parameter process $\{x(t), y(t)\}$ in which each component is an oscillatory process. Each component can be written as follows:

[2]A discrete process corresponds to a process of which the value of T is countable. Indeed, a time series is considered as a discrete process.

[3]A continuous process is a process used to describe the physical signal.

$$\boldsymbol{X(t) = \int_{-\pi}^{\pi} A_{t,x}(w_1)\ e^{iwt}\, dZ_X(w_1)} \tag{1}$$

$$\boldsymbol{Y(t) = \int_{-\pi}^{\pi} A_{t,Y}(w_2)\ e^{iwt}\, dZ_Y(w_2)} \tag{2}$$

Where

$$\boldsymbol{E[dZ_x(w_1)\, dZ_x^*(w_2)] = E\left[dZ_y(w_1)\, dZ_y^*(w_2)\right] = E\left[dZ_x(w_1)\, dZ_y^*(w_2)\right] = 0, for\ w_1 = w_2}$$

$$\boldsymbol{E\left[|dZ_x(w_1)|^2\right] = d\mu_{xx}(w_1);\ \left[\left|dZ_y(w_1)\right|^2\right] = d\mu_{yy}(w_1);}$$

$$\boldsymbol{\left[\left|dZ_x(w_1)\, dZ_y^*(w_1)\right|\right] = d\mu_{xy}(w_1);}$$

with $[.]^*$denoting the conjugate function of $[.]$.

Let $\boldsymbol{F_x, F_y}$ denote, respectively, the families of oscillatory functions, $\boldsymbol{\{\varphi_{t,x}(w_1) \equiv A_{t,x}(w_1)e^{iwt}\}}$ Priestley and Tong (1973) define the evolutionary power cross-spectrum at time $\boldsymbol{t}$ with respect to the families $\boldsymbol{F_x, F_y, dH_{t,xy}}$ by

$$\boldsymbol{dH_{t,XY}(w) = A_{t,X}(w)A_{t,Y}^*(w)d\mu_{XY}(w)} \tag{3}$$

Further, if $\boldsymbol{\{X(t), Y(t)\}}$ is a bivariate stationary process, such that $\boldsymbol{\{F_x, F_y\}}$ may be chosen to be the family of complex exponentials, namely $\boldsymbol{F_x \equiv\ F_y \equiv e^{iwt}, dH_{t,xy}(w)}$ reduces to the classical definition of the cross-spectrum. Thus, for each t, we write

$$\boldsymbol{dH_{t,XY}(w) = \left[A_{t,X}(w)dZ_X(w)A_{t,Y}^*(w)dZ_Y^*(w)\right]} \tag{4}$$

Priestley and Tong (1973) extend the above relation to the case of a non-stationary bivariate process where the amplitudes are time-dependent, and correspondingly, the cross-spectrum is also time-dependent. Clearly, $\boldsymbol{dH_{t,XY}(w)}$ is complex-valued, and, by virtue of the Cauchy–Schwarz equality, we immediately find that

$$\boldsymbol{\left|H_{t,XY}(w)\right|^2 \leq dH_{t,XX}(w)H_{t,YY}(w)}\text{for each } \boldsymbol{t} \text{ and } \boldsymbol{w}. \tag{5}$$

If the measure $\boldsymbol{\mu_{xy}(w)}$ is absolutely continuous with respect to the Lebesgue measure, we write for each $\boldsymbol{t}$:

$$\boldsymbol{H_{t,XY}(w) = h_{t,XY}(w)dw} \tag{6}$$

where $\boldsymbol{h_{t,XY}(w)dw}$ is then termed the evolutionary cross-spectral density function.

3.2 Estimation of the Evolutionary Co-spectral Density Function

The evolutionary cross-spectral density function estimation, which we develop here, is an extension of Priestley and Tong (1973) from the estimation of the evolutionary spectral density function in the univariate case, such as developed by Priestley (1965–1966). In our analysis, we are interested in time series as discrete process.[4] We analyse two pairs of series- oil price series and stock market index of a country. Therefore, we detail the procedure to estimate the evolutionary cross-spectral density function.

