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Gourène, Grakolet Arnold Zamereith and Mendy, Pierre and Ake N'gbo, Gilbert Marie

Mathematics of the Decision and Numerical Analysis Laboratory, Cheikh Anta Diop University,, Department of Economics, Education and Research Unit of Economics Science and Management, Felix Houphouet Boigny University,

16 March 2017

Multiple Time-Scales Analysis of Global Stock Markets Spillovers in African Stock Markets

Grakolet Arnold Z. Gourène[a], Pierre Mendy[a], Gilbert Marie N'gbo Ake[b]

[a] *Laboratory of Mathematics of Decision and Numerical Analysis, Cheikh Anta Diop University, B.P. 5005 Dakar-Fann, Sénégal.*
[b] *Department of Economics, Education and Research Unit of Economics Science and Management, Felix Houphouet Boigny University, BP V34 Abidjan 01, Côte d'Ivoire.*

Abstract

This paper examines the spillovers in time and frequency from emerging (Brazil, Russia, India, China), developed (US, UK, France, Germany and Japan) stock markets and oil prices toward seven African stock markets. The spillovers are examined from 2005 to 2016, taking into account the recent financial crises and the recent oil prices fall. We combine the generalized Vector AutoRegressive (VAR) framework and the Maximum Overlap Discrete Wavelet Transform (MODWT) to obtain the spillovers at different time scales. The results show that the relationships between African stock markets, world stock markets and oil prices depend on time scales. African stock markets could be a way of capital diversification for global stock markets at scale 1 (2-4 weeks) and for investors active in the oil market at scale 2 (4-8 weeks).

Keywords: African Stock Markets, Spillovers, Time Scales, Generalized VAR.
JEL Classification: F3, C1, G1

1. Introduction

In recent years, globalization has been one of the main economic guidelines. Links between the world's economies have grown strongly through international trade, foreign direct investment, monetary integration and many other channels. All of these has been the basis for a growing interdependence between global stock markets. Despite the disastrous consequences of this financial integration on the world economy[1] in recent financial turmoil[2], several authors remain ardent defenders of the financial opening.

Chinn and Ito (2005), Calderón and Kubota (2009), Kim and Singal (2000) and Levine and Zervos (1998a) demonstrated that opening the capital account contributes to the development of the financial system by improving efficiency, depth, portfolio diversification, size, stability and liquidity. Chinn and Ito (2002) and Klein and Olivei (2006) also showed the importance to develop the financial institution structure for a positive effect of financial openness on financial development.

All these studies show that an integrated financial market can be a means of financial development and therefore of economic growth (see Bagehot, 1873; Hicks, 1969; Schumpeter, 1912; Levine, 1997). For African economies[3], financial openness is therefore crucial. However, as some authors have pointed out above, a good institutional structure is essential.

Recently, the African authorities have introduced numerous reforms and policies aimed at development and the opening of the stock market[4] (see ARIA III, 2008; ARIA V, 2012; ASEA, 2015). Indeed, African stock markets experienced a certain growth [5] (see ASEA, 2015). This significant growth and the fact that global financial markets seem increasingly connected raises the question of the relations of the African financial markets with the world finance.

Authors such as Collins and Biekpe (2003a,b); Wang et al. (2003) were interested in the co-movement between African

Email addresses: grakolet88@gmail.com (Grakolet Arnold Z. Gourène), pierre.mendy@ucad.edu.sn (Pierre Mendy), akeapiyi@gmail.com (Gilbert Marie N'gbo Ake)

[1] negative impacts on unemployment, consumption, investment, growth ...

[2] U.S financial crisis, European debt crisis and oil prices fall (see The Global Social Crisis, 2011; Stracca, 2013; Hou et al., 2015)

[3] mostly developing or emerging

[4] Harmonization, common stock markets, attractiveness...

[5] The capitalization of the 10 largest African financial markets tripled from 2002 to 2008.

and global stock markets during and after the Asian crisis of 1997. Adjasi and Biekpe (2006); Agyei-Ampomah (2008); Boamah (2013) studied links between African and world stock markets. Using the Diebold and Yilmaz (2012) method, Sugimoto et al. (2014); Fowowe and Shuaibu (2016) analyzed the relationship between African stock and global stock markets during the US financial crisis and the European debt crisis. All these works have concluded that African stock markets are weakly integrated with each others and with global stock markets.

However, these studies have limitations. The analysis of the relationship between financial markets with only the temporal aspect is not realistic. Indeed, the time scale is very important in the stock markets. Investors act at different frequencies or time scales depending on their investment horizon. The behavior of financial agents affecting stock prices, take into account many heterogeneous investors who make decisions at different scales (see Candelón et al., 2009) is crucial in the analysis of co-movement between financial markets.

The co-integration and the error correction model (see Engle and Granger, 1987) that are frequently used, remain limited because it takes into account only two-time scales[6] on several available.

Wavelet methods allow us to overcome these limitations. Indeed, these methods can analyze the relationship between stock markets at multiple time scales[7] (simultaneously in time and frequency). Wavelet methods allow a better (more detailed) understanding of the co-movement between stock markets. Some authors have used these wavelet methods in the analysis of stock markets linkage. Gallegati (2005) applied these wavelet methods in MENA[8] and global stock markets, Rua and Nunes (2009) among many global stock markets, Graham and Nikkinen (2011) and Fernández-Macho (2012) between main European stock markets, Graham and al. (2012); Graham et al. (2013), Madaleno and Pinho (2012) between emerging and developed stock markets, Tiwari et al. (2013), Loh (2013) between the Asian and global stock markets and Aloui and Hkiri (2014) in the Gulf Cooperation Council stock markets integration.

We combine traditional econometric methods with wavelet methods. First, we apply the Maximal Overlap Discrete Wavelet Transform method to stock markets returns. This allows to obtain stock returns at different time scales. Then, we apply the Diebold and Yilmaz (2012) method based on VAR [9] at each scale.

The objective of this paper is to analyze the contribution of global stock markets and oil prices to African stock markets at different time scales. We also want to see if all the reforms and policies put in place to open the African stock markets are effective. Our study sample covers the US financial crisis, the European debt crisis and the oil prices shock of 2015[10].

The contribution of this work to the literature is twofold. First, this document is one of the first to our knowledge to analyze the co-movement of African and global stock markets at different scales. Secondly, this work is more precise and realistic than the previous ones and opens up new prospects for a better diversification of capital.

The rest of the study is structured as follows. Section 2 presents first a brief analysis of African stock markets evolution. Section 3 gives an overview of the literature on wavelet applications in the relationship between stock markets. Section 4 details the econometric methodology used to inspect the stock markets relationship. Section 5 examines the data. Section 6 analyzes empirical results and Section 7 concludes.

2. African Stock Markets Evolution

The African stock market has evolved very rapidly. Indeed, from 12 in 1990, the number of African stock markets increased to more than 25 in 2016. More than 2/3 of the African countries are currently covered by a local or regional stock exchange. According to ASEA (2015, 2012); de France (2011), the capitalization of the 10 largest African stock markets[11] recorded exceptional growth of 390.77% from 2000 to 2010 and 32% from 2011 to 2014. Table 1 shows the February 2012 to February 2016 performance of the main indices of some of the largest African stock markets except South Africa.

These African stock markets performed well except the Moroccan stock market, which declined during the analysis period. According to Cejefic Consulting (2014), this de-

[6] the short and the long run
[7] scale or horizon
[8] Middle East and North Africa.
[9] Vector AutoRegressive.
[10] Nigeria is the leading producer and exporter of oil in Africa and Africa South is the largest importer of African oil
[11] In capital term

Table 1: African stock markets performance over 4 year.

Stock Markets	Indices reference 2012	Indices reference 2016	Performance
Nigeria	20652	23826	15%.
Egypt	5350	5906	10%
Morocco	11399	8938	-21%
Kenya	73	138.08	89%
WAEMU	153	293	91%
Tunisia	4820	5434	12%
Ghana	1047	1972	88%
Mauritius	1 831	1857	1%
Average performance over 4 years			40%

Source: African-markets.com, mays-mouissi.com, authors calculation.

crease is attributable to a low volume of transactions dating from 2007[12] due to the lack of liquidity (low turnover ratio). The average performance is 40% and three of these markets have even exceeded 80% over a period of 4 years. The African stock market also experienced an upsurge in the IPO[13]. Indeed, we had 125 IPOs from 2011 to 2016 (raising $ 6.1bn[14]). In 2015, 28 companies listed on the African stock markets raises $1.991bn. Concerning FO[15], there have been more than 300 from African companies, raising $35.2bn in African and international stock markets (see PwC, 2015, 2016). According to ASEA (2015), The increasing number of IPOs in 2014 and 2015 shows that exchanges on the African stock markets is improving.

This growth of financial markets is part of the various reforms of the financial sector recently introduced by the African authorities ARIA III (2008); ARIA V (2012); ASEA (2015); Rambaccussing (2010).

Despite this progress, the African financial market remains on the margins of emerging financial markets. According to PwC (2015), African stock market capitalization reache almost $ 1tn[16] by the end of 2015, with 77 % of this value only for the South African stock market and 23% for the rest of African stock markets. The African stock market, excluding South Africa, accounts for only about 0.34% of the world stock markets capitalization which is $ 67tn. African financial markets are weakly integrated into global finance and are not very liquid.

The 2014 capitalization-to-GDP and the turnover ratios of the 10 largest stock markets in Africa gives disparate results (see Table 2). Indeed, stock markets such as Ghana, Morocco, Mauritius, and Egypt, to a lesser extent, have a relatively high capitalization in terms of their economy and

Table 2: Capitalization-to-GDP and turnover ratios 2014.

Stock Markets	Capitalization-to-GDP ratio 2014 %	Turnover ratios 2014 %
South Africa	267.93 %	35.2%
Nigeria	11.81% %	11.65%
Egypt	25 %	38%
Morocco	53.56%	5.7%
Kenya	41.7%	9.27%
WAEMU	13.31%	2.47%
Tunisia	20.9%	9.5%
Ghana	184.36%	9.5%
Mauritius	72.9%	6.77%

Source: ASEA (2015), data.worldbank.org, authors calculation.

are more liquid than other. As regards the turnover ratio, the market activity in view of the size of these markets remains very low for the mostly except for Ghana, South Africa and Egypt. According to Ntim et al. (2011), the small size of some African stock markets hampers their information and allocative efficiencies (see Mlambo and Biekpe, 2005).

