Spillover effect in African stock markets

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Abstract:

The purpose of this study is to investigate the spillover in the African stock markets; using the VAR-EGARCH model over an 11 years period which cover the recent global financial crisis. The estimates of restricted and the unrestricted model confirm the existence of first and second moment interdependence. The results of this study show that:(i) volatility spillover is asymmetry, this asymmetry decreases as the market become interdependent. (ii) The persistence in volatility in stock market is very high close to unity, and the time needed to reduce it by half is more than six days for all markets, this persistence increases as the markets become interdependent. (iii)The spillover effect in term of both return and volatility increased in period followed the crisis due to the contagion effect caused by the crisis; the persistence in volatility decreases, while the degree of asymmetry is increased in the post-crisis period.

Keywords: African Stock markets; spillover effect, financial crisis; VAR-EGARCH model.

JEL Classification Codes: G1, G01, C58

ملخص:

الهدف من هذه الدراسة هو البحث في تأثير الامتداد القائم بين أسواق الأوراق المالية الأفريقية؛ باستخدام نموذج VAR-EGARCH على مدى 11 عامًا والتي تغطي الأزمة المالية العالمية الأخيرة. تؤكد تقديرات النموذج المقيد وغير المقيد وجود الترابط اللحظي الأول والثاني. تظهر نتائج هذه الدراسة ما يلي: (1) امتداد التقلب غير متماثل، وهذا التباين يتناقص كلما كانت الأسواق مترابطة. (2) درجة استمرارية التقلبات في سوق الأوراق المالية مرتفع للغاية بالقرب من الوحدة ، والوقت اللازم لتقليله بمقدار النصف هو أكثر من ستة أيام لجميع الأسواق ، وتزداد استمرارية التقلبات عندما تكون الأسواق مترابطة. (3) زاد تأثير الامتداد من حيث كل من العائد والتقلب في الفترة التي أعقبت الأزمة بسبب تأثير العدوى الناجم عن الأزمة ؛ تتناقص درجةاستمرارية التقلب، بينما تزداد درجة عدم التماثل في فترة ما بعد الأزمة.

كلمات مفتاحية: أسواق الأوراق المالية الأفريقية؛ تأثير الامتداد ، الأزمة المالية ؛ نموذج VAR-EGARCH.

تصنيفات JEL: G1،G01،C58

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1. Introduction

International stock markets have been experiencing an increasing interdependency in both regional and international level, this due to information spillovers among stock markets. Spillover effect defined as the impact of return and volatility of given market that have spread to other markets; in other words, an external shock which affects one market may be transmitted to another because of spillover effects which may be present.

This study analyzes the interdependence between African stock markets in greater depth, by posing the following problematic:

Is the interdependence between African stock markets due to returns or volatility (or both)? Which are the direction and the degree of influence within those markets before and after the 2008- financial crisis?

The main aim of this study is: To investigate the dynamic links of African stock markets among themselves as well as with developed markets from the perspective of return and volatility transmission; and to shed light on how and to what extent equity returns and volatility in African markets are affected by regional and global markets. And to show the degree of influence of external shocks (the financial crisis) on the interdependence of those markets.

The information flow across markets might be through returns (correlation in first moment) or through volatility (correlation in second moment). So, in this study we test the hypothesis which state that, if two or more markets are interdependent, than any external shock in one market will not only affect the mean but also the variance of return in other markets.

To do, we examine both the return and volatility spillovers, adopting a more appropriate methodology which is the multivariate VAR-EGARCH model. While, univariate models ignore the impact of innovation in one market in the mean and variance of another market, the multivariate VAR-EGARCH model allows the simultaneous estimation of the mean and variance equation in different markets. The multivariate EGARCH model is suitable as it is able to capture the asymmetric effect in each market.

2. Literature review

The increasing international interdependence of financial markets has motivated economists to examine the mechanism through which stock market movements are transmitted around the world. These studies assess how stock returns and volatility in one national stock market affect the returns and volatility of other stock markets. At the beginning the studies on interdependence among international markets have been mainly focused on the interaction through returns (i.e. interdependence in first moments of the distribution of returns). While recently, the studies investigate stock market interdependence through both return and volatility (i.e. interaction in term of both first and second moment of distribution of returns). Most of the studies have focused on developed markets especially interdependence among U.S., Japanese and major European markets; some other have been done in the case of Asian and emerging markets.

Some previous researches investigate the impact of the quantity of news (i.e. the size of an innovation), as well as the quality (i.e. the sign of an innovation) on volatility spillovers across markets. Several studies provide the evidence of such fact; the first is (Nelson, 1991) attempt to capture the asymmetric effect of shocks on volatility by developing the exponential GARCH model (EGARCH). The results reveal that negative innovations rise volatility more than positive one in US market.

Five years later, (Koutmos & Booth, 1995) analyzed the asymmetric effect of news (good and bad) on volatility transmission across the New York, Tokyo and London stock exchanges, using a multivariate EGARCH model. Their results reveal strong evidence of asymmetric volatility spillover, especially for the period after October 1987.

One year later, in another study (Koutmos, 1996) analyzes the stock markets interaction in terms of lead-lag relationships and volatility in four major European stock markets using EGARCH modeling. The results of the study show multidirectional lead-lag relationship across the markets. Their results were supported by (Jeong, 1999) who found volatility spillovers across US and UK stock markets. Recently, (Antoniou , Pescetto , & Violaris, 2003) support the conclusion made by (Koutmos, 1996), which states that volatility respond asymmetrically, with bad news.

(Theodossiou & Lee, 1993) analyzed markets in Canada, Germany, Japan, UK, and US using a multivariate GARCH in mean model. They discovered that the US market was the most influential in terms of volatility transmission to other markets in the sample. Likewise, (Isakov & Peringnon, 1999) analyze the dynamic interaction of returns and volatility of Swiss with the major stock market in the world. Their results also reveal that US is the most influential market, and Swiss market is affected by events in foreign market.

(Kanas, 1998)used daily data over period from January 1984 to December 1993, which is splitted into two periods the pre- and post-1987 stock market crash period for three European stock markets. Author applied both univariate and bivariate EGARCH extensions to analyze spillovers effect. He found bidirectional volatility spillovers between Paris and Frankfurt stock exchange and between London and Paris stock market; unidirectional spillovers from London to Frankfurt. The results also revealed that bad news had a more pronounced effect than good news in volatility spillover effects, and the spillovers increased in the period post-1987 stock market crash. (Savva, Osborn, & Gill, 2004) used dynamic correlation framework to examine the spillover among U.S., German, UK and France markets, they found that only UK and German are affected by the U.S. market. Furthermore, they found evidence of increased correlation between European markets after the introduction of the EURO.

The analysis of volatility transmission in the European, U.S., and Japanese stock markets is extended by (Caporale, Pittis, & Spagnolo, 2006) by including the effects of financial crisis. Using the GARCH-BEKK model and data spanning the period from January 1986 to October 2000, they found evidence of volatility spillovers. In addition, the causal linkage among the markets is found to be unidirectional and it originated from markets that experienced financial crisis. Results also found that the stock markets integration disappears during the crisis period.

Numerous studies have been focused on Asian emerging markets see for example: (Worthington & Higgs, 2004) analyze the return and volatility transmission among three developed markets (Hong Kong, Japan and Singapore) and six emerging markets (Indonesia, Korea, Malaysia, Philippine, Taiwan and Thailand) using a multivariate GARCH model and weekly return over January 1988 to October 2000. The results show evidence of positive return and volatility spillover. In addition, the results highlighted that for most markets, the own stock market volatility spillovers were greater than cross-volatility spillover. (Wang, Gunasekarage, & Power, 2005) used daily data for five countries during the period January 1993 to December 2003. Authors applied a univariate EGARCH model to examine returns and volatility spillovers among these markets. The results revealed evidence of Return spillovers from both the US and Japan to all three South Asian stock markets while volatility spillovers were found from the US to India and Sri Lanka and from Japan to Pakistan. In addition, authors indicated that spillovers increased in period post-1997 Asian crisis which is consistent with the finding of (Liu & Pan, 1997), (Kanas, 1998); all their finding support the fact that interdependence among the markets increased during the crisis due to a contagion effect. (Chuang, Lu, & Tswei, 2007) used the VAR-BEKK technique to examine the volatility spillover among six East Asian markets. Authors pointed out that the Japanese market is most influential in transmitting volatility to the other East Asian markets; their results reveal that this market is less vulnerable to volatility stimuli from other markets. (Li, 2007) analyzed the interdependence between Shanghai and Shenzhen, Hong Kong and US, using daily share price indices and multivariate GARCH model. The results reveal no evidence of spillover effect in term of both return and volatility between these stock markets. Author found that Chinese stock exchanges were integrated with the regional stock exchanges. The results also show the presence of bidirectional shock spillover between the stock exchange of Hong Kong with those of Shanghai and Shenzhen, and there was an asymmetric response of volatility in all selected stock exchanges.

Recently, (Mukherjee & Mishra, 2010) used daily data for 13 Asian countries on the period from July 1997 to April 2008; they employed a GARCH model to examine stock market integration and volatility spillovers. The results reveal bidirectional spillovers among India and most of the other Asian countries. Furthermore, returns in Hong Kong, Korea, Singapore and Thailand caused movements in India Similarly, among others, stock markets Pakistan and Sri Lanka are found to be strongly influenced by movements in Indian market.