Let a non-stationary discrete bivariate process $\{x(t), y(t)\}$ have the Gramer representation for each $-\pi < w < \pi$:

Let a non-stationary discrete bivariate process

$X(t) = \int_{-\pi}^{\pi} A_{\mathrm{t,x}}(w)\ e^{iwt}\, dZ_X(w) \quad and \qquad Y(t) = \int_{-\pi}^{\pi} A_{\mathrm{t,Y}}(w)\ e^{iwt}\, dZ_Y(w)$

with

$$\boldsymbol{E[dZ_x(w_1)\, dZ_x^*(w_2)] = E\left[dZ_y(w_1)\, dZ_y^*(w_2)\right] = E\left[dZ_x(w_1)\, dZ_y^*(w_2)\right] = 0, for\ w_1 = w_2}$$

$$\boldsymbol{E\left[|dZ_x(w_1)|^2\right] = d\mu_{xx}(w_1);\ \left[\left|dZ_y(w_1)\right|^2\right] = d\mu_{yy}(w_1);}$$

$$\boldsymbol{\left[\left|dZ_x(w_1)\, dZ_y^*(w_1)\right|\right] = d\mu_{xy}(w_1);}$$

By virtue of the Cauchy–Schwarz inequality, we can write that:

$\left|dH_{t,XY}(w)\right|^2 \leq dH_{t,XX}(w)H_{t,YY}(w)$

And $H_{t,XY}(w) = h_{t,XY}(w)dw$ for each t and w

where $h_{t,XY}(w)dw$ may then be termed the evolutionary cross-spectral density function.

The estimation of the evolutionary cross-spectral density function needs two filters. For the discrete univariate process, Priestley (1966) gives two relevant windows. These are relevant filters and they are tested by several works, such as Ahamada and Boutahar (2002), Ftiti (2010), and Bouchouicha and Ftiti (2012). For the discrete bivariate process, Priestley and Tong (1973) adopt the same choice, that is:

$$g(u) = \begin{cases} \frac{1}{2\sqrt{h\,\pi}} & if\ \ |u| \leqslant h \\ 0 & if\ \ |u|\ > h \end{cases} \qquad W_v = \begin{cases} \frac{1}{T'} & if\ \ |v| \leqslant \frac{T'}{2} \\ 0 & if\ |v|\ > \frac{T'}{2} \end{cases} \tag{7}$$

Then, the estimation of the evolutionary cross-spectral density function is as follows:

$$\widehat{h}_{t,XY} = \sum_{v\in Z} W_T'(v)U_x(w, t-v)U_Y(w, t-v) \tag{8}$$

with

$$\boldsymbol{U_x(w,t) = \sum_{u\in Z} g(u)X(t-u)e^{iw(t-u)}du} \tag{9}$$

$$\boldsymbol{U_X^d(w,t) = \sum_{u\in Z} g(u)X^d(t-u)e^{iw(t-u)}du} \tag{10}$$

In this paper, we take $h = 7$ and $T' = 20$.

[4]For more details on continuous process, see Ftiti (2010).

We make the same choice[5] as Artis et al. (1992), Priestley (1995), Ftiti and Essaadi (2008), Ahamada and Boutahar (2002), Allégret and Essaadi (2011).

According to Priestley (1988), if we have $E\left(\widehat{h_t}(w)\right) \approx h_t(w)$, $var\left(\widehat{h_t}(w)\right)$ decreases when T' increases. $\forall(t_1, t_2)$, $\forall(w_1, w_2), cov\left[\hat{h}_{t_1}(w_1), \hat{h}_{t_2}(w_2)\right] = 0$, if at least one of the following conditions (i) or (ii) is satisfied.

(i): $|w \pm w'|$ are enough wide such as $|w_1 \pm w_2| \gg$ to the band width $|\Gamma|^2$.
(ii): $|S - t|$ is more broader than the function of $\{w(u)\}$

In order to respect conditions (i) and (ii), we choose $\{t_i\}$ and $\{w_j\}$ as follows:

$t_i = \{18 + 20i\}_{i=1}^{I}$ Where $I = \left[\frac{T}{20}\right]$ and T the sample size

$$\boldsymbol{w_j = \left\{\frac{\pi}{20}(1 + 3(j-1)\right\}_{j=1}^{7}}$$

To respect the *(ii)* condition, we inspect instability in these frequencies: $\frac{\pi}{20}, \frac{4\pi}{20}, \frac{7\pi}{20}, \frac{9\pi}{20}, \frac{10\pi}{20}, \frac{13\pi}{20}, \frac{16\pi}{20}, \frac{19\pi}{20}$.