To remedy this, Fish and Biekpe (2002) argued that an African regional stock market can improve liquidity while reducing the cost of operations. Irving (2005) proposed integration between African financial markets from African economic zones for greater depth and better selection of financial products. According to Lugangwa (2012), if African markets cooperate and are more integrated, they will be larger and therefore more visible to global investors. UNCTAD (2014) said that the development of African stock markets, given their small size, would be achieved through their unification on a regional or continental scale.

Several reforms have been made in order to harmonize the African stock markets and open them to external capital. The African Securities Exchanges Association (ASEA)[17] was established in 1993 in Kenya and now is composed of 25 stock exchanges in Africa. The objectives of this association are to improve the visibility of African securities worldwide to attract investors, provide better knowledge of the African

[12] Volumes lower by approximately 75% from 2007 to 2012
[13] Initial Public Offering
[14] Billion
[15] Futures Options
[16] Trillion
[17] URL: http://www.african-exchanges.org/

stock markets and promote trade between African financial markets.

ASEA signed a partnership with the Financial Times Stock Exchange (FTSE) Group in 2011 for the creation of the FTSE ASEA pan African Index Series and in 2012 the FTSE ASEA pan Africa Index ex South Africa to improve the visibility of the performance of African stock markets and facilitate the development of new financial products (ASEA, 2015).

The FTSE Group and the Casablanca Stock Exchange signed a partnership in 2010 and launched the FTSE CSE Morocco. In 2013, the Bourse Régionale des Valeurs Mobilières (BRVM) of West African Economic and Monetary Union (WAEMU) countries signed an agreement with Paris EUROPLACE. In 2014, the Nigerian Stock Exchange and the London Stock Exchange Group (LSEG) signed a partnership to develop the cooperation and promote mutual development between the two stock exchanges.

All these partnerships are aimed at improving the visibility of the financial market in order to broaden the base of international investors in the African financial market. With regard to the regional integration of the African stock market, several major actions have been taken.

The African financial horizon has now two regional stock exchanges, the BRVM from WAEMU and the Bourse des valeurs Mobilières de l'Afrique Centrale (BVMAC) from the Central African Economic and Monetary Community (CEMAC). Economic Community of West African States (ECOWAS) stock markets[18] favor a closer cooperation and harmonization in order to improve the liquidity and the depth of the market and be more attractive to investors (ASEA, 2015). They analyze the creation of a harmonized trading and trading platform with 300 companies from each of the stock exchanges. Since 2014, East African Financial Markets[19] initiated steps towards a harmonized capital market (see UNCTAD, 2014; PwC, 2015). Within the Arab Maghreb Union (AMU) stock exchanges, steps have been taken to promote integration. Cooperation and partnership agreements have been signed by Libya, Morocco, Tunisia and Egypt in technical and regulatory areas to enable investors to intervene in all stock markets in the region (ARIA III, 2008) . All these actions demonstrate the willingness of the financial authorities to have internationally competitive stock markets, integrated between themselves and with global stock markets.

3. Literature Review

Papers focused on the relation between stock markets using the wavelet methods are recent. Gallegati (2005) is one of the first authors to work in this field, he studied the co-movement between the MENA, US[20] and Eurozone stock markets at different time scales using the Maximal Overlap Discrete Wavelet Transform (MODWT). The author found that MENA[21] stock markets were neither regionally nor internationally integrated.

Rua and Nunes (2009) used the wavelet coherence to study the integration between Germany, Japan, U.K.[22] and U.S stock markets and found that the Japan stock market was weakly integrated with others and this integration varied according to the time scales. Graham and Nikkinen (2011) showed that the co-movement between the Finnish and emerging stock markets was localized in the long run, but between Finnish and developed stock markets it was present at almost all frequencies, with a strong co-movement in the short run. Subsequently, Graham and al. (2012) studied the co-movement between emerging and U.S stock markets and found that the level of contagion varied across countries. The United States had a weak correlation with North Africa but had strong co-movement with Brazil, Korea and Mexico. The authors also noted that at the beginning and during the US financial crisis, the co-movement between stock markets increased in the short run. Using the Morlet wavelet coherence to analyze the U.K., U.S, Japan and Brazil stock markets co-movement, Madaleno and Pinho (2012) found that the strong or the weakness of the co-movement depended on the time scales. Fernández-Macho (2012) proposed the Wavelet Multiple Correlation and the Wavelet Multiple Cross-Correlation and applied these methods to the study of the Eurozone stock markets integration. The author found a strong correlation near perfect between Eurozone stock markets in the long run but small inconsistencies between Eurozone markets appearing in short and medium run. This analysis put to the

[18] BRVM, NGSE (Nigerian Stock Exchange), GSE (Ghana Stock Exchange), SSE (Sierra Leone Stock Exchange)
[19] Kenya, Uganda, Tanzania, Rwanda, Burundi
[20] United States
[21] Middle East and North Africa.
[22] United Kingdom

light that CAC40 tended to lead the rest of the Eurozone stock markets in short and medium run. Graham et al. (2013) used wavelet squared coherence with simulated confidence to study integration between the MENA and U.S stock markets. They found a weak correlation in the short run but strong in the long run. More recently, Tiwari et al. (2013) analyzed the integration of Asian markets using the methods proposed by Fernández-Macho (2012). They showed that Asian stock markets were highly integrated in the long term and comparatively less integrated in the short and medium terms term. Loh (2013) studied the integration of Asia-Pacific stock markets with global stock markets using wavelet coherence. The author has shown that co-movement of Asia-Pacific and global stock markets was generally strong at low frequencies (long run) and in times of financial crisis. Aloui and Hkiri (2014) were interested in the co-movement of the GCC[23] stock markets. Using a wavelet coherence method, they found frequent changes in the relationship at the onset of the short-term financial crisis and a strong co-movement during the US financial crisis.

4. Econometric Methodology

In this section, the econometric methodology used to study the relationship between the stock markets is presented. First we provide a overview of the Maximum Overlap Discrete Wavelet Transform and then a description of the Diebold-Yilmaz spillover index proposed by Diebold and Yilmaz (2012).

4.1. Maximum Overlap Discrete Wavelet Transform (MODWT)

We use the MODWT to implement the stock market returns at different time scales (see Percival and Walden, 2000). The MODWT localizes variations in time series in time and frequency simultaneously. The variability and the evolution over time can be captured.

Let X_t, the stock markets returns. The time series can be decomposed by a sequence of projections onto wavelet basis:

$$s_{J,k} = \int X_t \Phi_{J,k}(t)dt \tag{1}$$

[23] Gulf Cooperation Council.

$$d_{j,k} = \int X_t \psi_{j,k}(t)dt \tag{2}$$

where $j = 1, 2 \dots J$, the level of multiresolution and $J = log2(T)$; Φ, the father wavelet and Ψ, the mother wavelet. $s_{J,k}$, the smooth wavelet coefficient (long run movements) provides a smooth or overall pattern of the original signal and $d_{j,k}$, the detailed wavelet coefficients (short run movements) capture local fluctuations in each scale over the entire period of time series. $\Phi_{J,k}$ and $\Psi_{j,k}$ are the scaling and translation obtained from Φ and Ψ and are defined as following.

$$\Phi_{J,k}(t) = 2^{-j/2}\Phi(2^{-j}t - k) = 2^{-j/2}\Phi(\frac{t - 2^j k}{2^j}) \tag{3}$$

$$\Psi_{J,k}(t) = 2^{-j/2}\Psi(2^{-j}t - k) = 2^{-j/2}\Psi(\frac{t - 2^j k}{2^j}) \tag{4}$$

For the decomposition, we use Daubechies Least Asymmetric (LA) wavelet filter of length 8 because it is one of the best and most used in wavelets theory (see Percival and Walden, 2000).

The decomposition of the series by the MODWT is usually implemented by the Pyramidal Algorithm (see Mallat, 1999). The multiresolution analysis of the stock markets returns X_t using the MODWT can be written as follows.

$$X_t = \sum_{j=1}^{J} d_{j,k} + s_{J,k}, \tag{5}$$

4.2. Diebold-Yilmaz spillover index method

We apply the method proposed by Diebold and Yilmaz (2012) to the wavelets coefficients obtained at different timescales. This method analyzes the spillovers from African stock markets toward African stock markets over many timescales.

The Diebold and Yilmaz (2012) spillover index method is an update of the previous method proposed by Diebold and Yielmaz (2009). Here, the directional spillovers is measured in a generalized VAR framework that eliminates the possible dependence of the results to the order of variables.

Assume a covariance stationary of N-variable VAR(p).

$$X_t = \sum_{i=1}^{p} \Phi_i X_{t-i} + \epsilon_t, \tag{6}$$

where $\epsilon \sim (0, \Sigma)$ and ϵ is an i.i.d disturbances vector.

The moving average representation can be written as follows, $X_t = \sum_{i=0}^{\infty} A_i \epsilon_{t-i}$, where A_i is an $N \times N$ coefficients matrix defines as follows, $A_i = \Phi_1 A_{i-1} + \Phi_2 A_{i-2} + \ldots + \Phi_p A_{i-p}$ with A_i, an identity matrix and $A_i = 0$ for $i < 0$.

The moving average coefficient allows a better understanding of the method. It is based on the decomposition of the variance for analyzing forecast error variance of each variable over the entire period of the study. The variance decomposition gives access to the fraction of the H-step ahead error variance in forecasting x_i that is due to shocks to x_j, $i \neq j$ for each i.

Usually VAR innovations are simultaneously correlated while the calculation of the variance decompositions requires orthogonal innovations. The Diebold and Yielmaz (2009) method based on the Cholesky factorization depended on the order of variables. The new method use the generalized VAR framework of Koop et al. (1996) and Pesaran and Shin (1998), which are invariant to the order of the variables. The H-step ahead forecast error variance decomposition for $H = 1, 2, \ldots,$ that uses the generalized impulse responses is defined as follows.

$$\Theta_{ij}^{g}(H) = \frac{\sigma_{jj}^{-1} \sum_{h=0}^{H-1} (e_i' A_h \Sigma e_j)^2}{\sum_{h=0}^{H-1} e_i' A_h \Sigma A_h' \Sigma e_i}, \tag{7}$$

where $i = j$, for own variance shares, $i \neq j$ for cross variance shares or spillovers with x_i and x_j, $i, j = 1, 2, \ldots N$. Σ is the variance matrix for the error vector ϵ, Θ_{ij} the standard deviation of the error run for the j^{th} equation, and e_i the selection vector with one as the i^{th} element and zeros elsewhere.

