

OIL PRICE IMPACT ON FINANCIAL MARKETS: CO-SPECTRAL
ANALYSIS FOR EXPORTING VERSUS IMPORTING COUNTRIES

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Oil price impact on financial markets: co-spectral analysis for exporting versus importing countries

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Abstract

The aim of this paper is to study the degree of interdependence between oil price and stock market index into two groups of countries: oil-importer countries (US, Italy, Germany, Netherland and France) and exporter ones (Emirate Arab Units, Kuwait Saudi Arabia and Venezuela). The dataset consists of monthly data from 03/09/2000 to 03/12/2010. We propose a new empirical methodology setting a time-varying dynamic correlation measure between the stock market index and the oil price series. We use the frequency approach proposed by Priestley and Tong (1973), and developed by Ftiti (2010) that is the evolutionary co-spectral analysis. This method allows us to distinguish between short-run and long-run dependence. We find that interdependence between oil price and stock markets is higher in the exporters countries than in the importers one.

Keywords: oil prices, stock markets, evolutionary co-spectral analysis

JEL Classifications: C14, C22, G12, G15, Q43

1. Introduction

Energy markets have been recently marked by considerable price movements. In particular, from 2001 to 2009, energy prices in international exchange platforms have been rising strongly, and record high prices for oil have been accompanied by important volatility and sudden decrease. This high volatility makes oil one of the major macro-economic factors potentially causing unstable economic conditions for stock markets around the world.

Oil price can impact stock markets trough several channels. First, the price of a share being equal to its discounted future cash flow, rising oil prices can increase the interest rate to limit inflationary pressure, tighten the cost of doing business, put pressure on output prices thus decreasing profits (Jones et al., 2004). High interest rates also make bond investments more attractive than stock ones (Chittedi, 2012). Financialization of oil markets and intensive oil trading can also be factored in (Creti et al., 2013). All these effects generally trigger a

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negative relationship between oil and stock markets, which parallels the one between high oil prices and macroeconomic indicators.

Given that the roots of the link between oil and stock markets are of different nature, it is interesting to explore whether the co-movements between oil and stock price emerge in a given time frame, either short or long-term.

Moreover, while there is a sizeable empirical literature on oil and stock markets, less is known about this relationship in the context of oil-importing versus oil-exporting countries. Most of the studies focus on oil-importing countries, mainly the U.S. However, specific effects on different set of countries are worth investigating. on one hand, an increase of oil prices negatively influences the economy of importing countries. When oil price rises, importing countries can experience strong negative consequences and economic recession (Ferderer, 1996). Instead, an increase in the oil prices influences positively oil-exporting countries' macro-economic balance. On the other hand, 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).

Our study tackles the issues of oil and stock market interdependence in five oil-importing countries (US, Italy, Germany, Netherland and France) and three oil-exporting countries (Emirate Arab Units, Kuwait Saudi Arabia and Venezuela), from 03/09/2000 to 03/12/2010. We measure the interaction between oil price and stock markets indices according to the evolutionary co-spectral analysis as defined by Priestley and Tong (1973). While existing studies applies either VAR or volatility analysis, 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 it is the case of volatility analysis, for instance, which requires the series to be stationary, or cointegration techniques 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 processes. 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 a 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 focus on the negative relationship between oil prices and stock market returns. 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) seem to have a significant impact on the relationship between oil and stock market prices, both in oil-importing or oil-exporting countries. In exporting countries, our analysis unveils higher and multiple peaks which coincide with very important events (as the oil price crisis occurred in 2008). In the case of importing countries, the pattern of interaction is clearly smoothed compared to exporting countries. All other oil price shocks originated by OPEC's productions cuts, hurricanes etc., do not seem to have a significant impact on the coherence between oil and stock markets in importing countries. In our study, the interdependency between oil and stock markets is not very strong in the short-run (i.e. 10 months), but it is revealed more clearly in the medium run (3 years and one quarter).

This paper is organized as follows. Section 2 summarize the relevant literature. Section 3 presents our methodology. Section 4 illustrates the main features of our dataset. The results of our analysis are then presented and discussed. Section 5 concludes.

2. Related Literature

The relationship between oil price and real economic activity has been widely investigated. Hamilton (1983) argues 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, find a negative relationship between oil prices and stock markets activities. One of the first paper exhibiting this relationship is Sadorsky (1999), who shows that oil prices shocks have asymmetric effects on the economy, positive shocks having a greater impact on stock markets and economic activity than negative ones. 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).

A vast body of the literature has then investigated specific aspects of the oil-stock price relationship.⁴ However, a few papers tackle consider different group of countries on the basis

⁴ Hammoudeh et al. (2004) examines the long-run interaction between five GCC stock markets (Bahrain,

of the weight of oil in their economy. 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 Park (2011) and Park and Ratti (2008) argue that the negative effect of oil price on stock markets only holds for a few oil-importing 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. Concerning specifically oil-exporting countries, Al Janabi and *al.* (2010) use bootstrap test for causality to study non-normal financial data with time-varying volatility. They conclude that oil prices do not tend to affect these stock markets and thus oil prices cannot be used as predictors for the Gulf Cooperation Council stock markets. More recently, Arouri and Rault (2011) study the impact of oil prices shocks on Gulf countries, with a bootstrap panel cointegration model, and 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).