More recently, (Zheng & Huo, 2013) examine the volatility spillover effect among a sample of developed markets including US, UK, Germany, Japan and Hong Kong. They introduce a Markov switching causality method in order to model the instability of volatility spillover relationships over tranquil and turmoil periods. They found evidence of spillover effects among the markets under consideration. More specifically, they show that the bilateral volatility is striking during crisis periods, especially during the last subprime mortgage crisis. (Bing & Wang, 2014)examine return and volatility spillovers between China and world oil markets. Extending (Diebold & Yilmaz, 2012) method of catching spillover dynamics, it is found that return and volatility spillovers between China and world oil markets are bi-directional and asymmetric. The Chinese oil market is highly affected by world oil markets and exerts an influence on world oil markets, although to a lesser extent. Moreover, the volatility spillover index has increased significantly since the peak of the last financial crisis in September 2008. Although the US oil market impacts China's market most in terms of spillover, the influence of China's oil market on the world oil market has intensified in recent years.

(Yusaku, Yoshiro, & Kenjiro, 2015) analyzed the mechanism of return and volatility spillover effects from the Chinese to the Japanese stock market. Authors constructed a stock price index comprised of those companies that have substantial operations in China. The China-related index responds to changes in the Shanghai Composite Index more strongly than does the market index of the Tokyo Stock Exchange). This result suggests that China has a large impact on Japanese stocks via China-related firms in Japan. Furthermore, the results show evidence that this response has become stronger as the Chinese economy has gained importance in recent years.

3. Data and Methodology

3.1 Data

In this study we use daily data for African markets index[1] (Egypt (EGX30), Kenya (NASI), Mauritius (SEMDEX), Morocco (MADEX), Nigeria (NSE_ASI),

[1] Africa Security Exchange Association year book, https://mondovisione.com/_assets/files/ASEA-Yearbook-2013.pdf

South Africa (FTSE/JSE),Tunisia (TUNIDEX) and Zambia (LASI)) as well as international markets[2] (Japan: N225, UK: FTSE100 and US: S&P 500), the data cover the period from June 2, 2004 to April 30, 2014, which includes 2574 observations for each series. We use the high frequency data to get more accurate correlation and volatility estimates, since the lower frequency data smoothed variation between adjacent observations resulting in smoothed estimates of correlation and volatility that discard important information. The daily returns in each market are represented as the natural logarithmic of relative prices: $r_{it} = 100*ln\ (P_{it}/ P_{it-1})$, where r_{it} is the return on index i in day t, P_{it} is the price level of the index in day t, P_{it-1} represents the price level of the index for the previous day. Since the daily stock returns have a small number, algorithm for estimation can become badly scaled and may fail to converge for this, the logarithmic of stock returns are multiplied by 100 to avoid convergence problem, and for approximate percentage changes. The asymmetric effect of innovations on volatility may come from some extreme observations such as financial crisis or crash so, to investigate this fact and the possible changes in the nature of return and volatility spillovers in period post 2008 global financial crisis, we split the entire period into two sub-periods; pre- and post-crisis and we estimate the model for each periods. A detailed analysis of the data as it relates to the analysis of the current study is given as follow:

Figurer1 in the appendix, presents the returns of the share price indices during the sample period. Most of the indices move in the same way; there appear to have been a prolonged period of relative tranquility in all markets during the period mid-2004 to beginning of 2008, evidenced by only relatively small positive and negative returns. Since then, influenced by the financial crisis, there was more volatility, when several large positive and large negative returns were observed during a short space time. This means that the return series show the evidence of leverage effect, which suggest that a negative shock (bad news such as crisis) is likely to cause volatility to rise by more than a positive shock to the same magnitude, this called asymmetric effect which we can modeled through exponential GARCH model. In addition, from the figures, we can observe that all the indices are characterized by volatility clustering as large returns (of either sign) follow large returns for a long period, and small returns (of either sing) follow small returns for a long period; this means that we have a justification to use the ARCH family model (such as EGARCH).

3.2 Methodology

[2] Bloomberg, https://www.bloomberg.com/professional/product/reference-data/
Yahoo finance, https://finance.yahoo.com/

Financial time series data are characterized by the fact that bad news had considerable impact on volatility than "good" news. As shown by many studies, volatility transmission mechanism is asymmetric i.e., the bad news in one market had a substantial influence than good news on the volatility of other markets; we refer to this mechanism as "leverage effect". To this end, we have to choose a model that can capture such asymmetry in the time series data. After performing the preliminary analysis of our data, we find that the two pre-conditions (volatility clustering and the asymmetric effect) for run ARCH family model are fulfilled, so, we adopt the multivariate exponential generalized autoregressive conditional heteroscedasticity (VAR-EGARCH) model to investigate market interdependence and volatility transmission between the selected stock markets. Our model is suitable to answer our questions in the sense that, including the lag returns from each market in the mean equation allows us to catch the return spillovers from one to another market. Furthermore, the inclusion of other markets innovation into one market volatility equation, allow us to capture volatility spillover effects. The multivariate EGARCH model is ideally suited to test the possibility of asymmetries in the volatility transmission mechanism. Since, our selected market open and close sequentially and there is short time overlap between them. So, the estimation of the means and variance in each market is conditional on own past information as well as information generated by the other markets. The return and innovation in market *j* enter the information set of traders in market *i*. If for example *i = Egypt*, the information set for traders in Egypt at the opening of the market in a given day includes past Egypt return and innovations as well as the past return and innovations form the ten other markets; all these past information (i.e. part of the information set $\Omega_{i,t-1}$).

3.2.1. Empirical model

As the aim of this study is to capture the dynamic interdependence and volatility transmissions across different markets, so, the multivariate VAR-EGARCH model will be appropriate. The VAR-EGARCH model has a few distinctive features; first, market interactions can be investigated and analyzed in a one-step estimation procedure (Koutmos, 1996). Second, the multivariate VAR-EGARCH model can explicitly test the hypothesis that innovations within and across markets influence volatility asymmetrically[3].

Then, these require that we specify the models used for both the mean and the variance equations. For the mean equation, as all of the series are stationary, we use Vector Autoregressive (VAR) model. The return spillovers among the markets are examined by the mean equation in the VAR-EGARCH model, whereas the variance

[3] *The asymmetric impact of past innovations on current stock return volatility is well known, and it has been attributed to the so-called `leverage effect'.*

equations investigate the volatility spillovers in and across the eleven markets.
The mean equation of the following form is used:

$$r_{i,t} = \beta_{i,0} + \sum_{j=1}^{N} \beta_{ij} r_{j,t-1} + \varepsilon_{i,t} \quad \textit{for } i = 1,\ldots.11 \textit{ and } j=1,2,\ldots..11 \textit{ and } i \neq j \tag{1}$$

Here $r_{i,t}$ is return for market *i*. $\mu_{i,t}$ is the conditional mean, $\varepsilon_{i,t} = r_{i,t} - \mu_{i,t}$ is the innovation at time *t*.

The conditional mean in each market $r_{i,t}$ is a function of own past returns and cross market returns $r_{j,t}$. $\beta_{i,j}$ capture the lead-lag relationship between returns in different markets $i \neq j$. Market j lead market i when β_{ij} is significant; in other words, it captures the relation in terms of return spillovers across the markets. ε_t is the innovation for each market at time t. Finally, the term $\beta_{i,0}$ represents constants.

Following (Koutmos & Booth, 1995), we model the conditional variance (variance equation) according to the multivariate EGARCH model as follows:

$$\sigma_{i,t}^2 = exp\left[\alpha_{i,0} + \sum_{j=1}^{n} \alpha_{i,j} f_j(z_{j,t-1}) + \delta_i \ln(\sigma_{i,t-1}^2)\right] \tag{2}$$

or $\ln(\sigma_{i,t}^2) = \alpha_{i,0} + \sum_{j=1}^{n} \alpha_{i,j} f_j(z_{j,t-1}) + \delta_i \ln(\sigma_{i,t-1}^2)$

$$f_j(z_{j,t-1}) = (|z_{j,t-1}| - \mathrm{E}[|z_{j,t-1}|] + \gamma_j z_{j,t-1}) \tag{3}$$

The Equation (2) show the conditional variance of returns ($\sigma_{i,t}^2$), which is determined for each markets as an exponential function of past own conditional variance and past standardized innovations ($z_{j,t-1} = \varepsilon_{j,t-1}/\sigma_{j,t-1}$) resulted from both its own market and other markets. Conditional variance follows an extended EGARCH process that allows its own lagged standardized innovation as well as cross markets standardized innovations to exert an asymmetric impact on volatility of market i. The volatility spillovers across markets is determined by the coefficient $\alpha_{i,j}$ (for $i \neq j$ and $i,j = 1,2,\ldots.n$). If $\alpha_{i,j} > 0$, means that, volatility is an increasing function of past standardized innovations. The asymmetry is modeled by equation (3), with partial derivatives being

$$\frac{\partial f_j(z_{j,t})}{\partial z_{j,t}} = 1 + \gamma_j \quad \text{for } z_j > 0 \quad \text{and} \quad \frac{\partial f_j(z_{j,t})}{\partial z_{j,t}} = -1 + \gamma_j \quad \text{for } z_j < 0$$

The parameter γ_j measures the asymmetric in volatility transmission mechanism, the asymmetry is present if γ_j is negative and statistically significant. In empirical perspective if $\gamma_j = 0$, this means a positive and negative shock have the same effect and same size; while when $-1 < \gamma_j < 0$, then the unexpected market deterioration rises the volatility more than market improvement however if $\gamma_j < -1$, a negative shock tends to rise the volatility, while a positive shock reduces it.