To normalize the sum of the elements in each row equal to 1 to have the information available in the variance decomposition matrix in the spillover index calculation, own variance and cross-variance shares or spillovers are defined as follows.

$$\tilde{\Theta}_{ij}^{g}(H) = \frac{\Theta_{ij}^{g}(H)}{\sum_{j=1}^{N} \Theta_{ij}^{g}(H)}. \tag{8}$$

We can calculate the spillovers index using the variances obtained.

$$S^{g}(H) = \frac{\sum_{i=1}^{N} \sum_{j=1, i \neq j}^{N} \tilde{\Theta}_{ij}^{g}(H)}{\sum_{i=1}^{N} \sum_{j=1}^{N} \tilde{\Theta}_{ij}^{g}(H)} \times 100 = \frac{\sum_{i=1}^{N} \sum_{j=1, i \neq j}^{N} \tilde{\Theta}_{ij}^{g}(H)}{N} \times 100. \tag{9}$$

The problem of variance decompositions invariant to the variables order being set, we use standardized elements of the generalized decomposition variance matrix to calculate the directional spillovers from one market (i) to others and from all other markets to one market (j).

$$S_i^{g}(H) = \frac{\sum_{j=1, i \neq j}^{N} \tilde{\Theta}_{ij}^{g}(H)}{N} \times 100 \tag{10}$$

$$S_j^{g}(H) = \frac{\sum_{i=1, i \neq j}^{N} \tilde{\Theta}_{ij}^{g}(H)}{N} \times 100. \tag{11}$$

5. Data

The data are composed of different global financial indices. In Africa market, we selected the seven largest stock markets in Africa in runs of capitalization, South Africa (TOP40), Egypt (EGX30), Nigeria (NGSE), Morocco (MADEX), Kenya (NSE), West African Economic and Monetary Union[24] (BRVM10) and Tunisia (TUSISE). In emerging markets, we selected the BRIC[25], Brazil (Bovespa), Russia (RTSI), India (BSE Sensex) and China (SHCOMP[26]). In the developed markets, we selected U.S (S&P500), United Kingdom (FTSE100), France (CAC40), Germany (DAX) and Japan (Nikkei 225). Finally, we selected oil prices (OPEC) as commodity prices. We use weekly data. this choice is justified for a greater robustness of the results due to the difference in working days between the different stock exchanges (see Sugimoto et al., 2014). Data sample covers the period from January 7, 2005, to June 29, 2016 (550 observations). It covers the major financial turmoil of this last recent years: The U.S financial crisis, the European debt crisis and the oil prices fall of 2014. Moreover, this period of study takes into account the recent development of African financial markets. All data were obtained from Bloomberg and Quandl databases. The

[24] WAEMU.
[25] Brazil, Russia, India and China
[26] Shanghai Stock Exchange Composite Index

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.

Table 3: Wavelet time scales analysis.

Wavelet Scales	Time Horizon
Scale1	2-4 weeks
Scale2	4-8 weeks
Scale3	8-16 weeks

Several summary statistics of stock markets returns are reported in Table 4. All stock returns have a positive mean. They are profitable and generate profits. The largest standard deviation of RTSI (Russia) means that is the most volatile stock market of the panel. The TUSISE (Morocco) which has the lowest standard deviation is the least volatile stock market. The analysis of skewness show a negative value[27] for most of the stock market returns. These results indicate that there is more negative returns in these series than positive returns. The high coefficient of kurtosis reveals that the returns distributions are leptokurtic. The Jarque-Bera normality test confirms the skewness and kurtosis results with a $pvalue < 0.05$ for all the returns.

We calculate the wavelet coefficients using the MODWT[28]. For the decomposition we use Daubechies least asymmetric (LA) wavelet filter of length 8 because it is one of the best and most used in wavelets theory (Percival and Walden, 2000). Note that for MODWT, a specific choice of wavelet filter is not required. The maximum scales number of decomposition allowed is $log_2(N)$[29] where N is the number of observations. However, the wavelet coefficients become too small for large large scales, we stop to 3 decompositions or scales with 3 wavelet details [30] and 1 smooth wavelet coefficient[31] (long run dynamic).

The analysis of Table 5 shows that for the scales D_1 to D_3, the stationarity hypothesis is not rejected while for the $S3$ scale it is rejected.

The VAR stationarity hypothesis does not allow to analyze the smooth wavelet coefficients $S3$. We will, therefore, focus on the 3 time scales of the wavelet details (see Table 3). With regard to the choice of the optimum VAR lag, we use the AIC, BIC, SC and FPE on the original returns data (see Table 11). Based on the different criteria, we selected one lag. For the length of the rolling sample, we use 100 weeks[32] (about 2 years). For the length of the forecast period, we use the same as used in Diebold and Yielmaz (2009); Diebold and Yilmaz (2012), H = 10. We use this approach at each scale.

6. Empirical Results

First, we analyze the spillovers between stock markets at different scales by using the spillovers tables (see Table 7, Table 8, Table 9, Table 10 and Table 11). Then, we focus on the dynamics spillovers at different time scales of global stock markets toward the African stock markets using the rolling sample analysis (Fig. 2, Fig. 3 and Fig. 4). To do this, we have separated our stock markets into different groups: developed markets[33], emerging markets[34], African markets[35] and oil prices[36]. In order to have the spillovers of the different groups on the African stock markets, we have calculated the average of the stock markets spillovers of the different countries that compose them.

6.1. Full Sample Analysis at different scales

The analysis of Table 7, Table 8, Table 9 and Table 10 shows that spillovers between stock markets vary according to time scales (see Table 3). The most influential stock market in our sample is surprisingly that of Russia. The Russian stock market contributes more than all other stock markets in the sample. The spillovers of the Russian stock market reach their maximum at scale 2 (4 to 8 weeks) like most other global stock markets. However, the Russian stock market is not the most open to other markets. The U.K stock market receives most of spillovers from other stock markets and those at all scales. The emerging and developed stock markets are the most open markets of the study. The least open stock markets are those of Nigeria and WAEMU respectively at scale 1 and at scales 2 and 3. The South African stock market is the most integrated African stock market with the world finance. The South African

[27] The thickest portion of their distributions is to the left
[28] Maximum Overlap Discrete Wavelet Transform.
[29] $log_2(550) = 9.10$
[30] D_1, D_2, D_3
[31] S_3
[32] the choice of this window is motivated by the analysis of the financial crisis of 2007
[33] US, UK, France, Germany and Japan
[34] BRIC: Brazil , Russia, India and China
[35] South Africa, Egypt, Nigeria, Morocco, Kenya, WAEMU and Tunisia
[36] OPEC prices

Table 4: Descriptive Statistics of stock markets returns.

Variables	Mean	Median	Maximum	Minimum	Standard Deviation	Skewness	Kurtosis	Jarque-Bera (p-value)
BOVESPA	0.0006	0.0018	0.0732	-0.1542	0.01705443	-1.203964	15.935121	3967.2 (2.2e-16)
BSE SENSEX	0.001139	0.002328	0.057200	-0.095000	0.01436936	-0.7050128	7.979893	613.88 (2.2e-16)
BRVM10	0.0007516	0.0003215	0.0499800	-0.1050000	0.01165198	-1.017844	17.06578	4628.9 (2.2e-16)
CAC40	4.113e-05	0.1.623e-03	5.399e-02	-1.175e-01	0.01412267	0.2879606	-1.269285	2169.8 (2.2e-16)
DAX	0.0006123	0.0020560	0.0648900	-0.1253000	0.01450724	-1.331961	14.565	3227.7 (2.2e-16)
EGX30	0.0007567	0.0016560	0.0737500	-0.1202000	0.01993612	-0.9968836	8.108837	689.23 (2.2e-16)
FTSE100	0.0002261	0.0010220	0.0546500	-0.1120000	0.01167371	-1.675342	20.118	6972.5 (2.2e-16)
MADEX	0.0006377	0.0001490	0.0444500	-0.0582400	0.009480763	-0.5231318	8.915534	827.02 (2.2e-16)
NIKKEI225	0.0002341	0.0006923	0.0497300	-0.1575000	0.01464294	-2.465105	27.13586	13907 (2.2e-16)
NGSE	0.0001551	0.0004440	0.0698900	-0.0642200	0.0148682	-0.2026078	6.442766	275.39 (2.2e-16)
NSE20	0.0001560	0.0005939	0.0633800	-0.0558900	0.01147321	-0.09335184	8.717247	749.87 (2.2e-16)
RTSI	0.0003284	0.0018090	0.1485000	-0.1823000	0.02322203	-0.8995249	13.71598	2705.7 (2.2e-16)
S&P500	0.0004509	0.0009491	0.0493200	-0.1301000	0.01161685	-2.535499	32.56019	20614 (2.2e-16)
SSE	0.0006992	0.0013760	0.0605600	-0.1126000	0.01744808	-0.6214436	7.185238	436.81 (2.2e-16)
TOP40	0.001072	0.001849	0.077830	-0.079330	0.01301125	-0.220894	8.970226	821.31 (2.2e-16)
TUSISE	0.001093	0.000929	0.036890	-0.050360	0.006813221	-0.8241799	13.44368	2561.8 (2.2e-16)

Table 5: Stationarity test results from scale 1 to scale 5.

