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

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Abstract

This paper investigates the time and frequency interdependence relationship between seven African stock markets, emerging stock markets (Brazil, Russia, India, China), developed stock markets (United States, United Kingdom, France, Germany and Japan) and oil prices commodity. The spillovers are examined from 2005 to 2016 taking into account the recent financial crisis and the recent fall in oil prices. We combine the generalized VAR framework proposed by [Diebold and Yilmaz \(2012\)](#) method and the Maximal Overlap Discrete Wavelet Transform (MODWT) in order to obtain the spillovers at different time scales. Results show that African financial markets integration with themselves and the outside depends on the time scales, the economic relations, the world financial markets state. Relationships with global financial markets are generally weak in the short run but tend to grow in the long run. Concerning interdependence with oil prices, it is strong in short and medium run but weak in long run. African stock markets could be an opportunity of capital diversification in short run for world financial agents.

Keywords: African Stock Markets, Interdependence, Time Scales, Generalized VAR, Financial Crisis

JEL Classification: F3, C1, G1

1. Introduction

Globalization has been one of the main economic guidelines. Nexus between world economies through international trade, foreign direct investment, monetary integration and other channels increased significantly being thus the basis of a growing interdependence between global financial markets.

The process of almost complete liberalization of capital exchanges based on the 3D rule (Deregulation, Decentralization, Disintermediation) (see [Bourginat et al., 1992](#)) has allowed the growth of international capital flows.

However, these strong links and this interdependence showed some limits especially in times of financial turmoil.

During the financial crisis of 2007, the transmission of spillovers effects from one market to another become very fast driving to the turbulence in the world stock markets,

in the exchange market volatility and in others financial mechanism with negative impact in the global economy¹ (see [The Global Social Crisis, 2011](#)).

The European debt crisis in 2010 has had global consequences in the international economic due financial ties of the euro area. According to [Stracca \(2013\)](#), this crisis has led to an increase in global risk aversion, followed by significant negative returns, especially in the financial sector, and even in countries such as Germany and the United States².

More recently, the increase in the supply of oil to the United States, which began in 2008, has led to a worldwide price decline in the oil market, which has had a considerable impact on international trade, inflation, investment and growth of world economy (see [Hou et al., 2015](#)).

Despite this, these increased linkages between financial markets are not only unfavorable and even have several advantages also for emerging and developing countries. Some

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¹ Rising unemployment and a lower consumption and investment.

²Refuges safe in runs of the reaction of their government bond yields.

authors have highlighted the relationship between economic growth, financial development and financial integration.

Bagehot (1873), Hicks (1969) and Schumpeter (1912) argue that efficient financial institutions raise the capital productive and promote the technical innovation. According to Levine (1997), the financial market plays a pertinent role in growth, capital accumulation and economic development.

Moreover, Chinn and Ito (2005) and Calderón and Kubota (2009) demonstrate that the capital account opening contributes to the development of the financial system in run of efficiency, depth of the stock market, portfolio diversification, size, stability and liquidity of the financial markets.

Levine and Zervos (1998a) show that emerging stock markets become larger and more liquid after the entrance of foreign investment. Kim and Singal (2000) based on variance ratio calculation, find a greater efficiency of stock markets after opening to foreign investment.

Chinn and Ito (2002) and Klein and Olivei (2006) demonstrate also importance of the development of the financial institutional structure for a positive effect of financial openness on the local financial development.

An integrated financial market can be a means of financial development and therefore of economic growth. For African economies³, an openness to external financial markets is proving to be crucial. However, as some authors above are precise, a good institutional structure is also essential.

Recently various measures, reforms and policies have been put in place by African authorities with for purpose the development and opening of stock markets⁴ (see ARIA III, 2008; ARIA V, 2012; ASEA, 2015). The African financial horizon has experienced great change.

African financial market has boomed in runs of capitalization⁵, transactions, depth and quality of financial institutions (see ASEA, 2015).

Indeed apart from South Africa stock markets, recognized internationally we have financial markets such as Ghana, Kenya, Nigeria, Morocco and others who tend to be competitive. Ghana's stock exchange is elected the most performing financial market in the world in 2004. This African financial market growing and the increased integration between world financial markets highlighted in crises begs the

question of his effective relationship with the outside. there are some studies. Collins and Biekpe (2003a) suggest that the most integrated markets in Africa, which are Egypt and South Africa are suffered from contagion during Hong Kong's 1997 crisis. Collins and Biekpe (2003b) find that the interdependence of African financial markets in regional blocks are falling and excepted South Africa and Egypt, there is no integration with the global emerging markets. Wang et al. (2003) using co-integration and error correction model show that African stock markets have an integration which varies in time and that appears to decrease after the Asian crisis of 1997. Adjasi and Biekpe (2006) find a long-run unique relationships between African stock markets and also short-run dynamic returns from others African stock markets that affect South African and Ghanaian stock market. Agyei-Ampomah (2008) uses the measurement's method of the integration score market proposed by Barari (2004) and find low correlation levels between African markets themselves and with global stock markets. More recently Boamah (2013) through a multi-factor pricing model, indicates that the integration of African financial markets evolve through time. He underlines that this evolution may be the result of global economic conditions changing⁶. Sugimoto et al. (2014) using the 2012 Diebold and Yilmaz Spillovers Index⁷, demonstrate that the recent European crisis in its beginning, affects African stock markets. Fowowe and Shuaibu (2016)

These studies generally show that African stock markets are weakly integrated between them and with the outside. Furthermore, these studies have some limitations in their understanding of the relationship between financial markets. The only temporal aspect of their analysis is not very realistic given the nature of the financial markets.

Indeed stock market is a complex system composed of agents with different investment horizons together forming the movement market's dynamic. The frequency or investment scale (investment horizon) is therefore an aspect significant that influences the behavior of traders and then the stock market prices. Take into account the fact that many heterogeneous investors make decisions at different scales of time and perform their operations (see Candelón et al., 2009) according to them could give more information on the relationship between stock markets.

³Most in the process of development or emerging.

⁴Harmonization, common stock market, attractiveness...

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

⁶The level of openness and accessibility of African markets.

⁷See Diebold and Yilmaz (2012)

Moreover, the relationship between financial markets evolves over time. This relationship can be strong at a given horizon time and weak to another. The only temporal analysis is not able to apprehend all these parameters. Methods such as co-integration and the error correction model (see [Engle and Granger, 1987](#)), which are proved in the dynamic analysis between variables, take into account only two times scale, the short and the long run, which is rather limited in view of the various time scales (horizon) on a financial market.

The wavelet methods apprehend the relationship between stock markets simultaneous into time and frequency⁸. These methods analyze the relationship between stock markets at different time scales and allow then a better study of the dynamic evolution of the relationship between financial markets. This approach giving more details and a better understanding of the co-movement between financial markets is proving crucial for an efficient capital diversification and for financial authorities.

Some authors used this wavelets methods in the stock markets linkage analysis. [Gallegati \(2005\)](#) apply these wavelets methods among MENA⁹ stock markets and outside, [Rua and Nunes \(2009\)](#) among many world stock markets. [Graham and Nikkinen \(2011\)](#), [Fernández-Macho \(2012\)](#) between main European stock markets, [Graham and al. \(2012\)](#); [Graham et al. \(2013\)](#), [Madaleno and Pinho \(2012\)](#) in emerging and developed world financial markets relationship, [Tiwari et al. \(2013\)](#), [Loh \(2013\)](#) between Asian financial markets themselves and the outside and [Aloui and Hkiri \(2014\)](#) in Gulf Cooperation Council stock markets integration.

The objective of this study is to analyze the contribution of world financial markets and oil stock prices in the African stock markets at different times scales. We want to see if the measures put in place for an opening to global financial markets these last years are actually effective. We will also see the evolution¹⁰ of relations of the financial markets in Africa with outside in the midst of crisis or turbulence in the global financial market. Our study sample covers the 2007 global financial crisis, the 2012 Euro debt crisis¹¹ and

the oil prices shock of 2014¹².

In our paper, we combine traditional econometric methods with wavelet methods. Firstly We apply to every sample the Maximal Overlap Discrete Wavelet Transform method to have data of the stock markets data at different time scales. Then we apply the 2012 Diebold-Yilmaz spillover index method (see [Diebold and Yilmaz, 2012](#)) based on VAR¹³ method to determine the contribution of global financial markets and oil stock prices in African financial markets at different time scales during the hole period and also during different turmoil specifically. This approach could be beneficial for financial authorities to decision-making purposes.

We find that African financial markets integration with themselves and the outside (world stock markets and oil prices) depends on the time scales, economic relations, financial markets state. The integration with global financial market is generally weak in the short run but tend to grow in the long run. We find also the African markets and oil prices relationship is strong in short and medium run but weak in long run.

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

2. African Stock Markets Evolution

The African financial market has evolved very rapidly. Indeed to 12 in 1990, the number of African financial markets increased to more than 25 in 2016. More 2/3 of the African countries are currently covered by a local or regional exchange, with At the top of the list, South Africa, Egypt, Morocco, Nigeria and Kenya. According to data from [ASEA \(2015, 2012\)](#); [de France \(2011\)](#), we note that the capitalization of the 10 largest African stock markets¹⁴ recorded an exceptional growth of 390.77% from 2000 to 2010 and from 2011 to 2014 of 32%. [Table 1](#) shows the performance of the principal indices of some largest African

⁸Scale or horizon .

⁹Middle East and North Africa.

¹⁰It has been proved that in periods of instability on financial markets, relations between financial markets increase (see [Forbes and Rigobon, 2002](#); [McAleer and Nam, 2005](#))

¹¹Africa and Europe have strong economics relationship.

¹²Nigeria is the 1st African oil producer and the 4th largest world oil producer and South Africa is the largest African oil importer.

¹³Vector AutoRegressive.

¹⁴In runs of capital

stock markets from February 2012 to February 2016 excluding South Africa.

Africa Stock markets from this sample have globally reached good levels of performance excepted the Morocco stock market that is declining over the analysis period. According to [Cejefic Consulting \(2014\)](#); This decline is due to a low volume of transactions that dates from 2007¹⁵ due to lack of liquidity (turnover ratio weak). The Nigeria stock market has seen a rise of 15

The average performance is 40% for our sample and three of these financial markets have even performed beyond the 80% over a period of 4 years. The African financial market has also experienced an upsurge in IPO¹⁶. Indeed, we had 125 IPOs from 2011 to 2016 (raising \$6.1bn¹⁷). In only 2015, 28 companies listed on African stock markets raises \$1.991bn. Concerning, FO¹⁸ there have been more of 300 from African companies, raising \$35.2bn on both African and international stock markets (see [PwC, 2015, 2016](#)). According to [ASEA \(2015\)](#), The increasing number of IPOs in 2014 and 2015 means the enhancing of the African exchanges efficiency.

This growth and increased development of financial markets are part of the various reforms of the financial sector recently introduced by the African financial authorities [ARIA III \(2008\)](#); [ARIA V \(2012\)](#); [ASEA \(2015\)](#); [Rambaccussing \(2010\)](#).

Despite these dramatic advances, the African financial market remains marginal to other emerging financial markets. According to [PwC \(2015\)](#), the African stock market capitalization reach almost \$1tn¹⁹ at the end of 2015, with 77% of this value for only South Africa Stock and 23% for the rest of African financial market. The African financial market excluding South Africa represents only about 0.34% of the global market capitalization which is \$67tn. African financial markets remain very small opposite to the global finance and not very liquid. Moreover, we note a decrease of this percentage compared to the year 2011 which was of 0.94% ([Ntim, 2012](#)).

The 2014 capitalization-to-GDP and the turnover ratios of the 10 largest African financial markets in runs of capitalization give disparate results (see [Table 2](#)). Indeed stock

exchanges such as South Africa, Ghana, Morocco, Mauritius, and Egypt, to a lesser extent are relatively higher market capitalization in view of their economy and are rather deeper while the others remain rather illiquid. As regards turnover ratio (table), market activity according to the size of these markets, it remains very low for the majority of the African financial markets with the exception of Ghana, South Africa and Egypt. According to [Ntim et al. \(2011\)](#), the small size of some African financial markets hinders the informational and allocative efficiencies of the African stock markets (see [Mlambo and Biekpe, 2005](#)).

To remedy this, [Fish and Biekpe \(2002\)](#) argue that an African regional stock market can improve liquidity while reducing the cost of operations. [Irving \(2005\)](#) proposes an integration between African financial markets from different African economic zones, for a better depth and a more exhaustive selection of financial products.

According to [Lugangwa \(2012\)](#), cooperating, being integrated and therefore larger, African markets will be more visible to global investors. [UNCTAD \(2014\)](#) say that for the development of the African financial markets in view of their small size could be done on the continental or regional scale by their unification.

Among the reforms that are at the basis of the growth of the financial financial markets, many continue to be taken with a view to harmonizing the African financial markets and opening up to international capital. The African Securities Exchanges Association (ASEA)²⁰ was Established in 1993 in Kenya now has 25 securities exchanges in Africa. The goals of this association are to improve the visibility of African Securities at the world level to attract investors Provide a better knowledge of African stock market, promote trade between African financial markets themselves.

In this dynamic, 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. These indices could improve the visibility of the performance of African stock market and facilitate the development of new financial products ([ASEA, 2015](#)).

In 2014, the Nigerian Stock Exchange and the London Stock Exchange Group (LSEG) signed a partnership to develop the cooperation and promote mutual development

¹⁵Lower volumes of approximately 75 % from 2007 to 2012

¹⁶Initial Public Offering

¹⁷billion

¹⁸Futures and Options

¹⁹Trillion

²⁰URL: <http://www.african-exchanges.org/>

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.

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.

between the two stock exchanges. In 2013, the Bourse régionale des valeurs mobilières (BRVM) of West African Economic and Monetary Union (WAEMU) countries signed an agreement with Paris EUROPLACE. The FTSE Group and the Casablanca Stock Exchange signed a partnership in 2010 and launched the FTSE CSE Morocco

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 financial market for competitiveness and efficiency, 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).

In west Africa, Economic Community of West African States (ECOWAS) stock markets²¹ are working for closer cooperation and harmonization, to enhance market liquidity and deeper, and be more attractive for investors looking to invest across the region (ASEA, 2015). They are also analyze the creation of a harmonized listing and trading platform with 300 companies of each stock exchanges. Since

²¹BRVM, NGSE (Nigerian Stock Exchange), GSE (Ghana Stock Exchange), SSE (Sierra Leone Stock Exchange)

2014, East African Financial Markets²² initiated steps towards a harmonized capital market (see UNCTAD, 2014; PwC, 2015).

In Arab Maghreb Union (AMU) stock exchanges take measures to promote integration. Cooperation and partnership agreements have been signed by Libya, Morocco, Tunisia and Egypt in the technical and regulatory areas to enable investors to intervene on all markets in the region (ARIA III, 2008).

All these actions show the willingness of the financial authorities to have financial markets that are internationally competitive, integrated between themselves and with the financial world.

3. Literature Review

Papers focused in the relation between stock markets using the wavelet methods are recent. Some financial economists worked in this topic and make their contribution to this. Gallegati (2005) is one of the first authors to work in this domain, he studies the co-movement between five major MENA, the U.S.²³ and Eurozone financial markets at different time scales using the Maximal Overlap Discrete Wavelet Transform (MODWT). The author find that MENA²⁴ financial markets are neither regionally nor internationally integrated according to the frequency or the scale. Rua and Nunes (2009) use wavelet coherence method in his study on the stock markets integration among between Germany, Japan, U.K.²⁵ and U.S. and shows that the Japan financial market is weakly integrated with others and this integration varies according to the time scales. In the same continuity, Graham and Nikkinen (2011) show

²²Kenya, Uganda, Tanzania, Rwanda, Burundi

²³United States

²⁴Middle East and North Africa.

²⁵United Kingdom

that the co-movement between Finland and emerging regions stock markets is located in long-run but between Finland and developed world regions stock markets, it is present across all frequencies, with strong co-movement in short run. Thereafter, [Graham and al. \(2012\)](#) investigate the integration between emerging and U.S. financial markets, use the wavelet coherence method. Authors discover that the level of contagion varied by country. The U.S. had a low correlation with North Africa but presents a strong co-movement with Brazil, Korea and Mexico. They note also that at the beginning and during the financial crisis of sub-primes in 2007, the co-movement between stock markets relatively grow in short run. [Madaleno and Pinho \(2012\)](#) analyze U.K., U.S., Japan and Brazil stock markets relationship using the Morlet coherence wavelet and find like [Rua and Nunes \(2009\)](#) that the strong or the weakness of the co-movement depends of the time scales. Otherwise, [Fernández-Macho \(2012\)](#) proposes two new methods based on wavelet: the Wavelet Multiple Correlation and the Wavelet Multiple Cross-Correlation and uses them to study the Eurozone financial markets co-movement. He finds a strong correlation near perfect between Eurozone stock markets in the long run but show small inconsistencies between Eurozone markets appearing in high and medium frequencies arising out of the different agents interactions with different time horizon of investments in stock markets. His analysis put to the light through the wavelet multiple cross-correlation analysis that CAC40 tends to lead the rest of the Eurozone stock markets in short and medium run. Still in their dynamics research, [Graham et al. \(2013\)](#) uses wavelet squared coherence with simulated confidence bounds to study the integration between MENA and U.S. stock markets. They discovered a relationship, weak in short run but strong in long run. More recently, [Tiwari et al. \(2013\)](#) analyze nine Asian stock markets integration using the two wavelets methods proposed by [Fernández-Macho \(2012\)](#) and find that Asian stock markets are highly integrated in long run and comparatively less integrated in short and medium run. [Loh \(2013\)](#) works on the integration of Asia-Pacific stock markets with world stock markets using the wavelet coherence. The author show that generally the co-movement of Asia-Pacific stock markets with outside is strong at low frequencies(long run) and increase in financial crisis period. [Aloui and Hkiri \(2014\)](#) are in-

terested in GCC²⁶ emerging stock markets co-movement. By using wavelet squared coherence method, they find frequent changes in the relationship after crisis beginning for the GCC markets at relatively in short run and a strong co-movement among GCC stock markets during financial crisis. All these studies show the advantage of wavelets for a better analysis of the relationships between financial markets, which is more suited to the complexity of financial markets.

