# Oil Prices and African Stock Markets Co-movement: A Time and Frequency Analysis

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# Oil Prices and African Stock Markets Co-movement: A Time and Frequency Analysis

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**Abstract**

This paper explores the co-movement between OPEC (Organization of the Petroleum Exporting Countries) oil prices and six largest African stock markets in term of capital. The Wavelet Coherence method is used to analyze the evolution of this relationship in both time and frequency. Our results show that the co-movement between the African financial markets and oil prices is relatively low except for the emerging stock markets such as South Africa and Egypt and is related for the majority of stock markets in large time scales during the period of the 2007 financial crisis and after. At small time scales, African stock markets could be a way of diversification benefits for oil market active investors.

*Keywords:* African Stock Markets, OPEC oil prices, Co-movement, Wavelet Coherence
*JEL Classification:* F3, C1, G1

## 1. Introduction

For several decades, Oil has been one of the most used commodities before gold. It is used in different forms in all sectors and at almost every level of the world economy. The advent of renewable and alternative energies recently, has not practically changed the importance of the world oil consumption. In 2014, for example, the IEA[1] announced a rise of consumption relative to that planned earlier for the current year. The developed and industrialized countries are by far the largest consumer of this oil wealth. Low consumption of this commodity in Africa does not mean it is on the sidelines of global petroleum market.

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Since the 70s, the African continent is known internationally as a non-negligible partner in oil production. African countries such as Algeria, Nigeria, Libya, and Angola, all OPEC's members have emerged as major players in global oil production. Gabon, Congo Brazzaville and Chad whose oil production plays a very important role in the economy of these countries, are major producers of this commodity at the African level. Cameroon recorded a doubling of its current production in less than five years and South Africa which, despite its low oil production compared to big African oil producing countries, is nonetheless one of the biggest oil importers in Africa. The discovery of oil wells off Ivory Coast and Ghana allowed them to enter in the restricted circle of African oil producing countries. Very recently oil was discovered in Senegal. The creation of the APPA[2], an intergovernmental organization founded in 1987 in Lagos, Nigeria, to serve as a platform for cooperation, collaboration, knowledge and expertise sharing for all African oil producers is an asset. This association is an illustration of the importance taken by the oil market in African economies.

Nowadays, oil pricing depends on market demand, quantity produced, available reserves, geopolitical situation and many other factors. For years, their impact on various economic and financial variables is always a very popular subject. With specific regard to the relationship between oil prices and financial markets, it is theoretical first. Indeed, the value of a share is equal to the sum of discounted future cash flows. These discounted cash flows are affected by economic factors that are influenced by the oil prices. Thus, oil prices fluctuations can have a significant impact on stock prices of active countries in the tanker market (importer or exporter) or for stock markets whose components are more or less related to petroleum markets or its derivatives and reciprocally. This relationship was illustrated during the 2008 financial crisis. Indeed Medlock and Jaffe (2009) argues that the 2000s institutional reforms in the United States[3] and more specifically the Commodity Future Modernization Act (CFMA) reduced the limitations related to speculation and allowed a increase in the oil market of the number of non-commercial agent[4] which uses the speculation to make profits. After 2002 they represent more than 50% of agents having an open position on oil future markets, against 20% before. The entry of these agents is also strongly correlated with the oil prices increase causing a speculative process grafting on cyclical expectations that are not subsequently confirmed

[2]African Petroleum Producers Association.
[3]U.S
[4]A trader who does not use oil futures contracts to hedge a position.

(Chevallier, 2010). Indeed from 2006 to 2007 the global oil supply is stabilized and the demand continues to increase in exceeding in the early 2008. This stimulates speculative acts of non-commercial agents based on an oil price increase at the end of the year (Buyuksahin et al., 2008). However the U.S economic recession, direct consequence of the financial crisis, is manifested by a decrease in oil consumption (Redoulès, 2009) and thus an increase of supply which led to a speculative reversal. This speculative reversal causes a decrease in oil prices that have a direct impact in American financial markets returns being strongly linked to them. On their side, Dupuis and D'Anjou (2008) show that fear and lack of confidence spread into the financial system and by speculators during financial crisis led investors to withdraw their money from the oil market. This reaction generates lower oil prices which dramatically reduces access to credit and leads to a risk of investing in new oil production capacity. Mba (2009) notes that the majority of small and medium oil companies listed are out of cash because they can no longer raise the necessary funds from banks. The major oil companies are forced to invest their own funds which cause a decrease in their financing projects. These poor moves lead to a decline in the oil demand of these companies which caused a drop in crude oil prices.

The analysis of this relationship, for a continent with a booming financial market and being tipped as a future major player in the production of oil is very interesting. This would make it possible to better understand or prevent financial and oil prices shocks through various economic and financial measures in place to either side of these markets that beyond their complementary relationship described above can have positive effects on the economy. Furthermore to determine the nature of this relationship would attract foreign investors more or less related to the oil market and looking to diversify their capital especially in view of a weakly integrated African stock market (Collins and Biekpe, 2003a,b).

