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Evaluating interdependencies in African markets A VECM approach

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Abstract

This study evaluates the linkages between stock markets and macroeconomic data in the sub-Sahara Africa during the 2008 –2018 period by using VECM. Our findings confirm unidirectional and bidirectional causalities, and a long-run equilibrium between the indexes, the stock exchanges and their national economies. The contemporaneous sectoral infectivity surpasses the long-run responses. While the banking sector was found to lead markets and macroeconomic indices, Nigerian, Moroccan and Swaziland markets were found to be most weakly integrated. Our findings provide a unique evidence of interdependence between African peripheral markets that could be used in cross-hedging and speculative strategies in fund management.

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Keywords: Asset pricing, Africa, interdependence, VECM.

1 Introduction

Fama (1970) argues that the individual investor should not be able to outpace the entire market through expert security selection or market timing since current share prices fully mirror available information, whilst scholars and finance professionals have documented that information about stock markets, and their sectors are vital tools used by investors in tracking the performance of other stocks/sectors/indexes or the market as a whole (Emenike, 2017). With the growing number of literature examining the market efficiency and the risk-return correlation (Fama & French, 1992; Garcia, Mantilla-Garcıa, & Martellini, 2014; Eiling, Gerard, Hillion, & Roon, 2012) there is also an increasing interest to linkages between stock markets. While some studies analysed comovements in stocks across nations (Bekaert, Hodrick, & Zhang., 2009; Zhang, 2018), a lot more assessed how the 2008 global financial crisis impacted on comovements of international stock trading (Alomari, Power, & Tantisantiwong, 2017; Baur, 2012). Comovements are critical inputs in financial management as hedges require return correlation estimates between the assets in the hedge (Engle, 2002). Such information on the linkages between

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assets could be used by smart investors to predict their returns. The market would be considered inefficient where price predictability or patterns among stock returns is evident, which would of course impact on the hedging strategies by investors while also affecting traders' ability to make profits (Alomari *et al*. 2017). Whilst several studies (Farooq & Shawkat, 2007; Kouki, Harrathi, & Haque, 2011), employed econometric techniques in investigating intersectoral return correlations within a country, most of the studies on the factors responsible for the return correlations found that the restrictive comovements were linked to specific economic variables including the P/E ratio, and implied volatilities among others (Kim & Sun, 2016; Chiang & Chen, 2016). However, despite the increasing role of African countries on a global scale, there is lack of literature on the intersectoral correlations in stock returns in African Stock markets.

Our study fills the above-mentioned gap and investigates intersectoral movements, providing evidence of interdependence between indices, economic indicators and African peripheral markets. The current study is unique by adding to the little existing literature on inter-sectoral linkages of a stock market by analysing the volatility spillovers among select sectors and evaluate the impact of a shock or innovation to a single sector or index on other returns on sectoral indexes. We examine eight select African markets to establish the pattern of equity return correlations within the sub-continent and provide an investing guide to both local and international investors willing to cash-in on the aggressively emerging African markets.

The remainder of this work follows this path: Section 2 provides Literature review and Hypothesis testing Section 3 presents a review of existing literature on cases of comovements of asset returns and their possible determinants. Section 4 discusses the data used and provides some preliminary analysis. Section 5 sets out the empirical results. Section 6 presents the Conclusion.

2 Literature review and Hypothesis testing

Africa's status as the next big market has been brought to limelight by the global financial crisis as it is warming up for unparalleled growth in the coming years with about eight emerging markets recently recognised by the International Monetary Fund (IMF) in the Sub-Sahara Africa (ABP, 2018). Understanding inter-sectoral linkages are critical to sound financial decision-making (Alomari, Power, & Tantisantiwong, 2017). The research tests the efficacy of the EMH, particularly whether correlations between sectoral equity returns could be useful in return prediction or security selection and market timing by portfolio managers such as Pension Funds Administrators. In line with the Arbitrage Pricing Theory (APT), this work would also provide proofs about the risk-return outlook of these sectors (Cao, Long, & Yang, 2013), and guide investors in decision-making. The Contrarian and Momentum theory of assets marketing entails the propensity of rising prices to keep rising while falling prices to keep falling (Hogan & Stein., 1999; Forner & Marhuenda, 2003). This theory would be applied to determine the risk characteristics of investing in certain sectors of the markets to minimising losses in the event of a shock in any segment of the market. These provide the basis for the trading strategies of "buying the winners and selling the losers" capable of generating abnormal returns. However, it is not clear if these theories are faithfully applied by investors/traders or the strategies adequately generate even the required rate of return. Therefore, the Prospect Theory examines the actual investor behaviour to ascertain their impact on investor expectations

and the market generally. The series of financial crises indicate that these strategies are not always fair. This research has added another strategy by which investors could track and predict their returns using other sectoral returns by applying these theories to African markets in determining optimal investment choices. Furthermore, the research will serve as a reference point for hedging by players on the Exchanges to reduce risk, as comovements between security prices are a critical element in determining the optimal hedge ratio. Hedgers tend to take advantage of favourable price movements which create arbitrage opportunities (Johnson, 1960). The possibility of predicting futures prices of some sectors with spot prices of other sectors has been explored (Cartwright, 2015). Lastly, the research would promote the imperativeness of Hedging through derivatives as a tool for risk diversification among African stock markets.

The equilibrium theory of Mean Reversion and Excess Volatility provides that the tendency for stock prices converging to their mean values vary according to seasons (Marcus, 1989). Therefore, examining financial septicity or macroeconomic risk has received a growing attention in the last decade (after the global financial crisis) from scholars, with many evaluating returns, variance and covariance spillovers (Chuang, Lu, & Tswei, 2007; Billio, Captorin, Frattaloro, & Petizon, 2016; Phylaktis & Xia, 2009; Alomari, Power, & Tantisantiwong, 2017). Some theories justify the financial septicity on financialisation, increased trading volume, and investor psychology (Forbes & Rigobon, 2002). Billio *et al*. (2016) identified some markets as risk sources and others as risk destinations; While countries like Germany, Italy and Greece were found to have played a central role in spreading risk, others like Ireland and Spain were found to be susceptible receivers of spillover effects. Crisis-based contagion theories likened "Contagion" increased globalisation occasioned by a shock in a single market or a collection of markets (Claessens & Forbes, 2004). To Phylaktis and Xia (2009), it is an 'excess correlation'. The concept explains the possibility of the spread of economic risks in the form of crisis and booms across countries or regions or even sectors of an economy. It is therefore pertinent to evaluate the direction of risk spread between sectors of a/an market/economy; to insulate vulnerable sectors from macroeconomic risk by reducing their susceptibility to financial crisis.