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 Maximum Overlap Discrete Wavelet Transform, then a description of The Diebold-Yilmaz spillover index method proposed by [Diebold and Yilmaz \(2012\)](#) and finally the asymmetric causality test methodology developed by [Hatemi-J \(2012\)](#).

4.1. Maximum Overlap Discrete Wavelet Transform (MODWT)

We use the MODWT to implement the stock markets returns data at different time scales (see [Percival and Walden, 2000](#)). Wavelet analysis localizes variations of signal or time series within time. Both the variability and their evolution in time can be captured by decomposing a time series into many time-scale or time-frequency. Maximum Overlap Discrete Wavelet Transform (MODWT) decompose times series in both time and frequency domain simultaneously.

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

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

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

where $j = 1, 2 \dots J$, the level of multiresolution and $J = \log_2(T)$; 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

²⁶Gulf Cooperation Council.

and $d_{j,k}$, the detailed wavelet coefficients (short run movements) capture local fluctuations in each scale over the entire period of a time series. $\Phi_{J,k}$ and $\psi_{j,k}$ are scaling and translation obtained from Φ and Ψ and are defined as follow

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

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

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

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

4.2. Diebold-Yilmaz spillover index method

We apply the method proposed by [Diebold and Yilmaz \(2012\)](#) to our wavelets coefficients at different times scales obtained from the stock markets returns data to analyze the contribution of global financial markets in African financial markets. The 2012 Diebold-Yilmaz spillover index method is an update of the anterior method proposed by [Diebold and Yilmaz \(2009\)](#). Here, the directional spillovers are measured in a generalized VAR framework that eliminates the possible dependence of the results to the ordering of variables.

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

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

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, $A_i = \Phi_1 A_{i-1} + \Phi_2 A_{i-2} + \dots + \Phi_p A_{i-p}$ with A_i , an identity matrix and $A_i = 0$ for $i < 0$.

The moving average coefficient allow a better understanding of the method. It is based on the decomposition of the variance for analyzing forecast error variance of each vari-

able throughout the entire study period. The variance decompositions 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 Yilmaz \(2009\)](#) method based on the Cholesky factorization depended on the order of variables But in the new method, the use of the generalized VAR framework of [Koop et al. \(1996\)](#) and [Pesaran and Shin \(1998\)](#), which are invariant to change in order solve this problem. The H-step ahead forecast error variance decomposition for $H = 1, 2, \dots$, using the generalized impulse responses is defined as follows.

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

where $i = j$ for own variance shares and $i \neq j$ for cross variance shares or spillovers with x_i and x_j , $i, j = 1, 2, \dots, N$, Σ 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 in another way.

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

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

We can calculate the spillovers index using the variances obtained.

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

The problem of variance decompositions invariant to the variables order being set, using standardized the elements of the generalized decomposition variance matrix we can calculate the directional spillovers from one market (i) to others,

from all other markets to one market (j) respectively.

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

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

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 Union²⁷ and Tunisia (TUSISE).

Table 3: Wavelet time scales analysis.

Wavelet Scales	Time Interpretation
Scale1	2-4 weeks
Scale2	4-8 weeks
Scale3	8-16 weeks
Scale4	16-32 weeks
Scale5	32-64 weeks

In emerging markets, we selected the BRIC²⁸, Brazil (Bovespa), Russia (RTSI), India (BSE Sensex) and China (SHCOMP²⁹). In the developed markets, we selected United States (S&P500), United Kingdom (FTSE100), France (CAC40), Germany (DAX) and Japan (Nikkei 225). Finally for commodity, we selected OPEC oil prices. We use weekly data. In view of the mismatch of open days between different financial markets, this choice is justified for a greater robustness of the results (see Sugimoto et al., 2014). Data sample covers the period from January 7, 2005 to June 29, 2016 (550 observations). We selected this data sample is because it covers the major financial crises of this last recent years: The world financial crisis of 2008, the European debt crisis in 2010 due to the strong economic relations between Africa and Europe and the fall in oil prices in 2014. Moreover this period of study takes into account too the recent development of African financial markets. All data were obtained from Bloomberg and Quandl database. The stock markets and OPEC oil prices returns were calculated as follows.

²⁷WAEMU.

²⁸Brazil, Russia, India and China

²⁹Shanghai Stock Exchange Composite Index

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

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

Several summary statistics of returns are reported in Table 4. They all have a positive mean. That means that the African financial markets and OPEC oil prices are profitable and generate profits. The RTSI has the largest standard deviation and therefore is the most volatile market of the studied panel while the TUSISE which has the lowest is the least volatile market. The analysis of skewness show a negative value³⁰ for all the returns excepted excepted that of the CAC40 which is positive³¹. These results indicate that there is more negative returns in these series than positive returns and that they would be more likely to experiment periods of negative returns than the CAC40. The high coefficient of kurtosis for all returns excepted for the CAC40 (*kurtosiscoefficient* < 0 ³²) reveals that their distributions have thicker than normal Gaussian distribution tails. The Jarque-Bera normality test confirms the skewness and kurtosis results with a *pvalue* < 0.05 for all the returns. In order to obtain market returns at different time scales, we compute the wavelet coefficients using the MODWT³³. 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 $\log_2(N)$ ³⁴ where N is the number of observations. However, since the wavelet coefficients become too small for large large scales, we stop to 5 decompositions or scales with 5 wavelet details and 1 smooth wavelet coefficient (long run dynamic).

Table 5 and Table 6 show the stationarity tests of stock markets returns at different time scales. The analysis of Table 5 indicates that for the smooth wavelet coefficient, The ADF test rejects the assumption of stationarity for most returns. The Philips-Perron test confirms the results obtained by the ADF test by rejecting the hypothesis of stationarity for all returns with the exception of MADEX. Moreover Table 6, the Phillips-Perron and ADF test reveals that for all time scales of the wavelets details, the returns of all our financial markets are stationary.

³⁰The thickest portion of their distributions is to the left

³¹The thickest portion of their distributions is to the right

³²Distribution has thinner tails than normal distribution

³³Maximum Overlap Discrete Wavelet Transform.

³⁴ $\log_2(550) = 9.10$

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 of smooth wavelet coefficient S_5 .

Variables	ADF (pvalue)	KPSS(T.stat)	PP (pvalue)
(S_5)			
BOVESPA	0.01865	1.2947	0.7686
BSE SENSEX	0.07935	0.5973	0.7542
BRVM10	0.01811	0.3452	0.77
CAC40	0.09523	0.3696	0.8311
DAX	0.06182	0.3191	0.8153
EGX30	0.03151	0.3994	0.7922
FTSE100	0.133	0.2965	0.8327
MADEX	0.0006377	0.0001490	0.0444500
NIKKEI225	0.1506	0.5168	0.8508
NGSE	0.1009	0.5455	0.9154
NSE20	0.06664	0.4071	0.8576
RTSI	0.5233	0.8436	0.7758
S&P500	0.1842	0.5591	0.8043
SSE	0.2242	0.4531	0.805
TOP40	0.2021	0.7185	0.7924
TUSISE	0.04396	2.078	0.7644
OPEC Oil prices	0.04812	1.0442	0.7882

The VAR stationarity hypothesis prevents us from using the smooth wavelet coefficients in our analysis. We will therefore focus on the 5 time scales of the wavelet details (see Table 3). With regard to the choice of the optimum VAR lag, we use the AIC and BIC on the original returns data (see). Based on the different criteria, we selected two lags. For the length of the rolling sample, we use 100 weeks³⁵ (about 2 years). For the length of the forecast period, we use the same as used in Diebold and Yilmaz (2009); Diebold and Yilmaz (2012), $H = 10$. We apply these approach at each scale.

6. Empirical Results

We first present the global results showing the mean of the spillovers between the different markets of our full sample on the interval studied at different scales using the spillovers table (see Table 9, Table 10, Table 7, Table 8 and Table 11). Then, we will be interested in the specific dynamics spillovers of the different markets and groups at different time scales on the African markets using the rolling sample analysis (Fig. 2, Fig. 3, Fig. 4, Fig. 5, Fig. 6, Fig. 7, Fig. 8,

Fig. 9, Fig. 11). To do this, we have separated our financial markets into different groups: developed markets³⁶, emerging markets³⁷ and the African markets³⁸ themselves and oil prices³⁹. As far as the relative spillovers from the different groups to African stock markets, we have calculated the average of their spillovers of each country composing them. For a better analysis, we will first analyze the table to get a general idea of the relations between the financial markets. Then we will split up in order to have the spillovers of different groups and individual financial markets on the African financial market and their dynamics over time and at different scales or frequencies.

6.1. Full Sample Analysis at different scales

The analysis of Table 9, Table 10, Table 7 and Table 8 shows that the spillovers between stock markets vary according to the time scale (see Table 3). The contribution of a market to the performance of a another market evolves according to the frequency or the time scale. This means that a variation in a market is explained at such a percentage after 2 to 4 weeks (scale 1), whereas after 32 to 64 weeks

³⁶United States, United Kingdom, France, Germany and Japan

³⁷BRIC: Brazil, Russia, India and China

³⁸South Africa, Egypt, Nigeria, Morocco, Kenya, WAEMU and Tunisia

³⁹OPEC oil prices

³⁵the choice of this window was motivated by the analysis of the financial crisis of 2007

Table 6: Stationarity Test Results from scale 1 to scale 5.

Variables	ADF(pvalue)	KPSS(pvalue)	PP (pvalue)
Scale1(D_1)			
BOVESPA	0.01	0.0055	0.01
BSE SENSEX	0.01	0.0168	0.01
BRVM10	0.01	0.0059	0.01
CAC40	0.01	0.0063	0.01
DAX	0.01	0.0055	0.01
EGX30	0.01	0.0116	0.01
FTSE100	0.01	0.0058	0.01
MADEX	0.01	0.0062	0.01
NIKKEI225	0.01	0.0057	0.01
NGSE	0.01	0.0102	0.01
NSE20	0.01	0.0063	0.01
RTSI	0.01	0.0055	0.01
S&P500	0.01	0.0068	0.01
SSE	0.01	0.0089	0.01
TOP40	0.01	0.0071	0.01
TUSISE	0.01	0.0096	0.01
OPEC Oil prices	0.01	0.0174	0.01
Scale2(D_2)			
BOVESPA	0.01	0.0216	0.01
BSE SENSEX	0.01	0.0101	0.01
BRVM10	0.01	0.0088	0.01
CAC40	0.01	0.0097	0.01
DAX	0.01	0.0087	0.01
EGX30	0.01	0.0383	0.01
FTSE100	0.01	0.017	0.01
MADEX	0.01	0.0062	0.01
NIKKEI225	0.01	0.009	0.01
NGSE	0.01	0.0067	0.01
NSE20	0.01	0.0148	0.01
RTSI	0.01	0.0073	0.01
S&P500	0.01	0.0089	0.01
SSE	0.01	0.0122	0.01
TOP40	0.01	0.009	0.01
TUSISE	0.01	0.0144	0.01
OPEC Oil prices	0.01	0.0073	0.01
Scale3(D_3)			
BOVESPA	0.01	0.0086	0.01
BSE SENSEX	0.01	0.0061	0.01
BRVM10	0.01	0.0043	0.01
CAC40	0.01	0.0091	0.01
DAX	0.01	0.0074	0.01
EGX30	0.01	0.0245	0.01
FTSE100	0.01	0.004	0.01
MADEX	0.01	0.0062	0.01
NIKKEI225	0.01	0.0098	0.01
NGSE	0.01	0.0111	0.01
NSE20	0.01	0.0113	0.01
RTSI	0.01	0.0058	0.01
S&P500	0.01	0.0054	0.01
SSE	0.01	0.0043	0.01
TOP40	0.01	0.0118	0.01
TUSISE	0.01	0.004	0.01
OPEC Oil prices	0.01	0.0088	0.01
Scale4(D_4)			
BOVESPA	0.01	0.0142	0.01
BSE SENSEX	0.01	0.0053	0.01
BRVM10	0.01	0.0063	0.01
CAC40	0.01	0.0069	0.01
DAX	0.01	0.0051	0.01
EGX30	0.01	0.0287	0.01
FTSE100	0.01	0.0053	0.01
MADEX	0.01	0.0062	0.01
NIKKEI225	0.01	0.0064	0.01
NGSE	0.01	0.0189	0.01
NSE20	0.01	0.0053	0.01
RTSI	0.01	0.0089	0.01
S&P500	0.01	0.0044	0.01
SSE	0.01	0.0053	0.01
TOP40	0.01	0.0055	0.01
TUSISE	0.01	0.0074	0.01
OPEC Oil prices	0.01	0.0092	0.01
Scale5(D_5)			
BOVESPA	0.01	0.0505	0.01
BSE SENSEX	0.01	0.0247	0.01
BRVM10	0.01	0.0276	0.01
CAC40	0.01	0.0163	0.01
DAX	0.01	0.0166	0.01
EGX30	0.01	0.0175	0.01
FTSE100	0.01	0.0222	0.01
MADEX	0.01	0.0062	0.01
NIKKEI225	0.01	0.0222	0.01
NGSE	0.01	0.0314	0.01
NSE20	0.01	0.0347	0.01
RTSI	0.01	0.0263	0.01
S&P500	0.01	0.0234	0.01
SSE	0.01	0.0398	0.01
TOP40	0.01	0.0198	0.01
TUSISE	0.01	0.025	0.01
OPEC Oil prices	0.01	0.033	0.01

(scale 5) it is another percentage. The market, the most influential in our sample, is surprisingly Russia, whatever the

scale. The Russian market contributes more than all other markets in the sample. This contribution varies according to the time scales and reaches its maximum at scale 2 (4 to 8 weeks). However the Russian financial market is not the most open to the outside. The spillovers received from other markets ranged from 68.1% to 71.9% of its variance as the time scale evolved. Concerning spillovers received from other markets, the emerging and developed financial markets are the most open of our sample with in the top of the list the U.K stock market. The U.K financial market receives the most from other markets and those at almost all scales except the scale 4 or the U.S stock market receive the most contribution. The markets with the fewest spillovers vary according to time scales. At scale 1.4, it is Nigeria financial market, at scale 2.5, it's the WAEMU stock markets. At scale 3, the two countries are also the least open to the others stock markets of the panel.

The African financial market most open to spillovers from others stock markets and which contributes most to the markets of our panel is South Africa financial markets excepted at the scale 4 or the Egypt stock market contributes even more than this.

We see that the contributions of emerging and developed markets to African markets increase with time scales. We note that the Japanese financial market explains the African financial markets more than the others from scale 1 to scale 4. After about a year (scale 5), the spillovers emitted from the Japanese markets fall drastically. The South African financial market is the most integrated african financial market with world finance. It receives the most of spillovers from others at almost all scales except at scale 4, or the variations in the Nigerian financial market explained by the BRIC are higher than those of South Africa. Regarding the contributions of the global and African financial markets to the African financial market as a whole, we will carry out a scale by scale analysis.

At scale 1 (2-4 weeks), we find that, on average, developed markets contribute more to African financial markets than other African financial markets and the BRIC. The African financial market is the second largest contributor. The variations in South Africa are explained at 38.4% by the developed markets, 27.9% by the BRIC and only 8% by the African financial markets, besides itself. WAEMU markets come second with 17.7% of these fluctuations explained by developed markets. Nigeria and Kenya are the

least open financial markets to developed financial markets. In runs of relations with emerging markets, the Moroccan market occupies the second place 11.9% of these variations explained by the BRIC. The Nigerian and Kenyan markets are still the least open with respectively 6.3 % and 5.3 % of spillovers received from the BRIC. As for the contributions of the African markets, among themselves, we find that they are generally rather weak. Tunisia is the most open market to the African financial market with 18.5% besides its own fluctuations explained by it. Nigeria is the least open market to the African financial market with 6.5% of contributions received. As regards oil prices, the markets of South Africa and UEMOA are the ones with the largest contributors, respectively, with 6.7% and 6.3% respectively. Fluctuations in the Nigerian financial market are only explained at 3.5%.