Several articles are devoted to this relationship. We can cite, Papapetrou (2001) that investigates the crude oil prices and stock prices relationship in Greece. Sadorsky (1999) and Kilian and Park (2009) analyze the link between U.S[5] stock markets and oil prices. Malik and Hammoudeh (2007) is interested in the impact of oil prices in GCC[6] financial market. Park and Ratti (2008) focused in co-movement between oil prices variation and U.S and European stock markets. Talukdar and Sunyaeva (2012) studies the oil prices influences in stock markets returns of some OECD members. Ono (2011) inspects

[5]United States
[6]Gulf Countries Council

BRIC's[7]stock markets and oil prices link. Jones and Kaul (1996) examines the relationship between developed stock markets and oil prices during the postwar period.

In African stock markets specifically, the majority of the study are generally focused in Nigeria stock Market in view of the status of a major oil producer of the country. Asaolu and Ilo (2012), Babatunde et al. (2013), Adebiyi et al. (2009) and Ogiri et al. (2013) investigate the impact oil prices in the Nigerian stock market returns. Chisadza et al. (2013) is interested in oil prices influence in the South African stock market. In Kenya, Gatuhi and Macharia (2013) inspect the relationship between east Africa diesel prices and stock market returns. Maghyereh (2004) analyze the link between oil prices shocks and 22 emerging financial markets returns including South Africa, Egypt and Morocco.

These papers despite their success and the results obtained show some limitations as they only take into account the temporal aspect. They analyze the relationship between financial markets and oil prices linearly without considering the frequency field or the different time scales. Financial and oil markets depend on the behavior, the objectives of the various speculators, investors and financial agents and thus their investment horizons (short, medium and long term) or the importance of taking into account the different time horizons (time scales) in the study of this relationship. Methods taking into account these different aspects have been recently proposed by researchers and are based on wavelet analysis. They analyze the relationship between variables, here the financial markets and the oil prices both in time and frequency (study at different time scales), of way more efficient than traditional methods (temporal aspects only) that are not really suitable to the co-movements kind and not helpful enough for investment portfolio and financial agents decision. These wavelet methods offer a refinement of the analysis as they provide a unified framework to measure the dependencies between two variables in a time-frequency space. Therefore, it is possible to determine the variations of frequencies of variables in time and to compare them. The applications of the wavelet methods in this relationship are illustrated in the worlds major financial markets in studies as those of Jammazi and Aloui (2010), Jammazi and Aloui (2012), Vavřina (2012), Vo (2011) and Martín-Barragán et al. (2013). In GCC and Islamic stock markets, Akoum et al. (2012), Abdullah et al. (2014) and Rithuan et al. (2014). These studies in their majority, neglect an African financial market in full growth process.

In our paper we apply the Wavelet Coherence method and its increments to study the co-movement between six main African financial markets and OPEC oil prices in time

[7]Brazil, Russia, India and Canada.

and frequency. The contribution of our work is in two points. First, this study at different time scales between oil prices and African stock markets is the first to our knowledge on African financial markets specifically which is based on wavelets methods more precisely the wavelet coherence. Second, this is the first study comparing the price of oil and African financial markets that extends its analysis simultaneously on many African stock markets.

The rest of the study is structured as follows. Section 2 presents a brief literature review in stock markets and oil prices relationship. Section 3 details the methodology used to inspect the co-movement between stock markets and crude oil prices. Section 4 examines the data and empirical results and Section 5 concludes.

## 2. Literature review

Many authors are interested to the nexus between stock markets and oil prices. For example, Papapetrou (2001) found that the rise of crude oil prices affects negatively the stock prices in Greece. In the U.S[8] financial markets, Sadorsky (1999) showed that changes in oil prices and stock returns go to opposite directions and Kilian and Park (2009) demonstrated that the impact of oil prices shocks on the financial markets varied as it is caused by supply shocks or demand. Malik and Hammoudeh (2007) revealed in their work that the volatility of world oil prices affects in a general way all the financial markets of the GCC[9] but the impact is strongest on the market of Saudi Arabia, one of the worlds leading oil producer. Park and Ratti (2008) in their study on the co-movement between oil prices shocks, U.S and 13 European stock markets, revealed that fluctuations in oil prices and oil exporter countries stock markets returns have a negative relationship except for Norway. Talukdar and Sunyaeva (2012) analyzed the impact of oil prices shocks in stock markets returns of 11 members of OECD. They found that the effects of oil prices in the financial markets varied. The effects are negative when the countries are oil importers and positive when they are oil exporters. Wang et al. (2013) showed that the oil exporting countries and those in which oil plays a role whether importing or exporting are those whose financial markets are most affected by price changes of oil and this impact vary upon whether the shock is caused by demand or supply. Ono (2011) found first that the Brazil financial market unlike other BRICs financial markets that

[8]United States.
[9]Gulf Countries Council.

responded positively to oil prices changes, showed no statistical significant response with that. Then he found an asymmetric effect of oil prices in the Indian stock market and finally showed that volatility in oil prices greatly affected the China and Russia financial markets. Jones and Kaul (1996) during the postwar period demonstrated that for U.S and Canada, major oil producers, the oil prices shocks in stock prices are explained first by their impact in real cash flows of these countries which in turn have a direct impact on stock prices.

