# Stock Market Integration amongst Selected African Countries: Evidence from Non-Linear Co-integration and Conditional Correlation Analyses

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## ABSTRACT

Previous studies show that the heterogeneity of African Stock Markets (ASMs) makes integration difficult. This paper investigates this claim by applying a two-step procedure. The study applies the Breitung's Rank test for nonlinear cointegration to a monthly data (2004:02 to 2015:09) to determine the tendency for long-run price convergence in the selected markets. In the second step, the study then applies the MGARCH models to a daily dataset (May 2, 2007, to November 30, 2015) to evaluate the volatility spillover in returns amongst the selected markets. The results reveal some evidence of integration amongst the markets. Specifically, it was found that activities in the South African market tend to significantly affect the Egyptian and Nigerian markets. The study concludes that notwithstanding the general impression, some stock markets in Africa are fairly integrated with spillover effects nonlinearly transmitted.

**Keywords:** Correlations, Volatility Spillover, Stock Markets, MGARCH

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## 1 INTRODUCTION

Following the rapid improvements in information technology and communication, the key question that arises is whether stock markets in Africa have become more integrated. This is because these improvements have facilitated the occurrence of a number of events, which could enable greater stock market integration in the continent. The *first* of these major events is the rise in the automation of stock exchanges and Central Depositary Systems (CDS).

Secondly, the demutualization of exchanges has started gaining popularity since the 1990s. For instance, between 1999 and 2003, the number of demutualized and public exchanges in the world increased from 10 to 25 (IOSCO, 2005). This has removed the cultural, economic and regulatory barriers to the development of new companies that manage more than one stock market at once. That is, the new opportunities provided by ICT supported the development of stock exchanges in doing their business and made international stock exchanges feasible (Dorodnykh, 2013).

Thirdly, a number of memoranda of understanding (MoUs) have been signed by some countries in order to pave the way for more cross-border listings of companies based in foreign countries, thereby potentially boosting the supply of listed securities and market capitalisation and liquidity (Irving, 2005). For instance, the stock exchanges in Eastern and Southern Africa have signed such MoUs, largely as a means of encouraging information exchange and, in some cases, technology sharing and cross-border listings. In addition, Johannesburg Stock Exchange (JSE) has signed many MoUs with African exchanges outside the Southern African Development Community (SADC) region (for example, in Egypt, Ghana, Kenya, Nigeria, and Uganda). The Nairobi Stock Exchange (NSE) also signed a number of MoUs with exchanges outside the East and Southern African region, including the Nigeria Stock Exchange (NSE) and the Ghana Stock Exchange (GSE) (Yartey & Adjasi, 2007). Apart from the MoUs between the stock exchanges in Africa, there has been increasing interactions and relationships developing amongst African exchanges, including cross and dual listing of equities.

Fourthly, there has been increased internationalization of exchanges and opening up of capital accounts in many African economies. The dual listing between African exchanges and the internationalization of exchanges as well as opening up of capital accounts allow African exchanges to have a common set of investors whose portfolio optimization will simultaneously affect all the African markets in which they operate. These recent events, therefore, suggest that African stock markets are likely to be more integrated than they were. Greater integration would also suggest that volatility of one African stock market (ASM) may spill over to another.

This paper, therefore, sets out to examine the nature and extent of stock market integration using a sample of African Stock Markets. To achieve this, the study examines the presence of price co-movements (cointegration) and estimates the nature and extent of volatility spillover between them. The empirical knowledge of the extent to

which volatilities (potentially) spillover between ASMs is important to policymakers for a number of reasons. First, it could inform the policymakers which of the external market developments they should monitor and incorporate as important consideration before taking financial sector policy decisions. In addition, the empirical knowledge of the nature of the volatility spillover could help international investors in identifying markets for risk diversification.

The rest of the paper is organized as follows. Section two briefly reviews the existing literature; section three describes the methodology; section four presents the results; while section five concludes the paper.

## 2 LITERATURE REVIEW

Recent developments, which point to a clear trend towards the internationalization of stock exchange, have posed the question of whether the growing linkages between these stock markets do produce volatility spillovers among them. Few studies also have been conducted investigating the dynamics of volatility and spillover effects among emerging stock markets. These include, for instance, Appiah-Kusi and Menyah (2002), Alagidede (2011), Alagidede, (2011) who examined the predictability of stock returns in Africa. Neidhardt (2009) analyses spillover effects between the NSE (Kenya) and the JSE in order to estimate the level of market integration between the two. Bashir (2013) explored and investigated the risk and portfolio behaviour in three regional stock markets in sub-Saharan Africa (SSA); and King & Bootha (2015); Hearn (2002) and Piesse & Hearn (2001) found evidence of volatility transmission among ten markets in SSA; Hearn & Piesse (2002); Alagidede, & Panagiotidis (2009) examined stock return dynamics and the implication of conditional volatility models; and King & Bootha (2015) established evidence on volatility transmission among competing markets in SSA; Saleem (2013) studied stock market integration among the African financial markets, in a regional setting, namely, Sub-Saharan Africa (i.e. South Africa, Kenya, Nigeria respectively), and North Africa (i.e. Morocco, Egypt and Tunisia).

Results from these studies could be summarized as follows: there is the need for financial and economic integration within the African continent. These offer a better understanding of the nature of stock market interdependence within Africa, which is very valuable for the international investors, multinational corporations and portfolio managers, all of whom are involved in minimizing and managing their financial risk exposure. These studies have also provided a natural extension of the traditional bivariate analysis conducted to estimate a k-variate model, and to examine volatility spillovers among all markets and sectors with more recent techniques.