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. The authors find that oil price movements do not have direct effects on any GCC stock markets, while the latter counts for less than 4% of the variations in oil prices after a 20 week period. Using a multi-factor approach, Syed and Sadorsky (2006) argue 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 of stock markets over the long-term period. 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) use a GARCH model to inspect the effect of oil prices on European sector returns rather than only on aggregate stock market index returns. They conclude 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.

Our paper takes a novel perspective in assessing the links between oil prices and stock markets. We use a technique which has not yet been used so far in that context, that is 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 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 to study 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 when importing and exporting countries are accounted for.

3. Empirical methodology: the evolutionary co-spectral analysis

As mentioned in the introduction, our objective is to measure the dynamic interaction between oil price series and stock market index for oil importer and exporter countries. The interaction between these series is measured according to a frequency approach based on the theory of evolutionary co-spectral analysis of Priestley and Tong (1973). We measure co-movements between series 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 discrete⁵ process or a continuous⁶ process can be written as equation (1). Priestley and Tong (1973) extend the theory of the evolutionary spectral analysis of Priestley (1965–1966), presented by Ftiti and Essaadi (2008), to the case of a bivariate non-stationary process. In this sub-section, we summarize

⁵A discrete process corresponds to a process of which the value of T is countable. Indeed, a time series is considered as a discrete process.

⁶A continuous process is a process used to describe the physical signal.

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:

$$X(t) = \int_{-\infty}^{+\infty} A_{t,x}(w_1) e^{iwt} dZ_x(w_1) \quad (1)$$

$$Y(t) = \int_{-\infty}^{+\infty} A_{t,y}(w_2) e^{iwt} dZ_y(w_2) \quad (2)$$

where

$$\begin{aligned} E[dZ_x(w_1) dZ_x^*(w_2)] &= E[dZ_y(w_1) dZ_y^*(w_2)] \\ &= E[dZ_x(w_1) dZ_y^*(w_2)] = 0 \quad \text{for } w_1 = w_2 \end{aligned}$$

$$E[|dZ_x(w_1)|^2] = d\mu_{xx}(w_1) \quad ,$$

$$E[|dZ_y(w_1)|^2] = d\mu_{yy}(w_1),$$

$$E[dZ_x(w_1) dZ_y^*(w_1)] = d\mu_{xy}(w)$$

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

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

$$dH_{t,XY}(w) = A_{t,x}(w) A_{t,y}^*(w) d\mu_{xy}(w) \quad (3)$$

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

$$dH_{t,XY}(w) = E[A_{t,x}(w) dZ_x(w) A_{t,y}^*(w) dZ_y^*(w)] \quad (4)$$

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

$$|dH_{t,XY}(w)|^2 \leq dH_{t,XX}(w) dH_{t,YY}(w), \quad \text{for each } t \text{ and } w \quad (5)$$

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

$$dH_{t,XY}(w) = h_{t,XY}(w)dw \quad (6)$$

and $h_{t,XY}(w)dw$ is 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.⁷ We analyse two pairs of series-oil price series and stock market index of a country which constitute a non-stationary discrete bivariate process $\{X(t), Y(t)\}$. They have the Gramer representation for each $-\pi < w < \pi$:

$$X_t = \int_{-\pi}^{\pi} A_{t,X}(w) e^{iwt} dZ_X(w) \quad \text{and} \quad Y_t = \int_{-\pi}^{\pi} A_{t,Y}(w) e^{iwt} dZ_Y(w)$$

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 and Essaadi (2008), Ftiti (2010), and Bouchouicha and Ftiti (2012). For the discrete bivariate process, Priestley and Tong (1973) adopt the same choice, that is:

$$g_u = \begin{cases} 1/(2\sqrt{h\pi}) & \text{si } |u| \geq h \\ 0 & \text{si } |u| > h \end{cases} \quad \text{et} \quad W_{T',v} = \begin{cases} 1/T' & \text{si } |v| \leq T'/2 \\ 0 & \text{si } |v| > T'/2 \end{cases} \quad (7)$$

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

$$\hat{h}_{t,XY}(w) = \sum_{v \in Z} W_{T',v} U_X(w, t-v) U_Y(w, t-v) \quad (8)$$

with

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

$$U_Y(t, w) = \sum_{u \in Z} g(u) Y(t-u) e^{-iw(t-u)} du \quad (10)$$

⁷For more details on continuous process, see Ftiti (2010).

In this paper, we take $h = 7$ and $T = 20$. We make the same choice⁸ as Artis et al. (1992), Priestley (1995), Ahamada and Boutahar (2002), Essaadi and Boutahar (2008) and Ftiti and Essaadi (2008).