In African financial markets, the study conducted by Asaolu and Ilo (2012) found that an increase in oil prices leads to lower stock returns in Nigeria. However, the authors pointed out that given the status of a major oil producer, the governing authority should ensure that the revenues of oil has a rather positive impact on financial markets. Adebiyi et al. (2009) used multivariate VAR[10] analysis and demonstrated that oil prices have a negative impact on stock returns in Nigeria and that the variation in the markets is explained by the volatility of oil prices. In Kenya, Gatuhi and Macharia (2013) showed the presence of a positive relationship between east Africa diesel prices and stock market returns. Chisadza et al. (2013) deduced from their researches that stock returns in South Africa react positively when the oil price increase is caused by a positive global demand and react negatively to other shocks such as supply. By applying several empirical methods, Ogiri et al. (2013) found that oil prices have a large impact on the price formation in Nigerian stock market. Maghyereh (2004) in his study on 22 emerging financial markets including Egypt, Morocco and South Africa revealed a low incidence of oil prices shocks in emerging financial markets. Babatunde et al. (2013) showed that the Nigerian financial markets have a statistically significant positive response to variations in oil prices, which tends to be negative in accordance with the nature of the shock. They concluded that changes in oil prices negatively affect the Nigerian stock market returns.

Concerning the application of wavelet methods in the relation between stock markets and oil prices, it is relatively recent. One of the pioneer studies using wavelet in this framework is that of Jammazi and Aloui (2010) which found that in France, Japan and U.S financial markets by combining the wavelet and MSVAR[11] that the impact of oil prices changes in the markets is asymmetric but on the overall of the study, the relationship is negative, especially in the short term. Thereafter, Vo (2011) found that at high frequencies, i.e the short term, the relationship between crude oil prices and stock

[10] Vector AutoRegressive

[11] Markov Switching Vector AutoRegressive.

markets of OECD[12] is retroactive and they have a lead/lag relationship with each others. At lower frequencies, i.e long-term and larger scales, OEDC financial markets lead crude oil prices with a positive correlation. Vavřina (2012) in his master thesis applied wavelet tools to relationship between four main financial world markets and four main commodities over the period of the 2007 global financial crisis. Results of this researches showed that oil prices move together with all stock markets in the second half of 2009 at high and medium frequencies. Always in line with their previous paper, Jammazi and Aloui (2012) used Haar à trous wavelet transform to explain the relationship between oil prices and 5 developing stock markets in both time and frequency. The wavelet correlation analysis showed that oil prices and the performance of financial markets does not move together at intermediate scales (medium run). The cross correlation at short and medium term presented no sign of co-movement between stock markets and oil prices despite the large variations in oil prices in this period, while in the large scales, the two variables have a negative relationship for Canada and two oil-importing countries (United Kingdom and Germany). Otherwise, in GCC, Akoum et al. (2012) used wavelet coherence on stock markets and oil prices relationship and showed that the co-movement is strong in long term even for non-oil producing countries in the area. The co-movement tend to become stronger after 2007 that is to say after the crisis. Martín-Barragán et al. (2013) demonstrated in their study on major global financial markets and oil prices relationship that the correlation between them reacts slightly to stock markets crash but in periods of crisis where oil prices suffer large shocks, this relationship tended to be negative excepted for the oil price spike of 2008 where it is positive. In Islamic financial markets, Abdullah et al. (2014) used Dynamic Conditional Correlations Analysis and wavelets methods to analyze the link between the Islamic stocks indexes and some commodities. They found a correlation between markets ISIR[13] and crude oil prices, low at small time scales (16 days or less), average with the intermediate time scales (16 to 64 days) but very strong at large scales (64 days and more). Furthermore, Rithuan et al. (2014) deduced by an analysis based on MODWT[14] that crude oil prices leads Saudi Arabia ISIR in the short term but the trend is reversed in the long run. ISIR Oman is led by crude oil prices in the long and short run. The CWT[15] analysis shows that the ISIR financial markets are not strongly correlated to the crude oil prices except in long term for Kuwait, Bahrain

[12]Organization for Economic Cooperation and Development
[13]Islamic Stock Index Returns.
[14]Maximal Overlap Discrete Wavelet Transform.
[15]Continuous Wavelet Transform

and Qatar.

## 3. Methodology

We favor a temporal and frequency analysis because it allows a study at different time scales of the African financial markets and OPEC oil prices co-movement. The Wavelet Coherence use Continuous Wavelet Transform (CWT) (Percival and Walden, 2000) that allows to decompose time series at different time scales and can be presented as follows.

Let $X$ and $Y$, two multivariate stochastic processes with $X_n = (X_1, X_2, \ldots, X_n)$ and $Y_n = (Y_1, Y_2, \ldots, Y_n)$. $W_n^X$ and $W_n^Y$ are respectively the wavelet transform of series obtained through the Continuous Wavelet Transform. The Wavelet Coherence of $X$ and $Y$ which allows the analysis of both time and frequency relationship between the two variables is done in several steps.