In addition, numerous researchers have studied stock market integration among developed countries and that the emerging African Stock Markets (ASM) received little attention in the literature. The research on the African stock market integration was conducted over a short period of time. Despite the existence of these studies, the empirical literature shows that few studies have investigated the interdependence between national markets within a specific region or continent. There seems to be no empirical evidence of stock market integration (measured using the respective stock

indices) and the dynamics of volatility spillover of returns in Africa. This serves as motivation to explore further empirical studies in this literature.

## 3 METHODOLOGY

### 3.1 Conceptual Framework

Figure 1 presents our conceptualization of the mechanisms through which African Stock Markets may be connected, allowing events in one market to be transmitted to others.

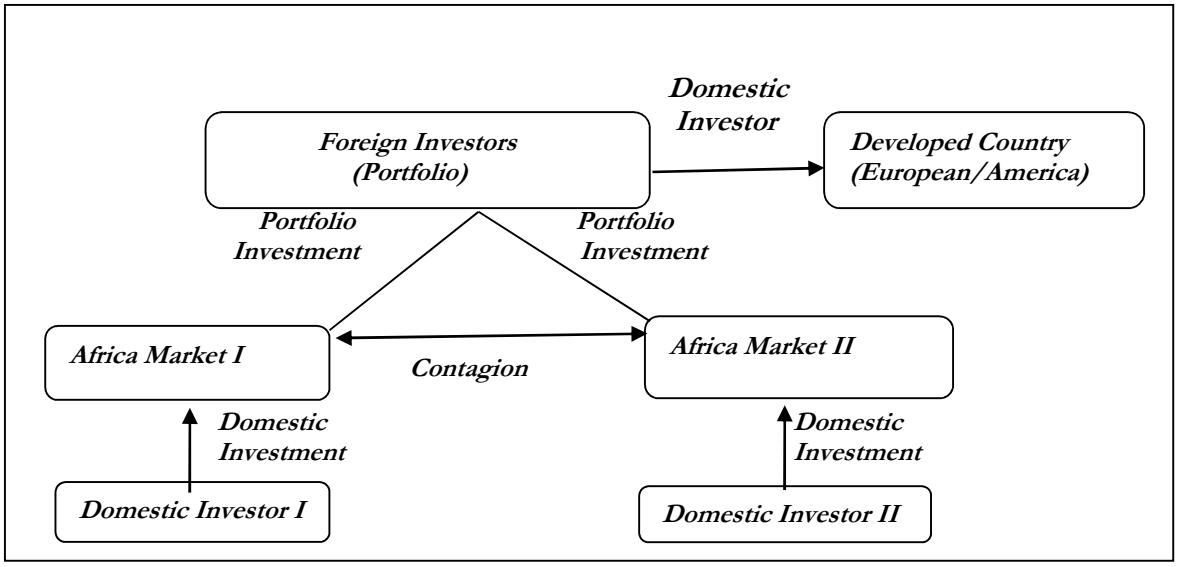


Figure 1: Stock Market Integration in Africa
*Source: Adapted from Auwal & Sanusi (2016)*

The schematic representation above shows how volatilities in one African stock market, say African Market I, are transmitted to another, say African Market II. First, it is assumed that the two hypothetical markets have common foreign investors who also invest domestically in their countries of origin. Second, there is the assumption that the African Markets I and II have domestic investors, and the foreign investors also hold a significant share of the market capitalisation. One basis for contagion under this setting is that changes in the developed economies, such as economic boom or recession, could yield two possible scenarios. For instance, economic boom in the countries of foreign investors could increase their wealth and lead to higher investment in other markets (including African Markets I and II). Similarly, recession in their economies of residence will lead to the withdrawal of investment in these other markets. Through this mechanism, therefore, we could observe changes in Market I correlating with those of Market II and vice-versa.

It is also possible that changes originating in Market I (Market II) will cause changes in Market II (Market I) as foreign investors re-optimize their portfolios. In addition, changes in trade volumes between Market I and Market II or between the two markets and the developed economies will affect the wealth of domestic investors.

### 3.2 Data and Sampling issues

In selecting the sample for the study, therefore, four sets of criteria were developed for each market. The stock market must have (i) a fully electronic trading, clearing and settlement system; (ii) presence of foreign participation; (iii) regional cross- border listing; and (iv) registered with General Agreement on Tariff and Trade (GATT) and World Trade Organization (WTO). Based on these criteria, we would expect greater integration because they are likely to share common investors. After screening each of the African stock markets against the four criteria, six markets were selected, namely, Egypt (EGX), Mauritius (SEM), Nigeria (NSE), South Africa (JSE), Tunisia (BVMT) and Zambia (LuSE). Egypt (EGX), Nigeria (NSE) and South Africa (JSE) were chosen on the bases of size, history of existence and data availability.

The study collected daily data for the period May 2, 2007 to November 30, 2015 (2090 observations of stock price indices for each market). The data was then transformed into continuously compounded returns ($R_t$), calculated as:

$$R_{i,t} = 100^{*}\left(\ln P_{i,t} - \ln P_{i,t-1}\right),$$

Where $P_{i,t}$ is the index of stock market *i* at time *t*, *ln* is the natural logarithm operator. Where i represents each of the three stock markets. In addition, monthly data was obtained from the respective websites of the stock exchanges covering the period February 2004 to September 2015 (140 observations).