Given the preceding, this research idea has been fashioned to evaluate the interdependencies between asset returns for industries within the same economy, and the direction of causality between stock markets and their host economies in the sub-Sahara Africa. Alomari *et al*. (2017) found that future returns of sectors were significantly related to the past values, thus violating the weak form of EMH. The authors also found significant spillovers of shocks and volatilities between sectors within Amman Stock Exchange.

Quite a lot of research had made use of both fundamental and macroeconomic factors in explaining stock returns and volatility (Binder, 2001; Kolluri & Wahab, 2008). In the recent time, however, attention has been on how to explain return correlations (Chiang *et al*. 2007, 2017; Chiang and Chen 2016; Kim and Sun 2016). Some of the literature concentrated on comovements in prices within sectors of a market or a group of markets (Chiang *et al*. 2015; Phylaktis and Xia 2009), or the cross-border comovements asset prices (Chiang *et al*. 2007). There has been observed an increasing trend in stock return correlations among banks attributable to their idiosyncratic risks factors including their share of the market, their loan portfolios – size and composition (Nicolo & Kwast, 2002). Systemic risk factors including herding behaviour of banks and volatility of macro variables including the exchange rate or currency risk among others, also determine these

correlations (Binici, K¨oksal, & Orman, 2012; Patro, Qi, & Sun, 2013; Eiling, Gerard, Hillion, & Roon, 2012).

Several studies in this regard have investigated the septicity of shocks by evaluating volatility transmission to the less developed economies from the developed economies such as Japan, the US and the UK (Bernabe, Parcon-Santos, & Hallig, 2016). Such studies documented a unidirectional spillover especially from the US, to the emerging markets (Alomari *et al*. 2017), and attributed such spillovers to different factors.

Herding by analysts could explain the correlation in asset prices (David & Simonovska, 2016). That return on assets tends to follow correlated analysts' forecasts. To Simmons and Tantisantiwong (2014), Investors' reactions to shocks in asset markets could cause shifts in the lower bound of comovements assets prices. They explained that observed associated fluctuations in asset prices vary with time and are often upward sloping during instabilities than when the market is stable. Investors respond to changes in forecasts by analysts in a similar manner as return correlations do, with changes in time. This position was collaborated by Chiang *et al*. (2015), Chiang and Chen (2016), Kim and Sun (2016). However, cases of spill-overs from exchange rate and developed equity markets to African stocks were only observed in periods after acute crisis (Boaka and Alagidede, 2017).

Within the African continent, stock markets were found to be segregated from global markets despite recent structural adjustments and that index volatilities were not an inter-market contagion, but a country-specific scenario that can be reduced through cross-country diversification (Agyei-Ampomah, 2017). Deltuvaite (2016) found that even though Baltic stock markets are less integrated both globally and regionally, system-wide shocks in the global financial centres still affect them. The Estonian and Lithuanian stock markets were found to be more prone to cross-border risk spillovers than the Latvian stock market which was reportedly conservative.

On the sectoral interdependence of stock returns, Stevens and Tiddens (2017) applied the Multivariate Generalised Autoregressive Conditional Heteroskedasticity (MV-GARCH) in investigating the inter-sector return correlations between South African, the US, the UK and Europe, and found that on aggregate, same sector comovements heighten during periods of economic uncertainty. Other studies however confirmed heterogeneity of contagion – some sectors could still be used to achieve international diversification during crises despite prevailing market contagion (Phylaktis & Xia, 2009). A shock to one sector can trigger near proportionate shocks in other sectors (Hong, Torous, & Valkanov, 2004; Abrams, Celaya-Alcala, Gonda, & Chen, 2017). For instance, the real sectors of an economy sequentially respond to a shock in the financial sector in form of interruptions to the payment processing, creation of illiquidity and finally a deflation in the prices of assets (Group of Ten., 2001). The transmission could result to an economic-wide recession.

Evaluating the impact of size on volatility spillovers, Amini *et al*. (2016) attributed network instability to the degree of connectivity and size of contagious links among institutions, and that prices of large stocks are more sensitive to information than those of small stocks. This is a weak form of efficiency. While evaluating the shock and volatility spillovers, Hassan and Malik (2007) applied multivariate GARCH model to six sectors of the US market using daily stock prices while Hammoudeh *et al*. (2009) applied trivariate VAR(1)-GARCH(1,1) model to the equity sectors of the Gulf Cooperation Council stock markets from 2001 – 2007. Precisely, they examined the shock and volatility in banking, industrial and services sectors for Kuwait, Qatar and Saudi Arabia; and financial, insurance and series sectors for the United Arab Emirates. Findings

documented by Hassan and Malik (2007), and Hammoudeh *et al*. (2009) indicated impulse responses between sectors within each country. These confirmed the benefits of cross-border hedging derivable from investor collaboration across sectors of the same economy due to their interdependencies (Alomari *et al*., 2017). Kim and Sun (2016) documented that whenever the growth potential of the US S&P500 index was above average, its return closely correlates with that of the Chinese sector. This was after controlling for the growth of the economy, the inflation rate, real interest rate, firm size and gross profit margin.

Generally, previous studies on domestic sectoral integration made use of an expanse of econometric analytical tools including but not limited to Cointegration, Granger causality test, Vector Error Correction Models (VECM), and the bivariate or trivariate GARCH models (Wang *et al*. 2005; Harris and Pisedtasalasai 2006; Hassan and Malik 2007; Hammoudeh *et al*. *2009*).