At scale 2 (4-8 weeks), fluctuations in the African financial market are on average explained more by the emerging financial markets than other financial markets developed and African ⁴⁰ of the panel. However, there are some changes. The variations in the South African market are now explained at 45.8% by the developed markets, 31.1% by the BRIC and 2.8% by the African financial markets, which makes the less open African financial market. The Egyptian market is now in second place with 19.4% of its variations explained by developed markets. As for the BRIC, it now accounts for 21.5% of the variations in Nigeria, which comes second in relations with the emerging countries. The least open African stock markets with emerging markets are Tunisia and UEMOA with respectively 13.8% and 8.5% of their variations coming from the BRIC. The Moroccan and Tunisian stock markets are the most open to the contribution of the African markets with respectively 22.9% and 21.9% of their fluctuations explained by them. Moreover, this openness is the consequence of a strong contribution from Egypt in the fluctuations of these markets ⁴¹. The Kenyan and Nigerian financial markets are those where oil prices contribute the most with respectively 5.3% and 5.1%. The Nigerian Financial Market is the one with the least contribution of oil prices (only 1.1%).

At scale 3 (8-16 weeks), most of the changes in the African financial market are on average explained again by the con-

tributions of the financial markets developed. African financial markets contribute less than BRIC and developed markets to other financial markets. The fluctuations in the South African financial markets are explained at 49.3% by the developed markets, 25.7% by the BRIC and only 3% by the African financial market. The Nigerian market is the least open African market to developed markets with only 2.7% they explain. The BRIC contribute respectively to 16.6% and 16.5% to fluctuations in the Moroccan and Kenyan markets. Kenya is the most open African market to others African financial markets of the Panel with 23.2% of their contribution in its fluctuations including 13.6% from Egypt stock market. Tunisia followed by South Africa and Nigeria with the same level of spillovers, are the most open African financial markets to the oil prices spillovers (respectively 2.6% and 2.4%). The least open market is the Moroccan market (only 0.4%).

At scale 3 (8-16 weeks), most of the changes in the African financial market are explained again by the contributions of the developed financial markets. African financial markets contribute less than BRIC and developed markets to African financial returns. The fluctuations in the South African financial markets are explained at 49.3% by the developed markets, 25.7% by the BRIC and 3% by the African financial market. South Africa is the least open market to other African financial markets. The Nigerian market is the least open to developed markets with only 2.7% of their contribution. The BRIC contribute respectively to 16.6% and 16.5% of fluctuations in the Moroccan and Kenyan markets. Kenya is the most open African market to other African financial markets of the Panel with a contribution of 23.2% in its fluctuations including 13.6% of Egypt only. Tunisia followed by South Africa and Nigeria with the same level of spillovers, are the most open African financial markets at oil prices (respectively 2.6% and 2.4%). The least open market is the Moroccan market with only 0.4%.

At scale 4 (16-32 weeks), emerging markets contribute more than developed markets to fluctuations in African markets. The South African financial market receive 42.6% of its movements from the developed financial markets, 30.7% from the BRIC and 9.1% from African stock markets. The market that receives the most contribution from developed financial markets after South Africa is Egypt with 23.8% of contribution received. Morocco becomes the most open African market to emerging markets (33.6% of its fluctu-

⁴⁰African financial markets give the fewest spillovers to the African financial market

⁴¹11.9 % for Morocco and 7.2% for Tunisia

tuations explained by the BRIC). The Tunisian market is the least open to the BRIC (8.4% of its fluctuations explained by the BRIC) but the most open to the contributions of the African financial markets (41.1% of its fluctuations explained by the African markets of which 21.5% Egypt only). The South African market is still the least open African market to the African financial market. The WAEMU's financial market is the African market which receives the most oil spillovers (9.6% of its variations). Nigeria receives only 0.1% of oil prices spillovers.

At scale 5 (32-64 weeks), emerging financial markets contribute more to African financial market. South African stock market are explained by 38.9% from developed financial markets, 29.0% from emerging countries and 12.4% from African financial markets. Nigeria is the financial market whose fluctuations are mostly explained by emerging markets, 34.8%. Morocco is the market that contribute least to other African stock market but also the least open to developed markets (only 5.7% of its fluctuations that they explain). The UEMOA financial market is the one with the least contribution from BRIC, only 2 % of its fluctuations. Regarding the contributions of the African market, we note that Morocco receives more contribution in its variations of other African financial markets (32.8%). South Africa remains the African financial market with the least spillovers from other African markets. Oil prices contributed 7.3% to the Kenyan financial market (the most open African market to the contribution of oil prices). The African financial markets the least open to oil prices spillovers are Morocco and Tunisia (0.1% of spillovers for each of the markets).

Spillovers to financial markets vary according to the time scale. The BRIC contribute greatly to the fluctuations of the African financial markets. Markets developed in the short run therefore explain the African financial markets. However, as time scales increase, BRIC are increasingly contributing to African financial markets. African financial markets are weakly integrated among themselves. However, the spillovers between them is rather low. However, over time scales (1 to 5), the average contribution of other African financial markets increases⁴². Whatever the scales, Morocco and Tunisia are the markets most open to other African markets spillovers and Egypt is the market that contributes most to other African financial markets.

⁴²from scale 1 to scale 5, respectively, from 12.8% to 19.4% (See table for more details)

We note, moreover, that the Nigerian financial market, despite its status of leading producer of oil in Africa, is only slightly explained by oil, except at scale 4. This may be due to the fact that the market is very weakly open to World finance (Emerging and developed markets), that are generally heavily priced at oil prices⁴³) or the low oil company representation in the NGSE index All Shares⁴⁴.

⁴³Huang et al. (1996)

⁴⁴only 10% of the Total capitalization

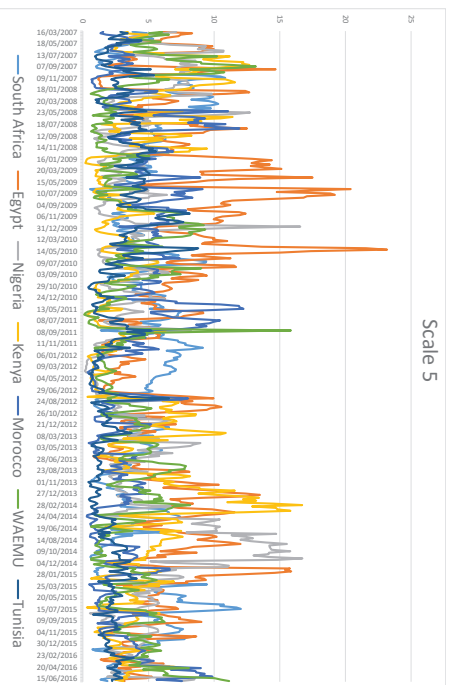
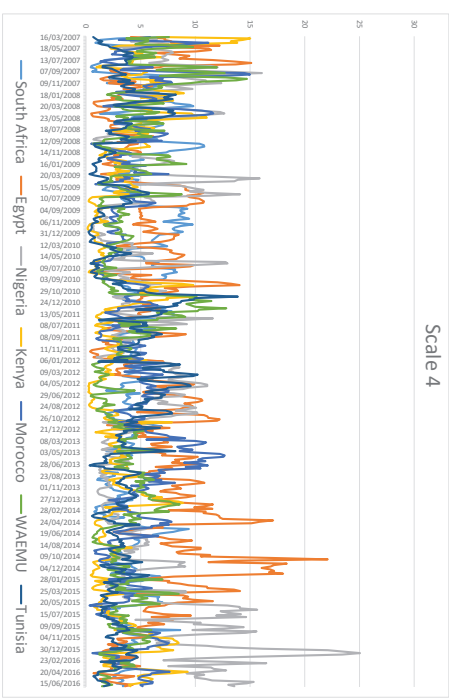
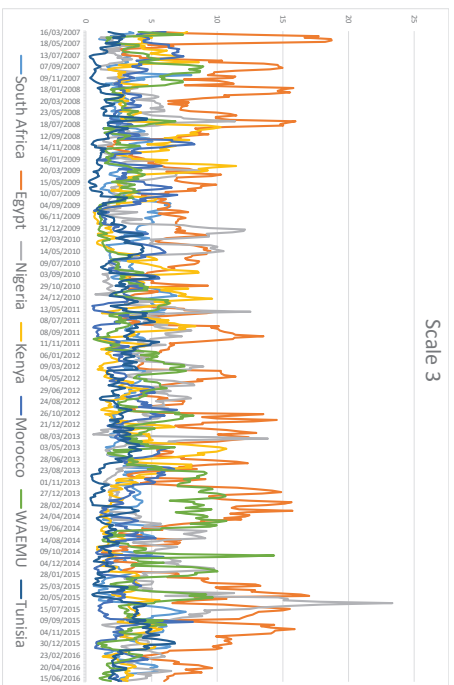
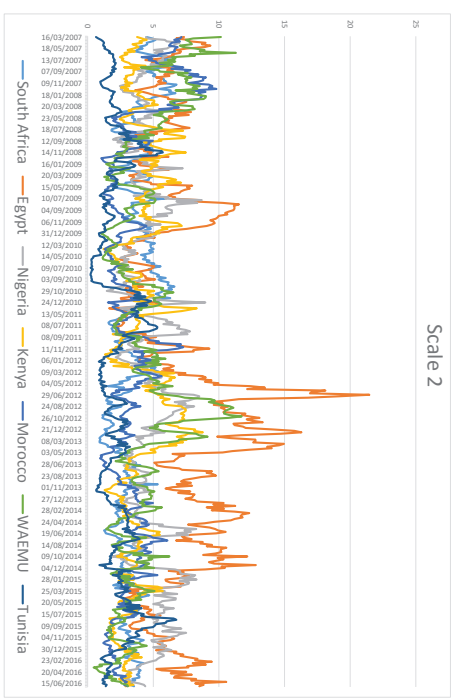
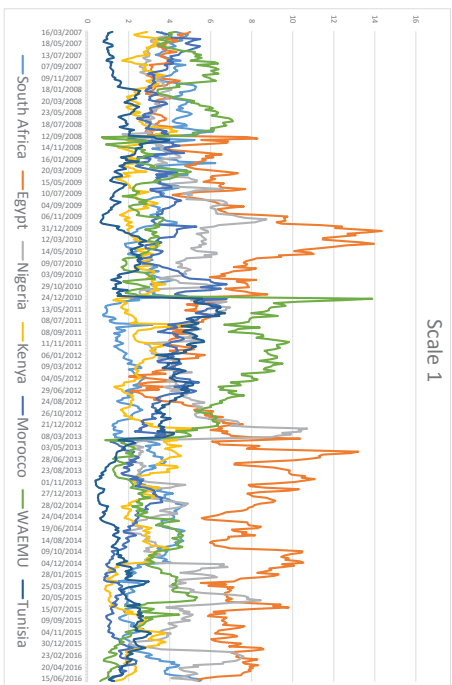


Fig. 1: Spillovers from individual African stock markets to African region stock market at scale 1,2,3,4,5

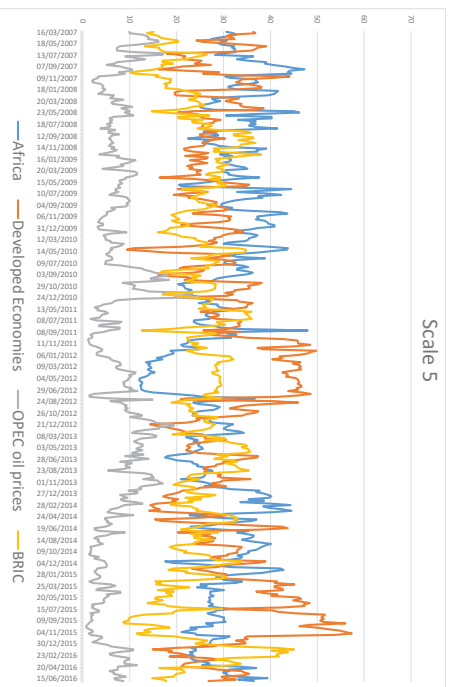
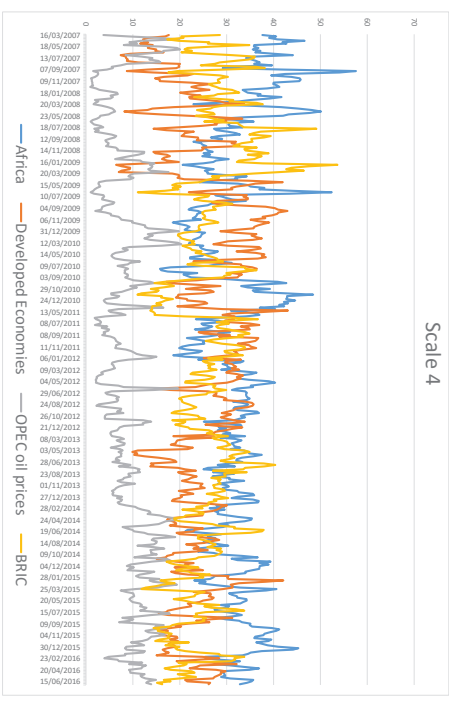
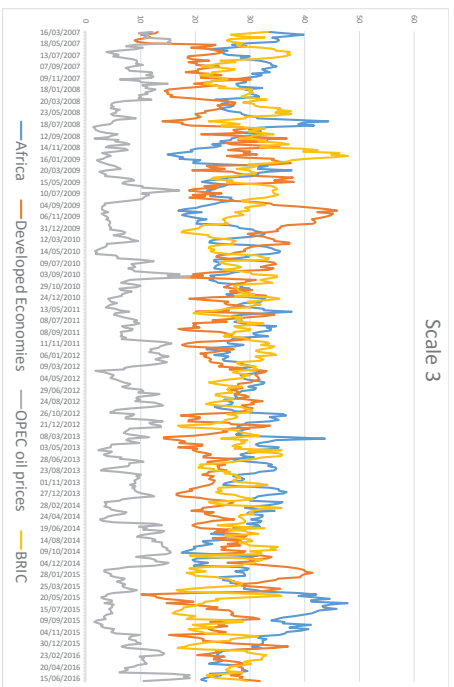
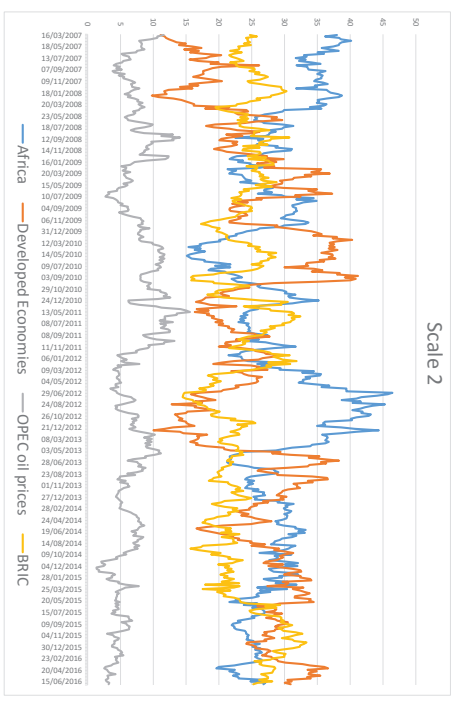
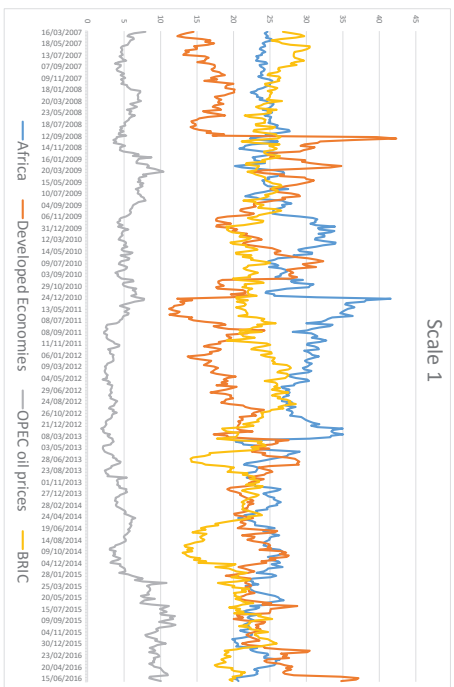


Fig. 2: Spillovers from world groups stock markets and oil prices to African stock markets at scale 1,2,3,4,5