### 3.3 The Model Specification

To examine the extent of stock market integration amongst the selected markets, the two-step procedure involves, first, testing for the long-run tendency of the markets to move together or converge. This convergence of the markets is examined by testing for long-run relationships among the variables in the model. The functional specification is given below:

$$x_i = f(y)$$

Where $x_i$ represents $x_1$ and $x_2$ for Egypt (EGX) and Nigeria (NSE) respectively, and $y$ represents the stock exchange of South Africa (JSE).

The functional relation is due to the fact that South Africa solely formed the first tier for being the oldest, largest, and most developed among them. The study adapts the nonparametric approach to nonlinear cointegration test developed by Breitung (2001) to determine the extent of integration/segmentation among African stock markets. Breitung (2001) demonstrates that residual-based test for nonlinear cointegration (BR, henceforth) is inconsistent for some classes of non-linear functions (Sargan and Bhargava, 1983; Phillips and Oularis, 1990). In order to overcome this problem, Breitung (2001)

proposed a cointegration test based on the rank transformation of the time series. Such rank transformation enables us to get away from the specific functional forms of the cointegrating relationship. One particular advantage of these rank tests is that there is no requirement to be explicit with regard to the exact functional form of the non-linear cointegrating relationship. Therefore, the rank and score tests (Breitung, 2001) are used for testing nonlinear cointegration.

The second step involves the empirical examination of the dynamics of volatility between stock market returns under study, and determination of the extent of shock transmission from one African stock market to another. To do this, a variant of the MGARCH models was used. The econometric investigation presents a univariate analysis where stock returns are modelled according to a GARCH (1, 1) with an AR (1) term, and to analyze spillover between different stock market returns, MGARCH models are used. Specifically, the study employs Bollerslev (1990) Constant Conditional Correlation (CCC) and Tse and Tsui (2002) Dynamic Conditional Correlation (TTDCC) to examine the dynamics of the volatility spillovers between the stock markets under consideration.

## 4 RESULTS AND DISCUSSION

### 4.1 The Univariate Analysis

From Table 1, the monthly mean for all the stock indices indicates that the variables exhibit significant variations in terms of magnitude. The values of standard deviation indicate that Egypt and Nigeria are relatively more volatile compared to South Africa. The positive skewness coefficients are in excess of the normal distribution's reference value for Nigeria, and are considered fairly extreme. The low kurtosis value for South Africa indicates extreme platykurtic while for Egypt and Nigeria it indicates extreme leptokurtic. The JB statistic for Nigeria and South Africa reject the normality assumption.

All the series are non-stationary at levels but become stationary after first difference (i.e. I (1)). The sample autocorrelation statistic rejects the null hypothesis of uncorrelated price changes up to ten lags for the three markets. Investigation of ARCH behavior of stock returns show evidence of return volatility persistence for all markets.

**Table 1: Summary Statistics and Stochastic Properties**

| | Monthly | | | Daily | | |
|---|---|---|---|---|---|---|
| ***Statistic*** | **Egypt** | **Nigeria** | **South Africa** | **Egypt** | **Nigeria** | **South Africa** |
| ***Mean*** | 6223.295 | 33774.77 | 232.4286 | -0.000125 | -0.000112 | -2.95E-05 |
| ***Std. Dev.*** | 2220.369 | 14330.47 | 62.18702 | 0.007798 | 0.004861 | 0.008086 |
| ***Skewness*** | 0.053066 | 1.457464 | 0.231930 | -1.072377 | 0.353736 | -0.246752 |
| ***Kurtosis*** | 3.003869 | 4.822219 | 2.200173 | 13.02968 | 7.721953 | 8.090477 |
| ***JB test*** | 0.065793 | 68.44179 | 4.986859 | 9156.302 | 1984.320 | 2276.706 (0.00) |
| ***(p-value)*** | (0.97) | (0.00) | (0.08) | (0.00) | (0.00) | |
| ***Q (10)*** | 598.698 | 582.745 | 819.923 | 19.2334 | 445.894 | 21.3575 |
| ***(p-value)*** | (0.00) | (0.00) | (0.00) | [0.0374]** | [0.00]* | (0.0187)** |
| ***Q2(10)*** | 574.690 | 414.867 | 809.562 | 81.2443 | 719.474 | 1201.98 [0.00]* |
| ***(p-value)*** | (0.00) | (0.00) | (0.00) | [0.00]* | [0.00]* | |
| ***LM ARCH (1)*** | 823.37 | 159.33 | 989.25 | 24.695 | 202.78 | 75.820 |
| ***(P-value)*** | (0.00) | (0.00) | (0.00) | [0.00]* | [0.00]* | [0.00]* |
| ***LM ARCH (5)*** | 327.86 | 70.221 | 365.88 | 12.947 | 93.825 | 68.114 |
| ***(P-value)*** | (0.00) | (0.00) | (0.00) | [0.00]* | [0.00]* | [0.00]* |
| ***Unit root test:*** | | | | | | |
| ***- Level*** | -4.025924 | -4.025924 | -4.025924 | -3.433284* | -3.433284* | -3.433284* |
| | (-2.088444) | (-1.529921) | (-10.54283) | (-42.80469) | (-29.71003) | (-44.06604) |
| ***- 1st Difference*** | -4.025924* | -4.028496* | -4.025924* | | | |
| | (-9.830854) | (-4.602420) | (-10.54283) | | | |
| ***Obs.*** | 140 | 139 | 140 | 2089 | 2089 | 2089 |

*Source:* Authors' computation using E-views 8.0 and Ox-Metrics software
*Notes:* Numerals in parenthesis are p-value for the JB test, Q (.) is the Ljung-Box statistics for (squared) standardized residuals, LM ARCH values, and Augmented Dickey-Fuller (ADF) statistics for the unit root test.
All the stock returns are computed as the first differences of the natural log of stock indices multiplied by 100.
*, ** and *** denotes significant at 0.01, 0.05 and 0.10 levels, respectively.