The relative importance of the asymmetry (or leverage effect) is measured by the ratio $|-1 + \gamma_j|/(1 + \gamma_j)$. A significant positive $\alpha_{i,j}$ coupled with negative γ_j implies that negative innovations in market *j* have higher impact on the volatility of market *i* than positive innovation, i.e. the volatility spillover mechanism is asymmetric. The coefficient δ_i measures the persistence in volatility; if $\delta_i < 1$, the unconditional variance is finite, but if $\delta_i = 1$ the unconditional variance does not exist and the conditional variance follows an integrated process of order 1. The persistence of volatility may also be quantified by the half-life (HL) (Bhar, 2010) as follow: $HL = \frac{\ln(0.5)}{ln|\delta_i|}$ which measure the time period requires for the shock to be reduced to the one-half of their original size.

4. Results and Discussion

4.1. Results from benchmark model

To evaluate the importance of market interdependence (i.e. lead lag relationship and volatility interactions) and to test the joint significance of first and second moment interactions using likelihood ratio statistics, we first estimate the model given by equation above by restricting all cross-market coefficients to zero, means not allowing for price and volatility spillovers. This restriction reduces the multivariate model to eight univariate EGARCH models. This restricted model is used as the benchmark model, in which the conditional variance for each market is defined as a function of past innovations and past conditional variances, with coefficient $\alpha_{i,i}$ and δ_i respectively. Coefficient γ_i measures the leverage effect (or asymmetric impact) of past innovation on current volatility.

The maximum likelihood estimates of this model are documented in table 1. The autoregressive coefficients $\beta_{i,i}$ are statistically significant for all markets, indicating that either non-synchronous trading or market inefficiency induces autocorrelation in the return series. The coefficients $\alpha_{i,i}$ for each market are statistically significant, means that the current stock market volatility in each market is highly affected by its own past innovation. The volatility persistence measured by δ_i, is significant and high close to unity in all cases; it is highest for South Africa, followed by Mauritius. The asymmetric impact of past innovations on current volatility is significant in all cases except Morocco, Nigeria and Zambia, means that the conditional volatility of the returns in Egypt, South Africa, Kenya, Mauritius, Tunisia respond asymmetrically to own past innovations. The degree of asymmetry is low, on the basis of the estimated $\gamma_i$coefficients, is highest for the South Africa market (negative innovations increase volatility approximately1.17 times more than positive innovations), followed by Egypt market (approximately 1.16 times). The estimated coefficients are still slightly significant in most cases compared to the results found in previous studies on the developed markets; this indicates that the developed countries have a more evident response to the negative shocks than do the emerging and developing markets such as African markets.

Table 1: Result from benchmark model. Full sample period (02/06/2004 to 30/04/2014)

Mean: $r_{i,t} = \beta_{i,0} + \sum_{j=1}^{N} \beta_{ij} r_{j,t-1} + \varepsilon_{i,t}$

Variance: $\sigma_{i,t}^2 = exp\left[\alpha_{i,0} + \sum_{j=1}^{n} \alpha_{i,j} f_j(z_{j,t-1}) + \delta_i \ln(\sigma_{i,t-1}^2)\right]$ For $\beta_{ij} = \alpha_{ij} = 0$ when $i \neq j$

	Egypt (i =1)	South Af. (i=2)	Zambia (i =3)	Morocco (i =4)	Kenya (i =5)	Nigeria (i =6)	Mauritius (i =7)	Tunisia (i =8)
$\beta_{i,0}$	**0.1654***	–0.0722	**0.1722***	0.0299	**0.1183***	0.0105	**0.0246***	**0.0301***
	(0.033)	(0.0285)	**(0.0107)**	(0.0187)	**(0.0217)**	(0.0237)	**(0.0094)**	**(0.0134)**
$\beta_{i,i}$	**0.1774***	**0.0137***	0.0237	**0.1418***	**0.2951***	**0.2923***	**–0.095***	**0.1204***
	(0.0186)	**(0.0197)**	(0.0203)	**(0.0192)**	**(0.0182)**	**(0.0199)**	**(0.0179)**	**(0.0217)**
$\alpha_{i,0}$	**–0.047***	**–0.0722***	**–0.1941***	**–0.154***	**–0.1329***	**–0.2393***	**–0.1827***	**–0.3631***
	(0.0049)	**(0.0099)**	**(0.0088)**	**(0.011)**	**(0.0041)**	**(0.0146)**	**(0.0072)**	**(0.0264)**
$\alpha_{i,i}$	**0.107***	**0.1134***	**0.3071***	**0.1989***	**0.204***	**0.2988***	**0.2561***	**0.3329***
	(0.0056)	**(0.0134)**	**(0.0151)**	**(0.0145)**	**(0.0068)**	**(0.0186)**	**(0.0106)**	**(0.0219)**
δ_i	**0.9035***	**0.9833***	**0.9449***	**0.9705***	**0.959***	**0.9149***	**0.9836***	**0.8668***
	(0.0023)	**(0.0029)**	**(0.0038)**	**(0.0049)**	**(0.0027)**	**(0.0083)**	**(0.0021)**	**(0.0163)**
γ_i	**–0.0748***	**–0.0787***	0.010	0.0009	**–0.0132***	–0.013	**–0.0179***	**–0.0396***
	(0.0057)	**(0.0085)**	(0.0093)	(0.0076)	**(0.0062)**	(0.0112)	**(0.0058)**	**(0.0127)**

*Note: * indicates the significance at 5% level of confidence. The value between parenthesis is the standard error.* ***Source:*** *Stata outputs*

4.2. Price and volatility spillovers results (entire period)

Now, the system of equations above are estimated in its unrestricted form thus taking into account market interdependence across countries. This also allows an examination of the correlations of conditional volatilities across markets in different countries, providing information on the level of interdependence among these markets. The full model considers both price and volatility spillovers[4] from other markets to one market. The results of the two tables show that the interdependence among stock market is due to both return and volatility spillovers; this confirms the hypothesis, which states that if markets are interdependent, an unanticipated event in one market will influence not only returns but also volatility of return in other markets. The existence of such financial spillover may be the result of real economic and financial ties between the African countries' economies as well as to the contagion effect caused by the recent financial crisis. These spillovers might be unidirectional or bidirectional and the volatility transmission might be symmetric or asymmetric; in the following we present some empirical evidences:

- **Return Spillover (Entire period)**

In term of the first moment interdependencies the results show that for all countries the current return in each market is highly predicted by the own past stock return as the coefficient of $\beta_{i,j}$ for $i=j$ are all significant at 5% level, as well as by the cross market past returns as some of $\beta_{i,j}$ for $i\neq j$ are significant at 5% level . This means that there is evidence of positive price spillover in the African stock markets among themselves as well as with developed market. The result indicates that the own past stock returns play a greater role than the cross-market past returns in the

[4] *Price spillover is the impact of an innovation from market i on the conditional mean of market j, whereas volatility spillover is the impacts of an innovation from market i on the conditional variance of market j.*

current return of each African markets, and this can be explained by the fact that the less mature markets are more affected by its own past returns. As it is observed that the value of $\beta_{i,j}$ for $i = j$ ($\beta_{i,i}$) are high for all markets and goes from 0.101 to (0.294). The coefficients $\beta_{i,j}$ indicate that there are return spillovers from the developed stock market to the African stock markets as well as among the African stock markets. The highly significant coefficient $\beta_{i,j}$ is observed in the case of South Africa with UK (0.952) this strong transmission of return among these two stock markets is mainly due to a high connection between these two markets (the dual listing of companies). These spillovers are found to be positive and unidirectional in some case and bidirectional in some other.

Table 2: Return spillover for entire period (2/6/2004 to 30/4/2014)