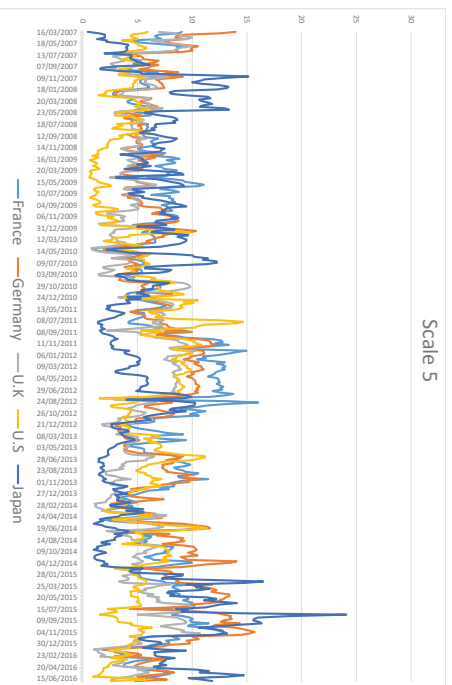
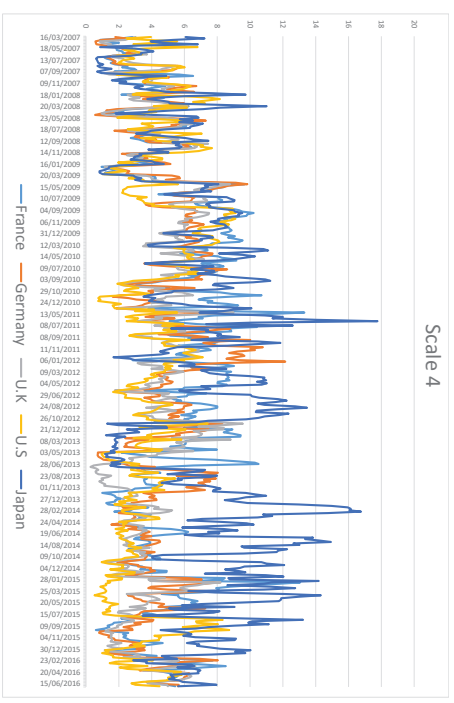
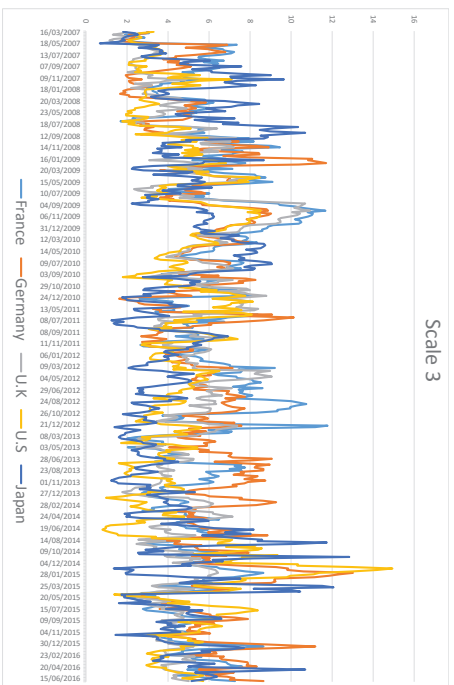
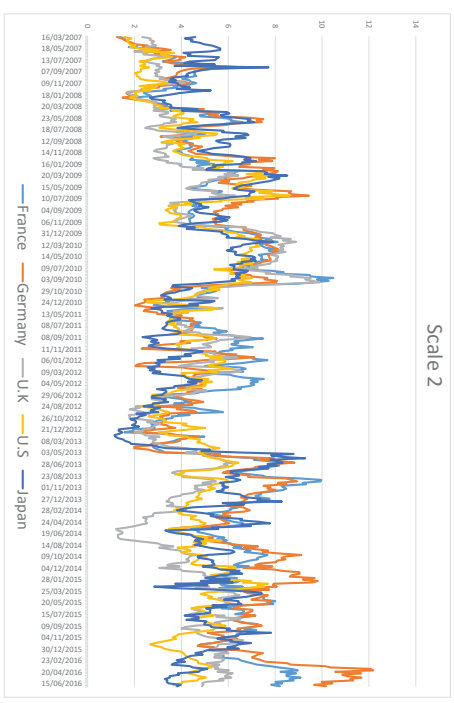
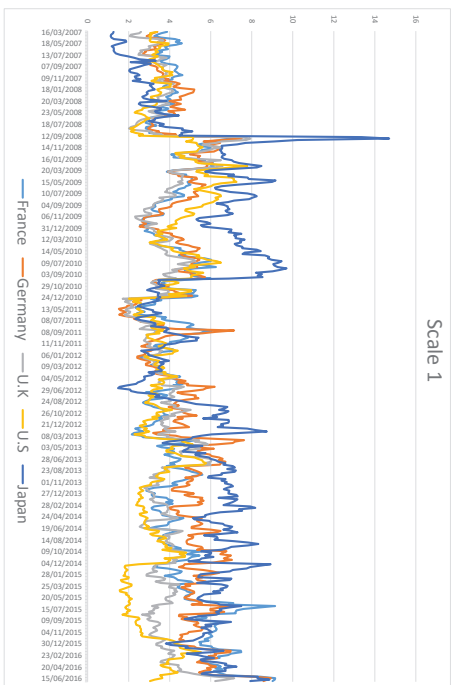


Fig. 3: Spillovers from developed economies to African stock markets at scale 1,2,3,4,5

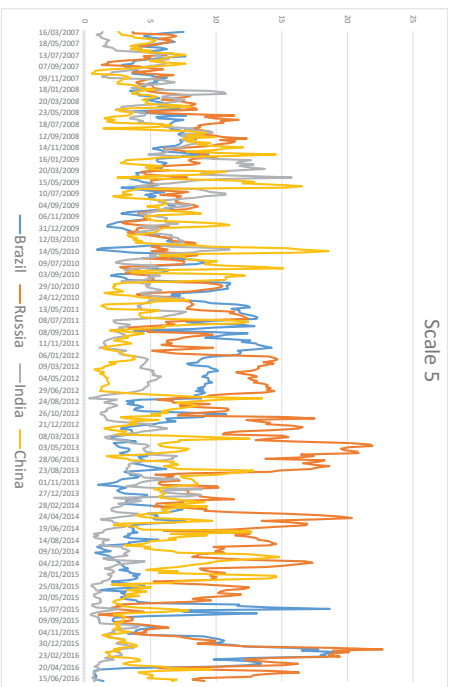
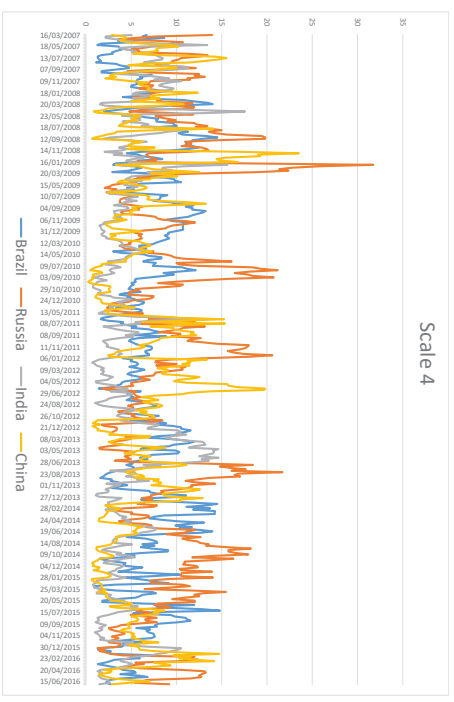
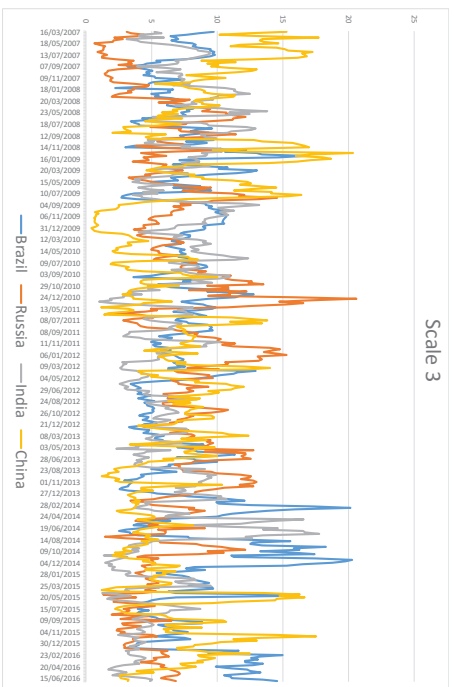
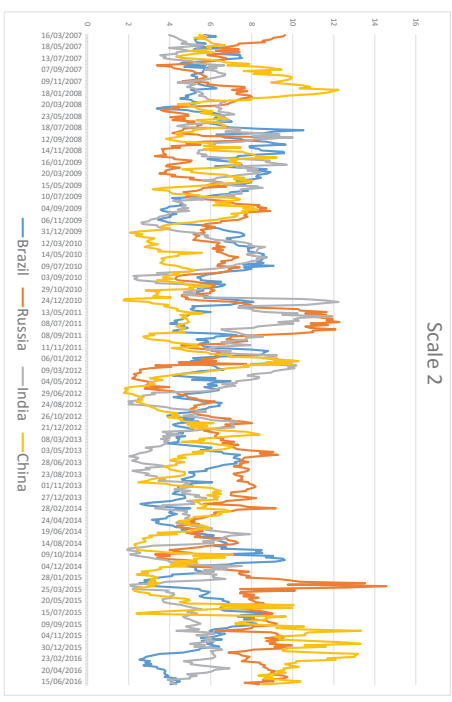
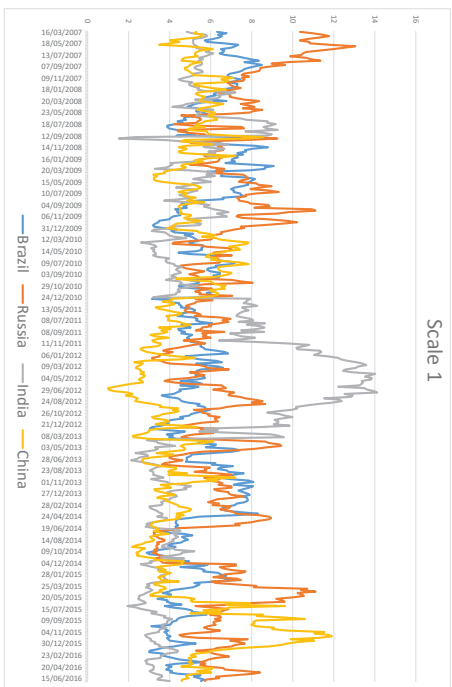


Fig. 4: Spillovers from BRIC stock markets to African stock markets at scale 1,2,3,4,5

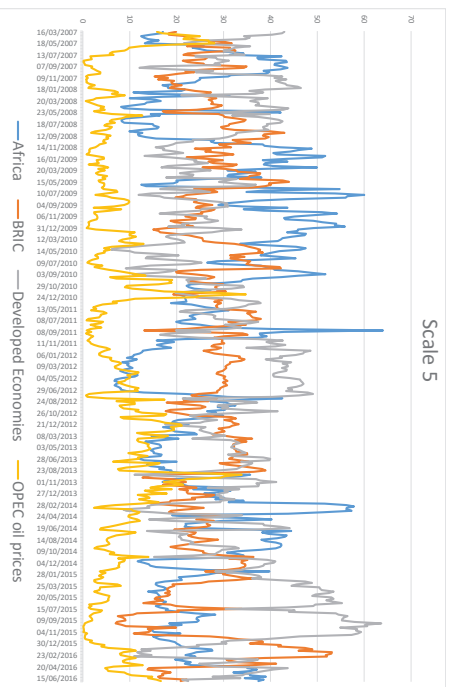
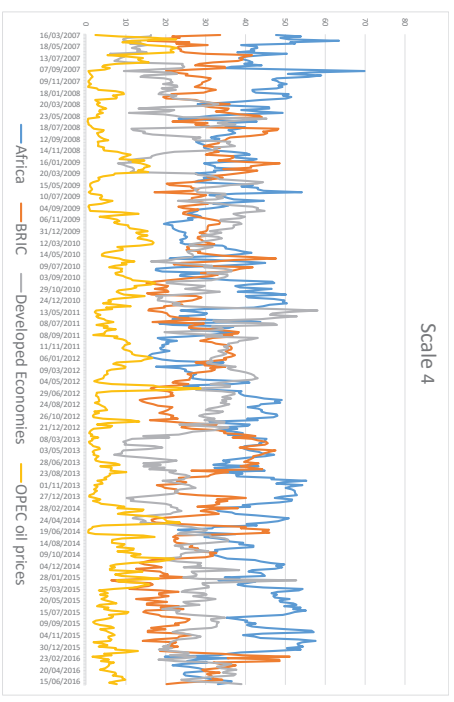
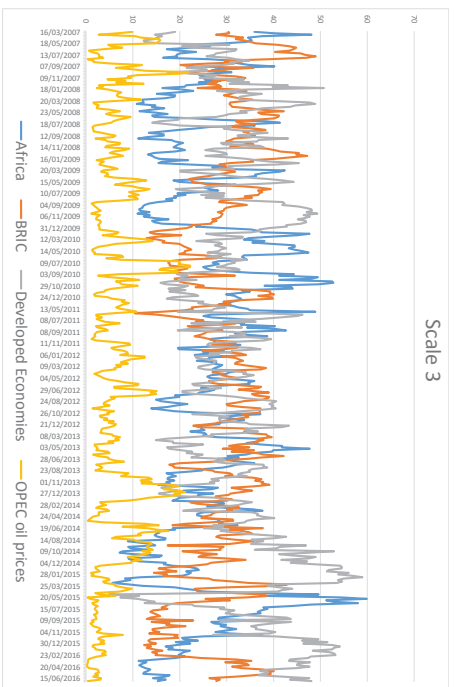
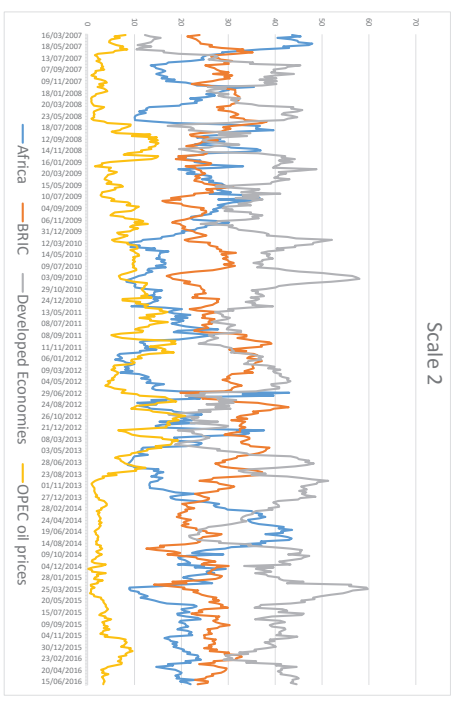
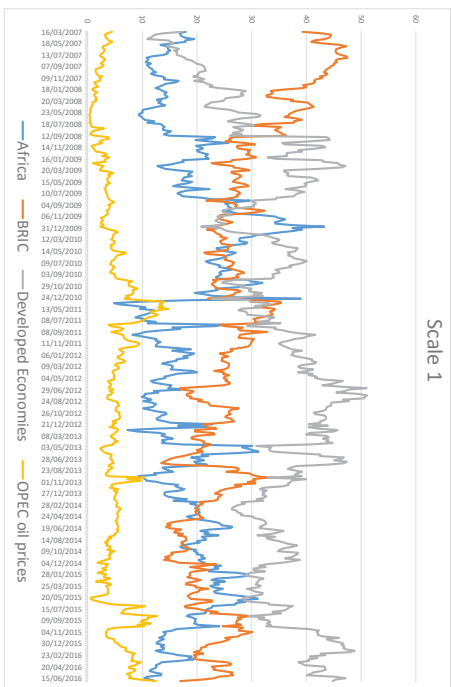


Fig. 5: Spillovers from world groups stock markets and oil prices to South Africa stock market at scale 1,2,3,4,5