Variables	ADF(pvalue)	KPSS(pvalue)	PP (pvalue)
Scale1(D_1)			
BOVESPA	0.01	0.1	0.01
BSE SENSEX	0.01	0.1	0.01
BRVM10	0.01	0.1	0.01
CAC40	0.01	0.1	0.01
DAX	0.01	0.1	0.01
EGX30	0.01	0.1	0.01
FTSE100	0.01	0.1	0.01
MADEX	0.01	0.1	0.01
NIKKEI225	0.01	0.1	0.01
NGSE	0.01	0.1	0.01
NSE20	0.01	0.1	0.01
RTSI	0.01	0.1	0.01
S&P500	0.01	0.1	0.01
SSE	0.01	0.1	0.01
TOP40	0.01	0.1	0.01
TUSISE	0.01	0.1	0.01
OPEC	0.01	0.1	0.01
Scale2(D_2)			
BOVESPA	0.01	0.1	0.01
BSE SENSEX	0.01	0.1	0.01
BRVM10	0.01	0.1	0.01
CAC40	0.01	0.1	0.01
DAX	0.01	0.1	0.01
EGX30	0.01	0.1	0.01
FTSE100	0.01	0.1	0.01
MADEX	0.01	0.1	0.01
NIKKEI225	0.01	0.1	0.01
NGSE	0.01	0.1	0.01
NSE20	0.01	0.1	0.01
RTSI	0.01	0.1	0.01
S&P500	0.01	0.1	0.01
SSE	0.01	0.1	0.01
TOP40	0.01	0.1	0.01
TUSISE	0.01	0.1	0.01
OPEC	0.01	0.1	0.01
Scale3(D_3)			
BOVESPA	0.01	0.1	0.01
BSE SENSEX	0.01	0.1	0.01
BRVM10	0.01	0.1	0.01
CAC40	0.01	0.1	0.01
DAX	0.01	0.1	0.01
EGX30	0.01	0.1	0.01
FTSE100	0.01	0.1	0.01
MADEX	0.01	0.1	0.01
NIKKEI225	0.01	0.1	0.01
NGSE	0.01	0.1	0.01
NSE20	0.01	0.1	0.01
RTSI	0.01	0.1	0.01
S&P500	0.01	0.1	0.01
SSE	0.01	0.1	0.01
TOP40	0.01	0.1	0.01
TUSISE	0.01	0.1	0.01
OPEC	0.01	0.1	0.01
Scale3(S_3)			
BOVESPA	0.27	0.09	0.01
BSE SENSEX	0.34	0.1	0.01
BRVM10	0.5	0.1	0.01
CAC40	0.33	0.1	0.01
DAX	0.20	0.1	0.01
EGX30	0.47	0.1	0.01
FTSE100	0.43	0.1	0.01
MADEX	0.41	0.01	0.01
NIKKEI225	0.21	0.1	0.01
NGSE	0.42	0.1	0.01
NSE20	0.42	0.1	0.01
RTSI	0.5	0.1	0.01
S&P500	0.23	0.1	0.01
SSE	0.47	0.1	0.01
TOP40	0.3	0.1	0.01
TUSISE	0.28	0.01	0.01
OPEC	0.43	0.1	0.01

stock market receives spillovers mainly from emerging and developed stock markets at all scales. Regarding the contributions of the global and African stock markets to the African stock market, we will carry out a scale by scale analysis.

At scale 1 (2-4 weeks), we find that the spillovers from African stock markets and developed towards the African financial market are practically the same. The Nigerian stock market is the least open African financial market to African stock markets spillovers. The Nigeria and Kenya stock markets are the least open to emerging and developed stock markets. The spillovers from oil prices are high toward the Tunisian and WAEMU financial markets with 10.06% and 9.48% of their respective variances.

At scale 2 (4-8 weeks), changes in the African stock market are explained more by the spillovers from developed and emerging stock markets than by the fallout from African financial markets. We also see that the spillovers from the global markets are on the rise as spillovers between African financial markets are falling. The South African market remains the most open African stock market to emerging and global financial markets (respectively 29.54% and 44.42%) but is the least open to from African stock markets spillovers. The least open African stock markets with emerging stock markets are the Egyptian and UEMOA markets with 11.77% and 6.77%, respectively of their fluctuations from the BRIC financial markets. The Moroccan and Tunisian stock markets are the most open to the contribution from African financial market, which contributes respectively to 16.73% and 14.84% of their fluctuations. This opening may be a consequence of Egypt's strong contribution to the fluctuations of these stock markets[37]. The spillovers from oil prices are highest toward Tunisian and

[37] 9.00% for Morocco and 4.37% for Tunisia

Table 6: Spillovers table from world stock markets and oil prices to African stock markets: January 7, 2005-June 29, 2016.

Scale 1	Brazil	China	Egypt	France	Germany	India	Japan	Kenya	Morocco	Nigeria	OPEC	Russia	South Africa	Tunisia	U.K	U.S	WAEMU	From others
Brazil	24.46	4.64	2.94	8.77	7.77	4.57	7.27	0.05	1.03	1.88	5.69	8.41	6.17	0.70	7.72	7.81	0.11	75.54
China	2.23	71.41	1.74	4.03	3.09	1.88	3.81	0.99	0.07	1.10	2.20	1.68	0.85	0.11	2.69	2.01	0.11	28.59
Egypt	1.70	2.06	65.73	1.92	1.90	2.88	2.61	1.39	1.82	7.50	0.72	3.43	1.18	0.87	1.54	1.51	1.22	34.27
France	7.73	3.81	3.18	16.86	14.33	4.38	8.89	0.07	0.58	1.72	4.58	7.17	6.39	0.31	11.02	8.92	0.08	83.14
Germany	7.45	3.70	3.56	14.97	17.09	4.25	8.93	0.02	0.84	1.71	3.24	7.99	6.08	0.59	10.33	9.19	0.04	82.91
India	6.44	4.38	4.91	7.27	7.12	28.26	7.33	1.21	2.46	2.15	4.20	9.26	4.36	0.38	5.62	4.50	0.14	71.74
Japan	6.36	6.04	3.87	9.44	8.64	4.20	29.45	0.29	1.23	1.38	3.77	5.75	4.19	0.36	7.60	7.08	0.35	70.55
Kenya	0.32	1.22	5.76	0.13	0.70	4.31	0.87	70.05	3.53	2.72	1.52	6.75	0.95	0.30	0.31	0.34	0.22	29.95
Morocco	2.17	0.29	8.43	0.92	1.95	2.67	1.66	4.32	69.43	1.86	1.29	0.98	0.67	0.55	0.83	1.36	0.46	30.40
Nigeria	0.28	0.29	3.77	0.58	0.23	0.32	1.07	0.72	0.83	83.97	1.18	4.43	0.39	1.02	0.37	0.40	0.14	16.03
OPEC oil prices	5.51	2.47	2.33	4.85	3.30	3.58	3.29	0.19	0.19	1.64	49.66	11.48	4.64	0.33	3.90	2.15	0.51	50.34
Russia	7.70	2.12	7.26	5.07	6.03	5.14	3.88	0.83	0.69	1.36	8.88	36.08	5.19	0.39	4.89	4.21	0.28	63.92
South Africa	9.11	2.09	3.62	9.53	9.10	5.00	7.55	0.05	1.70	3.25	7.10	9.73	17.84	0.29	8.36	5.61	0.07	82.16
Tunisia	3.17	1.22	7.00	3.32	3.40	3.61	0.85	0.27	1.68	0.63	10.06	2.43	3.75	51.29	1.40	1.63	4.28	48.71
U.K	9.06	4.12	3.78	13.17	11.89	4.31	8.55	0.03	0.93	2.35	4.81	7.73	6.78	0.59	13.01	8.80	0.09	86.99
U.S	8.44	5.85	3.72	12.60	11.55	3.67	9.61	0.05	0.61	1.31	3.76	6.86	4.44	0.68	11.07	15.75	0.03	84.25
WAEMU	3.01	0.62	0.40	4.39	2.17	0.16	2.73	0.83	1.04	1.49	9.48	3.96	3.10	0.73	1.81	1.53	62.54	37.46
To others	80.69	44.92	66.26	100.95	93.18	54.94	78.91	11.31	19.23	34.04	72.47	98.05	59.11	8.19	79.45	67.07	8.16	976.91

Scale 2	Brazil	China	Egypt	France	Germany	India	Japan	Kenya	Morocco	Nigeria	OPEC	Russia	South,Africa	Tunisia	U.K	U.S	WAEMU	From others
Brazil	22.08	2.07	0.94	8.40	7.37	4.54	5.60	2.70	0.18	0.45	3.71	17.87	6.58	0.31	8.84	8.15	0.21	77.92
China	4.87	59.00	1.03	4.84	4.83	1.22	2.27	1.83	0.43	0.65	2.25	4.79	3.65	1.30	3.18	3.48	0.38	41.00
Egypt	2.78	0.79	58.19	5.48	4.65	2.91	4.80	1.54	0.96	0.64	1.08	5.29	2.95	0.65	3.33	2.68	1.28	41.81
France	6.96	1.58	1.48	16.90	14.48	5.04	7.85	1.89	0.06	0.41	2.88	12.58	7.30	0.29	11.03	8.89	0.37	83.10
Germany	6.59	1.84	1.32	14.91	17.43	5.79	6.81	1.67	0.03	0.41	1.98	13.99	7.27	0.27	10.52	8.76	0.39	82.57
India	7.59	1.23	1.61	9.95	10.76	24.09	5.47	1.52	0.50	0.83	1.52	11.63	5.23	0.85	8.96	7.97	0.28	75.91
Japan	7.15	1.41	1.99	12.83	10.86	4.62	24.94	1.44	0.03	0.29	2.41	8.15	6.43	0.21	9.68	7.39	0.15	75.06
Kenya	7.13	2.22	2.45	9.02	6.89	3.36	4.98	26.58	0.09	0.32	2.54	10.66	5.89	1.98	8.47	6.77	0.63	73.42
Morocco	4.44	1.47	9.00	1.16	1.62	4.65	0.37	0.96	62.53	2.59	2.19	2.72	2.38	0.64	0.88	1.22	1.17	37.47
Nigeria	3.97	0.71	1.25	2.87	3.94	4.58	2.34	0.83	1.50	58.81	2.60	9.77	2.59	0.61	2.34	1.15	0.15	41.19
OPEC oil prices	4.63	0.89	1.06	3.14	1.71	0.76	1.43	1.59	0.52	1.10	60.43	11.70	3.25	0.47	3.83	3.22	0.28	39.57
Russia	10.26	0.98	1.24	8.39	8.75	3.95	3.72	1.75	0.20	0.42	4.66	32.56	7.37	0.28	7.86	7.18	0.44	67.44
South Africa	8.25	1.34	1.31	10.65	9.85	3.83	5.91	2.01	0.18	0.44	2.96	16.12	18.81	0.23	10.40	7.61	0.11	81.19
Tunisia	3.65	1.11	4.37	4.13	4.37	7.21	3.35	5.44	1.01	2.40	4.20	6.27	1.18	45.69	3.46	1.72	0.44	54.31
U.K	8.61	1.24	1.04	12.89	11.78	5.23	6.96	2.37	0.05	0.22	3.37	13.74	8.33	0.31	13.98	9.74	0.14	86.02
U.S	9.00	1.57	0.86	11.93	11.07	4.95	6.16	2.40	0.08	0.57	3.01	14.46	6.84	0.26	11.12	15.55	0.15	84.45
WAEMU	0.28	2.49	7.60	0.30	0.58	0.14	0.32	2.04	1.06	0.18	0.20	3.85	0.32	0.09	0.75	0.33	79.46	20.54
To others	96.15	22.96	38.54	120.90	113.51	62.78	68.35	31.98	6.90	11.93	41.56	163.57	77.55	8.78	104.66	86.25	6.58	1062.97