The discussion about general interdependence among sectors of an economy or region starts since Quesnay (1758), and empirically examined by Leontief (1936) who used government and trade publications to evaluate interrelations of the whole economy to adduce that the activities of all economic units in an economy affect the whole economy. Gilchrist & Zakrajˇsek (2008) provide a review of the 2008 financial crisis that indicates that the financial and real sectors of the US economy are highly correlated. Generally, the stock market will reflect the conditions of an economy through the fundamental valuation of equity which provides that stock prices have a direct relationship with future profitability, which is supposedly linked with economic activities (Foresti, 2007). If the economy is growing, then the output will be increasing, and most firms should record higher profitability which makes these companies more attractive due to higher dividend payouts. The growth in an economy cannot just begin in all the sectors simultaneously. Instead, there are source/lead sectors and destination/lagged sectors. The latter only respond to volatilities in the former (Billio *et al*. 2016). There exists a bi-directional causality between economic growth and stock market development (Ishioro, 2013). It is therefore pertinent to examine the linkages between sectors represented on exchanges by indexes to exploring them for the development of the entire financial system stability.

In this study we fill the existing gap in the literature by examining if there are long-run linkages among domestic sectors of African Stock Markets, and if these sectors influence each other in the short-run. We also investigate to what extent do shocks or innovations to a sector explain variations in other sectors within the same African stock market and condition in economy.

To provide answers to these issues the following hypotheses were tested:

H_1: Sectors of Stock Markets in sub-Sahara Africa are not cointegrated

H_2: Equity returns to a sector do not explain equity returns to other sectors of Stock Markets

H_3: Sectoral Equity Returns are not related to the economies of African countries

The study population for this research is the sub-Sahara Africa with a sample of Eight African stock markets (countries) selected through the maximum variation/heterogeneous purposive sampling from among the over thirty stock exchanges within the continent. Africa's immense potential as the world's business destination is being marred by political instabilities, weak public institutions and policy inconsistencies (AFX, 2018).

The choice of Africa is underpinned by the findings of previous studies that African Stock markets have high average returns and volatility (Nwosu, Orji, & Anagwu,

2013). It is also owing to the realisation that Africa is likely to provide the next business destination for the world (ABP, 2018), and to provide potential investors with the relevant information about this market, it is pertinent to evaluate the intersectoral contagion in African stock markets. Previous research has also reported that majority of African stock markets have weak form efficiency, as stock returns reflect past price changes and are highly fragmented despite the growth in their sizes (Smith & Dyakova, 2013; Ntim, 2012). Therefore, sectoral return comovements in African stock markets may also be predictable. There has been reported of significant contagion among African stock markets during and after acute financial crises Boaka (2017). However, if this contagion is rooted in the sectors of these markets is still unknown as most of the previous researches have concentrated on the efficiency of African markets and their contagion with other markets. The presence of this contagion among the sectors of the markets is examined in this research. Researchers outside of Africa found elements of cointegration a011nd linkages among sectoral indexes using the VECM (Al-Fayoumi, Khamees, & Al-Thuneibat, 2009). The authors investigated the dynamic linkages among the daily returns of four sectors of the Amman Stock Exchange from September 2000 to August 2007, and the results showed short-run causality and long-run cointegration among the general, industrial, financial and services sectors. Further robustness tests using the Variance Decomposition confirmed the financial as the lead sector whereas the services sector is the most segregated and recommended that the latter could effectively be used for diversification within the market. An identified gap in their study is that they ignored the comovements and volatility of the returns.

3 Examined markets

The selected exchanges are shown in Table 1 below with the levels of their benchmark indexes as at the second quarter of 2015. The selection is also based on the availability of data also ensuring that all the regions within the continent are represented.

Table 1: Sample of sub-Sahara African Countries/Stock Markets

S/No.	Economy	Exchange	Ticker/Index
1	South Africa	Johannesburg Stock Exchange	JSE All Share
2	Nigeria	Nigerian Stock Exchange	NGSE All Share
3	Morocco	Casablanca Stock Exchange	MASI
4	Egypt	Egyptian Exchange	EGX30
5	Tunisia	Bourse de Tunis	Tunis All Share
6	Namibia	Namibia Stock Exchange	Namibia Overall
7	Zimbabwe	Zimbabwe Stock Exchange	ZSE Indus. Index
8	Swaziland	SSE	SSE All Share

Source: Nigerian Stock Exchange (NGSE, 2015).

Johannesburg Stock Exchange (JSE) was founded in 1887 during the South Africa's gold rush, and it offers both primary and secondary capital market for a wide range of securities to both domestic and foreign companies. It joined the world federation of exchanges in 1963 and launched the electronic trading system in 1990 and an alternative exchange in 2003. It is the 20th largest exchange in the world by capitalisation (JSE, 2016)with over 400 listings (AFX, 2018). Nigerian Stock Exchange (NSE) was established in 1960 as the Lagos Stock Exchange, offers live trading with about 169 listings, and member of International organisation of Securities Commission (IOSCO) (NGSE, 2015). Egyptian Stock Exchange (EGX) started in 1883 as Alexandra Stock Exchange until the Cairo Stock Exchange was established in 1903(ASEA, 2018). In 2011 its operations were marred by the financial crisis; however, it is gradually being reorganised (EGX, 2018). Casablanca Stock Exchange (CSE) was established in 1929 with headquarters in Casablanca, Morocco, and operates an electronic trading system which was launched in 1997, and by 2001, the T+5 clearing system was reduced to T+3 (CSE, 2018). Namibian Stock Exchange (NSX) started in 1904 in Lodentz with the diamond rush and listed about 40 companies with the FTSE/Namibia Overall index as the benchmark (NSX, 2018; S&P Capital IQ, 2018). The Tunisia stock exchange - Bourse de Tunis – was opened in 1969, has about 81 companies listed and operates an up-to-date electronic trading system (BdT, 2018).

Stock exchanges in Zimbabwe were opened in 1896 in Bulawayo, Gweru and Mutare. That of Bulawayo ceased operation after six years while that of Mutare closed in 1924 when it was realised that mining deposits there were not extensive. A new exchange commenced trading in Bulawayo in 1946 after the Second World War with another floor in Salisbury (Harare) opened in December 1951. Trading between the two floors was by telephone until a legislative backing was giving which empowered the Reserve Bank of Zimbabwe to intervene by suspending the operations of the exchanges in November 2008 (African Markets, 2016). In February 2009 the Zimbabwe Stock exchange was reopened and share prices quoted in US dollars due to the hyperinflation that rendered trading in Zimbabwean dollar on the exchange impossible (AFX, 2018). There are two indexes - Industrial index (the benchmark index) and the Mining index for the bourse and sixty-three securities in total are listed on the ZSE (ZSE, 2018). Swaziland Stock Exchange (SSX) is located in Mbabane, Swaziland, with seven equities which are all included in the sole index – the SSX (SSX, 2018).