First the Cross Wavelet Transform introduced by Hudgins et al. (1993) is calculated as follows.

$$W_n^{XY} = W_n^X W_n^Y \tag{1}$$

Secondly the Cross Wavelet Power defined by Liu (1994) is determined by $\left|W_n^{XY}\right|$ and is basically the local covariance of $X$ and $Y$.

After having defined the Cross Wavelet Power, thirdly we calculate the wavelet coherence, see Grinsted et al. (2004) for more details. It is defined as the ratio of the cross-spectrum to the product of the spectrum of each series, and also called local correlation, both in time and frequency of $X$ and $Y$ is obtained as follows.

$$R_n(s)^2 = \frac{\left|S(s^{-1}W_n^{XY}(s))\right|}{S(s^{-1}\left|W_n^X\right|)^{1/2} S(s^{-1}\left|W_n^Y\right|)^{1/2}} \tag{2}$$

S is a smoothing operator. Consideration of smoothing is important insofar without smoothing the coherence is specifically 1 for all time scales. Smoothing is achieved by convolution in time and scale. Finally, the phase difference presented by Torrence and Webster (1999), Bloomfield (2004) is used to analyze the different cycles of the correlation

between the two series with more details. It is defined in the following manner.

$$\phi_{X,Y} = \tan^{-1} \frac{I\{W^{XY}\}_n}{R\{W^{XY}\}_n} \tag{3}$$

Where I and R, are respectively Imaginary and Real parts of smooth cross wavelet power spectrum. The phase difference is represented by arrows in the wavelet coherence plots. When arrows points to the right, times series are in-phase and when the arrows point to left, it is the opposite i.e, anti-phase. When the arrow is pointing up, the first series leads the second and when it is pointing down, this is the opposite.

## 4. Data and Empirical Results

Data is composed of the main indexes of the six largest African stock markets in terms of capitalization, South Africa (TOP40), Egypt (EGX30), Morocco (MADEX), Nigeria (NGSE), Kenya (NSE20), West African Economic and Monetary Union[16] (BRVM10) and OPEC oil prices. We use daily data because of their characteristics that are more representative of stock market activity and oil pricing which are daily. Data sample covers the period from 6 January 2003 to 3 October 2012 (1739 observations). The choice of this sample data is justified by the fact that it covers two major financial crises of recent years that have had an impact on oil prices and market returns. First, the global financial crisis of 2008 despite the weak African financial integration rate relatively protected African economies of direct effects of the financial crisis, the main levers of recent growth in Africa has been affected nonetheless by the decline in demand and prices of African commodities and promises of increased aid threatened. Then the European debt crisis in 2010, because of the strong economic relations between Africa and Europe which is the main external economic partner of the African continent. Finally this period of study takes into account both the recent but the fast development of African financial markets. Note the presence of missing data at some point due to the lack of data on certain periods for some stock markets and to the mismatch of open days between different financial markets and OPEC oil prices. All data were obtained from Bloomberg and Quandl database. The stock markets and OPEC oil prices returns were calculated as follows.

$r_t = LN(P_t/P_{t-1})$,

where $r$, the returns and $P$, the closing prices.

[16] WAEMU.

Several summary statistics of stock markets and OPEC oil prices returns are reported in Table 2. All returns have a positive mean then the African financial markets and OPEC oil prices are profitable and generate profits. EGX30 (Egypt) has the largest standard deviation which is equivalent to saying that it is the most riskiest and volatile market of the studied panel where it is possible to make big profit but also big losses while MADEX (Morocco) who has the lowest is the less risky and volatile market. We note that the coefficient of skewness is positive for the NGSE, NSE20 and BRMV10. This means that the thickest portion of their distributions is to the right while for the TOP40, the EGX30, MADEX and OPEC oil, the thick portion of their distributions is to the left. This proves the existence of an asymmetric behavior of the studied returns. The series also has a non-Gaussian behavior, since there is no value of skewness equal to 0. In other words, the series randomly oscillate around a mean value. Referring to kurtosis, we found a high coefficient of kurtosis for the majority of cases and even very high for some returns. Indeed, the kurtosis of the returns are greater than 3 and therefore, these series are heavy tails, that is to say that the distributions are more concentrated around the mean and have thicker than normal Gaussian distribution tails. We therefore find an asymmetry that demonstrated for the presence of non-normality in the process of changes in daily returns of the studied series. The skewness and kurtosis results of the tests can be confirmed through the normality test Jarque-Bera. By observing the results obtained to the significance threshold of 5%, we find that for all returns, the Jarque-Bera test presents a value a pvalue$<0.05$. We therefore reject the normality assumption. We can say that the returns reject normal distribution and have a non-Gaussian behavior, in other words they oscillate randomly around a mean value. Table 1 presents the Pearson correlation between stock indexes and OPEC oil prices returns. Among the 6 financial markets returns, we note that South Africa stock market is the most correlated with OPEC oil prices returns. WAEMU and Kenya stock markets show even a negative correlation. The WAEMU stock markets returns is the one that has the lowest correlation with OPEC oil prices returns. The Nigerian financial market despite its status as the leading oil producing country before all those used in the study shows a correlation with the OPEC oil prices in second place behind South Africa. However, it should be noted that South Africa is the first African oil importer. Egypt financial stock market is in third place. Morocco stock markets returns despite a low correlation with the OPEC oil prices returns remain ahead of Kenya and WAEMU financial markets. African stock markets generally show a weak linear correlation with OPEC oil prices.