We finally have a co-spectral density function in 7 frequencies. However, we retain only two frequencies reflecting respectively short-term and medium-term. Indeed, the first frequency $\frac{\pi}{20}$ traduces the medium-term interdependence and the frequency $\frac{4\pi}{20}$ traduces the short-term one. The shift from the frequency domain to the time domain takes place through the following formula: $\frac{2\pi}{\lambda}$, where λ is the frequency.

In our study, we have chosen to investigate the following frequencies: the frequency $\frac{\pi}{20}$ that corresponds to $\frac{2\pi}{\frac{\pi}{20}}$ months = 3 years and one quarter; and the frequency $\frac{10\pi}{20}$, referring to 10 months' time frame.

3.3 Coherence Function

According to Priestley and Tong (1973), the evolutionary cross-spectral density function may be written as:

$$\boldsymbol{h_{t,XY}(w) = C_{t,XY} - iQ_{t,XY}(w)} \tag{11}$$

$$\boldsymbol{C_{t,XY} = \mathcal{R}\left\{h_{XY}(w_j, t)\right\}}$$

$$\boldsymbol{Q_{t,XY} = Im\left\{h_{XY}(w_j, t)\right\}} \tag{12}$$

and the real-valued functions $C_{t,xy}(w)$ and $Q_{t,xy}(w)$ termed the evolutionary co-spectrum and the evolutionary quadrature spectrum, respectively. If the measures $\mu_{xx}(w)$ and $\mu_{yy}(w)$ are absolutely continuous, Priestley and Tong (1973) similarly define the evolutionary auto-spectral density functions, $h_{xx}(w_j, t)$ $h_{yy}(w_j, t)$.[6] The coherency function is defined by the following expression:

$$\boldsymbol{C_{t,XY} = \frac{|h_{t,XY}(w)|}{\{h_{t,XX}(w)h_{t,YY}(w)\}^{\frac{1}{2}}} = \frac{|E[dZ_Y(w)\,dZ_y^*]|}{\{E[dZ_X(w)\,]^2\ E|dZ_Y(w)\,|^2\}^{\frac{1}{2}}}} \tag{13}$$

[5]This choice of values is justified by the fact that they respect the conditions (i) and (ii).
[6]For more details see Ftiti (2010).

Priestley and Tong (1973) interpret $C_{t,xy}(w)$ as the modulus of the correlation coefficient between $dZ_x(w)$, $dZ_y(w)$or, more generally, as a measure of the linear relationship between corresponding components at frequency w in the processes $\{Y(t)\}$ and $\{X(t)\}$.

The estimation of the coherency function is based on the estimation of the cross-spectral density function between two processes $\{Y(t)\}$ and $\{X(t)\}$ and the estimation of the auto-spectral density function of each process. So, the estimation coherency can be written as follows:

$$\widehat{\boldsymbol{C}}_{t,XY}(\boldsymbol{w}) = \frac{|\widehat{\boldsymbol{h}}_{t,XY}|}{\{\widehat{\boldsymbol{h}}_{t,XX}\widehat{\boldsymbol{h}}_{t,YY}\}^{1/2}} \qquad (14)$$

4. DATA AND EMPIRICAL FINDINGS

In this Section, we describe our database and discuss the results of our analysis.

4.1 Data Description

We use monthly data for oil prices and stock market indices. The sample consists of the major OPEC countries (Emirate Arab United, Kuwait, Saudi Arabia and Venezuela). To select the sample, we have adopted two criteria: (i) the presence of a well-established stock market and (ii) a rank in the top 10 OPEC oil-exporters countries.[7] Stock markets of the OPEC countries under consideration have progressively developed. However, after 2008 crisis, stock market capitalization in these countries exhibits a slowdown (see Chart 1 in the Appendix). Venezuela stock market is the smallest one. For instance, this country has also a special role in the oil market: it is the largest oil producer in the in the Western Hemisphere, the United States' fourth largest supplier of imported crude oil and petroleum products behind Canada, Mexico, and Saudi Arabia. However, U.S. imports from declining in recent years, Venezuela has attempted to diversify its crude oil export, supplying now the Caribbean, Europe and China (EIA, 2012).