4 Data and Preliminaries

The research examines ten years' quarterly sectoral returns (in local currencies) of three sectors each for the eight exchanges. The equity capitalisations for these exchanges and the quarterly GDP for their host economies are also examined alongside the selected sectors to account for the effect of sizes of both the stock markets as well as their economies from 2008Q3 to 2018Q2. This period is interesting because the research will indirectly unveil the effect of the global financial crisis on African markets. The data is obtained from Bloomberg, DataStream, the World Bank as well as the research sites of the selected stock exchanges. The sample is a mixture of the giants, intermediate and the least markets in sub-Saharan Africa. Its composition is based on data availability towards answering the research questions set out earlier. The sectoral indexes chosen for each of the sampled exchanges are presented in Table 2 below.

Table 2: Sample of Sectoral Indexes

Country/Stock Market	**Sectors/Variables**				
South Africa/JSE	Banking	Industrials	Consumer Goods	Mkt Cap	GDP
Nigeria/NSE	Banking	Oil & Gas	Consumer Goods	Mkt Cap	GDP
Egypt/EGX	Banking	Industrials	Consumer Goods	Mkt Cap	GDP
Morocco/CSE	Financials	Mining	Transport	Mkt Cap	GDP
Tunisia/BdT	Banking	Oil & Gas	Consumer Goods	Mkt Cap	GDP
Namibia/NSX	Banking	Mining	Consumer Goods	Mkt Cap	GDP
Zimbabwe/ZSE	Housing & Energy	Hospitality	Food & Beverages	Mkt Cap	GDP
Swaziland/SWX	Housing & Energy	HealthCare	Food & Beverages	Mkt Cap	GDP

5 Methodology

The main methodology applied in this study is within the framework of the Vector Error Correction Model (VECM). Through this framework, the linkages between sectors of an economy are examined by analysing both the short-run and long-run relationships between their returns. The VECM enables us to interpret the comovements between sectoral equity returns from where statistical inference is made, and sound financial decisions are taken for the growth and development of the stock market and the economy in general. The choice of the VECM is based on the fact that the series being examined are non-stationary at levels and stationary at first difference. The VECM besides accounting for the long-run structural relations also provides information on adjustment which impacts economic processes more intuitively (Asteriou & Hall, 2007). To develop the VECM, we proceed in series of steps including unit root testing, lag selection, a test of cointegration, the model specification (VECM), and test for causality. This is applied to all the markets/exchanges for comparison and confirmation of the authenticity of the results.

By inspection, the graphs and series plots of ACF and PACF indicate that non-stationarity in levels and stationarity in first differences. Since trended series result to spurious regression, it is practicable to ascertain their stationarity or otherwise so that an appropriate model would be employed in evaluating their return correlations. We employ a unit root testing of the data series for each market before further examining their linkages. Since this study uses unbalanced quarterly data across countries, the attendant limited sample size and the possibility of cross-sectional dependence, we employ the Im, Pesaran, and Shin (1997) individual and group unit root tests

$$\Delta Y_{it} = P_i Y_{it-1} + \theta_{it} \Delta Y_{it-L} + a_{mi} + d_{mt} + \varepsilon_{it} \quad (1)$$

Where the null $H_0: P_i = 0$ of stationarity for individual members of the group is assumed, and to account for serial correlations of the errors e_{it} (Pedroni & Vogelsang, 2005), this

also accounts for individual and cross-sectional correlations (Kutlu, 2010). To reject the null hypothesis of a unit root, the probability value of the test statistic should be less than the appropriate alpha value.

Table 3: Summary of Unit Root Tests for the countries' series

Country	**Im, Pesaran and Shin T-Stat (Country)**			
	Level		**1st Difference**	
	Statistic	**Prob****	**Statistic**	**Prob****
South Africa	-0.486	0.883	-11.40	0.000
Nigeria	-0.244	0.596	9.511	0.000
Egypt	2.232	0.987	-10.82	0.000
Morocco	2.513	0.994	-9.602	0.000
Tunisia	2.729	0.996	-10.61	0.000
Namibia	1.105	0.865	-10.96	0.000
Zimbabwe	-0.744	0.228	-6.212	0.000
Swaziland	-0.869	0.192	-9.292	0.000

Confirms that all the sectoral indexes are non-stationary at levels but stationary at first difference at the 1% significance level. That is, all the indexes are integrated of order one. However, differencing to induce stationarity affects the long-run solution (Asteriou & Hall, 2007), therefore, we employ a methodology that accommodates these variables in their non-stationary forms to arrive at representative inferences.

Since the variables have unit root processes, the optimal lag lengths have been selected (Table 4 below) and applied to all the models for each country using the Likelihood Ratio (LR), Final Prediction Error (FPE) and the Akaike Information Criterion (AIC). This leads to the selection of the most parsimonious model that minimises the information criterion.

Table 4: Summary of Lags selected

Country	**Lags Selected**	**Criteria**				
		LR	**FPE**	**AIC**	**SIC**	**HQ**
South Africa	1	280.62*	2.231*	86.37*	87.67*	86.83*
Nigeria	1	207.25*	2.082*	65.56*	66.88*	66.02*
Egypt	1	232.43*	2.362*	61.08	62.40*	61.54*
Morocco	1	229.44*	7.982*	62.30*	63.62*	62.76*
Tunisia	2	48.079*	4.208*	56.97*	59.38	57.81*
Namibia	1	238.62*	1.158*	55.75*	57.07*	56.21*
Zimbabwe	4	63.93*	1893*	25.97*	29.53*	27.20*
Swaziland	1	178.09*	2480*	28.89*	30.22*	29.35*

Apart from Tunisia and Zimbabwe, all the markets have been modelled with one lag (quarter) each as indicated in table 20 above. * indicates lag order selected by the criterion.