Scale 3	Brazil	China	Egypt	France	Germany	India	Japan	Kenya	Morocco	Nigeria	OPEC	Russia	South,Africa	Tunisia	U.K	U.S	WAEMU	From others
Brazil	21.47	1.30	1.04	6.48	7.15	7.50	5.83	1.63	0.18	1.87	4.87	13.79	11.00	0.20	8.03	7.60	0.08	78.53
China	3.99	51.52	0.73	4.73	5.63	5.05	5.15	1.70	0.54	1.93	0.83	2.36	3.34	1.38	6.57	4.42	0.13	48.48
Egypt	2.20	1.34	54.67	2.27	1.95	4.50	8.55	3.15	0.85	2.44	1.47	5.66	3.67	0.92	3.86	1.99	0.51	45.33
France	5.33	1.40	1.73	16.95	15.21	7.01	8.57	1.34	0.40	1.30	1.62	6.49	8.66	2.08	11.50	9.81	0.60	83.05
Germany	4.96	1.40	0.68	15.25	18.40	7.37	8.18	0.94	0.88	1.28	0.97	6.28	8.92	2.16	10.78	10.94	0.60	81.60
India	7.05	1.55	2.55	7.33	7.99	23.28	8.86	0.56	0.30	2.64	2.24	11.01	6.75	0.19	7.64	7.43	2.62	76.72
Japan	4.22	0.88	3.32	8.18	7.62	8.27	22.12	4.01	0.39	5.18	2.90	7.77	7.01	0.10	8.16	8.05	1.80	77.88
Kenya	3.70	3.32	9.98	2.98	2.05	0.33	8.08	44.55	0.24	3.39	2.81	2.78	7.90	1.10	3.96	2.66	0.17	55.45
Morocco	3.47	0.57	2.52	1.28	1.69	0.29	2.95	1.52	56.22	0.29	7.07	1.72	2.52	9.51	0.52	2.28	5.57	43.78
Nigeria	5.10	2.02	6.41	1.92	2.39	1.86	4.00	1.62	1.90	40.89	2.30	12.36	2.37	0.16	5.45	3.24	6.01	59.11
OPEC oil prices	7.01	9.14	0.71	3.53	3.84	2.91	5.86	0.61	0.25	0.87	35.63	13.58	8.46	0.18	3.79	3.31	0.31	64.37
Russia	9.12	0.58	3.92	5.50	6.11	7.57	7.62	2.05	0.24	2.69	6.01	28.04	7.94	0.49	6.63	5.18	0.31	71.96
South Africa	9.78	1.27	2.43	8.39	8.15	6.71	7.55	1.57	0.49	0.73	4.88	9.49	20.57	0.39	8.93	8.49	0.18	79.43
Tunisia	1.56	8.45	0.73	0.83	0.67	1.32	1.14	5.20	2.46	1.00	20.64	1.60	0.32	48.21	0.63	0.62	4.61	51.79
U.K	7.09	1.44	2.24	11.64	10.86	7.05	9.43	1.05	0.85	2.04	2.56	8.57	8.52	0.60	14.23	10.43	1.41	85.77
U.S	7.10	0.89	1.33	10.99	10.45	7.77	9.69	1.48	0.75	0.63	2.55	9.08	10.99	0.88	11.08	13.56	0.78	86.44
WAEMU	0.54	0.59	3.12	5.36	2.53	4.06	3.17	1.41	6.50	0.87	2.13	0.66	0.98	1.10	3.12	3.22	60.65	39.35
To others	82.19	36.13	43.45	96.67	94.30	79.58	104.63	29.84	17.21	29.16	65.86	113.21	99.35	21.44	100.66	89.67	25.69	1129.03

Table 7: Spillovers table from African stock markets to African stock markets: January 7, 2005-June 29, 2016.

Scale 1	Egypt	Kenya	Morocco	Nigeria	South Africa	Tunisia	WAEMU	From others
Egypt	65.73	1.39	1.82	7.50	1.18	0.87	1.22	13.99
Kenya	5.76	70.05	3.53	2.72	0.95	0.30	0.22	13.48
Morocco	8.43	4.32	69.43	1.86	0.67	0.55	0.46	16.29
Nigeria	3.77	0.72	0.83	83.97	0.39	1.02	0.14	6.87
South Africa	3.62	0.05	1.70	3.25	17.84	0.29	0.07	8.99
Tunisia	7.00	0.27	1.68	0.63	3.75	51.29	4.28	17.61
WAEMU	0.40	0.83	1.04	1.49	3.10	0.73	62.54	7.59
To others	28.98	7.59	10.61	17.45	10.04	3.76	6.40	84.83

Scale 2	Egypt	Kenya	Morocco	Nigeria	South Africa	Tunisia	WAEMU	From others
Egypt	58.19	1.54	0.96	0.64	2.95	0.65	1.28	8.02
Kenya	2.45	26.58	0.09	0.32	5.89	1.98	0.63	11.37
Morocco	9.00	0.96	62.53	2.59	2.38	0.64	1.17	16.73
Nigeria	1.25	0.83	1.50	58.81	2.59	0.61	0.15	6.92
South Africa	1.31	2.01	0.18	0.44	18.81	0.23	0.11	4.27
Tunisia	4.37	5.44	1.01	2.40	1.18	45.69	0.44	14.84
WAEMU	7.60	2.04	1.06	0.18	0.32	0.09	79.46	11.30
To others	25.97	12.82	4.81	6.57	15.30	4.21	3.78	73.45

Scale 3	Egypt	Kenya	Morocco	Nigeria	South Africa	Tunisia	WAEMU	From others
Egypt	54.67	3.15	0.85	2.44	3.67	0.92	0.51	11.54
Kenya	9.98	44.55	0.24	3.39	7.90	1.10	0.17	22.78
Morocco	2.52	1.52	56.22	0.29	2.52	9.51	5.57	21.94
Nigeria	6.41	1.62	1.90	40.89	2.37	0.16	6.01	18.47
South Africa	2.43	1.57	0.49	0.73	20.57	0.39	0.18	5.78
Tunisia	0.73	5.20	2.46	1.00	0.32	48.21	4.61	14.32
WAEMU	3.12	1.41	6.50	0.87	0.98	1.10	60.65	13.98
To others	25.20	14.46	12.43	8.72	17.76	13.17	17.05	108.81

Table 8: Spillovers table from developed stock markets and oil prices to African stock markets: January 7, 2005-June 29, 2016.

Scale 1	France	Germany	Japan	U.K	U.S	Total
Egypt	1.92	1.90	2.61	1.54	1.51	9.48
Kenya	0.13	0.70	0.87	0.31	0.34	2.35
Morocco	0.92	1.95	1.66	0.83	1.36	6.72
Nigeria	0.58	0.23	1.07	0.37	0.40	2.65
South Africa	9.53	9.10	7.55	8.36	5.61	40.14
Tunisia	3.32	3.40	0.85	1.40	1.63	10.61
WAEMU	4.39	2.17	2.73	1.81	1.53	12.63
Total	20.78	19.45	17.36	14.61	12.39	
						84.58
Scale 2	France	Germany	Japan	U.K	U.S	Total
Egypt	5.48	4.65	4.80	3.33	2.68	20.94
Kenya	9.02	6.89	4.98	8.47	6.77	36.13
Morocco	1.16	1.62	0.37	0.88	1.22	5.25
Nigeria	2.87	3.94	2.34	2.34	1.15	12.65
South Africa	10.65	9.85	5.91	10.40	7.61	44.42
Tunisia	4.13	4.37	3.35	3.46	1.72	17.02
WAEMU	0.30	0.58	0.32	0.75	0.33	2.28
Total	33.61	31.90	22.08	29.64	21.48	
						138.71
Scale 3	France	Germany	Japan	U.K	U.S	Total
Egypt	2.27	1.95	8.55	3.86	1.99	18.62
Kenya	2.98	2.05	8.08	3.96	2.66	19.73
Morocco	1.28	1.69	2.95	0.52	2.28	8.73
Nigeria	1.92	2.39	4.00	5.45	3.24	17.01
South Africa	8.39	8.15	7.55	8.93	8.49	41.52
Tunisia	0.83	0.67	1.14	0.63	0.62	3.89
WAEMU	5.36	2.53	3.17	3.12	3.22	17.40
Total	23.04	19.45	35.45	26.47	22.50	
						126.90

Table 9: Spillovers table from BRIC stock markets to African stock markets: January 7, 2005-June 29, 2016.