| | OPEC oil prices | TOP40 | EGX30 | MADEX | NGSE | NSE20 | BRVM10 |
|---|---|---|---|---|---|---|---|
| OPEC oil prices | 1 | | | | | | |
| TOP40 | 0.168** | 1 | | | | | |
| EGX30 | 0.011 | 0.221** | 1 | | | | |
| MADEX | -0.044 | 0.113** | 0.142** | 1 | | | |
| NGSE | 0.037 | 0.055 | 0.107** | 0.098** | 1 | | |
| NSE20 | -0.016 | 0.111** | 0.162** | 0.081** | 0.078** | 1 | |
| BRVM10 | -0.031 | 0.019 | 0.057** | 0.100** | 0.031** | 0.090** | 1 |

Table 1: Pearson Linear Correlations of stock markets and OPEC oil prices returns.

(**) significance code: (5%)

| | TOP40 | EGX30 | MADEX | NGSE | NSE20 | BRVM10 | OPEC oil prices |
|---|---|---|---|---|---|---|---|
| Mean | 0.0007465 | 0.002157 | 0.0006595 | 0.0004339 | 0.0005950 | 0.000396 | 0.0007186 |
| Median | 0.0013186 | -0.009167 | 0.0003421 | 0.0000000 | 0.0001264 | 0.0000000 | 0.0014432 |
| Maximum | 0.1157054 | 0.270457 | 0.0667500 | 0.1175836 | 0.1226793 | 0.1091000 | 0.1732352 |
| Minimum | -0.1108063 | -0.201026 | -0.0826294 | -0.1094187 | -0.1536887 | -0.110334 | -0.1482591 |
| Standard Deviation | 0.01727041 | 0.02357086 | 0.01147604 | 0.01488382 | 0.01416611 | 0.01256833 | 0.02189757 |
| Skewness | -0.1245803 | -0.04788301 | -0.2018168 | 0.3737232 | 0.4053332 | 0.5638438 | -0.3610772 |
| Kurtosis | 7.700966 | 19.66901 | 9.706388 | 14.30699 | 26.71967 | 18.7383 | 10.57585 |
| Jarque-Bera | 1604.838 | 20122.07 | 3268.784 | 9298.784 | 40790.87 | 18029.28 | 4194.013 |
| (pvalue) | (2.2e-16) | (2.2e-16) | (2.2e-16) | (2.2e-16) | (2.2e-16) | (2.2e-16) | (2.2e-16) |

Table 2: Descriptive Statistics of stock markets and OPEC oil prices returns.

The analysis of Fig.1 shows that OPEC oil prices and African stock returns are generally more or less correlated at large time scales (low frequency).

In South Africa, first African oil importer, the co-movement is mainly located at the scales 7 and 8 during the period between 2006 and 2011. The South African financial index is generally led by OPEC oil prices except for a few small moments at the beginning of the scale 8 between 2007 and 2008. There are some points of strong co-movement especially after 2007 from scale 3 to scale 6 . Note that the TOP40 have the highest co-movement of all African financial markets with OPEC oil prices. Concerning Egypt, the stock market moves together with oil prices at large time scales. Between 2006 and 2008, at scale 8 and from 2008 to 2011 at scales 7 and 8, the OPEC oil prices and the EGX30 are in phase and OPEC oil prices usually leads the EGX30 except at the beginning of the scale 8 between 2008 and 2010. At scales 4 and 5, the co-movement is strong in some places but remains generally weak. In Morocco, second African oil importer we see that the MADEX and OPEC oil co-movement are relatively strong at scale 7 only between 2008 and 2012. Generally they are not in phase on the whole period except during 2008-2011 at scale 7 where they are in phase and each variable leads the other at a given moment. There are some small places of strong correlation scattered in the different time scales during the study period. Otherwise, the Nigerian Stock Exchange is in phase with crude