The preconditions for the Johansen test of Cointegration have all been met – variables are non-stationaary at levels and stationary at first difference. They are all integrated of the same order; we therefore conducted the test of cointegration and reject the null hypotheses at 5% significance level, given that both the Trace Statistic and the Maximum Eigenvalues are greater than their critical values and significant. Accordingly, all the variables in all the countries are cointegrated (a long-run equilibrium relationship exists among them) (Johansen, 1991)

The presence of cointegration among sectors of the economies calls for the estimation of the Vector Error Correction Model (VECM). A restricted VAR model or VECM with an error correction term or a speed of adjustment of the form specified below is estimated to ascertain both the long-run and short-run causality among the variables specified for each country

$$X_t = \beta_0 + \beta_{3i}\Delta Y_{i-1} + \varphi Z_{t-1} + \mu_t \quad (2)$$

$$Y_t = \beta_0 + \beta_{5i}\Delta X_{i-1} + \varphi Z_{t-1} + \mu_t \quad (3)$$

Z is the error correction term (ECT) and is the OLS residual from the long-run cointegrating regression

$$Y_t = \beta_0 + \beta_1 X_t + \epsilon_t \quad (4)$$

And is defined as

$$Z_{t-1} = ECT_{t-1} = Y_{t-1} - \beta_0 - \beta_1 X_{t-1} \quad (5)$$

Where, β_0 is the intercept, β_{3i} and β_{5i} are short-run coefficients; which must be jointly significant for a bidirectional causality to hold from X to Y and vice versa. If B_{3i} are significant while β_{5i} are insignificant, then Y is a leading index while X is the lagged index or sector in the short-run (Al-Fayoumi et al. 2009). The term, *error correction,* relates to the fact that last period or quarter deviations from the long-run equilibrium (the error) influences the short-run dynamics of the dependent variable; the coefficient of ECT φ is the *speed of adjustment* as it measures the speed of return to equilibrium after a change in X. However, all the variables are considered endogenous.
Specifically, Δ is the change in indexes, and the a priori expectation is that the long-run coefficient φ in all the models should be negative and significant if the dependent variable has a long-run relationship with other variables represented in the model (Engle, 2002; Al-Fayoumi, 2009).

6 Empirical Findings

We also employed the Wald block test in examining the short-run linkages between the variables where the parameters β_{3i} and β_{5i} have to be positive and significant for the null hypothesis of no short-run causality to be rejected. The causality test has also been conducted using the systems equation model to ascertain the direction of short-run causalities between the variables (Masih & Winduss, 2006). The models' residuals have been subjected to a series of checks of the goodness of fit, serial correlation, normality, and heteroscedasticity, and finally the Impulse Response Function has been applied to test the forecasting power of the models, that is, to confirm the degree of septicity among

sectoral returns. The Variance Decomposition has been used to determine the magnitude (sign) of causality. This would show the extent to which returns to a sector could be used to forecast returns to another sector and the future of the entire economy. Our estimates indicate the Wald Joint X^2 statistics, which evaluates the (joint) significance of lags of variables in the VECM validating our results. The optimal lags have been determined based on both the LR, FPE, AIC, SIC and HQ. Δ represents the first difference operator. The $\mathbf{ECT_{t-1}}$ indicates a long-run equilibrium relationship, and the estimates in the last column are test results of the null that the lagged **ECT** is statistically insignificant for each equation. (*) and (**) denote rejection at 1% and 5% significance respectively. The VECM for the three major markets (South Africa, Nigeria and Egypt) are presented, indicating significance of ECT for at least half of the models examined as follows.

Table 5: Estimated VECM for South Africa, Nigeria and Egypt

Panel A. South Africa					
D.Variable	ΔBanking	ΔIndustrials	ΔConsumer Goods	ΔMcap	ΔGDP
ECT_1	0.0315 (2.3181)	0.0007 (4.8621)	-0.3068 (-3.2599)	2.7780 (2.3491	0.4928 (1.2020)
ΔBanking(-1)	0.0507 (0.1635)	0.0054 (1.5078)	-1.4244 (-0.6629)	-0.7438 (-0.0275)	-1.7019 (-0.1818)
ΔIndustrials(-1)	2.8658 (0.1613)	-0.1017 (-0.4901)	-188.9373 (-1.5368)	556.1028 (0.3600)	-255.0886 (-0.4763)
ΔCons. Goods(-1)	-0.0366 (-1.3878)	-0.0002 (-0.6514)	0.3867 (2.1175)	-3.3453 (-1.4578)	0.2771 (0.3483)
ΔMarket Cap(-1)	0.0029 (1.1791)	3.2298 (1.1161)	-0.0020 (-0.1200)	0.1414 (0.6568)	0.0171 (0.2298)
ΔGDP(-1)	0.0095 (1.6221)	9.9910 (1.1592)	0.0574 (1.4163)	0.4251 (0.8342)	-0.2864 (-1.6211)
C	21.0175 (0.1597)	1.3961 (0.9081)	950.2677 (1.0433)	1510.265 (0.1319)	20268.19 (5.1088)
R-squared	0.3326	0.5782	0.3403	0.2537	0.2116
Adj. R-squared	0.2035	0.2126	0.2126	0.1093	0.059
F-statistic	2.5756	2.6653	2.6653	1.757	1.3869
Panel B. Nigeria					
D.Variable	ΔBanking	ΔOil & Gas	ΔConsumer Goods	ΔMcap	ΔGDP
ECT_1	-0.1904 (-1.1686)	-0.3415 (-2.2184)	0.6573 (0.6906)	1.7738 (0.0911)	-0.3343 (-2.8657)
ΔBanking(-1)	0.0364 (0.1337)	0.2279 (0.8856)	-0.8828 (-0.5547)	-19.0812 (-0.5862)	0.1724 (0.8840)
ΔOil & Gas (-1)	-0.2667 (-1.7233)	-0.4129 (-2.8244)	0.6055 (0.6699)	-37.7524(-2.0420)	-0.1847 (-1.6668)
ΔCons. Goods(-1)	-0.0318 (-0.9450)	-0.0306 (-0.9632)	-0.1542 (-0.7835)	-3.6955 (-0.9180)	-0.0027 (-0.1156)
ΔMarket Cap(-1)	-0.0004 (-0.2228)	-0.0002 (-0.1351)	-0.0051 (-0.4036)	0.4809 (1.8391)	-0.0001 (-0.0787)
ΔGDP(-1)	0.0395 (0.1543)	0.0696 (0.2878)	0.8165 (0.5461)	-30.2743 (-0.9900)	0.1055 (0.5760)
C	1.4994 (0.1553)	-4.0555 (-0.4449)	19.3465 (0.3433)	155.1681 (0.1346)	1.9126 (0.2768)
R-squared	0.227	0.3048	0.1015	0.2206	0.2236
Adj. R-squared	0.0725	0.1657	-0.0781	0.0647	0.0684
F-statistic	1.469	2.1924	0.5648	1.4153	1.4406
Panel C. Egypt					
D.Variable	ΔBanking	ΔIndustrials	ΔConsumer Goods	ΔMcap	ΔGDP
ECT_1	0.0875 (0.7765)	-0.0654 (-0.3695)	0.06868 (2.4188)	-25.0174 (-2.3151)	0.0084 (0.3244)
ΔBanking(-1)	0.1354 (0.4512)	0.1562 (0.3313)	0.0001 (0.0026)	23.9576 (0.8329)	-0.0108 (-0.1554)
ΔIndustrials (-1)	-0.2974 (-1.1352	-0.2508 (-0.6096)	-0.1148 (-1.7410)	-1.4064 (-0.0560)	-0.0251 (-0.4141)
ΔCons.Goods(-1)	0.2421 (0.1911)	-0.0990 (-0.0498)	0.4124 (1.2934)	-74.2944 (-0.6122)	0.1352 (0.4598)
ΔMarket Cap(-1)	0.0011 (0.4588)	0.0014 (0.3694)	0.0005 (0.8396)	-0.1220 (-0.5195)	0.0004 (0.7323)
ΔGDP(-1)	-3.1591 (-3.1652)	-4.6268 (-2.9522)	-0.9827 (-3.9116)	-74.3857 (-0.7779)	-0.0136 (-0.0590)
C	48.0558 (2.7662)	50.6876 (1.8581)	11.2772 (2.5787)	-435.3302 (0.2615)	2.2294 (0.5527)
R-squared	0.2625	0.2928	0.3962	0.2147	0.0229
Adj. R-squared	0.115	0.1513	0.2755	0.0576	-0.1724
F-statistic	1.7799	2.0704	3.2819	1.3671	0.1173