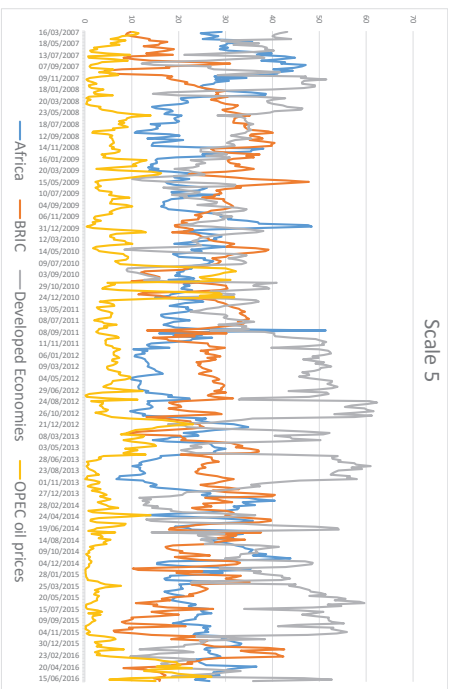
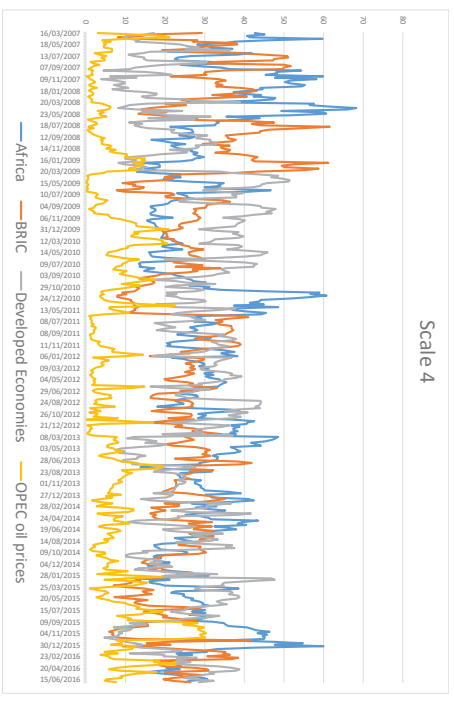
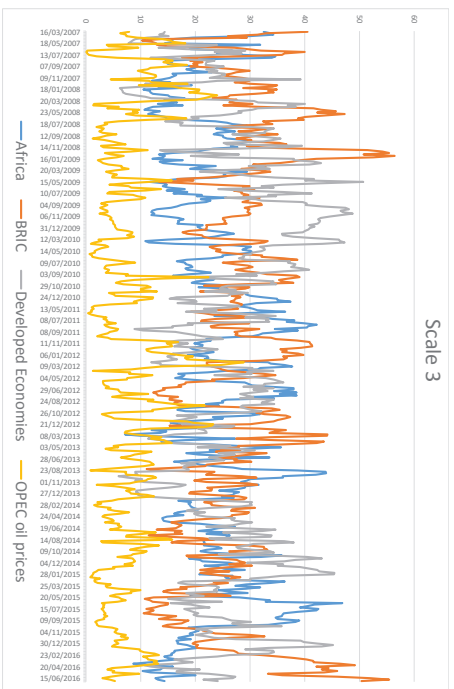
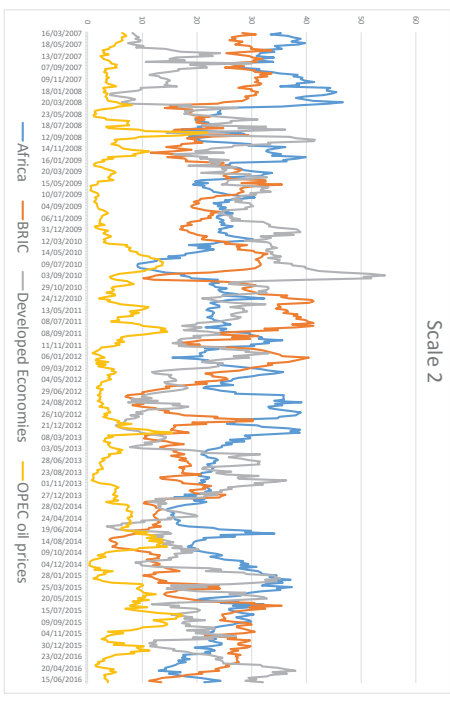
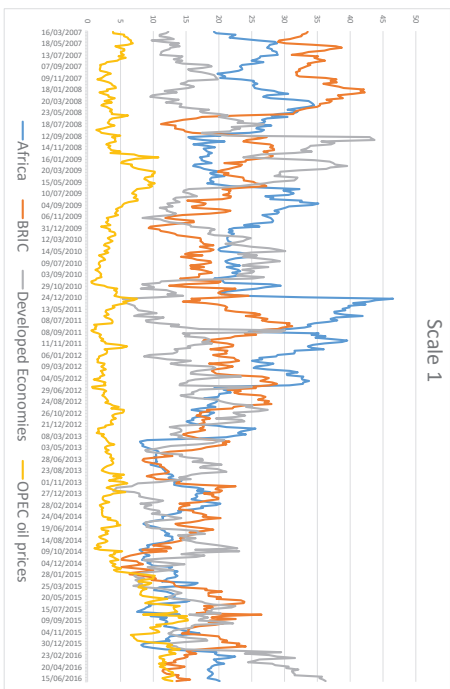


Fig. 6: Spillovers from world stock markets and oil prices to Egypt stock market at scale 1,2,3,4,5

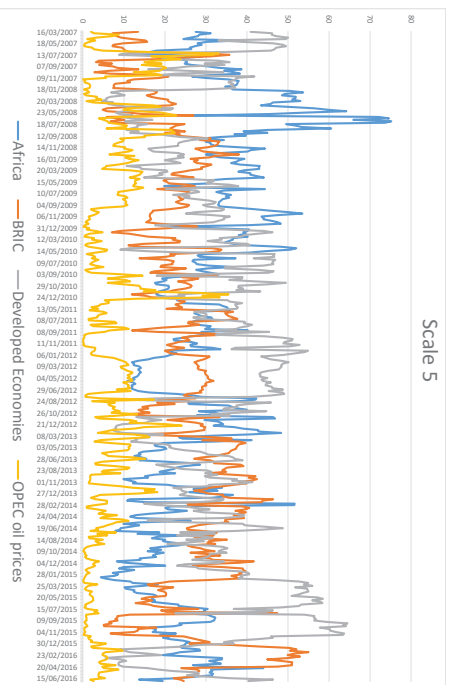
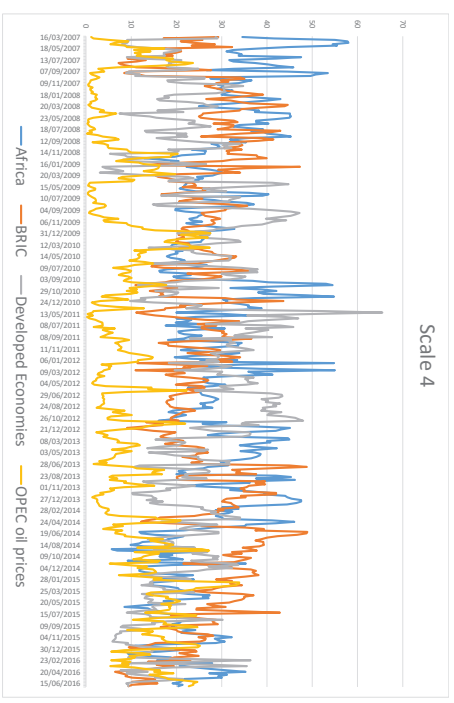
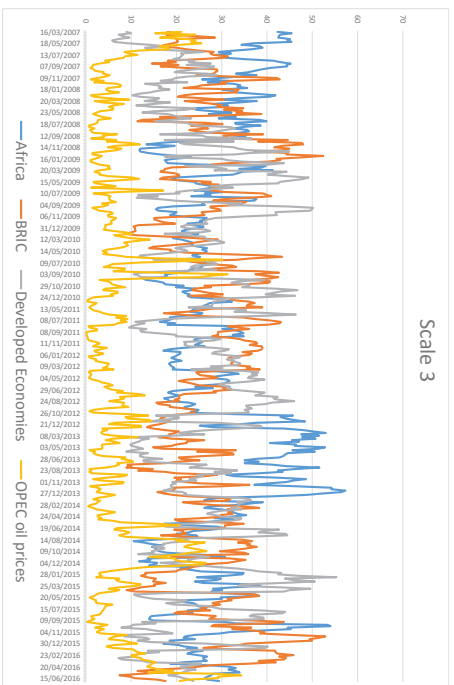
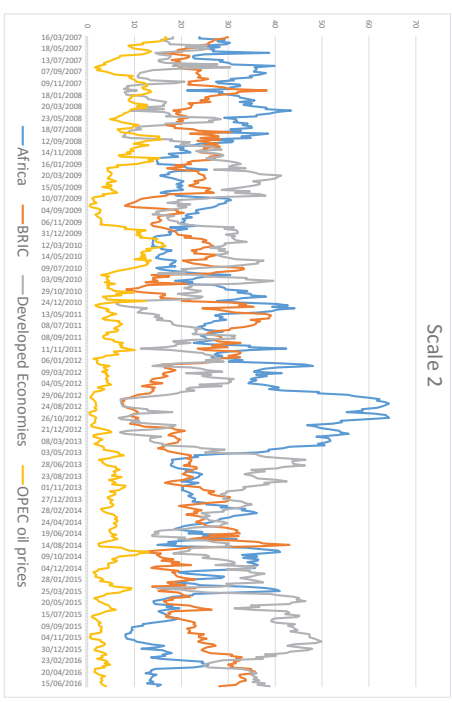
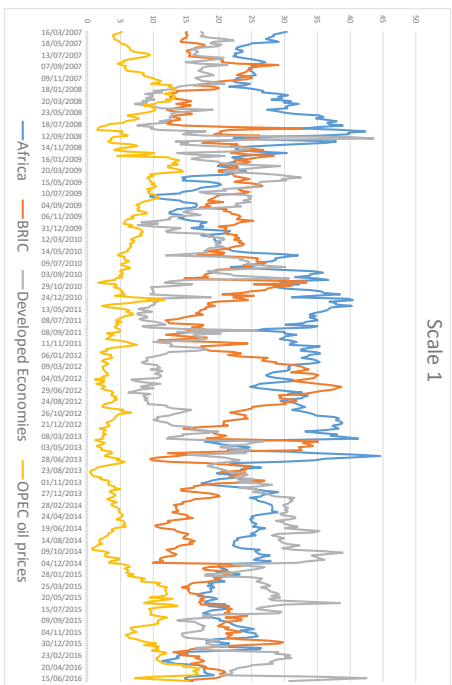


Fig. 7: Spillovers from world groups stock markets and oil prices to Nigeria stock market at scale 1,2,3,4,5

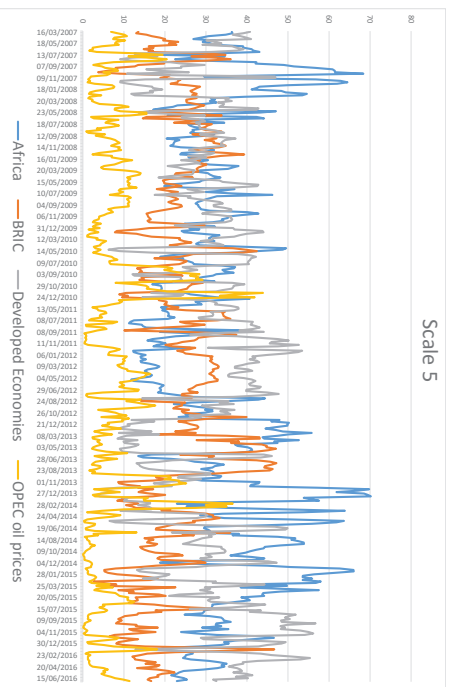
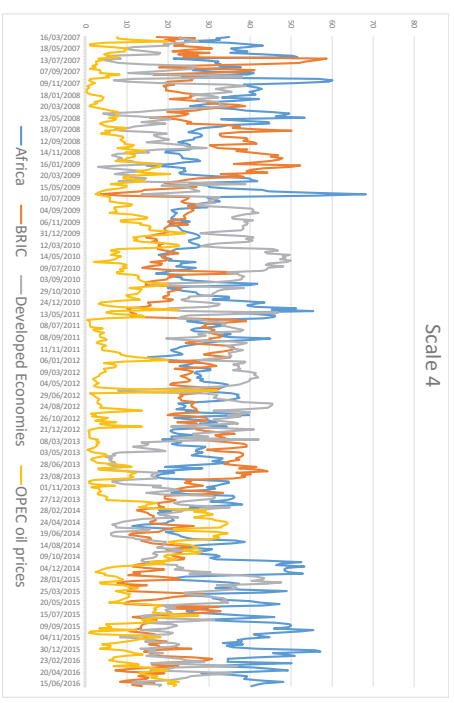
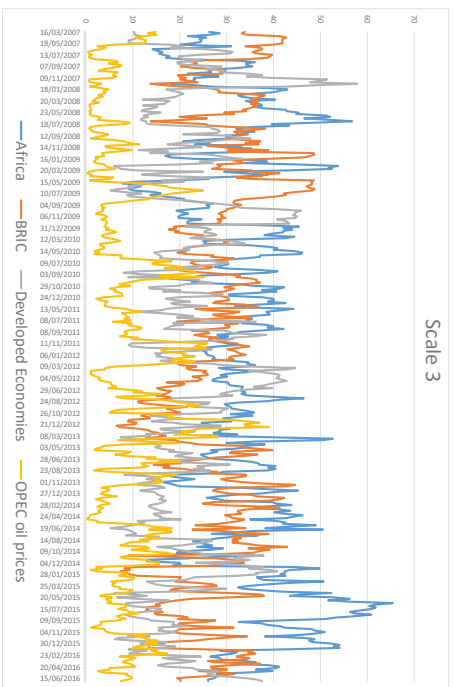
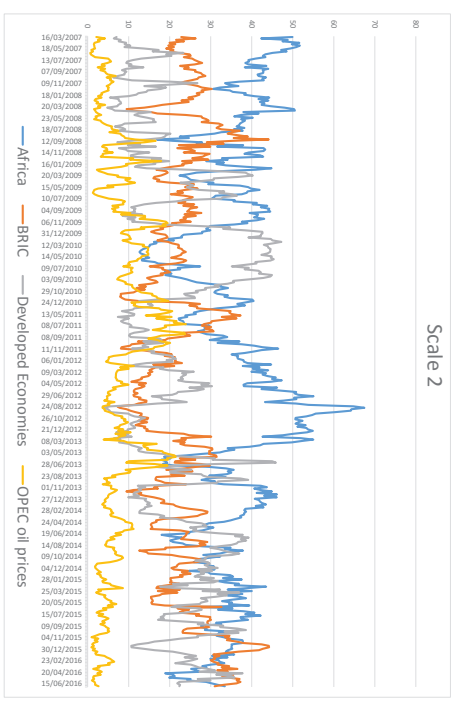
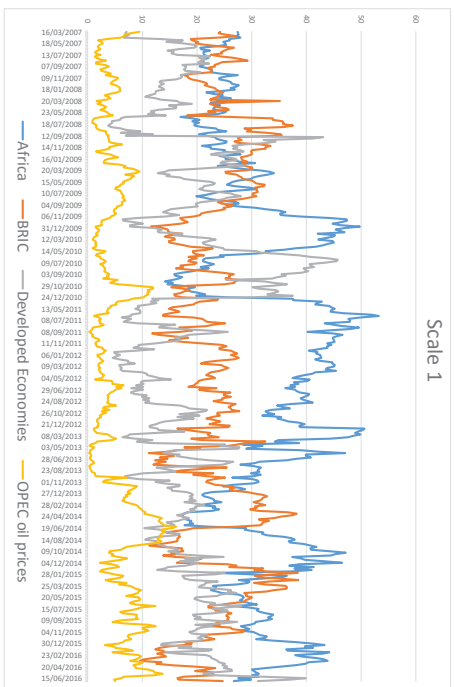


Fig. 8: Spillovers from world groups stock markets and oil prices to Morocco stock market at scale 1,2,3,4,5

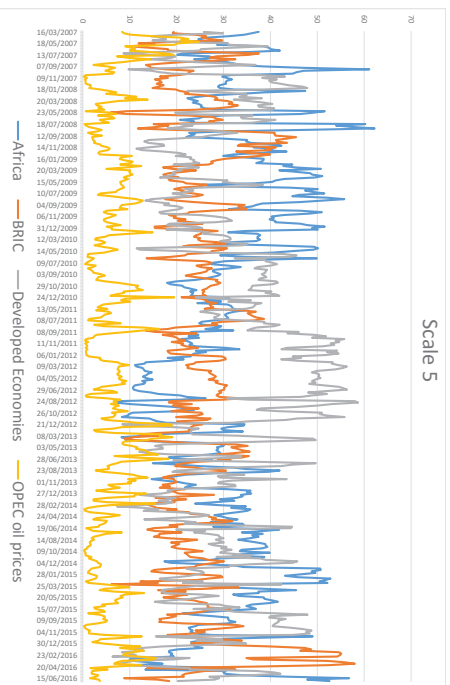
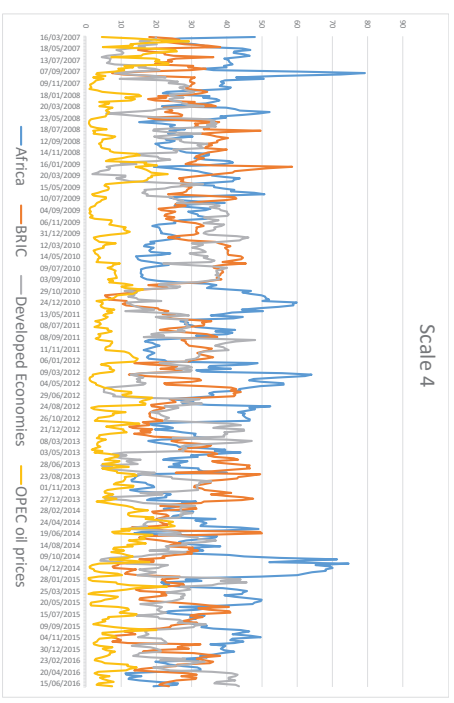
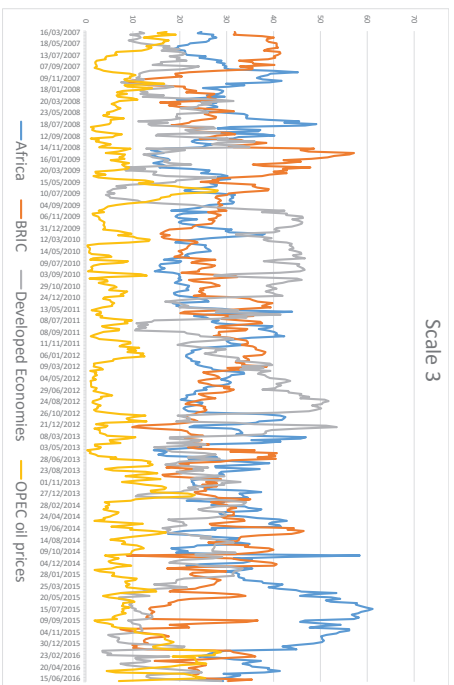
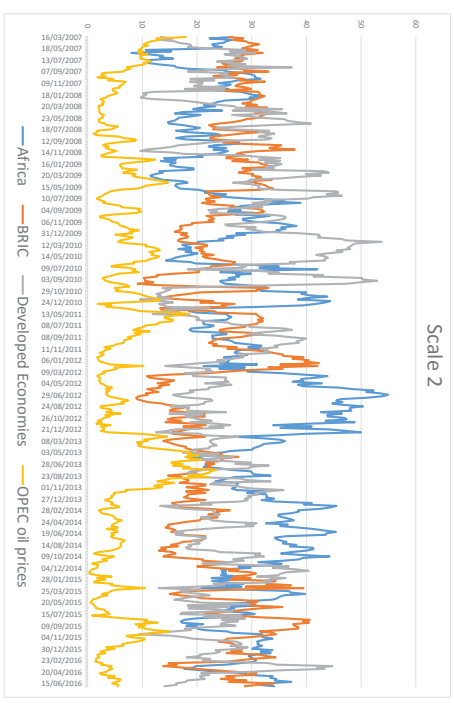
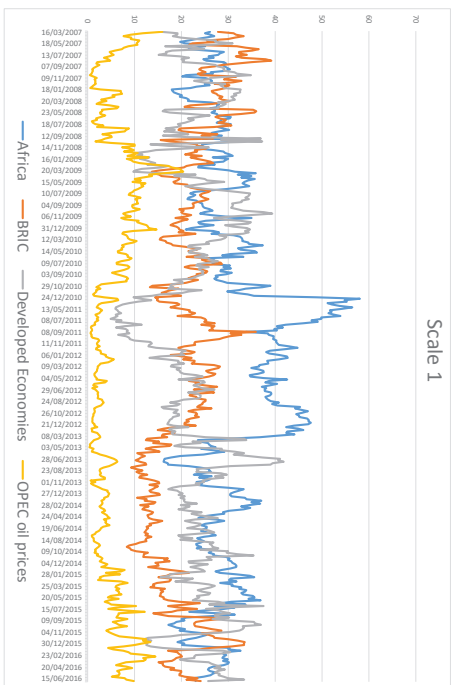