According to Priestley (1988), if we have $E(\hat{h}(w)) \approx h_t(w)$, $\text{var}(\hat{h}(w))$ decreases when T increases. $\forall (t_1, t_2), \forall (w_1, w_2), \text{cov}(\hat{h}_{t_1}(w_1), \hat{h}_{t_2}(w_2)) = 0$, if at least one of the following conditions (i) or (ii) is satisfied.

$$(i): |w \pm w'| \text{ are wide enough such as } |w_1 \pm w_2| \gg \text{to the band width } |\Gamma(w)|^2$$

$$(ii): |S - t| \text{ is broader than the function of } \{w(u)\}$$

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

$$t_i = \{18 + 20i\}_{i=1}^I \quad \text{Where } I = \left\lfloor \frac{T}{20} \right\rfloor \text{ and } T \text{ the sample size}$$

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

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

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 $\pi/20$ traduces the medium-term interdependence and the frequency $4\pi/20$ traduces the short-term one. The shift from the frequency domain to the time domain takes place through the following formula: $2\pi/\lambda$, where λ is the frequency. For example, the frequency $\pi/20$ corresponds to $\frac{2\pi}{(\pi/20)}$ months = 3 years and one quarter, whereas

$\frac{2\pi}{(4\pi/20)}$ refers to 10 months time frame.

3.3 Coherence Function

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

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

⁸This choice of values is justified by the fact that they respect the conditions (i) and (ii).

$$\begin{aligned}
C_{t,XY}(w) &= R\{h_{XY}(w_j, t)\} \\
Q_{t,XY}(w) &= \text{Im}\{h_{XY}(w, t)\},
\end{aligned} \tag{12}$$

where the real-valued functions $C_{t,XY}(w)$ and $Q_{t,XY}(w)$ are 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, $h_{XX}(w_j, t)$, $h_{YY}(w_j, t)$.⁹ The coherency function is defined by the following expression:

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

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 of the coherency function can be written as follows:

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

4. Data, empirical findings and discussions

We use monthly data for oil prices and stock market indices. The sample consists of oil-importing (US, Italy, Germany, Netherland and France) and exporting countries (Emirate Arab Units, Kuwait Saudi Arabia and Venezuela). To select the countries belonging to the sample, we have adopted two criteria: (i) the presence of a well-established stock market and (ii) a rank in the top 20 oil-importers and exporters countries.

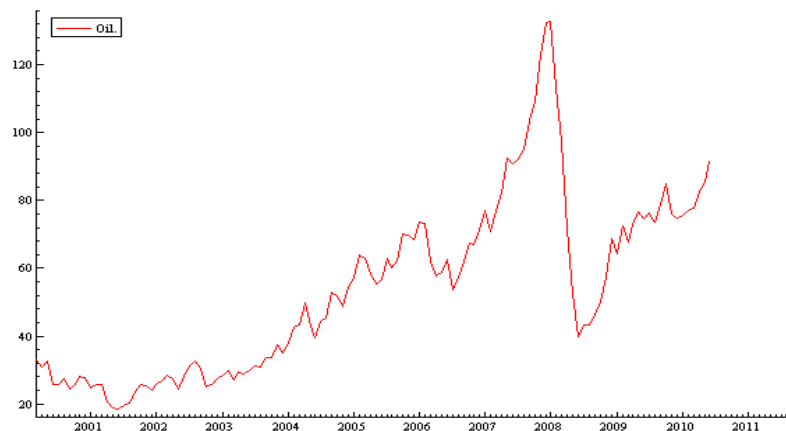
⁹For more details see Fiti (2010).

We use the Brent crude oil index which accounts for the 65% of the world oil daily production (IMF, 2010). 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.

4.1. Oil price and stock market movement

Figure 1 presents the Brent crude oil prices, in dollars, from September 2000 to October 2010 in levels.¹⁰

Fig 1. Brent crude oil price, in dollars, from 2000 to 2010



Oil price movements show some important peaks and troughs during the period we investigate. The main peaks are observed between 2007 and 2008. Another peak is observed in June 2009, where prices increased by more than 60% since the January 2009 price levels. All these changes are linked to aggregate demand-side oil price shocks. The first one occurred during the Asian economic crisis, the second took place in 2000, where interest rates decreased significantly creating a bust in the housing market and construction industries. The third one took place in the period 2006–2007, a result from the rising demand of oil from

¹⁰The series appears to have a non-stationary behavior in the sense that it does not converge towards its long term means while the series in first difference fluctuates around zero and seems to be stationary.

China and the fourth demand-side oil price shock took place in the global financial crisis of 2008.

Figures 2 and 3 describe stock market indices during the period under analysis respectively for oil-exporting and oil-importing countries.