Note: t-statistics in parenthesis

Generally, the null hypothesis of 'no short-run causality' among sectoral indexes in the sub-Sahara Africa is rejected at 1% significance level. There is evidence of comovements among the indexes in most of the sampled markets. Specifically, in South Africa, there is short-run causality running from the Consumer Goods sector to the Industrials sector. This implies that a shock or innovation in the Consumer Goods sector will impact on the Industrial Sector. That is if there is a change in demand for consumables, the production of same would be affected. In the same vein, the null hypothesis of no linkage between the economy and the stock market is also rejected, since there is short-run causality running from GDP to Market capitalisation. There is no evidence of short-run causality within the Nigerian, Moroccan, and the Swaziland markets. This implies no cross-sectoral contagion in these markets, even in the post-recession Nigeria, and tends to differ from Boaka and Alagidede (2017). Investors in such markets could therefore adopt cross-sectoral hedging to maximise returns. However, there is short-run causality from Banking to Consumer Goods in Egypt; and from GPD to Banking in Tunisia. The Zimbabwean market has evidence of bidirectional causality running from Housing & Energy to GDP and vice versa. This implies that the functioning of the stock market also depends on the condition of its host economy. This agrees with the findings of Abu-Sharia (2005) that a smooth functioning stock market can affect the economy by mobilising savings for investment and increased productivity. However, Duca (2007), held a parallel opinion when he established a unidirectional causality from stock prices to GDP. The market exhibits the highest correlation between the sectors, the economy and the stock market. There are short-run causalities running from Housing & Energy to the Hospitality sector and the economy (GDP); from Food & Beverages to Hospitality; from the Market capitalisation to Hospitality, Food & Beverages sectors, and GDP; and finally, from GDP (Economy) to Housing & Energy, and Food Beverages Sectors. The Hospitality sector appears to be the most integrated among the sectors of the Zimbabwean market as much as the economy is itself compared to other African markets. The Zimbabwean market is by implication the most vulnerable to crisis as a shock to a single sector could affect nearly the whole economy. It is obvious from the results above that, the level of correlation among the sectoral indexes is influenced by sizes of the stock exchange, and the economy in general. Inconsistencies in policy and data capturing, high levels of political instability, regulation and corruption may be responsible for the lack of integration in some economies which have no evidence of short-run causalities among sectoral returns (see AFX, 2018). This is also evident from the World Bank Governance Indicators' data. The causal relationship between GDP and stock indexes is a confirmation that the economy is a rational forecast of the stock market and vice versa. This conforms with Fama (1981).

On the long-run causality between the sectors, we also reject the null hypothesis of no cointegration between the variables under study as there are evidence that returns to a sector can be predicted partially by the information provided by other indexes within the same African market (see Al-Fayoumi and Al-Thuneibat (2009). This is shown in the last columns of the causality results shown above which shows the significance of the estimates of at least one equation. That is, there is at least one cointegrating relationship in every market sampled with Namibia having the highest number of cointegrating relationships. This implies that disequilibrium in the sectoral returns could be corrected within a quarter. The general low level of cointegration in the region within the sample period may be due to the minimal impact of the global financial crisis as the level of volatility is low among the sectoral returns. This result affirms the Theory of

Mean Reversion and Excess Volatility which provides that cointegration vary with seasons (Marcus, 1989). On the direction of the causality, the indexes share both positive and negative long-run relationships. The inspection of residuals indicate that the convergence to equilibrium of stock returns vary with seasons (Marcus, 1989). The residuals are further examined for serial correlation, normality and heteroskedasticity. Serial Correlation Tests fail to reject the null hypothesis of no serial correlation in the residuals for all the countries up to lag 4, except for Egypt and Namibia where it is rejected at 1% and 5% significance respectively. The results are further confirmed by autocorrelation and partial autocorrelation graphs. Except for South Africa and Tunisia, the null hypothesis of normality is rejected at a maximum of 5%. **Joint test for Heteroscedasticity shows that t**here is no evidence to reject the null hypothesis of homoskedasticity in the residuals for all the countries.