Fig. 9: Spillovers from world groups stock markets and oil prices to Kenya stock market at scale 1,2,3,4,5

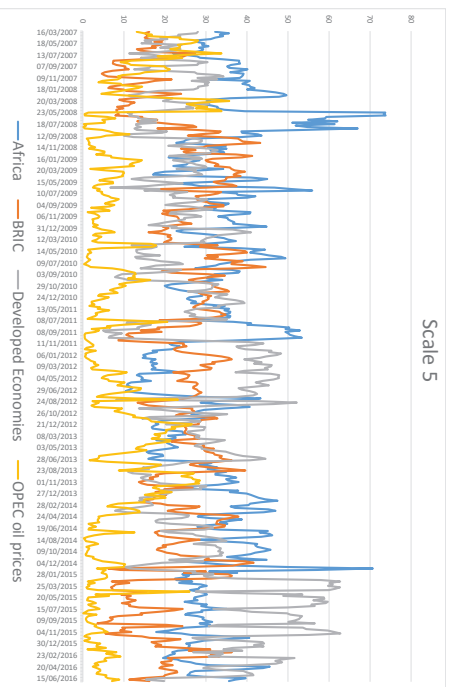
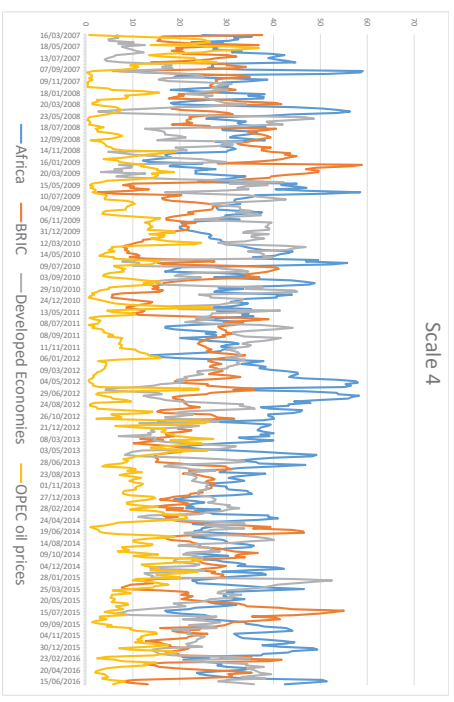
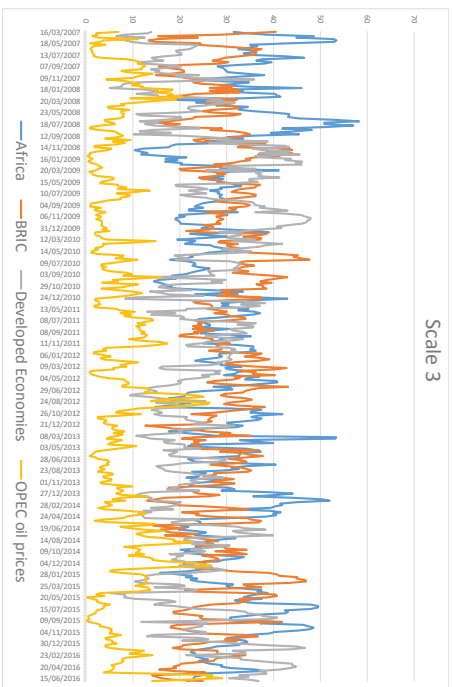
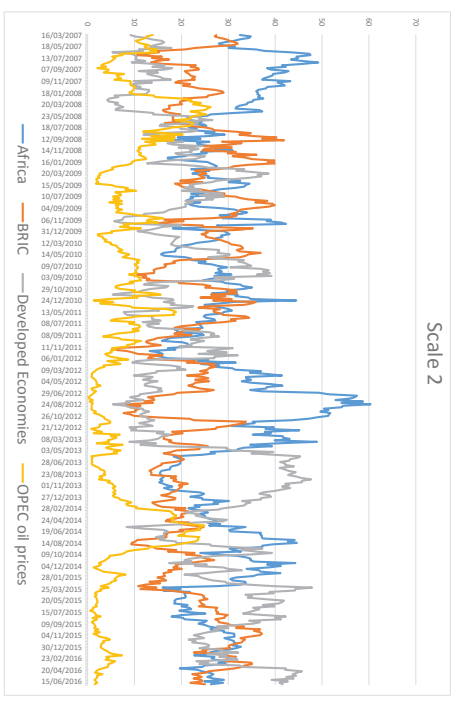
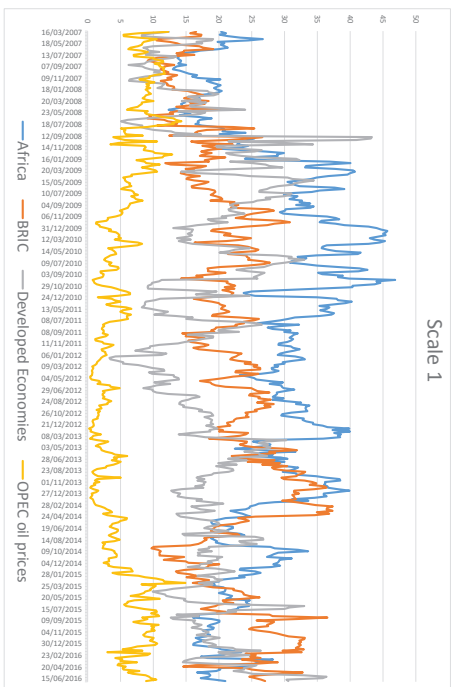


Fig. 10: Spillovers from world groups stock markets and oil prices to WAEMU stock market at scale 1,2,3,4,5

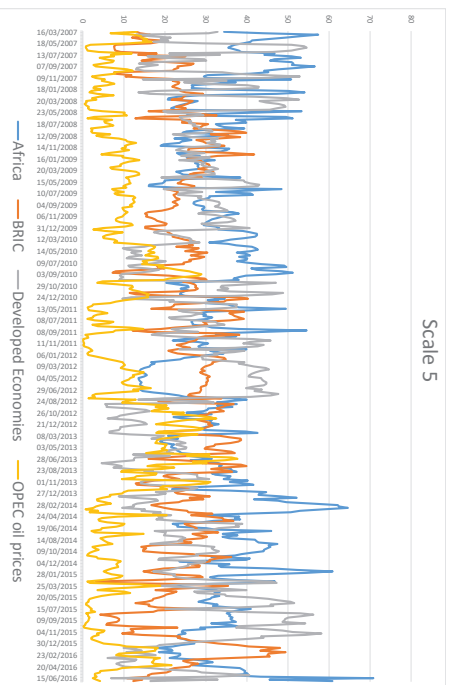
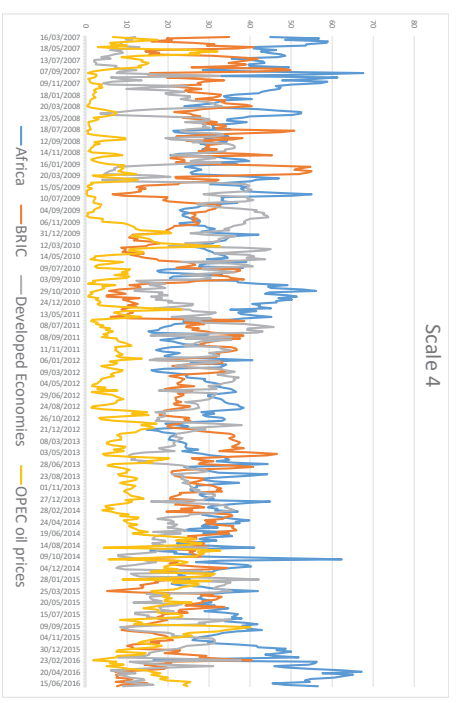
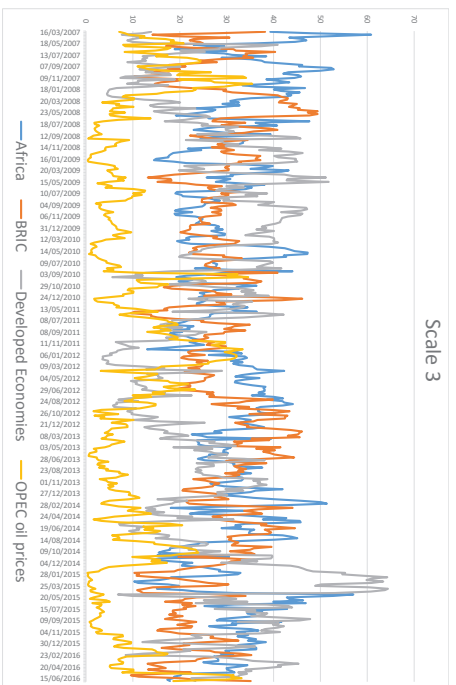
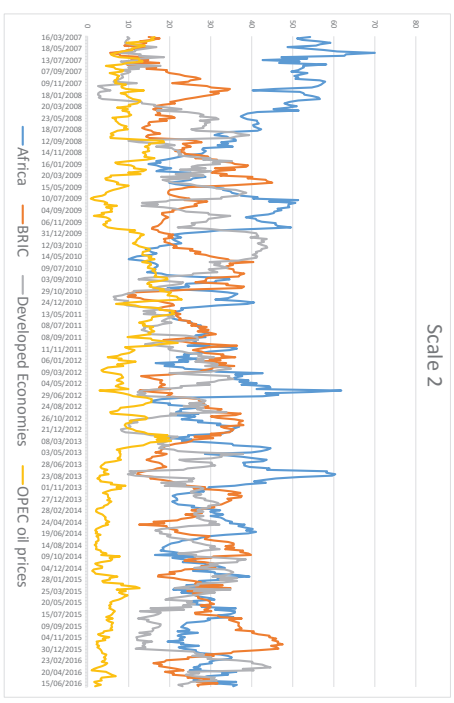
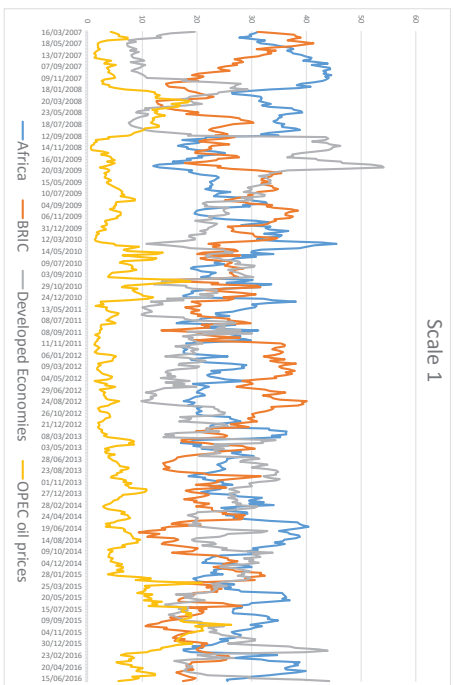


Fig. 11: Spillovers from world groups stock markets and oil prices to Tunisia stock market at scale 1,2,3,4,5

6.2. Rolling sample analysis at different scales

The analysis of Fig. 1, Fig. 2, Fig. 3, Fig. 4, Fig. 5, Fig. 6, Fig. 7, Fig. 8, Fig. 9, Fig. 10 and Fig. 11 shows that the spillovers or contribution from world financial markets to the African financial market generally evolves in a disparate way according to the time scales in accordance with the results obtained by the spillovers table. We will analyze here the dynamic evolution of these spillovers to the aggregate African stock market and individually in time and at different scales. The contributions of different markets vary over time and across scales.

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

Fig. 1 indicates that at scale 1, before the financial crisis of 2008, the spillovers from the African financial markets towards this one is rather weak. During the financial crisis of 2008, the WAEMU experienced a slight increase in its spillovers towards the African market. In the autumn of 2008, the Egyptian market's spillovers to the African market increased sharply, reaching up to 14% of the fluctuations of the African market. From 2010, Egyptian market contributions to the African market returns while remaining the main contributor are falling. As of December 2011, the WAEMU becomes the market that gives the most spillovers to the African market until December 2012, or the contribution from Nigerian market increase. From 2013 until 2016, the Egyptian financial market is the main contributor to the African financial market. However, there are peak spillovers from the Nigerian financial markets, between 2014 and 2016.

At scale 2, the spillovers from the markets markets is declining just at the beginning of the crisis. Before the crisis, the WAEMU market is one of the biggest contributor to African markets. At the beginning of the crisis, the Moroccan market contributed the most to the African market. During all the period study, the spillovers from African markets have peaks that are dominated by the Kenyan and Nigerian stock markets and at the end 2009, the Egyptian market contributes to 12% of the movement in the aggregate African financial market. During 2010, South Africa is the market that gives the most spillovers. During the year 2011, spillovers from African markets to the others increased slightly. In 2012, Egypt contributes to 22% of the African market fluctuations and remains the market that gives the most spillovers until 2016. However in 2012, we

note a rise of spillovers from the WAEMU stock market to other markets. Moreover, during the year 2015, Nigeria stock market is the one that contributes most to the African market returns (7%). Beginning in 2015, the spillovers from the African financial markets declines.

At scale 3, market spillovers are slightly higher than the two previous scales over the entire study period. Before and during the financial crisis of 2008, Egypt is the market that give the most spillovers to others African financial markets. From the summer of 2008, the Kenyan and Tunisian stock markets send peaks of spillovers towards the African market. At the beginning of 2010, the contributions from the Nigerian market rise. Until the middle of 2014, the Egyptian market remains the one that contributes the most to others African financial markets. However, we note an increase in spillovers from the WAEMU market from the end of 2013 until mid-2014. During this period, the spillovers between African financial markets decreases. We note spillovers peaks from WAEMU stock market at the end of 2014. The spillovers from Nigerian financial market knows a slight rise in 2014 summer and a spillovers peak of 24% in mid 2015.

At scale 4, Before the crisis, the Kenyan market is the most influential in the African financial market. With the beginning of the crisis, the spillovers from African countries declines. The market of WAEMU, is the market that gives the most of spillovers to other African financial markets over this period. We note an increase in the spillovers from the South African markets during the entire financial crisis of 2008. The spillovers from Nigeria rises in mid 2009. The Egyptian financial market is growing between 2009 and 2010. After mid 2010, The Tunisian financial market, until the least influential contributes up to about 14% of the aggregate African financial market fluctuations. The end of 2011 is characterized by a decline in the spillovers. Beginning in 2012, the contribution from the markets towards the others increases with an increasing from the Nigerian and Tunisian stock markets. From 2014 to mid 2015, the Egyptian financial market, is the main contributor to the fluctuations of the African financial markets. Subsequently, contributions from the Nigerian financial market to other markets rise sharply to over 25% of the overall African financial market.

At scale 5, spillovers from African financial markets to others rise. Before and at the start of the 2007 subprime

crisis, spillovers toward African market are up sharply for some markets⁴⁵ and slight for others. At the beginning of 2008, market spillovers decline, with the exception of those in South Africa, which rise. Just after the spillovers from WAEMU know a drop until 2011 or they know a peak. From 2009 to 2011, the Egyptian market is the market that contributes the most to the fluctuations of other African financial markets. From mid-2011 to mid-2012, the South African market is the main contributor of the African market, although this remains low (7% only). The Kenyan market becomes between 2012 and 2014, the most influential market in the overall African financial market except a decline in mid 2013, or the spillovers from Nigeria and WAEMU stock market increase. From mid 2014 to 2015, the Nigerian market contributes significantly to the variation of African markets until to reach 17% in December 2014. During the year 2015, Egypt and South Africa are the markets giving the most spillovers to aggregate African stock market. During the year 2016, the spillovers from WAEMU stock market to the African financial market rise.