Fig 2. Stock Market indices of Oil-Exporting Countries

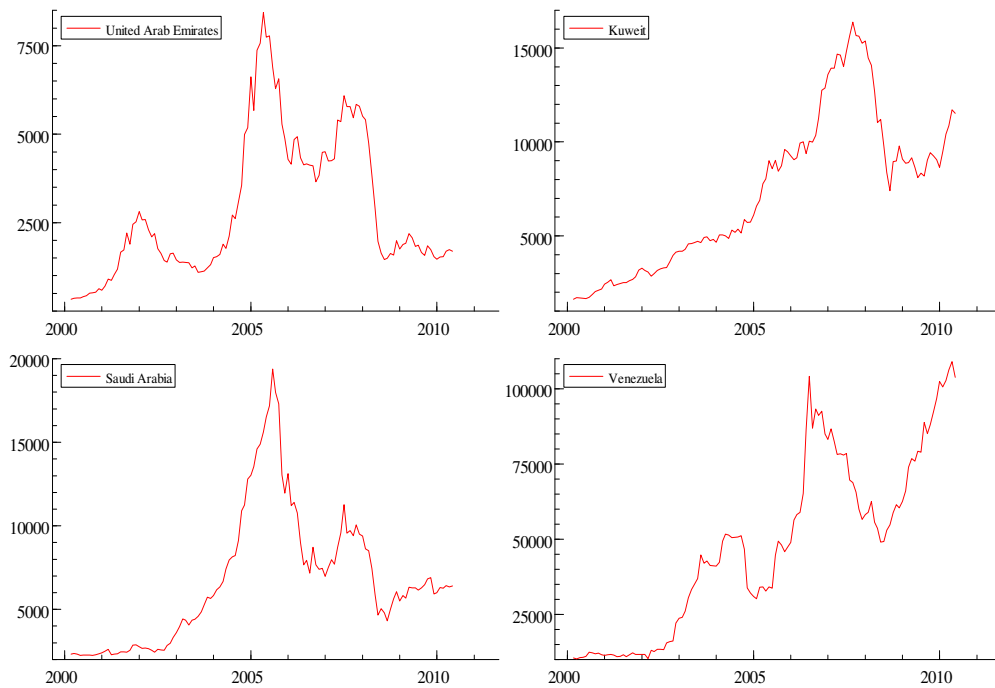
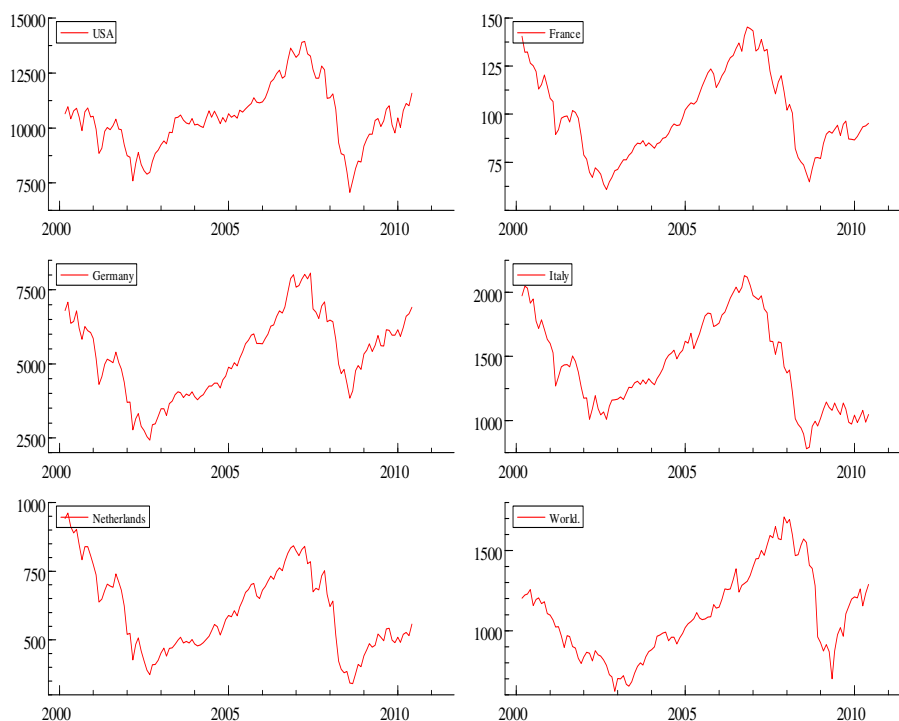


Fig 2. Stock Market indices of Oil-Exporting Countries



Taking into account the peaks and troughs of oil prices and the events that took place during the period we study, the relation between oil and stock market indexes exhibit some noteworthy aspects.