Return spillover for entire period (2/6/2004 to 30/4/2014)								
Mean: $r_{i,t} = \beta_{i,0} + \sum_{j=1}^{N} \beta_{ij} r_{j,t-1} + \varepsilon_{i,t}$ ***for i = 1,….8 and j=1,2,…..11 and i≠j***								
Coefficient	Egypt *(i = 1)*	South Africa *(i=2)*	Zambia *(i = 3)*	Morocco *(i = 4)*	Kenya *(i = 5)*	Nigeria *(i = 6)*	Mauritius *(i = 7)*	Tunisia *(i = 8)*
$\beta_{i,0}$	**0.0702***	0.01	**0.118***	0.005	**0.112***	0.011	0.018	**0.026***
	(0.034)	(0.017)	**(0.017)**	(0.017)	**(0.023)**	(0.024)	(0.012)	**(0.012)**
$\beta_{i,1}$	**0.174***	**0.033***	0.0081	0.006	**0.035***	**0.019***	-0.001	0.002
	(0.023)	**(0.011)**	(0.01)	(0.009)	**(0.01)**	**(0.008)**	(0.007)	(0.007)
$\beta_{i,2}$	**0.059***	**0.123***	**0.065***	**0.039***	0.005	0.016	0.006	**0.043***
	(0.024)	**(0.019)**	**(0.015)**	**(0.014)**	(0.016)	(0.013)	(0.012)	**(0.009)**
$\beta_{i,3}$	0.029	-0.008	**0.101***	0.0034	0.0039	0.014	**0.026***	-0.006
	(0.018)	(0.014)	**(0.01)**	(0.011)	(0.01)	(0.01)	**(0.009)**	(0.008)
$\beta_{i,4}$	-0.004	**0.041***	-0.02	**0.134***	-0.005	-0.006	**0.041***	**0.134***
	(0.031)	**(0.019)**	(0.02)	**(0.02)**	(0.018)	(0.016)	**(0.01)**	**(0.012)**
$\beta_{i,5}$	**0.067***	-0.0063	0.001	0.0049	**0.281***	**0.024***	0.006	-0.002
	(0.022)	(0.015)	(0.016)	(0.013)	**(0.018)**	**(0.012)**	(0.011)	(0.009)
$\beta_{i,6}$	**0.112***	-0.0056	**0.043***	0.013	0.014	**0.294***	0.015	0.007
	(0.024)	(0.018)	**(0.017)**	(0.015)	(0.013)	**(0.02)**	(0.01)	(0.009)
$\beta_{i,7}$	**0.061***	0.0053	**0.078***	**0.022***	**0.028***	-0.009	**0.109***	0.011
	(0.02)	(0.017)	**(0.017)**	**(0.01)**	**(0.012)**	(0.012)	**(0.018)**	(0.01)
$\beta_{i,8}$	0.056	**0.0102***	**0.056***	**0.256***	0.034	-0.014	0.017	**0.106***
	(0.042)	**(0.029)**	**(0.025)**	**(0.02)**	(0.025)	(0.02)	(0.02)	**(0.022)**
$\beta_{i,9}$	**0.146***	**0.114***	**0.046***	**0.052***	0.007	-0.016	**0.025***	0.0005
	(0.019)	**(0.015)**	**(0.012)**	**(0.012)**	(0.009)	(0.011)	**(0.011)**	(0.008)
$\beta_{i,10}$	0.007	**0.095***	**0.036***	-0.022	-0.004	0.029	0.003	**0.029***
	(0.029)	**(0.023)**	**(0.013)**	(0.016)	(0.016)	(0.014)	(0.016)	**(0.011)**
$\beta_{i,11}$	**0.112***	**0.952***	**0.124***	**0.039***	0.031	0.008	0.005	**0.086***
	(0.034)	**(0.022)**	**(0.021)**	**(0.015)**	(0.023)	(0.019)	(0.019)	**(0.013)**

*Note: * indicates the significance at 5% level of confidence. The values between parentheses are the standard error. the coefficient βi,j where j=1if its Egypt, 2 if it South Africa, 3 for Zambia, 4 for Morocco, 5 for Kenya, 6 for Nigeria, 7for Mauritius, 8 for Tunisia, 9 for Japan, 10 for US and 11 if its UK provides the spillover in term of return across markets. The coefficients βi,i provide the own effect for each markets.* ***Source:*** *Stata outputs*

- **Volatility Spillover (Entire period)**

In term of second moment interdependencies, the results of different equations show that the current stock market volatility in each market is affected highly by its own past innovation as well as innovation coming at least from four other markets. This means that there is volatility spillover among the selected markets, the results highlighted that for most markets, the own volatility spillover were greater than cross-volatility spillover. This indicates that in the African stock market, the own past innovation play a greater role than the cross-market past innovation in the conditional volatility, and this can be explained by the fact that the less mature markets are more affected by its own past shocks. As it is observed that the value of $\alpha_{i,j}$ for $i = j$ ($\alpha_{i,i}$) are high for all markets and goes from 0.148 to 0.352. The coefficients estimates of different $\alpha_{i,j}$ indicate that there are volatility spillovers from one stock market to another. The values of $\alpha_{i,j}$ are ranged from 0.011 and 0.091, and these values indicates that the transmissions of volatility have different magnitude between the African markets and between the developed market with the African markets.

The results show that there is past shock spillover from some developed markets to the African market. For the volatility spillover, the only highly significant parameter in all groups is $\alpha_{i,11}$ which measured the volatility spillover from the UK stock market to the African stock markets. The range of this parameter is from 0.031 to 0.091 Tunisia. The highly significant shock spillovers from the UK market to the African markets is the results of overlapping trading hours, as well as the high connection of this market with the African markets. It seems that our results support the conventional expectation that the spillover is high from a developed market to a less developed or emerging market (due to the quick spread of information, and the dependence of less developing economies on the developed economies). The volatility spillovers are found to be positive and unidirectional in some case; and bidirectional volatility spillovers in some other cases.

We also note from Table 3 that the transmission mechanism of fluctuations is asymmetric in some cases. The size of the asymmetry calculated using this formula: $|-1+\gamma_i|/(1+\gamma_i)$ indicate that negative innovation or bad news in (i) Egypt, (ii) South Africa and (iii) Tunisia increase own volatility and volatility in other markets by (i) 1.16, (ii) 1.04 and (iii)1.07 times than positive innovation or good news respectively. For example: stock market decline in Egypt will increase the own volatility and the return volatility in Morocco, Nigeria and Mauritius 1.16 times more than positive news or market advance. The Asymmetry response is due to the sensitivity of investors to different news especially the bad news, and the presence of asymmetry on these three cases is due to the fact that these three markets are the most active and the biggest in the region, so any news emerge from these market affect the volatility of the other market, and when it is bad the news causes a more volatility in the other African markets.

The magnitudes of persistence in volatility (δ_i) are close to one, and that indicates a typical characteristic of the financial data, which is a high degree of volatility persistence this suggest that the volatility from period to period (day to day) remains quite stable for all countries. The volatility persistence is high for African market this means that these markets derive relatively more of their volatility from the own past volatility. The time needed by stock market to reduce the shock by half is calculated using this formula ln (0.5)/ln δ_i. For example, the half-life values are 8.8, 45.5, 15.7, 31.3, 20.5, 8.4, 36.7 and 6.15 days for Egypt, South Africa, Zambia, Morocco, Kenya, Nigeria, Mauritius and Tunisia respectively. All the values are more than 6 suggesting that the adjustment took more than six days (one working week); i.e., the different markets are relatively inefficient in adjusting shock from other markets. The persistence in the volatility is high in this model compared to the benchmark model, since here we take cross markets volatility spillover so, the persistence increases as the market become more interdependent with other market, this because when the markets are interacted the factors affecting the volatility are not only domestic but global so, the adjustment of the past volatility in one market take a long time compared to the case when the market is isolated from the other markets.

Table3: Volatility spillover for the entire period (2/6/2004 to 30/4/2014)

Volatility spillover for the entire period (2/6/2004 to 30/4/2014)

Variance: $\sigma^2_{i,t} = \exp\left[\alpha_{i,0} + \sum_{j=1}^{n} \alpha_{i,j} f_j(z_{j,t-1}) + \delta_i \ln(\sigma^2_{i,t-1})\right]$ ***for i = 1,….11 and j=1,2,…..11 and i≠j***

Coefficient	Egypt *(i = 1)*	South Africa *(i=2)*	Zambia *(i = 3)*	Morocco *(i = 4)*	Kenya *(i = 5)*	Nigeria *(i = 6)*	Mauritius *(i = 7)*	Tunisia *(i = 8)*
$\alpha_{i,0}$	**-0.124***	-0.037	**0.202***	**0.173***	**-0.114***	**-0.236***	**-0.173***	**-0.446***
	(0.017)	(0.008)	**(0.011)**	**(0.013)**	**(0.006)**	**(0.018)**	**(0.009)**	**(0.037)**
$\alpha_{i,1}$	**0.301***	0.0026	0.01	**0.011***	0.007	**0.017***	**0.015***	-0.001
	(0.026)	(0.003)	(0.007)	**(0.004)**	(0.005)	**(0.008)**	**(0.004)**	(0.009)
$\alpha_{i,2}$	0.014	**0.148***	-0.005	**0.035***	**0.022***	**0.021***	0.009	**0.079***
	(0.015)	**(0.01)**	(0.01)	**(0.014)**	**(0.009)**	**(0.01)**	(0.01)	**(0.017)**
$\alpha_{i,3}$	**0.042***	0.001	**0.306***	-0.003	**0.039***	**0.02***	0.008	**0.025***
	(0.012)	(0.005)	**(0.016)**	(0.007)	**(0.005)**	**(0.008)**	(0.006)	**(0.013)**
$\alpha_{i,4}$	**0.039***	**0.0153***	**0.021***	**0.214***	-0.004	-0.003	-0.01	0.004
	(0.013)	**(0.006)**	**(0.011)**	**(0.017)**	(0.009)	(0.009)	(0.008)	(0.016)
$\alpha_{i,5}$	**0.028***	**0.0116***	**0.014***	-0.011	**0.167***	**0.033***	0.002	**0.024***
	(0.011)	**(0.005)**	**(0.006)**	(0.007)	**(0.01)**	**(0.01)**	(0.007)	**(0.012)**
$\alpha_{i,6}$	-0.001	0.002	0.0024	**0.018***	0.009	**0.293***	0.003	**0.036***
	(0.012)	(0.004)	(0.006)	**(0.007)**	(0.06)	**(0.023)**	(0.006)	**(0.012)**
$\alpha_{i,7}$	-0.024	0.0019	**0.026***	-0.001	**0.015***	0.005	**0.241***	**0.041***
	(0.017)	(0.007)	**(0.01)**	(0.011)	**(0.008)**	(0.012)	**(0.012)**	**(0.018)**
$\alpha_{i,8}$	0.021	**0.028***	-0.017	0.011	0.004	**0.041***	0.0038	**0.352***
	(0.02)	**(0.009)**	(0.013)	(0.01)	(0.011)	**(0.017)**	(0.012)	**(0.025)**
$\alpha_{i,9}$	0.018	**0.024***	0.01	-0.005	0.002	-0.003	**0.049***	**0.039***
	(0.016)	**(0.008)**	(0.01)	(0.014)	(0.011)	(0.014)	**(0.011)**	**(0.015)**
$\alpha_{i,10}$	**0.082***	-0.016	-0.011	-0.009	**0.036***	**0.046***	0.011	-0.004
	(0.018)	(0.014)	(0.017)	(0.019)	**(0.017)**	**(0.019)**	(0.017)	(0.025)
$\alpha_{i,11}$	**0.031***	**0.054***	-0.029	**0.039***	**0.089***	0.004	-0.014	**0.091***
	(0.012)	**(0.012)**	(0.021)	**(0.015)**	**(0.018)**	(0.02)	(0.019)	**(0.031)**
δ_i	**0.9246***	**0.9848***	**0.957***	**0.9781***	**0.9667***	**0.921***	**0.9813***	**0.8935***
	(0.014)	**(0.003)**	**(0.004)**	**(0.007)**	**(0.003)**	**(0.01)**	**(0.003)**	**(0.023)**
γ_i	**-0.074***	**-0.022***	0.002	-0.003	0.013	-0.002	0.032	**-0.033***
	(0.014)	**(0.008)**	(0.01)	(0.009)	(0.008)	(0.013)	(0.008)	**(0.015)**