The spillovers from African markets to African markets increase significantly as scales increases. We note that at scale 1 (1-2 weeks), the financial financial crisis has no impact on the relations between the African financial markets. However, starting from the scale 2 to 5, the beginning of the crisis (subprime crisis) marks a drop in the spillovers between African stock markets. We also note that the Egyptian financial market, regardless of scale, is the most influential African market, consequences of large spillovers to the Maghreb market (Confirming the presence long-run relationship between Egypt, Morocco, and Tunisia stock markets showed by [Onour \(2010\)](#)). We find that The South African financial market is one of the least connected African markets to others. However, at scales 2, 4 and 5 in times of crisis (2008 financial crisis, European debt crisis), the spillovers from South Africa stock market to other African markets increase. The information or impact from market eventually reaches others markets even though it is rather decreasing. This could be due to a concern of capital diversification at different time horizon from this market. Indeed, spillovers increase at large scales. they could be derunined by the behavior of the financial actors, who at scale 2 (about a month after the crisis) or else, would prefer to diversify their investments in the African financial

⁴⁵Nigeria, WAEMU and Kenya

markets⁴⁶. The Nigerian financial market could confirm this result in that during the crisis of oil prices fall (2014-2016), at scales 2 to 5, the Nigerian financial market is one of the main contributors to other African stock markets . This could be an attempt of diversification of capital towards African markets less affected by the fall in oil prices. WAEMU stock market strong contribution can be explained by the recent and rapid development of this market and its African partnerships (see section 2).

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

[Fig.2](#) shows that at scale 1, before and at the beginning of the 2008 crisis, fluctuations in the African financial markets are mainly explained by the spillovers from the BRIC and to some extent by those of the African markets. At the height of the crisis in the autumn of 2008, the spillovers from developed markets to African markets increase until 2009. From the beginning of 2009 to 2013, the spillovers from African markets rise. During the same period, the spillovers from developed markets are falling. However, we note an increase in the contributions from developed stock markets in mid-2010. From 2011 to 2016, the spillovers from developed stock markets constantly increase. The spillovers from oil prices increase from the end of 2015 to the end of the study period.

At scale 2, during the 2008 crisis. The spillovers from African markets explain 35% of African stock markets fluctuations. The BRIC contribution increase between 2007 and 2009. At the beginning of 2009, contribution from developed markets increase, excepted from the end of 2009 to the fall of 2010. The spillovers from these markets subsequently decline. During 2012 year, the spillovers from African markets know a peak of up to about 47% of their aggregate African stock market fluctuation. At the end of 2012, contributions from developed markets considerably increase until to be the most contributor to African financial market movements. From 2015 to the end of the study period, emerging⁴⁷ and developed stock markets are those that contribute the most to the African financial markets. We also note that a fall of spillovers from African financial markets during the period 2014-2016. The oil markets

⁴⁶The African financial market being least affected than the world markets

⁴⁷BRIC

spillovers towards the African financial market from 2009 to 2011, generally rise.

At scale 3, the spillovers from all global groups to the African financial market are rising slightly. The spillovers from the African financial markets decline before the 2007 financial crisis and increase just after its beginning. During 2007, contributions from developed markets to African markets increase until September 2007. Subsequently, these spillovers decrease until the beginning of 2008 and increase until 2009. At the end of 2009, developed stock markets contribute most to African fluctuations markets. At the end of 2008, contributions from African financial markets fall. In 2008, BRIC's spillovers increase until explain about 50% of the African market variations. It should be noted, however, that from the end of 2012, African markets contribution increase to aggregate African financial market. These contributions reach their peak throughout 2015. Then we note a decline in the spillovers from African financial markets and increase in the contributions from financial BRIC and developed stock markets. As for oil prices, we see an increase in their spillovers at the beginning of the 2007 financial crisis. The contribution of oil prices to African financial markets rise during 2009-2010, throughout the second half of the years 2014 and in June 2016.

At scale 4, Before and during almost the entire 2008 financial crisis, the spillovers from African markets mainly explain the aggregate African stock market fluctuations. In autumn 2009, these contribution peaked until at about 60% of the variations of the African financial market. From the second half of 2008 to the middle of 2009, spillovers from BRIC stock markets considerably rise. Subsequently, contribution from developed markets to African markets increase until autumn 2010. From 2011 to 2016, variations in African markets are mainly explained by the spillovers from African stock markets. However, in 2011 spillovers from emerging and developed stock market explain a large part of the African stock market fluctuations. The contributions from oil prices increase at the beginning of the 2008 crisis but then drop significantly. From the end of 2009 to the beginning of 2010, the spillovers in African markets is increasing. Subsequently, their contribution towards the African financial market varies around 10% of their variations. However, there is a general increase in their contribution from the second half of 2014 to 2016.

At scale 5, before the of 2008 financial crisis, the spillovers

from developed financial markets mainly explain the fluctuations of the African markets. From the start of the 2007 subprime crisis to the end of 2010, the spillovers from African markets contribute most to the fluctuations of the aggregate African financial market. However, we note a increase in spillovers from emerging markets during the same period. In May 2010, the contribution from developed financial markets to the African market fall sharply. At the end of 2011, contributions from African markets after a peak of around 50% fell sharply. From the end of 2011 to 2012, fluctuations in African financial markets are mainly explained by the spillovers from developed financial markets. From the second half of 2012 to 2014, the contribution from African financial markets increase. From mid 2014 to the end of 2015, developed stock markets spillovers considerably rise. The contribution to the African market during the year 2016 are dominated by spillovers from BRIC, from developed and from African financial markets.

The spillovers from developed markets to aggregate African market are not negligible. their contribution are high at scale 1 and 3 during the period of the 2008 financial crisis, at scale 2 and 4 at the beginning of the 2008 financial crisis and at scale 5 during the European debt crisis and price fall period⁴⁸. This spillovers could be diversification behavior of investors from this markets at different scale in African markets during crisis period to minimize their loss. As for the BRIC, their spillovers seem more or less constant over the scales. Note, however, that during the period of the financial crisis, at scale 1, spillovers tend to decrease over time while at scale 4 they are on the rise. We can assume that African financial agents could invest in these emerging markets but on relatively high time scales (scale 4: 16-32 weeks) and vice versa. The different investment horizons (scales) could also explain these spillovers varying across scales. With regard to oil prices, we see that when there is a more or less sharp increase or decrease of its returns, spillovers toward African financial markets increase. At scale 1 and 4 during the oil prices fall in 2014, the contribution to the African market increases. During the same period, at scales 2 and 5, spillovers from oil prices experience ups and downs. These differences can be explained by the fact that the price shock affects the listed companies, which are strongly linked to the price of oil almost automatically (see scale 1). These shocks therefore explain some of

⁴⁸2014-2016

the stock markets returns. Thereafter, 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. The adjustment from this, could be the reason of the spillovers increase with high scales. The markets finally adapts. In addition, scale 5 shows a relative decline in oil price spillovers compared to the spillovers from stock market that increase with high scales. As far as the contribution from African financial market, spillovers raise with scales. At scale 1 and 3 after crisis (subprime and European debt crisis), these spillovers are strong. African stock markets in long run⁴⁹ this last years (2011-2016) are very active between them.

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

Fig. 3 analysis indicate that at scale 1, we observe that the spillovers from developed financial markets towards the African market have almost the same behavior. Before 2007 and at the beginning of the subprime financial crisis, the German and French stock markets give the most part of the spillovers to the aggregate African stock market. In the summer 2008, the spillovers from the Japanese financial markets raise drastically reaching a high level in autumn 2008. During the end of 2010 to the middle of 2012 the spillovers from Japan considerably increase. The Japan stock markets is the main contributor to African market fluctuations in the middle of 2015.

At the 2 scale, before and at the crisis beginning, the Japanese market give the more of spillovers to the African market. From 2008 to the end of 2009, German and Japan stock market spillovers increase. At the beginning of 2010, the spillovers from U.K stock markets increase. In 2012, spillovers from all the stock markets decrease. Thereafter, spillovers from Japan, Germany and France stock markets raise. At the start of 2015, spillovers from Japan stock market fall. In 2016, the contribution from France and Germany stock markets to aggregate African stock market are rising.

At scale 3, we note that spillovers are high than past scales. Before the 2007 crisis, France and Germany markets spillovers are higher. During the financial crisis from 2007 to 2009, Japan stock market is the main contributor to African stock markets fluctuations. Thereafter spillovers from European developed stock market increase. At the beginning of

2010, spillovers from Japan stock markets to African stock market rise. To the end of 2011, spillovers from all stock markets decrease. In 2013 and 2014 the spillovers from Germany and France stock markets increase again. from the middle of 2014 to the end of 2015 spillovers from U.S and Japan stock markets increase with a peak of 15% of the fluctuations of aggregate African stock market. In 2016, Germany and Japan spillovers to African stock markets movement rise.

At scale 4, we find that the Japan stock markets spillovers are higher than spillovers from other markets on the whole sample. At the beginning of 2007 financial crisis and the end of 2012, the spillovers from all stock markets decrease. The spillovers from the U.S stock market are more high than spillovers from developed European stock markets before and during 2007 crisis. At the end 2011 and from the end of 2012 to the middle of 2013, the spillovers from Japan, Germany and France stock markets respectively rise. At the end of 2012, the spillovers from U.K and France stock markets increase.

At scale 5, Before 2007, German, U.K and French stock market spillovers are rising but at the beginning of the 2007 crisis, the spillovers decrease. At the beginning of the 2008 financial crisis, the spillovers from Japan stock markets increase and are more high than others markets. However during the year 2009 the spillovers from France rise. From the end of 2010 to the end of 2011, spillovers from U.S stock market are more higher than other stock markets. From 2012 to the beginning of 2014 spillovers from France stock market are those who contribute more to the African stock market fluctuations. During year 2014, spillovers from U.S and Germany stock markets increase. From 2015 to the 2016, spillovers from Japan stock market contributes most to the variation of African financial markets. Note however, a general decline in all the spillovers in the end of the years 2012 and 2015.

Individual spillovers from developed markets are disparate across countries, scales and circumstances⁵⁰. We note that spillovers from Japanese market during the period of the financial crisis of 2008 towards African markets are very high and those until to scale 5. The spillovers from France increase in 2009 but at scale 5. We also note that during the European debt crisis, the spillovers from

⁴⁹Scale 4 and 5 (16-64 weeks)

⁵⁰Financial and economic crisis

European stock markets decrease relatively to others developed stock markets (Japan and US) from scale 1 to scale 5. This confirms the long run impact (scale 5:32-64 weeks) the 2008 financial crisis and European debt crisis. Indeed, up to the 5th scale, the spillovers of the markets directly affected by the various crises are always decreasing, which could be the effects of the crises even in the long run. In our sample, we find that before the 2008 financial crisis, at almost all scales, the spillovers from African stock markets are high. However, this era of crisis, having a long-run impact changes the situation. The Japan stock market seems to be one of the markets that contributes the most to the African financial market at all time horizons. This high spillovers comfort the strong economic and financial actions in the African market posed by Japan through the JICA⁵¹ and the different TICAD⁵² since many years (UN Africa Renewal 2016, Boost in Japan-Africa ties⁵³).

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

Fig. 4 shows that at scale 1, from 2007 to the middle of 2008, the spillovers from Russian stock market are those that contribute the most to the African stock markets. During 2008 and 2009, spillovers from India and Brazil stock markets respectively rise. At the beginning of the 2007 financial crisis and the autumn 2008, spillovers from all stock markets generally decrease. From the end of 2010 to 2013, the spillovers from India stock market increase. From the middle of 2013 to the end of the sample, the spillovers from Russian stock markets explain the majority of African stock markets fluctuation. At the end of 2015, the Chinese stock market gives the most spillovers to African stock markets.

At scale 2, before the crisis, spillovers from Russia stock market drop. From the beginning of the 2007 crisis to the 2008, spillovers from China increase. From the half of 2008 to the half of 2009, spillovers from India and Brazil stock markets to African stock markets decrease. At the end of 2010, the spillovers from the BRIC fall. During 2011, spillovers from Russia and India stock markets increases. From the half of 2012 to 2014, spillovers from Russia rise. At the beginning of 2015, these spillovers explain until approximately 14% of African stock market movement. From

2015 to the end of the sample spillovers from China stock markets to African stock markets are higher than others stock markets.

At scale 3, At the beginning of the crisis, spillovers from BRIC stock markets drop excepted from Russian stock market. Note that in the same period, the China stock market contribute to the African stock markets more than the other stock markets. During the 2008 year, India stock market spillovers towards African stock market increase. From the end of 2008 to the end of 2009, spillovers from China and Brazil are the most important markets. From the beginning until the fall of 2010, spillovers from India towards African stock markets are generally most important. From 2011 to the end of 2013 Russia and China stock markets are those that mostly contribute to the African stock markets fluctuations. During the year 2014, the most part of spillovers come from Brazil and India stock markets. In 2015 and 2016, the majority of spillovers from BRIC toward African stock markets come from China and Brazil stock markets respectively.

At scale 4, spillovers from BRIC stock markets fall at the beginning of 2007 financial crisis. During the 2007 financial crisis the spillovers generally increase. Spillovers from Russia stock markets reach until 32% of African stock markets fluctuations at the beginning of 2009. In general way, Russia and China stock market give the most of spillovers from BRIC to African markets. At the end of 2012, spillovers from Brazil and India stock markets increase. From 2013 to 2016, Brazil and Russia are the BRIC stock markets that give the most spillovers to the African markets excepted at the beginning of 2016 where its the China stock markets.

At scale 5, spillovers toward African financial market are rising in the period of the 2007 financial crisis. At the end of 2009, spillovers from stock markets decline. During 2010, spillovers from Chinese financial market peak up approximately 19% of African financial markets fluctuations. During 2011, Brazil's contributions increase. At the end of 2013 and the fall of 2015, spillovers from BRIC to the African financial markets decline. From 2012 to 2016, Russia is the market that contributes the most to African financial markets exceeding the 20% of their fluctuations.

The results of the spillovers from BRIC show that the Russian and Chinese markets are the ones that give the most spillovers to the African financial markets confirming the results of the spillovers table. During the 2008 finan-

⁵¹Japan International Cooperation Agency

⁵²Tokyo International Conference on African Development

⁵³<http://www.un.org/africarenewal/magazine/april-2016/boost-japan-africa-ties>

cial crisis, spillovers from BRIC to African markets increase at all scales. Spillovers from Chinese market, from 2014 to 2016, from scale 1 to scale 4 experience an increase towards the African financial markets confirming the strong economic and financial relations between China and Europe (see Zheng, 2016). With an average of 30% of annual trade growth between China and Africa in the last 15 years, China has become Africa's largest trading partner with \$180 trillion exchanged in 2015 (UN comtrade 2016⁵⁴). In the long run (scale 5), the Russian market is the one that contributes the most to the African market⁵⁵. This could be the result of long-run relationships (long-run investment and others). During the European debt crisis, we note that in the short run (scales 1 to 3), the spillovers from the Indian market to Africa increase. During the European crisis, the spillovers from BRIC stock markets are rising in the long run (scale 4 and 5) especially those of Russia and China. BRIC and Africa's stock market relationship vary according to the time scale and conditions in the financial markets.

6.2.5. Spillovers from world groups stock markets and oil prices to individual African stock markets

In this subsection, we analyze the spillovers from world financial market groups and oil prices towards individual African stock markets. We will conduct an analysis of all African markets simultaneously scale by scale.

The analysis of Fig. 5, Fig. 6, Fig. 7, Fig. 8, Fig. 9, Fig. 10 and Fig. 11 show that at scale 1, during the European sovereign debt crisis, the spillovers toward South Africa⁵⁶, increase and come mainly from developed countries. For other African countries, world market spillovers are generally rising before and during the 2008 financial crisis and come mainly from the BRIC. During the European crisis, spillovers from aggregate African market toward African stock markets increase, followed by those of the BRIC. From 2014 to 2016, spillovers from BRIC and developed stock markets generally dominate global spillovers toward African financial markets excepted for Morocco. Concerning oil prices, their spillovers generally increases toward all markets during The recent period of oil prices fall (2014-2016).

⁵⁴<https://comtrade.un.org/>

⁵⁵Possible consequence of the return of Russia in the African market (see Arkhangels and Shubin, 2013) or the recent financial opening (Chinn-Ito website: The Chinn-Ito Index - A de jure measure of financial openness)

⁵⁶The largest African financial market

At scale 2, For the majority of African financial markets, spillovers received from other African financial markets raise before and at the beginning of the 2007 financial crisis excepted from Kenya and South Africa. In autumn 2008, in the midst of the financial crisis, the impact of the developed financial markets in the African market increase. During the debt crisis start and in 2015, The BRIC stock markets generally contribute much more. The spillovers from oil prices varies from market to market, but periods of rising and falling are located in instability period in financial markets or in oil prices.