The Brent crude oil index is used as it accounts for the 65% of the world oil daily production (IMF, 2010; Platts 2010).[8] The data range from 03/09/2000 to 03/12/2010 and have been extracted from Federal Reserve Bank of Saint Louis and Datastream Database. The time horizon depends on data availability and includes, in addition to the major economic crisis and political events such as the different monetary and financial crises in Asian and Latin American and Middle East region, the first and the Gulf war, the Russian economic crisis and the terrorist attack in US. This will allows making important conclusion regarding the link between the dynamic of oil prices and the financial market returns.

4.2 Results

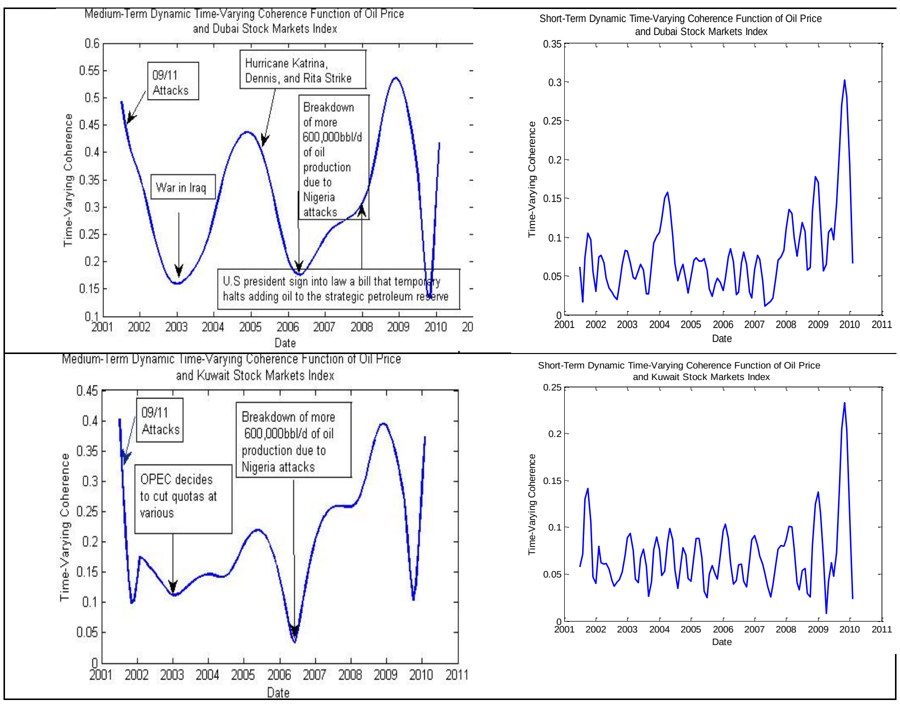
The analysis resulting from the time-varying coherence functions as computed from equation (14) between each stock market index and crude oil prices for oil-exporting countries is shown in Figure 3. The

[7] Table 1 in the Appendix reports the main macroeconomic and oil market indicators for the selected countries (average and standard deviation of OPEC annual data, over the period under investigation). The data clearly shows the importance of oil in the economy of these countries, as well as their significant role in the OPEC area.

[8] We believe that given our interest between national stock markets and international oil price, Brent is a representative reference price. A few papers study price differential between Brent and WTI (see among others Bacon and Tordo, 2004; Lanza et al; 2005; Fatthou, 2007, 2010; Pirrong 20120; Borenstein and Kellong 2012). Brent oil traditionally trades at a small discount with respect to West Texas Intermediate (WTI) or Dubai prices. An inversion of this tendency has been remarked after 2008 and according to Buyuksahin et al. (2013), this was mainly due to world business cycles, infrastructure bottlenecks affecting the transportation and storage of oil in the United States, and constraints affecting the extraction of non-U.S. sweet crudes. Brent and OPEC announcements of "fair prices" are shown to have a non-significant impact on the WTI (Brunetti et al., forthcoming). However, the existence and the origin of such differences are beyond the scope of the present study.

authors have developed the code on MATLAB Software to estimate the coherence function between stock markets and oil price for each country according to the methodology of Priestley (1965) presented in section 2.