*Note: * indicates the significance at 5% level of confidence. The values between parentheses are the standard error. the coefficient $\alpha_{i,j}$ where j=1if its Egypt, 2 if it South Africa, 3 for Zambia, 4 for Morocco, 5 for Kenya, 6 for Nigeria, 7for Mauritius, 8 for Tunisia, 9 for Japan, 10 for US and 11 if its UK provide the volatility spillover across market. The coefficients $\alpha_{i,i}$ provide the own effect for each markets. **Source:** Stata outputs*

4.3. pre- and post- 2008 crisis analysis

We hypothesize that the asymmetric response of volatility to innovations may be the results of few extreme observations such as those associated with the crises. So, it is very interesting to investigate this possibility, as well as possible changes in the nature of price and volatility spillovers in the period following the 2008 global financial crisis; to this end, we estimate the same model for the two sub-periods (pre- and post-financial crisis). The results for the unrestricted model for the two sub-periods are reported in following two tables. Table 4 reports the results of mean equation, while the table 5 shows the results of variance equation for the pre-crisis period.

- **Return Spillover (Pre-crisis period)**

In term of the first moment interdependencies the results show that, in addition to the own past stock return the current return in each market is also predicted by the cross market return as some of the coefficients $\beta_{i,j}$ are significant at 5% level. This means that, there is return spillover from one market to another which is found to be unidirectional in some case and bidirectional in some other cases; in the following we provide some empirical evidences: The result indicates that the own past stock returns play a greater role than the cross-market past returns in the current return of each African markets, except in the case of Zambia and Morocco as it is observed that morocco is highly affected by the Tunisia market while the Zambia is highly affected by South Africa market. Indeed, the autoregressive coefficients $\beta_{i,i}$ are high for all markets and goes from (0.052) in Zambia to (0.363) in Nigeria. and this can be explained by the fact that the less mature markets are more affected by its own past returns. The coefficients $\beta_{i,j}$ indicate that there are return spillovers from the developed stock market to the African stock markets as well as among the African stock market. The average values of $\beta_{i,j}$ show that the magnitude of transmissions is the same between African markets as well as among the developed market with the African markets, in the long run. The highly significant coefficient $\beta_{i,j}$ is observed in the case of Morocco with Tunisia (0.275) this strong transmission of return among these two stock markets is mainly due to strong convergence in the economic, geographic and cultural conditions of these two markets. The South African market plays a predominant role as information producer, since it is the most influenced and influential this is mainly due to its size and this market is the most active and developed in the region. In other hand for the developed markets, it seems that the three markets have the same degree of influence; as it is evident that Japanese, UK and US are all contribute in transmitting information to the African markets. In other hand, in this sub-period it seems that Kenya, Mauritius and Nigeria are the less dependent market as they are the less influenced and influential compared to the other markets.

Table 4: Return spillover for pre-crisis period (2/06/2004 to 29/08/2008)

Return spillover for pre-crisis period (2/6/2004 to 29/8/2008)

Mean: $r_{i,t} = \beta_{i,0} + \sum_{j=1}^{N} \beta_{ij} r_{j,t-1} + \varepsilon_{i,t}$ ***for i = 1,….11 and j=1,2,…..11 and i≠j***

Coefficient	Egypt *(i = 1)*	South Africa *(i=2)*	Zambia *(i = 3)*	Morocco *(i = 4)*	Kenya *(i = 5)*	Nigeria *(i = 6)*	Mauritius *(i = 7)*	Tunisia *(i = 8)*
$\beta_{i,0}$	**0.194*** **(0.05)**	0.019 (0.012)	**0.141*** **(0.023)**	**0.078*** **(0.032)**	**0.134*** **(0.036)**	0.04 (0.038)	0.023 (0.018)	**0.066*** **(0.019)**
$\beta_{i,1}$	**0.161*** **(0.031)**	**0.033*** **(0.015)**	0.019 (0.016)	-0.016 (0.015)	**0.033*** **(0.015)**	0.009 (0.014)	-0.019 (0.012)	-0.011 (0.01)
$\beta_{i,2}$	0.014 (0.04)	**0.193*** **(0.026)**	**0.136*** **(0.02)**	**0.073*** **(0.023)**	-0.002 (0.024)	0.0014 (0.019)	0.026 (0.015)	**0.043*** **(0.016)**
$\beta_{i,3}$	-0.005 (0.026)	**0.037*** **(0.017)**	**0.052*** **(0.013)**	0.009 (0.018)	-0.001 (0.019)	-0.011 (0.02)	0.006 (0.011)	-0.005 (0.013)
$\beta_{i,4}$	-0.023 (0.04)	0.036 (0.029)	-0.007 (0.031)	**0.176*** **(0.031)**	-0.023 (0.032)	-0.004 (0.023)	0.091 (0.014)	**0.089*** **(0.018)**
$\beta_{i,5}$	**0.057*** **(0.028)**	0.009 (0.02)	0.006 (0.021)	**0.047*** **(0.018)**	**0.173*** **(0.029)**	-0.013 (0.019)	-0.003 (0.016)	-0.001 (0.014)
$\beta_{i,6}$	0.051 (0.037)	-0.009 (0.033)	-0.015 (0.028)	0.007 (0.028)	-0.025 (0.03)	**0.363*** **(0.033)**	-0.005 (0.01)	-0.009 (0.019)
$\beta_{i,7}$	-0.024 (0.044)	**0.063*** **(0.03)**	0.037 (0.033)	0.029 (0.023)	**0.039*** **(0.018)**	0.0004 (0.001)	**0.054*** **(0.023)**	0.004 (0.017)
$\beta_{i,8}$	0.041 (0.067)	**0.112*** **(0.055)**	-0.071 (0.038)	**0.275*** **(0.042)**	0.027 (0.053)	-0.041 (0.037)	-0.019 (0.029)	**0.095*** **(0.035)**
$\beta_{i,9}$	**0.129*** **(0.033)**	**0.121*** **(0.026)**	**0.082*** **(0.022)**	**0.057*** **(0.018)**	0.005 (0.02)	-0.031 (0.016)	0.004 (0.015)	0.017 (0.014)
$\beta_{i,10}$	**0.006*** **(0.04)**	0.06 (0.04)	0.062 (0.037)	**0.092*** **(0.027)**	0.008 (0.033)	**0.054*** **(0.023)**	-0.007 (0.02)	**0.047*** **(0.021)**

*Note: * indicates the significance at 5% level of confidence. The values between parentheses are the standard error. the coefficient βi,j where j=1if its Egypt, 2 if it South Africa, 3 for Zambia, 4 for Morocco, 5 for Kenya, 6 for Nigeria, 7for Mauritius, 8 for Tunisia, 9 for Japan, 10 for US and 11 if its UK provides the spillover in term of return across markets. The coefficients βi,i provide the own effect for each markets.* ***Source:*** *Stata outputs*

➢ Volatility Spillover (Pre-crisis period)

In term of second moment interdependencies, the results show that the current stock market volatility in each market is affected by its own past innovation (as all the coefficient of $\alpha_{i,j}$ for *i=j* are significant) as well as by innovation coming at least from one of other markets (as some of the coefficient of $\alpha_{i,j}$ for *i≠j* are significant). This means that there is unidirectional and bidirectional volatility spillover from one market to another and these spillovers are found to be symmetric in some case and asymmetric in some other. The results point out that for most markets, the own volatility spillover was greater than cross-volatility spillover. This indicates that in the African stock market, the own past innovation plays a greater role than the cross-market past innovation in the conditional volatility, as it is observed that the value of $\alpha_{i,i}$ are high for all markets and goes from 0.113 to 0.535. The coefficients estimate of different $\alpha_{i,j}$ indicate that there are volatility spillovers from one stock market to another. For the volatility spillover, the only highly significant parameter in all groups is $\alpha_{i,11}$ which measured the volatility spillover from the UK stock market to the African stock markets. The range of this parameter is from 0.084 (South Africa) to 0.139 (Nigeria). The highly significant shock spillovers from the UK market to the African markets may be the results of overlapping trading hours, as well as the high connection of this market with the African markets. The results indicate that South Africa and UK play a predominant role in both return and volatility spillovers as source of market information to the other African markets.