From Table 1, the skewness coefficients of the daily data are not in excess of the normal distribution's reference value for the two markets except for Egypt that is considered fairly extreme. With the exception of Nigeria that has evidence of positive skewness, there is evidence of negative skewness in Egyptian and South African markets. Also, the summary statistics suggest that they are all leptokurtic. Hence, GARCH models are capable of dealing with the property of the data. The high kurtosis value for all the markets indicates that the stock market returns are extremely leptokurtic. The value of the standard deviation for the three stock returns indicates that South Africa and Egypt are relatively more volatile as compared to Nigeria. The JB test results show that the distribution of stock index returns is not normal and the sample autocorrelation statistic rejects the null hypothesis of uncorrelated stock returns changes up to ten lags for all the markets. The ARCH behavior of stock returns show evidence of volatility persistence for all markets. The results of ADF unit root test reveal that all the series are highly significant at the 1% level and integrated of order zero, I (0).

### 4.2 Results of the Integration/Segmentation Analysis: Non-Linear Cointegration

From table 2, the BR results test reject the null hypothesis for the two cases of the African stock exchanges examined because the test statistics are larger than the critical values at the 1 percent significance level. According to the $\psi^*$ statistic, we observe cointegrating relationships between the two stock exchanges for the two cases. Also, the score test statistic $T.R^2$ has asymptotic Chi-squared ($\chi^2$) distribution with one degree of

freedom. With the exception of South Africa - Nigeria that is linearly cointegrated, the null hypothesis of nonlinear cointegration is supported against the linear cointegration for South Africa and Egypt. Therefore, linear and nonlinear cointegration relationship only exists between Nigeria and South African stock Exchanges, while non-linear cointegration relationship exists between South Africa and Egypt.

**Table 2: Results of the Cointegration and Non-Linearity Rank Tests**

| *Case* | *Cointegration between the countries* | *Rank Test*[a] $(\psi^*)$ | *Linearity Test*[b] $(T.R^2)$ |
|---|---|---|---|
| **1** | **South Africa - Egypt** | 0.003339* | 0.03304 |
| **2** | **South Africa - Nigeria** | 0.003657* | 9.3716* |
| | **Critical Value (%)** | | |
| | 10 % | 0.0232 | 2.71 |
| | 5% | 0.0188 | 3.84 |
| | 1% | 0.0130 | 6.63 |

**Source: Authors' computation using E-views and Microsoft Excel**

[a]. The rank test is adjusted for autocorrelation. The null hypothesis of the rank test is that no cointegration exists between the two stock exchanges; the alternative hypothesis is that cointegration does exist between the two exchanges. The null hypothesis is rejected when the critical value exceeds the test statistic.

[b]. The null hypothesis of the linearity test is that a linear relationship exists with no cointegration between the two African Exchanges; the alternative hypothesis is that a linear relationship does not exist and cointegration does exist between the two exchanges. The null hypothesis is rejected when the computed $T{\cdot}R^2$ value exceeds the critical value.

*, **, *** denotes significance at 0.01, 0.05 and 0.1 level, respectively.

### 4.3 Results of the Returns Volatility Spillover Analysis

Figure 3 shows the daily returns of the three stock markets, suggesting the presence of volatility clustering. The result implies that, since squared return measure the second order moment, the time series for the three stock markets exhibit time varying conditional heteroskedasticity and volatility clustering. This means that the data can better be modelled with Multivariate GARCH, as presented in the next section.

Figure 3 depicts is the trend charts of the three stock price indices during the sample period. The graphical representation of the series indicates that all the series exhibit volatility behavior. This supports the findings in Table 1 which established the existence of stock return volatility persistence in the three markets. To visualize the returns in these markets, Figure 4 plots the returns series over the sample period.

In standard financial econometric literature, return series are converted using some appropriate transformation formula specified in section 3.0. This transformation ensures that the returns are corrected for the problem of serial autocorrelation and that the stationarity of the returns is guaranteed. Figure 4 appears to show that the volatilities of these three stock market returns have not only the volatility clustering phenomenon, but also appear to be related with one another. This is the main motive for discussing the relationships of stock returns among the three African stock markets.