According to the graphics below, we observe a divergence between the medium-term interdependence of and the short-term one. More precisely, for all markets under investigation, the interdependence between oil prices and stock market indices is less important in the short-term than in the medium-term. In the short-term, the average interdependence does not exceed 10%, while in the medium-term, on average, it reaches more than 40%.[9] Hence stock market indices react weakly to transitory fluctuations of oil price (short-term interdependence). Stock market indices for all countries, instead, react to persistent fluctuations of oil price (medium-term interdependence).



[9] No exact empirical standards have been set to consider that a coherence function is significant. The measure of dependence between two series in a frequency approach (coherence function) has results different from those in the time domain (correlation function). This is explained by the fact that the dependence measure is divided into many frequencies (short-run, medium-run and long-run). Ftiti (2010) shows that a coherence function higher than 20% is significant (figures 1 and 3 in Ftiti, 2010, pages 470-471). Moreover, Boutahar and Essaadi (2010) have showed for some frequencies that are higher than 20% are significant (Essaadi and Boutahar, 2010, table page 15). In the business cycle literature, some authors consider that coherence higher than 30% is significant (as Moneta and Rüffer, 2009; Girardin, 2004; and Leeet al., 2003). Studying the co-movement of exchange rate of Asian countries, Orlov (2009) obtains several co-spectral functions, which never exceed 30%.

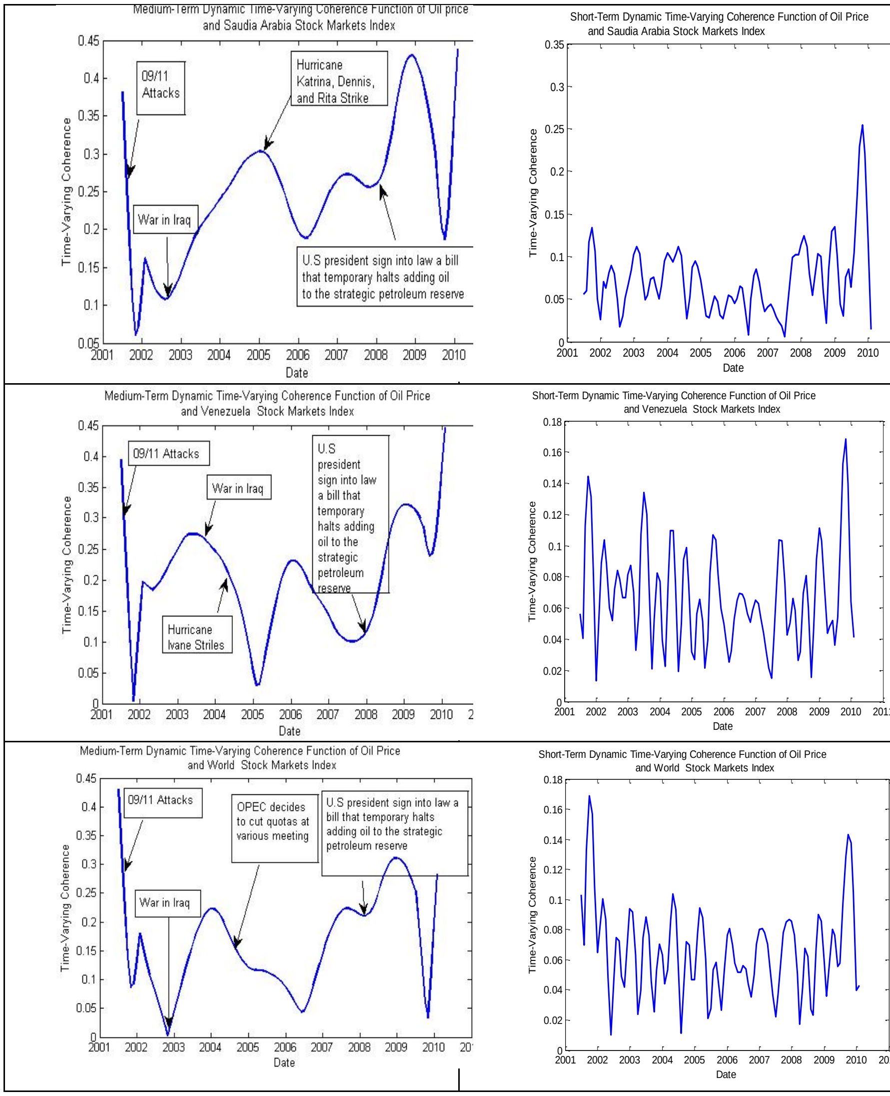


Figure 3: Dynamic coherence functions between stock market index and oil price in main OPEC ountries