Quantitative measures of the causal relations between the variables for each market, for quarters 3 and 20 quarterly horizons indicate in South Africa the short- is higher than the long-run percentage of forecast error variance (PFEV) especially in the banking and industrial sectors. Secondly, changes in the variables are mostly explained by their lags than other variables. That is, a higher percentage of error variance is accounted for by innovations in the same index or variable, and this percentage explained by the same index is also higher in short- than in the long run. Besides the same sector effect, the banking sector appears the most influential in the JSE. This is because the banking sector is the life wire of every economy through which finances circulate to other sectors. This result corresponds with those of Wang *et al*. (2005) and Al-Fayoumi *et al*. (2009). Similarly, the Nigerian Banking sector is most influential, followed by Oil & Gas. The cashless policy of the Federal Government of Nigeria may be the reason behind the strength of banks in the Nigerian market. The growth of the stock market is seen to have a major impact on that of its host economy, and investors could profitably invest on the NSE ASI given that the size of the stock market is not integrated with the sectoral returns. It is almost the same story for Egypt, with banking having a grip on almost all the sectors followed by the industrial, then consumer goods sectors. The GDP also seems to explain variations in stock returns. The Moroccan Oil & Gas seem to take the lead, followed by the Financials, and the Transport sector could be an option for diversification since the percentage effect of its innovations on others is the least. A shock in the stock mark*et al*so has average impact on the economy and the size is more integrated with its sectors than the Nigerian market. In Namibia, the innovations to the mining sector impose greatest variations on the indexes, followed by banking. The bidirectional causality between GDP and Market Capitalisation is higher in the short than in the long-run. Innovations from the Tunisian banking sector are most effective in explaining variations in other sectoral indexes than even the same sector innovations. The size of the stock market explains variations in the sectoral returns. Returns from the Oil & Gas seem to compete with those from the Consumer Goods sector favourably. In the same vein, the same index effect is more than that from other indexes and the fluctuations in the variables caused by shocks to others are higher in short- than in the long run. In terms of the comparative influence, shocks emanating from the Housing Energy Sector account for higher forecast errors in the Zimbabwean model, followed by the Hospitality sector, and in Swaziland, the Food and Non-Alcoholic Beverages sector is the most influential while the short-run effect is also higher than the long-run effect of shocks or innovations to the same or other indexes. Overall, banking index is the most influential index, and the contemporaneous effect is high between the indexes since the PFEV is higher between quarters one and three than

beyond. This could have some negative implications for investors with a long-term horizon.

6.1 Impulse Response Test Results to One Standard Deviation Innovations

Overreaction and Underreaction to information are the key elements of the Contrarian and Momentum strategies respectively in stock trading. These imply buying the winners and selling the losers. Figure 1 to Figure 3 present the duration and magnitude of responses to one standard deviation shock or innovation to a variable, by other variables within South Africa, Nigeria and Egypt, respectively over forecast horizons from 1 to 20 quarters. Overall, the impulse responses confirm that the initial responses to shocks or innovation are larger and positive than the long-run except for Morocco where the response of Financials to Oil and Gas are an increasing function of time. Conversely, in Tunisia, the impulse responses of Housing and Energy to itself is a decreasing function of the time horizon. Overall, responses to banking are larger, and there is a mixture of positive, negative and no correlations or impulse responses between the indexes, the stock markets and their national economies. It therefore means that the movements in the variables (sectors) could be used in forecasting those in other variables or sectors within the same market. We present IRs for the 3 major markets (South Africa, Nigeria and Egypt) as follows, on Figure1, Figure2 and Figure 3.