Table 5: Volatility spillover for pre-crisis-period (2/06/2004 to 29/08/2008)

Volatility spillover for the entire period (2/6/2004 to 29/8/2008)

Variance: $\sigma_{i,t}^2 = \exp[\alpha_{i,0} + \sum_{j=1}^{n} \alpha_{i,j} f_j(z_{j,t-1}) + \delta_i \ln(\sigma_{i,t-1}^2)]$ *for i = 1,….11 and j=1,2,…..11 and i≠j*

Coefficient	Egypt (i = 1)	South Africa (i=2)	Zambia (i = 3)	Morocco (i = 4)	Kenya (i = 5)	Nigeria (i = 6)	Mauritius (i = 7)	Tunisia (i = 8)
$\alpha_{i,0}$	**-0.143***	**0.016***	**-0.194***	**-0.255***	**-0.184***	**-0.309***	**-0.378***	**-0.191***
	(0.026)	**(0.008)**	**(0.015)**	**(0.026)**	**(0.015)**	**(0.046)**	**(0.021)**	**(0.049)**
$\alpha_{i,1}$	**0.259***	-0.003	**0.031***	0.016	0.001	**0.051***	0.031*	0.005
	(0.037)	(0.004)	**(0.009)**	(0.013)	(0.013)	**(0.016)**	(0.015)	(0.012)
$\alpha_{i,2}$	0.008	**0.138***	0.012	**0.056***	0.027	**0.105***	0.024	**0.093***
	(0.024)	**(0.012)**	(0.019)	**(0.028)**	(0.021)	**(0.027)**	(0.021)	**(0.025)**
$\alpha_{i,3}$	-0.004	0.002	**0.287***	0.016	**0.053***	0.013	**0.058***	0.026
	(0.018)	(0.006)	**(0.022)**	(0.015)	**(0.015)**	(0.022)	**(0.018)**	(0.015)
$\alpha_{i,4}$	**0.029***	0.009	0.008	**0.309***	0.013	0.011	**0.079***	-0.007
	(0.013)	(0.005)	(0.015)	**(0.033)**	(0.019)	(0.023)	**(0.011)**	(0.019)
$\alpha_{i,5}$	**0.031***	**0.019***	0.006	-0.019	**0.275***	-0.024	0.008	-0.023
	(0.014)	**(0.006)**	(0.011)	(0.018)	**(0.023)**	(0.047)	(0.017)	(0.014)
$\alpha_{i,6}$	-0.025	**0.018***	**0.027***	0.016	**0.055***	**0.313***	**0.051***	**0.041***
	(0.02)	**(0.005)**	**(0.008)**	(0.018)	**(0.016)**	**(0.05)**	**(0.016)**	**(0.016)**
$\alpha_{i,7}$	-0.032	0.009	-0.013	0.0039	**0.101***	-0.024	**0.535***	-0.035
	(0.03)	(0.007)	(0.017)	(0.025)	**(0.02)**	(0.021)	**(0.029)**	(0.024)
$\alpha_{i,8}$	0.031	**0.029***	-0.002	**0.093***	0.013	0.034	**0.058***	**0.113***
	(0.033)	**(0.014)**	(0.022)	**(0.033)**	(0.03)	(0.041)	**(0.026)**	**(0.029)**
$\alpha_{i,9}$	0.029	**0.072***	-0.015	-0.006	**0.086***	-0.02	0.015	0.008
	(0.021)	**(0.026)**	(0.018)	(0.027)	**(0.023)**	(0.021)	(0.027)	(0.023)
$\alpha_{i,10}$	0.013	**0.072***	0.003	0.071	**0.106***	**0.034***	0.022	-0.052
	(0.047)	**(0.026)**	(0.023)	(0.05)	**(0.038)**	**(0.047)**	(0.036)	(0.046)
$\alpha_{i,11}$	**0.133***	**0.084***	0.005	0.04	**0.125***	**0.139***	0.052	**0.127***
	(0.052)	**(0.019)**	(0.043)	(0.055)	**(0.042)**	**(0.057)**	(0.044)	**(0.053)**
δ_i	**0.931***	**0.998***	**0.928***	**0.938***	**0.918***	**0.913***	**0.9305***	**0.863***
	(0.018)	**(0.005)**	**(0.005)**	**(0.013)**	**(0.009)**	**(0.031)**	**(0.012)**	**(0.025)**
γ_i	-0.024	**-0.028***	-0.009	0.012	0.054	0.053	0.069	0.034
	(0.02)	**(0.012)**	(0.014)	(0.018)	(0.017)	(0.026)	(0.022)	(0.016)

*Note: * indicates the significance at 5% level of confidence. The values between parentheses are the standard error. the coefficient $\alpha_{i,j}$ where j=1if its Egypt, 2 if it South Africa, 3 for Zambia, 4 for Morocco, 5 for Kenya, 6 for Nigeria, 7for Mauritius, 8 for Tunisia, 9 for Japan, 10 for US and 11 if its UK provide the volatility spillover across market. The coefficients $\alpha_{i,i}$ provide the own effect for each markets.* ***Source:*** *Stata outputs*

The results of the table 6 indicate that the coefficient γ_i are negative and significant only in South Africa market; means that the volatility transmission mechanism from this market to other markets is asymmetric. The size of the asymmetry shows that negative innovation or bad news in South Africa increases its own volatility and the volatility in Morocco, Nigeria and Tunisia markets by 1.057 times more than positive innovations. The asymmetry in volatility transmission in the case of South Africa is due to the fact that this market is the most active and the biggest in the region, so any news emerge from this market affect the volatility of the other markets, and when it is bad the news cause a more volatility in the other African markets. However, if we compare this result with the results found in previous studies on the developed markets; this indicates that the developed countries have a more evident response to the negative shocks than do the developing markets such as African markets.

The persistence of volatility assessed by parameter δ_i are all highly significant and close to unity this means that the volatility from day to day is quite stable. The coefficient of volatility ranges from 0.8632 for Tunisia to 0.9979 for South Africa, this means that the volatility takes long time to die out in South Africa compared to the other markets. The volatility persistence is high for African market this means that these markets derive relatively more of their volatility persistence from the own past volatility. The time needed by each stock market to reduce the shock by half are 9.7, 33.61, 9.3, 10.8, 8.2, 7.7, 9.6 and 6.8 days for Egypt, South Africa, Zambia, Morocco, Kenya, Nigeria, Mauritius and Tunisia respectively. All the values are more than 6 suggesting that the adjustment took more than six days, and this means that the African stock market take a long time to adjust the shock (volatility) come from the other markets.

- **Return Spillover (Post-crisis period)**

In term of the first moment interdependencies, the results of mean equation show that the current return in a given market is highly determined by its own past stock return, as well as by cross markets past returns. This means that there is return spillover from one market to other and these spillovers are found to be unidirectional in some case and bidirectional in some others. The result indicates that the own past stock returns play a greater role than the cross-market past returns in the current return of each African markets, as it is observed that the value of $\beta_{i,i}$ are high for all markets and goes from 0.052 to 0.309. However, in this period (post-crisis) it is observed that some markets are affected highly by the cross market past returns than own past return, this is the result of the contagion effect caused by the crisis, this means that in post-crisis period the markets current returns is highly affected by both own past return as well as cross market return. The coefficients $\beta_{i,j}$ indicate that there are return spillovers from the developed stock market to the African stock markets as well as among the African stock market. The average values of $\beta_{i,j}$ show that the magnitude of transmissions are the same between African markets as well as between a developed market and the African markets, in the long run. The highly significant coefficient $\beta_{i,j}$ is observed in the case of South Africa with UK (0.902) this strong transmission of return among these two stock markets is mainly due to a high connection between these two markets (the dual listing of companies). Another important point derived from these results is that the return spillover among the markets is increased in the period post-crisis. As the number of the significance coefficient is increased from 33 to 46 in post crisis; and in 46 case of return spillover among the markets 11 are found to be bidirectional. The increase in the spillover effect is result of contagion which defined as the significance increase in stock market comovement during a crisis. In this period all country stock market return become highly affected, for example, the current return in Mauritius is determined by only its own past return in pre-crisis, while in post-crisis the number of market that affect stock market return in Mauritius are six. From these results we conclude that the interdependence among the African stock markets is increased in the period followed the crisis, as there is more spillover in term of return of the markets and each market become a source of market information for the other market, so we can say that each market become an integral part of a single global market. These results are consistent with the finding of (Kanas, 1998) (Masih & Masih, 2004) (Liu & Pan, 1997); all their findings support the fact that interdependence among the markets increased during the crisis due to a contagion effect.