Although the dynamic interaction between oil price and stock market indices is weak in the short-run, it rises slightly in crisis period. In fact, the short-run dynamic of stock market does not depend strongly on oil price in stable periods. However, in crisis periods, stocks markets are affected by oil price, even though this interdependency is not very strong in the short-run. One possible explanation for this result is that in the aftermath of the financial crisis, OPEC seems to behave as a competitive industry. Oil price then can move as other financial assets.[10] In particular, we observe a rise in the short-run coherence pattern around the

[10] The impact of OPEC countries on the oil price is a question widely discussed in the literature, yielding conflicting results. In fact, there is no consensus regarding the market structure of the crude oil market, which is analysed according to a wide range of hypothesis, from perfect competition, to a perfect cartel, or a leader-fringe models (see Brunetti et al. 2013; Hupmenn and Holtz, 2012 and the reference therein). Therefore, depending on the underlying market structure, OPEC decisions can impact or not oil price. Recent research (Kilian and Murphy 2013, Hupmenn and Holtz, 2012) empirically investigating oil price movements in the last 10 years, seem to conclude that in calm periods, and in particular from 2005 to 2007, OPEC did have an impact on oil prices before the 2008 turmoil, with Saudi Arabia acting as swing producer (or Stackelberg leader), other OPEC countries being either Cournot players or a competitive fringe (Kilian and Murhpy use as oil price US refineries acquisition costs while Hupmenn and Holts refer

occurrence of some exogenous shocks (see Tables 2 and 3 in the Appendix). For instance, Awartani et al. (2013) report similar findings in measuring spillovers from the oil market to the stock market.

The nature of dynamic interaction is different in medium-term. According to Figures 4 and 5, we observe a higher interdependence between oil price and stock market indices of all exporting countries. This finding is in contrast with Arouri et al. (2012), who, using cointegration analysis, find only short-run effects, but not long-term ones. Moreover, OPEC countries face higher and multiple peaks in the dynamic coherence patterns, which coincide with very important events (such as the 2008 oil price crisis). We conclude that stocks markets indices in exporting countries is highly interdependent to oil price, as their stock markets are dominated by oil companies, much larger than other listed companies.[11] This effect is novel with respect to the results obtained by Wang et al. (2012).

According Figure 3, we also observe a peak in the coherence pattern observed around the year 2001 for all countries (40%). This high level of coherence between oil and stock market prices is due to the rapid increase in the housing market and construction industry, a result of decreasing interest rates worldwide in 2000. In addition, the 2001 attack can explain the higher coherence level observed in this period.

In 2003 the coherence pattern is smoothed. This result can be explained by the war in Iraq in Mars 2003 and PdVSA Strike in Venezuela. We observe a breakdown, for all exporting countries, in coherence pattern in 2006. We explain this decrease in interdependence between oil price and stock market index by the military attack in Nigeria which caused the shutting down of more than 800 000 barrels per day.[12]

Another period of interest is the one running from 2006 until mid 2008, characterized by high oil prices due to rising demand, mainly by China. The coherence level shows an increasing and positive pattern for all countries. This aggregate demand-side oil price shock has a positive effect on stock markets, as it signals an increase in world trade. These findings are in line with Hamilton (2009b) and Kilian and Park (2009), who suggest that aggregate demand-side oil price shocks, originated by world economic growth, have a positive impact on stock prices.

From mid-2006 and early 2009, the coherence pattern rises sharply and reaches a higher value (higher than 40%) for oil-exporting stock markets. The main event in this period is the global financial crisis initiated from the export of US mortgages to the rest of the world, as asset backed securities, which can be regarded as an aggregate demand-side oil price shock (International Energy Agency 2009). The higher interaction between oil and stock market prices can be explained by the fact that such crisis caused stock markets to enter bearish territories and caused oil prices to decline heavily, as also documented by Creti et al. (2013).