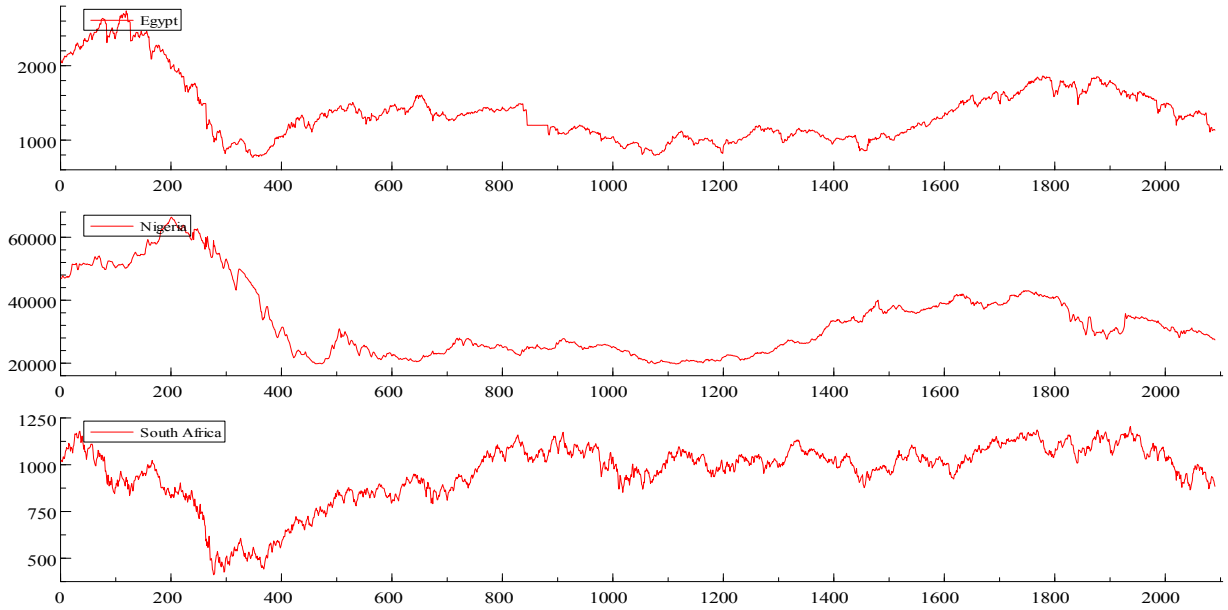


Figure 3: Graphical Presentation of the Stock Market Indices

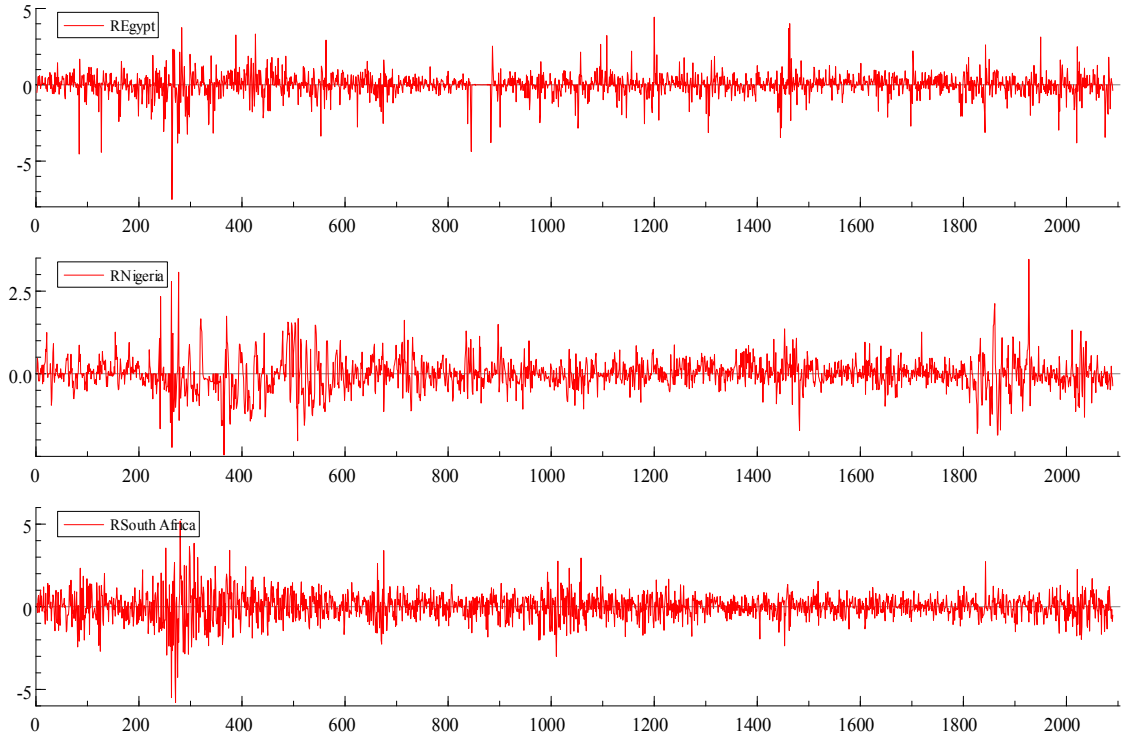


Figure 4: Graphical Presentation of the Stock Market Returns

### 4.4 MGARCH Models Estimation Results

Table 3 reports significant returns spillover. All the estimated ARCH coefficients reject the null hypothesis of no ARCH effect, and are incompatible with the existence of their kurtosis. The estimated short run persistence $(\alpha)$ is found to lie between 0.057 and 0.223, while the long run persistence $(\beta)$ lies between 0.711 and 0.927. It is found that $\alpha + \beta < 1$ (i.e. 0.902 - 0.99), in all the markets.