Scale 1	Brazil	China	India	Russia	Total
Egypt	1.70	2.06	2.88	3.43	10.07
Kenya	0.32	1.22	4.31	6.75	12.60
Morocco	2.17	0.29	2.67	0.98	6.10
Nigeria	0.28	0.29	0.32	4.43	5.33
South Africa	9.11	2.09	5.00	9.73	25.92
Tunisia	3.17	1.22	3.61	2.43	10.43
WAEMU	3.01	0.62	0.16	3.96	7.75
Total	19.76	7.95	18.95	31.71	
					78.20
Scale 2	Brazil	China	India	Russia	Total
Egypt	2.78	0.79	2.91	5.29	11.77
Kenya	7.13	2.22	3.36	10.66	23.38
Morocco	4.44	1.47	4.65	2.72	13.29
Nigeria	3.97	0.71	4.58	9.77	19.02
South Africa	8.25	1.34	3.83	16.12	29.54
Tunisia	3.65	1.11	7.21	6.27	18.24
WAEMU	0.28	2.49	0.14	3.85	6.77
Total	30.50	10.15	26.68	54.67	
					122.00
Scale 3	Brazil	China	India	Russia	Total
Egypt	2.20	1.34	4.50	5.66	13.70
Kenya	3.70	3.32	0.33	2.78	10.13
Morocco	3.47	0.57	0.29	1.72	6.05
Nigeria	5.10	2.02	1.86	12.36	21.33
South Africa	9.78	1.27	6.71	9.49	27.24
Tunisia	1.56	8.45	1.32	1.60	12.93
WAEMU	0.54	0.59	4.06	0.66	5.84
Total	26.34	17.56	19.06	34.27	
					97.23

South African stock markets.

At scale 3 (8-16 weeks), fluctuations in the African financial market are mainly explained by developed and African financial markets. Developed stock markets contribute more than others groups to African stock returns. The variations in the South African stock markets are explained to 41.52% by the developed markets, 27.24% by the emerging markets and only 5.78% by the African market. Tunisia and the UEMOA stock markets are the least open African markets to the emerging and developed stock markets, respectively. The returns of African stock markets are highest in the Kenyan stock market (22.78% of its variance). The Tunisian stock market is the most open stock market to oil prices spillovers.

The spillovers from global stock markets to African stock markets vary according to the time scale. Developed stock markets contribute greatly to fluctuations in African stock markets at all scales. African stock markets are weakly integrated compared to their proximity and the impact of other global groups. The contribution of African stock markets varies across scales but increases to scale 3 (see table for details). Whatever the scale, Morocco's stock market, Tunisia and Kenya are the most open to the spillovers from African stock markets. The spillovers from Egyptian stock market are high. In addition, the Nigerian stock market, despite the status of the largest producer of oil in Africa of this country, is weakly explained by oil prices. This may be due to the fact that the Nigerian stock market is weakly open to global finance (emerging and developed markets), which are generally very related to oil prices [38]) or by the low representation of oil companies on the NGSE index All Shares[39].

6.2. Rolling sample analysis at different scales

We study the dynamic evolution of the spillovers toward the African stock market. The analysis of Fig. 1, Fig. 2, Fig. 3 and Fig. 4 shows that the spillovers or contribution from the global financial markets generally vary according to the time scale in accordance with the spillovers table results.

6.2.1. Spillovers from individual African stock markets to the aggregate African stock market

At scale 1 (2-4 weeks), Fig. 1 indicates that Egyptian stock market is the one that contributes most to the African stock markets. During the U.S financial crisis, the spillovers from African stock markets varied but generally decreased. In the autumn of 2008, at the height of the financial crisis, spillovers between African financial markets decline. At the beginning of the European debt crisis, spillovers between African stock markets are on the rise. At the end of

[38] Huang et al. (1996)

[39] only 10 % of the total capitalization

Table 10: Spillovers table from OPEC oil prices to African stock markets: January 7, 2005-June 29, 2016.

Scale 1	OPEC	Scale 2	OPEC	Scale 3	OPEC
Egypt	0.72	Egypt	1.08	Egypt	1.47
Kenya	1.52	Kenya	2.54	Kenya	2.81
Morocco	1.29	Morocco	2.19	Morocco	7.07
Nigeria	1.18	Nigeria	2.60	Nigeria	2.30
South Africa	7.10	South Africa	2.96	South Africa	4.88
Tunisia	10.06	Tunisia	4.20	Tunisia	20.64
WAEMU	9.48	WAEMU	0.20	WAEMU	2.13
Total	31.34		15.76		41.30

Table 11: Lag order selection of the VAR model.

Lag Order					
	1	2	3	4	5
AIC(n)	-1.557395e+02*	-1.555076e+02	-1.551939e+02	-1.549254e+02	-1.546407e+02
BIC(n)	-1.531798e+02*	-1.506576e+02	-1.480536e+02	-1.454949e+02	-1.429199e+02
SC(n)	-1.547386e+02*	-1.536111e+02	-1.524018e+02	-1.512377e+02	-1.500574e+02
FPE(n)	2.308841e-68*	2.919683e-68	4.024964e-68	5.338934e-68	7.262311e-68

2010, spillovers from WAEMU stock market are the highest. After the oil prices fall in 2014, the spillovers from the Nigerian stock market are higher than the others. It should be noted that the South African stock market, despite its low contribution to other African stock markets, is the most influential stock market during the 2013 summer.

At scale 2 (4-8 weeks), in fall 2008, the spillovers between African stock markets decline. The Egyptian stock market is the most influential. At the beginning of the US financial crisis, the spillovers from African stock markets decrease with the exception of Morocco. During the European debt crisis, the spillovers are lower than spillovers during the US financial crisis. At the beginning of the European debt crisis, spillovers from the Tunisian stock market to others African stock markets increase. During the oil price crisis of 2014, the spillovers from Nigerian market are rising sharply.

At scale 3 (8-16 weeks), the stock markets spillovers are greater than the two previous scales. Before and during the US financial crisis, the Morocco and WAEMU stock markets are the most influential. The end of the US financial crisis is characterized by an increase in the spillovers from Kenyan stock market. At the beginning of the European debt crisis, spillovers from WAEMU stock market are increasing. In the 2011 summer, spillovers from Egyptian stock market to others African stock markets experience a sharp rise. The fall in oil prices in 2014 is characterized by a drop followed by an increase in spillovers from Egyptian stock market. In 2016, the spillovers from Nigerian market increase slightly.

The spillovers between African fstock markets are stronger at scale 3. At the height of the U.S financial crisis and at the beginning of the European debt crisis, spillovers between African stock markets declined at scales 1 and 2. The fall in spillovers at these intermediate scales show a non-sustainable impact of these crises in the relationship between African stock markets. Whatever the scale, the Egyptian stock market is the most influential African stock market, consequences of its significant impact on other Maghreb stock markets (confirmation of the relation of long-term stock market relations between Egypt, Morocco and Tunisia shown by Onour (2010). We also found that the South African stock market was one of the least connected to others African stock markets. However, at scale 2, during the US financial crisis, spillovers from the South Africa stock market to African markets are increasing. This could be explained by the fact that South African stock market players have diversified their capital by investing in African financial markets[40] at scale 2 (about one month after the crisis). At scale 2, the spillovers from the Nigerian stock market is on the rise during the period of oil prices fall (2014-2016). This could be an attempt to diversify capital into African markets less affected by lower oil prices. The high spillovers from WAEMU stock market can be explained his rapid development and his partnerships with other African stock exchanges (see section 2). We also noted that spillovers between African stock markets have not increased significantly in recent years.

6.2.2. Spillovers from world groups stock markets and oil prices to African stock market

At scale 1 (2-4 weeks), Fig. 2 shows that before and at the beginning of the US financial crisis, fluctuations in African stock markets are mainly explained by spillovers from emerging and African stock markets. In the fall of 2008, spillovers from developed and BRIC stock markets

[40]Less affected by The crisis that the world markets

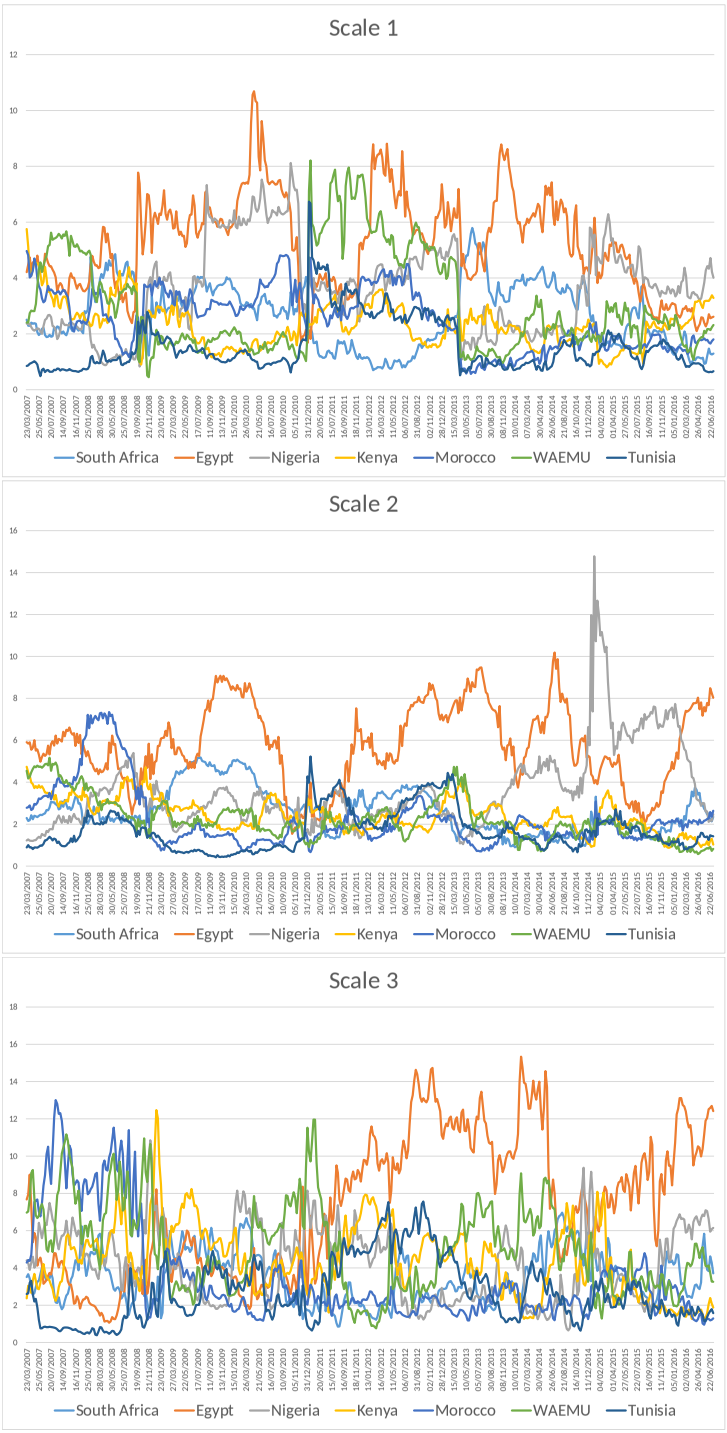

Fig. 1: Spillovers from individual African stock markets to African region stock market at scale 1,2,3

and oil prices rise sharply. From 2009 to 2013, the spillovers from African stock markets are rising. Over the same period (European debt crisis), the spillovers from developed markets decline. However, we note an increase in spillovers from developed stock markets in 2010. The years 2015 and 2016 are characterized by an increase in spillovers from the emerging and developed stock markets. The spillovers from oil prices to African stock markets increase from 2015 to the end of the study period.