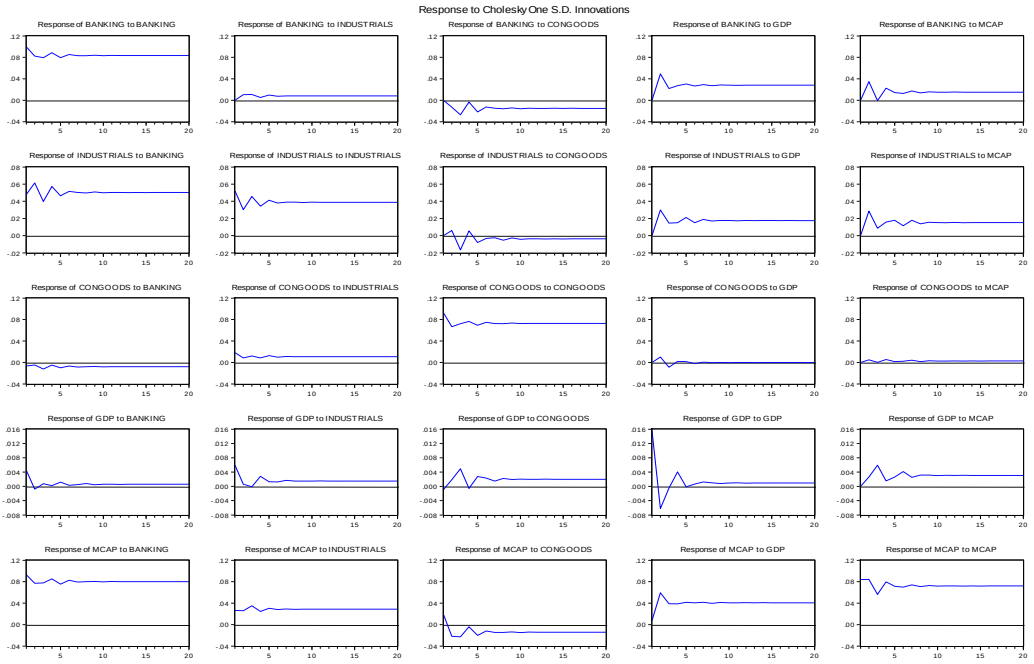

Figure 1: Impulse Responses (IRs) for South Africa

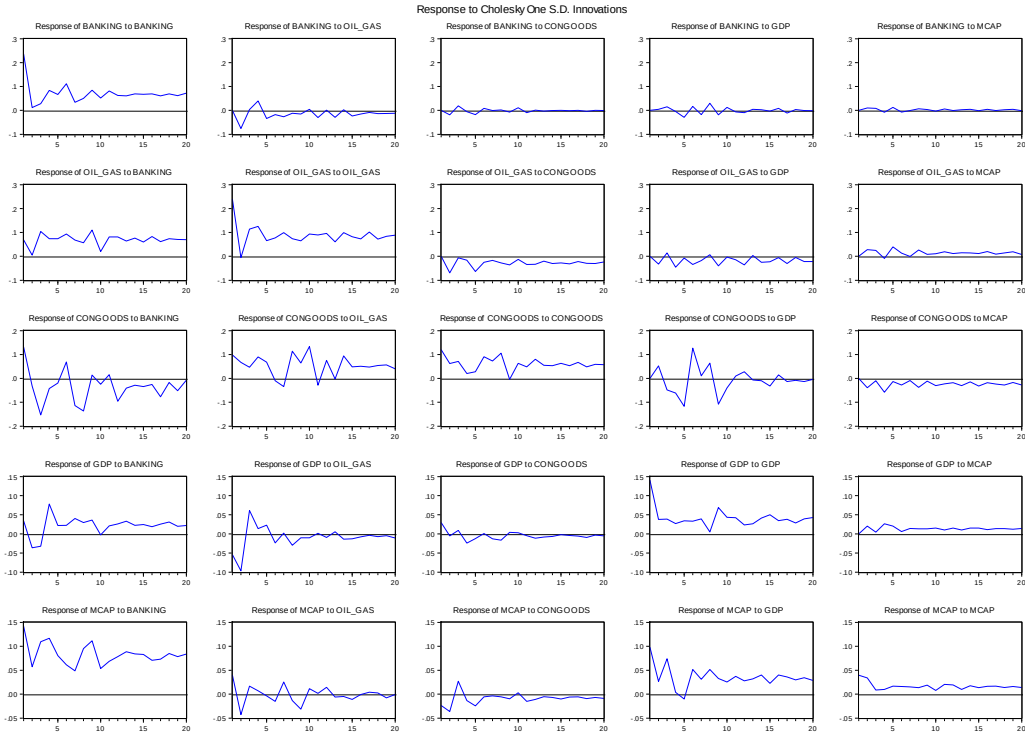

Figure 2: Impulse Responses (IRs) for Nigeria

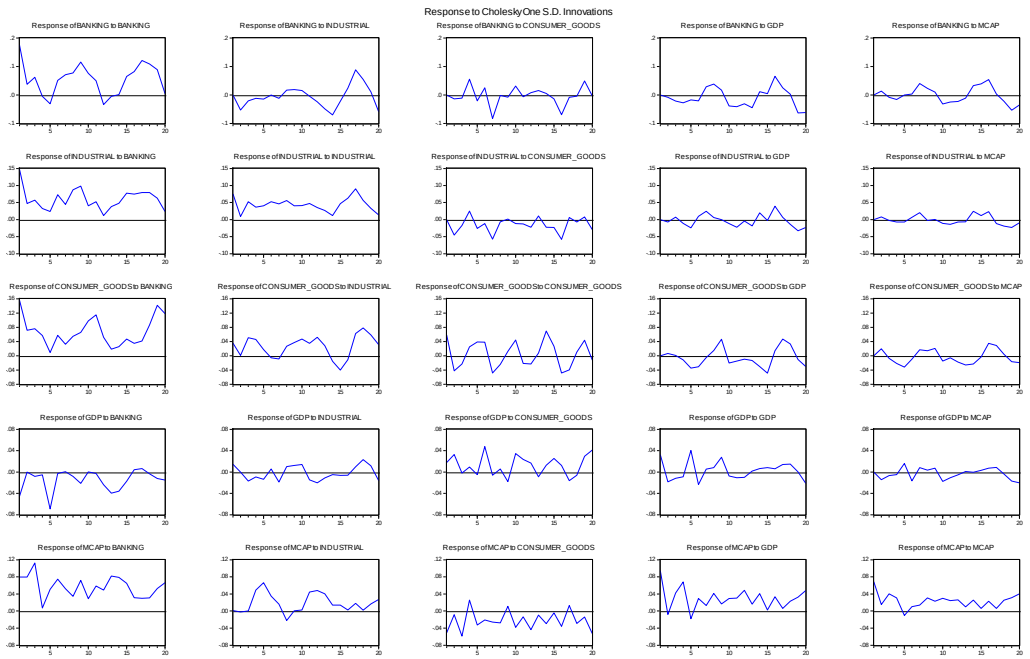

Figure 3: Impulse Responses (IRs) for Egypt

7 Conclusion

This study evaluates comovements between sectoral equity indexes, the stock markets and the economies of eight countries in the sub-Sahara Africa from Q3 2008 to Q2 2018 using the Vector Error Correction Model (VECM). Group unit root tests conducted indicate that all the series are integrated of order one, and multivariate cointegration tests indicate that there is at least one cointegrating equation for each country or a long-run equilibrium relationship exists among them. Further hypothesis tests also prove that the sectoral returns move together in the short-run, implying that the fluctuations in stock prices of one index could be predicted by the information set provided by other indexes. It was also discovered that Nigeria is the most segregated whereas Zimbabwe is the most integrated market, due to the size effect and data inaccuracies, with banking as the most influential index as confirmed by the VDCs and IRFs results. Any shock to the banking sector affects all other sectors of the economy. It was also found that a bidirectional causality exists between the stock markets and their host economies. The sectoral returns in the sub-Sahara African markets generally have violated the Weak Form Efficiency since there is evidence of comovements between them. Accordingly, there is a significant transmission of shocks or innovations from one sector to another, and this could be effectively used by investors to predict the direction of movements in the sectoral indexes and hence their component securities. Also, some sectors are found to be risk sources or lead sectors like banking, industrial, and oil and gas while sectors like consumer goods, housing are risk destinations or lagged sectors. Our findings confirm and extend the findings of Wang *et al*. (2005), Al-Fayoumi *et al*. (2009) and Garcia *et al*. (2014) in the African markets. Our unique findings provide evidence that can be used for optimal portfolio performance, and cross-country hedges within the African sub-continent by allocating significant percentages of their portfolios to the weakly integrated economies like Morocco, Swaziland and Nigeria which also offers the largest market due to her population.

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