There are only three periods of noteworthy higher or lower coherence between oil prices and stock markets for exporting countries. These are the early 2000 until 2001 (aggregate demand-side oil price shocks — higher coherence), 2003-2005 higher coherence (aggregate demand-side oil price shocks — higher coherence), and 2007–2008 (aggregate demand-side oil price shock — positive correlation).

The explanation of such findings can depend on the boom that the housing market experienced in 2000 creating a positive environment for world markets and at the same time a high demand for oil, driving the prices of both markets to higher levels. The 9/11 terrorist attack and the second war in Iraq also created significant uncertainty in all economies, causing similar movements in their stock markets and thus similar coherence with oil prices. In addition, the Chinese growth and its impact in the world trade caused euphoria in all stock markets regardless the country of origin. Similarly, the last world financial crisis influenced all stock market similarly and thus their co-movements.

Our analysis shows two main findings. Oil price shocks in periods of world turmoil or during fluctuations of the global business cycle (downturn or expansion) exhibit a significant impact on the relationship between oil and stock market prices in OPEC countries. Moreover, aggregate demand-side oil price shocks (housing market boom, Chinese economic growth, and the latest global financial crisis) cause a significant higher correlation between stock market prices and oil prices. Important precautionary demand-side oil price shocks

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to the WTI). After 2008, other forces were at stake: the oil market reverted to a perfect competitive situation, and business cycle fundamentals did drive oil price ups and downs.

[11] This phenomenon can be attenuated by the fact that oil-exporting countries depend on export revenues that decline smoothly, due to the low demand elasticity of oil demand (Bjornland, 2009; Park and Ratti, 2011).

[12] See Babatunde (2012).

(i.e. second war in Iraq, terrorist attacks) tend to cause higher coherence but with a less magnitude compared to aggregate demand-side oil price shocks.

5. CONCLUSION

OPEC countries offer an interesting example to test the properties of the relationship between oil price and financial markets. One could think that the economy of these countries is completely driven by oil exports volume and value, thus expecting positive co-movements between oil and stock market prices. Our analysis unveils the complexity of this interdependence. By using a novel econometric technique, the namely the evolutionary co-spectral analysis as defined by Priestley and Tong (1973), we find that co-movements between oil and stock markets in the four major oil-exporting countries (Emirate Arab United, Kuwait, Saudi Arabia and Venezuela) can be either positive or negative, thus revealing some potential for portfolio diversification. However, over the period under investigation, that is 2000-2010, this interdependence matters in the medium-term (three years and one quarter horizon) and is weak in the short-run (ten months). Oil shocks strengthen the links between oil price and financial markets. Additionally, the origin of the shock seems to be an important determinant of the correlation magnitude between oil prices and stock markets. In particular, oil shocks originating from major events of world turmoil, such as wars or changes in the phase of the global business cycle, strongly affects oil demand and in turn wealth and stock markets of oil-exporting countries. We leave for further research the study of these aspects in oil-importing countries.