**Table 3: Parameter Estimates of the GARCH (1, 1) - AR (1) model**

| Country | $\omega$ | $\alpha$ | $\beta$ | $\alpha+\beta$ | $(\alpha+\beta)^2+2\alpha^2$ |
|---|---|---|---|---|---|
| ***Egypt*** | 0.036409 | 0.057416* | 0.88357* | 0.940986 | 0.958273 |
| | (1.560) | (2.975) | (15.72) | | |
| ***Nigeria*** | 0.014625 | 0.223115** | 0.711042* | 0.934157 | 0.901899 |
| | (1.155) | (1.931) | (4.234) | | |
| ***South Africa*** | 0.005999* | 0.062603* | 0.927258* | 0.989861 | 0.991823 |
| | (2.530) | (5.866) | (78.03) | | |

**Source:** Author's computations using OxMetrics software.
This table provides the estimated coefficients with t - values in parenthesis for the conditional variance equations for the Egypt, Mauritius, Nigeria, South Africa and Tunisia stock markets. $\varpi$ is the constant in the conditional variance equation, $\alpha$ is the ARCH coefficient, $\beta$ is the GARCH coefficient.
*, **, *** denotes significant at 0.01, 0.05 and 0.10 level.

Therefore, volatility is highly persistent for all the three African stock markets with the highest recorded for South Africa. This implies that the effects of shocks are likely to be long-lasting in these markets, but longest in South Africa. Similarly, results of the CCC and TTDCC shown in Table 5 indicate that significant correlations are found between Egypt and South Africa (positive across the two models) and between Nigeria and South Africa (negative for only one model), respectively. The correlations mean that these pairs are integrated with significant spillover effects.

In an integrated DCC, the Chi-square ($X^2$) value can be used for the null of integrated DCC against an alternative of CCC, as well as for the null of CCC against an alternative of an integrated DCC. In relation to this study, we test the null of CCC against an alternative of TTDCC by running a restricted VAR which can be estimated by OLS – the software used in this study does routinely select appropriate model by comparing the three information criteria. Therefore, to decide on the best model between the CCC and TTDCC for all three markets, Table 6 indicates that the CCC assumption is accepted on the basis of the log likelihood (LL), AIC and SIC. Clearly, the CCC process has the ability to accommodate the CCC volatility spillovers across the three African stock markets.

The spillover effects are stronger between Egypt and South Africa, (0.168 for CCC & 0.188 for TTDCC), than it is between Nigeria and South Africa (-0.039). The latter means a greater tendency for investors to treat the Nigerian and South African markets as substitutes.

**Table 5: Coefficient of Conditional Correlations.**

| $\rho_{ij}$ | CCC Model Coefficient | TTDCC Model Coefficient |
|---|---|---|
| $P_{South\ Africa\_Egypt}$ | 0.168312* (8.027) | 0.188298* (5.367) |
| $P_{South\ Africa\_Nigeria}$ | -0.039406** (-1.955) | -0.038639 (-1.154) |
| $P_{Nigeria\_Egypt}$ | -0.004963 (-0.2275) | -0.003741 (-0.1023) |
| ***df*** | 5.536235* (19.21) | 5.535381* (19.19) |
| $\theta_1$ | | 0.003449 (0.1663) |
| $\theta_2$ | | 0.991879* (122.6) |
| ***Parameters*** | 19 | 21 |
| ***LnL*** | -5203.920 | -5200.745 |
| ***AIC*** | 5.000402 | 4.999277 |
| ***SC*** | 5.051739 | 5.056019 |

**Source:** Authors' computation using Ox-Metrics software 8.0

*, ** and *** denote the significance level at 0.01, 0.05and 0.1 respectively.

**NOTE:** This table provides the estimated coefficients, standard errors and p-values for the conditional correlations for the CCC—constant conditional correlation, TTDCC—Tse and Tsui's (2002) dynamic conditional correlation, ρij is the correlation between market i and market j, df is the degrees of freedom, LnL is the log likelihood, LR test: $\theta_1 = \theta_2 = 0$ (constant correlation assumption); AIC and SIC are the Akaike Information Criterion and Schwartz Criteria, respectively.

### 4.5 Test of Goodness of Fit (Portmanteau Test) of the MGARCH Models

One of the most important stages of building a model is that of its diagnosis. In particular, we are interested in finding whether the residuals of our model are white noise. This study employed the multivariate portmanteau statistics to detect departures from these standard assumptions. Table 8 presents the Hosking's as well as Li and McLeod's Multivariate Portmanteau Statistics on the Standardized and Squared Standardized Residuals of the CCC and DCC-MGARCH models.

The results indicate that the return series of all markets exhibits conditional heteroskedasticity and that a GARCH process is an appealing candidate for modeling their time series behavior. The model adequacy of the CCC and TTDCC has eliminated the serial correlation in the series at various levels of lags. This suggests that the model of multivariate GARCH is appropriate in the understanding of the spillover dynamic behavior of the stock returns of the three African stock markets.