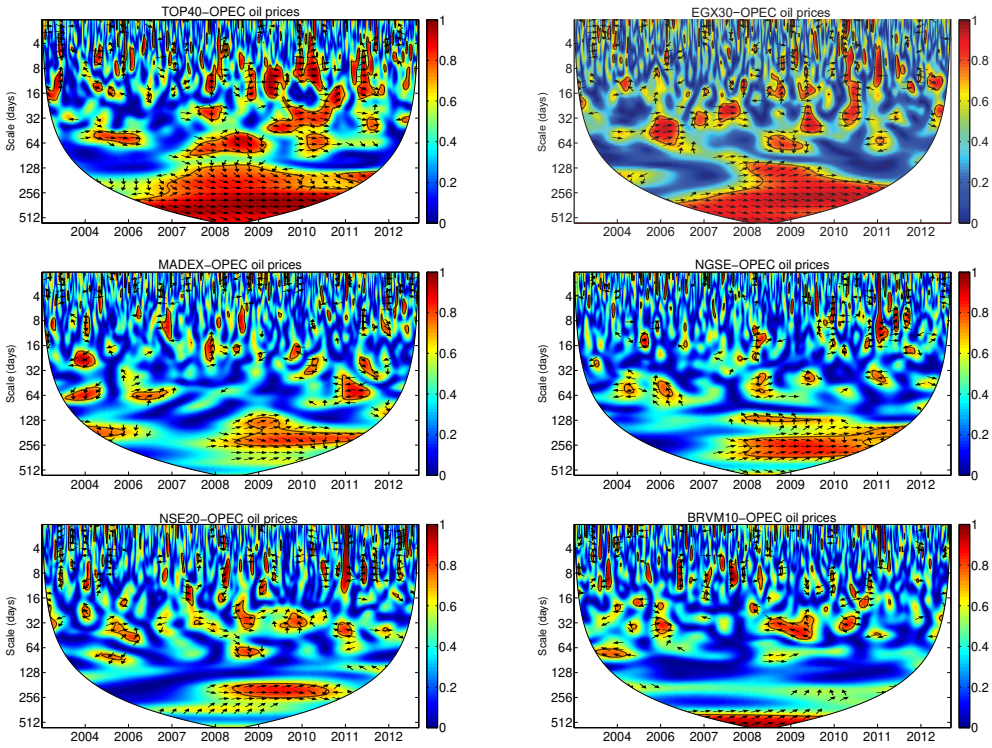


Fig. 1: Wavelet coherence between TOP40, EGX30, MADEX, NGSE, NSE20, BRVM10 and OPEC Oil prices

*Time is defined on the horizontal axis, the scale is represented in abscissa and is defined the following way, scale 1:(0-4 days), scale 2:(4-8 days), scale 3:(8-16 days), scale 4:(16-32 days), scale 5:(32-64 days), scale 6:(64-128 days), scale 7:(128-256 days) and scale 8:(256-512 days) i.e, it varies from the high frequencies to the low frequencies. The thick black line that surrounds the colored part of the plot designates the* 5% *significance level Monte Carlo simulations estimated from using phase randomized surrogate series. The level of correlation is measured by the color from blue (low correlation) to dark red (high correlation). The black line represents the cone of influence that it delimits the region affected by the edge, the outside of the cone does not affect in the study. When the arrows points to the right, times series are in-phase and when the arrows point to left,it is the opposite i.e, anti-phase. When the arrow is pointing up, the first series leads the second and when it is pointing down, this is the opposite.*

oil prices but the relationship seems low despite the status of largest oil producing country and the first African oil exporter. At scales 6 and 7, the NGSE and crude oil prices move together between 2008 and 2012 and NGSE mainly leads OPEC oil prices. NSE20, the main stock index of Kenya meanwhile shows a relatively low co-movement with OPEC oil prices. They move together between 2008 and 2011 at scale 7, they are in phase and the NSE20 usually runs oil prices. For scales 4 and 5, we note small areas of high co-movement distributed throughout time. Finally, in WAEMU, BRVM10 and OPEC oil prices co-movement is only strong at scale 8 from 2006 to 2010 and the oil prices are led

by BRVM10.

The strong correlation in the long-term between oil prices and South African stock market can be interpreted by the fact that South Africa is the largest importer of African oil[17] and has the most powerful African financial market but also the more integrated into the global economy. For the Egyptian market, the co-movement can be explained by the fact that Egypt has also an emerging financial market and therefore is more or less connected to the global market (Boamah, 2013) which is subject to petroleum price fluctuations and also that Egypt was a major exporter of oil at African level but recently exports less given the huge demand for oil. The Nigerian capital market despite the status of leading producer and exporter of oil in Africa presents a low co-movement with oil prices because the Nigerian stock market despite its recent expansion remains poorly integrated into the global economy but is also to the image of the Nigerian economy which despite its status is quite diverse and the oil and gas industry will present only 15% of GDP[18]. This weak relation could be also explained too by a relatively low representation of oil companies in the NGSE index All Shares with only 10% of the total capitalization of the index. Morocco second African oil importing country presents a weakly correlated relation with financial market price of oil. The small representation of oil company in the MADEX quotation (Afriquia Gas and very recently Total Morocco)[19] could be the cause but also like Nigeria and other African stock markets in general, the Morocco stock market is weakly integrated into the World economy and therefore with the petroleum market. For the WAEMU and Kenya financial markets, the weak correlation with the oil prices is the consequence of very weakly integrated stock markets with the global finance market but also with representations of any oil company recently on the main indexes of these financial markets, the BRVM10 and the NSE20 respectively[20].

The analysis of the different results obtained by the Pearson method and Wavelet Coherence method give us different conclusions. Specifically, for the first method, Nigeria is Africa's second financial market the most correlated with the price of oil while for the wavelet coherence, Egypt is the 2nd African financial market more correlated with oil prices. These differences can be explained by the fact that the Pearson correlation is static and therefore not evolved over time while the analysis of correlation with wavelet coherence is dynamic. It shows us how the relationship evolved between our two variables

[17] http://lespoir.jimdo.com/
[18] http://databank.banquemondiale.org/data/databases.aspx
[19] http://www.casablanca-bourse.com/
[20] http://www.african-markets.com/en/stock-markets.

at different time scales. This difference in results may be the fact that wavelet analysis is more detailed and provides more information than the correlation Pearson that does not take into account the evolution over time of the relationship between stock markets and oil prices.