Table 6: Return spillovers for post-crisis period (16/09/2008 to 30/04/2014)

Return spillover for entire period (16/9/2008 to 30/4/2014)

Mean: $r_{i,t} = \beta_{i,0} + \sum_{j=1}^{N} \beta_{ij} r_{j,t-1} + \varepsilon_{i,t}$ ***for i = 1,….11 and j=1,2,…..11 and i≠j***

Coefficient	Egypt *(i = 1)*	South Africa *(i=2)*	Zambia *(i = 3)*	Morocco *(i = 4)*	Kenya *(i = 5)*	Nigeria *(i = 6)*	Mauritius *(i = 7)*	Tunisia *(i = 8)*
$\beta_{i,0}$	0 .004	0.012	0.039	0.026	**0.063***	0.008	0.015	0.004
	(0.047)	(0.021)	(0.03)	(0.02)	**(0.033)**	(0.017)	(0.017)	(0.017)
$\beta_{i,1}$	**0.128***	**0.039***	-0.023	0.008	**0.039***	0.022	**0.023***	0.005
	(0.034)	**(0.014)**	(0.015)	(0.013)	**(0.012)**	(0.013)	**(0.01)**	(0.009)
$\beta_{i,2}$	**0.144***	**0.135***	**0.077***	0.019	0.021	**0.052***	-0.025	**0.042***
	(0.036)	**(0.023)**	**(0.027)**	(0.021)	(0.018)	**(0.018)**	(0.019)	**(0.013)**
$\beta_{i,3}$	-0.0036	**0.038***	**0.052***	-0.0027	**0.032***	**0.045***	**0.053***	-0.014
	(0.029)	**(0.017)**	**(0.02)**	(0.016)	**(0.014)**	**(0.018)**	**(0.017)**	(0.011)
$\beta_{i,4}$	0.0042	0.033	-0.012	**0.124***	**0.051***	0.034	**0.061***	**0.169***
	(0.043)	(0.03)	(0.032)	**(0.025)**	**(0.025)**	(0.024)	**(0.026)**	**(0.016)**
$\beta_{i,5}$	**0.057***	0.009	0.008	**0.045***	**0.309***	**0.107***	**0.037***	-0.011
	(0.026)	(0.024)	(0.025)	**(0.019)**	**(0.026)**	**(0.021)**	**(0.018)**	(0.014)
$\beta_{i,6}$	**0.129***	0.005	**0.078***	0.007	**0.047***	**0.232***	0.019	0.013
	(0.032)	(0.023)	**(0.025)**	(0.019)	**(0.017)**	**(0.027)**	(0.022)	(0.01)
$\beta_{i,7}$	**0.122***	-0.035	**0.135***	0.029	0.023	-0.018	**0.172***	**0.021***
	(0.028)	(0.024)	**(0.022)**	(0.02)	(0.018)	(0.018)	**(0.024)**	**(0.01)**
$\beta_{i,8}$	0.038	**0.094***	-0.039	**0.252***	0.012	0.009	**0.055***	**0.134***
	(0.055)	**(0.035)**	(0.037)	**(0.028)**	(0.03)	(0.034)	**(0.025)**	**(0.031)**
$\beta_{i,9}$	**0.186***	**0.081***	0.012	**0.038***	**0.032***	-0.001	**0.054***	**0.017***
	(0.024)	**(0.019)**	(0.017)	**(0.015)**	**(0.015)**	(0.016)	**(0.014)**	**(0.009)**
$\beta_{i,10}$	0.026	**0.123***	0.008	0.004	0.003	0.023	-0.016	**0.029***
	(0.037)	**(0.03)**	(0.026)	(0.021)	(0.02)	(0.019)	(0.025)	**(0.013)**
$\beta_{i,11}$	0.034	**0.902***	0.016	**0.141***	-0.009	0.018	0.001	**0.099***
	(0.046)	**(0.029)**	(0.034)	**(0.027)**	(0.025)	(0.024)	(0.031)	**(0.016)**

*Note: * indicates the significance at 5% level of confidence. The values between parentheses are the standard error. the coefficient $\beta_{i,j}$ where j=1if its Egypt, 2 if it South Africa, 3 for Zambia, 4 for Morocco, 5 for Kenya, 6 for Nigeria, 7for Mauritius, 8 for Tunisia, 9 for Japan, 10 for US and 11 if its UK provides the spillover in term of return across markets. The coefficients $\beta_{i,i}$ provide the own effect for each markets.* ***Source:*** *Stata outputs*

➢ Volatility Spillover (Post-crisis period)

Turning to second moment interdependencies the results show that the current stock market volatility in a given market is highly affected by its own past innovation as well as innovation coming at least from one of other markets; this means that there is unidirectional and bidirectional volatility spillover from market to another these spillover might be symmetric or asymmetry. Particularly, the results point out that for most markets, the own volatility spillover were greater than cross-volatility spillover.

This indicates that in the African stock market, the own past innovation plays a greater role than the cross-market past innovation in the conditional volatility, as it is observed that the value of $\alpha_{i,i}$ are high for all markets and goes from 0.072 to 0.535. The coefficients estimate of different $\alpha_{i,j}$ indicate that there are volatility spillovers from one stock market to another. The values of $\alpha_{i,j}$ are ranged from 0.01 and 0.129, and these values indicates that the transmissions of volatility have different magnitude between the African markets and between the developed market with the African markets. The results also show that there is past shock spillover from some developed markets to the African market. For the volatility spillover, the only highly significant parameter in all groups is $\alpha_{1,10}$ which measured the volatility spillover from the US stock market to Egypt stock market. Compared the results of this period to those of pre-crisis, the US become more influential this may due to the contagion effect as the crisis is originated in this market; this means that in this period both UK and US markets are influential in transmitting volatility to the African markets. In the post-crisis period, the African stock markets become more vulnerable to external shock, this evident from the results, which show that the number of the significant coefficient measuring volatility spillover is increased from 36 in pre-crisis to 48 in post crisis. For instance, the current return volatility of morocco is influenced by the past innovation come from two markets in pre-crisis, while in post-crisis we observe a volatility spillover from seven markets to Morocco market. These results indicate that the all markets become influential in transmitting volatility to the other market and all markets become a source of market information for the other markets, as these information built a set of information for the investors in each countries. These results confirm the lead lag relationship between the markets and the existence of the transmission of volatility from one market to another.

The results of table 7, indicate that the parameter measuring the asymmetry (γ_i) are negative and significant in four markets namely Egypt, South Africa Morocco and Tunisia. The size of the asymmetry assessed by this ratio: $|-1+\gamma_i|/(1+\gamma_i)$ indicate that, negative innovation or bad news in Egypt increase its own volatility and volatility of South Africa, Morocco and Mauritius by 1.24 times than positive shock. The market decline in South Africa increases its own volatility and volatility of Egypt, Morocco, Kenya, Mauritius and Tunisia by1.025 times more than market advance. These results confirm that the asymmetry in the volatility transmission increased in post-crisis as almost all volatilities respond asymmetrically with bad news, this is due to the behavior of the investors and their sensitivity to the news especially the noise investors who makes decisions regarding buy and sell trades without the use of fundamental data. These investors generally have poor timing, follow trends, and over-react to good and bad news. Thus, when there is bad news from domestic or other regional and global market the bid ask operations will happen in short space of time (very quickly) which led to high volatility.

The persistence in volatility is given by the parameter δ_i, which are highly significant for all cases and close to one, with South Africa has the highest value and Tunisia has the lowest value, this means that the volatility takes long time to die out in South Africa compared to the other markets. The time needed by stock markets to reduce the shock by half is 5.2, 19.45, 8.03, 8.4, 4.3, 7.2, 7.7 and 2.2 days for Egypt, South Africa, Zambia, Morocco, Kenya, Nigeria, Mauritius and Tunisia respectively. All the values are more than 2, means that in period after crisis the adjustment took more than two days, which less than in period before crisis. This indicates that, in the period of crisis and post-crisis the stock market become more efficient in adjusting external shocks and the past volatility is adjusted in fairly rapid fashion in markets.

Table 7: Volatility spillovers for post-crisis period (16/09/2008 to 30/04/2014)

Volatility spillover for the entire period (16/9/2008 to 30/4/2014)								
Variance: $\sigma^2_{i,t} = \exp\left[\alpha_{i,0} + \sum_{j=1}^{n} \alpha_{i,j} f_j(z_{j,t-1}) + \delta_i \ln(\sigma^2_{i,t-1})\right]$ ***for i = 1,...11 and j=1,2,...11 and i≠j***								
Coefficient	Egypt *(i = 1)*	South Africa *(i=2)*	Zambia *(i = 3)*	Morocco *(i = 4)*	Kenya *(i = 5)*	Nigeria *(i = 6)*	Mauritius *(i = 7)*	Tunisia *(i = 8)*
$\alpha_{i,0}$	**-0.141***	0.011	**-0.193***	**0.013***	**-0.331***	**-0.246***	**-0.056***	**-0.645***
	(0.028)	(0.008)	**(0.019)**	**(0.006)**	**(0.028)**	**(0.026)**	**(0.008)**	**(0.062)**
$\alpha_{i,1}$	**0.337***	**0.011***	-0.006	**0.012***	-0.009	0.012	**0.024***	0.0004
	(0.038)	**(0.004)**	(0.011)	**(0.004)**	(0.013)	(0.01)	**(0.005)**	(0.016)
$\alpha_{i,2}$	**0.039***	**0.159***	0.013	**0.051***	**0.037***	-0.005	**0.042***	**0.057***
	(0.019)	**(0.011)**	(0.016)	**(0.008)**	**(0.017)**	(0.019)	**(0.012)**	**(0.026)**
$\alpha_{i,3}$	**0.066***	-0.0096	**0.286***	-0.009	**0.041***	0.012	0.0004	0.014
	(0.019)	(0.006)	**(0.028)**	(0.0045)	**(0.016)**	(0.012)	(0.007)	(0.021)
$\alpha_{i,4}$	**0.039***	0.0056	**0.047***	**0.072***	-0.032	-0.006	**0.035***	**0.054***
	(0.018)	(0.0065)	**(0.018)**	**(0.01)**	(0.02)	(0.014)	**(0.011)**	**(0.027)**
$\alpha_{i,5}$	0.015	-0.0058	**0.036***	**0.011***	**0.417***	**0.041***	-0.003	-0.006
	(0.01)	(0.005)	**(0.013)**	**(0.004)**	**(0.035)**	**(0.013)**	(0.007)	(0.019)
$\alpha_{i,6}$	0.017	**0.01***	**0.015***	**0.012***	**0.031***	**0.317***	0.0052	**0.048***
	(0.012)	**(0.004)**	**(0.007)**	**(0.005)**	**(0.014)**	**(0.033)**	(0.006)	**(0.021)**
$\alpha_{i,7}$	0.022	**0.017***	**0.048***	**0.015***	**0.072***	0.011	**0.073***	**0.058***
	(0.023)	**(0.008)**	**(0.017)**	**(0.007)**	**(0.025)**	(0.019)	**(0.011)**	**(0.027)**
$\alpha_{i,8}$	0.016	**0.019***	**0.048***	**0.033***	0.021	0.046	-0.016	**0.521***
	(0.029)	**(0.007)**	**(0.02)**	**(0.008)**	(0.02)	(0.023)	(0.01)	**(0.045)**
$\alpha_{i,9}$	0.031	**0.026***	0.053	0.001	0.001	-0.004	-0.012	0.027
	(0.023)	**(0.009)**	(0.018)	(0.01)	(0.02)	(0.021)	(0.011)	(0.021)
$\alpha_{i,10}$	**0.129***	0.016	-0.003	**0.025***	**0.061***	-0.038	**0.028***	0.033
	(0.025)	(0.01)	(0.025)	**(0.012)**	**(0.029)**	(0.027)	**(0.011)**	(0.03)
$\alpha_{i,11}$	-0.018	**0.069***	**0.075***	**0.061***	0.001	0.036	**0.033***	0.052
	(0.023)	**(0.013)**	**(0.028)**	**(0.015)**	(0.032)	(0.027)	**(0.016)**	(0.045)
δ_i	**0.876***	**0.996***	**0.917***	**0.921***	**0.851***	**0.908***	**0.913***	**0.732***
	(0.018)	**(0.001)**	**(0.009)**	**(0.003)**	**(0.02)**	**(0.011)**	**(0.002)**	**(0.038)**
γ_i	**-0.106***	**-0.0124***	0.026	**-0.0143***	0.024	-0.0142	0.008	**-0.069***
	(0.022)	**(0.005)**	(0.019)	**(0.006)**	(0.022)	(0.019)	(0.008)	**(0.027)**