**Table 8: Multivariate Portmanteau Statistics of the MGARCH Models.**

| *Test* | | *Statistics on Standardized Residuals* | | | |
|---|---|---|---|---|---|
| | | *Standardized Residuals** | | *Squared Standardized Residuals*** | |
| | Lags (Q) | ***CCC*** | ***TTDCC*** | ***CCC*** | ***TTDCC*** |
| ***Hosking's Multivariate Portmanteau*** | 5 | 115.353 (0.000) | 116.321 (0.000) | 130.845(0.000) | 133.886 (0.000) |
| | 10 | 160.301 (0.000) | 161.167 (0.000) | 169.794 (0.000) | 173.116 (0.000) |
| | 20 | 245.644 (0.001) | 247.820 (0.001) | 323.534 (0.000) | 329.126 (0.000) |
| | 50 | 512.849 (0.020) | 517.682 (0.014) | 606.600 (0.000) | 614.361 (0.000) |
| ***Li and McLeod's Multivariate Portmanteau*** | 5 | 115.273(0.000) | 116.240 (0.000) | 130.773 (0.000) | 133.812 (0.000) |
| | 10 | 160.218 (0.000) | 161.082 (0.000) | 169.744 (0.000) | 173.064 (0.000) |
| | 20 | 245.588 (0.001) | 247.753 (0.000) | 323.110 (0.000) | 328.688 (0.000) |
| | 50 | 512.852 (0.020) | 517.629 (0.014) | 606.142 (0.000) | 613.857 (0.000) |

Source: Authors' computations using Ox Metrics software

Note: The numbers in parentheses are p-values. Q (5), Q (10), Q (20) and Q (50) denote the $5^{th}$, $10^{th}$, $20^{th}$ and $50^{th}$ order tests for serial correlation of standardized and squared standardized residuals respectively. *Warning: *and ** denotes that the p-values have been corrected by 1 and 2 degrees of freedom respectively.

## 5 Conclusion

This paper sets out to investigate the extent of stock market integration among selected African stock markets. The results indicate evidence of integration amongst the selected ASMs. Results from the non-parametric non-linear cointegration test suggest the existence of long-run tendency for price co-movement between Egypt and South Africa, and between South Africa and Nigeria. Results from the returns volatility spillover dynamics suggest some evidence of volatility spillover between the markets. Specifically, the volatility spillover in returns between the South African and Egyptian markets was found to facilitate diversification of risks since volatility spillover is positive. This means investors treat these markets as substitute destinations for investment purposes. It was also found that volatility spillover between Nigeria and South Africa is negative, suggesting that South African investors cannot diversify portfolio risks by investing into Nigeria's stock market, and vice-versa, since booms and bursts are more synchronized. Therefore, a key conclusion arising from this study is that, notwithstanding the general impression and the low levels of intra African trade and investment, stock markets in Africa are indeed fairly integrated with spillover effects nonlinearly transmitted.

**REFERENCES**

Agyapong, D (2014). *Stock Market Integration in West African Monetary Zone: A Linear and Nonlinear Cointegration Approach*. Asian Economic and Financial Review, 2014, 4(5): 563-587

Alagidede, P. (2011). Return behaviour in Africa's emerging equity markets. *The Quarterly Review of Economics and Finance* 51 (2011) 133–140

Alagidede, P. and T. Panagiotidis (2009). Modelling stock returns in Africa's emerging equity markets. International Review of Financial Analysis 18 (2009) 1–11

Appiah-Kusi, J. and K. Menyah (2003). Return predictability in African stock markets. *Review of Financial Economics* 12 (2003) 247–270

Auwal, U. and A. R. Sanusi (2016). *The Dynamics of Volatility Spillover between African Stock Markets in the Context of Political Uncertainty: The Case of Nigeria and South Africa.* International Conference on Corruption, Security and National Development, Faculty of Social Sciences, Ahmadu Bello University. 28th – 30th September

Bollerslev, T. (1990). Modeling the coherence in short-run nominal exchange rates: A multivariate generalized ARCH model. *Review of Economics and Statistics, 72, 498–505.*

Breitung, J., (2001). Rank tests for nonlinear cointegration. *Journal of Business and Economic Statistics*, 19(3): 331–340.

Brooks, C. (2008). *Introductory economics for finance*. U.K: Cambridge University Press

Burns, P. (2002). *Robustness of the Ljung-Box Test and its Rank Equivalent*, Burns Statistics working paper. http://www.burns-stat.com

Cybo-Ottone, A., Di Noia, C., Murgia M., (2000). *Recent developments in the structure of securities markets.* Brookings-Wharton Papers on Financial Services.

Diebold, F. X. and Yalmaz, K. (2009). Measuring Financial Asset Returns and Volatility Spillovers, with Application to Global Equity Markets. *The Economic Journal*, 119(534): 158 – 171.

Domowitz, I., Steil, B., (1999). *Automation, trading costs, and the structure of the trading services industry.* Brookings-Wharton Papers on Financial Services.

Dorodnykh, E. (2013). *Stock Market Integration: An International Perspective*". Palgrave Macmillan, 4 Nov 2013 – Business and Economics - 116 pages

Engle, R.F. (2002), Dynamic Conditional Correlation: A Simple Class of Multivariate GARCH Models. *Journal of Business and Economic Statistics*, 20, 339-350.

Eun, C. and S. Sabherwal (2003): Cross-Border Listings and Price Discovery: Evidence from U.S.-Listed Canadian Stocks. *Journal of Finance* 58 (2): 549–75.

Gramming, J., M. Melvin, and C. Schlag (2005). Internationally cross-listed stock prices during overlapping trading hours: price discovery and exchange rate effects. *Journal of Empirical Finance*, 12, 139– 164.

Harrison, J.M., Kreps, D.M., (1979). Martingales and arbitrage in multiperiod securities markets. *Journal of Economic Theory* 20, 381-408.

Hasan, I., Schmiedel, H., (2004). 'Networks and equity market integration: European evidence', *International Review of Financial Analysis*, 13, pp. 601-619.