At scale 2 (4-8 weeks), spillovers from emerging and developed financial markets are superior to those from African stock markets according to the spillovers table (see Table 6). At the beginning of the US financial crisis, the spillovers between the African financial markets are the highest. In the

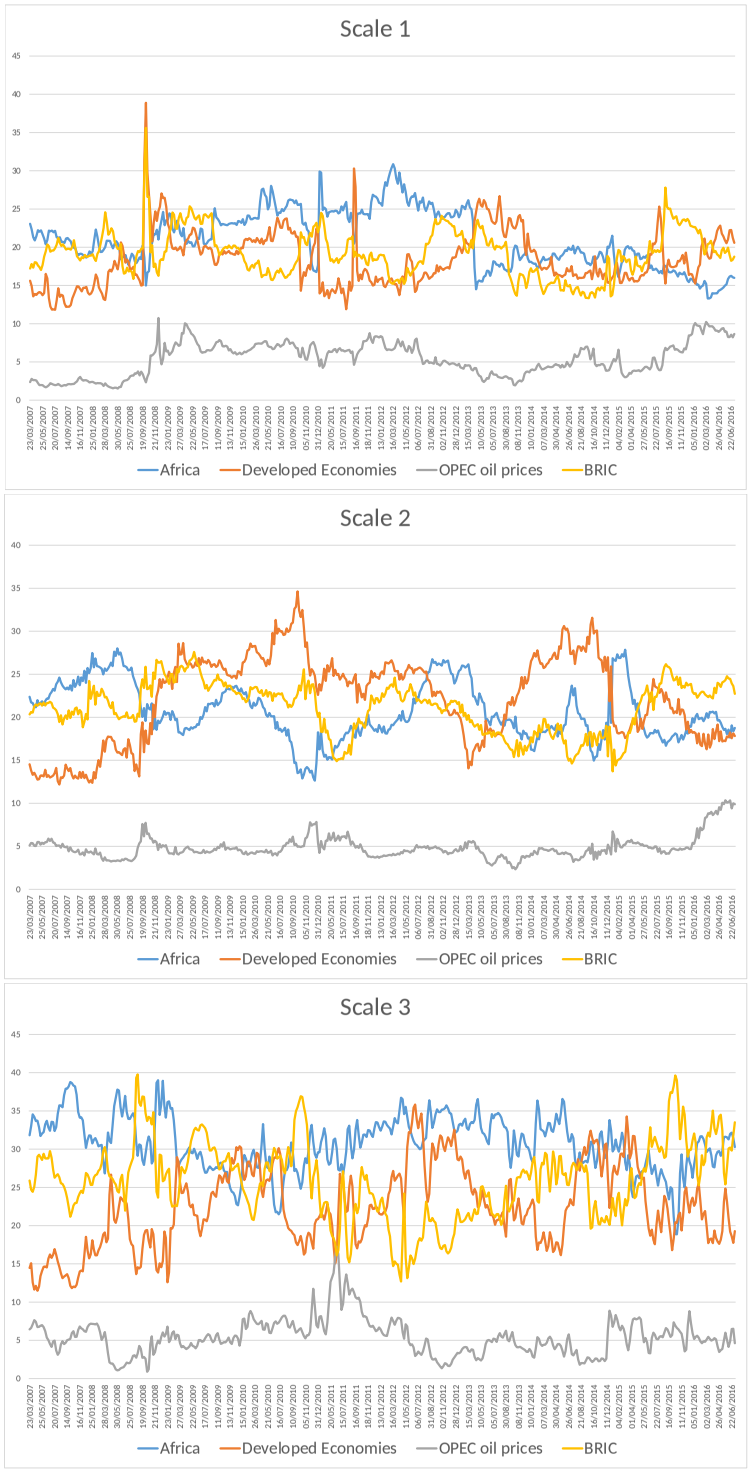

Fig. 2: Spillovers from world groups stock markets and oil prices to African stock markets at scale 1,2,3

fall of 2008, spillovers from global markets are on the rise. Spillovers from developed markets and BRIC are the most important during the period of the European debt crisis. At the end of 2013, we also note a drop in the spillovers from African stock markets followed by an increase at the beginning of 2015. From 2015 to the end of the study period, spillovers from emerging stock markets to the African stock market are rising. In 2016, the impact of oil prices on the African financial market increases.

At scale 3 (8-16 weeks), the spillovers between African stock markets increase. During the US financial crisis, the spillovers from the African and BRIC stock markets are

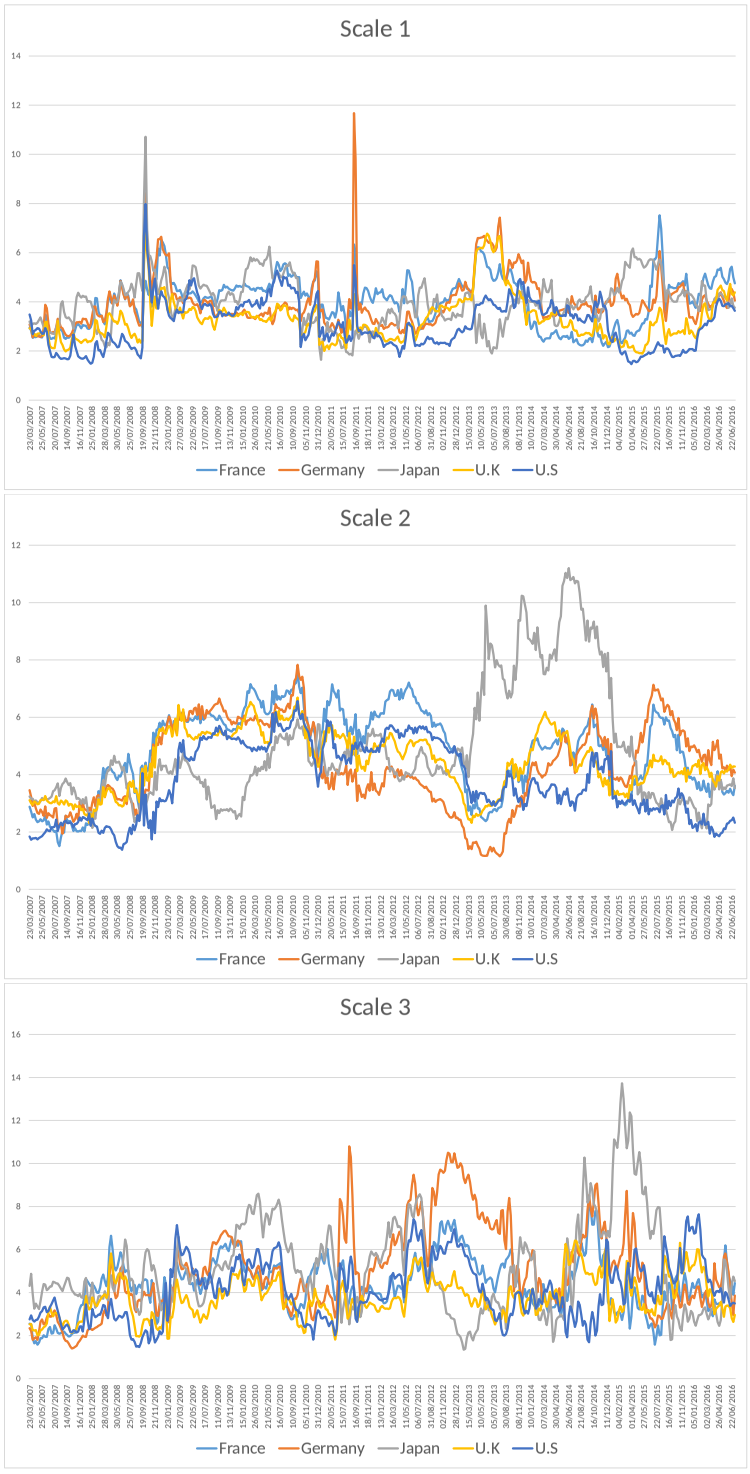

Fig. 3: Spillovers from developed economies to African stock markets at scale 1,2,3

highest. At the end of the US financial crisis, the spillovers from developed stock markets are rising. The European debt crisis is initially characterized by a drop in spillovers from developed stock markets. During this period, the spillovers between African stock markets are higher. Concerning oil prices, we note high spillovers toward African stock markets in 2011 and at the end of 2014.