First, in exporting countries (Figure 2), we remark that stock markets have the same movement of oil prices fluctuation under the sub-period 2000-2005. In this timeframe oil price and stock market prices increase. However, for the sub-period 2005–2010, oil prices were increasing steadily. In particular, the period 2005 until mid-2007 is characterized mainly by a continuous oil price increase, as well as increased stock market prices. During mid-2006 until early 2007, when an oil price trough is observed, stock markets also exhibited a decrease in their price levels. Moreover, during 2007 until 2009, both oil prices and stock indexes are bullish. Finally, after the sub-period 2008-2009, both oil and stock market prices experienced a bearish performance. These patterns are similar for all countries, except for Venezuela that exhibits a slightly different pattern, given a weaker development of its financial markets.

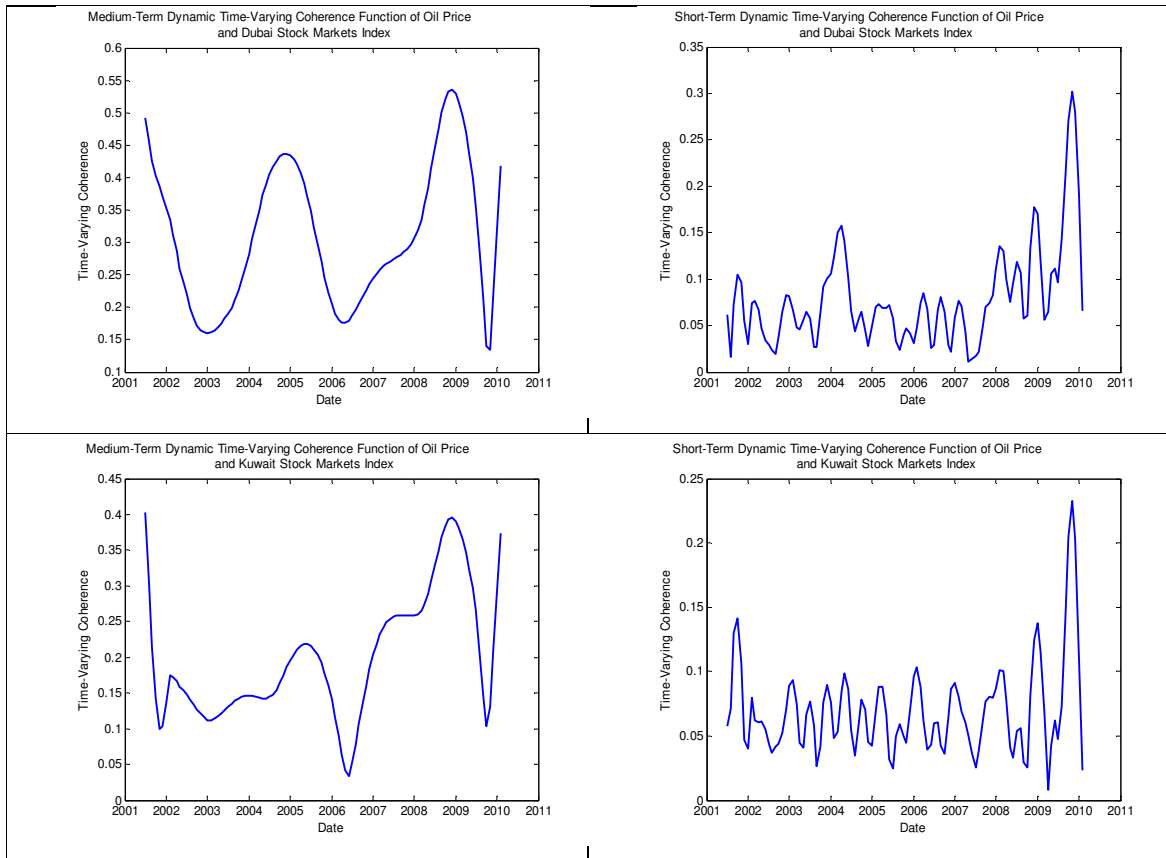
As preliminary result, we notice that the visual inspection of the series does not provide a clear distinction between stock market performance and oil prices on oil-importing and oil-exporting countries. However, we observe that stock indices of importing countries (Figure3) do not move in the same direction with oil prices. For example, during the sub-period 2000-

2003, oil prices exhibited an increase, whereas the majority of the stock markets showed a decrease. For the sub-period 2007-2008, stock prices decrease when the oil prices were rising.

4.2 The results of the dynamic coherence

The analysis resulting from the time-varying coherence functions as computed from equation (14) between each stock market index and the crude oil prices is shown in Figures 4 and 5, for oil-exporting and importing countries respectively, both for the short and the medium-term.