*Note: * indicates the significance at 5% level of confidence. The values between parentheses are the standard error. the coefficient $\alpha_{i,j}$ where j=1if its Egypt, 2 if it South Africa, 3 for Zambia, 4 for Morocco, 5 for Kenya, 6 for Nigeria, 7for Mauritius, 8 for Tunisia, 9 for Japan, 10 for US and 11 if its UK provide the volatility spillover across market. The coefficients $\alpha_{i,i}$ provide the own effect for each markets.*

5. Conclusion

This study investigated the interdependence of African stock markets by examining whether the interdependence relate to return or volatility or both, in other words, if there is evidence of return and volatility spillovers on the African stock markets among themselves as well as with developed markets. The empirical results revealed that:

(i) The interdependence in stock markets is due to both return and volatility spillovers, as it is found that the current return in one stock market is highly predicted by its own past stock returns, as well as by the cross market past returns; and the current stock market return volatility in one market is affected highly by its own past innovation as well as past innovation coming at least from one of other markets. The existence of first and second moment interaction, means that there is price and volatility spillovers from one market to another, and the direction of spillover is found to be bidirectional in some cases and unidirectional in some others. In addition, the volatility spillover is found to be symmetric in some case and asymmetric in some other cases. Furthermore, the African stock market show a high degree of volatility persistence, with South Africa has the highest value and Tunisia lowest value. This means that the volatility from day to day is quite stable and the time needed by each market to reduce the volatility is far long, this indicate that the African markets are inefficient in adjusting shock from other markets.

(ii) The Pre-and post-crisis results show that in both sub-periods there is evidence of price and volatility spillovers from market to others, however, the interdependence and spillovers effect in term of both return and volatility is increased after crisis; means that, in post-crisis the stock markets become more vulnerable to external shocks, this finding is consistent with the finding of (Kanas, 1998) and (Wang, Gunasekarage, & Power, 2005) etc.

(iii) In both periods the volatility persistence is high and close to unity, with South Africa display the highest value and Tunisia the lowest value; however, it is observed that the persistence is decreased after crisis; this means that, the volatility takes long time to die out in period of stability, while a relatively short time in period of crisis, this because in the period post-crisis the operations of bid-ask happen very fast, so the volatility shows less persistence.

(iv)The degree of asymmetry is increased after financial turmoil; this means that the asymmetric response of the volatility to innovations is the results of few extreme observations such as those associated with the crisis. The increase in the asymmetry in the volatility might be due to fact that, in the period followed the crisis investors become more sensitive to the news especially the bad news in their treatment of asset.

Finally, the results indicate that South Africa plays a predominant role as information producer, since it is most influenced and influential. Furthermore, we find that south Africa return is highly Affected by return spillover from UK stock market this because these two market are highly related as in 2001, an agreement was struck with the London Stock Exchange allowing cross-dealing between the two markets and then, substituting the JSE's trading system with that of the LSE

Recommendations

Based on the results obtained from this study, we suggest:

- Investors and the authorities in the African countries to pay more attention to the policy implementation and the movements of stock price and volatility in the UK stock market.

- The current study covers the period of the mortgage crisis, it showed that the crisis increases the interdependence of stock markets, so we suggest that investors avoid trading in the period of the crisis due to bad news circulating among traders, which leads to a rise in market volatility and uncertainty.

No piece of academic research is fully complete and perfect and the current research is not an exception. The current research demonstrates the learning process of the researcher and contributes to knowledge about this important topic. As a result, it should represent a starting point for further work on the topic of spillover effect in stock markets.

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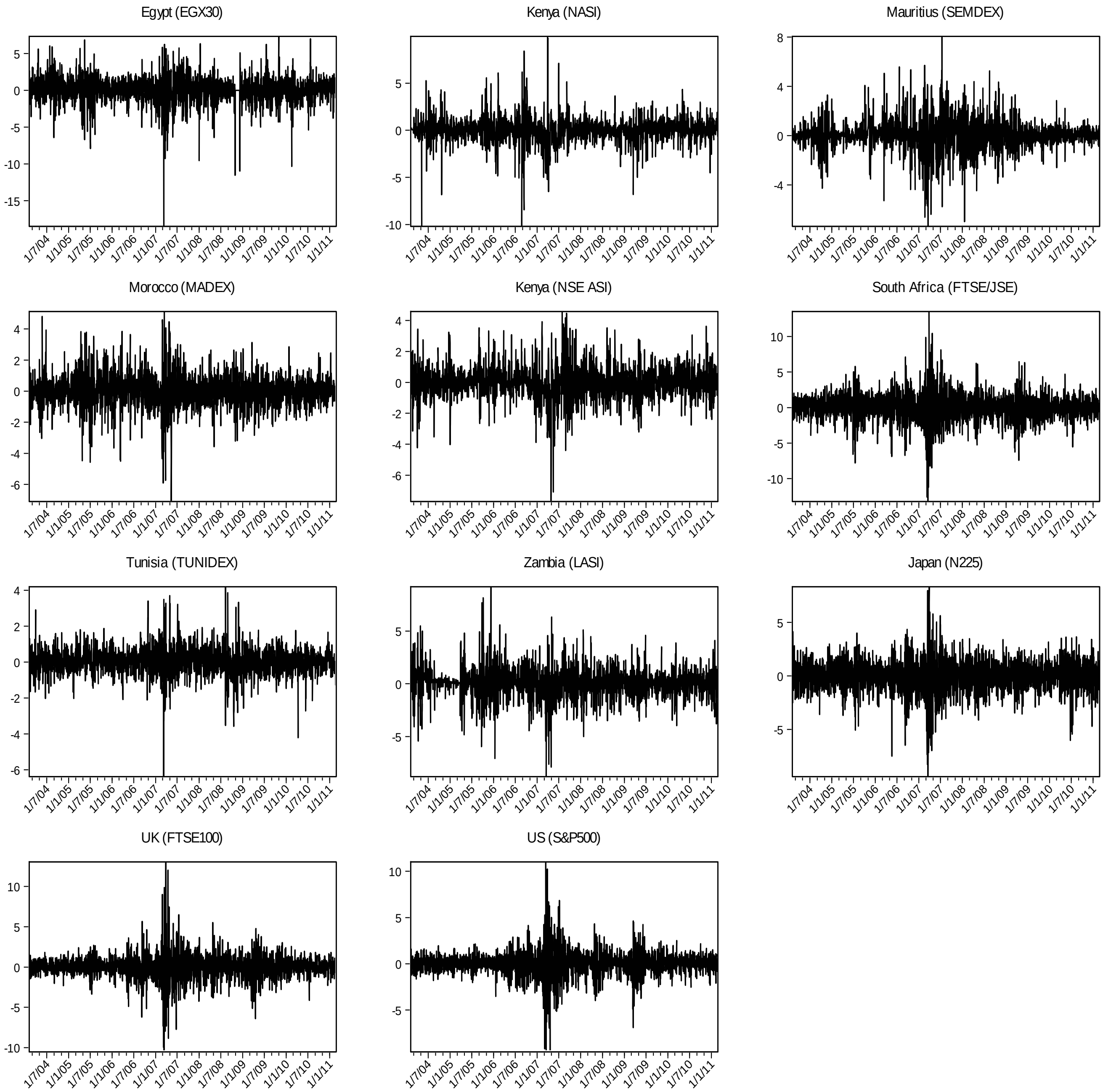
6. Appendices

Figure 1: Stock market returns of the share price indices



Source: author elaboration based on the data collected and Stata framework