The spillovers from emerging and developed stock markets to African stock market are not negligible. Their contributions are high at scale 1 and 2. The increase in spillovers from global stock markets at the onset of the financial crises at scale 2 could be due to a capital diversi-

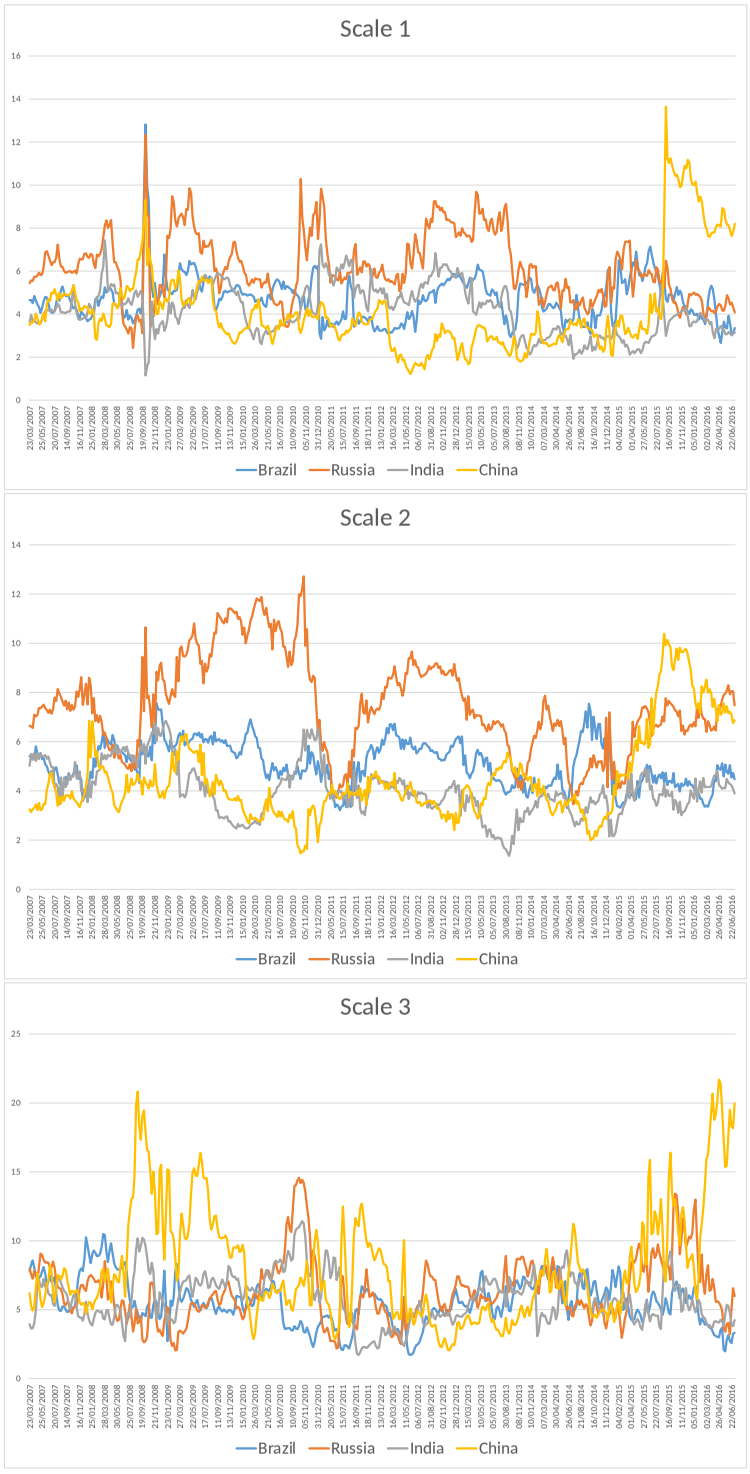

Fig. 4: Spillovers from BRIC stock markets to African stock markets at scale 1,2,3

fication of investors from these stock markets at this scale. During the fall of oil prices in 2014, at scales 1 and 2, the spillovers from oil prices increase but at scale 3 do not vary significantly. That can be explained by the fact that the oil prices shocks affect almost automatically (scale 1 and 2) the listed companies, which are strongly linked to them. Thereafter at scale 3, we assume that some companies could take precautions and try to find alternatives to oil as much as possible while others will adjust their production and prices accordingly. We also note that spillovers between world group and African stock markets have not increased significantly in recent years.

6.2.3. *Spillovers from individual developed stock markets to African stock market*

At scale 1 (2-4 weeks), Fig. 3 analysis indicates that the spillovers from developed stock markets towards the African stock market are practically the same. During the US financial crisis, spillovers from the German, Japanese and French stock markets are the highest. In autumn 2008, the spillovers from developed stock markets drastically increase mainly those from the Japanese stock market. During the European debt crisis, we note that spillovers from the French stock market are generally higher than those of other European stock markets. From late 2010 to mid-2012, spillovers from Japan increase considerably. After the European debt crisis, the spillovers from European stock markets are increasing. At the beginning of 2015, Japan stock market is the most influential market in African stock markets. From 2015 summer, spillovers from the French stock market are the highest. The US financial market is the least influent developed stock markets in the African stock market.

At scale 2 (4-8 weeks), at the height of the US financial crisis, in autumn 2008, spillovers from the Japanese and French stock markets are the highest. After the autumn of 2008, we see an increase in spillovers from European stock markets (France, Germany, U.K). The end of the US financial crisis is characterized by a drop in spillovers from the Japanese financial market. During the European debt crisis, spillovers from the French stock market are the highest. From 2013 to 2015, Spillovers from the Japanese stock market are experiencing a drastic rise. At the beginning in 2015, German stock market spillovers are higher than those of other developed stock markets.

At scale 3 (8-16 weeks), we note that spillovers are greater than past scales. Before and during the US financial crisis, the spillovers effects from French and Japanese stock markets were higher. In early 2009, we note that the spillovers from developed stock markets are declining. During the first half of 2009, spillovers from the US stock markets are the highest. During the European debt crisis, spillovers from the Japanese stock market are generally higher than those ifrom others stock markets. During the year 2013, the spillovers from German stock market are the highest. From 2014 to 2015, spillovers from the Japanese stock market are experiencing a very strong increase. The end of 2015 is characterized by an increase in spillovers from the US stock market.

Individual spillovers from developed stock markets are disparate across countries, scales and circumstances[41]. During the US financial crisis, we note that the spillovers from the Japanese and French stock markets toward the African stock markets are very high. During the European debt crisis, we also note that, European stock market returns are high at scale 1 and 2, but decline to scale 3 where Japanese stock markets spillovers are the highest. This could be explained by a decline in investment from European stock markets to the African stock market in view of the persistence of the European debt crisis. Spillovers from Japanese stock markets are quite high and those at all scales. These high spillovers confirm the strong economic and financial actions on the African market posed by Japan through the JICA[42] and the different TICAD[43] since many years (UN Africa Renewal 2016, Boost in Japan-Africa ties[44]. We note that spillovers between developed and African stock markets have not increased significantly in recent years.

6.2.4. *Spillovers from individual emerging stock markets to African stock market*

At scale 1 (2-4 weeks), Fig. 4 analysis shows that during the US financial crisis, the spillovers from the Russian stock market are highest. In the autumn of 2008, we see an increase in the spillovers from the emerging stock markets with the exception of the Indian stock market. During the European debt crisis, spillovers from the Russian markets still are the highest. This period is also characterized by an increase in spillovers from the Indian stock market. In 2014, the emerging stock market spillovers experienced some decline. From the end of 2015, spillovers from the Chinese stock market are higher

At scale 2 (4-8 weeks), spillovers from emerging stock markets rise and those from the Russian stock market are highest. In autumn 2008, spillovers from BRIC stock markets fall. The period of the European debt crisis is characterized by an increase in spillovers from the Russian and Brazilian stock markets. As of the year 2015, the spillovers as at the previous scale are experiencing a strong rise.

At scale 3 (8-16 weeks), unlike the other scales, Chinese stock market spillovers to the African stock market

[41] financial and economic crisis
[42] Japan International Cooperation Agency
[43] Tokyo International Conference on African Development
[44] http://www.un.org/africarenewal/magazine/april-2016/boost-japan-africa-ties

are higher than other emerging stock markets. The US financial crisis and the European debt crisis are characterized by a sharp rise in spillovers from the Chinese stock market. We note however that at the end of these economic crises, spillovers from the Chinese stock market are falling while spillovers from the Indian and Russian stock markets increase. From the end of 2015, spillovers from the Russian and Chinese stock markets rise sharply.

Spillovers from the Russian and Chinese stock markets are the highest confirming the results of the spillovers table. During the US financial crisis, emerging stock markets fall until autumn 2008 but after generally increase. During the European debt crisis, the spillovers from BRIC stock markets vary according to the scale. However, it should be noted that during the year 2012, the emerging stock markets spillovers generally increase with the exception of the Chinese stock market at scale 3. From 2015 to 2016 The spillovers from Chinese stock market to African stock markets increase, confirming the strong economic and financial relations between China and Africa (see Zheng, 2016). We note that spillovers between Chinese and African stock markets have increased significantly in recent years.

7. Conclusion

This paper provides a new insight of the interdependence between African and global stock markets in time and frequency (scale). We have been interested in these relationships especially during the recent turmoil (subprime financial crisis and European sovereign debt crisis) and the recent decline in oil prices. We examine the stock return transmissions between global stock markets, OPEC oil prices and the seven largest African stock markets.

The results show that the integration of the African financial markets with global stock markets and oil prices depends on the time scales, the economic relations and the state of the world financial markets (financial and economic turmoil). This integration with the global stock markets is generally weak in the small time scales but tend to grow at large time scales excepted for South Africa. Despite considerable progress and reforms, integration with outside remains generally weak and is only located at large scales. Concerning the integration between African stock markets specifically, it is also weak and located at large scales. We can argue that the various measures put in place to open and integrate the African stock markets have not worked well. Last years the integration between African stock markets did not grow. About African markets and oil prices relationship, the spillovers are high during oil prices shocks.

The combination with wavelets also confirm the results from studies on the African financial markets integration using the Diebold and Yilmaz (2012) method (see Fowowe and Shuaibu, 2016; Sugimoto et al., 2014). However our paper go further showing that global spillovers during the subprime financial crisis on the African financial markets vary according to the scale. Moreover, we have also shown that relations between African financial markets are not not static and evolve according to the timescales. It should be noted, however, that it would be possible to increase the number of scales, which would give even more detailed results.

Conclusions from this paper are relevant for portfolio diversification strategies and policy makers. Firstly, this strong integration specific at larges scales means that African stock markets excepted South Africa do not react immediately to world financial shocks. This long run integration could be an opportunity of capital diversification for financial agents in small time scales. Secondly this large scales integration could be explained by channels of transmission of the financial information flow between the African and external stock markets that are not sufficiently developed (non-efficient financial institutions and a low representation of African or world enterprises listed in African stock markets...). The authorities concerned should therefore redouble their efforts in view of the substantial economic advantages stemming from developed stock markets(Hicks, 1969; Levine, 1997; Calderón and Kubota, 2009).

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