Figure 4: Dynamic coherence functions between stock market index and Oil price of exporting countries



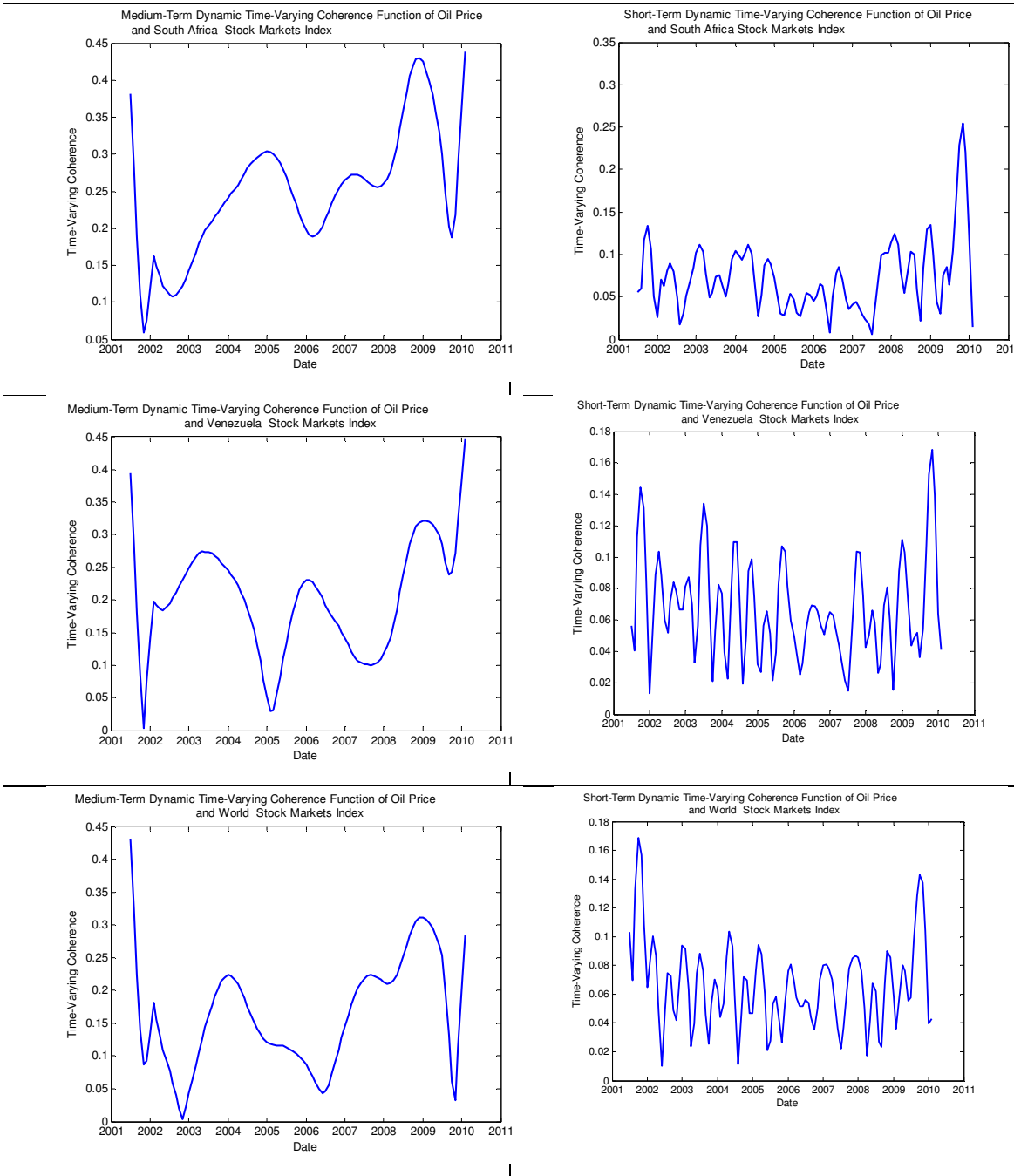
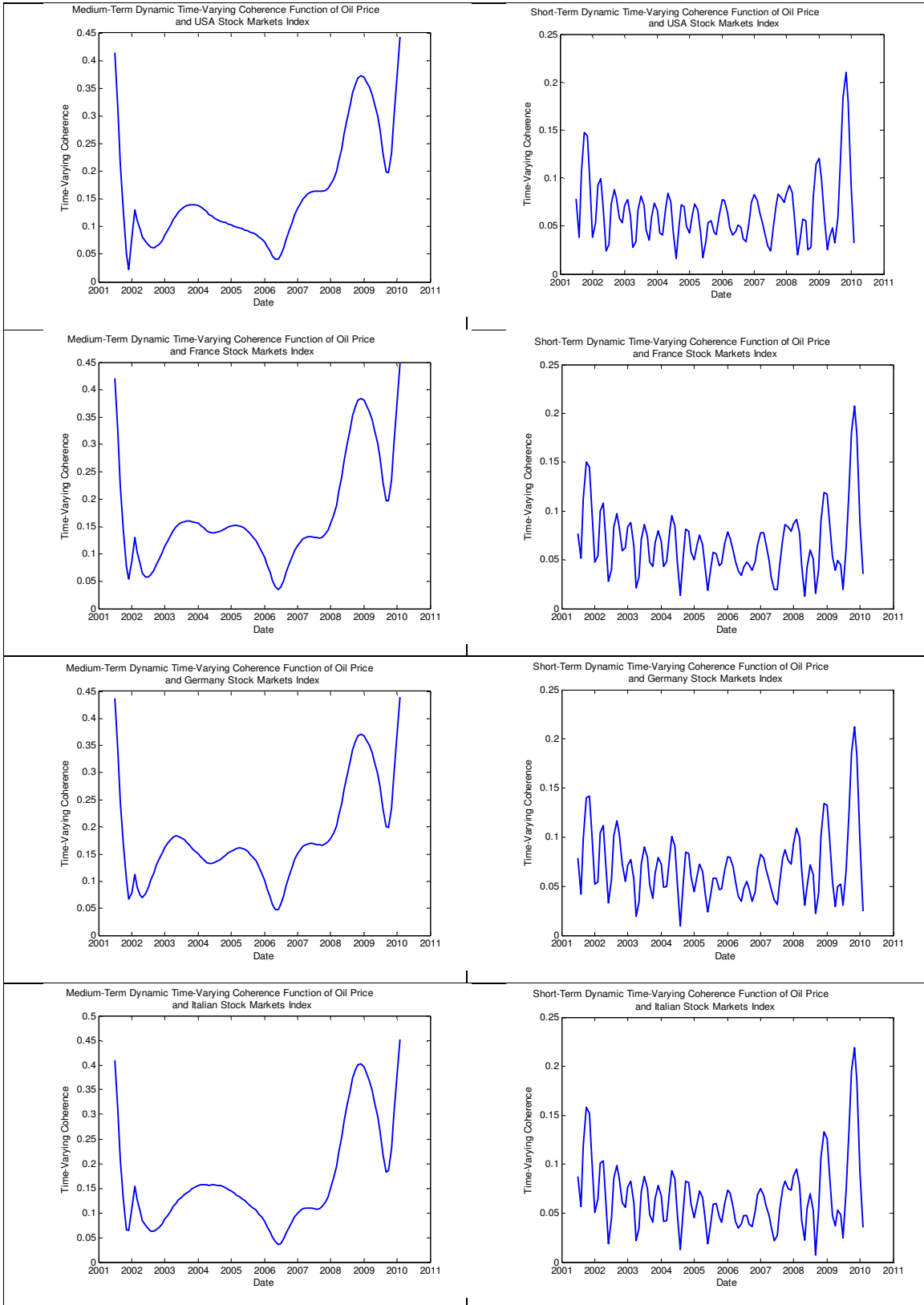
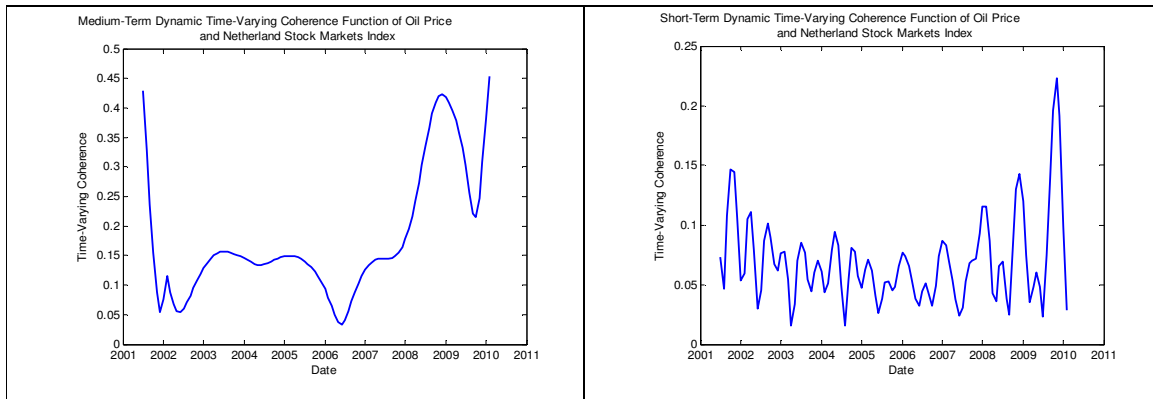