Hearn B. and Piesse J. (2002). Equity Market Integration versus Segmentation in Three Dominant Markets of the Southern African Customs Union: Cointegration and Causality Tests, *Applied Economics*, Vol. 14, No. 1.

Hsueh, S.J. and Y.C. Tsao, (2011). The cointegration relationship between mergers variable and stock market-evidence from 10 developed countries. *100(9): 15-22.* http://cm.csu.edu.tw/epapers/filesno3/02.pdf

IOSCO, (2005). *Exchange Demutualization in Emerging Markets*, Emerging Markets Committee of the International Organization of Securities Commission IOSCO, April 2005

Irving, J (2005). *Regional Integration of Stock Exchanges in Eastern and Southern Africa: Progress and Prospects*, African and International Capital Markets Departments, International Monetary Fund (IMF), Working Paper, WP/05/122

Jenkins, C. and L. Thomas (1998). *Divergent Growth Experience in the SADC*, CREFSA.

Kenny, Charles J. and Todd J. Moss. (1998). *Stock Markets in Africa: Emerging Lions or White Elephants?* World Development, Vol. 26(5), pp. 829 - 843.

King, D. and F. Botha (2015): Modelling stock return volatility dynamics in selected African markets, *Economic Modelling* 45 (2015) 50–73

Magnusson, M.A., and Wydick, B. (2002). How Efficient Are Africa's Emerging Markets? *Journal of Development Studies*, Vol. 38, No. 4, pp.141-156.

Manganelli, S., & Engle, R. F. (2001). Value at risk models in finance. Working Paper No. 75, European Central Bank, August 2001, Frankfurt am Main.

Masson, P. and C. Pattillo (2005). *The Monetary Geography of Africa*, Brookings Institution Press, Washington, D. C.

Mlambo, C. & Biekpe, N. (2007). The efficient market hypothesis: Evidence from ten African stock markets. *Investment Analysts Journal* – No. 66.

Mlambo, C., and Biekpe, N. (2005). Thin Trading on African Stock Markets: Implications for Market Efficiency Testing. *Investment Analyst Journal*, 61, pp.29-40.

Neidhardt, T. (2009). *Solving the Puzzle: Stock Market Spillover Effects Between Namibia and South Africa*. February 19. Electronic copy available at: http://ssrn.com/abstract=1340147

Ntim, C.G., Opong, K.K., and Danbolt, J. (2007). An Empirical Re-Examination of the Weak Form Efficient Markets Hypothesis of the Ghana Stock Market Using Variance-Ratios Tests. *African Finance Journal*, Vol. 9, No. 2, pp.1-25

Ntim, C.G., Opong, K.K., Danbolt, J., and Dewotor, F. (2011). Testing the Weak-Form in African Stock Markets, *Managerial Finance*, Vol. 37, No. 3, pp.195-218.

Ntim, C. G. (2012). Why African Stock Markets Should Formally Harmonise and Integrate their Operations. *African Review of Economics and Finance*, Vol. 4, No.1, Dec. African Centre for Economics and Finance. Published by Print Services, Rhodes University, P.O. Box 94, Grahamstown, South Africa.

Odera, O. (2012). Theoretical issues on the African Stock Markets and Portfolio Performance. *Research Journal of Finance and Accounting*, Vol 3, No 3, 2012, ISSN 2222-1697 (Paper).

Phillips, P.C.B. and S. Oularis, (1990). Asymptotic properties of residual based tests for cointegration. *Econometrica, 58(1): 165-193.*

Pirrong, Craig (2000). A Theory of Financial Exchange Organization. *Journal of Law and Economics* 43 pp. 437-471

Ross, S.A., (1978). A simple approach to the valuation of risky streams. *Journal of Business*, 51, 453-475.

Rubinstein, M., (1976). The valuation of uncertain income streams and the price of options. *Bell Journal of Economics* 7, 407-425.

Saleem, K. (2013): Regional integration: Evidence from Africa, *African Journal of Business Management*, Vol. 7(22), pp. 2086-2096, 14 June,

Sargan, J.D. and A. Bhargava, (1983). Testing residuals from least squares regression for being generated by the gaussian random walk. *Econometrica, 51(1): 153-174.*

Silvennoinen, A., and T. TerÄasvirta (2005). *Multivariate Autoregressive Conditional Heteroskedasticity with Smooth Transitions in Conditional Correlations.* SSE/EFI Working Paper Series in Economics and Finance No. 577.

Silvennoinen, A., and T. TerÄasvirta (2009): Modelling Multivariate Autoregressive Conditional Heteroskedasticity with the Double Smooth Transition Conditional Correlation GARCH Model. *Journal of Financial Econometrics*, 7, 373{411.

Tse, Y. K. (2000), "A Test for Constant Correlations in a Multivariate GARCH Model," Journal of Econometrics, 98, 107-127.

Tse, Y.K., Tsui, A.K. (2002). A Multivariate Generalized Autoregressive Conditional Heteroskedasticity Model with Time-Varying Correlations. *Journal of Business and Economic Statistics*, 20(3): 351-362;

Yartey, C. A. and C. K. Adjasi (2007). *Stock Market Development in Sub-Saharan Africa: Critical Issues and Challenges*. International Monetary Fund (IMF) Working Paper, August, African Department, WP/07/209

Yeyati, E., S. Schmukler, and N Van Horen (2009). International financial integration through the law of one price: The role of liquidity and capital controls. *Journal of Financial Intermediation*, 18, 432–463