There is also an increase in the correlation between financial markets and oil prices during financial crisis and those just after. It is explained by the phenomenon of contagion arising of the financial markets in times of crisis and which is illustrated by the spread of financial instability among financial markets causing a strong co-movement between them (Forbes and Rigobon, 2002), (McAleer and Nam, 2005). This strong correlation obviously extends to oil prices through their contiguous relationship and leads to a strong co-movement between stock markets and oil prices during periods of crisis.

We note finally that the co-movement between the African financial markets and OPEC oil prices shocks is low. The moments of strong correlation is usually located in long run and are really significant for the Egyptian and South African financial markets only.

## 5. Conclusion and implications

This work studies the relationship between six largest African stock markets and OPEC oil prices. We presented an analysis in time and frequency based on wavelets and more specifically on wavelet coherence method to have a study of the relationship at different time scales (horizons) . Wavelet coherence results show that the co-movement between OPEC oil prices and the African financial markets is very low excepted for the two emerging African markets, Egypt and South Africa and is generally focused on large time scales for all the stock markets (128-512 days). We note that for most financial markets, there is strong correlation generally during the period of the 2007 financial crisis and after crisis at this large time scales.

We can conclude that oil prices and African stock markets co-movement is generally weak in short and medium term horizon excluding South African and Egypt stock markets. This relationship is especially strong in the long run for almost all the stock markets.

The results from this study are relevant for optimal portfolio diversification strategies and financial authorities. The integration with the oil prices specific in long term and sometimes even lower in medium term means that African financial market did not react immediately to oil prices shocks. This long term integration could be a benefit for a diversification for financial agents linked to global oil market in the short and medium term and in some cases for all time horizons.

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## References

Abdullah, A. M., Saiti, B., Masih, A. M. M., (2014) "The Impact of Crude Oil Price on Islamic Stock Indices of South East Asian (SEA) Countries: A Comparative Analysis". Munich Personal RePEc Archive.

Adebiyi, M. A., Adenuga, A. O., Abeng, M. O., Omanukwue, P. N. (2009) "Oil price shocks, exchange rate and stock market behaviour: Empirical evidence from Nigeria". In Proceedings of the 14th Annual Conference of the African Econometric Society.

Akoum, I., Graham, M., Kivihaho, J., Nikkinen, J., Omran, M., (2012) "Co-movement of oil and stock prices in the GCC region: A wavelet analysis". The Quarterly Review of Economics and Finance, 52(4), 385-394.

Asaolu, T. O., Ilo, B. M., (2012) "The Nigerian Stock Market and Oil Prices: A Cointegration Analysis". Kuwait Chapter of Arabian Journal of Business and Management Review, 1(5), 39-54.

Babatunde, M. A., Adenikinju, O., Adenikinju, A. F., (2013) "Oil price shocks and stock market behaviour in Nigeria". Journal of Economic Studies, 40(2), 180-202.

Bloomfield, P., (2004). "Fourier analysis of time series: an introduction". John Wiley and Sons

Boamah, N.A., (2013). "Global Integration of African Stock Markets". Available at SSRN 2313538.

Buyuksahin, B., Haigh, M. S., Harris, J. H., Overdahl, J. A., Robe, M. A., (2008). "Fundamentals, trader activity and derivative pricing". In EFA 2009 Bergen Meetings Paper.

Caldern, C., Kubota, M., (2009). "Does financial openness lead to deeper domestic financial markets". World Bank Policy Research Working Paper Series, Vol2009.

Candelon, B., Hecq, A., Verschoor, W., (2005). "Measuring common cyclical features during financial turmoil: evidence of interdependence not contagion". Journal of International Money and Finance 24, 1317-1334.

Chevallier, J., (2010). "Spéculation et marchés dérivés du pétrole". Revue d'économie financière, 353-371.

Chisadza, C., Dlamini, J., Gupta, R., Modise, M. P., (2013) "The impact of oil shocks on the South African economy". Energy Sources Part B.

Collins, D., Biekpe, N., (2003). "Contagion and interdependence in African stock markets". South African Journal of Economics 71, 181-194.

Collins, D., Biekpe, N., 2003. "Contagion: a fear for African equity markets?". Journal of Economics and Business 55, 285-297.

Dupuis, F., D'Anjou, M., (2008) "Tendance des matières premières". Desjardins Etudes économiques, 1-8.

Engle, R.F., Granger, C.W.J., (1987). "Co-integration and error correction: representation, estimation, and testing". Econometrica: journal of the Econometric Society, 251-276.

Forbes, K.J., Rigobon, R., (2002) "No contagion, only interdependence: measuring stock market co-movements". The Journal of Finance 57, 2223-2261.

Gatuhi, S. K., Macharia, P. I., (2013) "Oil prices impact on the performance of stock market in Kenya". Management, Business and Economics, 1(2).