At scale 3, the spillovers from different groups vary widely from one market to another in different markets. We note that for the majority of African markets, the BRIC spillovers are highest for all markets except South Africa. The spillovers from developed markets generally increase toward African markets at the end of 2008 financial crisis. However, during the year 2015⁵⁷, we note an increase in spillovers coming from the aggregate African market. For the three largest African financial markets, Nigeria, Egypt and South Africa, the spillovers from African stock markets are relatively small compared to the spillovers of other groups. As for the other financial markets of the panel, before and during the financial crisis of 2008, the spillovers received from the African financial market are high. The impact of oil prices varies from one market to another. However, there is a common increase in oil spillovers in 2014⁵⁸ to African markets. For Nigeria, the spillovers are greater.

At scale 4, before the 2008 financial crisis, spillovers spillovers received from aggregate African financial markets are the most important. During the financial crisis period, for most African financial markets, the spillovers from the BRIC increase. At the end of the 2008 financial crisis, the spillovers from developed markets to all African markets increase. In 2011, in the midst of the European debt crisis, the spillovers from BRIC raise. The years 2015 and 2016 are synonymous of increased spillovers between African financial markets. The spillovers from oil prices rise before and during oil prices crisis (period of oil prices fall).

At scale 5, spillovers from developed markets raise for most African financial markets throughout the study period. In the midst of the debt crisis, the spillovers from

⁵⁷Period of high activity and development of African financial markets

⁵⁸Oil prices fall start

developed markets are intensifying towards African stock markets. This could be the effect of a diversification of long-run capital from developed markets to African markets or of the delayed impact of the crisis⁵⁹. We also note that spillovers between African financial markets are rising before and during the 2008 financial crisis. As for the spillovers from BRIC, they are low relative to the spillovers from the others financial markets groups. Concerning oil prices, it can be argue that outside of a few isolated peaks, spillovers are low on almost all markets during the period of falling oil prices (2014-2016). Particularly for Nigeria, the spin-offs are very low. It could be argued here that in the long run, the impact of oil price changes in the NGSE return is negligible.

The impact of global markets varies among different African countries. We note that South Africa is strongly correlated with developed markets and those at almost all scales. In the short run and long run during the 2008 financial crisis, the spillovers from developed stock markets rise in the African financial market confirming the immediate impact but not permanent of the financial crisis on African markets except for South Africa stock market. During the period of the European debt crisis, in the short run (scale 1), the spillovers from developed markets decrease but in the long run (scale 5) they are rising sharply⁶⁰. From scale 2 to scale 4, spillovers from BRIC are higher. The years 2015-2016 are characterized from scale 3 to scale 5 by an increase in spillovers between the African financial markets. These results confirm that the last few years are characterized by strong activity on the African market making local transactions more attractive. According to PwC (2015, 2016), the African market has experienced 48 IPOs and 184 FOs with \$21.5Bn proceed raised between 2015 and 2016 About oil price impact, we note a short and medium-run impact (scale1 to scale 3). At long-run scales, their spillovers decrease and those even on the Nigerian stock market.

⁵⁹Decline in investments at short run toward Africa due to the crisis (BAD, 2009)

⁶⁰This decrease could be the consequence in long run of a decline in the FDI from European countries stemming from the crisis

Table 7: 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 From others							
Egypt	1,6	1,4	3,5	1,4	0,9		8,7
Kenya	1,4	2,2	0,8	1,3	0,7		6,5
Morocco	2,1	3,4	2,9	2,4	2,9		13,7
Nigeria	1,1	0,7	2,3	0,5	0,6		5,2
South.Africa	8,5	9,4	6,4	8,4	5,7		38,4
Tunisia	2,1	2,4	6,0	3,4	3,4		17,3
WAEMU	4,1	3,2	5,3	2,8	2,3		17,7
Scale 2 France Germany Japan U.K U.S From others							
Egypt	3,5	4,3	6,6	2,8	2,1		19,4
Kenya	4,0	2,2	5,4	3,7	2,8		18,2
Morocco	1,1	2,0	0,7	1,5	0,6		5,9
Nigeria	0,8	1,3	2,3	1,0	0,9		6,3
South.Africa	10,3	9,0	8,5	10,1	7,9		45,8
Tunisia	2,2	2,5	3,4	1,6	1,0		10,7
WAEMU	0,2	1,0	0,9	1,0	0,7		3,9
Scale 3 France Germany Japan U.K U.S From others							
Egypt	4,9	4,2	7,4	4,0	2,5		23,0
Kenya	6,3	5,6	4,9	5,5	6,9		29,3
Morocco	2,8	2,3	1,0	3,1	2,0		11,2
Nigeria	0,3	0,4	0,9	0,6	0,5		2,7
South.Africa	10,5	8,8	8,7	10,9	10,4		49,3
Tunisia	1,5	2,5	5,2	0,9	0,5		10,5
WAEMU	0,2	2,7	1,3	0,5	0,9		5,7
Scale 4 France Germany Japan U.K U.S From others							
Egypt	2,9	4,2	8,1	3,1	2,8		21,2
Kenya	2,2	3,0	8,1	2,6	3,5		19,5
Morocco	6,2	7,1	1,7	3,4	2,4		20,8
Nigeria	2,0	2,5	0,2	0,1	0,2		5,0
South.Africa	8,5	10,0	6,9	9,3	7,9		42,6
Tunisia	0,5	0,5	5,7	0,2	0,1		6,9
WAEMU	0,5	0,5	0,4	0,3	0,8		2,6
Scale 5 France Germany Japan U.K U.S From others							
Egypt	4,4	1,7	8,1	2,9	3,4		20,4
Kenya	4,6	4,9	0,8	2,5	5,0		17,8
Morocco	2,7	0,7	0,1	0,8	1,2		5,6
Nigeria	1,3	4,0	0,0	1,3	1,5		8,1
South.Africa	8,9	7,2	6,9	7,8	8,0		38,9
Tunisia	10,4	6,1	1,2	9,7	7,2		34,6
WAEMU	3,6	8,3	0,7	1,8	2,0		16,4

Table 8: Spillovers table from BRIC stock markets to African stock markets: January 7, 2005-June 29, 2016.

Scale 1 Brazil China India Russia From others						
Egypt	1,0	1,6	1,3	2,8		6,7
Kenya	0,6	1,8	1,6	1,3		5,3
Morocco	3,5	0,2	2,2	5,9		11,9
Nigeria	1,4	1,2	0,6	3,5		6,7
South.Africa	9,1	2,4	4,9	11,5		27,9
Tunisia	4,9	1,8	0,5	3,8		11,1
WAEMU	2,0	0,6	0,3	4,1		6,9
Scale 2 Brazil China India Russia From others						
Egypt	4,2	2,2	3,2	11,3		20,9
Kenya	5,0	6,2	1,7	7,7		20,7
Morocco	2,3	0,7	2,6	4,5		10,2
Nigeria	3,4	3,0	1,7	13,4		21,5
South.Africa	9,6	3,3	4,6	13,6		31,1
Tunisia	4,7	3,9	1,2	4,0		13,8
WAEMU	0,7	2,3	1,5	4,0		8,5
Scale 3 Brazil China India Russia From others						
Egypt	3,9	0,9	5,7	5,4		15,9
Kenya	6,7	1,4	3,2	5,2		16,5
Morocco	3,7	2,8	2,3	7,9		16,6
Nigeria	1,4	2,1	1,2	7,7		12,4
South.Africa	10,2	0,7	8,2	6,6		25,7
Tunisia	0,3	8,2	3,6	2,0		14,0
WAEMU	0,8	2,2	5,8	2,9		11,7
Scale 4 Brazil China India Russia From others						
Egypt	9,0	1,3	9,7	9,2		29,2
France	9,2	0,5	8,5	10,5		28,7
Kenya	4,6	5,2	9,0	6,4		25,2
Morocco	5,7	3,4	8,0	16,4		33,6
Nigeria	0,5	8,2	0,0	3,6		12,3
South.Africa	11,8	0,5	9,0	9,4		30,7
Tunisia	0,2	0,6	7,4	0,2		8,4
WAEMU	1,2	6,6	1,6	2,2		11,5
Scale 5 Brazil China India Russia From others						
Egypt	2,3	1,1	3,8	9,4		16,6
Kenya	13,9	0,9	1,0	6,9		22,7
Morocco	6,3	4,9	0,8	2,4		14,4
Nigeria	0,1	20,6	0,7	13,5		34,8
South.Africa	8,9	0,7	5,1	14,4		29,0
Tunisia	11,6	5,6	2,9	7,5		27,5
WAEMU	0,3	0,2	0,8	0,7		2,0

Table 10: 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	72,0	2,5	2,4	2,7	1,2	0,8	1,6	11,2
Kenya	4,4	67,1	3,0	2,6	6,0	0,7	1,6	18,4
Morocco	6,4	2,6	55,3	2,6	1,7	0,6	2,3	16,2
Nigeria	1,2	1,4	1,5	78,1	0,6	1,2	0,6	6,5
South.Africa	2,7	0,7	1,5	2,6	19,0	0,3	0,3	8,0
Tunisia	7,9	1,1	2,3	1,2	1,1	51,2	4,9	18,5
WAEMU	3,1	2,4	1,2	1,1	2,8	0,2	58,3	10,8
To others	25,6	10,7	12,0	12,7	13,5	3,8	11,3	
Scale 2	Egypt	Kenya	Morocco	Nigeria	South.Africa	Tunisia	WAEMU	From others
Egypt	46,8	2,9	1,0	2,4	1,8	1,6	1,1	10,9
Kenya	3,8	42,3	0,9	2,2	2,1	3,0	1,4	13,4
Morocco	11,9	2,2	59,0	1,4	2,7	4,2	0,5	22,9
Nigeria	2,6	1,1	1,5	61,1	1,2	1,1	2,6	10,1
South.Africa	0,6	0,8	0,0	1,0	15,3	0,2	0,1	2,8
Tunisia	7,2	6,3	1,7	5,1	0,5	50,9	1,1	21,9
WAEMU	6,9	2,2	1,7	1,1	1,1	0,1	70,7	13,2
To others	33,0	15,6	6,8	13,3	9,4	10,2	6,7	
Scale 3	Egypt	Kenya	Morocco	Nigeria	South.Africa	Tunisia	WAEMU	From others
Egypt	48,5	3,4	2,2	2,1	1,8	2,0	0,1	11,6
Kenya	13,6	30,3	0,4	2,4	4,1	2,4	0,2	23,2
Morocco	11,2	0,7	53,8	0,8	3,1	1,6	0,7	17,9
Nigeria	2,7	2,8	0,7	74,4	0,7	0,2	0,9	8,1
South.Africa	0,7	0,5	0,4	1,2	19,6	0,1	0,1	3,0
Tunisia	6,1	4,4	3,1	1,4	0,1	56,5	1,3	16,4
WAEMU	3,2	0,7	0,5	1,6	0,2	0,9	74,4	7,1
To others	37,5	12,4	7,3	9,5	10,0	7,3	3,4	
Scale 4	Egypt	Kenya	Morocco	Nigeria	South.Africa	Tunisia	WAEMU	From others
Egypt	34,8	3,3	3,0	0,1	1,7	3,4	0,6	12,1
Kenya	9,2	29,8	1,8	1,7	4,2	6,3	0,7	23,8
Morocco	11,4	0,9	26,8	0,2	1,6	3,6	0,4	18,0
Nigeria	0,3	1,7	0,2	71,8	0,7	5,0	3,0	10,8
South.Africa	4,1	3,6	0,0	0,3	13,0	0,2	0,9	9,1
Tunisia	21,5	6,7	7,2	4,0	0,4	38,7	1,3	41,1
WAEMU	16,6	1,6	0,1	0,3	2,7	0,3	54,6	21,7
To others	62,9	17,8	12,3	6,6	11,3	18,8	6,7	
Scale 5	Egypt	Kenya	Morocco	Nigeria	South.Africa	Tunisia	WAEMU	From others
Egypt	42,4	0,3	0,4	1,4	10,1	3,1	0,0	15,3
Kenya	4,5	35,3	0,0	5,6	4,0	1,9	1,0	17,0
Morocco	5,1	0,7	47,1	0,1	5,0	15,4	6,5	32,8
Nigeria	4,9	0,3	1,0	31,8	0,3	1,5	14,0	21,9
South.Africa	4,3	0,2	0,6	0,0	15,9	1,7	5,4	12,4
Tunisia	7,7	1,5	0,6	0,3	11,5	16,1	0,0	21,7
WAEMU	1,9	0,4	0,3	7,7	4,3	0,4	65,0	15,1
To others	28,5	3,4	3,0	15,1	35,3	24,0	26,9	

Table 11: Spillovers table from OPEC oil prices to African stock markets: January 7, 2005-June 29, 2016.

Scale 1 OPEC.oil.prices	Scale 2 OPEC.oil.prices	Scale 3 OPEC.oil.prices	Scale 4 OPEC.oil.prices	Scale 5 OPEC.oil.prices					
Egypt	1,4	Egypt	2,1	Egypt	1,0	Egypt	2,6	Egypt	5,2
Kenya	2,8	Kenya	5,3	Kenya	0,7	Kenya	1,7	Kenya	7,3
Morocco	2,9	Morocco	2,1	Morocco	0,4	Morocco	0,8	Morocco	0,1
Nigeria	3,5	Nigeria	1,1	Nigeria	2,4	Nigeria	0,1	Nigeria	3,4
South.Africa	6,7	South.Africa	5,1	South.Africa	2,4	South.Africa	4,6	South.Africa	3,8
Tunisia	1,9	Tunisia	2,8	Tunisia	2,6	Tunisia	4,9	Tunisia	0,1
WAEMU	6,3	WAEMU	3,7	WAEMU	1,0	WAEMU	9,6	WAEMU	1,4

7. Conclusion

This paper provides a new insight of the relationship between African financial markets and global financial 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 in financial markets and the recent decline in world oil prices. We examine the return transmissions between World stock markets (Brazil, Russia, India, China, United States, United Kingdom, France, Germany and Japan), OPEC oil prices and the seven largest African stock markets in capitalization run (South Africa, Egypt, Nigeria, Morocco, Kenya, West African Economic and Monetary Union

and Tunisia) from January 7, 2005 to June 29, 2016. For the analysis we combine the MODWT and the Diebold and Yilmaz (2012) methods spillover indices based on the forecast error variance decompositions that allow to study the spillovers from markets according to the different time scales (short, medium, long run. . .). First we study the transmission of returns between African markets to determine the level of integration of African market. We then analyze the benefits of global markets by grouping them according to characteristics (emerging, developed, commodity. . .).

The results show that the spillovers to the African financial markets vary according to time scales. During the subprime crisis, the impact from the developed stock markets excepted Japan (high spillovers from Japanese stock

market to African markets at almost all scales confirming the conclusions on the high spillovers from Asian countries of [Fowowe and Shuaibu \(2016\)](#) only increase in the short⁶¹ and very long run⁶² (short run and very long run impact of the subprime financial crisis on African financial markets), while at intermediate scales (scale 2, 3, 4), spillovers come mainly from emerging⁶³ and African stock markets respectively. The impact of the European debt crisis on the spillovers from developed markets is mostly in long-run for European stock markets⁶⁴. The contribution at intermediate scales during this crisis are relatively low from developed stock markets and come mainly from the African financial markets and the BRIC respectively. The impact of oil prices on the financial market during the recent decline in oil prices is consequent in the short and medium run (scale1-4) but in long run, oil prices spillovers is negligible (even for Nigeria stock market). Moreover, In recent years (2014-2016), we note that at medium and large scales, contribution between African financial markets are increasing, thus confirming the recent measures taken by the African markets authorities([ASEA, 2015](#); [UNCTAD, 2014](#))

We can conclude that the integration of the African financial markets with the outside (world financial Markets and oil prices) depends on the time scales, the economic relations with the countries concerned, the state of the world financial markets. This integration with global financial market is generally weak in the short run but tend to grow in the long run (see spillovers tables) excepted for South Africa. Concerning the integration between African financial markets specifically, despite considerable progress, it remains weak and is only located in medium and long run. About African markets and oil prices relationship, spillovers is strong in short and medium run but weak in long run.

Compared to studies on the African financial markets integration using the [Diebold and Yilmaz \(2012\)](#) method (see [Fowowe and Shuaibu, 2016](#); [Sugimoto et al., 2014](#)), the combination with wavelets allowed us to confirm their authors results but to go further showing that the subprime financial crisis had an impact on the African financial markets even though it was in short and long run. Moreover, we have also shown that relations between African financial markets are

not not static and that according to the scale studied they evolve.

Conclusions from this paper are relevant for portfolio diversification strategies and policy makers. Firstly, this specific integration in long run means that African financial 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 the short run. Secondly this long-run integration could be explained by channels of transmission of the financial information flow between the African and external financial markets that are not sufficiently developed (non-efficient financial institutions, low representation of African or global firms represented markets in African markets. . .) and hence difficulties in Information or financial flow to spread due to lack of financial link. The authorities concerned should therefore redouble their efforts in view of the substantial economic advantages stemming from developed markets([Hicks, 1969](#); [Levine, 1997](#); [Calderón and Kubota, 2009](#)).

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⁶¹Scale 1

⁶²Scale 5

⁶³Mostly China

⁶⁴Possible consequence of the decline in FDI and others investments to African countries ([BAD, 2009](#))

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