Figure 5: the dynamic coherence functions between stock market index and oil price of importing countries





According to the graphs in Figures 4 and 5, we observe a divergence between the medium-term interdependence of and the short-term one. More precisely, for all exporting and importing countries, 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%. Hence, for both importing and exporting countries, stock market indices react weakly to transitory fluctuations of oil price (short-term interdependence). Stock market indices for all countries, instead, react strongly to persistent fluctuations of oil price (medium-term interdependence).

In the short-run, there is no difference in the pattern of dynamic coherence function between exporting and importing price. The dynamic interaction between oil price and stock market indices is weak in the short-run, but it rises slightly in crisis period. In fact, the short-run dynamic of stock market, for both importing and exporting countries, 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. For example, we observe a rise in the short-run coherence pattern around the occurrence of some exogenous shocks (see Tables 1 and 2 in the Appendix).

The nature of dynamic interaction is different in medium-term. According to Figures 4 and 5, we observe a higher interdependence, in the medium-run between oil price and stock market indices of all countries. However, there is some difference in the pattern between exporting and importing countries. Exporting countries (Figure 4) exhibit different regimes in the time-varying dynamic coherence; there is instead a fewer periodicity (or fewer regimes) for the case of importing countries. In other words, exporting countries experience higher and multiple peaks which coincide with very important events (such as the 2008 oil price crisis).

Moreover, in the case of importing countries the pattern of interaction is clearly smoothed compared to exporting countries. We conclude that stocks markets indices in exporting countries are more interdependent with respect to oil price than importing countries. This result has its roots in the composition of stock markets in exporting countries, which 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).

Concerning exporting countries, we observe a peak in 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 there is a relatively less high of the coherence pattern in the case of exporting countries (Dubai, Kuwait and South Africa). This result is 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 at the date of 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 600 000 billion barrel per day.

Another period of interest is the one running from 2006 until mid 2008, characterized by high oil prices due to rising demand, mainly originated 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 (both in oil-importing and oil-exporting countries), 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 all stock markets, both in exporting and importing countries. 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

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).

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 years 2003-2005 represent the sole period showing little difference¹² between importing and exporting countries in term of coherence pattern of oil and stock market prices.

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) seem to have a significant impact on the relationship between oil and stock market prices, regardless the status of the market (i.e. belonging to an oil-importing or oil-exporting country). However, all other oil price shocks originated by OPEC's productions cuts, hurricanes etc., do not seem to have a significant impact on the coherence between oil and stock markets in importing countries.

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 (i.e. second war in Iraq, terrorist attacks) tends to cause higher coherence but with a less magnitude compared to aggregate demand-side oil price shocks. The origin of the shock seems to be an important determinant of the correlation magnitude between oil prices and

¹² The coherence level of importing countries is smoother compared to those of exporting countries during 2003-2005 periods.

stock markets, as long as the oil shocks originate from major events of world turmoil, such as wars or changes in the phase of the global business cycle.

Overall, the results of the previous literature are confirmed concerning the impact of oil shocks on stock markets of oil-importing and oil-exporting countries, whereas for the case of supply shocks our findings show some aspects that have been neglected so far. In particular, we stress the role of crisis periods in the oil prices as drivers of the co-movements between oil and stock markets. Moreover, distinguishing the pattern of interdependence in the short-term frame (10 months) with respect to the medium-term one (3 years and one quarter), we show that oil price shocks mainly have medium-lived effects on stock markets, a result that complements the existing ones.

5. Conclusion

The paper investigates the issues of oil and stock market interdependence in oil-exporting and importing countries by measuring the interaction between oil price and stock markets indices according the evolutionary co-spectral analysis as defined by Priestley and Tong (1973). For all studied markets studied, the interdependence between oil prices and stock market is shown to be a medium-term phenomenon. Moreover, while there is substantial homogeneity of the interdependence patterns within the two groups of countries under investigation, our analysis shows that high oil prices deriving from demand shocks move together with stock prices, especially in exporting countries. Supply shocks cause higher coherence only in exporting countries. Therefore, in terms of diversification potential, oil is not always countercyclical with respect to stock markets, as generally predicted by the previous literature. Oil can have this role in importing countries, when high oil prices originate from supply shocks. At the opposite, if the shock originates from demand, oil prices and stock market tend to move together, with a strength that varies depending on the origin of the shock, in both importing and exporting countries. In such scenario, oil does not have a save heaven role to counteract changing returns of a portfolio of stocks in none of the countries studied.

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Appendix

Table 1: Oil price chronology from 2000 to 2010: the main events

| Months | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2008 | 2009 | 2010 |
|--------|---|---------------|----------------------------|-------------|---|------|---|---|------|------|
| 01 | | | OPEC decides to cut quotas | | OPEC decides to cut quotas at various meeting | | | Rising demand, low spare capacity | | |
| 02 | | | | | | | Breakdown of more 600,000bbl/d of oil production due to Nigeria attacks | | | |
| 03 | OPEC oil agree to increase the oil production | | | War in Irak | | | | | | |
| 04 | | | | | | | | | | |
| 05 | | | | | | | | U.S president sign into law a bill that temporary halts adding oil to the strategic petroleum reserve | | |
| 06 | | | | | | | | | | |
| 07 | | | | | | | | | | |
| 08 | | | | | | | Hurricane Katrina, Dennis, and Rita Strike | | | |
| 09 | | 09/11 Attacks | | | Hurricane Ivane Striles | | | Hurricane Gustav strikes | | |
| 10 | | | | | | | | | | |
| 11 | | | | | OPEC decides to cut quotas at various | | | | | |
| 12 | | | PdVA Strike in Venezuela | | | | | OPEC decides to cut quotas. | | |

Source: US Energy Information Administration.

Table 2: 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 |
| Global debt crisis | 2010 | Aggregate demand side |

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