Grinsted, A., Moore, J. C., Jevrejeva, S., (2004) "Application of the cross wavelet transform and wavelet coherence to geophysical time series". Nonlinear processes in geophysics, 11(5/6), 561-566.

INTERNATIONAL MONETARY FUND (2000). "The Impact of Higher Oil Prices on the Global Economy". IMF Research Department.

Hicks, J. R., (1969). "A theory of economic history". OUP Catalogue.

Huang, R. D., Masulis, R. W., Stoll, H. R. (1996). "Energy shocks and financial markets". Journal of Futures markets, 16(1), 1-27.

Hudgins, L., Friehe, C. A., Mayer, M. E., (1993) "Wavelet transforms and atmospheric turbulence". Physical Review Letters, 71(20), 3279.

Jammazi, R., Aloui, C., (2010) "Wavelet decomposition and regime shifts: assessing the effects of crude oil shocks on stock market returns". Energy Policy, 38(3), 1415-1435.

Jammazi, R., Aloui, C., (2012) "Crude oil price forecasting: Experimental evidence from wavelet decomposition and neural network modeling". Energy Economics, 34(3), 828-841.

Jones, C. M., Kaul, G., (1996) "Oil and the stock markets". The Journal of Finance, 51(2), 463-491.

Kilian, L., Park, C., (2009) "The impact of oil price shocks on the U.S stock market". International Economic Review, 50(4), 1267-1287.

Levine, R., (1997). "Financial development and economic growth: views and agenda". Journal of economic literature, 688-726.

Liu, P. C., (1994) "Wavelet spectrum analysis and ocean wind waves". Wavelets in geophysics, 4, 151-166.

Maghyereh, A., (2004) "Oil price shocks and emerging stock markets: a generalized VAR approach". International Journal of Applied Econometrics and Quantitative Studies, 1(2), 27-40.

Malik, F., Hammoudeh, S., (2007) "Shock and volatility transmission in the oil, US and Gulf equity markets". International Review of Economics Finance, 16(3), 357-368.

Martín-Barragán, B., Ramos, S. B., Veiga, H., (2013) "Correlations between oil and stock markets: a wavelet-based approach". Universidad Carlos III, Departamento de Estadstica y Econometra, Statistics and Econometrics Working Papers

Mba, O.C., (2009) "Les secteurs miniers et pétroliers face la crise financière internationale". Conférence gouvernementale sur la crise financière : La crise financière internationale et les perspectives de l'économie gabonaise, 1-9.

McAleer, M., and Nam, J.C.W., (2005) "Testing for contagion in ASEAN exchange rates". Mathematics and Computers in Simulation 68, 517-525.

Medlock III, K. B., Jaffe, A. M., (2009) "Who is in the oil futures market and how has it changed?". Houston, TX: Mimeo. James Baker III Institute for Public Policy, Rice University.

Ogiri, I. H., Amadi, S.N., Uddin, M. M., Dubon, P., (2013) "Oil price, stock market performance in Nigeria: An empirical analysis". American Journal of Social and Management Sciences, 4(1), 20-41.

Ono, S., (2011) "Oil price shocks and stock markets in BRIC's". The European Journal of Comparative Economics, 8(1), 29-45.

Papapetrou, E., (2001) "Oil price shocks, stock market, economic activity and employment in Greece". Energy Economics, 23(5), 511-532.

Park, J., Ratti, R. A., (2008) "Oil price shocks and stock markets in the US and 13 European countries". Energy Economics, 30(5), 2587-2608.

Percival, D. B., Walden, A. T., (2000) "Wavelet Methods for Time Series Analysis". Cambridge Series in Statistical and Probabilistic Mathematics.

Redoulès, O., (2009). "Léconomie mondiale en 2008: du ralentissement  la récession". Insee, L'économie franaise, édition.

Rithuan, S. H. M., Abdullah, A. M., Masih, A. M. M., (2014) "The Impact of Crude Oil Price on Islamic Stock Indices of Gulf Cooperation Council (GCC) Countries: A Comparative Analysis". Munich Personal RePEc Archive

Sadorsky, P., (1999) "Oil price shocks and stock market activity". Energy Economics, 21(5), 449-469.

Talukdar, K. H., Sunyaeva, A., (2012) "Oil Price Shocks And Stock Market Returns: Evidence From 11 Member Countries Of Organization Of Economic Cooperation And Development (OECD)". Lambert Academic Publishing

Torrence, C., Webster, P. J., (1999) "Interdecadal changes in the ENSO-monsoon system". Journal of Climate, 12(8), 2679-2690.

Vavřina, M., (2012) "Co-movement of Stock Markets and Commodities: A Wavelet Analysis". Charles University in Prague, Faculty of Social Sciences, Institute of Economic Studies.

Vo, X. H., (2011) "A wavelet-based approach to model oil and stock market relationships". University of Paris 1 Pantheon Sorbonne.

Wang, Y., Wu, C., Yang, L., (2013) "Oil price shocks and stock market activities: Evidence from oil-importing and oil-exporting countries". Journal of Comparative Economics, 41(4), 1220-1239.