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APPENDIX

Chart 1. Stock market capitalization of OPEC major producers

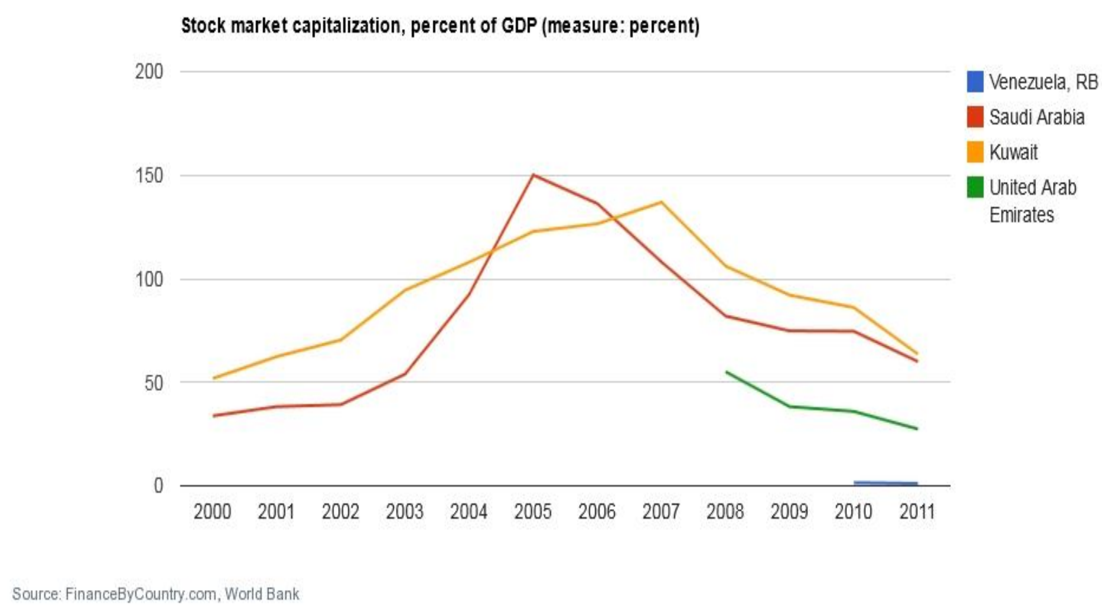

Table 1: Main macroeconomic and oil market indicators for the major OPEC countries – Average and standard deviation of annual data over the period 2000-2010

	Emirates Arabes United		Saudi Arabia		Kuwait		Venezuela	
	Mean	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**
Macroeconomic indicators								
GDP at current market price (m $)	164990	95093	306761	107833	81310	40049	185476	94033
Volume of Export (m $)	107141	66595	165373	83394	45784	28736	51195	22271
Volume of Petruleum Export (m $)	49901	26171	145603	73486	40078	23039	42410	23005
Volume of Import (m $)	102914	62417	64670	32228	15453	6259	5066	12218
Estimated of current account balance (m $)	14865	9554	53555	42801	27668	18553	15552	9818
Annual average of exchange rate (units of national currency/$)	3.673	00	3.74	0.0017	0.29	0.011	1.76	0.63
Oil indicators								
Proven crude oil reserves (m $)	97,8	00	263739	800	99909	2311	121409	73620
Crude oil production (1,000 b/d)	2135	667	8482	686	2286	313	2910	141
$\frac{Crude\ oil\ Production}{Total\ OPEC\ Crude\ oil\ Prdduction}$ (%)		2.15	28.76	0.67	7.72	0.53	9.9	0.44
Refining capacity (1,000 b/cd)	466	18.14	2029	133	915	32	1066	81
Output of refined products (1,000 b/d)	393	47.3	1832	144	849	107	1174	119
Consumption of refined products (1,000 b/d)	200	32	1195	196	217	48	553	80
Crude oil exports (1,000 b/d)	2071	257	6576	594	1431	218	1763	209
$\frac{Crude\ oil\ Export}{Total\ OPEC\ Crude\ oil\ Export}$ (%)	9.4	0.63	29.8	1.32	6.45	0.55	8.01	0.98

Note: m$=million dollars; b/d=barrel per day. Source: Authors' elaboration on OPEC data

Table 2: Oil Price Chronology from 2000 to 2010: The Main Events
Source: US Energy Information Administration

Mo	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
1			OPEC decides to cut quotas		OPEC decides to cut quotas at various meetings				Rising demand, low spare capacity		
2							Breakdown of more 600,000 bbl/d of oil production due to Nigeria attacks				
3	OPEC oil agree to increase the oil production		War in Iraq								
4											
5									U.S president sign into law a bill that temporary halts adding oil to the strategic petroleum reserve		
6											
7											
8						Hurricane Katrina, Dennis, and Rita Strike					
9		09/11 Attacks			Hurricane Ivane Striles			Hurricane Gustav strikes			
10				OPEC decides to cut quotas at various meetings							
11											
12			PdVA Strike in Venezuela						OPEC decides to cut quotas		

Table 3: Oil price shock origin and their main events

Events	Year	Oil price shock origin
Housing Market boom	2000	Aggregate demand side
09/11 Attacks	2011	Precautionary demand
PdVSA worker's strike	2012	Supply side
Second war in Iraq	2003	Precautionary demand
Chinese economic growth	2006-2007	Aggregate demand side
Global financial crisis	2008	Aggregate demand side
Golbal debt crisis	2010	Aggregate demand side

Sources: Kilian's (2009) and Hamilton (2009a,b) findings